Table of Contents

Greetings from the Conference Coordinating Committee Chair

As the chair of the Conference Coordinating Committee, I would like to welcome you to the second collocated ASME International Manufacturing Science and Engineering and SME North American Manufacturing Research Conference. I particularly extend a warm welcome to members of the International Research Group on Tribology in Manufacturing and members from the ASME Plant Engineering and Maintenance Division who are joining us this year. Our thanks go to the conference host at Notre Dame, Steven Schmid, and others at the university as well as those responsible for the technical programs, Shreyes Melkote, Hitomi Yamaguchi, and Laine Mears. A conference of this size and quality with involvement from three professional societies does not happen without considerable effort, and we are truly indebted to them all for their hard work. I also wish to thank the leadership teams of each society for being visionary, open-minded, patient and collaborative as we collocate our conferences. Finally, I would like to thank the members of the Conference Coordinating Committee, Drs. John Agapiou, Robert Ivester, Shreyes Melkote, Z. Cedric Xia, and Hitomi Yamaguchi, for their dedication and efforts to the strategic planning of this conference and future ones.

In closing, on behalf of our CCC members, I wish you a productive conference and hope you will take advantage of this international conference setting to meet old friends, make new acquaintances, and establish new collaborations. Enjoy beautiful South Bend!

Regards,

Brad Kinsey
University of New Hampshire

Welcome from the Host

On behalf of the MSEC/NAMRC/ICTMP Organizing Committee and the University of Notre Dame, I would like to welcome you to northern Indiana for the 2012 ASME International Manufacturing Science and Engineering Conference (MSEC), the 40th Annual SME North American Manufacturing Research Conference (NAMRC XL), and the Fifth International Conference on Tribology in Manufacturing Processes. We are excited to bring these three exceptional conferences together to form the premier manufacturing research event of the year in North America.

I would also like to welcome you to the University of Notre Dame. Notre Dame is world renowned for its storied athletic history and ranks among the Nation's Top 25 Institutions of Higher Learning. With 1250 acres containing two lakes and 137 buildings, Notre Dame is well known for the quality and beauty of its campus. I encourage you all to take in a campus tour and hope you enjoy the social events as much as you benefit from the technical sessions, keynote talks, and panels.

South Bend is centrally located in the Chicago-Detroit corridor, and as such has a large number of automotive and recreational vehicle companies located in the area. Northern Indiana in general, and the Michiana area in particular, are home to four of the five largest orthopedic implant manufacturers, which remains a thriving and dynamic industry.

A conference such as this one cannot possibly be the undertaking of one individual. Special thanks are due to Ms. Harriet Baldwin and Ms. Lauri Roberts of Notre Dame's Academic Conferences Department for their creativity and hard work that have helped make this event a reality. Thanks also go to the collocation coordinating committee and the many volunteers, organizers and panelists that have made this a truly unique event. Elana Saperstein of ASME was very helpful with my many questions, and the constant assistance of Mark Stratton at SME was invaluable. Also, last year's host, Brian Paul of Oregon State University, helped me constantly with his advice, reminders, and numerous helpful suggestions.

My sincere appreciation also goes to our sponsors including the University of Notre Dame Department of Aerospace and Mechanical Engineering, Los Alamos National Laboratory, The National Institute of Standards and Technology, Cummins, DePuy, Biomet, Paragon Medical, Zimmer, Aerotech, Kistler, and the Metal Powder Industries Federation. Further, the ASME Old Guard were kind enough to sponsor the Early Career Forum, and the National Science Foundation provided funding to assist graduate student participation in the conference.

Finally, I would like to thank all of you for showing your support by attending the conference. I hope you have an enjoyable stay at Notre Dame and hope you find inspiration for your work in advancing manufacturing engineering education and technology.

Go Irish!

Steven Schmid
University of Notre Dame

Greetings from ASME/MED, NAMRI/SME and IRGTM

Following the first collocated conferences between MED and NAMRI in 2011, the ASME Manufacturing Engineering Division and the North American Manufacturing Research Institute of SME are again joining the effort to bring the annual flagship event to the manufacturing engineering research community. This year, we are pleased to welcome the International Research Group on Tribology in Manufacturing to join us at the beautiful University of Notre Dame campus.

Manufacturing as the means to generate products is essential to the enhancement of global living standards. By working together, we can advance the science and technology of manufacturing at a much faster pace. This conference has a unique position in the history of MED and NAMRI as it is the conference immediately preceding the launch of manufacturing innovation institutes and many other manufacturing initiatives in the United States that our members have been diligently working on for years. As a result of this joint effort, we sincerely hope that you will take advantage of this international conference setting to meet old friends, make new acquaintances, find talents for your organization, and establish new collaborations.

None of this technically stimulating and socially rich gathering would be possible without the hard work of our host, Prof. Steven Schmid, our conference Program and Scientific Chairs, Prof. Hitomi Yamaguchi of the University of Florida and Prof. Shreyes Melkote of the Georgia Institute of Technology, the kind financial sponsorships of more than ten corporations and government units, and the contribution from the Vice-Chair of IRGTM, Prof. Niels Bay of the Technical University of Denmark, and the conference collocation committee members including Dr. Cedric Z. Xia of Ford – Vice-Chair of MED, Prof. Brad Kinsey of University of New Hampshire – Program Chair of MED, Dr. John Agapiou of GM – President-Elect of NAMRI, and Dr. Robert Ivester of NIST – Secretary of NAMRI. Last, but most importantly, we would like to thank all of you who contribute to the success of this conference via paper/poster submissions, and serving as reviewers, panelists, symposium organizers, session chairs and registrants.

Enjoy the conferences and we look forward to your continued active involvement in future collocated conferences, starting with the next one at the University of Wisconsin, Madison in 2013, if not before.

With our best wishes,

Matthew Bement, Ph.D. Los Alamos National Laboratory Chair – MED/ASME	Jian Cao, Ph.D., FSME, FASME Northwestern University President, NAMRI/SME	Kuniaki Dohda, Ph.D., FASME President – IRGTM

Foreword from the MSEC/NAMRC/ICTMP Technical Program Chairs

We welcome you to the joint Manufacturing Conference consisting of the seventh ASME International Manufacturing Science and Engineering Conference (MSEC2012), sponsored by the Manufacturing Engineering Division (MED) of ASME, and the 40th North American Manufacturing Research Conference (NAMRC40), sponsored by the North American Manufacturing Research Institution of the SME (NAMRI/SME). As leading world-class societies in the Mechanical Engineering field, ASME and SME act as global bridges between industries, government laboratories, and academic institutions. Each of the collocated conferences includes technical sessions covering the full range of manufacturing topics. Moreover, this year's event is in participation with the fifth International Conference on Tribology in Manufacturing Processes (ICTMP5), sponsored by the International Research Group on Tribology in Manufacturing.

While the conferences are held jointly, the paper submission, review, and acceptance processes were conducted separately for MSEC and NAMRC. Of the 163 technical papers received, MSEC's peer review process accepted 140 papers for publication in the MSEC2012 proceedings. In addition, 10 technical posters were submitted; 7 posters were accepted for publication in the proceedings and 3 were accepted for presentation at the conference. The technical papers and posters in the proceedings come from authors representing 16 countries around the world. MSEC is pleased to present four technical tracks in the MSEC2012 proceedings: Processing, Systems, Micro and Nano Technologies, and Sustainable Manufacturing. The Sustainable Manufacturing track appears for the first time in MSEC. In the four technical tracks, a total of 17 symposia with 54 sessions have been planned. For the first time, the Plant Engineering and Maintenance Division has participated with the Manufacturing Engineering Division at this conference.

NAMRC40 received 108 technical papers and after a rigorous peer review process 94 papers authored by researchers from 15 countries were accepted for publication in the *Proceedings of NAMRI/SME* and presentation at the conference in 32 technical sessions. The papers included in the conference address a wide range of basic and applied manufacturing research topics of current interest.

ICTMP5 papers were submitted to either MSEC2012 or NAMRC40 and are included in their respective proceedings. Joint ICTMP/MSEC and ICTMP/NAMRC technical sessions containing these papers are clearly identified in the conference program.

The joint conference consists of 3 keynote speeches, 5 plenary panel presentations, a NAMRI/SME Founders Lecture (NAMRC), 80 concurrent technical sessions, an early career forum, industry and laboratory tours, a student manufacturing design competition (MSEC), and a student author research presentation competition (NAMRC). To help conference attendees to plan their participation and interact with others, equal time has been allotted for each technical paper presentation regardless of the conference (MSEC, NAMRC, or ICTMP) in which it is included.

The conference program is the result of the outstanding efforts of many people. Firstly, we would like to express our gratitude to all the authors for their technical paper and poster submissions. Secondly, we would like to acknowledge the work of the track chairs, symposium organizers, and reviewers for delivering high-quality paper reviews and well-organized sessions. Thirdly, we would like to thank the host Organizing Committee, the Conference Coordinating Committee, the NAMRI/SME Scientific

Committee, and the ASME MED Executive and Technical Committees. Our thanks also go to the ASME staff for their outstanding job in presenting conference information on the Internet, managing the submitted technical papers and posters, and ensuring high-quality publication of the conference proceedings for MSEC2012 and NAMRC40. We would like to extend our gratitude to all sponsors for providing financial support. Additionally, we would like to thank the Advanced Manufacturing Cluster within the Civil, Mechanical, and Manufacturing Innovation (CMMI) Division of the National Science Foundation for providing registration support for US student participants.

Two event organizers deserve a special thanks. Xiaoping Yang from Cummins has organized the Student Manufacturing Design competition, with eight different teams, and sponsorship by Cummins, Inc. Kevin Chou of GE organized the Early Career Forum, including arranging speakers and organizing the entire event. We are grateful for their dedication.

We wish you a productive and enjoyable conference in Notre Dame, Indiana. We hope that the proceedings are beneficial and further stimulate your research and learning. We also hope you take full advantage of the many opportunities offered by the collaborative conferences.

Hitomi Yamaguchi
University of Florida, USA
2012 MSEC Technical Program Chair

Laine Mears
Clemson University, USA
2012 MSEC Technical Program Vice-Chair

Shreyes N. Melkote
Georgia Institute of Technology, USA
NAMRI/SME Scientific Committee Chair

Miguel Angel Selles Canto
Universitat Politècnica de València, Spain
2012 ICTMP Technical Program Chair

Masahiko Yoshino
Tokyo Institute of Technology, Japan
2012 ICTMP Technical Program Vice-Chair

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University of Florida
Term: 2012, 2013, 2014

X. Zhang
University of California-Berkeley
Term: 2010, 2011, 2012

And all members of the
NAMRI/SME Board of Directors

List of MSEC Tracks and Symposia

Track 1: Processing

1-1 Advances in Abrasive Processes
1-2 Advances in Nontraditional Manufacturing Processes
1-3 Advances in Modeling, Analysis, and Simulation of Manufacturing Processes
1-5 Advances in Metal Forming
1-6 Laser, Process Innovations, and Energy Field Manufacturing Methodologies
1-7 Advances in Biomanufacturing
1-8 Mechanical Polymer Processing

Track 2: Systems

2-1 Monitoring, Sensing, and Control for Intelligent Machining and Inspection
2-2 Robotics in Manufacturing
2-3 Integrated Prognostics and Health Management System
2-4 Advances in Quality and Process Control in Manufacturing Systems
2-5 Advanced and Adaptive Manufacturing Systems

Track 3: Micro and Nano Technologies

3-1 New Developments in Micro/Nano Manufacturing and Micro/Nano Metrology
3-3 Nanomaterials, Nanofabrication and Nanoscale Modeling, Simulation, and Control

Track 4: Sustainable Manufacturing

4-1 Research Advances in Green Energy Product
4-2 Sustainable Manufacturing Processes and Systems

MSEC Symposium Organizers

A special thank you for all the hard work and dedication from the following individuals, without whose support the conference would not have been successful.

Mohamed AbuAli, University of Cincinnati
Sam Black, Honeywell International
Qing Chang, Stony Brook University
Hongqang Chen, GE Global Research
Gary J. Cheng, Purdue University
Edmund Chu, Alcoa Inc.
Nikhil Churi, Crystal Technology Inc.
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Xiaoping Yang, Cummins Inc.
Donggang Yao, Georgia Institute of Technology
Chris Yuan, University of Wisconsin at Milwaukee
Hong Chao Zhang, Texas Tech University
Xugang Zhang, Johnson Controls
Wenwu Zhang, GE Global Research
Jack G. Zhou, Drexel University

Student Manufacturing Design Competition

We would like to congratulate all of our student manufacturing design competition finalists and welcome them to the MSEC conference. We would also like to invite all conference participants to attend the presentations by these outstanding future engineers.

Innovative Maintenance Process Planning for Marine Assets
Joshua C. Korman, Timothy N. Gallaway, Matthew J. Caccamo, *Lake Superior State University, Lupton, MI, United States. Faculty Advisor:* ***James D. Devaprasad.***

Augmented Reality: Assistive Technology for the Assembly of an Internal Combustion Engine
Hector Ramirez, Horacio Rios, Jesús Lerma, José Ramón Ruenes, Jorge Israel Herrera Alan Ferrera, Carlos Daniel, Eduardo González Mendívil, *Instituto Tecnológico y de Estudios Superiores de Monterrey, Monterrey, Mexico.*

Improving Industrial Processes with Augmented Reality and Gesture Recognition Technology for the Aeronautical Field on Mobile Devices
Horacio Rios Corzo, Carlos Castro, Javier Rustrián Martínez, Eduardo González Mendívil, *Instituto Tecnológico y de Estudios Superiores de Monterrey, Monterrey, Mexico.*

Temperature Control System for Electrically-Assisted Metal Forming
Luke Hemenetz, Tim Rockers, *Northwestern University, Evanston IL, United States. Faculty Advisor:* ***Jian Cao.***

Standalone Throughput of a Serial Product Line Segment
Yang Li, Michael P. Brundage, and Shiyao Wang, *Stony Brook University, Stony Brook, NY, United States. Faculty Advisor:* ***Qing Chang.***

Design and Fabrication of a Multi-axis Dynamometer for Measuring Cutting Forces in Drilling Processes
Medhi Karevan, *Georgia Institute of Technology, Atlanta, GA, United States. Faculty Advisor:* ***Kyriaki Kalaitzidou.***

Mauncher (Mini Marshmallow Launcher)
Ryan Surveski, Kevin Bryant, Brooke Cosko, Marissa Wright, Tammy Robbin, Amanda Thomas, Bill Carter, Steve Cimino, Ryan Quinn, John Vielkind, Patrick Vielkind, Henry Wettersten, *Rensselaer Polytechnic Institute, Troy, NY, United States. Faculty Advisor:* ***Sam Chiappone.***

Keynote Speakers and Panelists

Dr. Taylan Altan is a Professor in the Mechanical Engineering Department and the Integrated Systems Engineering Department at Ohio State University, where he directs the Center for Net Shape Manufacturing. He is a Founding Member of NAMRI, and an indefatigable expert on metal forming. Dr. Altan's major research capabilities include a) simulation and optimization of forging, sheet forming, hydroforming and metal cutting processes, b) cold precision forging using multiple action tooling, c) blank holder force control in stamping, d) die and mold manufacturing including high speed milling, and e) rapid tool manufacturing and prototyping of products and processes. Other interests include comparison of manufacturing education in various countries and industry related research and education.

Dr. Yusuf Altintas is NSERC-P&WC Industrial Research Chair Professor in Virtual Machining at the University of British Columbia, Canada. He obtained his Bachelor from Istanbul Technical University (1975), M.Sc. (1980) and Ph.D. (1987) in Canada. He joined University of British Columbia and founded Manufacturing Automation Laboratory in 1986. Dr. Altintas spent four years in industry as a machine tool and manufacturing engineer. He conducts research on metal cutting, machine tool vibrations, control and virtual machining. He has published over 125 archival journal articles with over 4000 citations, and a widely used text book. Professor Altintas is the Fellow of ASME, CIRP, SME, Pratt & Whitney Canada, Canadian Academy of Engineering, Tokyo University and the Royal Society of Canada. He received Pratt & Whitney Canada's (P&WC) university partnership, APEG BC's Meritorious Achievement, R.H. Machlaclan, UBC Killiam Teaching Prize of Engineering awards and the 2011 Gold Medal of Engineers Canada. He holds an Honorary Doctorate Degree from Stuttgart University. He currently directs NSERC CANRIMT Machining Research Network across Canada. He holds the NSERC – P&WC Industrial Research Chair Professorship to develop next generation Virtual High Performance Machining Technology.

Dr. Niels Bay is a Professor in the Department of Mechanical Engineering at the Technical University of Denmark. He completed his M.Sc. in mechanical engineering at the Technical University of Denmark (DTU) in 1972, Ph.D. (the Danish degree of licentiatus technices) in 1977 and D.Sc. (the Danish degree of doctor technices) in 1987. He is an indefatigable expert in manufacturing tribology, being a founding member of the International Research Group on Tribology in Manufacturing. He has also served as president of the International Cold Forging Group (1992-1995) and the Chairman of the CIRP Scientific Technical Committee on Forming (1998-2001), among many other professional activities. His awards include the Alexander Foss Gold Medal (1987), the JSTP International Prize for Research and Development in Precision Forging (2005) and the Doctor hc (honoris causa) from the Technical University of Lisbon (2011). His research interest includes, metal forming, metal forming tribology, cold welding, resistance welding, and manufacturing of superconductors. He is the author of 263 international publications and has presented numerous keynote papers at international conferences.

Ronald J. Bennett, PhD, is Honeywell Fellow in Global Technology Management in the School of Engineering at the University of St. Thomas after having served as the Founding Dean. He holds a Ph.D. in Metallurgical Engineering and an MBA. With a background of more than 20 years in industry, Bennett teaches and publishes on diverse topics including materials engineering, technical innovation, technology transfer, leadership and engineering education. He is an EAC of ABET, commissioner for SME, and leads the SME Center for Education.

J T. Black received his Ph.D. from Mechanical and Industrial Engineering, University of Illinois, Urbana, in 1969, an M.S. in Industrial Engineering from West Virginia University in 1963, and his B.S. in Industrial Engineering, Lehigh University, in 1960. J T. is Professor Emeritus from Industrial and Systems Engineering at Auburn University. He was the Chairman and a Professor of Industrial and Systems Engineering at the University of Alabama-Huntsville. He also taught at the Ohio State University, the University of Rhode Island, the University of Vermont, and the University of Illinois. He taught his first processes class in 1960 at West Virginia University. J T. is a Fellow in the American Society of Mechanical Engineers, the Institute of Industrial Engineering and the Society of Manufacturing Engineers. J loves to write music (mostly down home country) an poetry, play tennis in the backyard and show his champion pug dog, VBo.

Toby Buck has a varied background; he grew up in a dairy farming community in southeastern Minnesota. His educational background is in engineering and finance both at the undergraduate and graduate levels respectively. He is a graduate of Purdue University and the Harvard Executive Development Program as well as a graduate of MIT Birthing of Giants Program. He has worked for the past thirty years in three different markets: aerospace, automotive and the healthcare area. He is founder of Paragon Medical located in Pierceton, Indiana, a manufacturer of medical devices for the orthopaedic community worldwide, with nine global facilities and currently serves as Chairman, CEO and President. He has extensive experience in the Private and Public Equity Markets and has facilitated multiple equity and debt capitalization events. He was named 1998 Entrepreneur of the Year for small manufacturing firms, and received the 2004 Ernst & Young Entrepreneur of the Year award in the life sciences category for the State of Indiana. The Warsaw Kosciusko County Chamber of Commerce named Toby 2006 Man of the Year.

Joseph Budzinski received his B.S. at the University of Notre Dame and M.S. at the University of Colorado at Boulder, both in Mechanical Engineering. He joined Johnson & Johnson immediately after graduate school, and has had a varied career. He is currently the Business Group Manager at the Global Development Center, whose primary focus is supporting instrument new product development across the DePuy Franchise (knee, hip, trauma, spine and sports medicine). He actively works with R&D and marketing on aligning the instrument design transfer process to support prototyping of concepts, surgical evaluations and clinical trials; resulting in smooth, timely, successful new product launches. Over the course of his career, he has led many teams and projects, including the expansion of the Raynham investment casting foundry, setting up the Cork, Ireland foundry, and establishing foundry metallurgical and ceramic slurry testing labs as well as other key initiatives in JIT, Lean manufacturing, six sigma, and maintenance excellence.

Prof. David Dornfeld received his B.S., M.S. and Ph.D. degrees in Mechanical Engineering from the University of Wisconsin-Madison in 1976 in the area of Production Engineering. His Ph.D. thesis concerned the study of the fundamentals of the mechanical pulping process (abrasive machining). He joined the faculty of the University of California at Berkeley in the Mechanical Engineering Department in 1977 and is presently Professor of Manufacturing Engineering. Since July 1, 1999 he holds the first Will C. Hall Family Chair in Engineering. He currently serves as the Chair of the Mechanical Engineering Department. He served as Associate Dean for Interdisciplinary Studies in the College of Engineering. He holds an appointment as Special Division Deputy, Engineering Division, Ernst Orlando Lawrence Berkeley National Laboratory. He is past-Director of the Engineering Systems Research Center in the College of Engineering. In 1982 and 1992 he was Directeur de Recherche Associe, Ecole Nationale Superieure des Mines de Paris, Paris and Invited Professor, Ecole Nationale Superieure d'Arts et Metiers- ENSAM, Paris, respectively. Professor Dornfeld is a Fellow Member of the American Society of Mechanical Engineers (ASME), contributing to the technical programs and journals of the society. He is the past Technical Editor, Trans. ASME, Journal of Engineering for Industry. He was the recipient of the ASME Blackall Machine Tool and Gage Award in 1986 and 2010 ASME William T. Ennor Award. He is a Fellow and past-Director of the Society of Manufacturing Engineers (SME) and a recipient of the 2004 SME Fredrick W. Taylor Research Medal, member of Japan Society of Precision Engineering (JSPE) and recipient of the 2005 JSPE Takagi Prize, Fellow, School of Engineering at the University of Tokyo, Japan, member of American Society of Precision Engineering (ASPE), and Materials Research Society (MRS). He is past-President of the Board of Directors and a member of the Scientific Committee, North American Manufacturing Research Institute (NAMRI/SME). He is a Fellow of the CIRP (The International Academy for Production Engineering), Chair of the Editorial Committee and Vice-Chair of the Working Group on Energy Efficiency and Resource Effectiveness.

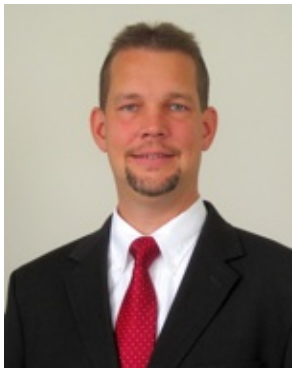
Michael Hawkins received a B.A. in Chemistry from the University of Indianapolis, an M.S. in Chemistry from Eastern Illinois University and a Ph.D. in Mechanical Engineering from Notre Dame. In 1980, he began his career with Zimmer, the world's largest pure-play orthopedic implant manufacturer, as a chemist. He progressed through various departments and positions including Quality, Research, Product Development, Trauma Marketing, and Manufacturing. He currently serves as the Vice President for Corporate Research at Zimmer. His technological areas of expertise include medical device design and manufacturing, materials science and tribology; he has performed research and commercialization of technologies such as: PMMA Precoat, Collagraft bone graft substitute, Epoch composite hip stem, Osteobond bone cement, bone cement mixing systems, HATCP (calcium phosphate) plasma spray, molding of ultrahigh molecular weight polyethylene. Dr. Hawkins holds 14 US Patents, with 8 current published patent applications.

Steve Hayashi is a Principal Engineer in the Manufacturing Technology Organization at GE Global Research. During and after his undergraduate studies at Union College, Steve worked on micrometeorite analysis at Dudley Observatory in Albany, NY. In 1976 he moved to GE Research to work on analysis and automation in the SEM and Microprobe group, then in 1980 he changed positions to work on high speed machining and has been in the manufacturing area since. He has developed sensor systems for cutting tool monitoring and investigated surface integrity for drilling and shot peening. He is a certified Six Sigma Master Black Belt and led the development of the GE-wide standard DFSS training curriculum. Steve holds a MS in Mechanical Engineering from Rensselaer Polytechnic Institute and personal research areas include: conventional machining, electro-machining, ultra-precision micro machining, CNC machines, sensors, electronics, signal processing and data analysis. Steve also collaborates on other technologies in his organization including laser material processing, casting, additive manufacturing, material processing mechanics, and manufacturing methods.

S. Jack Hu is Professor of Mechanical Engineering and the J. Reid and Polly Anderson Professor of Manufacturing Technology at the University of Michigan. He also holds a joint appointment as Professor of Industrial and Operations Engineering and co-directs the General Motors Collaborative Research Laboratory in Advanced Vehicle Manufacturing. Dr. Hu currently serves as the Associate Dean for Academic Affairs in the College of Engineering. Before this appointment, he served as Associate Dean for Research and Graduate Education. From 2002 to 2006, he was the Director of Program in Manufacturing (PIM) and Executive Director of Michigan Interdisciplinary and Professional Engineering. Dr. Hu is the recipient of various awards, including the SME Outstanding Young Manufacturing Engineer Award, National Science Foundation CAREER Award, ASME Design for Manufacturing Best Paper Award, and the College of Engineering Research Excellence Award. He was elected a fellow of ASME in 2003 and currently serves as the Editor in Chief of Journal of Manufacturing Systems. He was the G. Lawton and Louise G. Johnson Professor of Engineering at Michigan from 2009 to

2011. Dr. Hu received his B.S. from Tianjin University, China in 1983, M.S. and Ph.D. from the University of Michigan in 1986 and 1990 respectively.

Karen Huber is the division manager for Manufacturing Technology R&D at Caterpillar Inc. Karen has dual Bachelor's degrees in Biology and Welding Engineering from Millikin University in Decatur, IL. She has been at Caterpillar Inc. for 34 years. For the past 11 years, Karen has been focused on manufacturing process research, and incorporating new technologies into product development programs and operations facilities. Karen began her career in a business unit— predominantly on the manufacturing side and worked product introductions for the largest mining trucks and wheel loaders ever built. Karen and her team represent Caterpillar Inc. on several external international forums.



Dr. Robert W. Ivester currently serves as the Executive Secretary to the Interagency working group on Advanced Manufacturing, which was formed in 2011 under the NSTC Committee on Technology in the Executive Office of the President. The working group's primary purpose is to develop a national strategic plan for advanced manufacturing. Dr. Ivester's research interests include manufacturing process metrology, modeling, and optimization. Dr. Ivester has performed research to quantify uncertainty associated with measurements and model-based predictions of manufacturing process behavior. In particular, Dr. Ivester has performed extensive research on the measurement of temperature and strain during orthogonal cutting of metals. Dr. Ivester has been an instructor for the Johns Hopkins University Engineering for Professionals program for graduate-level studies in manufacturing engineering since 2001, including courses in design for manufacturability, manufacturing systems analysis, and computer-integrated manufacturing. Rob received his Ph.D., M.S, and B.S. from the University of Massachusetts Amherst.

Erin M. Johnson is the Vice President, Trauma Research and Development for Zimmer, Inc. in Warsaw, IN. Erin is responsible for research, development, and execution of the new product development strategy for the Trauma Division. She also oversees the Trauma Division Regulatory Affairs and Clinical Affairs departments supporting all actions with global regulatory bodies and overseeing all Trauma specific clinical studies. She provides strategic leadership and direction to the organization to support core technologies and new product launches. Erin has been with a Zimmer company for more than 20 years, serving in engineering, management and leadership roles. Erin holds a Bachelor of Science degree in Mechanical Engineering from Wichita State University, a Master of Science degree in Mechanical Engineering from Arizona State University, and an MBA from the University of Phoenix.

Dr.-Ing. E.h. Reiner Kopp is Professor emeritus at the RWTH Aachen University, Germany. He is the former Director of the Institute of Metal Forming, former Dean of the Faculty of Mining, Metallurgy and Geo-Science, former Vice Rector and member of the University Advisory Board at the RWTH Aachen University. He received a Diplom-Ingenieur degree (1965) in Mechanical Engineering from University of Technology, Stuttgart and Dr.-Ing. degree (1968) from Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf. He is the Fellow (Emeritus) of CIRP (International Academy for Production Engineering Research), former member of the Board of German Academy of Technical Sciences – acatech and former Vice Chairman and Member of the Euro-CASE Board (The European Council of Applied Sciences, Technologies and Engineering), former Vice President of DGM (Deutsche Gesellschaft für Materialkunde), former Coordinator of the DFG – research group "Extension of the limits of metal forming processes" and Member of the Academy of Science North Rhine-Westphalia, Düsseldorf.

Kevin W. Lyons is Leader for the Lifecycle Engineering Group within the Engineering Laboratory (EL), National Institute of Standards and Technology (NIST). He is currently the Manager for the Sustainable Manufacturing Program that is directed to develop and deploy advances in measurement science that will enable the assessment of sustainable manufacturing process performance. His research interests are design and manufacturing processes for sustainable manufacturing, simulation and modeling, and nanomanufacturing. From 2004 through 2006 he served as Program Director for the Nanomanufacturing Program at the National Science Foundation (NSF). From 2000 to 2004 he served as Program Manager of the Nanomanufacturing Program at NIST. From 1996 to 2000 he served as Program Manager with the Defense Advanced Research Projects Agency (DARPA) where he managed advanced design and manufacturing projects. From 1977 to 1992 he worked in industry in various staff and supervisory positions in engineering marketing, product design and analysis, factory automation, and quality engineering.

Dr. Dane Miller received his B.S. Degree in Mechanical Materials Science Engineering from General Motors Institute in 1969. He then received a Masters Degree and Ph.D. in Materials Science-Biomedical Engineering from the University of Cincinnati in 1971 and 1974, respectively. Dr. Miller began his professional career at the Frigidaire Division, GMC in Dayton, Ohio from 1964 to 1969, working as a cooperative engineering student. From 1972 to 1975 he was employed at Zimmer U.S.A. in Warsaw, Indiana, in the position of Director of Biomedical Engineering. His responsibilities included engineering, prototype design and fabrication, as well as basic research support for all new product development programs. He was also responsible for coordinating and developing a custom and special product group, including marketing, sales, and manufacturing of custom products. From 1975 to 1978, Dr. Miller served as Director of Biomedical Engineering for Cutter Biomedical, a division of Cutter Laboratories, Inc., in San Diego, California. His responsibilities included organizing and staffing of a complete product development group, including formal budgeting and product planning functions. Finally, in 1978, Dr. Miller returned to Warsaw and, along with three other local individuals with orthopedic manufacturing experience formed Biomet, Inc. Their

goal was to become the most responsive company in orthopedics while simultaneously providing patients with the highest quality and most clinically proven products in the marketplace. Since its inception in 1978 until March of 2006 Dr. Miller served as President and CEO of the company. With Dr. Miller at the helm, Biomet grew from $17,000 in sales its first year into one of the leading musculoskeletal companies in the world – with annual sales exceeding $2 billion.

Michael F. Molnar is serving as the first Chief Manufacturing Officer for the Commerce Department's National Institute of Standards and Technology (NIST). The position includes responsibility for planning and coordinating the Institute's broad array of manufacturing research and services programs, and serving as the central point of contact with the White House and other agencies on policy issues and initiatives related to advanced manufacturing. Additionally, Molnar is serving as the founding head of the Advanced Manufacturing National Program Office (AM NPO). As called for by the Advanced Manufacturing Partnership (AMP) initiative, the NPO's mission is 1) to convene and foster private-public partnerships to improve competitiveness and innovation in U.S. manufacturing, and 2) to form a "whole of government" approach to build America's advanced manufacturing capacity. Molnar has extensive industrial experience and leadership roles including advanced manufacturing, metrology, manufacturing systems, quality, technology development, sustainability and industrial energy efficiency. His credentials include service as a Federal Fellow in the White House Office of Science and Technology Policy, and election as Fellow of both the American Society of Mechanical Engineers and the Society of Manufacturing Engineers. He is a licensed Professional Engineer, a Certified Manufacturing Engineer and a Certified Energy Manager. He received a Master of Business Administration from the University of Notre Dame, and both a Master of Science in Manufacturing Systems Engineering and a Bachelor of Science in Mechanical Engineering from the University of Wisconsin. He is an active member of professional societies, consortia and volunteer organizations.

Prof. Thomas Neitzert started his career as an academic staff member of the University of Stuttgart, Germany, before joining the R&D departments of Mercedes-Benz AG in the same city. After immigrating to New Zealand and working for New Zealand Steel he took up the position of Engineering Manager of Fisher & Paykel Appliances being responsible for the development of laundry and later refrigeration products. He became the Foundation Professor of Engineering at the University of Waikato in Hamilton, New Zealand, and has been the Head of School of Engineering of AUT University in Auckland, New Zealand. Currently he is the director of AUT's Engineering Research Institute (ERI). He is a fellow of the Institution of Professional Engineers New Zealand (IPENZ) and a member of the Australasian Association of Engineering Education AAEE).

Dr. Elena Pérez-Bernabeu is in the Department of Applied Statistics, Operational Research and Quality at the Universidad Politécnica de Valencia, Campus of Alcoy, Spain, and has served as Vice-Dean for International Relations since 2008. She joined the university in October 2001. Pérez-Bernabeu has a bachelor's degree in telecommunications engineering and a master's in industrial organization. She holds a Ph.D. in Quality Control management. She teaches statistics and quality control undergraduate and graduate courses in the Campus of Alcoy, Universitat Politècnica de Valencia. Her research interests are quality control and decision making. She is member of the Spanish Society of Statistics and Operational Research.

Dr. John W. Sutherland is Fehsenfeld Family Head and Professor of Environmental and Ecological Engineering at Purdue University. He has been at Purdue since 2009 and also holds an appointment in the School of Mechanical Engineering. He is a well-known educator and one of the world's leading authorities on the application of sustainability principles to design, manufacturing, and other industrial issues. Professor Sutherland received his B.S., M.S., and Ph.D. degrees from the University of Illinois (UIUC). His previous positions include Vice President of a manufacturing consulting company, and the Henes Chair Professorship and Director of the Sustainable Futures Institute (at Michigan Tech,). He has mentored nearly 80 students to the completion of their graduate degrees, including 21 PhD students. He has published over 250 papers in various journals and conference proceedings. He is also a co-author of the textbook, Statistical Quality Design and Control: Contemporary Concepts and Methods. His honors and awards include the SME Outstanding Young Manufacturing Engineer Award (1992), Presidential Early Career Award for Scientists and Engineers (1996), SAE Ralph R. Teetor Educational Award (1999), SME Education Award (2009), Outstanding Lifetime Service Award from NAMRI/SME (2010), and SAE John Connor Environmental Award (2010). He is a member of numerous honor societies and is a Fellow of SME, ASME, and CIRP.

Dr.-Ing. A. Erman Tekkaya is Professor at the Technische Universität Dortmund, Germany and is leading the Institute of Forming Technology and Lightweight Construction (IUL). He is also adjunct professor at the Manufacturing Engineering Department of the ATILIM University in Ankara, Turkey, where he is the founding director of the "Metal Forming Center of Excellence". Having received his BSc and MSc degrees from Middle East Technical University in Ankara, Turkey in mechanical engineering, he completed his doctoral study with Professor K. Lange at the University of Stuttgart in Germany. Prof. Tekkaya has been editor-in-chief of the Journal of Materials Processing Technology (Elsevier) since 2007. He is fellow of the International Academy for Production Engineering (CIRP), and member of the German National Academy of Science and Engineering (acatech), the Japanese Society for Technology of Plasticity (JSTP), the International Cold Forging Group (ICFG) and the International Impulse Forming Group (I2FG). His research interests are metal forming technology, modeling of manufacturing processes and material characterization. Also engineering education is a prime interest of his.

Research Professions in Academia, Industry & National Laboratories: An Early Career Forum

Organized by AMSE/MED and NAMRI/SME
Sponsored by ASME Old Guard and University of Notre Dame

Date/Time/Place:

June 5, 2012, 5:30 – 8:15 pm, Central Dining Area, McKenna Hall. The forum will be held during the collocated manufacturing conferences: the ASME 2012 International Conference on Manufacturing Science and Engineering (MSEC2012) and the 40th North American Manufacturing Research Conference (NAMRC40).

Purpose:

The goal of this forum is to provide recent advanced degree graduates as well as current Master's and Ph.D. students with better information/knowledge of various research positions in industry, academia, as well as national laboratories available. The forum will further discuss how to be successful professionally in the various settings of research positions.

Tentative Agenda (Tuesday, June 5, 2012)

5:30 – 5:35 pm: Opening/Introduction
5:35 – 5:55 pm: Academic representative speaker
5:55 – 6:15 pm: National lab representative speaker
6:15 – 6:35 pm: Industrial representative speaker
6:35 – 7:15 pm: Breakout round-table panels (Panel I: academia, Panel II: government and industry)
7:15 - 8:15 pm: Light reception

Forum Format:

(1) The forum will start with presentations by a representative speaker from each of academic, government, and industrial sectors. Speakers will discuss such topics as how to search for a job, career management, funding for research, etc.
(2) 2 breakout round-table panels (parallel) will follow: one for academia and the other for government/industry). The round-table panels will each have 3 to 4 panelists from diverse background/positions.

Organized by **Prof. Kevin Chou**, University of Alabama.

Program at a Glance

Monday, June 4, 2012

8:00 – 15:30	NAMRI/SME Board meeting, 200 McKenna Hall
16:00 – 18:00	Conference Registration, McKenna Hall Atrium
17:30 – 19:30	Welcome reception, McKenna Hall Atrium

Tuesday, June 5, 2012

7:00 – 8:00	Breakfast, McKenna Hall Atrium
10:00 – 17:00	Registration
8:00 – 8:15	Welcome, McKenna Hall Auditorium
8:15 – 9:15	Keynote: Advanced Manufacturing Partnerships Program, Michael Molnar, McKenna Hall Auditorium
9:15 – 10:15	Panel: Advanced Manufacturing Partnerships Programs, McKenna Hall Auditorium
10:15 – 10:30	Break
10:30 – 12:00	Concurrent Technical Sessions
10:30 – 12:00	ASME/MED Executive Committee Meeting, 200 McKenna Hall
12:00 – 13:30	Lunch, Irish Courtyard
13:30 – 15:00	Concurrent Technical Sessions
13:30 – 15:00	Panel: Sustainability, Innovation and the Education of Engineering Methodologies, McKenna Hall Auditorium
15:00 – 15:30	Break
15:30 – 17:00	Concurrent Technical Sessions
17:00 – 17:30	ASME/MED Membership Meeting, McKenna Hall Auditorium
17:30 – 18:00	NAMRI/SME Membership Meeting, McKenna Hall Auditorium
17:30 – 20:00	Early Career Forum, McKenna Hall Central Dining Area
18:00 – 21:00	Studebaker History Tour and Dinner (optional event), buses depart from the McKenna Hall Atrium

Wednesday, June 6, 2012

8:00 – 17:00	Registration, McKenna Hall Atrium
8:00 – 9:00	Keynote: The History of Biomet, Dane Miller, McKenna Hall Auditorium
9:00 – 10:30	Panel: Research Needs in Orthopedics, McKenna Hall Auditorium
9:00 – 10:30	Concurrent Technical Sessions
10:30 – 11:00	Break
11:00 – 12:00	Concurrent Technical Sessions
12:00 – 14:00	Lunch and SME Founder's Lecture, South Dining Hall
14:00 – 15:30	Concurrent Technical Sessions
15:30 – 18:30	Plant Tours
18:30 – 21:30	Reception and Awards Banquet, Club Naimoli

Thursday, June 7, 2012

8:00 – 9:00	Keynote: A Methodology for Off-Line Testing of Sheet Metal Forming Lubricants, Niels Bay, McKenna Hall Auditorium
9:00 – 10:30	Panel: Advances in Metal Forming & Machining Through Global Collaborations – A Panel in Honor of Dr. Taylan Altan, McKenna Hall Auditorium
10:30 – 11:00	Break
11:00 – 12:30	Concurrent Technical Sessions
12:30 – 13:30	Lunch, Irish Courtyard
13:30 – 15:00	Concurrent Technical Sessions
15:00 – 15:30	Break
15:30 – 17:00	Concurrent Technical Sessions
17:00 – 18:00	University Tours, depart from McKenna Hall Atrium
18:00 – 20:00	Dinner in Honor of Steven Danyluk, Greenfield's, Hesburgh Peace Center (optional event)
18:00 – 20:00	Dinner in Honor of Taylan Altan, Notre Dame Room, Morris Inn (optional event)

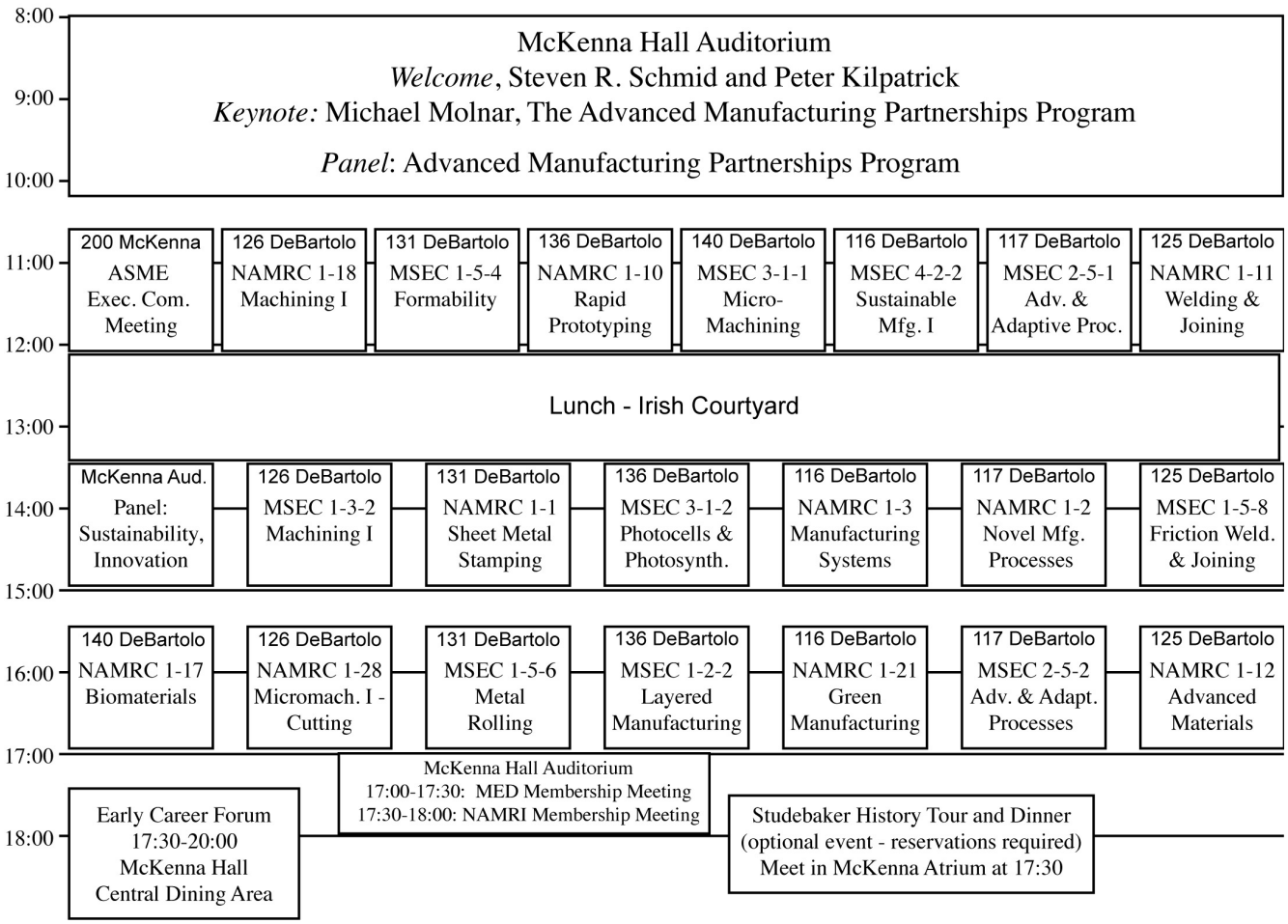
Friday, June 8, 2012

8:00 – 9:30	Concurrent Technical Sessions
9:30 – 10:00	Break
10:30 – 12:00	Panel: Global Research and Education Collaborations, McKenna Hall Auditorium
12:00 – 13:30	Lunch, Irish Courtyard
12:00 – 13:30	IRGTM Executive Committee Meeting, McKenna Atrium.

TECHNICAL PROGRAM - TUESDAY, JUNE 5, 2012

Overview

Spouse's Program: Michigan City Shopping



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00 to 8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 10:00 to 17:00, but heavily staffed from 10:00-2:00.

Conference Opening Ceremony
McKenna Hall Auditorium 8:00 – 10:15

Opening Remarks
Steven R. Schmid**,** *University of Notre Dame, Notre Dame, IN, United States*

Welcome
Peter Kilpatrick**,** *Dean, College of Engineering, University of Notre Dame, Notre Dame, IN, United States*

Keynote: The Advanced Manufacturing Partnerships Program
Michael Molnar*, Chief Manufacturing Officer, National Institute of Standards and Technology Gaithersburg, MD, United States*

Panel Session: Advanced Manufacturing Partnerships
Moderator: ***Steven Hayashi****, GE Global Research*
Panel: ***S. Jack Hu,*** *University of Michigan*
David Dornfeld*, University of California at Berkeley*
Karen Huber, *Caterpillar Inc.*
Robert W. Ivester, *National Institute of Standards and Technology*

Break, McKenna Hall Atrium
10:15-10:45

CONCURRENT TECHNICAL SESSIONS
10:45-12:15

ASME Executive Committee Meeting
200 McKenna Hall

NAMRC 1-10 Rapid Prototyping
136 DeBartolo Hall 10:45 - 12:15

Session Chair: **Yong Chen**, *University of Southern California, Los Angeles, CA, United States*
Session Co-Chair: **Sam Anand**, *University of Cincinnati, Cincinnati, OH, United States*

Optimum Part Orientation in Rapid Protopyping Using Genetic Algorithm
NAMRC40-7710
***Amar Phatak, Sanjay Pande**, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India*

Smooth Surface Fabrication in Mask Projection Based Stereolithography
NAMRC40-7715
***Yayue Pan, Xuejin Zhao, Chi Zhou, Yong Chen**, University of Southern California, Los Angeles, CA, United States*

Process Energy Analysis and Optimization in Selective Laser Sintering
NAMRC40-7738
***Ratnadeep Paul, Sam Anand**, University of Cincinnati, Cincinnati, OH, United States*

NAMRC 1-11 Welding and Joining
125 DeBartolo Hall 10:45 - 12:15

Session Chair: **John Agapiou**, *General Motors R&D Center, Warren, MI, United States*
Session Co-Chair: **Tim Rodts**, *University of Notre Dame, Notre Dame, IN, United States*

On the Choice of Tool Material in Friction Stir Welding of Titanium Alloys
NAMRC40-7717
***Gianluca Buffa, Livan Fratini, Fabrizio Micari**, University of Palermo, Palermo, Italy*, ***Luca Settineri**, Polytechnic University of Turin, Torino, Italy*

A Combined Experimental Simulative Method for Studying the Material Bonding of Different Aluminum Alloys
NAMRC40-7725
***Gianluca D'Urso, Michela Longo, Claudio Giardini**, University of Bergamo, Dalmine (BG), Italy*, ***Elisabetta Ceretti**, University of Brescia, Brescia, Italy*

Inertia Welding for Assembly of Copper Squirrel Cages for Electric Motors
NAMRC40-7816
***John Agapiou**, General Motors, R&D Center, Warren, MI, United States*

NAMRC 1-18 Machining I
126 DeBartolo Hall 10:45 - 12:15

Session Chair: **Steven Liang,** *Georgia Tech, Atlanta, GA, United States*
Session Co-Chair: **Mohamed El Mansori**, *Arts et Métiers ParisTech, Châlons-en-Champagne, France*

Process Damping Analytical Stability Analysis and Validation
NAMRC40-7758
***Chris Tyler, Tony Schmitz**, University of North Carolina at Charlotte, Charlotte, NC, United States*

Chip Morphology Characteristics During Dry Drilling of Austempered Ductile Iron (ADI)
NAMRC40-7768
***Anil Meena, Mohamed El Mansori**, Arts et Métiers ParisTech, Châlons-en-Champagne, France*

Mapping Microstructures From Severe Plastic Deformation in Machining
NAMRC40-7767
***Sepideh Abolghasem, Saurabh Basu, Shashank Shekhar, Jiazhao Cai, M. Ravi Shankar**, University of Pittsburgh, Pittsburgh, PA, United States*

MSEC 1-5-4 Formability
131 DeBartolo Hall 10:45 - 12:15

Session Chair: **Edmund Chu**, *Alcoa Inc, Alcoa Center, PA, United States*
Session Co-Chair: **Yannis Korkolis** *University of New Hampshire, Durham, NH, United States*

M-K Analysis of Forming Limit Diagram under Stretch-Bending
MSEC2012-7401
***Ji He**, Shanghai Jiao Tong University, Shanghai, China*, ***Z. Cedric Xia**, Ford Motor Company, Dearborn, MI, United States*, ***Shuhui Li**, Shanghai Jiao Tong University, Shanghai, China*, ***Danielle Zeng**, Ford Motor Company, Dearborn, MI, United States*

Numerical and Experimental Investigations of Key Assumptions in Analytical Failure Models for Sheet Metal Forming
MSEC2012-7319
***Raed Hasan**, GE Aviation, Vandalia, OH, United States*, ***Tugce Kasikci, Igor Tsukrov, Brad Kinsey**, University of New Hampshire, Durham, NH, United States*

Biaxial Work Hardening Characteristics of 6000 Series Aluminum Alloy Sheet for Large Strain Range
MSEC2012-7288
***Daisaku Yanaga, Toshihiko Kuwabara**, Tokyo University of Agriculture and Technology, Tokyo, Japan*, ***Naoyuki Uema, Mineo Asano**, Sumitomo Light Metal Industries Ltd, Nagoya, Japan*

MSEC 2-5-1 Advanced and Adaptive Manufacturing Systems
117 DeBartolo Hall 10:45 - 12:15

Session Chair: **Zhuming Bi**, *IPFW, Fort Wayne, IN, United States*
Session Co-Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden*

Web Based Monitoring and Control of Distant Robotic Operations
MSEC2012-7296
Magnus Holm, Mohammad Givehchi, Abdullah Mohammed, Lihui Wang, *University of Skövde, Skövde, Sweden*

Robust Work Planning And Development of a Decision Support System for Work Distribution on a Mixed-Model Automotive Assembly Line
MSEC2012-7350
Kavit Antani, ***Alireza Madadi, Mary E. Kurz***, ***Laine Mears***, ***Maria E. Mayorga***, *Clemson University, Clemson, SC, United States*, ***Kilian Funk***, *BMW Manufacturing Co., Greer, SC, United States*

Dynamic Strategies for Preventive Maintenance Scheduling with Throughput Target Variation
MSEC2012-7384
Xiaoning Jin, Jun Ni, *University of Michigan, Ann Arbor, MI, United States*

MSEC 3-1-1 Micro-Scale Machining I
140 DeBartolo Hall 10:45 - 12:15

Session Chair: **Qingwei Zhang**, *Drexel University, Philadelphia, PA, United States*
Session Co-Chair: **Takashi Matsumura**, *Tokyo Denki University, Tokyo, Tokyo, Japan*

Fabrication of Textured 3D Microstructures Using 'Bulk Lithography'
MSEC2012-7357
Prasanna Gandhi, *Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India*, ***Kiran Bhole***, *IIT Bombay, Mumbai, Maharashtra, India*, ***Naresh Chaudhari***, *Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India*

Micropatterning of Porous Polymer Structures
MSEC2012-7408
Wei Zhang, *Georgia Institute of Technology, Atlanta, GA, United States*, ***Min Li, Chaosheng Wang***, *Donghua University, Shanghai, China*, ***Jack Zhou***, *Drexel University, Philadelphia, PA, United States*, ***Donggang Yao***, *Georgia Institute of Technology, Atlanta, GA, United States*

A Microlens Array on Curved Substrates by 3D Micro Projection and Reflow Process
MSEC2012-7409
Hao Zhang, Lei Li, David McCray, *Ohio State University, Columbus, OH, United States*, ***Donggang Yao***, *Georgia Institute of Technology, Atlanta, GA, United States*, ***Allen Yi***, *Ohio State University, Columbus, OH, United States*

MSEC 4-2-2 Sustainable Manufacturing Systems
116 DeBartolo Hall 10:45 - 12:15

Session Chair: **Mahesh Mani**, *National Institute of Standards and Technology, Gaithersburg, MD, United States*
Session Co-Chair: **John Michaloski**, *National Institute of Standards and Technology, Gaithersburg, MD, United States*

Discovering Material Recovery Scenarios for Industrial Machinery: A Case-Based Approach
MSEC2012-7306
William Z Bernstein, Devarajan Ramanujan, *Purdue University, West Lafayette, IN, United States*, ***Mikko Koho***, *Tampere University of Technology, Tampere, Finland*, ***Karthik Ramani, Fu Zhao***, *Purdue University, West Lafayette, IN, United States*

Scheduling of Machine Startup and Shutdown to Reduce Energy Consumption in Bernoulli Production Lines
MSEC2012-7342
Guorong Chen, Liang Zhang, *University of Wisconsin-Milwaukee, Milwaukee, WI, United States*, ***Jorge Arinez, Stephan Biller***, *General Motors, Warren, MI, United States*

Ultrasonic-Vibration Assisted Pelleting for Cellulosic Ethanol Manufacturing: Effects of Particle Size and Moisture Content on Power Consumption
MSEC2012-7211
Qi Zhang, *Kansas State University, Kansas, United States*, ***Pengfei Zhang, Graham Pritchett, Z.J. Pei, Xiaoxu Song, Meng Zhang, T.W. Deines***, *Kansas State University, Manhattan, KS, United States*

Lunch, Irish Courtyard
12:15 - 13:30

CONCURRENT TECHNICAL SESSIONS
13:30-15:00

Panel: Sustainability, Innovation and the Education of Engineering Methodologies
McKenna Hall Auditorium 13:30 - 15:00

Moderator: ***Dr. Wenwu Zhang***, *GE Global Research Center, Schenectady, NY, United States*

Panelists:

Ronald J. Bennett, *University of St. Thomas, St. Paul, MN, United States*
Steve Hayashi, *GE Global Research, Niskayuna, NY, United States*
Kevin W. Lyons, *NIST, Gaithersburg, MD, United States*
John W. Sutherland, *Purdue University, West LaFayette, IN, United States*

NAMRC 1-1 Sheet Metal Stamping
131 DeBartolo Hall 13:30 - 15:00

Session Chair: **Livan Fratini**, *University of Palermo, Palermo, Italy*
Session Co-Chair: **Rajiv Shivpuri**, *Ohio State University, Columbus, OH, United States*

A Combined Dynamic Programming / Finite Element Approach for the Analysis and Optimization of Multi-Stage Deep Drawing of Box-Shaped Parts
NAMRC40-7741
Tamer F. Abdelmaguid, *Cairo University, Giza, Egypt*, ***Ragab K. Abdel-Magied***, *Beni-Sueif University, Beni-Sueif, Egypt*, ***Mostafa Shazly***, *British University in Egypt, ElShorouk, Egypt*, ***Abdalla Wifi***, *Cairo University, Giza, Egypt*

Effect of Specimen Planar Area on Electromagnetic Flanging
NAMRC40-7793
Reid VanBenthysen, Brad Kinsey, *University of New Hampshire, Durham, NH, United States*

Simulations and Experiments in Punching Spring-Steel Devices With Sub-Millimeter Features
NAMRC40-7826
Rakesh Kumar Pathak, A. Ravi Kumar, G. K. Ananthasuresh, *Indian Institute of Science, Bangalore, KA, India*

NAMRC 1-2 Novel Manufacturing Processes
117 DeBartolo Hall 13:30 - 15:00

Session Chair: **Z.J. Pei**, *Kansas State University, Manhattan, KS, United States*
Session Co-Chair: **Steve Hayashi**, *GE Global Research, Niskayuna, NY, United States*

Printed Energy Storage: From Prototype Towards Large-Scale Manufacturing
NAMRC40-7711
Paul K. Wright, David A. Dornfeld, Zuoqian Wang, Alic Chen, *University of California, Berkeley, Berkeley, CA, United States*, ***Rei-Cheng Juang***, *Industrial Technology Research Institute, Hsinchu,Taiwan*, ***James W. Evans***, *University of California, Berkeley, Berkeley, CA, United States*

Embedding Shape Memory Alloy Actuators in Miniature Articulating Polymer Structures Using In-Mold Assembly
NAMRC40-7760
Arvind Ananthanarayanan, *Massachusetts Institute of Technology, Cambridge, MA, United States*, ***Leicester Ehrlich, Mingyen Ho, Jaydev P. Desai, Satyandra K. Gupta***, *University of Maryland College Park, College Park, MD, United States*

A Prototype Printer for Laser Driven Micro-Transfer Printing
NAMRC40-7811
Placid Ferreira, Reza Saeidpourazar, Michael D. Sangid, John A. Rogers, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*

NAMRC 1-3 Manufacturing Systems
116 DeBartolo Hall 13:30 - 15:00

Session Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden*
Session Co-Chair: **Dragan Djurdjanovic**, *University of Texas, Austin, TX, United States*

Hierarchical Decomposition Based Approach to Process Design of Aeroengine Disk in Presence of Defects
NAMRC40-7723
***Kuldeep Agarwal, Rajiv Shivpuri**, Ohio State University, Columbus, OH, United States*

A Study on Optimal Machine Setups Using an Energy Modeling Approach
NAMRC40-7743
***Zhuming Bi**, Indiana University Purdue University Fort Wayne, Fort Wayne IN, United States*, ***Lihui Wang**, University of Skövde, Skövde, Sweden*

Flexibility in Manufacturing Automation: A Living Lab Case Study of Norwegian Metalcasting SMEs
NAMRC40-7787
***Rhythm Wadhwa**, NTNU Valgrinda, Trondheim, Norway*

MSEC 1-3-2 Machining I
126 DeBartolo Hall 13:30 - 15:00

Session Chair: **Ihab Ragai**, *Hitachi Truck Manufacturing, Guelph, ON, Canada*
Session Co-Chair: **Arif S. Malik**, *Saint Louis University, St. Louis, MO, United States*

Optimization of Machining Parameters in CFRP/Ti Stacks Drilling
MSEC2012-7216
***Krishnaraj Vijayan, Prabu Karthi Arumugam, Santhosh Murugan**, PSG College of Technology, Coimbatore, Tamilnadu, India*, ***Redouane Zitoune**, Clement Ader Institute, Toulouse, France*, ***Senthil Kumar Mouleeswaran**, PSG College of Technology, Coimbatore, India*

Optimization of Double Cone Drill Geometry During Drilling of Carbon Fibre Reinforced Plastic (CFRP)
MSEC2012-7244
***Redouane Zitoune**, Clement Ader Institute, Toulouse, France*, ***Sofiane AlmaBouacif**, ICA- Toulouse University, Toulouse, France*, ***Vijayan Krishnaraj**, PSG College of Technology, Coimbatore, India*, ***Francis Collombet**, ICA- Toulouse University, Toulouse, France*, ***Michel Matchoro**, Stoc Production, Toulouse, France*

Investigation on the Important Factors in Determining Aerodynamic Noise in Face Milling Cutters
MSEC2012-7250
***Chunhui Ji**, North Dakota State University, Fargo, ND, United States*, ***Zhanqiang Liu**, Shandong University, Jinan, Shandong, China*, ***Jing Shi**, North Dakota State University, Fargo, ND, United States*

MSEC 1-5-8 Friction Based Welding and Joining
125 DeBartolo Hall 13:30 - 15:00

Session Chair: **Aashish Rohatgi**, *Pacific Northwest National Laboratory, Richland, WA, United States*
Session Co-Chair: **Chetan Nikhare,** *University of New Hampshire, Durham, NH, United States*

Spiral Friction Stir Processing (SFSP) for the Extrusion of Lightweight Alloy Tubes
MSEC2012-7358
***Fadi Abu-Farha**, Clemson University, Greenville, SC, United States*

Characterization of Ultrasonic Metal Weld Quality for Lithium-Ion Battery Tab Joining
MSEC2012-7410
***Tae Hyung Kim, S. Shawn Lee**, **S. Jack Hu**, University of Michigan, Ann Arbor, MI, United States*, ***Wayne Cai**, GM Global R&D, Warren, MI, United States*, ***Jingjing Li**, University of Hawaii, Honolulu, HI, United States*, ***Jeffrey Abell**, GM Global R&D, Warren, MI, United States*

Tool-Workpiece Interface Temperature Measurement in Friction Stir Welding
MSEC2012-7326
***Axel Fehrenbacher, Joshua R. Schmale, Michael R. Zinn, Frank E. Pfefferkorn**, University of Wisconsin - Madison, Madison, WI, United States*

MSEC 3-1-2 Photocells and Photosynthesis
136 DeBartolo Hall 13:30 - 15:00

Session Chair: **Xugang Zhang**, *Johnson Controls, Milwaukee, WI, United States*
Session Co-Chair: **Chris Yuan**, *University of Wisconsin, Milwaukee, Milwaukee, WI, United States*

Nano Finishing of Brass Tubes by Using Mechanically Alloyed Magnetic Abrasives
MSEC2012-7264
***Sehijpal Singh Khangura**, Guru Nanak Dev Engg College, Ludhiana, India*, ***Lakhvir Singh Sran**, BBSB Engg College, Fathegarh Sahib, India*, ***Amarjit Singh**, Bureau of Indian Standards, Chandigarh, India*

Fabrication of Aluminum Composites with Patterned Silicon Carbide Reinforcement Architecture by Semi-solid Processing
MSEC2012-7352
***Can Zhu, Yufeng Wu, Gap-Yong Kim**, Iowa State University, Ames, IA, United States*

Micro and Nano Design and Fabrication of a Novel Artificial Photosynthesis Device
MSEC2012-7394
***Xiang Ren, Qingwei Zhang, Ho-lung Li, Jack Zhou**, Drexel University, Philadelphia, PA, United States*

Coffee Break, McKenna Hall Atrium
15:00-15:30

CONCURRENT TECHNICAL SESSIONS
15:30-17:00

NAMRC 1-17 Biomaterials
140 DeBartolo Hall 15:30-17:00

Session Chair: **Albert Shih,** *University of Michigan, Ann Arbor, MI, United States*
Session Co-Chair: **Michael Hawkins***, Zimmer Inc., Warsaw IN, United States*

Machining Assessment of Nano-Crystalline Hydroxyapatite Bio-Ceramic
NAMRC40-7783
Sanket Kulkarni*, AGCO Corporation, Hesston, KS, United States*, ***Yaowei Yong****, Ningxia University, Yinchuan, Ningxia, China*, ***Malgorzata Rys, Shuting Lei****, Kansas State University, Manhattan, KS, United States*

Selective Welding Reinforcement Within Three-Dimensional Fabric
NAMRC40-7799
Tim Rodts, Steven R. Schmid*, University of Notre Dame, Notre Dame, IN, United States*, ***Miguel A. Selles, Samuel Sanchez-Caballero****, Universitat Politecnica de Valencia, Alcoy, Spain*

Multi-Material Fabrication of Tissue Engineering Scaffold
NAMRC40-7742
Chuang Wei*, North Carolina State University, Raleigh, NC, United States*, ***Lei Cai, Shanfeng Wang****, University of Tennessee, Knoxville, Knoxville, TN, United States*, ***Jingyan Dong****, North Carolina State University, Raleigh, NC, United States*

NAMRC 1-21 Green Manufacturing
116 DeBartolo Hall 15:30 - 17:00

Session Chair: **John W. Sutherland***, Purdue University, West Lafayette, IN, United States*
Session Co-Chair: **Barbara S. Linke***, University of California, Berkeley, Berkeley, CA, United States*

Effect of Green Machining on Distortion and Surface Finishing in Advanced Ceramic
NAMRC40-7734
Luiz Sanchez, Arthur Fiocchi, Gill Bukvic*, Sao Paulo State University - Unesp, Bauru, Sao Paulo, Brazil*, ***Carlos Fortulan****, University of Sao Paulo - USP, Sao Carlos, Sao Paulo, Brazil*, ***Ioan Marinescu****, University of Toledo, Toledo, OH, United States*

Application of Axiomatic Design Principles to Identify More Sustainable Strategies for Grinding
NAMRC40-7735
Barbara S. Linke, ***David A. Dornfeld****, University of California, Berkeley, Berkeley, CA, United States*

Integration of Economic and Environmental Considerations Into Process Selection and Planning
NAMRC40-7800
Vance Murray, Fu Zhao, John W. Sutherland*, Purdue University, West Lafayette, IN, United States*

NAMRC 1-28 Micromachining I - Cutting
126 DeBartolo Hall 15:30 - 17:00

Session Chair: **Simon Park**, *University of Calgary, Calgary, AB, Canada*
Session Co-Chair: **Lara Rebaioli,** *Politecnico di Milano, Milano, Italy*

Finite Element Modeling and Simulation of Micro-Milling
NAMRC40-7745
Thanongsak Thepsonthi, Tugrul Özel*, Rutgers University, Piscataway, NJ, United States*

Parametric Glass Milling With Simultaneous Control
NAMRC40-7749
Takashi Matsumura, Mitsuo Kakishita*, Tokyo Denki University, Tokyo, Tokyo, Japan*

Performance Validation of a Micro Quick-Stop Device
NAMRC40-7781
Massimiliano Annoni, Lara Rebaioli, Quirico Semeraro*, Politecnico di Milano, Milano, Italy*

MSEC 1-2-2 Layered Manufacturing
136 DeBartolo Hall 15:30 - 17:00

Session Chair: **Sam Anand,** *University of Cincinnati, Cincinnati, OH, United States*
Session Co-Chair: **Yong Chen**, *University of Southern California, Los Angeles, CA, United States*

Rapid Manufacturing in Minutes: The Development of a Mask Projection Stereolithography Process for High-speed Fabrication
MSEC2012-7232
Yayue Pan*,* ***Chi Zhou, Yong Chen****, University of Southern California, Los Angeles, CA, United States*

Analysis of Voxel Size during Two-Photon Polymerization
MSEC2012-7374
Serge Gregory, Elijah Kannatey-Asibu*, University of Michigan, Ann Arbor, MI, United States*

Initial Investigation into Helical Milling of Laminated Stacks of Electrical Steel
MSEC2012-7239
Howard Liles, J. Rhett Mayor*, Georgia Institute of Technology, Atlanta, GA, United States*

MSEC 1-5-6 Metal Rolling
131 DeBartolo Hall 15:30 - 17:00

Session Chair: **Gracious Ngaile**, *North Carolina State University, Raleigh, NC, United States*
Session Co-Chair: **Yannis Korkolis**, *University of New Hampshire, Durham, NH, United States*

Development of Statically Determinate Plate Rolling Mills based on Micro-scale Parameters
MSEC2012-7311
***Guangxian Shen, Yongjiang Zheng, Ming Li**, Yanshan University, Qinhuangdao, Hebei, China*

Mixed Lubrication Model for Cold Rolling Considering the Inlet and Deformation Zones
MSEC2012-7245
***Martin Bergmann, Klaus Zeman, Alexander Kainz**, Johannes Kepler University, Linz, Upper Austria, Austria*, ***Konrad Krimpelstätter**, Siemens VAI Metals Technologies GmbH, Linz, Upper Austria, Austria*, ***Dieter G. Paesold**, voestalpine Stahl GmbH, Linz, Upper Austria, Austria*, ***Peter Schellingerhout, Bas Smeulders**, Quaker Chemical B.V., Uithoorn, Netherlands*

Formation Condition of Scale Layer on Work Roll in Hot Steel Rolling
MSEC2012-7235
***Kento Nakazawa, Akira Azushima**, Yokohama National University, Yokohama, Kanagawa, Japan*

MSEC 2-5-2 Advanced and Adaptive Manufacturing Systems II
117 DeBartolo Hall 15:30 - 17:00

Session Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden*
Session Co-Chair: **Zhuming Bi**, *IPFW, Fort Wayne, IN, United States*

Real-Time Error Prediction for High-Precision Operation of Parallel Kinematic Machines
MSEC2012-7201
***Zhuming Bi**, **Guoping Wang**, Indiana University Purdue University Fort Wayne, Fort Wayne, IN, United States*

Research on Intelligent Retrieval System for Networked Manufacturing Resources
MSEC2012-7266
***Defang Liu, Bin Wang**, Yancheng Institute of Technology, Yancheng, Jiangsu, China*, ***Congdong Ji**, Jiangsu University, Yancheng, Jiangsu, China*

Reduction of Vibrations in Ball Screw Driven Machine Tools by the Optimal Selection of Nut Parameters
MSEC2012-7283
***Chinedum Okwudire, Peng Zhao**, University of Michigan, Ann Arbor, MI, United States*

NAMRC 1-12 Advanced Materials
125 DeBartolo Hall 15:30 - 17:00

Session Chair: **Timotius Pasang**, *AUT University, Auckland, New Zealand*
Session Co-Chair**: Elena Pérez-Bernabeu**, *Universitat Politècnica de Valencia, Campus of Alcoy, Spain*

Size Effect and Ductile-to-Brittle Transition of Annealed AISI D2 Steel by SHPB Test of Hat-Shaped Specimen
NAMRC40-7755
***Feng Jiang, Lan Yan, Jianchao Yu, Yiming Rong**, Tsinghua University, Beijing, Beijing, China*

Perspirable Skin: Thermal Buckling Achieved by Complex Functionally Graded Materials
NAMRC40-7803
***Mingang Wang, Matt Lempke, Patrick Kwon**, Michigan State University, East Lansing, MI, United States*

Deflection for a Magnetostrictive Thin Film Bimorph in a Magnetic Field
NAMRC40-7819
***Xiaoli Wang, M. P. Ulmer, Michael E. Graham, Semyon Vaynman, Julia Savoie, Lien Hoffmann, Jian Cao**, Northwestern University, Evanston, IL, United States*

ADDITIONAL AND OPTIONAL EVENTS

MED Membership Meeting
McKenna Hall Auditorium 17:00 - 17:30

NAMRI/SME Membership Meeting
McKenna Hall Auditorium 17:30 - 18:00

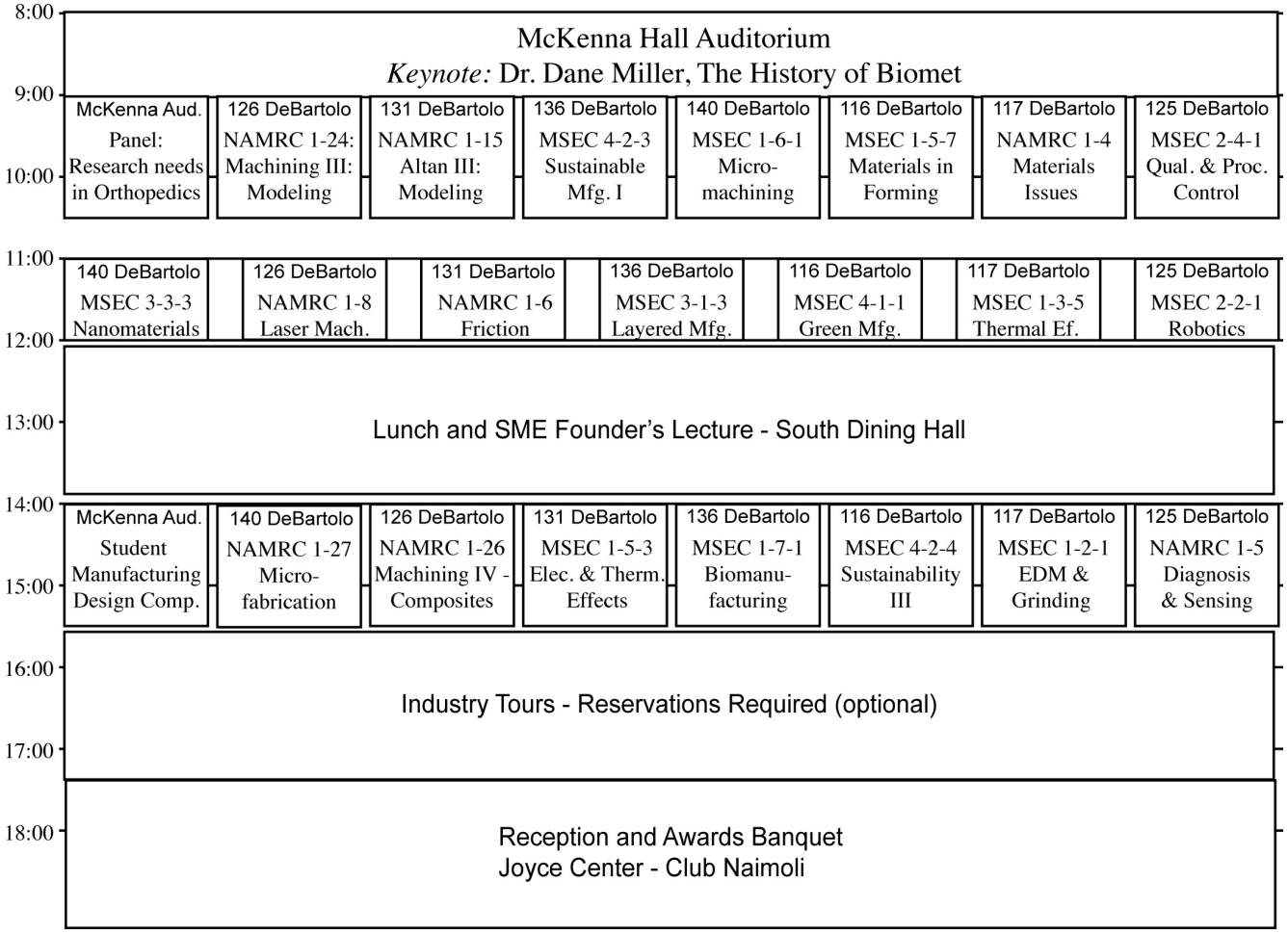
Early Career Forum
McKenna Hall, Central Dining Area 17:30 - 20:00

Studebaker History Tour (optional dinner – reservations required)
Meet in McKenna Atrium at 17:30

TECHNICAL PROGRAM - WEDNESDAY, JUNE 6, 2012

Overview

Spouse's Program: Fernwood Botanical Gardens & South Bend Chocolate Co.



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00 to 8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00 to 17:00.
3. Industry tours require reservations; space is limited. Sign up at the Registration Desk if you didn't pre-register. Options are:
    a. Zimmer, Inc. (Orthopedic Implants)
    b. DePuy, Inc. (Orthopedic Implants)
    c. Jayco, Inc. (Recreational Vehicles)

Keynote:
Dr. Dane Miller, The History of Biomet
McKenna Hall Auditorium 8:00 - 9:00

CONCURRENT TECHNICAL SESSIONS
9:00-10:30

Panel: Manufacturing Research Needs for the Orthopaedics Industry
McKenna Hall Auditorium 9:00 - 10:30

Moderators**:** ***Glen Niebur, Diane Wagner****, University of Notre Dame, Notre Dame, IN, United States*

Panelists:

Toby Buck**,** *Paragon Medical, Pierceton, IN, United States*
Joseph Budzinski**,** *DePuy Orthopaedics, A Johnson & Johnson Company, Raynham, MA, United States*
Michael Hawkins**,** *Zimmer Orthopedics, Inc., Warsaw, IN, United States*

NAMRC 1-4 Materials Issues
117 DeBartolo Hall 9:00 - 10:30

Session Chair: **Tim Rodts***, University of Notre Dame, Notre Dame, IN, United States*
Session Co-Chair: **Don Lucca***, Oklahoma State University, Stillwater, OK, United States*

An Evaluation into the Cause of Corrosive Failure in Autophoretic Coated Material
NAMRC40-7798
Sean Derrick, David Meade, Gary Nola, Margaret Joyce, Matt Johnson*, Western Michigan University, Kalamazoo, MI, United States*

The Effect of Pitting Corrosion on Split Sleeve Cold Hole Expanded: Bare 7075-T651 Aluminium Alloy
NAMRC40-7807
Glenn J. Stephen, Timotius Pasang*, AUT University, Auckland, New Zealand*, ***Benjamin P. Withy****, Defense Technology Agency, Auckland, New Zealand*

Hermetic Joining of 316L Stainless Steel Using a Patterned Nickel Nanoparticle Interlayer
NAMRC40-7820
Ravindranadh Tagore Eluri, Brian K Paul*, Oregon State University, Corvallis, OR, United States*

NAMRC 1-15 Altan Symposium III: Modeling
131 DeBartolo Hall 9:00 - 10:30

Session Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States*

Advances in Predicting Damage Evolution and Fracture Occurrence in Metal Forming Operations
NAMRC40-7736
***Paolo F. Bariani, Stefania Bruschi, Andrea Ghiotti**, University of Padova, Padova, Italy*

Analytical Prediction of Stepped Feature Generation in Multi-Pass Single Point Incremental Forming
NAMRC40-7761
***Dongkai Xu**, **Rajiv Malhotra, Jian Cao**, Northwestern University, Evanston, IL, United States*, ***N.V. Reddy**, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh, India*, ***Jun Chen**, Shanghai Jiao Tong University, Shanghai, Shanghai, China*

Springback Prediction in Bending of AHSS-DP 780
NAMRC40-7769
***Nimet Kardes Sever, Osman H. Mete, Yurdaer Demiralp, Changhyok Choi, Taylan Altan**, Ohio State University, Columbus, OH, United States*

NAMRC 1-24 Machining III - Modeling
126 DeBartolo Hall 9:00 - 10:30

Session Chair: **Christopher Saldana**, *Pennsylvania State University, University Park, PA, United States*
Session Co-Chair: **Yung Shin**, *Purdue University, West Lafayette, IN, United States*

Finite Element Modeling of Microstructural Changes in Turning of AA7075-T651 Alloy and Validation
NAMRC40-7765
***Giovanna Rotella**, Politecnico di Torino, Torino, TO, Italy*, ***O.W. Dillon**, University of Kentucky, Lexington, KY, United States*, ***Domenico Umbrello**, University of Calabria, Rende, Cosenza, Italy*, ***Luca Settineri**, , Politecnico di Torino, Torino, TO, Italy*, ***I.S. Jawahir**, University of Kentucky, Lexington, KY, United States*

Ball End Milling Mechanistic Model Based on a Voxel-Based Geometric Representation and a Ray Casting Technique
NAMRC40-7780
***Jason Wou**, Bishop Steering Technology, Indianapolis, IN, United States*, ***Yung Shin**, Purdue University, West Lafayette, IN, United States*, ***Hazim El-Mounayri**, Indiana University-Purdue University Indianapolis, Indianapolis, IN, United States*

Applying Axiomatic Design to Orthogonal Metal Cutting Creates a New Shear Strain Equation
NAMRC40-7823
***J T Black**, BRC, Auburn, AL, United States*

MSEC 1-5-7 Materials
116 DeBartolo Hall 9:00 - 10:30

Session Chair: **Aashish Rohatgi**, *Pacific Northwest National Laboratory, Richland, WA, United States*
Session Co-Chair: **Z. Cedric Xia,** *Ford Motor Company, Dearborn, MI, United States*

Modeling Mechanical Behavior of Materials Processed by Accumulative Roll Bonding
MSEC2012-7233
Justin L. Milner, Cristina J. Bunget, Thomas R. Kurfess*, Clemson University, Greenville, SC, United States*, ***Vincent H. Hammond****, US Army Research Laboratory, Aberdeen Proving Ground, MD, United States*

Study of Size Effects on Deformation Behavior and Formability in Micro Metal Forming of Ti Foil
MSEC2012-7411
Xu Jie, Guo Bin, Shan Debin, Li Baishun*, Harbin Institute of Technology, Harbin, China*

A New Approach to Predict Machining Force and Temperature with Minimum Quantity Lubrication
MSEC2012-7221
Xia Ji, Xueping Zhang*, Shanghai Jiao Tong University, Shanghai, China*, ***Y. Steven Liang****, Georgia Institute of Technology, Atlanta, GA, United States*

MSEC 1-6-1 Micromachining
140 DeBartolo Hall 9:00 - 10:30

Session Chair: **Wenwu Zhang**, *GE Global Research, Schenectady, NY, United States*
Session Co-Chair: **Gary J. Cheng**, *Purdue University, West Lafayette, IN, United States*

Microvia Formation for Multi-layer PWB by Laser Direct Drilling: Improvement of Drilled Hole Quality of GFRP Plates
MSEC2012-7219
Keiji Ogawa*, University of Shiga Prefecture, Hikone-shi, Japan*, ***Toshiki Hirogaki, Eiichi Aoyama****,* ***Tsukasa Ayuzawa****, Doshisha University, Kyotanabe, Japan*

Microfluidic Channel Fabrication with Tailored Wall Roughness
MSEC2012-7328
Jing Ren, Sriram Sundararajan*, Iowa State University, Ames, IA, United States*

Laser Shock Induced Nano-Patterning of Graphene
MSEC2012-7378
Ji Li*, Purdue University, West Lafayette, IN, United States*, ***Rongjun Zhang, Hanqing Jiang****, Arizona State University, Tempe, AZ, United States*, ***Gary J. Cheng****, Purdue University, West Lafayette, IN, United States*

MSEC 2-4-1 Quality and Process Control
125 DeBartolo Hall 9:00 - 10:30

Session Chair: **Dragan Djurdjanovic**, *University of Texas at Austin, Austin, TX, United States*
Session Co-Chair: **Jeonghan Ko**, *University of Nebraska-Lincoln, Linoln, NE, United States*

Characterization of Cutting Force Induced Surface Shape Variation Using High-Definition Metrology
MSEC2012-7276
***Hai Nguyen, Hui Wang, S. Jack Hu**, University of Michigan, Ann Arbor, MI, United States*

Kernel Density Estimation and Metrolopis-Hastings Sampling in Process Capability Analysis of Unknown Distributions
MSEC2012-7299
***Wenzhen Huang**, University of Massachusetts Dartmouth, North Dartmouth, MA, United States*, ***Ankit Pahwa, MS**, Surgical Monitoring Associates Inc., Springfield, PA, United States*, ***Dr. Zhenyu Kong**, Oklahoma State University, Stillwater, OK, United States*

Joint Maintenance and Production Operations Decision Making in Flexible Manufacturing Systems
MSEC2012-7258
***Merve Celen**, **Dragan Djurdjanovic**, University of Texas at Austin, Austin, TX, United States*

MSEC 4-2-3 Sustainable Manufacturing Methods I
136 DeBartolo Hall 9:00 - 10:30

Session Chair: **Chris Yuan**, *University of Wisconsin, Milwaukee, Milwaukee, WI, United States*
Session Co-Chair: **Liang Zhang**, *University of Wisconsin-Milwaukee, Milwaukee, WI, United States*

Synthesis of Manufacturing and Facility Data for Sustainability Analysis
MSEC2012-7294
***John Michaloski, Guodong Shao, Frank Riddick, Swee Leong**, NIST, Gaithersburg, MD, United States*, ***Jonatan Berglund**, Chalmers University of Technology, Gothenburg, Sweden*, ***Jorge Arinez, Stephan Biller**, General Motors, Warren, MI, United States*

A Computer Aided System for Sustainability Analysis for Die-Casting Processes
MSEC2012-7303
***Jatinder Madan**, System Integration Division, National Institute of Standards and Technology, Gaithersburg, MD, United States*, ***Princepal Singh**, Lovely Professional University, Phagwara, Punjab, India*, ***Amrik Singh**, Sant Longowal Institute of Engineering and Technology, Sangrur, Punjab, India*, ***Mahesh Mani**, National Institute of Standards and Technology, Gaithersburg, MD, United States*

A Process-Based Approach for Cradle-to-Gate Energy and Carbon Footprint Reduction in Product Design
MSEC2012-7405
***Ahmed J. Alsaffar, Karl Haapala**, Oregon State University, Corvallis, OR, United States*, ***Kyoung-Yun Kim**, Wayne State University, Detroit, MI, United States*, ***Gul Okudan Kremer**, Pennsylvania State University, University Park, PA, United States*

MSEC 5-1-1 Technical Poster Presentations
100 McKenna Hall 9:00 - 10:30

Session Chair: **Hitomi Yamaguchi**, *University of Florida, Gainesville, FL, United States*
Session Co-Chair: **Laine Mears**, *Clemson University, Greenville, SC, United States*

An Experimental Device for Cyclic Tension and Compression Tests
MSEC2012-7426
***Fuh-Kuo Chen, Heng-Kuang Tsai, Chih-Hsun Lin**, National Taiwan University, Taipei, Taiwan*

Reheating Effect on the Strength and Formability of DP980
MSEC2012-7416
***Jorge Cisneros, Xin Wu**, Wayne State University, Detroit, MI, United States*

Time-Resolved Study of Alginate Spheroid Formation in Inkjetting
MSEC2012-7417
***C. Leigh Herran, Yong Huang, Nicole Coutris, Changxue Xu**, Clemson University, Clemson, SC, United States*

Scaffold-Free Fabrication of Three-Dimensional Cellular Tubes
MSEC2012-7418
***Changxue Xu, Yong Huang, Wenxuan Chai**, Clemson University, Clemson, SC, United States*

Active Compliant Microassembly Platform with Integrated Force Measurement
MSEC2012-7419
***Paul Moore, Gloria Wiens**, University of Florida, Gainesville, FL, United States*

Ultra High-Speed Micro-Milling and Micro-Grinding
MSEC2012-7420
***Said Jahanmir, Hooshang Heshmat, Michael Tomaszewski, David Slezak**, Mohawk Innovative Technology, Inc, Albany, NY, United States*

Synthesis of Carbon Nanotube-Nanodiamond Hybrid Structures and Their Effect on the Mechanical Property of Polymer Composites
MSEC2012-7421
***Dae-Soon Lim, Seung-Koo Lee, Yang-Bok Lee, Kyung-Min Kim, Young-Kyun Lim, Seo-Hyun Yoon**, Korea University, Seoul, Seoungbuk-Ku, Korea (Republic)*

Experimental Study on the Cooled Air Effect for Hard Turning
MSEC2012-7422
***Hyung Wook Park, Dong Min Kim**, UNIST, Ulsan, Ulju-gun, Korea (Republic)*

Life Cycle Analysis of Diamond Coating of Machining Tools
MSEC2012-7423
***Carlos Wilfong, Humberto A Gomez, Delcie R Durham**, University of South Florida, Tampa, FL, United States*

RFID-Based 3D Indoor Real-Time Localization System
MSEC2012-7424
***Jiaqing Wu, Lianlin Zhao, Lance Pérez, Robert Williams**, University of Nebraska-Lincoln, Lincoln, NE, United States*

Coffee Break, McKenna Hall Atrium
10:30-11:00

CONCURRENT TECHNICAL SESSIONS
11:00-12:00

NAMRC/ICTMP 1-6 Friction
131 DeBartolo Hall 11:00 - 12:00

Session Chair: **Stefania Bruschi**, *DIMEG, University of Padova, Padova, Italy*
Session Co-Chair: **Akira Azushima**, *Yokohama National University, Yokohama, Japan*

Flatness Defects in Thin Strip Cold Rolling and the Friction Impact on It
NAMRC40-7728
Rebecca Nakhoul, Pierre Montmitonnet, *MINES Paristech - CEMEF, Sophia Antipolis, France*, ***Sami Abdelkhalek***, *ArcelorMittal, Maizieres-les-Metz, France*

Simulative Testing of Friction and Lubrication in Cold Forging of Steel and Aluminum
NAMRC40-7814
Ermanno Ceron, Niels Bay, *Technical University of Denmark, Kgs. Lyngby, Denmark*, ***Tetsuo Aida***, *Toyama University, Toyama, Japan*, ***Kuniaki Dohda***, *Northwestern University, Evanston, IL, United States*, ***Tor Erik Nicolaisen***, *Steertec Raufoss AS, Raufoss, Norway*

NAMRC 1-8 Laser Machining
126 DeBartolo Hall 11:00 - 12:00

Session Chair: **Abdullah Khalid Hafiz,** *University of Western Ontario, London, ON, Canada*
Session Co-Chair: **Jack Jeswiet,** *Queen's University, Kingston, ON, Canada*

The Effect of Overlap Percentage on Surface Quality in Laser Polishing of AISI H13 Tool Steel
NAMRC40-7766
Abdullah Khalid Hafiz, *University of Western Ontario, London, ON, Canada*, ***Evgueni Bordatchev***, *NRC-IMI-CAMM, London, ON, Canada*, ***Remus Tutunea-Fatan***, *University of Western Ontario, London, ON, Canada*

Predictive Modeling for Glass-Side Laser Scribing of Thin Film Photovoltaic Cells
NAMRC40-7774
Hongliang Wang, Shan-Ting Hsu, Huade Tan, Y. Lawrence Yao, *Columbia University, New York, NY, United States*, ***Hongqiang Chen, Magdi N. Azer***, *GE Global Research, Niskayuna, NY, United States*

MSEC 1-3-5 Thermal Effects
117 DeBartolo Hall 11:00 - 12:00

Session Chair: **Kumar Pallav**, *Northwestern University, Evanston, IL, United States*
Session Co-Chair: **Said Jahanmir,** *Mohawk Innovative Technology, Albany, NY*, *United States*

Hook Shaped Residual Stress, The Effect of Tool Ploughing, and the Analysis of the Mechanical and Thermal Effects
MSEC2012-7220
Xueping Zhang, Shenfeng Wu*, Shanghai Jiao Tong University, Shanghai, China*, ***C. Richard Liu****, Purdue University, West Lafayette, IN, United States*

Thermal Modeling of Electron Beam Additive Manufacturing Process - Powder Sintering Effects
MSEC2012-7253
Ninggang Shen*,* ***Kevin Chou****, University of Alabama, Tuscaloosa, AL, United States*

MSEC 2-2-1 Robotics in Manufacturing
125 DeBartolo Hall 11:00 - 12:00

Session Chair: **Martin Jun**, *University of Victoria, Victoria, BC, Canada*
Session Co-Chair: **Johnson Samuel**, *Rensselaer Polytechnic Institute, Troy, NY, United States*

Contour Detection for Robotic Chamfering Based on Optical Measurement Technologies: Fringe Projection vs. Profile Sensor
MSEC2012-7247
Richard Münder*,* ***Bernhard Karpuschewski****, University of Magdeburg, Magdeburg, Germany*

Study of Pressure Distribution in Compliant Coated Abrasive Tools for Robotic Polishing
MSEC2012-7396
Umer Muhammed, Kushendarsyah Saptaji, Sathyan Subbiah*, Nanyang Technological University, Singapore, Singapore*

MSEC 3-1-3 Layered Manufacturing
136 DeBartolo Hall 11:00 - 12:00

Session Chair: **Scott Smith**, *University of North Carolina – Charlotte, Charlotte, NC, United Sates*
Session Co-Chair: **Haibo Gong**, *Drexel University, Philadelphia, PA, United States*

Deposition of Al-doped Zinc Oxide by Direct Pulsed Laser Recrystallization at Room Temperature on Various Substrates for Solar Cell Applications
MSEC2012-7381
***Martin Y. Zhang, Qiong Nian, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States*

A Note on the High Aspect-Ratio SU-8 Micromechanical Structures Using Mask-Less Direct Laser Writing
MSEC2012-7413
***Siddharth Ghosh**, University of Birmingham, Birmingham, United Kingdom*, ***G.K. Ananthasuresh**, Indian Institute of Science, Bangalore, Karnataka, India*

MSEC 3-3-3 Nanomaterials
140 DeBartolo Hall 11:00 - 12:00

Session Chair: **Xiaoping Yang**, *Cummins Inc., Columbus, IN, United States*
Session Co-Chair: **Jack Zhou**, *Drexel University, Philadelphia, PA, United States*

Nanoparticles Embedding into Metallic Materials by Laser Direct Irradiation
MSEC2012-7379
***Dong Lin, Sergey Suslov, Chang Ye, Yiliang Liao, C. Richard Liu, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States*

Nanodiamond Reinforced PLLA Nanocomposites for Bone Tissue Engineering
MSEC2012-7393
***Qingwei Zhang, Yury Gogotsi, Peter Lelkes, Jack Zhou**, Drexel University, Philadelphia, PA, United States*

MSEC 4-1-1 Green Energy Product Research
116 DeBartolo Hall 11:00 - 12:00

Session Chair: **Lin Li**, *University of Illinois at Chicago, Chicago, IL, United States*
Session Co-Chair: **Xiaoning Jin**, *University of Michigan, Ann Arbor, MI, United States*

Simulation-Based Energy Efficiency Improvement for Sustainable Manufacturing Systems
MSEC2012-7242
Lin Li, Zeyi Sun, Haoxiang Yang, *University of Illinois at Chicago, Chicago, IL, United States*, ***Fangming Gu***, *General Motors, Warren, MI, United States*

Performance Analysis and Optimization of Remanufacturing Systems with Stochastic Returns
MSEC2012-7383
Guoxian Xiao, *General Motors R&D Center, Warren, MI, United States*, ***Xiaoning Jin***, *University of Michigan, Ann Arbor, MI, United States*, ***Qing Chang***, *Stony Brook University, Stony Brook, NY, United States*, ***Stephan Biller***, *General Motors, Warren, MI, United States*, ***Jun Ni***, ***S. Jack Hu***, *University of Michigan, Ann Arbor, MI, United States*

Lunch and SME Founder's Lecture, South Dining Hall
12:00-14:00

CONCURRENT TECHNICAL SESSIONS
14:00-15:30

NAMRC 1-5 Diagnosis and Sensing
125 DeBartolo Hall 14:00 - 15:30

Session Chair: **John Morehouse,** *Georgia Institute of Technology, Atlanta, GA, United States*
Session Co-Chair: **Jaime Camelio**, *Virginia Polytechnic Institute and State University, Blacksburg, VA, United States*

Multi Sensor Data Fusion in Surface and Dimensional Metrology Domains
NAMRC40-7790
Suresh Kumar Ramasamy, ***Jayaraman Raja, Brian Boudreau***, *University of North Carolina at Charlotte, Charlotte, NC, United States*

Current Envelope Analysis for Defect Identification and Diagnosis in Induction Motors
NAMRC40-7804
Jinjiang Wang, Shaopeng Liu, Robert Gao, Ruqiang Yan, *University of Connecticut, Storrs, CT, United States*

Damage Diagnosis and Fixture Classification Using Impedance-Based Sensors
NAMRC40-7824
Jeremy Rickli, Charles Crawford, Sudipto Aich, Jaime Camelio, *Virginia Polytechnic Institute and State University, Blacksburg, VA, United States*

NAMRC 1-26 Machining IV - Machining of Composites
126 DeBartolo Hall 14:00 - 15:30

Session Chair: **Jason Wou,** *Bishop Steering, Indianapolis, IN, United States*
Session Co-Chair: **Patrick Kwon,** *Michigan State University, East Lansing, MI, United States*

Effect of Machining on Tensile Strength of Composite Laminates
NAMRC40-7750
***Jamal Sheikh-Ahmad**, The Petroleum Institute, Abu Dhabi, United Arab Emir.*, ***Abdul Hamid Shahid**, The Petroelum Institute, Abu Dhabi, United Arab Emir*

Tool Wear of Ultra-Hard Coatings in Drilling CFRP
NAMRC40-7771
***Xin Wang, Patrick Kwon**, Michigan State University, East Lansing, MI, United States*, ***Caleb Sturtevant, Dave (Dae-Wook) Kim**, Washington State University Vancouver, Vancouver, WA, United States*, ***Jeff Lantrip**, Boeing Co, Seattle, WA, United States*

Development of Hole Making Apparatus Based on Double Eccentric Mechanism and its Capability in the Case of Bi-Layer Composite Materials Consisting of CFRP Laminates and Titanium Alloys
NAMRC40-7701
***Hukuzo Yagishita**, Numazu National College of Technology, Numazu, Shizuoka, Japan*

NAMRC 1-27 Microfabrication
140 DeBartolo Hall 14:00 - 15:30

Session Chair: **Brian K. Paul**, *Oregon State University, Corvallis, OR, United States*
Session Co-Chair: **Masahiko Yoshino**, *Tokyo Institute of Technology, Tokyo, Japan*

Towards Control of Carbon Nanotube Synthesis Process Using Prediction-Based Fast Monte Carlo Simulations
NAMRC40-7791
***Changqing Cheng, Satish Bukkapatnam, Lionel Raff, Ranga Komanduri**, Oklahoma State University, Stillwater, OK, United States*

Micro Fabrication on Cylinder Surface for Control of Wettability
NAMRC40-7792
***Takashi Matsumura, Hitoshi Sadakata, Hiroshi Makihata**, Tokyo Denki University, Tokyo, Japan*

Investigation of Carbon Nanotube (CNT) Nanocomposites Through Micro Scribing and Indentations
NAMRC40-7795
***Chaneel Park, Golam Mostofa, Mehdi Mahmoodi, Simon Park**, University of Calgary, Calgary, AB, Canada*

MSEC 1-2-1 Electrical Discharge Machining and Grinding
117 DeBartolo Hall 14:00 - 15:30

Session Chair: **Avanish Kumar Dubey**, *Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India*
Session Co-Chair: **Albert W.J. Hsue**, *National Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan*

Intelligent Modeling and Optimization of Material Removal Rate in Electric Discharge Diamond Grinding
MSEC2012-7252
Pankaj Kumar Shrivastava, *Vindhya Institute of Technology & Science, Satna, India*, ***Avanish Kumar Dubey***, *Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India*

Experimental Characterization of Vibration-Assisted Reverse Micro Electrical Discharge Machining (EDM) for Surface Texturing
MSEC2012-7314
Sachin Mastud, *Veermata Jijabai Technologial Institute, Matunga, Maharashtra, India*, ***Mayank Garg***, *Indian Institute of Technology*, *Bombay, Powai, India*, ***Ramesh Singh***, *Indian Institute of Technology Bombay, Mumbai, India*, ***Johnson Samuel***, *Rensselaer Polytechnic Institute, Troy, NY, United States*, ***Suhas Joshi***, *Indian Institute of Technology Bombay, Mumbai, India*

Milling Tool of Micro-EDM by Ultrasonic Assisted Multi-axial Wire Electrical Discharge Grinding Processes
MSEC2012-7415
Albert W.J. Hsue, *National Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan*, ***Jun-Jie Wang, Chia-Hung Chang***, *Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan*

MSEC 1-5-3 Electrical and Thermal Effects
131 DeBartolo Hall 14:00 - 15:30

Session Chair: **Cristina J. Bunget**, *Clemson University, Greenville, SC, United States*
Session Co-Chair: **Gracious Ngaile**, *North Carolina State Unv, Raleigh, NC, United States*

Electro-Hydraulic Forming of Advanced High-Strength Steels: Deformation and Microstructural Characterization
MSEC2012-7322
Aashish Rohatgi, Elizabeth V. Stephens, Danny J. Edwards, Mark T. Smith, Richard W. Davies, *Pacific Northwest National Laboratory, Richland, WA, United States*

Thermal Response Characterization of Sheet Metals During Electrically-Assisted Forming (EAF)
MSEC2012-7349
Joshua Jones, ***Laine Mears***, *Clemson University, Greenville, SC, United States*

Friction and Deformation-Induced Heating During Sheet Metal Stamping
MSEC2012-7278
Michael P. Pereira, Bernard F. Rolfe, *Deakin University, Geelong, Victoria, Australia*

MSEC 1-7-1 Advances in Biomanufacturing
136 DeBartolo Hall 14:00 - 15:30

Session Chair: **Wei Li**, *University of Texas at Austin, Austin, TX, United States*
Session Co-Chair: **Binil Starly,** *University of Oklahoma, Norman, OK, United States*

Force Model for Needle-Tissue Interaction
MSEC2012-7257
***Peidong Han, Kumar Pallav, Kornel Ehmann**, Northwestern University, Evanston, IL, United States*

Laser Micromachining Modeling and Laser Machined Surface Errors Prediction for Biomedical Applications
MSEC2012-7370
***Yuan-Shin Lee**, North Carolina State University, Raleigh, NC, United States*, ***Plawut Wongwiwat**, North Carolina State University, College of Engineering, Raleigh, NC, United States*, ***Roger J. Narayan**, University of North Carolina, Raleigh, NC, United States*

Effects of Lubricant on the Mechanical Properties and Microstructural Evolution of Aluminum 6063 Alloy after ECAE
MSEC2012-7223
***Joseph S. Ajiboye, Saheed A. Adebayo, Temitayo M. Azeez**, University of Lagos, Lagos, Nigeria*

MSEC 4-2-4 Sustainable Manufacturing Methods II
116 DeBartolo Hall 14:00 - 15:30

Session Chair: **Yuebin Guo**, *University of Alabama, Tuscaloosa, AL, United States*
Session Co-Chair: **Xiaoning Jin**, *University of Michigan, Ann Arbor, MI, United States*

Life Cycle Analysis of Diamond Coating of Machining Tools
MSEC2012-7206
***Carlos Wilfong, Humberto A Gomez, Delcie R Durham**, University of South Florida, Tampa, FL, United States*

Experimental Measurement of Nano-Particle Emissions from Atomic Layer Deposition
MSEC2012-7320
***Jingwan Huo, Xiu Lin**, **Chris Yuan**, University of Wisconsin-Milwaukee, Milwaukee, WI, United States*

Electric Power Resource Planning: A Case Study of Norway
MSEC2012-7215
***Rhythm Wadhwa**, NTNU, Trondheim, Norway*

MSEC 5-1-2 Student Manufacturing Design Competition
McKenna Auditorium 14:00 - 15:30

Session Chair: **Xiaoping Yang**, *Cummins Inc., Columbus, IN, United States*

Industry Tours
15:30-18:30

Space is limited, reservations are required. Please sign up for industry tours at the registration desk. Meet at the Atrium in McKenna Hall.

Options are:

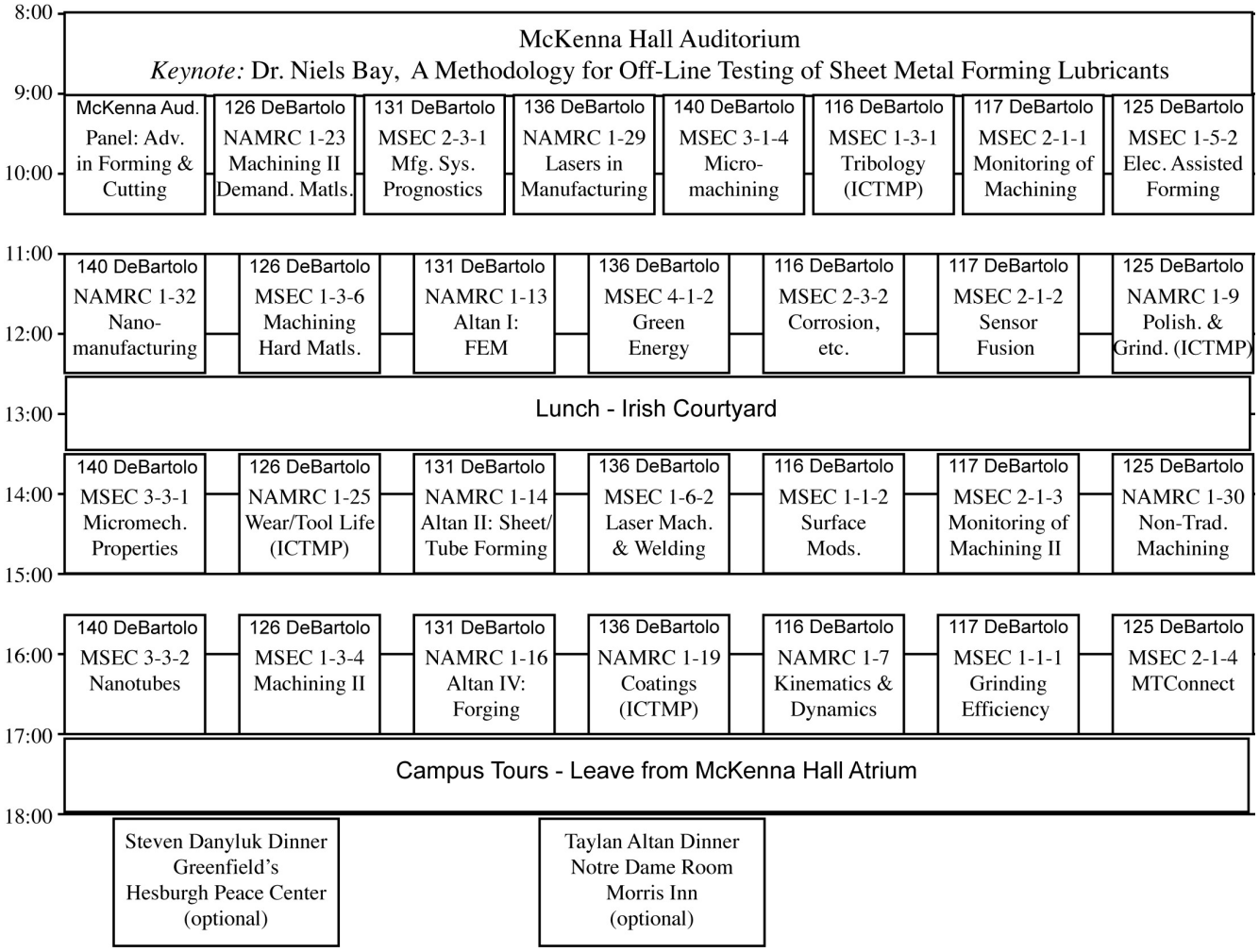
a. Zimmer Inc. (orthopedic implants)
b. DePuy, a Johnson & Johnson Company (orthopedic implants)
c. Jayco, Inc. (recreational vehicles)

Reception and Awards Banquet, Club Naimoli
18:30-22:00

TECHNICAL PROGRAM - THURSDAY, JUNE 7, 2012

Overview

Spouse's Program: Shipshewanna



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00 to 8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00 to 17:00.

Keynote:

Dr. Niels Bay, A Methodology for Off-Line Testing of Sheet Metal Forming Lubricants
McKenna Hall Auditorium 8:00 - 9:00

CONCURRENT TECHNICAL SESSIONS
9:00-10:30

Panel: Advances in Metal Forming & Machining Through Global Collaborations: A Panel in Honor of Dr. Taylan Altan
McKenna Hall Auditorium 9:00 - 10:30

Moderator: ***Taylan Altan****, Ohio State University, Columbus, OH, United States*

Panelists:

Yusuf Altintas**,** *University of British Columbia, Vancouver, BC, Canada*
Niels Bay**,** *Technical University of Denmark, Lyngby, Denmark*
Erman Tekkaya**,** *Technische Universität Dortmund, Dortmund, Germany*
Reiner Kopp, *RWTH Aachen University, Aachen, Germany*

NAMRC 1-23 Machining II
126 DeBartolo Hall 9:00 - 10:30

Session Chair: **I.S. Jawahir***, University of Kentucky, Lexington, KY, United States*
Session Co-Chair: **Peidong Han***, Northwestern University, Evanston, IL, United States*

Investigations in Subsurface Damage When Machining Nickel-Based Superalloys
NAMRC40-7775
Yujie Chen, Cristina Bunget, Thomas R. Kurfess*, Clemson University, Greenville, SC, United States*

Deformation of OFHC Copper During Cutting
NAMRC40-7806
Sreedhar Vasomsetti, Madhavan Vis*, Wichita State University, Wichita, KS, United States*

Experimental Study of Conventional and Peck Drilling Operations
NAMRC40-7759
Salman Pervaiz, Ibrahim Deiab*, American University of Sharjah, Sharjah, United Arab Emir.*, ***Hossam Kishawy****, University of Ontario Institute of Technology, Oshawa, ON, Canada*

NAMRC 1-29 Micromachining II – Lasers in Micromachining
136 DeBartolo Hall 9:00 - 10:30

Session Chair: **Y. Lawrence Yao,** *Columbia University, New York, NY, United States*
Session Co-Chair: **Frank Pfefferkorn,** *University of Wisconsin, Madison, WI, United States*

Nanosecond Pulsed Laser Micro-Machining of PMMA-Based Microfluidic Channels
NAMRC40-7746
Daniel Teixidor, Joaquim Ciurana*, University of Girona, Girona, Spain*, ***Thanongsak Thepsonthi, Tugrul Özel****, Rutgers University, Piscataway, NJ, United States*

Single Step Channeling in Glass Interior by Femtosecond Laser
NAMRC40-7815
Panjawat Kongsuwan, Hongliang Wang, Y. Lawrence Yao*, Columbia University, New York, NY, United States*

Effect of Applied Load, Cutting Speed and Laser Power on the Material Deformation and Removal of Semiconductors
NAMRC40-7777
Deepak Ravindra, John Patten, Muralidhar Ghantasala*, Western Michigan University, Kalamazoo, MI, United States*

MSEC/ICTMP 1-3-1 Tribology I
116 DeBartolo Hall 9:00 - 10:30

Session Chair: **John Morehouse***, Georgia Institute of Technology, Atlanta, GA, United States*
Session Co-Chair: **Hyunok Kim***, Edison Welding Institute, Columbus, OH, United States*

A Methodology to Determine Friction in Orthogonal Cutting with Application to Machining Titanium and Nickel Based Alloys
MSEC2012-7275
Durul Ulutan, Tugrul Özel*, Rutgers University, Piscataway, NJ, United States*

Evidence of Phase Dependent Tool Wear in Ti-6Al-4V Turning Experiments Using PCD and Carbide Inserts
MSEC2012-7332
David Schrock, Patrick Kwon*, Michigan State University, East Lansing, MI, United States*

The Correlation of Volumetric Tool Wear and Wear Rate of Machining Tools with the Material Removal Rate of Titanium Alloys
MSEC2012-7338
Mathew Kuttolamadom*,* ***Parikshit Mehta****,* ***Laine Mears, Thomas R. Kurfess****, Clemson University, Greenville, SC, United States*

MSEC 1-5-2 Electrically Assisted Forming
125 DeBartolo Hall 9:00 - 10:30

Session Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States*
Session Co-Chair: **Scott W. Wagner**, *Michigan Technological University, Houghton, MI, United States*

Modeling the Electroplastic Effect During Electrically-Assisted Forming of 304 Stainless Steel
MSEC2012-7241
***Wesley A. Salandro**, **Cristina J. Bunget, Laine Mears**, Clemson University, Greenville, SC, United States*

Sensitivities when Modeling Electrically-Assisted Forming
MSEC2012-7334
***Cristina J. Bunget**, **Wesley A. Salandro**, **Laine Mears**, Clemson University, Greenville, SC, United States*

Effects of Continuous Direct Current on the Yield Stress of Stainless Steel 304 Micro Tubes During Hydroforming Operations
MSEC2012-7309
***Scott W. Wagner, Kenny Ng**, Michigan Technological University, Houghton, MI, United States*, ***William J. Emblom**, University of Louisiana at Lafayette, Lafayette, LA, United States*, ***Jaime A. Camelio**, Virginia Tech, Blacksburg, VA, United States*

MSEC 2-1-1 Monitoring of Machining I
117 DeBartolo Hall 9:00 - 10:30

Session Chair: **Robert Ivester**, *National Institute of Standards and Technology, Gaithersburg, MD, United States*
Session Co-Chair: **Mike Vogler**, *Caterpillar Inc., Peoria, IL, United States*

Estimation of Cutting Force Model Coefficients to Track Wear in Milling Using Bayesian Analysis
MSEC2012-7259
***Mehdi Nouri, Barry K. Fussell, Robert B. Jerard, Ernst Linder**, University of New Hampshire, Durham, NH, United States*, ***Lei Gao**, George Mason University, Fairfax, VA, United States*

Machining Process Power Monitoring: Bayesian Update of Machining Power Model
MSEC2012-7277
***Parikshit Mehta**, **Mathew Kuttolamadom**, **Laine Mears**, Clemson University, Greenville, SC, United States*

Surface Variation Reduction for Face Milling Based on High-Definition Metrology
MSEC2012-7208
***Bruce L. Tai, Hui Wang, Hai Nguyen, S. Jack Hu, Albert Shih**, University of Michigan, Ann Arbor, MI, United States*

MSEC 2-3-1 Manufacturing System Prognostics
131 DeBartolo Hall 9:00 - 10:30

Session Chair: **Sang Won Lee**, *Sungkyunkwan University, Suwon, Korea (Republic)*
Session Co-Chair: **Seungchul Lee**, *University of Michigan, Ann Arbor, MI, United States*

Degradation-based Swapping Policy with Application to System-level Manufacturing Utilization
MSEC2012-7280
***Ahmad Almuhtady, Seungchul Lee, Jun Ni**, University of Michigan, Ann Arbor, MI, United States*

Dissimilarity Measures for ICA-based Source Number Estimation
MSEC2012-7340
***Wei Cheng**, **Seungchul Lee**, University of Michigan, Ann Arbor, MI, United States*, ***Zhousuo Zhang, Zhengjia He**, Xi'an Jiaotong University, Xi'an, China*

Extension of Maintenance Opportunity Windows to General Manufacturing Systems
MSEC2012-7346
***Xi Gu, Seungchul Lee, Xinran Liang, Jun Ni**, University of Michigan, Ann Arbor, MI, United States*

MSEC 3-1-4 Micro-scale Machining II
140 DeBartolo Hall 9:00 - 10:30

Session Chair: **Jack G. Zhou**, *Drexel University, Philadelphia, PA, United States*
Session Co-Chair: **Xiang Ren**, *Drexel University, Philadelphia, PA, United States*

Experimental Investigation of the Machinability of Epoxy Reinforced with Graphene Platelets
MSEC2012-7204
***Ishank Arora, Johnson Samuel, Nikhil Koratkar**, Rensselaer Polytechnic Institute, Troy, NY, United States*

Mathematical Modeling of Cutting Forces in Micro-Drilling
MSEC2012-7399
***Kumar Sambhav**, Indian Institute of Technology, Kanpur, Kanpur, Uttar Pradesh, India*, ***Puneet Tandon**, PDPM IIITDM Jabalpur, Jabalpur, Madhya Pradesh, India*, ***Shiv G. Kapoor**, University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ***Sanjay G. Dhande**, Indian Institute of Technology, Kanpur, Kanpur, Uttar Pradesh, India*

Process Stability and Energy Efficiency of the Grinding Process of High Performance Materials
MSEC2012-7297
***Eckart Uhlmann, Christoph Sammler, Fiona Sammler, Florian Heitmüller, Leif Hochschild**, Technische Universität Berlin, Berlin, Germany*

CONCURRENT TECHNICAL SESSIONS
11:00-12:30

NAMRC/ICTMP 1-9 Polishing and Grinding
125 DeBartolo Hall 11:00 - 12:30

Session Chair: **Hitomi Yamaguchi**, *University of Florida, Gainesville, FL, United States*
Session Co-Chair**: Ping Guo**, *Northwestern University, Evanston, IL, United States*

Characterization of Surfaces Produced by Abrasive Flow Machining Under Magnetic Field Assistance
NAMRC40-7702
Balkar Singh, *Punjab Technical University, Jallandhar, India*, ***Sehijpal Singh***, *Guru Nanak Dev Engineering College, Ludhiana, India*, ***Pradeep Kumar***, *Indian Institute of Technology Roorkee, Roorkee, India*, ***Harbhajan Singh Shan***, *Swift Institution of Engineering and Technology, Chandigarh, India*

A Case for 2-Body Material Removal in Prime LED Sapphire Substrate Lapping and Polishing
NAMRC40-7714
John J Gagliardi, Dr. Matt R. Atkinson, Dr. Jennifer J Sokol, *3M, St. Paul, MN, United States*, ***Don Kim***, *3M, Dongtan, Korea (Republic)*, ***Vincent D Romero, Larry Zazzera***, *3M, St. Paul, MN, United States*, ***Faisal Nabulsi***, *Rubicon, Franklin Park, IL, United States*, ***Harry Zhang***, *Rubicon, Chicago, IL, United States*

Highly-Efficient Polishing Technology for Glass Substrates Using Tribo-Chemical Polishing With Electrically Controlled Slurry
NAMRC40-7731
Yoichi Akagami, Hiroshi Ikeda, *Akita Industrial Technology Center, Akita, Japan*

NAMRC 1-13 Altan Symposium I: Finite Element Method
131 DeBartolo Hall 11:00 - 12:30

Session Chair: **Thomas R. Neitzert**, *Auckland University of Technology, Auckland, New Zealand*
Session Co-Chair: **Tugrul Özel**, *Rutgers University, Piscataway, NJ, United States*

Algorithm for Tool Geometry Updating in 3D FEM Environment Considering the Tool Wear
NAMRC40-7727
Aldo Attanasio, Elisabetta Ceretti, Cristian Cappellini, *University of Brescia, Brescia, Italy*, ***Claudio Giardini***, *University of Bergamo, Dalmine (BG), Italy*, ***Gérard Poulachon***, *Arts et Metiers ParisTech, Cluny, France*

New Developments in the FE Simulation of Closed Die Forging Processes
NAMRC40-7772
Bernd-Arno Behrens, *Institute of Forming Technology and Machines, Leibniz Universität Hannover, Garbsen, Lower Saxony, Germany*

Modeling Machining Distortion Using the Finite Element Method: Application to Engine Disk
NAMRC40-7827
Marko Knezevic, *Los Alamos National Laboratory, Los Alamos, NM, United States*, ***Byung Kwan Chun, Jin Yong Oh, Wei-Tsu Wu***, *Scientific Forming Technologies Corporation, Columbus, OH, United States*, ***Robert A. Ress III, Michael G. Glavicic***, *Rolls-Royce Corporation, Indianapolis, IN, United States*, ***Shesh Srivatsa***, *GE Aviation, Cincinnati, OH, United States*

NAMRC 1-32 Nanomanufacturing
140 DeBartolo Hall 11:00 - 12:30

Session Chair: **Placid Ferreira**, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*
Session Co-Chair: **Sathyan Subbiah,** *Nanyang Technological University, Singapore*

Ultrasonic Vibration Assisted Nanomachining on PMMA with an AFM
NAMRC40-7737
Li Zhang, Jingyan Dong, *North Carolina State University, Raleigh, NC, United States*

Effects of Process Conditions on Nano-Dot Array Formation by Thermal Dewetting
NAMRC40-7740
Masahiko Yoshino, *Tokyo Institute of Technology, Tokyo, Japan*, ***Hiroki Osawa***, *Sharp, Nara, Japan*, ***Akinori Yamanaka***, *Tokyo Institute of Technology, Tokyo, Japan*

Experimental Investigation and Characterization of Nano-Scale Dry Electro-Machining
NAMRC40-7789
Muhammad Jahan, Ajay Malshe, *University of Arkansas, Fayetteville, AR, United States*, ***K.P. Rajurkar***, *University of Nebraska-Lincoln, Lincoln, NE, United States*

MSEC 1-3-6 Hard Materials
126 DeBartolo Hall 11:00 - 12:30

Session Chair: **Jaime Camelio**, *Virginia Institute of Technology, Blacksburg, VA, United States*
Session Co-Chair: **Steven Schmid**, *University of Notre Dame, Notre Dame, IN, United States*

Experimental Investigation of Hard Turning Mechanisms by PCBN Tooling Embedded Micro Thin Film Thermocouples
MSEC2012-7262
Linwen Li, *Northwestern University, Evanston, IL, United States*, ***Bin Li***, *Huazhong University of Science and Technology, Wuhan, Hubei, China*, ***Xiaochun Li***, *University of Wisconsin-Madison Madison, Madison, WI, United States*, ***Kornel Ehmann***, *Northwestern University, Evanston, IL, United States*

Minimized Wear and Debris Generation through Optimized Machining of Co-Cr-Mo Alloys for Use in Metal-on-Metal Hip Implants
MSEC2012-7260
Ashish Deshpande, Shu Yang, Dave Puleo, David Pienkowski, Oscar Dillon, *University of Kentucky, Lexington, KY, United States*, ***Jose Outeiro***, *Portuguese Catholic University, Rio de Mouro, Lisbon, Portugal*, ***I.S. Jawahir***, *University of Kentucky, Lexington, KY, United States*

Robust Shearing Process for Improving AHSS Edge Stretchability
MSEC2012-7318
Hua-Chu Shih, Ming F. Shi, *United States Steel Corporation, Troy, MI, United States*

MSEC 2-1-2 Sensors and Sensor Fusion
117 DeBartolo Hall 11:00 - 12:30

Session Chair: **Yuebin Guo**, *University of Alabama, Tuscaloosa, AL, United States*
Session Co-Chair: **Kang B Lee**, *NIST, Gaithersburg, MD, United States*

Detection of Cutting Phenomena Using Sensor Fusion
MSEC2012-7307
John A. Slotwinski, Gregory Vogl, Robert Ivester, *National Institute of Standards and Technology, Gaithersburg, MD, United States*, ***Ian Younker***, *Lebanon Valley College, Annville, PA, United States*

Process Monitoring During Micro-drilling via Acoustic Emission, Ultrasonic Sound, and Spindle Load Sensors
MSEC2012-7341
Keith Bourne, Shiv G. Kapoor, *University of Illinois at Urbana Champaign, Urbana, IL, United States*

Classifier Fusion for Acoustic Emission Based Tool Wear Monitoring
MSEC2012-7380
Juil Yum, Tae Hyung Kim, ***Elijah Kannatey-Asibu***, *University of Michigan, Ann Arbor, MI, United States*

MSEC 2-3-2 Corrosion/Electrolytic Effects
116 DeBartolo Hall 11:00 - 12:30

Session Chair: **Seungchul Lee**, *University of Michigan, Ann Arbor, MI, United States*
Session Co-Chair: **Daniel Peters**, *Nu-Iron Unlimited, Point Lisas, Trinidad/Tobago*

Battery Prognostics: SoC and SoH Prediction
MSEC2012-7345
Seungchul Lee, ***Harry Cui***, *University of Michigan, Ann Arbor, MI, United States*, ***Mohammad Rezvani***, *University of Cincinnati, Cincinnati, OH, United States*, ***Jun Ni***, *University of Michigan, Ann Arbor, MI, United States*

Application of OLI Electrolyte Simulation to the Resolution of Corrosion Concerns Within a Reciprocating Compressor
MSEC2012-7224
Diane Stewart, P.E., *Praxair, Geismar, LA, United States*, ***Anthony J. Gerbino,*** *AQSim, Aqueous Process Simulations, Denville, NJ, United States*, ***Tony Scribner***, *Becht Engineering, Gilbert, SC, United States*

An Integrated Design Strategy for Dust Collection and Slurry Transport Systems and Implementation in a Steel Plant
MSEC2012-7390
Daniel Peters, Aquelius Young, *Nu-Iron Unlimited, Point Lisas, Trinidad and Tobago*

MSEC 4-1-2 Green Energy Product Manufacturing Research
136 DeBartolo Hall 11:00 - 12:30

Session Chair: **Hui Wang**, *University of Michigan, Ann Arbor, MI, United States*

Ultrasonic-Vibration Assisted Pelleting for Cellulosic Biofuel Manufacturing: Investigation on Power Consumption with Design of Experiment
MSEC2012-7212
Qi Zhang, ***Pengfei Zhang, Graham Pritchett, Z.J. Pei, Meng Zhang, Xiaoxu Song, T.W. Deines***, *Kansas State University, Manhattan, KS, United States*

Effects of Water Soaking on Biomass Particle Size in Cellulosic Biofuel Manufacturing
MSEC2012-7227
Hera Wu, *University of California, Berkeley, Berkeley, CA, United States*, ***Pengfei Zhang***, ***Qi Zhang***, ***Z.J. Pei***, *Kansas State University, Manhattan, KS, United States*

Sugar Yield Comparison of Wheat Straw Processed by Two Pelleting Methods for Cellulosic Biofuel Manufacturing
MSEC2012-7228
Qi Zhang, ***Pengfei Zhang***, *Kansas State University, Manhattan, KS, United States*, ***Kangqi Fan***, *Xidian University, Manhattan, KS, United States*, ***Meng Zhang, Xiaoxu Song, Z.J. Pei, Obair Siddiqui***, *Kansas State University, Manhattan, KS, United States*

Lunch, Irish Courtyard
12:30-13:30

CONCURRENT TECHNICAL SESSIONS
13:30-15:00

NAMRC 1-14 Altan Symposium II: Sheet Metal and Tube Forming
131 DeBartolo Hall 13:30 - 15:00

Session Chair: **Elisabetta Ceretti**, *University of Brescia, Brescia, Italy*
Session Co-Chair: **William J. Emblom**, *University of Louisiana at Lafayette, Lafayette, LA, United States*

The Development of a Simple Method for Micro Strain Measurement Applied to Bulge Microhydroforming
NAMRC40-7706
Richard J. Jones, *Caterpillar, Peoria, IL, United States*, ***William J. Emblom***, *University of Louisiana at Lafayette, Lafayette, LA, United States*, ***Gary A. Glass***, *University of North Texas, Denton, TX, United States*

Recent Developments in Non-Conventional Tube Forming
NAMRC40-7756
Lukas Kwiatkowski, ***O. Koray Demir***, ***Soeren Gies, A. Erman Tekkaya***, *Technische Universität Dortmund, Dortmund, NRW, Germany*

New Developments in Sheet Metal Forming of Stainless Steel: Current Investigations and Future Challenges
NAMRC40-7828
Philipp Schmid, *FGU mbH Stuttgart, Stuttgart, Baden-Wuerttemberg, Germany*, ***Mathias Liewald***, *University of Stuttgart, Stuttgart, Germany*

NAMRC/ICTMP 1-25 Machining IV - Wear and Tool Life
126 DeBartolo Hall 13:30 - 15:00

Session Chair: **Pierre Montmitonnet**, *MINES Paristech - CEMEF, Sophia Antipolis, France*
Session Co-Chair: **Kevin Chou**, *University of Alabama, Tuscaloosa, AL, United States*

Spindle Speed Selection for Tool Life Testing using Bayesian Inference
NAMRC40-7703
Jaydeep Karandikar, Tony Schmitz, *University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Ali Abbas***, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*

Updated Mechanistic Force Model to Account for Rapid Tool Wear when Milling Nickel-Based Superalloys
NAMRC40-7744
Andrew Henderson, Cristina Bunget, Thomas R. Kurfess, *Clemson University, Greenville, SC, United States*

Design and Evaluation of an Atomization-Based Cutting Fluid Spray System in Turning of Titanium Alloy
NAMRC40-7797
Chandra Nath, Shiv G. Kapoor, Richard E. DeVor, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ***Anil K. Srivastava***, *Techsolve Inc., Cincinnati, OH, United States*

NAMRC 1-30 Non-Traditional Machining
125 DeBartolo Hall 13:30 - 15:00

Session Chair: **Murali Sundaram**, *University of Cincinnati, Cincinnati, OH, United States*
Session Co-Chair: **K. Rajurkar,** *University of Nebraska-Lincoln, Lincoln, NE, United States*

Comparison of Different Approaches to Force Controlled Precision Honing of Bores
NAMRC40-7724
Dirk Bähre, Christina Schmitt, Uwe Moos, *Saarland University, Saarbrücken, Germany*

White Layer Thickness Formation in Electro Discharge Machining of Beryllium-Copper Alloys
NAMRC40-7764
Yakup Yildiz, *Dumlupinar University, Kutahya, Turkey*, ***Murali Sundaram***, *University of Cincinnati, Cincinnati, OH, United States*, ***K.P. Rajurkar***, *University of Nebraska-Lincoln, Lincoln, NE, United States*

Energy Dissipation, Microstructure and Hardening in Cryogenic Machining
NAMRC40-7779
Christopher Saldana, *Pennsylvania State University, University Park, PA, United States*

MSEC 1-1-2 Surface Modification
116 DeBartolo 13:30 - 15:00

Session Chair: **Barbara S. Linke**, *University of California, Berkeley, Berkeley, CA, United States*
Session Co-Chair: **John Webster**, *Cool-Grind Technologies, Ashford, CT, United States*

An Analysis of Polishing Forces in Magnetic Field Assisted Finishing
MSEC2012-7256
Vasishta Ganguly, Tony Schmitz, *University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Arthur Graziano, Hitomi Yamaguchi****, University of Florida, Gainesville, FL, United States*

Tribological Conditioning of Cylinder Running Surfaces
MSEC2012-7237
Florian Welzel, Bernhard Karpuschewski*, University of Magdeburg, Magdeburg, Germany*

Observations During Vortex Machining Process Development
MSEC2012-7272
Stephen C. Howard, Jacob Chesna, Brigid Mullany, Stuart T. Smith*, University of North Carolina at Charlotte, Charlotte, NC, United States*

MSEC 1-6-2 Laser Machining and Welding
136 DeBartolo Hall 13:30 - 15:00

Session Chair: **John Patten**, *Western Michigan University, Kalamazoo, MI, United States*
Session Co-Chair: **Avanish Kumar Dubey**, *Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India*

Modeling and Optimization of Kerf Taper in Pulsed Laser Cutting of Duralumin Sheet
MSEC2012-7243
Arun Kumar Pandey, Avanish Kumar Dubey*, Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India*

Laser Joining of Continuous Glass Fiber Composite Pre-forms
MSEC2012-7304
Huade Tan, Lawrence Yao*, Columbia University, New York, NY, United States*

Studying the Temperature Effect during the High-Pressure Phase Transformation of Silicon via Indentations
MSEC2012-7323
Deepak Ravindra, John Patten, Muralidhar Ghantasala*, Western Michigan University, Kalamazoo, MI, United States*

MSEC 2-1-3 Monitoring of Machining II
117 DeBartolo Hall 13:30 - 15:00

Session Chair: **Shreyes N. Melkote,** *Georgia Institute of Technology, Atlanta, GA, United States*
Session Co-Chair: **Kevin Chou***, University of Alabama, Tuscaloosa, United States*

A Two-Parameter Method to Monitor and Characterize Tool Wear in End Milling Inconel 718
MSEC2012-7362
Yuebin Guo, W. Li*, University of Alabama, Tuscaloosa, AL, United States*

End Milling Force Model Calibration using Measured Force Profiles
MSEC2012-7385
Barry K. Fussell, Yong Zhao, Robert B. Jerard*, University of New Hampshire, Durham, NH, United States*

Calibration and Characterization of a Low-Cost Wireless Sensor for Applications in CNC End Milling
MSEC2012-7386
Barry K. Fussell, Andrew Harmon, Robert B. Jerard*, University of New Hampshire, Durham, NH, United States*

MSEC 3-3-1 Micromechanical Properties
140 DeBartolo Hall 13:30 - 15:00

Session Chair: **Xinnan Wang***, North Dakota State University, Fargo, ND, United States*
Session Co-Chair: **Gary J. Cheng***, Purdue University, West Lafayette, IN, United States*

Extension of a Microscale Indentation Fracture Model to Nanoscale Contact in Purview of Mechanical Nanofabrication Processes
MSEC2012-7336
Jared Hann, Raul E. Riveros, Hitomi Yamaguchi, Curtis Taylor*, University of Florida, Gainesville, FL, United States*

AFM-Based Nanoindentation Process: A Comparative Study
MSEC2012-7356
Rapeepan Promyoo, Hazim El-Mounayri, Kody Varahramyan*, Indiana University - Purdue University Indianapolis, Indianapolis, IN, United States*

Micro Characterization of Mg and Mg Alloy for Biodegradable Orthopedic Implants Application
MSEC2012-7395
Haibo Gong, Yoontae Kim, Qingwei Zhang, Kavan Hazeli, Antonios Kontsos, Peter Lelkes*, Drexel University, Philadelphia, PA, United States*, ***Donggang Yao****, Georgia Institute of Technology, Atlanta, GA, United States*, ***Jack Zhou****, Drexel University, Philadelphia, PA, United States*

CONCURRENT TECHNICAL SESSIONS
15:30-17:00

NAMRC 1-7 Kinematics and Dynamics
116 DeBartolo Hall 15:30 - 17:00

Session Chair: **Tony Schmitz**, *University of North Carolina at Charlotte, Charlotte, NC, United States*
Session Co-Chair: **John Ziegert**, *University of North Carolina at Charlotte, Charlotte, NC, United States*

A Novel Design of Parallel Compliant Micro-Motion Stages With Kinematotropic Properties
NAMRC40-7773
Qiang Zeng, Kornel F. Ehmann, *Northwestern University, Evanston, IL, United States*

Joint Dynamics Modeling and Identification
NAMRC40-7784
Majid Mehrpouya, Eldon Graham, Simon Park, *University of Calgary, Calgary, AB, Canada*

Improved Reduced Order Modeling of Machine Tool Structures
NAMRC40-7825
Mohit Law, Yusuf Altintas, A. Srikantha Phani, *University of British Columbia, Vancouver, BC, Canada*

NAMRC 1-16 Altan Symposium IV: Forging
131 DeBartolo Hall 15:30 - 17:00

Session Chair: **Gracious Ngaile**, *North Carolina State Unv, Raleigh, NC, United States*

Investigation of the Fishtail Defect in Ring Rolling by a FEM Approach
NAMRC40-7753
Luca Giorleo, Elisabetta Ceretti, *University of Brescia, Brescia, Italy*, ***Claudio Giardini***, *University of Bergamo, Dalmine (BG), Italy*

Improvement of Tool Life and Production Efficiency in Continuous Grain Flow Forging of Diesel Engine Crankshafts
NAMRC40-7770
Manas Shirgaokar, Gerhard Epp, *Ellwood National Crankshaft, Irvine, PA, United States*, ***Brian Taylor***, *Ellwood Crankshaft Group, Hermitage, PA, United States*

Investigation of the Efficiency of Joint Designs for the Electro-Magnetic Welding (EMW) of the Ring-Shaft Assembly
NAMRC40-7785
Hyunok Kim, *Edison Welding Institute (EWI), Columbus, OH, United States*, ***Jianhui Shang***, *American Trim, Lima, OH, United States*, ***Jerry Gould***, *Edison Welding Institute (EWI), Columbus, OH, United States*, ***Ajay Yadav, Robert Meyer***, *Caterpillar Inc., Mossville, IL, United States*, ***Menachem Kimchi***, *Edison Welding Institute (EWI), Columbus, OH, United States*

NAMRC/ICTMP 1-19 Coatings
136 DeBartolo Hall 15:30 - 17:00

Session Chair: **Miguel A. Selles**, *Universitat Politecnica de Valencia, Alcoy, Spain*
Session Co-Chair: **Amy Libardi,** *University of Notre Dame, Notre Dame, IN, United States*

Analysis of Orthogonal Cutting Experiments Using Diamond-Coated Tools With Force and Temperature Measurements
NAMRC40-7718
Robert Ivester, Eric Whitenton*, NIST, Gaithersburg, MD, United States*, ***Jill Hershman, Kevin Chou****, University of Alabama, Tuscaloosa, AL, United States*, ***Qiang Wu****, Kennametal Inc., Latrobe, PA, United States*

PVD Coated Mill Rolls for Cold Rolling of Stainless Steel Strips: Tribological and Mechanical Laboratory Tests
NAMRC40-7720
Choumad Ould*, CEMEF Ecole des Mines de Paris, Sophia-Antipolis, France*, ***Xavier Badiche****, HEF R&D, Andrézieux-Bouthéon, France*, ***Pierre Montmitonnet****, MINES Paristech - CEMEF, Sophia Antipolis, France*, ***Yves Gachon****, HEF R&D, Andrézieux-Bouthéon, France*

Orthogonal Cutting of AISI D2 Steel With TiAlN Coated Inserts: Simulations and Experiments
NAMRC40-7757
Lan Yan, Feng Jiang, Yiming Rong*, Tsinghua University, Beijing, Beijing, China*

MSEC 1-1-1 Grinding Efficiency
117 DeBartolo Hall 15:30 - 17:00

Session Chair: **John Webster**, *Cool-Grind Technologies, Ashford, CT, United States*
Session Co-Chair: **Brigid Mullany**, *UNC Charlotte, Charlotte, NC, United States*

Higher Competitiveness of Speed-Stroke Grinding by Using Increased Wheel Speeds
MSEC2012-7240
Michael Duscha*, RWTH Aachen University, Aachen, NRW, Germany*, ***Barbara S. Linke****, University of California, Berkeley, Berkeley, CA, United States*, ***Fritz Klocke****, RWTH Aachen University, Aachen, NRW, Germany*, ***David Dornfeld****, University of California, Berkeley, Berkley, CA, United States*

Design and Analysis of Helical Needle Tip Grinding Process
MSEC2012-7274
Demeng Che, Ping Guo, Kornel Ehmann*, Northwestern University, Evanston, IL, United States*

In Vitro Dental Cutting of Feldspar and Leucite Glass Ceramics Using an Electric Handpiece
MSEC2012-7290
Xiao Fei Song, Jianhui Peng*, Tianjin University, Tianjin, China*, ***Ling Yin****, James Cook University, QLD, Australia*, ***Bin Lin****, Tianjin University, Tianjin, China*

MSEC 1-3-4 Machining II
126 DeBartolo Hall 15:30 - 17:00

Session Chair: **John Morehouse**, *Georgia Institute of Technology, Atlanta, GA, United States*
Session Co-Chair**: Yung Shin,** *Purdue University, West Lafayette, IN, Unites States*

High Speed Non-Linear Micro-Milling Dynamics
MSEC2012-7287
***Eric Halfmann, C. Steve Suh**, Texas A&M University, College Station, TX, United States*

A Metallo-Thermo-Mechanically Coupled Analysis of Orthogonal Cutting of AISI 1045 Steel.
MSEC2012-7300
***Hongtao Ding, Yung Shin**, Purdue University, West Lafayette, IN, United States*

Finite Element Analysis of Residual Stresses in High-Speed Dry Cutting of Biodegradable Magnesium-Calcium Alloy
MSEC2012-7361
***M. Salahshoor, Yuebin Guo**, University of Alabama, Tuscaloosa, AL, United States*

MSEC 2-1-4 Applications of MTConnect
125 DeBartolo Hall 15:30 - 17:00

Session Chair: **Radu Pavel**, *TechSolve Inc., Cincinnati, OH, United States*
Session Co-Chair: **John A. Slotwinski**, *National Institute of Standards and Technology, Gaithersburg, MD, United States*

PNEUVIZ: MTConnect Compliant Compressed Air Monitoring Application
MSEC2012-7389
***Sri Atluru**, University of Cincinnati, Cincinnati, OH, United States*, ***Amit Deshpande, Ron Pieper**, TechSolve Inc., Cincinnati, OH, United States*, ***Sam Huang**, University of Cincinnati, Cincinnati, OH, United States*

Integration of MTConnect and Standard-based Sensor Networks for Manufacturing Equipment Monitoring
MSEC2012-7398
***Kang B Lee, Eugene Y. Song, Peter Gu**, National Institute of Standards and Technology, Gaithersburg, MD, United States*

Statistical Process Monitoring with MTConnect
MSEC2012-7344
***Sri Atluru**, University of Cincinnati, Cincinnati, OH, United States*, ***Amit Deshpande**, TechSolve Inc., Cincinnati, OH, United States*

MSEC 3-3-2 Nanotube Applications
140 DeBartolo Hall 15:30 - 17:00

Session Chair: **Curtis Taylor**, *University of Florida, Gainesville, FL, United States*
Session Co-Chair: **Jing Shi**, *North Dakota State University, Fargo, ND, United States*

In-Situ Characterization of MWCNTs Reinforced Epoxy Nanocomposite under Mechanical Load
MSEC2012-7397
Xinnan Wang, ***Peng Cui***, ***Annie Tangpong***, *North Dakota State University, Fargo, ND, United States*

Estimating the Cohesive Zone Model Parameters for Carbon Nanotube-Polymer Interface Using Inverse Finite Element Analysis
MSEC2012-7400
Lingyun Jiang, ***Chandra Nath***, *University of Illnois at Urbana-Champaign, Urbana, IL, United States*, ***Johnson Samuel***, *Rensselaer Polytechnic Institute, Troy, NY, United States*, ***Shiv G. Kapoor***, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*

Titanium Oxide Nanotubes Doped for Use in a Visible-Light Biophotofuel Cell
MSEC2012-7255
Evan Clark, Yong Gan, Chao Xue, *University of Toledo, Toledo, OH, United States*

ADDITIONAL AND OPTIONAL EVENTS

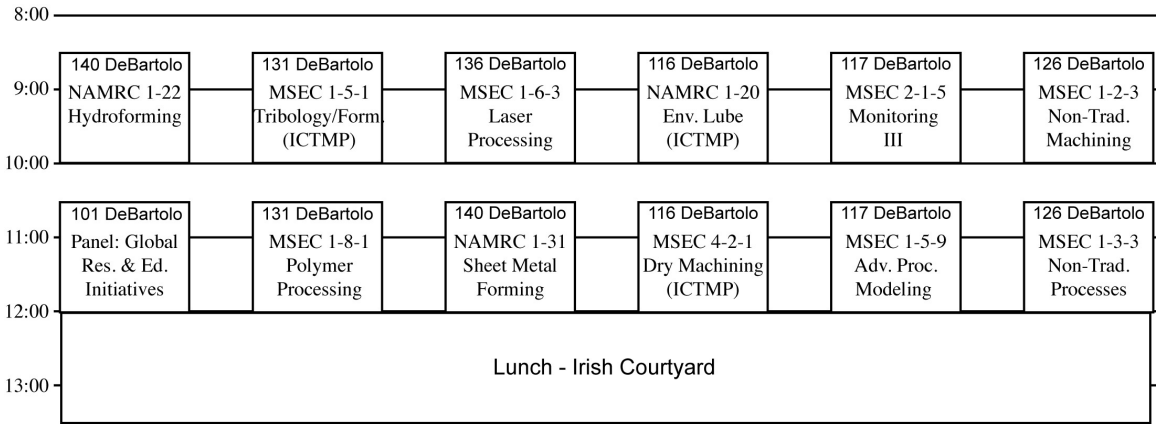
Campus Tours
Meet in McKenna Hall Atrium 17:00 – 18:00

Steven Danyluk Dinner
Greenfield's, Hesburgh Peace Center, 18:00-21:00. (Optional dinner – reservations required.)

Taylan Altan Dinner
Notre Dame Room, Morris Inn, 18:00-21:00. (Optional dinner – reservations required.)

TECHNICAL PROGRAM - FRIDAY, JUNE 8, 2012

Overview



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00 to 8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00 to 17:00.

CONCURRENT TECHNICAL SESSIONS
8:30-10:00

NAMRC/ICTMP 1-20 Environmentally Friendly Lubrication
116 DeBartolo Hall 8:30 - 10:00

Session Chair: **David Adams,** *Queen's University, Kingston, ON, Canada*
Session Co-Chair: **Kuniaki Dohda,** *Northwestern University, Evanston, IL, United States*

Feasibility of Vegetable Oil in Water Emulsion Achieved Through Ultrasonic Atomization as Cutting Fluids
NAMRC40-7707
***Geoff Burton**, University of Victoria, Victoria, BC, BC, Canada*, ***Chan-Seo Goo**, LG Electronics, Seoul, Korea (Republic)*, ***Martin Jun**, University of Victoria, Victoria, BC, Canada*

Evaluation of Environmentally Friendly Lubricant for Aluminum Cold Forging Using Friction Test Based on Spline Extrusion
NAMRC40-7709
***Yoshihiro Sagisaka**, Industrial Research Institute of Shizuoka Prefecture, Shizuoka, Japan*, ***Tamotsu Nakamura, Kunio Hayakawa**, Shizuoka University, Hamamatsu, Japan*, ***Itaru Ishibashi**, Sumico Lubricant, Inabe, Mie, Japan*

An Assessment of Environmentally Benign Lubricants With the Ring Test and Upset Forming
NAMRC40-7712
***Tristan J. Koivisto**, Queen's University, Kingston, ON, Canada*, ***Dustin L. Campbell**, Chinook Mobile Heating and Deicing, Nepean, ON, Canada*, ***Jack Jeswiet**, Queen's University, Kingston, ON, Canada*, ***Jessica R. Larmer**, Conestoga-Rovers and Associates Ltd, Waterloo, ON, Canada*

NAMRC 1-22 Hydroforming
140 DeBartolo Hall 8:30 - 10:00

Session Chair: **Jyhwen Wang,** *Texas A & M University, College Station, TX, United States*

Influence of Process Variables on Preform Design for Tube Hydroforming Based on Wrinkle Evolution
NAMRC40-7796
***Gracious Ngaile**, **Chen Yang**, North Carolina State University, Raleigh, NC, United States*

Stringer Sheet Forming
NAMRC40-7813
***Frederic Bäcker, Peter Groche, Scholeh Abedini**, Technische Universität Darmstadt, Darmstadt, Germany*

Failure Analysis of Hydroforming of Sandwich Panels
NAMRC40-7822
***Jyhwen Wang, Cheng-Kang Yang**, Texas A&M University, College Station, TX, United States*

MSEC 1-2-3 Nontraditional Machining
126 DeBartolo Hall 8:30 – 10:00

Session Chair: **Mehdi Asgharifar**, *Southern Methodist University, Dallas, TX, United States*
Session Co-Chair: **Murali M. Sundaram**, *University of Cincinnati, Cincinnati, OH, United States*

Pulse Electrochemical Micromachining of Tungsten Carbide
MSEC2012-7238
***Abishek Balsamy Kamaraj, Rachael Dyer, Murali M. Sundaram**, University of Cincinnati, Cincinnati, OH, United States*

Wettability Enhancement of Aluminum Alloys via Plasma Arc Discharge
MSEC2012-7331
***Mehdi Asgharifar, Joshua Abramovitch, Fanrong Kong, Radovan Kovacevic**, Southern Methodist University/RCAM, Dallas, TX, United States*, ***Blair Carlson**, GM Global R&D, Warren, MI, United States*

Characteristics of Cobalt Chromium Alloy Surfaces Finished using Magnetic Abrasive Finishing
MSEC2012-7367
***Arthur Graziano**, University of Florida, Gainesville, FL, United States*, ***Vasishta Ganguly**, University of North Carolina at Charlotte, Charlotte, NC, United States*, ***J. Whittaker Bullard**, University of Florida, Gainesville, FL, United States*, ***Tony Schmitz,** University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Hitomi Yamaguchi**, University of Florida, Gainesville, FL, United States*

MSEC/ICTMP 1-5-1 Tribology in Metal Forming
131 DeBartolo Hall 8:30 – 10:00

Session Chair: **Cristina J. Bunget**, *Clemson University, Greenville, SC, United States*
Session Co-Chair: **Miguel A. Selles**, *Universitat Politecnica de Valencia, Alcoy, Spain*

A Study on the Performance of Rolling Oil During Cold Rolling of Stainless Steel simulating Industrial Condition
MSEC2012-7373
***Rajendra Mahapatra, Jaspal Singh Rait, Samuel Pappy, Inder Singh Sudhir, Ajay Kumar Harinarain**,* ***Deepak Saxena**,* ***Vincent Martin**,* ***R.K. Malhotra**, Indian Oil Corporation R&D, Faridabad, Haryana, India*

Tribological Investigation of Deep-Drawing Processes using Servo Presses
MSEC2012-7292
***Peter Groche, Norman Moeller**, Institute for Production Engineering and Forming Machines, Technische Universitaet Darmstadt, Darmstadt, Germany*

Numerical Investigation of Residual Formability and Deformation Localization during Continuous-Bending-Under-Tension
MSEC2012-7302
***Chetan Nikhare, Yannis Korkolis, Brad Kinsey**, University of New Hampshire, Durham, NH, United States*

MSEC 1-6-3 Laser Processing
136 DeBartolo Hall 8:30 – 10:00

Session Chair: **Benxin Wu**, *Illinois Institute of Technology, Chicago, IL, United States*
Session Co-Chair: **Gary J. Cheng**, *Purdue University, West Lafayette, IN, United States*

Effect of Warm Laser Shock Peening on the Tensile Strength and Ductility of Aluminum Alloys
MSEC2012-7371
***Chang Ye, Dong Lin, Yiliang Liao, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States*

Enhanced Laser Shock by an Active Liquid Confinement
MSEC2012-7372
***Yiliang Liao, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States*

Nanotwins in Copper Nanowires Controlled by Laser Assisted Electrochemical Deposition
MSEC2012-7391
***Zhikun Liu, Gary J. Cheng, Yuefeng Wang, Yiliang Liao**, Purdue University, West Lafayette, IN, United States*

MSEC 2-1-5 Monitoring and Sensing III
117 DeBartolo Hall 8:30 – 10:00

Session Chair: **Amit Bagchi,** *Naval Research Laboratory, Washington DC, United States*
Session Co-Chair: **Anil K. Srivastava**, *TechSolve, Inc., Cincinnati, OH, United States*

Thin-Film PVDF Sensor Based Monitoring of Cutting Forces in Peripheral End Milling
MSEC2012-7217
***Lei Ma, Shreyes N. Melkote, John Morehouse**, Georgia Institute of Technology, Atlanta, GA, United States*, ***James Castle, James Fonda**, The Boeing Company, St. Louis, MO, United States*, ***Melissa Johnson**, The Boeing Company, Seattle, WA, United States*

Enabling Machining Vision using STEP-NC
MSEC2012-7310
***Martin Hardwick**, RPI Department of Computer Science, Troy, NY, United States*, ***David Loffredo**, STEP Tools, Inc., Troy, NY, United States*, ***Fred Proctor**, NIST, Gaithersburg, MD, United States*, ***Sid Venkatesh**, The Boeing Company, Tukwila, WA, United States*

Remote Tool Health Monitoring Using Wireless Sensors on Rotational Machinery
MSEC2012-7335
***David Loker, Mark Rynders, John Roth**, Penn State Erie, The Behrend College, Erie, PA, United States*

Break, McKenna Hall Atrium
10:00-10:30

CONCURRENT TECHNICAL SESSIONS
10:30-12:00

Panel: Global Research and Education Collaborations
101 DeBartolo Hall 10:30 – 12:00

Moderator: ***Jian Cao****, Northwestern University, Evanston, IL, United States*

Panelists:

Christine Furstoss**,** *GE Research, Niskayuna, NY, United States*
Thomas Neitzert**,** *AUT University, Auckland, New Zealand*
Elena Pérez-Bernabeu, *Universitat Politècnica de Valencia, Campus of Alcoy, Spain*
Erin Johnson, *Zimmer Inc., Warsaw, IN, United States*

NAMRC 1-31 Sheet Metal Forming
140 DeBartolo Hall 10:30 – 12:00

Session Chair: **Chetan Nikhare,** *University of New Hampshire, Durham, NH, United States*
Session Co-Chair*:* **Frederic Bäcker,** *Technishche Universität Darmstadt, Darmstadt, Germany*

Energy Consumption in Single Point Incremental Forming
NAMRC40-7704
David Adams, Jack Jeswiet*, Queen's University, Kingston, ON, Canada*

Optimization of the Design of Roll-Formers
NAMRC40-7705
Florian M. Kern, Thomas R. Neitzert*, Auckland University of Technology, Auckland, New Zealand*

Influences of Clamp Die Geometry and Friction on the Clamping Process in Rotary Draw Bending
NAMRC40-7732
Markus Hinkel, Bernd Engel*, University of Siegen, Siegen, Germany*

MSEC 1-3-3 Materials and Nontraditional Processes
126 DeBartolo Hall 10:30 – 12:00

Session Chair: **Arif S. Malik**, *Saint Louis University, St. Louis, MO, United States*
Session Co-Chair: **Norman Möller,** *Technische Universität Darmstadt, Darmstadt, Germany*

Real Time Dispatching Control of Multi-Dollies Material Handling systems in General Assembly Lines
MSEC2012-7333
Chaoye Pan, Jun Ni*, University of Michigan, Ann Arbor, MI, United States*, ***Qing Chang****, Stony Brook University, Stony Brook, NY, United States*

Application of Multiple Regression and Adaptive Neuro-Fuzzy Inference System for Prediction of Surface Roughness in EDM
MSEC2012-7273
Sunil Baraskar*,* ***Sukhwant Singh Banwait****, National Institute of Technical Teachers Training & Research, Chandigarh, India*

A Reliability-Based Approach to Flatness Actuator Effectiveness in 20-High Rolling Mills
MSEC2012-7281
Arif S. Malik, John Wendel*, Saint Louis University, St. Louis, MO, United States*, ***Mark Zipf****, Tenova I2S, LLC, Yalesville, CT, United States*, ***Andrew Nelson****, Saint Louis University, St. Louis, MO, United States*

MSEC 1-5-9 Advances in Process Modeling
117 DeBartolo Hall 10:30 – 12:00

Session Chair: **Edmund Chu**, *Alcoa Inc, Alcoa Center, PA, United States*
Session Co-Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States*

Twist in Incremental Forming
MSEC2012-7402
Venkata Reddy, Javed Asghar, E. Shibin, Anirban Bhattacharya*, Indian Institute of Technology, Kanpur, Kanpur, India*

A Preliminary Numerical Study of the Slurry Wire Sawing Process
MSEC2012-7289
Chunhui Chung*, National Taiwan University of Science and Technology, Taipei, Taiwan*

Finite Element Modeling of Pad Deformation Due to Diamond Disc Conditioning in Chemical Mechanical Polishing (CMP)
MSEC2012-7364
Emmanuel Baisie*,* ***Zhichao Li****, North Carolina Agricultural & Technical State University, Greensboro, NC, United States*, ***X.H. Zhang****, Seagate Technology, Minneapolis, MN, United States*

MSEC 1-8-1 Mechanical Polymer Processing
131 DeBartolo Hall 10:30 – 12:00

Session Chair: **Donggang Yao**, *Georgia Institute of Technology, Atlanta, GA, United States*

Investigation of the Machinability of PA-6/NANO-CACO3 Composite
MSEC2012-7203
***Reza Farshbaf Zinati, Mohammad Reza Razfar**, AmirKabir University of Technology, Tehran, Iran*, ***Mehdi Haghi**, Tabriz University, Tabriz, Azarbyjan Sharghi, Iran*

Development of a Fiber Orientation Measurement Methodology for Injection Molded Thermally-Enhanced Polymers
MSEC2012-7291
***Timothy Hall, Arumugham Subramoniam, Hugh Bruck, Satyandra Gupta**, University of Maryland, College Park, MD, United States*

Characteristics of the Exfoliated Graphite Nanoplatelets-Polyamide12 Nanocomposites Processed by Extrusion Injection Molding
MSEC2012-7388
***Mehdi Karevan, Kyriaki Kalaitzidou**, Georgia Institute of Technology, Atlanta, GA, United States*

MSEC/ICTMP 4-2-1 Sustainable Manufacturing - Lubricants and Dry Machining
116 DeBartolo Hall 10:30 – 12:00

Session Chair: **Delcie R Durham**, *University of South Florida, Tampa, FL, United States*
Session Co-Chair: **Fu Zhao**, *Purdue University, West Lafayette, IN, United States*

Designing Green Lubricants for Manufacturing Industry Using Renewable Base Materials
MSEC2012-7254
P.V. Joseph, Deepak Saxena, Pankaj Bhatnagar, Rajan Mookken, R. K. Malhotra, *Indian Oil Corporation R&D Center, Faridabad, Haryana, India*

Residual Stress and Fatigue Properties of AISI H13 Steel by Sustainable Dry Milling
MSEC2012-7363
Yuebin Guo, W. Li, *University of Alabama, Tuscaloosa, AL, United States*

Multi-Scale Friction Modeling for Manufacturing Processes: The Boundary Layer Regime
MSEC2012-7298
J. Hol, D.K. Karupannasamy, *Materials innovation institute (M2i), Delft, Netherlands*, ***T. Meinders***, *University of Twente, Enschede, Netherlands*

Microfracturing Ceramic Abrasive in Grinding
MSEC2012-7324
Jeffrey Badger, *The Grinding Doc Consulting, Bulverde, TX, United States*

Lunch, Irish Courtyard
12:00-13:30

MSEC ABSTRACTS

MSEC2012-7237

TRIBOLOGICAL CONDITIONING OF CYLINDER RUNNING SURFACES

Florian Welzel — University of Magdeburg
Bernhard Karpuschewski — University of Magdeburg

In the wake of increasing performance requirements for internal combustion engines, regarding downsizing, and rising mobility in Far Eastern markets efficient manufacturing processes gain significance. Also in consideration of increasing emission limits for these combustion engines investigations regarding alternative technologies for the efficient manufacturing of performance-optimized cylinder running surfaces were carried out by the Institute of Manufacturing Technology and Quality Management. The microstructure of these surfaces and the subsequent surface integrity are in the focus of considerations. Using tribological analysis of the mechanical running-in behavior of cylinder running surfaces conclusions will be drawn on the impact of the last honing step in the production of the engine. These investigations are carried out in terms of a possible conditioning of tribotechnical systems in their production and the concomitant reduction of friction and wear-intensive running-in processes. In this regard alternative finishing operations, such as metal-forming processes, are investigated.

MSEC2012-7240

HIGHER COMPETITIVENESS OF SPEED-STROKE GRINDING BY USING INCREASED WHEEL SPEEDS

Michael Duscha — Laboratory of Machine Tools and Production Engineering (WZL) of the RWTH Aachen University
Barbara S. Linke — University of California, Berkeley
Fritz Klocke — Laboratory of Machine Tools and Production Engineering (WZL) of the RWTH Aachen University
David Dornfeld —University of California, Berkeley

Production engineering faces the challenge to satisfy the increasing industrial demand for higher productivity and high requirements on workpiece quality at the same time. Furthermore, the rising environmental awareness adds additional constraints. Especially grinding processes have high relevance for industrial applications because they generate high quality surfaces and they are most effective for hard-to-machine materials. New technologies like speed-stroke grinding and high cutting speeds enable higher productivity. However, to be competitive to conventional grinding operations energy aspects have to be regarded thoroughly. This work shows how the combination of speed-stroke grinding and high speed machining can boost process performance, workpiece quality and process sustainability.

MSEC2012-7256

AN ANALYSIS OF POLISHING FORCES IN MAGNETIC FIELD ASSISTED FINISHING

Vasishta Ganguly — University of North Carolina at Charlotte
Tony Schmitz — University of North Carolina at Charlotte
Arthur Graziano — University of Florida
Hitomi Yamaguchi — University of Florida

Magnetic field assisted finishing (MAF) is used to polish free-form surfaces. The material removal mechanism can be described as a flexible “magnetic brush” that consists of ferromagnetic particles and abrasives that arrange themselves in the working gap between the magnet and the work piece. Relative motion between the brush and the work piece causes micro-cutting and improves surface finish. In this study, the contributions of the magnetic and polishing force components to the total force were evaluated. The effect of varying the polishing conditions, such as the working gap and the size of the ferromagnetic iron particles, on polishing forces and surface roughness was also analyzed. It was observed that the polishing forces varied considerably with working gap. Also, the iron particle size was found to have a strong relation to the rate at which the surface roughness decreased. Surface area roughness of 2-3 nm was achieved.

MSEC2012-7272

OBSERVATIONS DURING VORTEX MACHINING PROCESS DEVELOPMENT

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Vortex machining is a newly developed process that utilizes vortices generated by oscillating a micrometer sized fiber in colloidal abrasive slurry to remove material in highly localized regions [1]. Typical material removal footprints produced by our current machining process have micrometer sized lateral dimensions and nanometer depths with volumetric removal rates near 20 cubic micromenters per hour. The carbon fiber attached to the tuning fork oscillator is approximately 7 μm in diameter and 4 mm in length. Resonant frequencies of the probe (fiber and tuning fork) are the order of 30 kHz and oscillate with amplitudes of the fiber tip up to 50 micrometer. In initial tests a silicon substrate has been machined using 50 nanometer alumina colloidal slurry and

the resulting footprints were measured by a scanning white light interferometer. Details of the developed machine, the initial test results, process metrology, and future process challenges are provided in the following sections.

MSEC2012-7274

DESIGN AND ANALYSIS OF HELICAL NEEDLE TIP GRINDING PROCESS

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A generalized helical needle tip geometry model, which can describe many typical needle tip geometries, including conical, bevel, blunt and helical shapes with proper geometric parameters, is presented based on analogy to the helical point drill geometry. The generality of this model offers a general way for manufacturing various needle tip geometries. A mathematical model of the helical needle tip geometry is provided along with the formulation of the kinematic model of the tip grinding process. The control strategy on a 5-axis grinding machine system is also developed to implement the designed kinematic model. The needle tip's motions in the grinding process are simulated to characterize the effects of grinding parameters on needle tip properties and to predict the trajectory of the needle tip point during the grinding process. Finally, several types of needle geometries have been manufactured by the developed grinding process to verify the newly formulated models.

MSEC2012-7290

IN VITRO DENTAL CUTTING OF FELDSPAR AND LEUCITE GLASS CERAMICS USING AN ELECTRIC HANDPIECE

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Glass ceramics are important restorative materials in dentistry. They are used as veneer-core bilayer all-ceramic or metal-fused ceramic restorations or monolithic inlays/onlays/crowns to replace missing or damaged tooth structures for aesthetic and functional purposes. However, glass ceramic materials, such as feldspar and leucite glass ceramics, which are subject to this investigation, are brittle and easily induced microfractures in abrasive cutting using dental handpieces and coarse burs. In this paper, we investigated the dental abrasive cutting characteristics of feldspar and leucite glass ceramics using a high-speed electric handpiece and coarse diamond burs. Cutting forces, specific removal energy, surface roughness and morphology were investigated as functions of specific material removal rate and maximum undeformed chip thickness. The results indicate that increasing the specific material removal rate or the maximum undeformed chip thickness resulted in increases in both tangential and normal forces, but a decrease in specific removal energy for both ceramics. Tangential, normal forces and specific removal energy were significantly larger in up cutting than those in down cutting. Surface roughness for the two ceramics was not affected by the specific removal rate or the maximum undeformed chip thickness. Both microfrature and ductile microcutting morphology were observed in the machined surfaces for both ceramics. There existed a brittle to ductile transition trend when decreasing the specific material removal rate or the maximum undeformed chip thickness for the two ceramics. In comparison with feldspar glass ceramic, leucite glass ceramic generated better surfaces due to its more ductile deformation occurring in dental cutting.

MSEC2012-7232

RAPID MANUFACTURING IN MINUTES: THE DEVELOPMENT OF A MASK PROJECTION STEREOLITHOGRAPHY PROCESS FOR HIGH-SPEED FABRICATION

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The purpose of this paper is to present a direct digital manufacturing (DDM) process that is an order of magnitude faster than other DDM processes currently available. The developed process is based on a mask-image-projection-based Stereolithography process (MIP-SL), during which a Digital Micromirror Device (DMD) controlled projection light cures and cross-links liquid photopolymer resin. In order to achieve high-speed fabrication, we investigated the bottom-up projection system in the MIP-SL process. A set of techniques including film coating and the combination of two-way linear motions have been developed for the quick spreading of liquid resin into uniform thin layers. The process parameters and related settings to achieve the fabrication speed of a few seconds per layer are presented. Additionally, the hardware, software, and material setups developed for fabricating given three-dimensional (3D) digital models are presented. Experimental studies using the developed testbed have been performed to verify the effectiveness and efficiency of the presented fast MIP-SL process. The test results illustrate that the newly developed process can build a moderately sized part within minutes instead of hours that are typically required.

MSEC2012-7238

PULSE ELECTROCHEMICAL MICROMACHINING OF TUNGSTEN CARBIDE

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Pulse electrochemical micromachining (PECMM) is a non-conventional manufacturing method suitable for the production of micro-sized components on wide range of conductive materials. PECMM improves dimensional accuracy and simplifies tool design in machining hard, high strength, and heat resistant materials into complex shapes. Extremely small interelectrode gaps are required in PECMM for better dimensional accuracy. However, excessively small interelectrode gaps may lead to complications like short-circuiting. This imposes the need for better control of the PECMM process. In this study a feedback controlled PECMM system was developed for the electrochemical micromachining of tungsten carbide. It was noticed that while, higher ratios of return velocity to feed rate is preferred as it reduces the number of current spikes, very high value of this ratio result in poor machining rates due to increased interelectrode gap. Therefore, this ratio of return velocity to feed rate may be used to optimize the PECMM process.

MSEC2012-7239

INITIAL INVESTIGATION INTO HELICAL MILLING OF LAMINATED STACKS OF ELECTRICAL STEEL

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This paper serves to report the findings of an initial study on the holing of laminated stacks of electrical steels. Three different holing methods were considered: plunge milling, helical milling (orbit milling), and drilling. Stack delamination, axial thrust force, and burr formation were measured at various feed rates for each process and utilized as comparison metrics. Results from the initial experimental investigation indicate that drilling produces significant burr and plunge milling, whilst reducing burr formation compared to drilling, led to delamination of the stack. Helical milling minimized thrust forces, avoided delamination and minimized burr formation. An interesting spring back effect was also observed during the cutting of the laminated stacks. It is concluded that helical milling is a viable and effective processing method for making holes in laminated stack of hard electrical steels.

MSEC2012-7252

INTELLIGENT MODELING AND OPTIMIZATION OF MATERIAL REMOVAL RATE IN ELECTRIC DISCHARGE DIAMOND GRINDING

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Metal matrix composites (MMCs) have wide applications in modern manufacturing industries due to their specific and improved technological characteristics such as high strength to weight ratio, high hardness, high thermal, corrosion and wear resistances. Such characteristics are highly demanded in automobile, aircraft and space research organizations. Shaping of MMCs has been a big challenge for manufacturing industries due to their superior mechanical properties. Unconventional machining methods have become an alternative to give desired shapes with intricate profiles and stringent design requirements. The aim of present research is to investigate the machining performance of copper-iron-carbide MMC using hybrid machining process, electric discharge diamond face grinding (EDDFG). A hybrid approach of neural network and genetic algorithm has been used to develop the intelligent model for material removal rate (MRR) and subsequent optimization with the experimental data obtained by scientifically designed experimentation.

MSEC2012-7314

EXPERIMENTAL CHARACTERIZATION OF VIBRATION-ASSISTED REVERSE MICRO ELECTRICAL DISCHARGE MACHINING (EDM) FOR SURFACE TEXTURING

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There are several examples in nature where the biological surfaces exhibit unique functional response, such as velcro, fish scale and lotus leaves. The texture on lotus leaf exhibits super-hydrophobicity and self cleaning properties. Lotus leaf has hemispherical protrusions of 20-30 μm in diameters which are randomly distributed over the surface. This work is focused on creating similar textured surfaces on Ti6Al4V rods via a vibration assisted reverse micro Electrical Discharge Machining (R-MEDM) process. Textured surfaces containing micropillars of 40-50 μm in diameter spaced at 35 μm have been created during the process. These textured surfaces are expected to exhibit hydrophobicity and

hemocompatibility. To experimentally characterize the process, a full factorial design of experiments has been conducted to analyze the effects of voltage, capacitance, amplitude and frequency of the anode (plate electrode) vibrations on the erosion rate and process stability. The process stability is expressed in terms of the percentages of the normal, open circuit and the short circuit durations in the voltage-current (VI) signature obtained during the process. It has been observed that the normal discharge durations increase with an increase in the amplitude and the frequency of the vibrations. Fabricated texture exhibits hydrophobicity and the measured contact angles in a sessile drop test with water varied between 110 and 1150. Also, the textured surface was subjected to hemotoxicity tests which yielded positive results. Based on these results, it can be seen that the machined textured surface are hydrophobic and biocompatible in nature which could potentially find applications in cardiovascular biomedical implants. In addition, this process has been used to create hierarchical structures comprising of primary and a secondary structure over it to mimic the hierarchical structures found on lotus leaves.

MSEC2012-7331

WETTABILITY ENHANCEMENT OF ALUMINUM ALLOYS VIA PLASMA ARC DISCHARGE

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The aim of this study is to determine the wettability-enhancing effects of an atmospheric-pressure, direct current (DC) plasma arc discharge on aluminum alloys. Wettability is a critical factor in engineering applications such as biomedical implants, painting, and adhesive bonding. For example, in the realm of adhesive bonding, greater wettability improves a metal substrate's attraction to an adhesive material, which results in higher bond quality. In this study, the contact angle is determined and compared as a measure of the wettability using two different techniques, the sessile drop and ballistic deposition methods, with water as a test liquid. Additionally, this paper analyzes the impact of different arc discharge parameters, including arc current and plasma torch velocity, on the wettability.

MSEC2012-7367

CHARACTERISTICS OF COBALT CHROMIUM ALLOY SURFACES FINISHED USING MAGNETIC ABRASIVE FINISHING

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Freeform surfaces, including the femoral components of knee prosthetics, present a significant challenge in manufacturing. The finishing process is often performed manually, leading to high variation in quality. This study proposes using Magnetic Abrasive Finishing (MAF) to finish the cobalt chromium (Co-Cr) alloy femoral components of knee prosthetics and varying the surface pattern to alter surface wettability, which influences the tribological properties of the surfaces. As a first step, flat workpieces of the same material were used in this paper. To obtain an understanding of the relationship between surface pattern and wettability, two sets of finishing conditions were developed to yield two different surface patterns while maintaining roughness values (2-5 nm Ra). One surface consists of long cutting marks exhibiting strong directionality, while the other consists of short, intermittent cutting marks. The surface with strong directionality resulted in an increased contact angle between the workpiece and de-ionized water (from 90.0°±1.5° to 93.8°±2.5°), thus a decrease in wettability. The other surface showed a decreased contact angle (from 98.7°±5.3° to 93.3°±3.7°), thus an increase in wettability. This study experimentally demonstrates the feasibility of MAF to alter surface pattern—and to potentially alter the wettability—while maintaining initial surface roughness at a nanometer scale.

MSEC2012-7374

ANALYSIS OF VOXEL SIZE DURING TWO-PHOTON POLYMERIZATION

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Analysis of Voxel Size during Two-Photon Polymerization Abstract: Two-photon polymerization combines the concepts of multi-photon absorption with polymerization of a free radical polymerizable monomer. It can be used to fabricate a variety of micro-devices including micro-fluidic, biomedical, micro-optical, and micro-mechanical devices. During two-photon polymerization, energy from multiple photons excites photoinitiators thereby emitting free radicals, which then polymerize monomers that are susceptible to free radical polymerization. Since a very high intensity source is essential for the two-photon absorption effect, it only takes place at the focal point. Three dimensional microdevices can therefore be created in free form within the resin by tracing out the object features within the resin using the focal

point. This contrasts with traditional lithographic rapid prototyping processes which require layer by layer processing. A critical aspect of two-photon polymerization is the resolution of the process. This paper presents an analysis of the two-photon polymerization process which enables the shape and size of the solidified volume element, the voxel, to be predicted. The voxel size determines the resolution of the process. The beam and resin interaction is analyzed based on the input power, the lens used to focus the beam, the threshold intensity required for polymerization, and the resin sensitivity. The model assumes a beam with Gaussian intensity distribution and a sensitivity analysis was also performed, and the results show that the voxel formed is more sensitive to changes in beam power and resin threshold than to changes in the incident beam diameter.

MSEC2012-7415

MILLING TOOL OF MICRO-EDM BY ULTRASONIC ASSISTED MULTI-AXIAL WIRE ELECTRICAL DISCHARGE GRINDING PROCESSES

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Conventional micro EDM milling relies on time-consuming WEDG to achieve acceptable quality of micro tools. In this study, a rotational axis augmented to Wire Electrical Discharge Grinding (WEDG) processes with ultrasonic assistance and its application to EDM micro-milling is reported. On its removing mechanism, a quantitative analysis based upon wire-EDM discharge-angle was proposed to clarify fundamental understanding of such a novel multi-axial machining process. Then, a test on EDM micro-milling with 70 microns of diameter tool is conducted. Its significant effects on improving dressing efficiency and surface integrity of micro tools were verified, and the effectiveness for EDM micro-milling with a screw type of tool was also verified experimentally. Because of its geometric properties, the screw surface contributed to deliver debris from machining region to outsider. Therefore, a better EDM micro-milling configuration may be introduced into the micro-EDM manufacturing field.

MSEC2012-7216

OPTIMIZATION OF MACHINING PARAMETERS IN CFRP/TI STACKS DRILLING

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Carbon fibre reinforced plastics (CFRP) and titanium (Ti) stacks have been steadily replacing metals as choice for engineering materials in aerospace applications. Although materials can be manufactured separately and stacked together to attain a near-net shape, it still involves post processing operations such as trimming and drilling. In order to drill holes efficiently without defects (delamination, circularity, variation in hole diameter) in the CFRP/Ti stacks, it is essential to understand the machining behavior of stacks. An experimental study on the drilling of CFRP/Ti stacks was conducted using K20 carbide drill. The drilling characteristics were evaluated for drilling force and torque, delamination in CFRP, drilled-hole quality (hole diameter and circularity) and exit burr height in Ti. This paper describes an attempt made to maximize the hole quality parameters by employing multi-objective optimization using weighted sum method.

MSEC2012-7220

HOOK SHAPED RESIDUAL STRESS, THE EFFECT OF TOOL PLOUGHING, AND THE ANALYSIS OF THE MECHANICAL AND THERMAIL EFFECTS

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To investigate the unique hook-shaped residual stress profile generated from hard turning process, an improved orthogonal (2-D) Finite Element (FE) model is established to include the ploughing effect of cutting edge. The model is further decomposed into two FE sub-models (sub-model 1 and sub-model 2) to determine the thermal and mechanical effects on the residual stress profiles by saw-tooth chip formation process and honed-edge ploughing process respectively. The two FE sub-models are sequentially adopted to evaluate the compression effect induced by chip formation process and ploughing effect resulted from honed-edge cutting tool on residual stress profile. Their separated and integrated effects on residual stress hook-shape profile are addressed by comparing the predicted residual stresses by sub-model 1, sub-model 2, the two sub-models' superposition, and the whole improved FE model. The results show that chip formation effect on residual stress profile happens earlier than the ploughing effect. Chip formation effect provides a foundation for the finalized residual stress profile by determining the maximum depth

and magnitude of the compressive residual stress. Ploughing process generates much more thermal load to produce the tensile residual stress in hard turned surface and sequentially drives the final resultant residual stress into an obvious hook-shaped by modifying the previous compressive residual stress profile. The location with the maximum compressive residual stress is identified as the critical position to separate the mechanical load and thermal load generated from ploughing effect. The decomposition methodology on mechanical and thermal effects is proposed and thoroughly discussed in the paper.

MSEC2012-7244

OPTIMIZATION OF DOUBLE CONE DRILL GEOMETRY DURING DRILLING OF CARBON FIBRE REINFORCED PLASTIC (CFRP)

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In aeronautic fields, around 10 million holes are required for joining composites structures. However, due to their laminated constructions several types of damages like matrix degradation and thermal alterations, fibre pullout and fuzzing, are introduced during drilling in addition to geometrical defects similar to those found in metal drilling. Among the various tool geometries investigated for drilling of CFRP, double cone drill offers many advantages when compared to the modified geometries. Only a few investigations on drilling of CFRP laminates have been reported using double cone drill. In this paper, experimental study on drilling of CFRP laminate sandwiched with copper mesh has been carried out using carbide drills (K20) to study the influence of spindle speed, feed rate and lip length of the double cone drill on force and hole quality. It was found that the double cone drills used for the experimental analysis encountered less thrust force compared to the standard twist drill. Moreover double cone drills with the reference M2 give less roughness values compared to other double cone tools and standard twist drill. In addition the quality of the holes after drilling were evaluated, and found that no delamination even at higher feed rate (> to 0.1 mm/rev), because of the thermoplastic nodule in the CFRP. During drilling, continues and tangled chips were observed at low feed rate, when the feed rate was increased chips were broken comparable to that observed during drilling of metallic material. From the SEM observation it was noticed that, after machining with reference tool, several damaged areas were observed. These damaged areas (with high depth) are located mainly with the fibres orientations at -45° and 90°. However, with the double cone drill, we have less area of damages and here depths are small compared to the damage caused by the reference tool. In addition, it was noticed that the damages are uniformly distributed. The increasing of the feed rate from 0.05 mm/rev to 0.3 mm/rev show that, the extent of the damaged areas located on the wall of the hole increased when the drilling is performed with a reference tool. However, with double cone tools, extent of the damaged areas is less significant.

MSEC2012-7250

INVESTIGATION ON THE IMPORTANT FACTORS IN DETERMINING AERODYNAMIC NOISE IN FACE MILLING CUTTERS

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The aerodynamic noise spectrum of face milling cutters consists of a broad range of higher frequencies and discrete tones. This paper is to develop a method to calculate the flow field and the acoustic field of face milling cutters, and analyze the effects of cutter geometry on the generation of aerodynamic noise. Based on the computational fluid dynamics (CFD) method, the Ffowcs Williams-Hawkings (FW-H) equation is used to predict the sound pressure level of aerodynamic noise in face milling. The accurate calculation of time-varying flow variables as the cutter rotates is very important for the prediction of the aerodynamic noise. In this case, the Navier-Stokes (N-S) equation is carried out to evaluate the pressure and velocity fields on and around the milling cutters: firstly in a steady mode, and secondly in an unsteady mode by introducing the steady flow as the initial fields. The aerodynamic noise in face milling is significantly affected by the change of the number of cutter teeth. Four cutters with different number and structure of gullet regions are chosen to study the effects of gullet regions on the aerodynamic noise and the characteristics of sound spectra of four different gullet regions are analyzed lastly.

MSEC2012-7253

THERMAL MODELING OF ELECTRON BEAM ADDITIVE MANUFACTURING PROCESS – POWDER SINTERING EFFECTS

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In recently developed Additive Manufacturing (AM) technologies, high-energy sources have been used to fabricate metallic parts, in a layer by layer fashion, by sintering and/or melting metal powders. In particular, Electron Beam Additive Manufacturing (EBAM) utilizes a high-energy electron beam to melt and fuse metal powders to build solid parts. EBAM is one of a few AM technologies capable of making full-density metallic parts and has dramatically extended their applications. Heat transport is the center of the process physics in EBAM, involving a high-intensity, localized moving heat source and rapid self-cooling, and is critically correlated to the part quality and process efficiency. In this study, a finite element model was developed to simulate the transient heat transfer in a part during EBAM subject to a moving heat source with a Gaussian volumetric distribution. The developed model was first examined against literature data. The model was then used to evaluate the powder porosity and the beam size effects on the high temperature penetration volume (melt pool size). The major findings include the following. (1) For the powder layer case, the melt pool size is larger with a higher maximum

temperature compared to a solid layer, indicating the importance of considering powders for the model accuracy. (2) With the increase of the porosity, temperatures are higher in the melt pool and the molten pool sizes increase in the depth, but decrease along the beam moving direction. Furthermore, both the heating and cooling rates are higher for a lower porosity level. (3) A larger electron-beam diameter will reduce the maximum temperature in the melt pool and temperature gradients could be much smaller, giving a lower cooling rate. However, for the tested electron beam-power level, the beam diameter around 0.4 mm could be an adequate choice.

MSEC2012-7260

MINIMIZED WEAR AND DEBRIS GENERATION THROUGH OPTIMIZED MACHINING OF CO-CR-MO ALLOYS FOR USE IN METAL-ON-METAL HIP IMPLANTS

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More than 380,000 hips are replaced with total joint prostheses each year in the U.S. Wear debris generated by metal-on-metal implant designs is of concern due to potential adverse biological effects arising from chronic exposure of human tissue to the wear debris. This paper presents a new methodology for optimizing the wear performance of prosthesis made of Co-Cr-Mo alloys by varying tool edge geometry and machining conditions to alter the wear behavior of this alloy, while also controlling the residual stresses induced during the machining process. The machining process causes inhomogeneous inelastic deformations in the surface layer of machined parts, which create residual stresses in the surface of machined components. Residual stresses in the machined surface and the subsurface are affected by cutting tool material, tool geometry, workpiece, tool-work interface conditions, and the cutting parameters such as feed rate, depth of cut and cutting speed. In the current work, residual stresses were measured using X-ray diffraction technique (XRD). The surface residual stresses in two directions (radial and hoop) were measured on the machined pins after machining with different machining conditions, but prior to the wear test. Wear behavior of Co-Cr-Mo alloy pin specimens, produced from machining with varying tool edge geometry and machining conditions, was studied using a custom-made biaxial motion pin-on-disc tribological testing system in which the pin specimen is immersed in a simulated bio-fluid environment. Wear-induced weight loss (± 10 μg) and changes in surface roughness (± 0.001 μm) were obtained at 100,000 cycle intervals up to 500,000 cycles. Metallographic analysis was performed on the machined pin specimens to analyze the microstructure and microhardness before and after testing. The rate of wear for the specimens was lowest for those pins where the change of the subsurface microhardness was small due to prevention of additional steady state wear after the initial run-in wear in the wear tester. A combination or response surface methodology (RSM) and genetic algorithm (GA) was used for optimizing the various machining parameters for minimized wear generation. The optimal combination of the four machining parameters (feed 0.18 mm/rev, nose radius 0.6 mm, cutting speed 27.6 m/min and depth of cut 0.38 mm) produced the largest compressive residual stresses on the surface and subsurface of the pin specimen, thereby reducing the wear/debris generation by about fifty percent.

MSEC2012-7262

EXPERIMENTAL INVESTIGATION OF HARD TURNING MECHANISMS BY PCBN TOOLING EMBEDDED MICRO THIN FILM THERMOCOUPLES

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Temperature-distribution measurements in cutting tools during the machining process are extremely difficult and remain an unresolved problem. In this paper, cutting temperature distributions are measured by thin film thermocouples (TFTCs) embedded into Polycrystalline Cubic Boron Nitride (PCBN) cutting inserts in the immediate vicinity of the tool-chip interface. Using these measurements, steady and dynamic phenomena during hard turning as well as the chip morphology and formation process were analyzed based on the cutting temperature distributions in the insert. The relationship between the cutting temperature-field distributions in the PCBN insert and the segmented chip formation is analyzed using temperature-distribution mapping. It is shown that the temperature-distribution in the cutting zone depends on the shearing band distribution in the chip and the thermal transfer rate from the heat generation zone to the cutting tool. Furthermore, it became evident that the material flow stress and the shearing bands greatly affect not only the chip formation morphology but also the cutting temperature field distributions in the cutting zone of the cutting insert.

MSEC2012-7273

APPLICATION OF MULTIPLE REGRESSION AND ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM FOR PREDICTION OF SURFACE ROUGHNESS IN EDM

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A manufacturing system is oriented towards higher production rate, better quality and reduced cost and time to make a product. Surface roughness is an index parameter for determining the quality of a machined product and is influenced by various input process parameters. Surface roughness prediction in Electrical Discharge Machine (EDM) is being attempted with many methodologies, yet there is a need to develop robust, autonomous and accurate predictive system. This work proposes the application of hybrid intelligent technique, multiple regression and adaptive neuro-fuzzy inference system (ANFIS) for prediction of surface roughness in EDM. An experimental data set is obtained with current, pulse-on time and pulse-off time as input parameters and surface roughness as output parameter. Central composite rotatable design was used to plan the experiments. Multiple regression model is developed using the experimental data, to generate additional input-output data set. The input-output data set is used for training and validation of the proposed technique. After validation, data are forwarded for prediction of surface roughness. The proposed hybrid model for the prediction of surface roughness has very good agreement with the experimental results.

MSEC2012-7275

A METHODOLOGY TO DETERMINE FRICTION IN ORTHOGONAL CUTTING WITH APPLICATION TO MACHINING TITANIUM AND NICKEL BASED ALLOYS

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Friction plays a very important role in machining titanium and nickel alloys. It is the source for the high amount of heat generation, and as a result, the excessive tool wear during machining these materials. The worn tool is known to create lower surface qualities with tensile surface residual stresses and machine-induced hardening at the surface, as well as high surface roughness. It is essential to create a method to determine how and to what extent the friction is built up on the tool. This study facilitates a determination methodology to estimate the friction coefficients between the tool and the chip on the rake face, as well as the tool and the workpiece on the flank face of the tool. The results are validated with experimental results from the titanium alloy Ti-6Al-4V and the nickel alloy IN-100.

MSEC2012-7281

A RELIABILITY-BASED APPROACH TO FLATNESS ACTUATOR EFFECTIVENESS IN 20-HIGH ROLLING MILLS

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20-High rolling mills process high strength and/or very thin non-ferrous and ferrous metals using a complex, cluster arrangement of rolls. The 20-high roll cluster arrangement achieves specific flatness goals in the thin sheet by delivering maximum rolling pressure while minimizing the deflections of the small diameter rolls. 20-high mills also employ flatness control mechanisms with sophisticated actuators, such as those to shift intermediate rolls and deflect backup bearing shafts. The purpose of this is to compensate for variations in strip dimensional and mechanical properties which can cause poor flatness control quality from discrepancies in work-roll gap profile and distribution of rolling force. This suggests that the random property differences in the rolling parameters that substantially affect the flatness must be directly accounted for in flatness control algorithms in order to achieve strict flatness quality. The use of accurate mathematical models that account for the rolling pass target gage reduction can optimize the flatness control actuators and help gain an advantage in the thin gauge strip competitive global market. Based on the expected process parameter variations and nominal mill set-points (speed, tension, gage reduction, etc.), the mill's process control computer should determine the probability that target flatness control quality will be met for a required length of strip. The process computer should then either modify the number of rolling passes or adjust the thickness reduction schedule before rolling begins to secure an improved flatness probability estimate if the probability of achieving target strip flatness is too low for the required deliverable quality. Therefore, this research integrates 1) 20-high roll-stack mill mathematical modeling, 2) probability distribution data for random important rolling parameters, 3) reliability-based models to predict the probability of achieving desired strip flatness, and 4) optimization examples. The results can be used to reduce wasted rolled metal from poor flatness before rolling.

MSEC2012-7287

HIGH SPEED NON-LINEAR MICRO-MILLING DYNAMICS

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The efficiency of the milling process is limited due to excessive vibrations that negatively impact the tool and work-piece quality. This becomes even more of a concern in micro-milling where sudden tool breakage occurs before the operator can adjust cutting parameters. Due to different chip formation mechanisms in micro-milling, an increased tool-radius to feed-rate ratio, and higher

spindle speeds, micro-milling is a highly non-linear process which can produce multiple and broadband frequencies which increase the probability of tool failure. This paper investigates micro-milling through the development and analysis of a 3-D nonlinear micro-milling dynamic model. A lumped mass, spring, damper system is assumed for modeling the dynamic properties of the tool. The force mechanism utilized is a slip-line field model that provides the advantages of being highly dynamic by accounting for the constantly changing effective rake angle and slip-line variables. Accurate prediction of the chip thickness is important in correctly predicting the dynamics of the system since the force mechanism and its variables are a function of the chip thickness. A novel approach for calculating the instantaneous chip thickness which accounts for the tool jumping out of the cut and elastic recovery of the work-piece is presented. The derivation for the effective rake angle is given and the helical angle is accounted for resulting in a 3-D micro-milling model. The results of simulating the model demonstrate its capability of producing the high frequency force components that are seen in experimental data available in literature. The advantages of using this approach over the constant empirical force coefficient approach when studying micro-milling dynamics is discussed and the instability of the system is investigated utilizing instantaneous frequency.

MSEC2012-7300

A METALLO-THERMO-MECHANICALLY COUPLED ANALYSIS OF OTHOGONAL CUTTING OF AISI 1045 STEEL

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Materials often behave in a complicated manner involving deeply coupled effects among stress/stain, temperature and microstructure during a machining process. This paper is concerned with prediction of the phase change effect on orthogonal cutting of AISI 1045 steel based on a true metallo-thermo-mechanical coupled analysis. A metallo-thermo-mechanical coupled material model is developed, and a finite element model is used to solve the evolution of phase constituents, cutting temperature, chip morphology, and cutting force simultaneously using ABAQUS. The model validity is assessed using the experimental data for orthogonal cutting of AISI 1045 steel under various conditions, with cutting speeds ranging from 198 to 879 m/min, feeds from 0.1 to 0.3 mm, and tool rake angles from -7° to 5°. A good agreement is achieved in chip formation, cutting force and cutting temperature between the model predictions and the experimental data.

MSEC2012-7318

ROBUST SHEARING PROCESS FOR IMPROVING AHSS SHEARED EDGE STRETCHABILITY

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Results from a previous study have shown that a newly developed beveled shearing process is able to improve the quality of advanced high strength steel (AHSS) sheared edges and their edge stretchability. The objective of the current study is to further investigate and validate this phenomenon and to develop robust shearing conditions for improving the AHSS sheared edge stretchability. A straight edge shearing device with the capability of adjusting the shearing variables is used in this study. Two different advanced high strength steel grades, DP600 and DP980, with similar thicknesses are selected to assess the edge condition using various shearing variables. The edge stretchability of the straight edge sheared specimen is evaluated using the sheared edge tension test and a half specimen dome test. It was discovered that an optimal selection of the die clearance and other shearing variables would result in a less damaged sheared edge which would greatly delay edge fracture in the forming process and increase the edge stretchability of AHSS.

MSEC2012-7332

EVIDENCE OF PHASE DEPENDENT TOOL WEAR IN TI-6AL-4V TURNING EXPERIMENTS USING PCD AND CARIBIDE INSERTS

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This paper presents evidence of phase transformation in turning titanium work material and discusses its impact on tool wear. Tool wear of polycrystalline diamond inserts was studied in turning experiments on Ti-6Al-4V. Confocal laser scanning microscopy was conducted to analyze the rake face of the turning inserts. At cutting speeds of 61m/min, the rake face exhibited scalloped-shaped, fractured, uneven, and rough wear. This is characteristic of attrition wear. At cutting speeds of 122m/min, wear was smooth and even in nature, which is a typical characteristic of diffusion/dissolution wear. At a cutting speed of 91m/min, the wear was a combination of those observed at speeds of 61m/m and 122m/m. A comparison of the wear on the PCD tools to that of WC-6Co from earlier work is also discussed. The significant difference in wear exists between the two types of tool material at low cutting speeds. This difference in wear was linked to a transition from alpha to beta phase in the titanium work material.

MSEC2012-7333

REAL TIME DISPATCHING CONTROL OF MULTI-DOLLIES MATERIAL HANDLING SYSTEMS IN GENERAL ASSEMBLY LINES

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Material handling process on assembly lines is important because poor planning and control policies lead to low utilization of workforce and resources, which will cause more inadequate part delivery (part starvation) and reduce the overall system performance. Therefore, the delivery system must be optimized such that minimum number of workforce can be achieved without sacrificing production rate. In real assembly process, for better safety and higher efficiency, dolly trains are widely used to replace traditional forklifts for part delivery, which allows drivers to deliver more than one parts per trip and raises problems: how to choose proper number of parts and the delivery order at the beginning of each trip to achieve optimal dispatching control. Effective algorithms and strategies are addressed and compared in this study to provide practical guidelines for dolly material handling system in both deterministic and stochastic perspective.

MSEC2012-7338

THE CORRELATION OF VOLUMETRIC TOOL WEAR & WEAR RATE OF MACHINING TOOLS WITH THE MATERIAL REMOVAL RATE OF TITANIUM ALLOYS

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The objective of this paper is to assess the correlation of volumetric tool wear (VTW) and wear rate of carbide tools on the material removal rate (MRR) of titanium alloys. A previously developed methodology for assessing the worn tool material volume is utilized for quantifying the VTW of carbide tools when machining Ti-6Al-4V. To capture the tool substrate response, controlled milling experiments are conducted at suitable corner points of the feed-speed design space for constant stock material removal volumes. For each case, the tool material volumes worn away, as well as the corresponding volumetric wear profile evolution in terms of a set of geometric coefficients are quantified – these are then related to the MRR. Further, the volumetric wear rate and the M-ratio (volume of stock removed to VTW), which is a measure of the cutting tool efficiency, are related to the MRR – these provide a tool-centered optimal MRR in terms of profitability. This work not only elevates tool wear from a 1-D to 3-D concept, but helps in assessing machining economics from a stock material removal efficiency perspective as well.

MSEC2012-7361

FINITE ELEMENT ANALYSIS OF RESIDUAL STRESSES IN HIGH-SPEED DRY CUTTING OF BIODEGRADABLE MAGNESIUM-CALCIUM ALLOY

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Magnesium-Calcium (Mg-Ca) alloys have become attractive biodegradable orthopedic implant biomaterials recently. Residual stresses are proven to be very influential on degradation rate of these alloys in human anatomy. Due to time and cost inhibitive reasons, development of finite element models to predict residual stress profiles under various cutting regimes is highly desirable. In this context, a finite element model of orthogonal cutting without explicit chip formation is developed by adopting plowing depth approach in order to predict process induced residual stresses in high speed dry cutting of Mg-Ca0.8 (wt %) using diamond tools. Mechanical properties of Mg-Ca0.8 alloy at high strain rates and large strains are determined using split-Hopkinson pressure bar test. Internal state variable (ISV) plasticity model is implemented to model the material behavior under cutting regimes. The residual stress evolution process and effects of plowing speed and plowing depth on residual stress profiles are studied. Residual stress measurements are performed utilizing X-ray diffraction technique for validation purposes.

MSEC2012-7221

A NEW APPROACH TO PREDICT MACHINING FORCE AND TERMPERATURE WITH MINIMUM QUANTITY LUBRICATION

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A new model to predict cutting force and temperature is developed by incorporating the lubrication and cooling effects generated from minimum quantity lubrication (MQL) machining. The boundary lubrication theory is utilized to estimate the friction behavior in prediction model. The model is capable of predicting cutting force and temperature in MQL machining directly from given cutting conditions, as well as material properties. Subsequently, the response of temperature distributions to chip formation and MQL is quantified on the basis of a moving heat source/loss model which iterates with the initial cutting force to achieve the final predictions. The predicted cutting temperature and cutting force are validated by the experimental data for AISI 9310 steel and AISI 1045 steel, respectively. Results show that under cutting speeds of 223-483 m/min, feed rates 0.10-0.18 mm/rev, depth of cut 1.0mm, the predicted cutting temperature at the tool-chip interface are generally lower than experimental measurements by 2% to 19%. And the model provides an average error of 11% for temperature prediction. With respect to cutting force prediction, the model provides a prediction error of 13% on the average in the cutting direction and 12% in the thrust direction within the

experimental test condition range (cutting speeds of 45.75-137.25m/min, feeds 0.0508-0.1016 mm/rev, and depth of cut 0.508-1.016mm). In actual machining, the effects of possible tool wear causing higher temperature and force can contribute to deviations from model predictions involving only sharp tools.

MSEC2012-7233

MODELING MECHANICAL BEHAVIOR OF MATERIALS PROCESSED BY ACCUMULATIVE ROLL BONDING

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Nanostructured materials are a relatively new class of materials that exhibit high strength and toughness, thus improving performance and capabilities of products, with potential applications to automotive, aerospace and defense industries. Among the severe plastic deformation (SPD) methods currently used for achieving nanoscale structure of a material, accumulative roll bonding (ARB) is the most favorable method to produce grain refinement for continuous production of metallic sheets at a bulk scale. ARB is a deformation technique where metallic sheets are repeatedly prepared, stacked and rolled together, usually to a reduction of 50% in thickness. The main objective of this paper is to establish a model that relates the process parameters and number of ARB cycles to the mechanical properties of the resultant material. This model, established in this study, can be a useful tool in designing the process and establishing the number of cycles needed in order to achieve the desired properties. Accumulative roll bonding experiments of various materials are analyzed and the resultant materials strength, at the corresponding ARB cycles, is modeled with good agreement.

MSEC2012-7235

FORMATION CONDITION OF SCALE LAYER ON WORK ROLL IN HOT STEEL ROLLING

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It is well known that scale layer on work roll forms in hot sheet rolling of steel and scale layer on work roll plays an important role for the hot rolling process. The formation conditions of scale layer on work roll are slightly known qualitatively and are hardly understood quantitatively. In order to investigate quantitatively the conditions of scale formation, three steels are used and the slip rolling are carried out at a constant roll speed changing the scale thickness of the steel specimens and the reduction. The formation conditions of scale layer on work roll are examined quantitatively by observation of the work roll surface after the slip rolling. The experiments are carried out at constant rolling conditions of a velocity ratio of 20, a rolling speed of 50 m/min and a furnace temperature of 800 °C, changing the rolling reductions of 0.3, 0.5 and 1.0 mm and the scale thickness of the strip. The colza oil is used as base oil. The emulsion concentration is 3.0 %. The emulsion temperature is controlled at 40 °C. The scale layer on work roll formed easily with increasing rolling reduction and decreasing scale thickness of strip for three steels A, B and C. In order to estimate quantitatively the formation condition of scale layer on work roll, parameter a which is given by a ratio of the rolling reduction to the scale thickness of the strip is proposed. Scale layer on work roll forms when the values of parameter a become same for each steels. The values of parameter a become larger in order of the steels A, B and C and it can be understood that scale layer on work roll forms easily in order to steels A, B and C. When the FeO layer in the scale of steel surface adheres on the work roll surface, it is expected that scale layer on work roll forms easily and strongly by the transformation from FeO to Fe3O4, considering that the chemical composition of scale layer on work roll is Fe3O4.

MSEC2012-7241

MODELING THE ELECTROPLASTIC EFFECT DURING ELECTRICALLY-ASSISTED FORMING OF 304 STAINLESS STEEL

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Over the last decade, the Electrically-Assisted Manufacturing (EAM) technique, where electricity is applied to a metal during deformation, has been experimentally proven to increase the workability of many lightweight alloys which are highly desirable to the automotive industry. Recent research by the authors has led to ways of accounting for the formability increases due to the applied electricity, by way of an Electroplastic Effect Coefficient (EEC), and by utilizing this coefficient, simple EAM forming tests can ultimately be modeled. This work provides insight into the authors' EAM modeling methodology and how it differs from previous EAM modeling attempts. Additionally, from the Electrically-Assisted Forming (EAF) experiments, two methods of accounting for the electroplastic effect will be discussed and compared. Ultimately, these methods will be integrated into the thermo-mechanical model to predict compressive stress-strain profiles for electrically-assisted forming tests under various current densities and die speeds. Finally, the efficiency of applying electricity to the deformation process will be discussed.

MSEC2012-7245

MIXED LUBRICATION MODEL FOR COLD ROLLING CONSIDERING THE INLET AND DEFORMATION ZONES

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A mixed lubrication model for cold rolling was developed by separating, according to common concepts, the domain of calculation into two zones: the inlet zone and the zone of plastic strip bulk deformation. The analysis of the inlet zone mainly focuses on film formation from different lubricants based on the evolution of layers consisting of neat oil on the metallic surfaces. In the zone of plastic strip bulk deformation, contributions of boundary and hydrodynamic (mainly hydrostatic) friction are modeled incorporating longitudinal and transversal roughness components. Lubricant pressure, which is influenced by the geometry of these roughness structures, is governed by hydrodynamic (hydrostatic) mechanisms. Additionally, lubricant temperature in the roll bite is predicted by an integrated thermodynamics sub-model. While coupling between the inlet and plastic deformation zones is performed iteratively, the highly non-linear and coupled equations for the latter zone are solved simultaneously by applying a variant of the well-known damped Newton-Raphson method.

MSEC2012-7278

FRICTION AND DEFORMATION-INDUCED HEATING DURING SHEET METAL STAMPING

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This paper investigates the friction and deformation-induced heating that occurs during the stamping of high strength and advanced high strength sheet steels. Experimental and numerical techniques are employed to understand the temperature conditions experienced within the blank material. A thermal-mechanical finite element model of a typical plane strain stamping process was developed. Experimental measurements, from a novel semi-industrial stamping test facility, were used to validate the developed model. A high level of correlation between the finite element model results and the experimental forming data was achieved, for a range of operating conditions and parameters. It was shown that the heat generated during the 'cold' stamping process examined can result in high temperatures in the blank material, of over 100°C, when stamping high strength steels. The results provide new insights into the local conditions within the blank and are of direct relevance to sheet formability and tool wear performance during industrial stamping processes.

MSEC2012-7288

BIAXIAL WORK HARDENING CHARACTERISTICS OF 6000 SERIES ALUMINUM ALLOY SHEET FOR LARGE STRAIN RANGE

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Deformation behavior of 0.9-mm-thick 6016-T4 aluminum alloy sheet with a high intensity of the cube orientation under biaxial tension was investigated. First, many linear stress paths in the first quadrant of stress space were applied to cruciform specimens to precisely measure the deformation behavior of the test material up to an equivalent strain of 0.04. True stress-true plastic strain curves, contours of plastic work in stress space and the directions of plastic strain rates were measured and compared with those calculated using selected yield functions. Second, in an effort to observe the plastic deformation behavior of the sample up to much larger strains over 0.1, the sample was bent and YAG-laser welded to fabricate tubular specimens with an inner diameter of 44.6mm. Using a servo-controlled tension-internal pressure testing machine developed by one of the authors [T. Kuwabara, K. Yoshida, K. Narihara, S. Takahashi, Anisotropic plastic deformation of extruded aluminum alloy tube under axial forces and internal pressure, Int. J. Plasticity 21 (2005) 101-117.], plane strain tension tests were performed. Hydraulic bulge test were also performed. The material exhibits significant differential work hardening; the Yld2000-2d yield functions with exponents of 6, 12 and 32 had the best agreement with the experimental work contours for the equivalent plastic strains of 0.002, 0.04 and 0.14, respectively.

MSEC2012-7289

A PRELIMINARY NUMERICAL STUDY OF THE SLURRY WIRE SAWING PROCESS

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Slurry wire saw has been utilized to slice the brittle semiconductor wafer substrates for over 20 years. However, the complicated slicing process limits the further studies and advances of this exclusive slicing tool for big wafers. In this study, a numerical model of the slurry wire sawing process was developed based on the mechanism of brittle indentation cracks. The simulation results illustrate how the factors such as wire speed, wire tension, and feed rate of the ingot affect the slicing conditions including the bow angles of the wire and the local normal loads on both the

workpiece and the wire. In addition, the results show that the steady-state condition would be reached via overshooting or non-overshooting approach based on the slicing parameters. A higher wire speed is suggested to reduce the bow angles and local loads during slicing process. However, the limition of the wire speed depends on the material of the wire and the specification of the wire saw machine.

MSEC2012-7292

TRIBOLOGICAL INVESTIGATION OF DEEP-DRAWING PROCESSES USING SERVO PRESSES

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Deep-drawing is one of the most important processes for the economic production of sheet metal parts, especially for high quantities. The forming forces during the process are a limiting factor for the producible shapes. A particular importance is associated with the tribology, because the percentage of friction forces on the total forces is relatively high. The friction between sheet metal and tool is influenced by several factors, such as surface characteristics of the work piece and the tool, lubrication conditions and process parameters, like the contact pressure and the sliding speed. Controlling these parameters will expand the process window for deep-drawing. Lately, servo presses provide the possibility of controlling the process speed in dependency of the process progress. The subject of this paper is the Tribological investigation of deep-drawing processes. The friction coefficient decreases with an increasing sliding velocity. Investigating this correlation and utilizing it for the application with modern servo technology for industrial use is the main objective of this project. First of all the dependency of the friction coefficient on the gliding speed is investigated by the use of the strip drawing tests, which allows the control of every parameter independently. The dependencies are implemented in a FEM-simulation, evaluating the potential for real deep-drawing processes. Deep-drawing experiments are then used to validate the results of the simulation with a speed-dependent friction coefficient as well as for the verification of the force reduction due to the influencing of process speed. In the end, the numerical simulated results in comparisons to the experimental measured results are discussed.

MSEC2012-7302

NUMERICAL INVESTIGATION OF RESIDUAL FORMABILITY AND DEFORMATION LOCALIZATION DURING CONTINUOUS-BENDING-UNDER-TENSION

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A ubiquitous experiment to characterize the formability of sheet metal is the standard uniaxial tension test. Past research has shown that if the material is repeatedly bent and unbent during this test (termed Continuous-Bending-under-Tension, or CBT), the percent elongation at failure increases significantly (e.g., from 22% to 290% for an AISI 1006 steel). However, past experiments have been conducted with a fixed stroke of the CBT device, which limits the formability improvements. This phenomenon has also been empirically observed in industry; the failure strains of a sheet which is passed through a drawbead (i.e., that has been bent and unbent three times before entering the die) are higher than those of the original sheet. Thus, the residual formability of the material after a specified number of CBT passes is of interest, to determine if multiple drawbeads would be beneficial in the process. Also of interest is the localization of the deformation during the process as this will provide a better physical understanding of the improved formability observed. In this paper, numerical simulations are presented to assess these effects. Results show that the formability during CBT is dictated by the uniaxial response of the material until the standard elongation at failure is exceeded. This limit can be exceeded by the CBT process. However, failure then occurs as soon as the CBT process is terminated. Also, the deformation is more uniformly distributed over the entire gauge length during the CBT process which leads to the increased elongations observed.

MSEC2012-7309

EFFECTS OF CONTINUOUS DIRECT CURRENT ON THE YIELD STRESS OF STAINLESS STEEL 304 MICRO TUBES DURING HYDROFORMING OPERATIONS

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Hydroforming at the macro scale offers the opportunity to create products that have superior mechanical properties and intricate complex geometries. Micro tube hydroforming is a process that is gaining popularity for similar reasons. At the same time, due to the physical size of the operations, there are many challenges including working with extremely high pressures and available materials that are typically difficult to form. Increasing the

formability of micro tubes during the hydroforming process is desired. Being able to increase the formability is essential because as the tube diameters decrease in size, the required forming pressure increases. As a result, it is important to explore methods to decrease the yield stress during forming operations. Traditional methods for decreasing the materials yield stress typically involve heating either the sample or the process equipment. Using traditional methods typically sacrifice dimensional quality of the part, alter the mechanical properties and also raise the costs of the operations. Electrically Assisted Manufacturing (EAM) is a non-traditional method that is gaining popularity by reducing the necessary forces and pressures required in metal forming operations.

MSEC2012-7311

DEVELOPMENT OF STATICALLY DETERMINATE PLATE ROLLING MILLS BASED ON MICRO-SCALE PARAMETERS

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Contemporary plate rolling mills and pinch pass mills, which are unstable during the rolling process, are all statically indeterminate structures influenced by micro-scale parameters. The micro-scale parameters include bending deformations of the rolls and the side clearances between the chocks and the side surfaces of the housing window. All these are less than 1 mm, and they have an important effect on the skeletal structure of the roll systems of the mill. If the influence of micro-scale parameters is not considered in the design of the rolling mill, the skeletal structure of the roll system is incomplete and lacks kinematic links and pairs. The statically indeterminate nature of traditional rolling mills results in numerous disadvantages, including the frequent burning loss of the end-thrust bearing caused by excessive axial forces, the lateral movement of the strip owing to the deviation of the rolling load acting on the both ends of backup roll, the short service life of the four-row radial roller bearings on the back-up roll, and the quality of product tends to deteriorate due to the unstable operation of the control system, to mention a few. Because of the flattening effect between the rolls, the setting of the offset distance does not achieve the desired purpose and leads to the deviation of rolling load due to the asymmetric cross between the roll axes. To alleviate the above shortcomings, a new type of rolling mill with a statically determinate structure in which the horizontal offset distance between the roll axes is set to zero is thus proposed. In order to keep the rolls parallel and prevent cross between the rolls, a thrust device is designed, which also ensures sufficient free space to allow convenient roll replacement and allow for the thermal expansion of the chocks. In addition, back-up roll systems with component force bases as well as intermediate roll systems are designed in accordance with the theory of statically determinate characteristics with micro-scale parameters.

MSEC2012-7319

NUMERICAL AND EXPERIMENTAL INVESTIGATIONS OF KEY ASSUMPTIONS IN ANALYTICAL FAILURE MODELS FOR SHEET METAL FORMING

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In this paper, the key assumptions in the M-K and effective stress ratio models are investigated for AISI 1018 steel specimens with a thickness of 0.78 mm using experimental and numerical data from Marciniak tests. The experimental procedure included Digital Imaging Correlation (DIC) to measure the major and minor in-plane strains. Strain components were obtained at points inside (i.e., the defect region) and adjacent (i.e., the safe regions) to the high strain concentrations for four different strain paths. In the numerical analysis, FEA simulations with Marc Mentat were performed with shell elements to investigate the four specimen geometries. The key assumptions of interest are the incremental major strain ratio from M-K model and the critical stress concentration factor from effective stress ratio model. Thus, the mechanics- and material-based failure phenomena in these two analytical models are examined in this paper to provide insight into the material behavior at failure.

MSEC2012-7322

ELECTRO-HYDRAULIC FORMING OF ADVANCED HIGH-STRENGTH STEELS: DEFORMATION AND MICROSTRUCTURAL CHARACTERIZATION

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The deformation behavior and texture evolution during forming of an advanced high-strength steel (DP600 grade) were characterized. The deformation history of DP600 during electro-hydraulic forming (EHF) was quantified using a unique experimental capability developed at PNNL. The texture evolution during quasi-static and high-strain-rate deformation was determined using the electron backscatter diffraction (EBSD) technique. The deformation history of EHF formed steel sheets shows an amplification of the strain-rate, relative to free-forming conditions, when the forming was carried out inside a conical-die. This strain-

rate amplification was attributed to the focusing action of the conical die. The undeformed DP600 sheet was found to possess a {111} fiber texture in the sheet-normal direction. Quasi-static deformation was found to strengthen the pre-existing texture whereas high-rate forming using EHF had a lesser influence. The results of this work demonstrate the unique capability to correlate deformation history during high-strain-rate metal forming processes with the corresponding microstructural evolution. It is expected that results of this work can help fill-in the gaps in our understanding of high-rate forming processes, leading to development of accurate and validated numerical models.

MSEC2012-7326

TOOL-WORKPIECE INTERFACE TEMPERATURE MEASUREMENT IN FRICTION STIR WELDING

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The objectives of this work are to develop an improved temperature measurement system for Friction Stir Welding (FSW). FSW is a novel joining technology enabling welds with excellent metallurgical and mechanical properties, as well as significant energy consumption and cost savings compared to traditional fusion welding processes. The measurement of temperatures during FSW is employed for process monitoring, heat transfer model verification and process control, but current methods have limitations due to their restricted spatial and temporal resolution and have found only few industrial applications so far. Thermocouples, which are most commonly used, are either placed too far away from the weld zone or are destructively embedded into the weld path, and therefore fail to provide suitable data about the dynamic thermal phenomena at the tool-workpiece interface. Previous work showed that temperatures at the tool shoulder-workpiece interface can be measured and utilized for closed-loop control of temperature. The method is improved by adding an additional thermocouple at the tool pin-workpiece interface to gain better insight into the temperature distribution in the weld zone. Both thermocouples were placed in through holes right at the interface of tool and workpiece so that the sheaths are in contact with the workpiece material. This measurement strategy reveals dynamic temperature variations at the shoulder and the pin within a single rotation of the tool in real-time. Due to the thermocouple's limited response time and inherent delays due to physical heat conduction, the temperature response is experiencing attenuation in magnitude and a phase lag. Heat transfer models were constructed to correct for this issue. It was found that the highest temperatures are between the advancing side and the trailing edge of the tool. Further work is needed to increase the accuracy of the correction. Experimental results show that the weld quality is sensitive to the measured interface temperatures, but that temperature is not the only factor influencing the weld quality. The dynamic temperature measurements obtained with the current system are of unmatched resolution, fast and reliable and are likely to be of interest for both fundamental studies and process control of FSW.

MSEC2012-7334

SENSITIVITIES WHEN MODELING ELECTRICALLY-ASSISTED FORMING

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Laine Mears — Clemson University

Recent research by the authors has resulted in the conception of several methods of accounting for direct electrical effects during an Electrically-Assisted Manufacturing (EAM) process, where electricity is applied to a conductive workpiece to enhance its formability characteristics. The modeling and analysis strategy accounts for both mechanical effects and heat transfer effects due to the applied electrical power. This work presents a sensitivity analysis and explanation of several key material and process inputs during an Electrically-Assisted Forming (EAF) test on Stainless Steel 304 and Titanium Grades 2 and 5 specimens. First, the effect that the specific heat (Cp) value has on the model will be discussed and compared with another lightweight material. Second, the significance of all three heat transfer modes (conduction, convection, and radiation) will be noted, and any possible simplifications to the existing heat transfer model will be highlighted. Third, the general electroplastic effect coefficient (EEC) profile shape for the Stainless Steel 304 material will be compared to that of Titanium alloys. Fourth, a frequency analysis will be done on the data taken during the experiments, by way of a Fast Fourier Transform (FFT), and the variation of frequency response with the electric input is studied. Overall, this work provides insight into several factors affecting a material's EEC profile, and also compares resulting EEC profiles of various materials.

MSEC2012-7349

THERMAL RESPONSE CHARACTERIZATION OF SHEET METALS DURING ELECTRICALLY-ASSISTED FORMING (EAF)

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For the current practice of lightweight engineering in the automotive sector, it is common to introduce and use low density/high strength materials instead of costly engine/drivetrain technologies. With the introduction of these materials there are commonly many manufacturing difficulties which arise during their incorporation to the vehicle. As a result, new processes which improve the manufacturability of these materials are necessary. This work examines the manufacturing technique of Electrically-Assisted Forming (EAF) where an electrical current is applied to

the workpiece during deformation. As a result of the applied current, Joule heating is present which increases the temperature of the material. In this work the thermal response of sheet metal for stationary and deformation tests using this process are explored and modeled. The results of the model show good agreement for the stationary tests while the deformation model predicts that all of the applied electrical current may not be transformed into Joule heating. Thus, this work suggests from the observed response that a portion of the applied current may be directly aiding in deformation (i.e. the Electroplastic Effect).

MSEC2012-7358

SPIRAL FRICTION STIR PROCESSING (SFSP) FOR THE EXTRUSION OF LIGHTWEIGHT ALLOY TUBES

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While friction stir processing (FSP) has been used to refine the grain structure in sheet metals, this work explores the potentials of refining the grain structure of bulk material using the friction stirring phenomenon via the novel concept of spiral friction stir processing (SFSP). With this concept, the rotating stirring tool is plunged into the material, rather than being traversed across it as in FSP; this imposes severe plastic deformation on the material while pushing it radially outwards in complex spiral paths. By confining the material within a closed cylindrical die, the processed material is microstructurally-refined while forming a tube via a special form of SFSP called “friction stir back extrusion” (FSBE). The hypothesised concept was investigated using samples from the AA6063-T52 aluminium alloy and the AZ31B-F magnesium alloy. The preliminary results presented here demonstrate the viability of SFSP, and the special form of FSBE, in producing tubular samples that are structurally sound, with no signs of voids or internal channels. Optical microscopy was performed at key locations within selected tube specimens, and the obtained micrographs clearly show the presence of a stir zone with a fine grain structure; grain size measurements demonstrate the effectiveness of the processing technique in refining the microstructure of the starting material.

MSEC2012-7364

FINITE ELEMENT MODELING OF PAD DEFORMATION DUE TO DIAMOND DISC CONDITIONING IN CHEMICAL MECHANICAL POLISHING (CMP)

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Chemical mechanical planarization (CMP) is widely used to planarize and smooth the surface of semiconductor wafers. In CMP, diamond disc conditioning is traditionally employed to restore pad planarity and surface asperity. Pad deformation which occurs during conditioning affects the material removal mechanism of CMP since pad shape, stress and strain are related to cut rate during conditioning, pad wear rate and wafer MRR during polishing. Available reports concerning the effect of diamond disc conditioning on pad deformation are based on simplified models of the pad and do not consider its microstructure. In this study, a two-dimensional (2-D) finite element analysis (FEA) model is proposed to analyze the interaction between the diamond disc conditioner and the polishing pad. To enhance modeling fidelity, image processing is utilized to characterize the morphological and mechanical properties of the pad. An FEA model of the characterized pad is developed and utilized to study the effects of process parameters (conditioning pressure and pad stiffness) on pad deformation. The study reveals that understanding the morphological and mechanical properties of CMP pads is important to the design of high performance pads.

MSEC2012-7373

A STUDY ON THE PERFORMANCE OF ROLLING OIL DURING COLD ROLLING OF STAINLESS STEEL SIMULATING INDUSTRIAL CONDITION

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The primary role of rolling oil in cold rolling is to reduce friction at the rubbing interface of the work roll and metal sheet surface. The rolling performance as well as cost effectiveness of rolled products is influenced by quality of the rolling oil. Lubricants are required to function under increasingly stressful operating conditions, so it is a challenge to evaluate the product under simulated conditions to improvethe customer confidence in its performance. A steel rolling mill customer had requested us to develop a rolling oil to roll stainless steel in a new 3-stand 18-high rolling mill and demonstrate its performance on an experimental set up. The present paper describes the methodology adopted to assess the suitability of a rolling oil for the particular rolling mill. The screening was carried out with a SRV (Schwingungs Reibungs und Verschleisstest,meaning Vibration, friction and Abrasion) tribometer and EHD (Elasto-hydrodynamic) interferometry based film thickness apparatus to assess the frictional and film forming characteristics of the oil under simulated operating conditions. In addition, simulated tests were carried out on a laboratory 2-Hi Experimental rolling mill to find out the specific roll force (rolling force per unit width of the strip being rolled) required to obtain 55-60% cumulative reduction in three passes as desired by the customer for different grades of stainless steel. Based on results obtained in the laboratory mill simulating industrial test

conditions, the product was recommended and was accepted by the customer for use in their rolling mill.

MSEC2012-7401

M–K ANALYSIS OF FORMING LIMIT DIAGRAM UNDER STRETCH-BENDING

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Since the Forming limit diagram (FLD) was introduced developed by Keeler etc. about four decades ago, it has been intensively studied by researchers and engineers. Most work has been focused on the in-plane deformation which is considered as the dominant mode of the most forming processes. However the effect of out-of-plain deformation modes especially bending effect becomes important in predicting accuracy formability when thick sheet metal and smaller forming radii are encountered. Recent work on experiment research of stretch-bending induced FLD (BFLD) shows that it gives higher formability than conventional forming limit. In this paper, bending effect through the sheet metal thickness on right-hand side of FLD is studied. The Marciniak-Kuczynski (M-K) analysis is extended to include bending and models based on both flow theory and deformation theory are proposed. The radial return method is adopted as the frame to calculate the stress states from given strain and deformation history. The effect of bending and unbending process on the Right-Hand-Side FLD is investigated and compared. The obtained results show that the bending process slightly decreases the sheet metal formability on right-hand side in flow theory based model which is a discrepancy with the prediction of deformation theory based BFLD model. The insight gained from new proposed FLD prediction model in this paper provides an understanding of how the bending process effects on the FLD. This is important for the further research to reconsider the problems that how the bending effect evolves in forming process to enhance the conventional FLD and how can get a perfectly true theoretical explanation for this phenomenon.

MSEC2012-7402

TWIST IN INCREMENTAL FORMING

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Twist in incremental forming is observed in all configurations including single point incremental forming. In addition to tangential force, other parameters like stiffness seems to play a significant role in the twist phenomenon. Present work makes an attempt to experimentally study the twist in SPIF of conical components and compare the same with numerical predictions. Experimental and numerical results are found to be in good qualitative agreement. Further work is in progress to study the twist behavior in detail.

MSEC2012-7410

CHARACTERIZATION OF ULTRASONIC METAL WELD QUALITY FOR LITHIUM-ION BATTERY TAB JOINING

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Manufacturing of battery packs for battery electric vehicles (BEVs) requires a significant amount of joining such as welding to meet desired power and capacity needs. However, conventional fusion welding processes such as resistance spot welding and laser welding face difficulties in joining multiple sheets of highly conductive, dissimilar materials with large weld areas. Ultrasonic metal welding overcomes these difficulties by using its inherent advantages derived from its solid-state process characteristics. Although ultrasonic metal welding is well-qualified for battery manufacturing, there still lack scientific quality guidelines for implementing ultrasonic welding in volume production. In order to establish such quality guidelines, this paper first identifies a number of critical weld attributes that determine the quality of welds by experimentally characterizing the weld formation over time. Weld samples of different weld quality were cross-sectioned and characterized with optical microscopy, scanning electronic microscopy (SEM), and hardness measurements in order to identify the relationship between physical weld attributes and weld performance. A novel microstructural weld region classification for an ultrasonic metal weld is introduced for the first time to complete the weld quality characterization.

MSEC2012-7411

STUDY OF SIZE EFFECTS ON DEFORMATION BEHAVIOR AND FORMABILITY IN MICRO METAL FORMING OF TI FOIL

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Micro forming technology becomes a promising approach to fabricate micro-parts due to its advantages of high productivity, low production cost, good product quality and mechanical

properties, and near net or net shape characteristics. However, the deformation behaviors of material change and the so-called size effect occurs when the part dimension is decreased to micro-scale. To analyze the quality of micro-parts, the material flow stress, anisotropy, ductility and formability in micro-scale need to be considered. In the paper, micro tensile and micro deep drawing tests of Ti foils were used and the size effects on deformation behavior and formability of micro sheet metal forming were studied. The results show that the flow stress of Ti foils is related with foil thickness and grain size. The fracture behaviors also have been changed from shear dimple to slip separation with the decrease of foil thickness. The formability of micro deep drawing becomes worse with the decrease of micro cup dimension and the increase of grain size.

MSEC2012-7219

MICROVIA FORMATION FOR MULTI-LAYER PWB BY LASER DIRECT DRILLING: IMPROVEMENT OF DRILLED HOLE QUALITY OF GFRP PLATES

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Micro-via drilling technology using a laser has become the dominant method for drilling blind via-holes (BVHs) of multi-layer Printed Wiring Boards (PWBs). Cu-direct laser drilling has attracted attention as a new method. However, the Cu-direct drilling is problematic in that it produces a copper overhang as a result of copper and resin, which have different decomposition points, being melted simultaneously. In addition, the state of PWB surface after the laser drilling is very important quality. Therefore, first, we observed the appearance of a removal which was not clear up to now because it is a momentary process. We elucidated the removal process using a high-speed camera. Second, we examined the influence that the build-up layer gave removal process. Finally, we produced the prototype PWBs which was aimed to reduce the overhang length and sputter deposition, and the effect was demonstrated. As results, the removal process in Cu-direct drilling was visualized and revealed. It was found that sputter deposition on the PWB surface after drilling increased with inorganic substance in build-up layer. Using the prototype PWBs, we achieved the suppression of overhang length and sputter deposition. PWBs which was aimed to reduce the overhang length and sputter deposition, and the effect was demonstrated.

MSEC2012-7243

MODELING AND OPTIMIZATION OF KERF TAPER IN PULSED LASER CUTTING OF DURALUMIN SHEET

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Duralumin sheets are strong, hard, light weight and heat treated alloy of Aluminum, widely used by different sectors such as automobile, marine, aircraft and satellites. Many a times these applications demand complex shapes and intricate profiles with stringent design requirement which are not completely achieved by conventional sheet cutting methods. Laser cutting has capability of quality cutting with above requirements in thin sheetmetals. But highly reflective and thermally conductive sheetmetals like Duralumin pose difficulty in achieving quality cuts by laser beam. The kerf taper always occurs in laser cut specimen due to inherent converging-diverging profile of laser beam. The optimization of kerf taper and other cut qualities such as surface roughness, heat affected zone and recast layer formation in difficult-to-laser-cut sheetmetals like Duralumin or Aluminium alloy has become recent research interests. The aim of present research is to optimize kerf taper in pulsed laser cutting of Duralumin sheet using hybrid approach of ‘design of experiment (DOE)’ and ‘artificial intelligence tool’ such as genetic algorithm. The empirical model for kerf taper has also been proposed with the discussion on parametric effect.

MSEC2012-7304

LASER JOINING OF CONTINUOUS GLASS FIBER COMPOSITE PRE-FORMS

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A laser fusion joining method is investigated for the purpose of through thickness strengthening of fiber pre-forms used in the vacuum infusion fabrication of thick composite structures. Laser joining is achieved without using filler materials to replace adhesives, pins or stitches in conventional composite fabrication. A two step joining process is developed to fuse fibers within a single bundle and between multiple fiber bundles. Finite element analysis is used to investigate the joint strength with respect to joint morphology. Joint strength is found to be a function of the fiber contact angle and packing density at the joint interface. Tensile tests show that laser joined fiber bundles exhibit higher strength than comparable fastening methods. Lessons learned from the axial joining of fiber bundles are applied to joining in the radial and thickness directions of 3d pre-form architectures. Flow induced joint morphology and densification effects observed in the axial direction indicate the need for a two step joining process in the thickness direction. Fiber compaction effects on joint strength

in the axial direction motivate the need for high fiber packing fraction at joint interfaces in the thickness direction.

MSEC2012-7323

STUDYING THE TEMPERATURE EFFECT DURING THE HIGH-PRESSURE PHASE TRANSFORMATION OF SILICON VIA INDENTATIONS

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Micro-laser assisted machining (μ-LAM) is a novel micro/nano machining technique developed for ductile mode machining of ceramics and semiconductors. Ductile mode material removal is possible in a nominally brittle material due to the high-pressure phase transformation (HPPT) phenomenon during the machining process. This study isolates the pressure and temperature effect in the μ-LAM process. The μ-LAM process is unique whereby the pressure and temperature effect occur concurrently leading to the material removal process. The effect of temperature and thermal softening is studied via indentation tests using a cutting tool. In the precisely controlled indentation tests, laser heating is applied at various stages to determine the phase (i.e. atmospheric Si-I phase or high pressure phases that benefits most from the thermal softening effect. The indentation depths are measured and compared for each condition to identify the enhanced ductility of the nominally brittle material caused by the laser irradiation.

MSEC2012-7328

MICROFLUIDIC CHANNEL FABRICATION WITH TAILORED WALL ROUGHNESS

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Realistic random roughness of channel surfaces is known to affect the fluid flow behavior in microscale fluidic devices. This has relevance particularly for applications involving non-Newtonian fluids, such as biomedical lab-on-chip devices. In this study, a surface texturing process was developed and integrated into microfluidic channel fabrication. The process combines colloidal particle masking and reactive ion etching (RIE) for generating random surfaces with desired roughness parameters on the micro/nanoscale. The surface texturing process was shown to be able to tailor the random surface roughness on quartz. A Large range of particle coverage (around 6% to 67%) was achieved using dip coating and drop casting methods using a polystyrene colloidal solution. A relation between the amplitude roughness, autocorrelation length, etch depth and particle coverage of the processed surface was built. Experimental results agreed reasonably well with model predictions. The processed was further incorporated into microchannel fabrication. Final device with designed wall roughness was tested and proved a satisfying sealing performance.

MSEC2012-7371

EFFECT OF WARM LASER SHOCK PEENING ON THE TENSILE STRENGTH AND DUCTILITY OF ALUMINUM ALLOYS

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Gary J. Cheng — Purdue University

In this study, aluminum alloy 7075 (AA 7075) is processed by WLSP and compared with LSP at room temperature (RT-LSP). The microstructure of AA 7075 after processing is characterized by transmission electron microscopy (TEM) and X-ray diffraction (XRD). Tensile test and hardness test were carried out to investigate the effect of WLSP to material strength and ductility. It has been found that highly dense nanoscale precipitate particles are generated after WLSP. These nanoscale precipitate particles effectively block dislocations and thus increase the material strength.

MSEC2012-7372

ENHANCED LASER SHOCK BY AN ACTIVE LIQUID CONFINEMENT

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This letter investigates a unique process to generate the enhanced laser shock with a higher pressure by applying an active liquid confinement — hydrogen peroxide (H2O2). The mechanism of fast chemical etching-assisted laser ablation is proposed. As a result, comparing with utilizing water as confinement, the efficiency of underwater laser shock peening of aluminum alloy 6061 is improved by 150%, and the ablation rate of pulse laser ablation of zinc is enhanced by 300%. This method breaks the major limitation of underwater pulsed laser processing caused by the breakdown plasma.

MSEC2012-7378

LASER SHOCK INDUCED NANO-PATTERNING OF GRAPHENE

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Nano-patterning of graphene film by a novel approach making use of laser ablation generated pressure is presented in this paper. Arrays of nanoscale holes were fabricated by applying laser shock pressure on graphene film suspending on well trenches in silicon substrate. Round holes with diameters ranging from 50 to 200 nm on graphene film were successfully punched. The critical pressure was found to be dependent on the diameter of holes. Smaller the diameters, higher critical pressure, which was also captured by the molecular dynamic (MD) simulations. The laser shock based approach presented in this paper provides an effective way to pattern graphene film with nanoscale features at an easy, fast and scalable manner.

MSEC2012-7391

NANOTWINS IN COPPER NANOWIRES CONTROLLED BY LASER ASSISTED ELECTROCHEMICAL DEPOSITION

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Gary J. Cheng — Purdue University
Yuefeng wang — Purdue University
Yiliang Liao — Purdue University

Nanotwins in metallic nanowires can improve mechanical strength and maintain high electrical conductivity. We demonstrated a method of pulse laser assisted electrodeposition, which can generate dense nanotwins with different directions in copper nanowires of uniform length. Transmission electron microcopy characterization shows at lower electrochemical potential of -0.2 Volt, nanotwins tend to align along the longitudinal direction of the nanowires whereas at the high potential -0.8 Volt, nanotwins of {111}/<112> type that cross the width of the wire are formed. We investigated the two types of nanotwins by comparing the microstructures under different electrochemistry and laser setting. Two different mechanisms are proposed for two kinds of nanotwin - annealing twins and growth twins.

MSEC2012-7223

EFFECTS OF LUBRICANT ON THE MECHANICAL PROPERTIES AND MICROSTRUCTURAL EVOLUTION OF ALUMINUM 6063 ALLOY AFTER ECAE

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The purpose of this paper is to investigate the degree of improvement in mechanical properties of aluminum 6063 after processing through equal channel angular extrusion (hereafter referred to as ECAE) using four environmentally benign lubricants. Aluminum alloy (AA6063) bar was annealed at 350 degree. C. for 1hr, machined and cut to billets size of 14 mm x 14 mm x 44 mm. These specimens for extrusions were machined to the specified dimension to a visibly good finish. The billets were extruded through ECAE die of 14 x 14 mm2 channel cross-section area, the channel angle was 120degree, the angle of the outer arc of the channels was 30degree .The punch and container used for the experiment were made of tool steel alloy AISI D2, and were chromium coated and polished. Four lubricants such as palm oil, olive oil, coconut oil, and groundnut oil were used in this study. The yield, ultimate tensile strengths (UTS), ductility and grain refinement of the material ECAEed with palm oil as lubricant, which gave the least extrusion pressure, produces the maximum yield, ultimate tensile strengths, ductility and best grain refinement followed by groundnut oil and coconut oil while olive oil gave the least yield strength, (UTS) and ductility. This is probably due to the ability of the lubricant to extract heat from deformation zone thereby inhibiting grain growth that could have evolved from excessive heat generation during deformation. However, palm oil and olive oil has better load reduction than other lubricants. It is shown in the paper that all the lubricants tested greatly enhanced mechanical properties of Al 6063 and can effectively replace the petroleum based lubricants used in forging operations.

MSEC2012-7257

FORCE MODEL FOR NEEDLE-TISSUE INTERACTION

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Force modeling of needle insertion into soft tissue is important for accurate needle placement and efficient tissue cutting. In this paper, we studied the pre-puncture and puncture forces during needle insertion. A plane strain FE model was developed to simulate the pre-puncture force prior to tissue rupture. A sensitivity study was performed to investigate the influence of needle and tissue characteristics on pre-puncture force using FE simulation. A force model that incorporates needle geometry and tissue properties was proposed. The force model was able to accurately predict the needle tip force prior to tissue rupture. In

addition to studying the pre-puncture force, the puncture force was experimentally characterized for different needle diameters and tip angles. The experimental results show that the puncture force has a strong dependency on needle geometry.

MSEC2012-7370

LASER MICROMACHINING MODELING AND LASER MACHINED SURFACE ERRORS PREDICTION FOR BIOMEDICAL APPLICATIONS

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Roger J. Narayan — University of North Carolina

This paper presents an analytical modeling and laser micromachining technique of micro-channel and micro-structures for bio-devices manufacturing and biomedical applications. The ablation of the laser micromachining with direct-write method has been modeled and simulated for micro-channels or microstructures in bio-devices microfabrication. In this paper, the analytical model was adapted from the linear function for beam propagation in our previous research by using the Gaussian function to improve modeling accuracy. Basically, the new laser ablation model based on Gaussian distribution, beam propagation modeling and Beer's law were used to formulate and model the laser ablation phenomenon. After the simulation with MATLAB programming, the actual experiment on laser micromachining has been conducted to compare the simulated results with the actual ones. Finally, the purposed modeling technique can be applied in the surface error analysis and biomedical applications. The example case in this paper showed how the modeling could solve the complex phenomenon of the overlapping in laser micromachining.

MSEC2012-7203

INVESTIGATION OF THE MACHINABILITY OF PA-6/NANO-CACO3 COMPOSITE

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Nowadays, polymer nano-composites have attracted manufacturers' attention because of good mechanical, thermal, and physical properties. During the past decade, the requirement of the direct machining of polymer nanocomposites increases because most of the polymer nanocomposites were produced by extrusion method in simple cross section shapes and request for personalized products increases. In this study, the effect of milling parameters (spindle speed and feed per tooth) and nano-CaCO3 content on the machinability properties of PA-6/nano-CaCO3 composites was studied by means of analysis of variance. Additionally, the effect of nano-CaCO3 content on the mechanical properties of PA-6/nano-CaCO3 composites was investigated. To this end, several experiments were carried out on PA-6/nano-CaCO3 composites to attain the required data. The results reveal that the nano-CaCO3 content on PA-6 significantly decreases the cutting forces, but does not have a considerable significance on surface roughness.

MSEC2012-7291

DEVELOPMENT OF A FIBER ORIENTATION MEASUREMENT METHODOLOGY FOR INJECTION MOLDED THERMALLY-ENHANCED POLYMERS

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Thermally-enhanced polymer composites are a promising alternative to exotic metals in seawater heat exchanger applications due to the low cost and corrosion resistance of base polymers and heat transfer rates competitive with corrosion resistant metals such as titanium or stainless steel. While the properties of thermally-enhanced polymer composites are well suited for heat exchanger applications, fiber orientation has a strong influence on the structural and thermal performance of the manufactured components. In this study, a method of creating samples, sectioning and polishing them for imaging, microscope sampling for the identification of fibers, image processing to characterize fiber orientation, and finally comparison to predictions from computer-aided engineering (CAE) software is demonstrated for collecting experimental information on fiber orientation of molded parts. Understanding fiber orientation in injection-molded polymer heat exchangers is important for ensuring ideal heat transfer and structural performance and this study presents an experimental methodology for determining the influence of injection molding process parameters on fiber orientation in thermally-enhanced polymer composite geometries.

MSEC2012-7388

CHARACTERISTICS OF THE EXFOLIATED GRAPHITE NANOPLATELETS-POLYAMIDE12 NANOCOMPOSITES PROCESSED BY EXTRUSION INJECTION MOLDING

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Melt-mixing processes such as extrusion-injection molding induce shear mechanical forces to enhance the melt blend of nanofiller-polymer and have been considered as time and cost efficient in commercial processing of polymer nanocomposites (PNCs). Extensive research has been conducted so far to investigate the overall performance of melt-processed PNCs. However there is

lack of systematic studies on the nanomaterial induced phenomena that dominate the properties of the end-use melt mixing processed parts leading to engineered high quality PNCs. Furthermore, studies for exploration of the structure-property relationships in the melt processed PNCs are also limited. In this work, nanocomposites of Polyamide-12 (PA12) reinforced with exfoliated graphite nanoplatelets (xGnPTM) up to 15wt% were fabricated using two different compounding techniques: coating followed by melt mixing and direct melt mixing. Effects of the compounding methods on the reinforcing efficiency of xGnP within the PA12 matrix were investigated. To understand the reinforcing mechanisms contributing to alteration of the mechanical properties, rheological behavior of the PNCs were investigated in the linear viscoelastic region and correlated with the state of nanofiller-matrix interfacial interaction and the nanofiller dispersion. The results suggest that xGnP coating of the PA12 powder resulted in improved flexural strength of the PNCs with respect to that of the pure PA12 and of PNCs made by direct melt mixing. The rheological low-frequency measurements demonstrate that addition of xGnP resulted in a larger increase in the melt viscosity of the coated-melt mixed PNCs than the direct melt-mixed ones. This suggest stronger xGnP-PA12 interfacial interaction and better dispersion state of the nanofiller in the coated-melt mixed PNCs than the latter PNCs. Addition of xGnP content resulted in improved storage modulus for PNCs made by either compounding method. However, the results support the evidence of post-processing induced re-agglomeration or suppressed dispersing efficiency of the coating process at extreme xGnP content as was elucidated through the shear thinning behavior of the melt and the flexural modulus of the highly reinforced parts.

MSEC2012-7208

SURFACE VARIATION REDUCTION FOR FACE MILLING BASED ON HIGH-DEFINITION METROLOGY

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This paper develops a face milling planning method to reduce surface height variation based on the high definition metrology (HDM). HDM provides high-lateral resolution data over an area up to 300×300 mm2. The measurement results on production engine head surfaces reveal a strong correlation between the surface height and the effective material removal rate (eMRR) along the cutting path. Such a correlation can be explained by a cutting force model which verifies that the surface variation is attributed to the axial cutting force variations, and the axial force is proportional to the eMRR. This paper proposes a machining algorithm that minimizes eMRR to reduce the cutting force variation by altering the feed rate and cutter path, thereby reducing the surface height variation. The varying feed approach can eliminate one surface pattern in the case study without significantly changing the cycle time. The optimized cutter path results in 25% reduction in zone flatness on the other surface pattern. This improvement demonstrates the potential of the eMRR based approach in attaining cost-effective high-precision machining. The method may also be extended to a wide range of face milling applications.

MSEC2012-7217

THIN-FILM PVDF SENSOR BASED MONITORING OF CUTTING FORCES IN PERIPHERAL END MILLING

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A sensor module that integrates a thin film Polyvinylidene Fluoride (PVDF) piezoelectric strain sensor and an in situ data logging platform has been designed and implemented for monitoring of feed and transverse forces in the peripheral end milling process. The module, which is mounted on the tool shank, measures the dynamic strain(s) produced in the tool and logs the data into an on-board card for later retrieval. The close proximity between the signal source and the PVDF sensor(s) minimizes the attenuation and distortion of the signal along the transmitting path and provides high-fidelity signals. It also facilitates the employment of a first principles model based on Euler-Bernoulli beam theory and the constitutive equations of the piezoelectric sensor material to relate the in situ measured PVDF sensor signals to the feed and transverse forces acting on the tool. The PVDF sensor signals are found to compare well with the force signals measured by a platform type piezoelectric force dynamometer in peripheral end milling experiments.

MSEC2012-7259

ESTIMATION OF CUTTING FORCE MODEL COEFFICIENTS TO TRACK WEAR IN MILLING USING BAYESIAN ANALYSIS

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Our previous research has demonstrated the feasibility of monitoring tool wear during milling by continuously updating the coefficients of a cutting force model. The method requires a robust method for on-line model coefficient estimation. Estimation using Least Square Regression (LSR) is easily implemented but requires that the data points come from different cutting conditions which is

not always possible. In this paper, a method for coefficient estimation and wear tracking based on Bayesian updating is described. The Bayesian method has the advantage that it can be used when the cutting conditions are constant.

MSEC2012-7277

MACHINING PROCESS POWER MONITORING: BAYESIAN UPDATE OF MACHINING POWER MODEL

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Monitoring the CNC machine tool power provides valuable information that aids condition based maintenance, machine efficiency and machining process monitoring. Cutting force in machining process is an interesting variable to measure from monitoring and control point of view. Although the direct methods of measuring the cutting force exist, prohibitive costs do not allow deployment in industrial environment. In the indirect methods of measuring force, measuring the spindle motor current to estimate the cutting power and consequently the cutting force is popular. This work discusses the calibration of spindle current based torque sensor for the estimation of the cutting force in turning operation. The work undertakes handling uncertainty in measurement of the cutting torque measurement. Considering the steady state value, the cutting torque is represented as a polynomial function of the speed and measured power. Though the identification of the unknown coefficients can be done based on the offline tests, in current work, the Bayesian update of coefficients is proposed. This method allows online learning of these coefficients. The cutting torque value based on the model has some variability due to variation in the coefficients and unmodeled dynamics. The iterative learning happens in three stages, namely- Prior belief, likelihood function establishment and update in prior belief with observed data producing posterior belief. The establishment of the priors is done through some offline tests. The likelihood function accounts for noise in the measurement of torque. And finally, Markov Chain Monte Carlo (MCMC) simulations help sampling from unknown posterior distribution. This scheme has ability to sample from any distribution. A single update cycle shows high reduction in the variability of the torque. Experimental data is produced to verify the effectiveness of method; the Bayesian update scheme outperforms least-square polynomial fit method consistently for different cutting speeds and cutting load values.

MSEC2012-7307

DETECTION OF CUTTING PHENOMENA USING SENSOR FUSION

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This paper presents an investigation of the application of a suite of sensors for simultaneous in-situ measurements of machining processes. While not every individual sensor responds to all machining phenomena, the suite of sensors together responds to many machining phenomena of interest, including chip segmentation, chip breakage, and other vibrations. The simultaneous use of a suite of sensors with modest data-acquisition equipment and the use of careful preliminary laboratory testing for optimizing sensor performance distinguishes this present proof-of-concept work from prior process monitoring efforts using individual sensors. This paper includes discussion of pre-deployment laboratory measurements and a full description of the instrumented tool holder, associated circuitry, and data analysis methods. The deployment of multiple sensors of varying sophistication and cost lays a technical foundation for the ultimate objective of industrially practical measurement and monitoring systems for metal cutting processes.

MSEC2012-7310

ENABLING MACHINING VISION USING STEP-NC

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David Loffredo — STEP Tools, Inc.
Fred Proctor — National Institute of Standards and Technology
Sid Venkatesh — The Boeing Company

STEP-NC is a new data format for manufacturing control. One of its applications is to enable integrated on machine measurement of machining processes using vision systems and other sensors. In this paper we describe the manufacturing process and manufacturing resource models in STEP-NC that can be used to enable this type of measurement. These descriptions include the machine setup so that the configuration of the part can be identified and corrected, the machine kinematics so that the actions of a machine while adding or subtracting material can be verified, and the product tolerances so that the quality of the final part can be predicted and corrected during the machining.

MSEC2012-7335

REMOTE TOOL HEALTH MONITORING USING WIRELESS SENSORS ON ROTATIONAL MACHINERY

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A key concern in modern day manufacturing is developing a reliable method for monitoring tool health. This involves not only establishing a mathematical method for deriving tool failure, but also developing a reliable method for collecting and transmitting this information. This paper presents a reliable wireless network for collecting, analyzing, and predicting tool failure. The wireless network consists of three remote nodes and one coordinator node. Each remote node is mounted on a 1" R8 mill tool holder and consists of three major components: an accelerometer, microcontroller, and wireless transceiver. These wireless nodes transmit the Z-axis acceleration (the machines vertical Z-axis) as seen by the tool holder back to a central computer. This computer utilizes LabVIEW in order to collect and analyze the acceleration data. The LabVIEW program also acts as a simple user interface for indicating states of tool failure, along with providing a means for publishing the information to the internet for process monitoring by remote users. The wireless network discussed in this paper is robust, inexpensive, and was found to reliably monitor and predict tool health conditions. The innovative aspect of this work is the ability to use commercial-off-the-shelf wireless sensors to remotely monitor multiple rotational machines from a single location on site and over the internet to off-site locations.

MSEC2012-7341

PROCESS MONITORING DURING MICRO-DRILLING VIA ACOUSTIC EMISSION, ULTRASONIC SOUND, AND SPINDLE LOAD SENSORS

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Careful monitoring of conditions during micro-drilling is important for insuring production of consistent high-quality holes. In this study, acoustic emission, ultrasonic sound, and electric spindle load were used to monitor micro-drilling performed using a micro-scale machine tool (mMT). Experiments were conducted where 0.508 mm diameter holes were drilled in polyetheretherketone (PEEK) polymer and 316 stainless steel. It was found that spindle load significantly increased when tool gumming occurred during drilling of PEEK. Increased spindle load when cutting 316 stainless steel was found to correspond to increased incidences of tool breakage, and a large reduction in spindle load was present during additional drilling operations following a breakage event. It was found that elevated acoustic emission levels were always present during drilling and that a lack of sufficient acoustic emission generation during retraction of a tool indicated tool breakage. The ultrasonic sound spectra were found to change in a manner that is a function of depth of cut and hence a function of depth of cut dependent tool dynamics.

MSEC2012-7344

STATISTICAL PROCESS MONITORING WITH MTCONNECT

Sri Atluru — University of Cincinnati
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Statistical Process Control techniques are used widely in the manufacturing industry. However, it is sometimes observed that a deviation that is within the acceptable range of inherent process variation does not necessarily conform to specifications. This is especially true in the case of low volume; high precision manufacturing that is customary in aerospace and defense industries. In order to study the limitations posed by conventional SPC techniques in such manufacturing environments, a study was undertaken at TechSolve Inc., Cincinnati to develop a standalone SPC tool. The SPC tool so developed effectively communicates with an on-machine probe and analyzes the collected data to carry out a statistical analysis. MTConnect, a new-generation machine tool communications protocol, was used in developing the communication interfaces with the on-machine probe on a CNC machine. The XML (eXtensible Markup Language) code used to extend the MTConnect schema to include the data obtained from the probing routines is also presented. The statistical analysis was developed as a Graphical User Interface (GUI) in LabVIEW. The statistical analysis was carried out as a case study by producing a widget. Real machining was carried out to produce 48 of these widgets using a combination of end mills and face mills. The data obtained during the subsequent quality testing was used to carry out the statistical analysis. The limitations of conventional SPC techniques during the developmental and analytical phases of the study are discussed. The presence of a chip during an on machine probing routine, the variations due to disparities in tool macro geometry, and the demand for conformance to requirements are studied in the view of a statistical process monitoring standpoint. Various alternatives are also discussed that aim to correct and improve the quality of machined parts in these scenarios.

MSEC2012-7362

A TWO-PARAMETER METHOD TO MONITOR AND CHARACTERIZE TOOL WEAR IN END MILLING INCONEL 718

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Inconel 718 is among the most widely used superalloys in many industries. It is often used in very harsh conditions such as jet engines, combustors and nuclear reactors due to its high strength at elevated temperatures, high oxidation and corrosion resistance. Machining superalloy Inconel 718 has always been a challenging task due to its poor machinability including rapid work hardening, low thermal conductivity, and relatively short cutting tool life. The fast tool wear during cutting Inconel 718 results in longer production time, deteriorated surface integrity, and higher manufacturing cost. In this paper, an on-line optical tool monitoring system integrated with a CNC machine tool has been developed to examine tool wear evolutions in end milling Inconel 718 with PVD (Ti, Al) N/TiN-coated carbide insert. Three basic types of tool wear: flank wear, nose wear, and crater wear were examined and analyzed. A two-parameter method has been proposed to evaluate both flank wear and nose wear with respect to cutting time.

MSEC2012-7380

CLASSIFIER FUSION FOR ACOUSTIC EMISSION BASED TOOL WEAR MONITORING

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It is often difficult for a single classifier to achieve perfect classification during process monitoring. Sensor fusion enables the final decision to be improved, but uses voting methods, which usually do not perform well when there is a tie vote. In this paper, classifier fusion with class-weighted voting is investigated to further enhance the performance of monitoring systems. The overall performances of individual classifiers are used as the weighting factors to classifier fusion based on majority voting. When applied to tool wear monitoring of the coroning process, the classifier that was based on overall performance weighting improved the classification rate to 95.6 % and the one based on state performance weighting showed 98.5 % classification, compared to 87.7 % for classifier fusion with unity weighting. A classifier fusion further increased performance from 98.5 % to 99.7 % by applying a penalty vote on the weighting factor.

MSEC2012-7385

END MILLING FORCE MODEL CALIBRATION USING MEASURED FORCE PROFILES

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Yong Zhao — University of New Hampshire
Robert B. Jerard — University of New Hampshire

This paper introduces a method to use the cutting force profile, measured from a Kistler dynamometer, to calibrate a mechanistic based force model containing four cutting coefficients. The undesirable effects of tool vibration and force sensor dynamics are minimized by carefully choosing experimental conditions. Cutting force profiles provide an array of force versus chip thickness based values that can be used in a regression fit to find the model coefficients. Results show that different ranges of chip thickness used in the calibration process result in slightly different cutting coefficients, which implies chip thickness has an effect on cutting coefficients. The force profile based cutting coefficients are then used in the cutting force model to estimate the peak resultant cutting force. Comparison of model estimates and measured values show less than 10% error.

MSEC2012-7386

CALIBRATION AND CHARACTERIZATION OF A LOW-COST WIRELESS SENSOR FOR APPLICATIONS IN CNC END MILLING

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This paper describes recent research progress at the University of New Hampshire in the area of smart machining systems. Central to creating a smart machining system is the challenge of collecting detailed information about the milling process at the tool tip. This paper discusses the design, static calibration, dynamic characterization, and implementation of a low-cost wireless force sensor for end-milling. The sensor is observed to accurately measure force when most of the cutting power is band-limited below the sensor's natural frequency. Sensor geometry constrains the milling application to a single tooth cutter; while this constraint is impractical for industrial applications, our sensor is shown to provide useful information in a laboratory setting.

MSEC2012-7389

PNEUVIZ: MTCONNECT COMPLIANT COMPRESSED AIR MONITORING APPLICATION

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Compressed air is regarded as the fourth largest utility in the manufacturing industry behind electricity, natural gas and water. It is used in a wide variety of pneumatic, mechanical and maintenance applications in every manufacturing facility. However, very little efforts have been made in trying to monitor and optimize the utilization of compressed air. Hence, a project was conducted to study and analyze the utilization of compressed air under various scenarios that are typical during metal cutting operation in a manufacturing facility. PneuViz application was developed using LabVIEW programming package to monitor and analyze the results. PneuViz was seamlessly linked with the MTConnect data being broadcasted on the corporate network. PneuViz provides drill down capability to analyze cost of compressed air on a per part, per machine, and per customer order. Monitoring the utilization of compressed air by a stand-alone Computer Numerical Control (CNC) machine as well as the overall utilization on the shop floor was facilitated by the use of a sensor system comprising of a flow meter, Data Acquisition Device (DAQ), and a power sensor (load meter). MTConnect was used to enable plug-and-play functionality across the various machines on the shop floor. This was implemented by developing a system of MTConnect adapters that were able to capture the raw sensor data and broadcast it over the Ethernet network. Subsequently, analysis was carried out over various scenarios to determine the cost, energy and carbon footprint impact of the compressed air usage on the manufacturing shop floor.

MSEC2012-7398

INTEGRATION OF MTCONNECT AND STANDARD-BASED SENSOR NETWORKS FOR MANUFACTURING EQUIPMENT MONITORING

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MTConnect is an open and extensible protocol designed for the exchange of data between shop floor devices and software applications. MTConnect allows manufacturers to facilitate retrieval of information and data from factory devices, such as machine tools, sensors, and controllers. Currently, MTConnect users read data from sensors through proprietary sensor interfaces using adaptors. The suite of Institute of Electrical and Electronics Engineers (IEEE) 1451 standards defines a set of open, common communication interfaces for sensor networks, including both sensor interfaces and network interfaces. This paper proposes an integration architecture of MTConnect with IEEE 1451 standard-based sensor networks. In the architecture, MTConnect plays a network interface role in the IEEE 1451 standard-based sensor networks via an MTConnect Agent. An adaptor is used to provide the mapping between the MTConnect Agent and the IEEE 1451 sensor network. A prototype system integrating MTConnect with IEEE 1451.2-based sensor network has been developed. Two case studies are provided to illustrate the integration.

MSEC2012-7247

CONTOUR DETECTION FOR ROBOTIC CHAMFERING BASED ON OPTICAL MEASUREMENT TECHNOLOGIES: FRINGE PROJECTION VS. PROFILE SENSOR

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In the present paper, two competing methods for contactless detection of component geometries are compared. In principle, it is important to examine the extent to which automation can succeed by mechanical machining processes by using advanced sensors. As an example of a process here the chamfering of large gearings with an industrial robot is chosen. It will examine to what extent there is a possibility to ensure through selected sensor applications and configurations, a geometry detection. Here ostensibly application-related parameters are presented and referred. This should also be done in regard to their use in industrial environments where metallic gloss and external light sources often present a problem. Finally, it should be a statement made as to whether the methods discussed are suitable for this application due to their technological parameters.

MSEC2012-7396

STUDY OF PRESSURE DISTRIBUTION IN COMPLIANT COATED ABRASIVE TOOLS FOR ROBOTIC POLISHING

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Robotic polishing applications involve the use of coated abrasive tools along with a compliant backing pad. The compliance helps in conforming to curved surfaces and also in blending with unpolished areas. This compliance and its effect are currently controlled only by empirical choice of various backing pad designs

and materials. A better understanding of this important characteristic of these tools will lead to better process control. One of the effects of the compliance or stiffness of the backing pad under a certain applied load (robotic force control) is on the contact area and pressure distribution applied on the abrasive grains in that area. This pressure distribution in turn dictates how material is removed in the area of contact. Here, we report preliminary results of the pressure distribution exerted by an abrasive tool mounted on a robot using pressure film sensors and compare results with a simple finite element model.

MSEC2012-7224

APPLICATION OF OLI ELECTROLYTE SIMULATION TO THE RESOLUTION OF CORROSION CONCERNS WITHIN A RECIPROCATING COMPRESSOR

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Anthony J. Gerbino — AQSim, Aqueous Process Simulations
Tony Scribner — Becht Engineering

A 38 MMSCF/D Cooper Bessemer Model LM-9 reciprocating compressor in hydrogen service at the Praxair Westlake LA facility has experienced notable particulate contamination within the feed gas. The particulates were believed to be caused by upstream piping corrosion; however, to definitely state the cause, the properties of the fluid existing in the five-stage compressor needed to be more fully understood. An OLI ElectroChemical Simulation model [OLI Analyzer V3.1.6 (OLI Systems, Morris Plains, NJ)] was used for dew point prediction, determination of the condensed phase ionic equilibria, and corrosion rate prediction. These tasks were beyond capabilities of the site-licensed UniSim software, as presently configured. Specifically, the OLI model was used to identify the dew point conditions (temperature, pressure) and properties of the condensed water (pH, corrosivity, dissolved O2, and chlorine speciation). Model results were compared with site inspection findings. Subsequently, recommended limits for chlorine and oxygen in the feed gas were established to improve long term compressor reliability.

MSEC2012-7280

DEGRADATION-BASED SWAPPING POLICY WITH APPLICATION TO SYSTEM-LEVEL MANUFACTURING UTILIZATION

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Jun Ni — University of Michigan

Degradation is an inevitable course of any manufacturing tool, machine or system. The degradation of the health state of manufacturing tools results in some sort of an ineludible maintenance action which could be both costly and happening in a critical production time. In most manufacturing systems, a fleet of identical machines are assigned different tasks towards satisfying requirements within the production process. We introduce a degradation-based resource allocation policy to optimally utilize a fleet of identical machines. The policy, denoted as Degradation Based Swapping Optimization (DBSO), incorporates the optimal implementation of swapping scheduled tasks and scheduling maintenance actions throughout a finite time horizon to minimize projected maintenance costs and/or utilize the manufacturing productivity towards pre-specified logistics objectives. A mathematical model for the policy is provided and this model is optimized using elitist genetic algorithm and simulated annealing algorithm where numerical results have been introduced. The proposed policy succeeds in establishing substantial savings in the simulated example which amount to 43% of the estimated maintenance costs in comparison to the scenario where fixed scheduling is applied.

MSEC2012-7340

DISSIMILARITY MEASURES FOR ICA-BASED SOURCE NUMBER ESTIMATION

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Most of blind source separation problems are carried out with a priori knowledge of the source numbers. However, for source separation-based condition monitoring and fault diagnosis of large-scale equipment, it is a challenge work to determine the number of sources from the measured signals due to complex structures and nonlinear mixing mode. Therefore, source number estimation is a necessary and important procedure prior to source separation and fault detection. In this paper, we focus on a novel source number estimation method based on independent component analysis (ICA) and clustering evaluation analysis. In addition, we discuss the performances of different dissimilarity measures with typical mechanical vibration signals.

MSEC2012-7345

BATTERY PROGNOSTICS: SOC AND SOH PREDICTION

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Battery applications (computer, cell phones or even in cars) have been extensively used in our daily life. The reasons for their success and extensive usage in the real world applications are their light weight, smaller sizes and greater energy densities. These unique characteristics render this class of battery an ideal candidate for powering electrical vehicles. However, due to lack of battery information, often time we will observe machine down time,

operation malfunctioning, and even some catastrophic failure due to fast battery degradation and depletion. Thus, much of the attention has been focused on prognostics and health management of battery technologies for the stated purpose. In this paper, we will present two main algorithms that cannot only estimate a one-step-ahead prediction of the battery state but also can estimate the battery remaining useful life. The first method is the linear prediction error method. The second approach is the neural network algorithms. Both methods can predict the battery information accurately. However, particular algorithm specializes in different area of interest.

MSEC2012-7346

EXTENSION OF MAINTENANCE OPPORTUNITY WINDOWS TO GENERAL MANUFACTURING SYSTEMS

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In manufacturing systems, many maintenance tasks require equipment to be stopped in order to safely perform them. However, such tasks cannot last for a long time since the stoppage of machines might directly result in production losses. In this paper, we investigate how long we can perform maintenance during scheduled operations by strategically shutting down equipment without bringing extra production losses to the system. Using the concept of maintenance opportunity window (MOW) we calculate such time intervals with given information of manufacturing systems. MOWs are analytically derived with various system configurations. Simulations are used to deal with uncertainties in production lines such as random machine failures, starvations, blockages, etc. Moreover, the proposed MOW algorithms are demonstrated through numerical case studies.

MSEC2012-7390

AN INTEGRATED DESIGN STRATEGY FOR DUST COLLECTION AND SLURRY TRANSPORT SYSTEMS AND IMPLEMENTATION IN A STEEL PLANT

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Dust collection and slurry transportation systems are essential for effective collection and removal of metallic and dust fines. These are mainly used to eliminate pollution, recover water that is reused in the core steel process, and to capture solids which can be used in the raw material processes of making reduced iron. However, maintenance of slurry transportation systems is not only complex but also expensive, if not designed properly. This paper presents an integrated slurry transportation design strategy for greater performance, less maintenance and increased reliability thus resulting in effective asset management. This design has been implemented and successfully tested in an existing Steel plant. Experience suggests that the asset management is not merely a maintenance activity however methodical it may be. Although periodical maintenance cannot be totally eliminated, specifically in cases with slurry transport systems, the suggested approach in this paper uses a thoughtful design strategy with emphasis on safeguarding the environment, simplified routine maintenance and efficient system operation.

MSEC2012-7258

JOINT MAINTENANCE AND PRODUCTION OPERATIONS DECISION MAKING IN FLEXIBLE MANUFACTURING SYSTEMS

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In highly flexible and integrated manufacturing systems such as those in semiconductor manufacturing, there exist strong dynamic interactions between the equipment condition, operations executed on the equipment and the resulting product quality. These interactions necessitate a methodology that integrates the decisions of maintenance scheduling and production operations. Currently, maintenance and production operations decision-making are two decoupled processes. In this paper we aim to devise an integrated decision making policy for maintenance scheduling and production sequencing with the objective of maximizing an adaptive profit function, while taking into account operation-dependent degradation models and a production target. In order to obtain the optimal decision policy, a metaheuristic method based on the results of discrete-event simulations of the target manufacturing system is used. The new approach is demonstrated in simulations of a generic cluster tool routinely used in semiconductor manufacturing. The results show that jointly making maintenance and production sequencing decisions consistently outperforms the current practice of making these decisions separately.

MSEC2012-7276

CHACTERIZATION OF CUTTING FORCE INDUCED SURFACE SHAPE VARIATION USING HIGH-DEFINITION METROLOGY

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High-definition metrology (HDM) systems with fine lateral resolution are capable of capturing the surface shape on a machined part that is beyond the scope of measurement systems employed in manufacturing plants today. Such surface shapes can precisely reflect the impact of cutting processes on surface quality. Understanding the cutting processes and the resultant surface shape is vital to identifying opportunities for high-precision machining process monitoring and control. This paper presents

modeling and experiments of a face milling process to extract surface patterns from measured HDM data and correlate these patterns with cutting force variation. A relation is established between instantaneous cutting forces and the observed dominant patterns along the feed and circumferential directions. Potential applications of such relationship in process monitoring, diagnosis, and control are also discussed.

MSEC2012-7299

KERNEL DENSITY ESTIMATION AND METROLOPIS-HASTINGS SAMPLING IN PROCESS CAPABILITY ANALYSIS OF UNKNOWN DISTRIBUTIONS

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Strong normality assumption is associated with widely used process capability indices such as Cp, Cpk. Violation of the assumption will mislead the interpretation in applications. A nonparametric method is proposed for density estimation of any unknown distribution. Kernels are used for density estimation and Metropolis-Hastings (M-H) algorithm is adopted to generate samples from the density. M-H sampling provides a tool to accommodate different kernel functions and flexibility of future extension to multivariate cases. Conformity (yield) based indices (Yp, Y) are adopted to replace Cp, Cpk. These indices can be conveniently assessed by the proposed kernel density based M-H algorithm (K-M-H). The method is validated by several simulation case studies.

MSEC2012-7201

REAL-TIME ERROR PREDICTION FOR HIGH-PRECISION OPERATION OF PARALLEL KINEMATIC MACHINES

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Closed-loop parallel kinematic machines (PKMs) have been proposed to improve precision and operation speed over conventional machine tools and robots. However, an embarrassing dilemma is that most of the existing PKMs achieve very lower precision in contrast to equivalent serial machine tools or robots, which are competitive to same tasks. Limited works have been conducted to evaluate errors thus improve precision of machine in real-time control. It becomes necessary to explore the relation of the motion error with the dynamics of a PKM. In this paper, the new model of the error evaluation has been proposed; three major sources of error under consideration are the deformations of the components under dynamic loads, the deformations at joint contacts, and the clearances of passive joints. To illustrate the modeling procedure, the dynamic model of machine is developed to determine internal forces among components and locations of joint contacts. Errors caused by machine dynamics are evaluated analytically in real time; in particular, the errors happened at the contacts of passive joints are estimated based on Hertz theory. The developed error models can be applied to compensate the motion errors of tool tip in real-time. The Exechon parallel kinematic machine is used as a case study, the results from simulation has been compared with the test data.

MSEC2012-7266

RESEARCH ON INTELLIGENT RETRIEVAL SYSTEM FOR NETWORKED MANUFACTURING RESOURCES

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To retrieve networked manufacturing resources accurately and efficiently is an important step to organize and manage the networked manufacturing resources. On the basis of studying knowledge expression of networked manufacturing resources, this paper proposed seven factors to classify, describe, store, and manage manufacturing resource information, which are time, quality, cost, service, agility, advance and history. A networked manufacturing resource retrieval model was established based on the study of organization structure of knowledge base, classification and representation of manufacturing resource knowledge, and manufacturing knowledge acquisition. Execution mechanism of the system is given in this paper as well as description of association rules of knowledge points and knowledge base adjust increment and user behavior prediction algorithm.

MSEC2012-7283

REDUCTION OF VIBRATIONS IN BALL SCREW DRIVEN MACHINE TOOLS BY THE OPTIMAL SELECTION OF NUT PARAMETERS

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Due to the growing need for sustainable manufacturing processes, machine tool designers are constantly looking for ways to reduce unwanted structural vibrations without having to increase the mass/inertia of moving components, which in turn increases the energy consumption and cost of the machines. Recent research has shown that, due to the coupling introduced by the nut, the torque applied to ball screw drives by the motor causes undesirable lateral (bending) vibrations of the screw, which adversely affects the fatigue life and positioning accuracy of ball screw drives. By analyzing the stiffness matrix connecting the screw to the nut, this

paper shows that the helix angle of the screw and the entry/exit angles of the balls have the most influence on the degree of coupling between motor torque and lateral vibrations of the screw. Consequently, by carefully selecting the helix angle of the screw together with the entry/exit angles of the balls, the undesirable lateral vibrations of the screw can be minimized, without having to increase the diameter (i.e. stiffness/inertia) of the ball screw. The merits and limitations of the proposed method are demonstrated using simulations on a single-axis ball screw driven machine.

MSEC2012-7296

WEB BASED MONITORING AND CONTROL OF DISTANT ROBOTIC OPERATIONS

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In order to improve the production efficiency while facing the uncertainty of today's manufacturing environment, responsive and adaptive capabilities for rapid production changes are essential. This paper presents how the dynamic control and real-time monitoring function embedded in a web-based framework, can be realised by integrating virtual 3D models with a real shop floor.

MSEC2012-7350

ROBUST WORK PLANNING AND DEVELOPMENT OF A DECISION SUPPORT SYSTEM FOR WORK DISTRIBUTION ON A MIXED-MODEL AUTOMOTIVE ASSEMBLY LINE

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Line balancing is a very resource-intensive and time consuming process which is highly reliant on the experience and expertise of a few employees. Line balancing is made even more complex due to the high level of option content in luxury automobiles. The current phase of this study involves hands-on training on the automotive assembly line, precedence relationship mapping of all the tasks involved on a pilot assembly line, identification of constraints, and development of a strategy to manage option content and constraints. The second phase will include the generation of an optimal line balance through optimization on expected station utilization. The current line balancing process relies significantly on the experience level of the utility workers and team leaders. Although initially labor intensive, the precedence mapping exercise and option coding strategy will facilitate the development of a decision support system to aid the human decision-maker in making data-driven decisions about work distribution.

MSEC2012-7384

DYNAMIC STRATEGIES FOR PREVENTIVE MAINTENANCE SCHEUDLING WITH THROUGHPUT TARGET VARIATION

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This paper considers a period-review production and preventive maintenance (PM) scheduling problem for manufacturing systems subject to uncertain demand in a finite-horizon. We consider multiple levels of PM which provide the system with PM flexibility so that add to the opportunity of adopting various PM of different types or levels adaptive to the throughput target. A model with PM flexibility is proposed to simultaneously determine optimal production quantity and PM level for a single-product manufacturing system. A real option analysis (ROA) is applied to quantify the benefit of PM flexibility so that it can be considered in a cost function. The optimal strategy for a joint maintenance and production system that maximizes the overall expected profit of the system is obtained by a stochastic dynamic programming approach. Results are supported by numerical examples and show the comparison between the proposed PM-flexible model and the conventional PM planning model with single and fixed PM type. Managerial insights are provided on making adaptive PM and production decisions by trading off revenue and costs of corrective actions in different manufacturing applications.

MSEC2012-7204

EXPERIMENTAL INVESTIGATION OF THE MACHINABILITY OF EPOXY REINFORCED WITH GRAPHENE PLATELETS

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The objective of this research is to study the effect of graphene platelet (GPL) loading on the machinability of epoxy-based GPL composites. To this end, micro-milling experiments are conducted on composites with varying GPL content and their results are contrasted against that of plain epoxy. The material microstructure is characterized using transmission electron microscopy and scanning electron microscopy methods. Chip morphology, cutting force, machined surface morphology, and tool wear, are employed as the machinability measures for comparative purposes. At lower loadings of GPL (0.1% and 0.2% by weight) the deformation of the polymer phase plays a major role, whereas at a higher loading of 0.3% by weight, the GPL agglomerates and interface-dominated failure dictates the machining response. The minimum chip thickness value of the composites decreases with an increase in

GPL loading. Overall, the 0.2% GPL composite has the highest cutting force and the lowest tool wear.

MSEC2012-7264

NANO FINISHING OF BRASS TUBES BY USING MECHANICALLY ALLOYED MAGNETIC ABRASIVES

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With advancement of technology, finely finished surface is one of the major requirements of modern industry. Fine machining with conventional edged tools is uneconomical and sometimes impossible. Magnetic Abrasive Finishing (MAF) is one promising process which is able to remove the material at micro/nano from metallic and non metallic surfaces. The magnetic abrasives play vital role in MAF. Literature reveals different techniques such as sintering, plasma, chemical, etc. for manufacturing of bonded magnetic abrasives. In the present paper, the bonded magnetic abrasives prepared by a new technique called mechanical alloying have been successfully used for the internal finishing of the brass tubes. After rough boring operation, the inner surface of the tubes is finely finished by newly developed magnetic abrasives. Best surface finish obtained by using these magnetic abrasives is of the order of 3 nm. Key words- Magnetic Abrasives, Magnetic Abrasive Finishing (MAF), Fine finishing, SEM, AFM

MSEC2012-7297

PROCESS STABILITY AND ENERGY EFFICIENCY OF THE GRINDING PROCESS OF HIGH PERFORMANCE MATERIALS

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The application of high performance materials can lead to enhanced product properties. The associated challenging material properties set higher demands on the manufacturing processes. However, the ever-present demand for cost reduction of the manufacturing processes conflicts with the continuously increasing demands on product quality. In principle, higher surface quality results in higher energy consumption. Higher geometrical demands in combination with difficult to cut materials lead to increasingly complex machine tool and subsystem solutions, which also contribute to the higher energy consumption. However, the full potential of a process is often not utilized in order to ensure that damages to the workpiece at the end of cost intensive and long value chains are avoided. This leads to the situation that complex machine tools equipped with high performance tools operate under significantly reduced productivity. This means that the production process itself must be reliable in particular during high performance machining. In this paper, various grinding strategies were regarded in terms of possible increase in productivity and process stability. Furthermore a nonconventional option of flexible machining is presented. It will be shown that the process of speed stroke grinding of ceramic materials can be used as a highly productive alternative to reciprocating grinding and external cylindrical grinding with grooved cBN-grinding-wheels for example in the grinding of rolling bearing rings. The machining of high performance materials with simple machine concepts, such as robots, is presented with regards to more flexibility and at the same time machine accuracies comparable to these machine tools.

MSEC2012-7352

FABRICATION OF ALUMINUM COMPOSITES WITH PATTERNED SILICON CARBIDE REINFORCEMENT ARCHITECTURE BY SEMI-SOLID PROCESSING

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Semi-solid powder processing is a promising technology, combining the advantages of semi-solid forming and powder metallurgy. In this study, spray deposition process combined with semi-solid powder processing was used to synthesize an aluminum alloy composite and to control its microstructure. Silicon carbide (SiC) reinforced aluminum alloy composites were fabricated with and without microstructure pattern. The influence of different composite microstructure on mechanical properties was analyzed by microstructure analysis, bend test and fracture analysis. Bend test results showed that patterned microstructure has the potential to significantly improve composite strength with minimal sacrifice of ductility.

MSEC2012-7357

FABRICATION OF TEXTURED 3D MICROSTRUCTURES USING 'BULK LITHOGRAPHY'

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Micro-textured surfaces provide multifold enhancement in surface area as compared to the original surface area. Hence, they attract applications in several areas including biosensor (multiple sites enhance sensitivity), micro-heat exchangers, tissue engineering (scaffold development, cell substrate interaction) and so on. This

paper presents the method of fabrication of textured three dimensional (3D) microstructures in single scan of laser beam. The textured 3D microstructures are obtained on one of the free surface (surface opposite to the substrate) of the microstructure. Fabrication of textured 3D microstructure is achieved using newly developed 3D microfabrication process termed as 'Bulk lithography', which is proposed to be a promising solution for building a class of 3D microstructures which require high accuracy, non-overhanging surface features with limited depth dimension. In this process, CAD model of the desired microstructure is sliced along the scan path of the laser. These planes eventually get stacked on subsequent line scans. The required depth variation is obtained during fabrication by allowing unconstrained depth photopolymerization and varying laser exposure while scanning. Towards this end, the representative experimental results of dimensionless cured depth against dimensionless energy were obtained. Following three different regimes of cured depth, I: Absorption dominant zone, II: Transition regime and III: Scattering dominant zone, were observed under wide range of exposure energy. A predefined texture can be incorporated in CAD model itself and the structures can be fabricated with same method when restricted to regime I. However, the novelty of the proposed method lies in a distinct phenomenon observed in regime II and III based on characteristic multiple scattering leading to textured surfaces in these regimes. Further, it is observed experimentally that these textures are function of the exposure energy and are hypothyzed because of scattering of light. Structures in regime I show less RMS value of texture than those fabricated in regime II. Thus by tuning the dose of energy the desired value of RMS height of texture can be obtained. The experimental observations can be explained qualitatively as follows: during low energy exposure the light absorption is dominating the scattering effect of the light. Hence the resultant 3D microstructure shows lesser RMS value of texture. In case of higher energy exposure propagation of light ceases (extreme of this is saturation regime III), this leads to multiple light scattering to become more dominant. As a result of this textures with more RMS height are formed during higher energy.

MSEC2012-7381

DEPOSITION OF AL-DOPED ZINC OXIDE BY DIRECT PULSED LASER RECRYSTALLIZATION AT ROOM TEMPERATURE ON VARIOUS SUBSTRATES FOR SOLAR CELL APPLICATIONS

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In this study, a method combining room temperature pulsed laser deposition (PLD) and direct pulsed laser recrystallization (DPLR) are introduced to deposit superior transparent conductive oxide (TCO) layer on low melting point flexible substrates. As an indispensable component of thin film solar cell, TCO layer with a higher quality will improve the overall performance of solar cells. Alumina-doped zinc oxide (AZO), as one of the most promising TCO candidates, has now been widely used in solar cells. However, to achieve optimal electrical and optical properties of AZO on low melting point flexible substrate is challenging. Recently developed direct pulsed laser recrystallization (DPLR) technique is a scalable, economic and fast process for point defects elimination and recrystallization at room temperature. It features selective processing by only heating up the TCO thin film and preserve the underlying substrate at low temperature. In this study, 250 nm AZO thin film is pre-deposited by pulsed laser deposition (PLD) on flexible and rigid substrates. Then DPLR is introduced to achieve a uniform TCO layer on low melting point flexible substrates, i.e. commercialized Kapton polyimide film and micron-thick Al-foil. Both finite element analysis (FEA) simulation and designed experiments are carried out to demonstrate that DPLR is promising in manufacturing high quality AZO layers without any damage to the underlying flexible substrates. Under appropriate experiment conditions, such as 248 nm in laser wavelength, 25 ns in laser pulse duration, 15 laser pulses at laser fluence of 25 mJ/cm2, desired temperature would result in the AZO thin film and activate the grain growth and recrystallization. Besides laser conditions, the thermal conductivity and crystallinity of the substrate serve as additional factors in the DPLR process. It is found that the substrate's thermal conductivity correlates positively with the AZO crystal size; the substrate's crystallinity correlates positively with the AZO film's crystallinity. The thermal expansion of substrate would also contribute to the film tensile stress after processed by DPLR technique. The overall results indicate that DPLR technique is useful and scalable for flexible solar cell manufacturing.

MSEC2012-7394

MICRO AND NANO DESIGN AND FABRICATION OF A NOVEL ARTIFICIAL PHOTOSYNTHESIS DEVICE

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Artificial photosynthesis is a new method to generate sustainable energy. In order to constrain reaction solution in a solid state structure and increase the reaction efficiency, we designed a novel artificial photosynthesis device with porous chitosan scaffold with interconnected micro-channels. We build 3D interconnected chitosan channels with a home-made heterogeneous 3D rapid prototyping machine, and we use lyophilization method to generate the nano pores inside the chitosan scaffold. Chitosan gel in acetic acid can form different viscosities based on chitosan's molecular weight and the concentrations of both chitosan and the acetic acid, so we found a proper material to construct 3D scaffold by our own rapid prototyping machine. Optional support material sodium bicarbonate is used in printing 3D scaffold for permanently holding the printed structure, and the result shows that this method can make the scaffold stronger and harmless to further processes such as adding light reaction units and dark reaction solution.

MSEC2012-7399

MATHEMATICAL MODELING OF CUTTING FORCES IN MICRO-DRILLING

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In drilling, the primary cutting lips and the secondary cutting lips of the drill shear the material while the central portion of the chisel edge indents the workpiece, making the cutting process complex to understand. As we go for micro-drilling, it exhibits an added complexity to the cutting mechanism when the edge radius gets comparable to chip thickness at low feeds. The presented work models the forces by the primary cutting lip of a micro-drill analytically using slip-line field that includes the changes in the effective rake angle and dead metal cap during cutting for cases of shearing as well as ploughing. To study the variation of forces experimentally, the primary cutting lip and chisel edge forces are separated out by drilling through pilot holes of diameter slightly above the drill-web thickness. Finally, the analytical and experimental results have been compared and the model has been calibrated.

MSEC2012-7408

MICROPATTERNING OF POROUS POLYMER STRUCTURES

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In contrast to the immense literature in porous material generation, micropatterning of porous devices remains a technical challenge. In this study, a new process for micropatterning of porous structures with a controllable morphology was developed and investigated. This process combines polymer melt blending, hot embossing, and in mold annealing for geometrical pattern transfer and simultaneous morphological control. A special effort was made to generate a microgroove pattern with an open pore structure. Parametric experimental studies were conducted on stamps with different feature sizes under different processing conditions. The results demonstrated the feasibility and the versatility of the proposed technique in fabricating micropatterned porous structures. By varying the geometrical and boundary conditions during in mold annealing, micropatterns with graded porous structures were demonstrated.

MSEC2012-7409

A MICROLENS ARRAY ON CURVED SUBSTRATES BY 3D MICRO PROJECTION AND REFLOW PROCESS

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Microlens arrays are becoming increasingly important because of their widespread applications in optical, electronic, and energy fields. Currently, microlens array fabrication processes are mainly developed on planar substrates. For nonplanar substrates, existing fabrication methods suffer from various disadvantages. This is largely due to the inherent technical complexity of 3D microstructure fabrication processes. In this work, an innovative 3D fabrication method for microlens arrays on curved surfaces is introduced. To fabricate the microlens array, a PMMA microlens array on a curved surface was used as the projection microlens array. A thick layer of positive tone photoresist SPR 220 was spin coated on a curved, titanium-coated aluminum substrate. A pre-designed pattern was projected onto the photoresist by using a home built exposure system. The development process resulted in micro cylinders on the curved substrate. A thermal reflow process was then performed on the cylinder array, forming a microlens array. Experiments were conducted to evaluate the factors that affect the shapes of the microlenses. These factors include film thickness variation, exposure and development variation, slope of the substrate, height to width ratio and heating time in thermal reflow process. Finally microlenses were tested by using a Twyman-Green interferometer.

MSEC2012-7413

A NOTE ON THE HIGH ASPECT-RATIO SU-8 MICROMECHANICAL STRUCTURES USING MASK-LESS DIRECT LASER WRITING

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We report high aspect-ratio micromechanical structures made of SU-8 polymer, which is a negative photoresist. Mask-less direct writing with 405 nm laser is used to pattern spin-cast SU-8 films of thickness of more than 600 um. As compared with X-ray lithography, which helps pattern material to give aspect ratios of 1:50 or higher, laser writing is a less expensive and more accessible alternative. In this work, aspect ratios up to 1:30 were obtained on narrow pillars and cantilever structures. Deep vertical patterning was achieved in multiple exposures of the surface with varying dosages given at periodic intervals of sufficient duration. It was found that a time lag between successive exposures at the same location helps the material recover from the transient changes that occur during exposure to the laser. This gives vertical sidewalls to the resulting structures. The time-lags and dosages

were determined by conducting several trials. The micromechanical structures obtained with laser writing are compared with those obtained with traditional UV lithography as well as e-beam lithography. Laser writing gives not only high aspect ratios but also narrow gaps whereas e-beam can only give narrow gaps over very small depths. Unlike traditional UV lithography, laser writing does not need a mask. Furthermore, there is no adjustment for varying the dosage in traditional UV lithography. A drawback of this method compared to UV lithography is that the writing time increases. By using this novel method, we have fabricated some test structures as well as a compliant microgripper.

MSEC2012-7255

TITANIUM OXIDE NANOTUBES DOPED FOR USE IN A VISIBLE-LIGHT BIOPHOTOFUEL CELL

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Multiple metal and non-metal dopants were added to titanium oxide nanotubes to enhance the photosensitive behavior. Six elements including nitrogen, sulfur, zinc, copper, cobalt, and nickel were incorporated into titanium oxide as the dopants. The doped titanium oxide nanotubes were made into photosensitive anodes and placed in ethanol to form fuel cells. The open circuit voltage measurement results showed that after doping, all the specimens tested were allowed the absorption of visible light. However, the resulted in voltages were slightly less than of those obtained through ultraviolet light absorption tests. Among the transition metal doping elements and the non-metal elements, cobalt, nickel and zinc showed the most promise in improving the visible light absorption.

MSEC2012-7336

EXTENSION OF A MICROSCALE INDENTATION FRACTURE MODEL TO NANOSCALE CONTACT IN PURVIEW OF MECHANICAL NANOFABRICATION PROCESSES

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In this work, we investigate the extension of the Lawn and Evans indentation fracture model, developed primarily for microscale contact, to nanoscale contacts. Systematic nanoindentation fracture experiments are performed on Si (100) using a sharp diamond cube corner (radius, r = 32 nm) indenter as a function of load, load cycles, contact dimension, and contact separation. Atomic force microscopy is used to image and measure contact deformation and fracture. The experimental results show that the threshold load for fracture was 290 uN, which is lower than previously reported. Adjacent indents separated by less than three times the radius of each indent were observed to interact with each other, such that second indents were consistently deeper than the first at the same loads. There was an increase in crack length for pairs of indents that were separated by equally small distances (<3 indentation radii). These results have clear implications for nanofabrication where stress field interactions impose limits on the closeness (resolution) to which features can be generated and to free abrasive machining where stress field interactions enhance the ability to machine below the threshold load.

MSEC2012-7356

AFM-BASED NANOINDENTATION PROCESS: A COMPARATIVE STUDY

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Atomic force microscopy (AFM) has been widely used for nanomachining and fabrication of micro/nanodevices. This paper describes the development and validation of computational models for AFM-based nanomachining. Molecular Dynamics (MD) technique is used to model and simulate mechanical indentation at the nanoscale for different types of materials, including gold, copper, aluminum, and silicon. The simulation allows for the prediction of indentation forces at the interface between an indenter and a substrate. The effects of tip materials on machined surface are investigated. The material deformation and indentation geometry are extracted based on the final locations of the atoms, which have been displaced by the rigid tool. In addition to the modeling, an AFM was used to conduct actual indentation at the nanoscale, and provide measurements to which the MD simulation predictions can be compared. The MD simulation results show that surface and subsurface deformation found in the case of gold, copper and aluminum have the same pattern. However, aluminum has more surface deformation than other materials. Two different types of indenter tips including diamond and silicon tips were used in the model. More surface and subsurface deformation can be observed for the case of nanoindentation with diamond tip. The indentation forces at various depths of indentation were obtained. It can be concluded that indentation force increases as depth of indentation increases. Due to limitations on computational time, the quantitative values of the indentation force obtained from MD simulation are not comparable to the experimental results. However, the increasing trends of indentation force are the same for both simulation and experimental results.

MSEC2012-7379

NANOPARTICLES EMBEDDING INTO METALLIC MATERIALS BY LASER DIRECT IRRADIATION

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A methodology of half-embedding nanoparticles into metallic materials is represented in this paper. Transparent and opaque nanoparticles are half-embedded into the metallic material, which domenstrates the feasibility of this process. Dip coating method is used to coat nanoparticles on the metal surface prior to the laser irradiation. Nanoparticles are embedded into substrate under different laser fluencies and pulses. In this study, the mechanism and process of nanoparticle embedding are investigated by experimental results and simulation. It is found that both transparent and opaque nanoparticles embedding are with high densities and good uniformities.

MSEC2012-7393

NANODIAMOND REINFORCED PLLA NANOCOMPOSITES FOR BONE TISSUE ENGINEERING

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Nanodiamond (ND) is an attractive nanomaterial for reinforcement of biopolymers due to the ND's superior mechanical and chemical properties, and low biotoxicity. A novel composite material has been produced for bone scaffolds utilizing the biodegradable polymer poly(L-lactic acid) (PLLA) and octadecylamine-functionalized nanodiamond (ND-ODA). Composites were prepared by admixing to a PLLA/chloroform solution chloroform suspension of ND-ODA in concentration range of 0-10 % (w/w). The dispersion of ND-ODA evaluated by transmission electron microscopy (TEM) shows uniform distribution of ND-ODA in PLLA matrix. The composites were characterized by differential scanning calorimetry (DSC). DSC analysis of the composites showed no significant thermal behavior changes with the addition of ND-ODA into the polymer. Biomineralization test shows that ND-ODA can enhance the mineral deposition on scaffolds. Improved mechanical properties and good biocompatibility with enhanced biomineralization combined suggest that ND-ODA/PLLA might have potential applications for bone tissue engineering.

MSEC2012-7395

MICRO CHARACTERIZATION OF MG AND MG ALLOY FOR BIODEGRADABLE ORTHOPEDIC IMPLANTS APPLICATION

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Magnesium as a candidate metallic biomaterial for biodegradable orthopedic implants was evaluated in-vitro in terms of degradation behavior, biocompatibility and mechanical property both in macro- and micro-scale. Micro structure of pure Mg and AZ61 after degradation in both simulated body fluid (SBF) and cell culture environment were analyzed. Different from AZ61, pure Mg degraded at a higher rate and attracted large amount of salt precipitation which formed a layer covering the surface. Much less pitting degradation and salt deposition were observed on both pure Mg and AZ61 in cell culture environment compared to in SBF. After culturing for 7 days, EAhy926 cells growing on AZ61 showed significant higher proliferation rate as of cells growing on pure Mg. Higher proliferation rates indicated that cells grew better on slow-degrading AZ61 than on fast-degrading pure Mg. Cells growing on AZ61 proliferated much better and assembled together to form a consistent tissue-like micro-structure, while cells spread and reached out on the surface of pure Mg, possibly due to low cell density and lack of cellular communication. The elastic modulus and tensile yield strength of magnesium are closer to those of natural bone than other commonly used metallic biomaterials. It was shown that Mg was biodegradable, biocompatible and had appropriate mechanical strength, thus Mg and its alloys showed great potential for deployment in a new generation of biodegradable orthopedic implants.

MSEC2012-7397

IN-SITU CHARACTERIZATION OF MWCNTS REINFORCED EPOXY NANOCOMPOSITE UNDER MECHANICAL LOAD

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In this study, the mechanical properties of multi-walled carbon nanotubes (MWCNTs) reinforced epoxy nanocomposite were measured with the custom-built micro/nano three point bending tester mounted on an atomic force microscope (AFM). With in-situ observation of the AFM, the movement of an individual MWCNT on the sample surface was traced, captured, and quantified using the image correlation technique. The Halpin-Tsai and Hui-shia models were applied and compared with the experimental data.

Results showed that the elastic modulus from the experiment is much lower than the predicted values from the two models. Detailed mechanical deformation behavior and MWCNT reinforcement mechanism were discussed.

MSEC2012-7400

ESTIMATING THE COHESIVE ZONE MODEL PARAMETERS FOR CARBON NANOTUBE–POLYMER INTERFACE USING INVERSE FINITE ELEMENT ANALYSIS

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During machining of carbon nanotube (CNT)-polymer composites, the failure of the polymer elements occurs at the CNT-polymer interface. The interfacial behavior that can be represented by a cohesive zone model (CZM) is mainly influenced by two parameters, viz., interfacial strength and fracture energy. The objective of this study is to estimate these two specific CZM parameters using an inverse finite element (FE) simulation approach that works based on an iterative error minimization procedure. Nanoindentation tests have been conducted on a CNT-polyvinyl alcohol (PVA) composite sample containing 4 wt% multi-walled nanotubes (MWNTs). A 2D axisymmetric FE model of nanoindentation has been developed. This micro-structure based model considers the CNT, the PVA, and the cohesive zone of interface as three individual phases. The unknown interfacial parameters are determined by minimizing the error between the simulation load-displacement curve and the experimental results. The interfacial strength and the fracture energy at the CNT-PVA interface are estimated to be approximately 40 MPa and 16e-3 J/m2, respectively. This approach provides a convenient framework to understand the role of the CZM parameters at the interface between the CNT and polymer matrix.

MSEC2012-7212

ULTRASONIC-VIBRATION ASSISTED PELLETING FOR CELLULOSIC BIOFUEL MANUFACTURING: INVESTIGATION ON POWER CONSUMPTION WITH DESIGN OF EXPERIMENT

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Cellulosic biomass is abundantly available in the nature. It is an attractive feedstock to make alternative fuels to petroleum-based transportation fuels. Because of low bulk density and irregular shape, cellulosic biomass is difficult to handle, transport, and store. Pelleting can increase the density of cellulosic feedstocks. Pellets can be easily handled, resulting in reducing their transportation and storage costs. Ultrasonic vibration-assisted (UV-A) pelleting is a new pelleting method. Effects of input parameters (moisture content, particle size, pelleting pressure, and ultrasonic power) on pellet quality and sugar yield (proportional to biofuel yield) have been studied. However, their effects on power consumption in UV-A pelleting have not been adequately investigated. Since power consumption directly affects ethanol manufacturing costs, lower power consumption is desirable. This paper reports an experimental investigation of power consumption in UV-A pelleting. A 24 factorial design is employed to evaluate the effects of four input parameters (moisture content, particle size, pelleting pressure, and ultrasonic power) on power consumption in UV-A pelleting. Results show that three input parameters (moisture content, particle size, and ultrasonic power) significantly affect power consumption. Higher moisture content, lower ultrasonic power, and larger particle size result in higher power consumption. Only one interaction between two parameters is significant, i.e. with the increase of pelleting pressure, power consumption will increase at the high level of particle size while decrease at the low level of particle size.

MSEC2012-7227

EFFECTS OF WATER SOAKING ON BIOMASS PARTICLE SIZE IN CELLULOSIC BIOFUEL MANUFACTURING

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Cellulosic biofuels are an alternative to petroleum-based liquid transportation fuels. Ultrasonic vibration-assisted (UV-A) pelleting of cellulosic biomass in cellulosic biofuel manufacturing has been studied. Previous studies show that UV-A pelleting can increase the density and sugar yield of cellulosic biomass. A hypothesis of

the mechanism for UV-A pelleting to increase the density and sugar yield of cellulosic biomass is that UV-A pelleting can reduce biomass particle size. To test this hypothesis, biomass particle sizes before and after UV-A pelleting need to be compared. Soaking pellets in water is an efficient and non-invasive method to separate pellets into particles. However, water-soaking itself might change biomass particle size. This paper reports an investigation on effects of water-soaking on biomass particle size. The biomass particle sizes before and after water-soaking are measured and compared. Results show that effects of water-soaking on biomass particle size are dependent on the initial particle size (particle size before water-soaking) and time period of water-soaking.

MSEC2012-7228

SUGAR YIELD COMPARISON OF WHEAT STRAW PROCESSED BY TWO PELLETING METHODS FOR CELLULOSIC BIOFUEL MANUFACTURING

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Ethanol made from cellulosic biomass is an alternative to petroleum-based liquid transportation fuels. However, low density of cellulosic biomass causes high costs in handling and transportation of cellulosic biomass in cellulosic ethanol manufacturing. Pelleting processes can increase biomass density and thus reduce costs in handling and transportation of biomass. Ring-die pelleting and ultrasonic vibration-assisted (UV-A) pelleting are two pelleting methods. A previous study has compared them in terms of pellet quality and process power consumption. This paper reports an experimental comparison of sugar yield of these two pelleting methods.

MSEC2012-7242

SIMULATION-BASED ENERGY EFFICIENCY IMPROVEMENT FOR SUSTAINABLE MANUFACTURING SYSTEMS

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Energy efficiency improvement as well as carbon footprint reduction in the manufacturing industry becomes increasingly important for a green world from the point of sustainability. However, because of the complexity of modern manufacturing systems, most of the existing research efforts in energy efficiency improvement only focus on either single-machine system or process level. Seldom work has been performed to study the potential of energy consumption reduction for typical manufacturing systems with multiple machines and buffers. In this paper, a simulation-based method is proposed to study various strategies for energy efficiency improvement of complex manufacturing systems. This study provides an initial framework to study the real time energy control of multi-machine manufacturing systems, and demonstrates the energy efficiency improvement and energy saving potentials by adjusting the machines' power level according to their operation states while maintaining the system throughput. Comparison between the results with and without power level adjustment is performed to illustrate the effectiveness of the proposed method.

MSEC2012-7383

PERFORMANCE ANALYSIS AND OPTIMIZATION OF REMANUFACTURING SYSTEMS WITH STOCHASTIC RETURNS

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In this paper, we consider a modular product assembly and inventory system in a remanufacturing environment. The return process of end-of-life product is a stochastic process in terms of arriving time, quality and quantity. We investigate the returned module reassembly policies in an assemble-to-order strategy. We consider threshold policies to control the admission of the product returns. We study how the control parameters in these strategies relate to the average inventory level and stock out level of the remanufacturable modules. Starting with a single quality grade problem, we extend the analysis to a multiple quality grade problem and derive exact expression of the system performance measures as functions of the control parameters. Main objective of this paper is to provide managerial insights into decision-making for stochastic remanufacturing systems.

MSEC2012-7206

LIFE CYCLE ANALYSIS OF DIAMOND COATING OF MACHINING TOOLS

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To begin to identify the environmental impacts of coated cutting tools, lathe cutting inserts were coated with a thin film of diamond. To assess the environmental impacts of the coating process on the life cycle analysis (LCA) of a cutting tool, all chemical processes, including pre- and post- deposition processes and energy expenditures were monitored and recorded for entry into SimaPro

LCA software. For the conditions evaluated, the primary deposition process was found to have a carbon footprint of 6.6 equivalent kilograms of carbon dioxide, and the etching process was found to be responsible for 96.8 equivalent grams of carbon dioxide.

MSEC2012-7211

ULTRASONIC-VIBRATION ASSISTED PELLETING FOR CELLULOSIC ETHANOL MANUFACTURING: EFFECTS OF PARTICLE SIZE AND MOISTURE CONTENT ON POWER CONSUMPTION

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Ethanol produced from cellulosic biomass is an alternative to petroleum-based transportation fuels. However, its manufacturing costs are too high for cellulosic ethanol to be competitive at present. Raw cellulosic materials have low density, causing their transportation and storage expensive, contributing to high manufacturing costs of cellulosic ethanol. Pelleting can increase the density of cellulosic feedstocks and reduce their transportation and storage costs. Ultrasonic vibration-assisted (UV-A) pelleting is a new pelleting method. Earlier studies show that moisture content and particle size have significant effects on pellet quality and sugar yield. However, their effects on power consumption in UV-A pelleting have not been studied. Since power consumption directly affects ethanol manufacturing costs, lower power consumption is desirable. The objective of this paper is to study effects of moisture content and particle size on power consumption in UV-A pelleting of wheat straw. Results show that moisture content and particle size significantly affect power consumption. Higher moisture content and larger particle size result in higher power consumption.

MSEC2012-7215

ELECTRIC POWER RESOURCE PLANNING: A CASE STUDY OF NORWAY

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In this study, we propose to develop a comprehensive simulation based decision making framework to determine the most desirable combination of resource investments for electric power generation. The distributed power system considered here has three major components including energy generation via wind farm, and fossil fuel power generation transmission via a bus and two main substations in between the supply and demand of electricity. The proposed approach is demonstrated for the electric utility resource planning in Norway.

MSEC2012-7254

DESIGNING GREEN LUBRICANTS FOR MANUFACTURING INDUSTRY USING RENEWABLE BASE MATERIALS

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ABSTRACT (FOR ICTMP5) The majority of lubricants like cutting, forming and hydraulic oils and greases used in the manufacturing industry are based on mineral oil of petroleum origin. However, consistent availability of mineral oils in future is a concern. In addition to this, the poor biodegradability, adverse impact on the environment and workers' health on long term contact with existing lubricants, force the researchers to find out new alternative based on safe renewable materials. Research in the past two decades has identified several edible and non-edible vegetable oils, as one of the major alternatives to the conventional lubricants. These vegetable oil based lubricants are non-toxic and have excellent lubricating properties and high biodegradability. In the Indian context since edible oils are deficit in supply, the authors have chosen non-edible oils for designing the green lubricants. Vegetable oils are poor in oxidation stability. These oils are prone to oxidation due to presence of double bonds. Additionally, the hydrolytic stability and low temperature flow properties are two major concerns for long term usage in the circulating system. The present study was carried out to improve the oxidation stability and low temperature property of certain identified non-edible vegetable oils of Indian origin through blending and additive treating route. Mixtures of these particular vegetable oils with API Gp I, API Gp II and API Gp III categories of mineral base oils and esters were studied for thermo oxidation stability and flow properties. There was a remarkable difference observed in the oxidation stability of vegetable oil in combination with different groups of mineral oils and esters. Some of these blends have shown improved thermo oxidative stability also. Improvement on low temperature flow characteristics with the addition of additives was found limited. The biodegradability studies revealed that addition of vegetable oil in mineral oil was beneficial. Mixtures of vegetable oils and mineral oils showed lower values of coefficient of friction as compared to the mineral oil as such. The response of additives in these mixtures in physico chemical and tribological aspects was also studied. In view of the above, the renewable non-edible vegetable oils have shown excellent potential for designing the green lubricants of future.

MSEC2012-7294

SYNTHESIS OF MANUFACTURING AND FACILITY DATA FOR SUSTAINABILITY ANALYSIS

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This paper discusses data synthesis of production and facility knowledge for sustainability analysis by applying the ISA 95 "Activity Models of Manufacturing Operations Management" (MOM) model. Presently, production and facility management are "silo" operations, which basically function independently of each other. This paper presents the addition of facility activities to the MOM model, in accordance with the needs for attaining a holistic view of sustainability analysis. Historically, production and facility data are represented in various forms, e.g., data bases, CAD, and spreadsheets, without a common unifying representation. This paper addresses the issue by introduced Core Manufacturing Simulation Data (CMSD) Standard. A case study of the data synthesis for a precision sand casting production facility is provided.

MSEC2012-7298

MULTI-SCALE FRICTION MODELING FOR MANUFACTURING PROCESSES: THE BOUNDARY LAYER REGIME

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This paper presents a multi-scale friction model for large-scale forming simulations. A friction framework has been developed including the effect of surface changes due to normal loading and straining the underlying bulk material. A fast and efficient translation from micro to macro modeling, based on stochastic methods, is incorporated to reduce the computational effort. Adhesion and ploughing effects have been accounted for to characterize friction conditions on the micro scale. A discrete model has been adopted which accounts for the formation of contact patches ploughing through the contacting material. To simulate metal forming processes a coupling has been made with an implicit Finite Element code. Simulations on a typical metal formed product shows a distribution of friction values. The modest increase in simulation time, compared to a standard Coulomb-based FE simulation, proves the numerical feasibility of the proposed method.

MSEC2012-7303

A COMPUTER AIDED SYSTEM FOR SUSTAINABILITY ANALYSIS FOR DIE-CASTING PROCESS

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Currently available sustainability analysis systems for the die-casting process primarily depend on the material properties and do not account for process information. As a result they are unable to assess or compare the sustainability of parts made using different process plans. In this paper, we propose a new computer-aided system named Sustainability Analyzer for Die-casting Process. Here, we discuss the details of the architecture and the working of the proposed system. We analyze sustainability using three sustainability indicators, namely energy use, solid waste and carbon emissions. The proposed system is verified by comparing results with the actual data measured from the shop floor. The proposed system is beneficial for sustainability analysis comparing different plans alongside material properties, ultimately helping the die-casting industry to reduce carbon emissions and material waste besides improving energy efficiency.

MSEC2012-7306

DISCOVERING MATERIAL RECOVERY SCENARIOS FOR INDUSTRIAL MACHINERY: A CASE-BASED APPROACH

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Decision-making methodologies for evaluating a product's end-of-life options have become a significant area of research. Extensive work has been carried out in the area of product recovery, e.g. module-based disassemblability, reverse logistics, remanufacturing, material recyclability, among others. Some of these methods use graphical representations in the form of disassembly trees and/or networks to find feasible solutions with computational approaches, but have not been made applicable to larger, more complex electrohydraulic mechanical systems. The work presented in this paper aims to apply a disassembly

assessment technique by comparing a component's disassembly effort to a reward such as recycling value or energy recovery from recycling. First, the disassembly network is represented by a directed graph where weighted edges represent reward/cost. Next, an implementation of Dijkstra's algorithm is used to compute the optimal disassembly path that minimizes the sum of the edge weights. Lastly, the optimal disassembly paths for each individual reward are compared to discover the globally optimal disassembly scenario. This method is applied to a real-world case study of an underground mining drill rig with direct contributions from engineers involved in the development of the machine itself. Specific component recovery options are recommended based on the methodology and alternative design practices are suggested to improve product recyclability.

MSEC2012-7320

EXPERIMENTAL MEASUREMENT OF NANO-PARTICLE EMISSIONS FROM ATOMIC LAYER DEPOSITION

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Atomic layer deposition (ALD) is a key enabling nanotechnology for a broad array of applications due to its ability to grow conformal and pinhole-free thin films and control layer growth at atomic scale. Like many nanotechnologies, the potential amount of nano-particle emissions from ALD nano-manufacturing system is a significant concern for both occupational and public health exposure. Here we report our preliminary investigations of nano-particle emissions at end-of-the-pipe of ALD nano-manufacturing system. Scanning Mobility Particle Sizer (SMPS) spectrometer is used for the nano-particle measurement during the ALD process of Al2O3 high-k dielectric gate materials using Trimethyl Aluminum (TMA) and H2O binary reactions. Under various experimental conditions tested in our project, the results demonstrate that the aerosol nanoparticle emissions from ALD nano-manufacturing system are averaged with a mean diameter of 201.28 nm and 940,850 particle concentrations at 200 C reaction temperature.

MSEC2012-7324

MICROFRACTURING CERAMIC ABRASIVE IN GRINDING

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Microfracturing "ceramic" abrasives have been in common use for 20 years. However, their success has been limited because of a lack of understanding of how they function and in choosing grinding parameters that take advantage of their self-sharpening ability. A study was made into how these abrasives function and into which grinding parameters should be used to achieve optimum results.

MSEC2012-7342

SCHEDULING OF MACHINE STARTUP AND SHUTDOWN TO REDUCE ENERGY CONSUMPTION IN BERNOULLI PRODUCTION LINES

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Effective control of production operations usually leads to improved energy efficiency in manufacturing systems. In this paper, we investigate energy consumption reduction in production systems by scheduling of machine startup and shutdown. Specifically, we consider serial production lines with finite buffers and machines having Bernoulli reliability model. This machine reliability model is applicable in production situations, where the downtime is relatively short and comparable to machine cycle time (e.g., automotive paint shops and general assembly). Using transient analysis of the systems at hand, an analytical performance evaluation technique is developed for Bernoulli serial lines with time-dependent machine efficiencies. In addition, trade-off between productivity and energy-efficiency in production systems is discussed and the energy-efficient production problem is formulated as a constrained optimization problem. The effects and practical implications of operations schedule are demonstrated using a numerical study on automotive paint shop operations.

MSEC2012-7363

RESIDUAL STRESS AND FATIGUE PROPERTIES OF AISI H13 STEEL BY SUSTAINABLE DRY MILLING

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Dry machining is a cluster of sustainable manufacturing processes to eliminate the negative environmental effect of machining coolants. It is critical to ensure that product quality cannot be sacrificed for achieving sustainability. The progress of tool flank wear during hard milling adversely affects surface integrity and, therefore, fatigue life of machined components. This paper focuses on the influence of tool flank wear on residual stress and fatigue properties in dry end milling AISI H13 tool steel (50 ± 1 HRC) using PVD coated tools. The effects of flank wear (VB = 0, 0.1, and 0.2 mm) on residual stresses at three different feeds were studied. Four-point bending fatigue tests were performed on the samples machined at five levels of tool flank wears (VB = 0, 0.05, 0.10, 0.15, 0.20 mm) and surface fatigue initiations of the fatigued samples were identified by the fractographic method.

MSEC2012-7405

A PROCESS-BASED APPROACH FOR CRADLE-TO-GATE ENERGY AND CARBON FOOTPRINT REDUCTION IN PRODUCT DESIGN

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Karl Haapala — Oregon State University
Kyoung-Yun Kim — Wayne State University
Gul Okudan Kremer — The Pennsylvania State University

Interest in accounting for environmental impacts of products, processes, and systems during the design phase is increasing. Numerous studies have undertaken investigations for reducing environmental impacts across the product life cycle. Efforts have also been launched to quantify such impacts more accurately. Energy consumption and carbon footprint are among the most frequently adopted and investigated environmental performance metrics. The purpose of this paper is to serve two objectives – first, it provides a review of recent developments for carbon footprint reduction in manufacturing processes and supply chain operations. Second, a future vision is shared toward developing a method for reducing carbon footprint through simultaneous consideration of manufacturing processes and supply chain activities. The approach is demonstrated by developing analytical models for alternative manufacturing processes and supply chain networks associated in the manufacture of a bicycle pedal plate to realize its potential in assessing energy and GHG (greenhouse gas) emissions. The sustainable design and manufacturing research community should benefit from the review presented. In addition, a point of departure for concurrent consideration of multiple stages of the product life cycle for environmental performance is established for the research community to move current efforts forward in pursuit of environmental, economic, and social sustainability.

MSEC2012-7416

REHEATING EFFECT ON THE STRENGTH AND FORMABILITY OF DP980

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Ultra-High-Strength steels (UHSS) are introduced to autobody structures to reduce weight and increase safety, but the application is constrained by (1) the limitation of material's forming limit; (2) the limitation of available stamping press tonnage. One possible solution is to reheat-soften certain local high-strain regions where potential fracture may occur. This study is to investigate DP980's response to reheating, and the required thermal schedule, to resolve the problems of UHSS application. The effects of this local softening were studied through: tensile and hardness tests, and microstructure analysis. A new local tensile property evaluation technique was developed. Peak heating temperature and cooling rate was found to be the two most important parameters effecting the properties of the material. These were held constant during the various heat treatment. Within the range of 800-1000oC and in cooling rate of 2-20oC results showed reduced strength and increased fracture strain relative to the as-received DP980. The best result where seen at 900oC with a fast cooling rate. Microstructure observation indicates that; cooling rate affects reduction of martensite volume, which affect both strength and formability.

MSEC2012-7417

TIME-RESOLVED STUDY OF ALGINATE SPHEROID FORMATION IN INKJETTING

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Alginate-based tissue spheroids are finding increasing applications in tissue engineering, especially in organ biofabrication. Since alginate solution is a viscoelastic fluid, scale-up fabrication of viscoelastic alginate spheroids with the capability of achieving process consistency is of great manufacturing challenge. The objective of this study is to experimentally investigate an inkjetting-based alginate spheroid fabrication process. Alginate spheroids have been fabricated using drop-on-demand (DOD) inkjetting, and their formation has been studied especially as a function of the operating conditions such as the voltage amplitude and dwell time using a time-resolved imaging approach. It is found that the spheroid radius increases with the voltage amplitude, and satellite droplets and beads-on-a-string form under high voltage amplitudes (> 60V). There is no monotonic relationship between the spheroid size and speed with the dwell time as the size and speed increase until a critical dwell time then decrease. The resulting knowledge will help better optimize the fabrication of alginate-based tissue spheroids as well as the organ printing process.

MSEC2012-7418

SCAFFOLD-FREE FABRICATION OF THREE-DIMENSIONAL CELLULAR TUBES

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Wenxuan Chai — Clemson University

The ultimate goal of tissue engineering is to design and fabricate functional human tissues and organs suitable for regeneration, repair and replacement of damaged or injured human organs. Vascularization is often identified as a main technological barrier for building three-dimensional (3D) tissues and organs. As such, the fabrication of 3D cellular tubes is of great importance for the overall feasibility of the envisioned robust organ printing technology. This study aims to study the fabrication process and its associated manufacturing challenges in fabricating 3D zig-zag 3T3 fibroblast cell-based alginate tubes. At the first time, vertical 3D zig-zag cellular tubes were successfully fabricated using an inkjet-

based scaffold-free fabrication approach, and the post-fabrication cell viability was controlled around 85%.

MSEC2012-7419

ACTIVE COMPLIANT MICROASSEMBLY PLATFORM WITH INTEGRATED FORCE MEASUREMENT

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Micro-electro-mechanical systems (MEMs) are mechanisms that incorporate silicon-based mechanical and electrical components. These devices usually require a highly skilled human operator for assembly, which can be time consuming and expensive. Additionally, these devices are increasingly being used in conjunction with mesoscale parts, which can be problematic when machining due to the higher spindle speeds needed to create them. By dynamically tuning the stiffness of the workpiece holder in mesoscale machining, the negative effects of high spindle speed operations can be avoided. As a result, there is a need for assembly platforms which allow for nano-newton scale force feedback, allow for active fixturing, and which prevent the destruction of fragile parts during assembly. A compliant micro-assembly platform has been developed for this purpose. The platform measured forces in the range of 0-10 mN with a resolution of less than 10 μN and with compliance of 50 μm in two degrees-of-freedom. This platform was fabricated and tested using micro-positioners and nano-force sensors. Initial results showed that the platform behaved as predicted. However, it is desired to further reduce the scale of the platform and to add an additional degree-of-freedom of compliance and force measurement. It is proposed that a compliant micro-assembly platform with 0-1 mN range, 100 nN resolution and 5 μm compliance be developed with three degrees-of-freedom. As was the case in the first platform, this mechanism should have integrated force sensors allowing for closed-loop feedback during assembly processes. The platform will be developed using parallel mechanisms capable of actively tuning the stiffness of the system in all three degrees-of-freedom. The modal characteristics of the system will be determined using theoretical models, finite element software and by experimental testing. Upon completion of the fabrication and testing of the system, it will be used in an application such as biomedical device assembly in order to determine its efficacy in industrial applications. In this poster, the underlying theories are presented for which collectively form the preliminary proof of feasibility of the active compliant microassembly platform.

MSEC2012-7420

ULTRA HIGH-SPEED MICRO-MILLING AND MICRO-GRINDING

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A new ultra high-speed spindle was used for micro-milling of an aluminum alloy and micro-grinding of dental ceramics. Straight channels were machined by milling to obtain an array of square patterns on the surface. A maximum surface cutting speed of 340 m/min was achieved at 350,000 rpm. Inspection of the machined surfaces indicated that the edge quality improved and the burr formation tendency decreased as the surface speed and the feed rate were increased. Plunge and side grinding were performed with diamond tools in ceramics. Surface speed of 28 m/s was achieved. The occurrence of surface and subsurface damage in micro-grinding were reduced at higher rotational speeds. A major advantage of ultra high-speed machining is the generation of burr-free and damage-free micro-machined parts, besides potential for higher material removal rates.

MSEC2012-7421

SYNTHESIS OF CARBON NANOTUBE-NANODIAMOND HYBRID STRUCTURES AND THEIR EFFECT ON THE MECHANICAL PROPERTY OF POLYMER COMPOSITES

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Yang-Bok Lee — Korea University
Kyung-Min Kim — Korea University
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Seo-Hyun Yoon — Korea University

Carbon Nanotube (CNT) and nanodiamond (ND), which are the allotropes of the carbon, are very attractive materials for various application due to their unique structure and outstanding properties. These material provide new scientific and technological properties. However, agglomeration and entanglement of these materials obstacle to their homogeneous dispersion in a composite matrix. In this study, we demonstrate simple methods to fabricate a CNT/ND hybrid structure using polymer wrapping and electrostatic selfassembly methods. Microstructural observation by transmission electron microscopy revealed that NDs were adhered well to the CNTs. These CNT/ND hybrid structure was used as a filler in polyethylene (PE) composite for investigation of mechanical property. The hybrid materials showed enhanced mechanical properties of the composite. The effective dispersion

and good interfacial bonding to the PE matrix are believed to be responsible for the excellent mechanical property.

MSEC2012-7422

EXPERIMENTAL STUDY ON THE COOLED AIR EFFECT FOR HARD TURNING

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The hard-turning process can be used to manufacturing the mechanical components, such as shafts or bearing based on harden steels (45~60HRC) without using the coolant oil. Therefore, it can be the good candidate as the replacement of grinding. The hard turning is also a dry and environmental process. However, the temperature increase during hard turning can produce the significant damage of the workpiece surface. in this study, we have adapted the cooled air to the hard turning process using the vortex tube. Based on the sensitivity analysis of the key parameters of the hard turning process, Its optimization has been performed using the Taguchi method for the given CBN insert. In the experiment, the cooled air can efficiently lower the surface temperature of the tool and workpiece during hard-turning, which enhances the surface roughness of the workpiece.

MSEC2012-7423

LIFE CYCLE ANALYSIS OF DIAMOND COATING OF MACHINING TOOLS

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To begin to identify the environmental impacts of coated cutting tools, lathe cutting inserts were coated with a thin film of diamond. To assess the environmental impacts of the coating process on the life cycle analysis (LCA) of a cutting tool, all chemical processes, including pre- and post- deposition processes and energy expenditures were monitored and recorded for entry into SimaPro LCA software. For the conditions evaluated, the primary deposition process was found to have a carbon footprint of 6.6 equivalent kilograms of carbon dioxide, and the etching process was found to be responsible for 96.8 equivalent grams of carbon dioxide.

MSEC2012-7424

RFID-BASED 3D INDOOR REAL-TIME LOCALIZATION SYSTEM

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Robert Williams — University of Nebraska-Lincoln

An innovative RFID-based 3D indoor Real-Time Localization System is designed to demonstrate the advantage of the proposed hybrid algorithm. It is superior under various restrictions in real applications, such as anisotropic environmental impacts, non-monotonous RF signal distribution, and uneven deployment of reference tags in 3D space. The system is setup in a fully furnished regular-sized room with 4 readers and 24 reference tags, which are all commercial-ready products. The algorithm is implemented with MATLAB and is synchronized with RF signal data collection in real-time. The experimental results show that the hybrid algorithm improves the performance significantly comparing to kNN and RSSI ranging approaches. The 3D localization error of 1.37m is achieved on average.

MSEC2012-7426

AN EXPERIMENTAL DEVICE FOR CYCLIC TENSION AND COMPRESSION TESTS

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Chih-Hsun Lin — National Taiwan University

A novel clamping device that prevents the sheet metal from being buckled in the compression test was developed in the present study. The thickness change of sheet metal during the compression test was taken into consideration for the determination of the clamping gap that makes the cyclic tension and compression test can be conducted with the use of only one single specimen. To accommodate for sheet metal with different thicknesses, an empirical formula that suggests the relation between the sheet thickness and the clamping device gap was also established. The efficiency of the developed clamping device was validated by both the finite element analysis and the cyclic tension and compression tests conducted in the present study, with the material constants used in the Yoshida-Uemori model being determined as well.

NAMRC ABSTRACTS

NAMRC40-7701

DEVELOPMENT OF HOLE MAKING APPARATUS BASED ON DOUBLE ECCENTRIC MECHANISM AND ITS CAPABILITY IN THE CASE OF BI-LAYER COMPOSITE MATERIALS CONSISTING OF CFRP LAMINATES AND TITANIUM ALLOYS

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Construction parts consisting of 2-layer composite materials made of carbon fiber reinforced plastic (CFRP) laminates and TiAl6V4 still need to be machined, whereby drill holes are frequently manufactured. Special attention has to be paid to the machining quality, which implies dimensional accuracy as well as a defect-free peripheral zone. Machining defects often occur as a consequence of excessive mechanical and thermal loads, which are often caused by wrong process conditions or by the wrong choice of machining process itself. With respect to widely used state-of-the-art machine tools providing high performance and equipped with potent control unit, for the comparatively large drill hole, circular milling gains interest as an alternative to the drilling operation (Weinert at al. 2005). As a result of comparing drilling and circular milling for hole making of 6 mm diameter to carbon fiber reinforced plastic (CFRP) laminates and also 2-layer composite materials consisting of CFRP laminates and Titanium Alloys (TiAl6V4) using a vertical milling machine with CNC control, the author ascertained that circular milling is superior to drilling concerning not only dimensional accuracy but also defects on and peripheral zone (Yagishita, 2007 and 2008). The author devised a new spindle applying double eccentric mechanism so that a cutting tool can rotate on its axis with high speed at clockwise simultaneously revolve on eccentric axis with low speed at counter-clockwise. The new apparatus, which has the double eccentric spindle driven by an air motor, designed and manufactured, and also hole making tests were executed to 2-layer composite materials consisting of CFRP laminates and TiAl6V4 with cemented carbide end mill.

NAMRC40-7702

CHARACTERIZATION OF SURFACES PRODUCED BY ABRASIVE FLOW MACHINING UNDER MAGNETIC FIELD ASSISTANCE

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Pradeep Kumar — IIT Roorkee
Harbhajan Singh Shan — Swift Institution of Engg and Technology

The magnetic field assistance to Abrasive Flow Machining (AFM) has been explored for performance improvement in the recent past. The characteristics obtained on the surfaces finished with AFM and magnetic field assisted AFM have been analyzed in order to assess the effect of proposed magnetic field assistance. Data Dependent System approach is used for acquiring Auto Regressive Moving Average (ARMA) models of surface profiles of the work pieces. These models have been utilized for obtaining Green function plots and number of dynamic active grains in the media. The estimated parameters of ARMA models for surfaces produced by AFM and magnetic field assisted AFM indicate considerable effect of magnetic field in AFM. The number of dynamic active particles gets enhanced under the influence of magnetic field and they act more effectively on the surfaces.

NAMRC40-7703

SPINDLE SPEED SELECTION FOR TOOL LIFE TESTING USING BAYESIAN INFERENCE

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According to the Taylor tool life equation, tool life is dependent on cutting speed (or spindle speed for a selected tool diameter in milling) and their relationship is quantified empirically using a power law exponent, n, and a constant, C, which are tool-workpiece dependent. However, the Taylor tool life model is deterministic and does not incorporate the inherent uncertainty in tool life. In this work, Bayesian inference is applied to estimate tool life. With this approach, tool life is described using a probability distribution at each spindle speed. Random sample tool life curves are then generated and the probability that a selected curve represents the true tool life curve is updated using experimental results. Tool wear tests are performed using an inserted (uncoated) carbide endmill to machine AISI 1018 steel. The test point selection is based on the maximum value of information approach. The updated beliefs are then used to predict tool life using a probability distribution function.

NAMRC40-7704

ENERGY CONSUMPTION IN SINGLE POINT INCREMENTAL FORMING

David Adams — Queen's University
Jack Jeswiet — Queen's University

Single Point Incremental Forming (SPIF) is a dieless sheet metal forming technique that allows users to form complex asymmetrical shapes without specialized tooling. SPIF uses generalized tools to form complex shapes based on toolpath, rather than tool geometry as seen in stamping. Energy consumption in manufacturing is becoming increasingly important and this paper reports recent measurements of energy consumption for SPIF.

NAMRC40-7705

OPTIMIZATION OF THE DESIGN OF ROLL-FORMERS

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Finite element simulations are used for the prediction of strains during roll-forming and the results are verified with measurements on an experimental U-channel profile. For the optimization of the design of roll-forming equipment the inverse problem of knowing the final strain condition, but not knowing the original design parameters is iteratively resolved with a non-linear least square approach and embedded finite element simulations. An integrated design routine has been created and examples of optimization runs of important design parameters like forming angle increments, roll spacing, roll diameter, and gradient of the product measured against the horizontal axis are being demonstrated.

NAMRC40-7706

THE DEVELOPMENT OF A SIMPLE METHOD FOR MICRO STRAIN MEASUREMENT APPLIED TO BULGE MICROHYDROFORMING

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William J. Emblom — University of Louisiana at Lafayette
Gary A. Glass — University of North Texas

Strain measurement in sheet metal forming is essential to evaluating the processes being used and the material properties of the sheet being used. This presents a significant drawback for strain measurement on meso and micro scales because there are no simple, inexpensive methods for evaluating strains. On the macroscale, traditional methods such as gridding and either using a graduated scale or an optical-digital photographic approach have given way to Digital Image Correlation (DIC). Unfortunately, the cost of even a simple DIC system is frequently beyond the ability of many researchers. The problem of affordability of strain measurement systems is compounded by the research organization is interested in pursuing studies in microscale forming because DIC systems for microscale strain measurement are approximately twice the price of the macroscale DIC systems. Hence, many researchers in metal forming must develop alternative methods. The current paper describes the development of a microscale gridding and strain measurement system utilizing equipment that most research organizations already possess or are reasonably priced. Alternative methods for producing microscale grids are explored. Central to the method developed is the use of a conventional electro-chemical etching system that is used in combination with ultraviolet light sources including sun light, a proton beam, and an ultraviolet pen style flashlight. Masks for gridding were successfully produced as small as 37 microns and grids as small as 90 microns were successfully electrochemically etched on to as-received annealed SS-304 stainless steel. Digital photographs of grids were used in conjunction with the Matlab Image Processing Toolbox and a strain calculation graphic user interface (GUI).

NAMRC40-7707

FEASIBILITY OF VEGETABLE OIL IN WATER EMULSION ACHIEVED THROUGH ULTRASONIC ATOMIZATION AS CUTTING FLUIDS

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Chan-Seo Goo — LG Electronics
Martin Jun — University of Victoria

Significant amount of work is reported on development of vegetable oil based metalworking fluids (MWFs). Many also report on development and performance evaluation of vegetable based oils. For many of these water-based MWFs with vegetable oils, much effort is focused on stable emulsification of vegetable oil in water using a variety of surfactants. It has been found that surfactant-free stable emulsification of oil in water is possible through ultrasonic vibration. However, emulsification through ultrasonic atomization has not yet been considered, and the feasibility of emulsified metalworking fluids through ultrasonic atomization has not been investigated. In this paper, stable emulsification of vegetable oil in water has been achieved through ultrasonic atomization without using any surfactant. The emulsified vegetable oil in water is directly used to investigate its effectiveness as MWF in milling operations. Lower cutting forces, chip thickness, and burr amount are observed with vegetable oil-in-water emulsion compared to conventional MWF. The experimental results show strong potential for vegetable oil-in-water emulsion obtained through ultrasonic atomization as an effective MWF.

NAMRC40-7709

EVALUATION OF ENVIRONMENTALLY FRIENDLY LUBRICANT FOR ALUMINUM COLD FORGING USING FRICTION TEST BASED ON SPLINE EXTRUSION

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Kunio Hayakawa — Shizuoka University
Itaru Ishibashi — Sumico Lubricant

It is required to replace the aluminum fluoride coating, which is a popular lubricant for aluminum alloy cold forging in Japan, with environmentally friendly lubricants. Because the aluminum fluoride coating has high environmental risks and needs much cost. Evaluations of lubrication performance are necessary before lubricant replacement. The authors proposed new friction test based on combined forward spline-backward can extrusion. It can realize large surface expansion, which is a characteristic of

aluminum cold forging. In the present paper, a double-layer-type environmentally friendly solid lubricant film and the aluminum fluoride coating were applied to a precipitation hardened aluminum alloy. The lubrication performance was evaluated by the friction test. The double-layer-type lubricant showed superior performance enough for the replacement. The effect of surface treatment applied to workpiece on the lubrication performance was also investigated. The surface asperity generated by a wet-blasting showed high pickup resistance and low friction.

NAMRC40-7710

OPTIMUM PART ORIENTATION IN RAPID PROTOPYPING USING GENETIC ALGORITHM

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Part orientation is an important parameter in the planning of a Rapid Prototyping (RP) process as it directly governs productivity, part quality and cost of manufacturing. This paper reports the design and implementation of a system for obtaining optimum orientation of a part for RP. Developed in a modular fashion, the system comprises of functional modules for CAD model Pre-processing, Shelling (hollowing),Part Orientation and Optimization. CAD part model in STL format is an input to the system. The oriented CAD model is sliced and hollowed with desired shell thickness. Genetic Algorithm based strategy is used to obtain optimum orientation of the parts for SLS process. The objective criteria for optimization is considered to be a weighted average of the performance measures such as build time, part quality and the material used in the hollowed model. The developed system has been rigorously tested with several case studies.

NAMRC40-7711

PRINTED ENERGY STORAGE: FROM PROTOTYPE TOWARDS LARGE-SCALE MANUFACTURING

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In this work, we propose a roll-to-roll multi-station flexographic printing process for large-scale energy storage fabrication. By leveraging a previously developed solid-state zinc-based battery technology, we have scaled it to a potentially cost-effective and environmentally friendly manufacturing method. Due to the differences in flexographic printing from our previously used dispenser-printing methods, we have developed new functional materials for printing of large-scale batteries. We have also analyzed and compared the fluidic properties of both water-based flexographic inks with traditional solvent-based inks. This work ultimately establishes key criteria and methods for developing functional flexographic inks used for manufacturing energy storage devices.

NAMRC40-7712

AN ASSESSMENT OF ENVIRONMENTALLY BENIGN LUBRICANTS WITH THE RING TEST AND UPSET FORMING

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The need to find lubricants that are environmentally friendly has increased as industry becomes more environmentally conscious and as legislation becomes increasingly concerned with respect to the industrial application of hazardous lubricants. The coefficients of friction of three environmentally benign lubricants are tested using two experimental methods, the bulk upsetting test and the ring test, using a variety of materials and platen surface finishes. Extensive testing is performed with reductions in height of up to 50 percent for both billet and ring samples made of Al6061-T6, Al2017-T451, Al7075-T651 and Ti-6Al-4V-Grade 5. Palm oil, used cooking oil (canola), and mineral oil are used as the benign lubricants. Two sets of platens are used with different surface finishes, one set ground and the other left as turned. The slab technique analysis method as described by Hosford and Caddell is applied to the bulk upsetting test to calculate each coefficient of friction. The Ring test, as developed by Male and Cockcroft, is then used to find the coefficients of friction for the same setups as the bulk upsetting test, but based solely upon dimension changes. Additionally, the derivation of the charts and equations developed by Male and Cockcroft is discussed. Coefficients of friction are reported and compared between the slab technique and the ring test, as well as for all lubricant, material, and surface finish setups.

NAMRC40-7714

A CASE FOR 2-BODY MATERIAL REMOVAL IN PRIME LED SAPPHIRE SUBSTRATE LAPPING AND POLISHING

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An alternative, and potentially better, means to process prime LED sapphire wafers is proposed. A brief history of material removal mechanisms suggests that brittle materials can be abraded in a ductile regime and that this can be a superior mode of removal. Advantages in material removal rate, surface finish and subsurface damage for a 2-body ductile removal of sapphire are shown relative to 3-body material removal. A major difficulty with this approach may be getting the LED manufacturing industry to understand that the appearance of the sapphire surface is quite different, unfamiliar yet predictable. Finally, some potential alternative process approaches are discussed that utilize 2-body material removal.

NAMRC40-7715

SMOOTH SURFACE FABRICATION IN MASK PROJECTION BASED STEREOLITHOGRAPHY

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The surface finish is critical for applications such as optics, micro-fluid flow and mechanical assembly, in which optical lenses, fluidic channels and rotating components are all required to be smooth. However, the stair-stepping effect is well known in the layer-based additive manufacturing processes, in which a three-dimensional model is approximated by a set of two-dimensional layers. Consequently the fabricated surfaces have poor surface finishes especially those that are close to the horizontal plane. In this paper, a novel approach for achieving improved surface finish is presented for the mask-image-projection-based Stereolithography (MIP-SL) process. Theoretical models and parameter characterization are presented for the developed methods. Accordingly, the process planning and calibration approaches for fabricating smooth up-facing surfaces in the MIP-SL process have been developed. Multiple test cases based on various types of curved surfaces have been performed. A comparison of the build results based on the traditional and the newly developed approaches illustrates the effectiveness of our method.

NAMRC40-7717

ON THE CHOICE OF TOOL MATERIAL IN FRICTION STIR WELDING OF TITANIUM ALLOYS

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Friction Stir Welding (FSW) is a solid state welding process patented in 1991 by TWI; initially adopted to weld aluminum alloys, is now being successfully used also for magnesium alloys, copper and steels. The wide diffusion the process is having is due to the possibility to weld both materials traditionally considered difficult to be welded or "unweldable" by traditional fusion welding processes due to peculiar thermal and chemical material properties, and complex geometries as sandwich structures and straightening panels. Recently, research is focusing on titanium alloys thanks to the high interest that such materials are getting from the industry due to the extremely high strength-weight ratio together with good corrosion resistance properties. At the moment, the main limit to the industrial applicability of FSW to titanium alloys is the tool life, as ultra wear and deformation resistant materials must be used. In this paper a, experimental study of the tool life in FSW of titanium alloys sheets at the varying of the main process parameters is performed. Numerical simulation provided important information for the fixture design and analysis of results. W25Re tools are found to be the most reliable among the ones considered.

NAMRC40-7718

ANALYSIS OF ORTHOGONAL CUTTING EXPERIMENTS USING DIAMOND-COATED TOOLS WITH FORCE AND TEMPERATURE MEASUREMENTS

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Two dimensional (2D) orthogonal cutting experiments using diamond-coated tools were conducted with forces and tool-tip temperatures measured by dynamometry and infrared thermography, respectively. The objective of this study was to analyze cutting parameter effects on process behavior in diamond-coated tool machining. Special cutting tools and workpieces were prepared to realize orthogonal cutting. The specific cutting energy and the ratio of forces in the normal and cutting directions increased with decreasing uncut chip thickness. The tool temperatures generally increase with the uncut chip thickness. The specific cutting energy decreases slightly with the increase of the cutting speed. The tool temperatures increase significantly with the

cutting speed, but level off at a higher cutting speed, 5 m/s. The effect of increasing the edge radius was to increase the specific cutting energy and the force ratio. The tool temperatures were lowest at the middle edge radius value and increase at both the smaller and larger edge radii.

NAMRC40-7720

PVD COATED MILL ROLLS FOR COLD ROLLING OF STAINLESS STEEL STRIPS: TRIBOLOGICAL AND MECHANICAL LABORATORY TESTS

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Yves Gachon — HEF R&D

The cost of rolling is determined in particular by productivity (i.e. reduction per pass and speed) and lifetime of rolls before regrinding. Adhesive wear of the sheet gives rise to transfer on the roll surface (called “roll-coating” or “pick-up”). Its occurrence depends on rolling conditions (load, speed, temperature, lubrication) and is one of the determining factors of the maximal reduction for a given rolling speed. Abrasive wear of the roll is the second factor for roll lifetime. Both phenomena are strongly related to tribological and mechanical characteristics of the surface layer of rolls. Stainless steel is known for its high adhesiveness. As, furthermore, a good surface finish is needed, transfer is the main reason for frequent roll changes. Coatings with good tribological properties (anti-wear and first of all, anti-adhesive) could help extend the roll service. In the present paper, the potential of different PVD coatings (CrN, TiN and TiBN) is explored. The impact of these coatings on influential phenomena during rolling is analysed thanks to well adapted tribological and mechanical laboratory tests. The results show that TiN has a good potential in cold rolling of stainless steel strips.

NAMRC40-7723

HIERARCHICAL DECOMPOSITION BASED APPROACH TO PROCESS DESIGN OF AEROENGINE DISK IN PRESENCE OF DEFECTS

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High societal risks are associated with failure of manufactured products but their processing history is often ignored in the product design and failure analysis. It is assumed that safe life approach will cover for inhomogeneity and randomness in material state and that the multistep manufacturing route can be designed by optimizing shape and property at each individual step. The result of these assumptions has often been unintended catastrophic failure of product in service. This paper presents a novel approach to examine the role of manufacturing defects and their evolution on the life of an aeroengine disk. The life of disk is decomposed into being due to defect state, material state and loading. These states are decomposed into the process physics and further into design parameters affecting them. Advanced numerical models and experimental data are combined in a Bayesian framework involving the data model and the process model and used for the design of the forging process.

NAMRC40-7724

COMPARISON OF DIFFERENT APPROACHES TO FORCE CONTROLLED PRECISION HONING OF BORES

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Honing is a machining process which can economically produce exact bores regarding form, geometry and surface quality. During the honing process the tool, equipped with one or several abrasive honing stones, combines three movement components: rotation, oscillation in axial direction and radial feed movement of the honing stone. The feed movement is a decisive factor for the results of the honing process and can be controlled either by a gradual lining in fixed time intervals or by the regulation of the occurring forces. The presented studies show different approaches for the regulation of force controlled honing and their effects on the measured forces, the torque and the quality parameters of the process.

NAMRC40-7725

A COMBINED EXPERIMENTAL SIMULATIVE METHOD FOR STUDYING THE MATERIAL BONDING OF DIFFERENT ALUMINUM ALLOYS

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There are several production techniques, such as extrusion or friction welding (both friction stir welding and linear friction welding), in which solid state material bonding takes place thanks to the very high pressure and temperature at which the materials are subjected. FEM analysis can be a valid tool to correctly forecast if bonding phenomenon really takes place and how process parameters influence the welding quality, based on a valid welding criterion implemented in the software. Amongst the several welding criteria, the attention was focused on the Piwnik and Plata model saying that the material bonding occurs when the ratio between the interface pressure and the effective stress acting in the material integrated along the time w, reaches a limit value wlim. In the present research the Authors extended their previous studies showing how this value depends on both material type and temperature proposing a procedure for the wlim identification based on a coupled experimental-simulative strategy. In particular,

flat rolling experimental tests of sandwiches made of two rectangular specimens were considered for wlim calculation.

NAMRC40-7727

ALGORITHM FOR TOOL GEOMETRY UPDATING IN 3D FEM ENVIRONMENT CONSIDERING THE TOOL WEAR

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Recent researches showed the possibility of simulating with good accuracy cutting operations by means of FEM software. Typically, cutting operations under orthogonal cutting conditions are considered since the corresponding 2D model allows low computational time. However, when actual cutting operations are considered 3D models must be utilized. This paper deals with tool wear simulation using 3D FEM software. The relevance of simulating tool wear is due to the possibility of studying the influence of process parameters, tool material, tool geometry and workpiece material on tool wear without performing expensive experiments. For this purpose, a subroutine for updating the tool geometry was implemented into Deform 3D FEM software. The developed subroutine estimates wear rates according to analytical wear models and modifies the tool geometry as the wear goes on. In order to improve the accuracy of tool wear simulations, three different tool areas, namely rake, flank and cutting edge, were considered and suitable wear models together with appropriate tool mesh nodes movement strategies were selected for every zone. Preliminary results showing the ability of forecasting tool wear are reported at the end of this paper.

NAMRC40-7728

FLATNESS DEFECTS IN THIN STRIP COLD ROLLING AND THE FRICTION IMPACT ON IT

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Flatness defects are one of the major problems in strip rolling. They are manifested by a wavy shape on the edge, in the center or in between. Waves are most of the time transverse, but all directions can be observed. These defects come from the heterogeneity of the stress field and the resulting buckling of the compressive areas out of the roll bite. This paper is based on the approach proposed by [1-3] and [4], and programmed previously [5-7] in the FEM software LAM3/TEC3 [8]. In the present paper, the latter is enhanced and applied to the impact of friction and strip tension on flatness of a rolled thin strip. The study shows how the optimal setting of Work Roll Bending force (WRB) should be changed when friction varies.

NAMRC40-7731

HIGHLY-EFFICIENT POLISHING TECHNOLOGY FOR GLASS SUBSTRATES USING TRIBO-CHEMICAL POLISHING WITH ELECTRICALLY CONTROLLED SLURRY

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The novel polishing technology developed by the authors has the ability to reduce the cerium oxide abrasives consumption for polishing of glass substrate. This has been realized by introducing tribo-chemical polishing method along with controlled abrasives technique using an AC electric field. In this paper, we attempted to analyze the characteristics of the new polishing from the viewpoint of slurry distribution in the polishing area under various electric fields using a digital image processing and evaluated the polishing performance using the experimental set up for polishing. We confirmed the increase of slurry distribution in the polishing area under the AC electric field. Consequently, the removal rate was enhanced. Furthermore, the removal rate of electrical tribo-chemical polishing technology was 2.5 times higher than the conventional CMP (Chemical Mechanical polishing) method, while the surface roughness was comparable.

NAMRC40-7732

INFLUENCES OF CLAMP DIE GEOMETRY AND FRICTION ON THE CLAMPING PROCESS IN ROTARY DRAW BENDING

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Rotary Draw Bending (RDB) is applied to bend tubes and profiles with thin wall thicknesses and small bending radii. These are used in the automotive, chemical and furniture industry, for example. The determination of process parameters is done empirically or by FE-Analyses (FEA), so far. The required bending moment has to be transmitted by the clamp dies to the tube. Only by a correctly adjusted clamping force slipping of the tube through the clamp dies or inadmissible deformation can be prevented. For an analytical determination of the clamping force influences like friction and geometry of the clamp dies have to be considered. These influences are determined by calculations, FEA and experiments.

NAMRC40-7734

EFFECT OF GREEN MACHINING ON DISTORTION AND SURFACE FINISHING IN ADVANCED CERAMIC

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Advanced ceramics machining is generally carried out in order to correct distortions in pieces after sintering. Thus, grinding with diamond grains is commonly used under low material removal rates. Turning can also be used in ceramic machining, but its material removal must be fairly narrow, with nanometer depth of cut, which if exceeded changes the removal regime from ductile to brittle. An alternative is the machining of ceramic workpiece on the green state, which presents easy machining without the introduction of harmful defects to its mechanical resistance. However, after sintering there are invariably distortions caused by the heterogeneous distribution of density gradients, which are located in the most outlying portions of the workpiece compacted. In the attempt to minimize these density gradients, this study examined the influence of different allowance values removed and the corresponding distortion after sintering. Alumina specimens with 99.8 % purity were used for these tests, with allowances of 1.0, 2.0, 3.0, 4.0 and 5.0 mm removed by turning using a cemented carbide tool. The machining condition was kept constant during the tests and its value corresponds to the condition that produced the lowest damages on the specimen surface. Besides distortion, other output variables were analyzed, such as tool wear, cutting force and surface roughness of green ceramics and sintered. In relation to sintered specimens distortion, the results showed a reduction of up to 81.4% when the largest allowance value was removed from the green workpiece.

NAMRC40-7735

APPLICATION OF AXIOMATIC DESIGN PRINCIPLES TO IDENTIFY MORE SUSTAINABLE STRATEGIES FOR GRINDING

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It has become increasingly important for manufacturers to implement sustainability into tool and process design. Existing models that evaluate the sustainability of abrasive processes focus mostly on case studies of selected energy and resources streams and rarely contain holistic process models. This study uses basic principles of axiomatic design to fundamentally describe grinding technology in a way that can be used for life cycle assessment. The functional requirements of the machining process are linked to process, tool, and coolant design parameters based upon common process understanding. But, these connections leave space for future quantitative and qualitative formulae. Sustainability metrics are then connected to the axiomatic process model. This work represents a first effort in developing this type of model. Finally, the model is used to qualitatively evaluate the impact of grit size on process sustainability showing that the method is feasible to identify strategies to increase sustainability in grinding.

NAMRC40-7736

ADVANCES IN PREDICTING DAMAGE EVOLUTION AND FRACTURE OCCURRENCE IN METAL FORMING OPERATIONS

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The paper reports the latest trends in prediction of damage evolution and fracture occurrence during metal forming processes. Both energy-based and Continuum Damage Mechanics-based models are outlined and applications of the two approaches are presented. In particular, three application cases, which may be characterized by fracture events, are discussed: i) a cold forging sequence, where a fracture criterion is utilized in combination with a damage accumulation law; ii) a hot stamping operation conducted on high strength steel sheets, where the Continuum Damage Mechanics approach is used instead of the conventional one based on Forming Limit Curves; iii) a hot rolling operation, where the Lemaitre law is modified to take into account the influence of the temperature and initial microstructure.

NAMRC40-7737

ULTRASONIC VIBRATION ASSISTED NANOMACHINING ON PMMA WITH AN AFM

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This paper presents an ultrasonic vibration assisted nanomachining technique using an AFM, which enables high-rate tunable fabrication of nanoscale features. An ultrasonic z-vibration of the sample and the resulting ultrasonic force are utilized to regulate machining depth. A high frequency in-plane circular vibration is introduced between the tip and the sample to improve the speed of nanomachining and control the width of the machined features. Slot with widths spanning from tens of nm to hundreds of nm are fabricated in one scan. A lithography speed of 100μm/s can be achieved, which is significantly higher than other known mechanical modification based nanolithography. Furthermore, the machined patterns are transferred to silicon through reactive ion etching process.

NAMRC40-7738

PROCESS ENERGY ANALYSIS AND OPTIMIZATION IN SELECTIVE LASER SINTERING

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Layered Manufacturing (LM) processes are increasingly being used to manufacture complex precision parts for the automotive, aerospace and medical industries. One of the most popular LM processes is the Selective Laser Sintering (SLS) process which manufactures parts by sintering metallic, polymeric and ceramic powder under the effect of laser power. The laser energy expenditure of SLS process and its correlation to the geometry of the manufactured part and the SLS process parameters, however, have not received much attention from LM/SLS researchers. This paper presents a mathematical analysis of the laser energy required for manufacturing simple parts using the SLS process. The total energy expended is calculated as a function of the Total Area of Sintering (TAS) using a Convex Hull based approach and is correlated to the part geometry, slice thickness and the build orientation. The TAS and laser energy are calculated for three sample parts and the results are provided in the paper. Finally, an optimization model is presented which computes the minimal TAS and energy required for manufacturing a part using the SLS process.

NAMRC40-7740

EFFECTS OF PROCESS CONDITIONS ON NANO-DOT ARRAY FORMATION BY THERMAL DEWETTING

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In this paper, three kinds of self-organization processes for metal nano-dot array fabrication are compared; one is the conventional thermal dewetting, another is thermal dewetting of a grid patterned deposited metal layer, the other is thermal dewetting of a metal layer deposited on a patterned substrate. In these processes, nano plastic forming technique is utilized for patterning of groove grid. Effects of process conditions on nano-dot formation, such as substrate material, deposited metal, thickness of deposited layer, annealing condition, are experimentally studied. Also, effect of grid patterning on improvement of nano-dot array formation is studied. It is shown that thermal dewetting of a grid patterned deposited metal layer is advantageous to improve alignment and configuration of nano-dot array.

NAMRC40-7741

A COMBINED DYNAMIC PROGRAMMING / FINITE ELEMENT APPROACH FOR THE ANALYSIS AND OPTIMIZATION OF MULTI-STAGE DEEP DRAWING OF BOX-SHAPED PARTS

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Abdalla Wifi — Cairo University

In this paper, traditional process design rules for deep drawing of box shapes are used to develop constraints within a dynamic programming (DP) approach to generate a set of alternative optimized process plans that minimize the number of drawing stages and heat treatments. The DP approach is capable of scanning a wide range of different alternative values for process parameters which allows for generating more rational process plans compared to a traditional rule-based (RB) approach. The validation of the process parameters for the multi-stage deep drawing of box-shaped parts are investigated using the finite element method with full account of formability limits. This careful finite element analysis guides the selection of the appropriate optimized process plan leading to the least severity of deformation. Two case studies are presented which suggest that the combination of DP and finite element validation could be a valuable, reliable and a more rational computer aided process planning (CAPP) approach to this complicated problem.

NAMRC40-7742

MULTI-MATERIAL FABRICATION OF TISSUE ENGINEERING SCAFFOLD

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Three-dimensional (3D) porous structures facilitating cells attachment, migration, growth, differentiation, proliferation is critical to tissue engineering application in terms of biocompatibility, mechanical integrity and degradation rate. We present a multi-nozzle-based versatile deposition approach to flexibly fabricate scaffolds with distinct polymeric biomaterials such as thermoplastic and photo-crosslinkable polymers. The fabrication platform and process enable the integration different biomaterials into a single scaffold structure, which offers new capabilities to optimize the mechanical property and degradation rate. In this study, we present the development of the deposition system and fabrication of the scaffolds with different types of biomaterials in one layer and different layers. Besides the direct fabrication of thermoplastic PCL scaffolds, we specifically develop a layer molding approach for the fabrication of crosslinkable polymers, which traditionally can only be fabricated by stereolithography. The approach is capable of multiple

materials scaffold fabrication, in which a sacrificial thermoplastic supporting material (paraffin wax with modifier) is deposited. Then the photo-crosslinkable polymers are cured by UV light. The supporting materials can be removed later on to produce a porous scaffold without damage the integrity of the function materials.

NAMRC40-7743

A STUDY ON OPTIMAL MACHINE SETUPS USING AN ENERGY MODELING APPROACH

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In this paper, energy models are developed based on the kinematic and dynamic behaviors of chosen machine tools. One significant benefit of the developed energy models is their inherited relationship to the design variables involved in the manufacturing processes. Therefore, they can be readily applied to optimize process parameters to reduce energy consumption. A new parallel kinematic machine Exechon is used as a case study to demonstrate the procedures of energy model development with direct relation to appropriate process parameters. The derived energy model is then used for simulation of drilling operations on aircraft components to demonstrate its feasibility. Simulation results indicate that the developed energy model has led to an optimized machine setup which only consumes less than one-third of the energy of an average machine setup over the workspace. This approach can be extended and applied to other machines to establish their energy models for green manufacturing.

NAMRC40-7744

UPDATED MECHANISTIC FORCE MODEL TO ACCOUNT FOR RAPID TOOL WEAR WHEN MILLING NICKEL-BASED SUPERALLOYS

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Nickel-based superalloys are continuously being developed and used in applications where strength, oxidation and corrosion resistance, and creep resistance are critical while operating at high temperatures. The material properties which make these materials beneficial for those applications also make the materials much more difficult to machine than other more common materials, such as steel and aluminum. Limited research has been done in the area of modeling the forces incurred while machining nickel-based superalloys, even less in milling. Due to the critical nature of these components in operation, accurate process modeling is necessary so that these components can be manufactured with high quality while maintaining a competitive cost. Due to the extremely low machinability of these materials, traditional modeling approaches need to be revisited and modified in order to be applied to these non-traditional materials. This paper presents a modification to the common mechanistic cutting force model in milling. The proposed model accounts for the tool wear incurred during the machining of a nickel-based superalloy and shows promising results in comparison with actual forces measured during the machining operation.

NAMRC40-7745

FINITE ELEMENT MODELING AND SIMULATION OF MICRO-MILLING

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Mechanical micro-machining process such as micro-milling process is a promising fabrication process allowing miniaturization of conventional products and innovation of brand new micro-products. The advance of mechanical micro- machining process ultimately depends on the development of cutting tool since it is a tool-based process. Therefore, in this study an attempt to improve the performance of carbide micro-end mills using cBN coating was carried out. The 2-D finite element modeling (FEM) was used to simulate the effects of cBN coated micro-end mills in micro-machining of Ti-6Al-4V. Cutting forces, tool and workpiece temperature and tool wear obtained from FEM simulations were studied. Experiments were also conducted to verify the simulation results. The study clearly showed that cBN coated carbide tool outperformed the uncoated carbide tool in terms of tool wear surface roughness and cutting temperature.

NAMRC40-7746

NANOSECOND PULSED LASER MICRO-MACHINING OF PMMA-BASED MICROFLUIDIC CHANNELS

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Thanangsak Thepsonthi — Rutgers University
Tugrul Özel — Rutgers University

This paper reports an investigation on the effects of nanosecond laser processing parameters on the depth and width of microchannels fabricated from polymethylmethacrylate (PMMA). The Nd:YAG solid-state pulsed laser has a wavelength of 1064 nm and a measured maximum power of 4.15 W. The laser processing parameters are varied in a scanning speed range of 400 to 800 pulses/mm, a pulse frequency range of 5 to 11 Hz, a Q-switch delay time range of 170 to 180 µs. Main effects plots and microchannel images are utilized to identify the effects of the process parameters for improving material removal rate and surface quality simultaneously for laser micromachining of microchannels in PMMA polymer. It is observed that channel width and depth decreased linearly with increasing Q-switch delay time (hence average power) and increased non-linearly with increasing scanning rate and not much affected by the increase in pulse frequency.

NAMRC40-7749

PARAMETRIC GLASS MILLING WITH SIMULTANEOUS CONTROL

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Mitsuo Kakishita — Tokyo Denki University

Parametric glass milling is presented to machine complex channels on the glass plates for manufacturing micro testing devices. An end mill traverses in the linear motion during the workpiece rotation, which are synchronized by simultaneous control. The glass milling is controlled by 4 parameters in a mathematical model without NC program. Based on the principle of the parametric machining and the effect of the cutter axis inclination on the cutting process, a milling machine tool was developed to perform the parametric glass milling with an inclined ball end mill. The cutter axis inclination and the actual feed rate are associated with the maximum feed rate, at which a crack-free surface is finished, for the given cutting parameters. As a machining example, a periodical circular channel is machined with a transparent surface by simultaneous control.

NAMRC40-7750

EFFECT OF MACHINING ON TENSILE STRENGTH OF COMPOSITE LAMINATES

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Finish machining is often required to bring composite components to final dimensionla specifications. However, due to the inhomogeneous nature of these materials, their machining may generate undesirable defects such as delamination and surface roughness. These effects may result in compromising the meachanical strength of the machined component. In this work an experimental investigation was conducted to determine the effect of spindle speed, feed rate and tool condition on machining quality of CFRP laminates during edge trimming operation. Machining quality was quantified in terms of delamination depth and surface roughness. Delaminations were also characterized by their type and frequency of occurrence. Tensile tests were also conducted on machined samples to determine their tensile strength. Correlations were made between delamination depth and tensile strength. It was found that machining conditions which promote delamination also result in reducing the tensile strength of the machined sample.

NAMRC40-7753

INVESTIGATION OF THE FISHTAIL DEFECT IN RING ROLLING BY A FEM APPROACH

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Claudio Giardini — University of Bergamo

The fishtail defect is one of the most critical problem that occurs in a ring rolling process. This defect is generated by the pressure of an idle roll that forces a ring toward a driver roll and it results in a non uniform cross section of the produced ring. In this work the fishtail defect is investigated as a function of the process parameters by means of FEM approach. Several simulations were performed in order to evaluate a regression model able to predict the fishtail defect. Moreover, in order to optimize the process, two regression models were evaluated to estimate the idle roll compression load and the driver roll torque. Starting from the regression models an optimization of the process was computed to evaluate a set of process parameters that minimizes an objective function taking into account: the fishtail defect, the production time, the idle roll compression load and the driver roll torque. Results were found to be in good agreement with the numerical and predicted results.

NAMRC40-7755

SIZE EFFECT AND DUCTILE-TO-BRITTLE TRANSITION OF ANNEALED AISI D2 STEEL BY SHPB TEST OF HAT-SHAPED SPECIMEN

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Yiming Rong — Tsinghua University

Quasi-static and dynamic impact tests of hat shaped specimen of annealed AISI D2 steel with three different widths of shear zone (800um, 400um, 50um) were performed by electronic universal testing machine and split Hopkinson pressure bar (SHPB). It was found that the shear zone width of specimen obviously influenced the flow stress and failure strain of annealed AISI D2 steel. The flow stress and failure strain of material increased with the decrease of the width of shear zone, namely “size effect” phenomenon. The extent of “size effect” fell down with the increase of strain rate. The strain rate and temperature greatly influenced the generation of shear failure surface of hat-shaped specimens. Very smooth surface may be generated at the specified strain rate during impact process.

NAMRC40-7756

RECENT DEVELOPMENTS IN NON-CONVENTIONAL TUBE FORMING

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Modern vehicles emphasize lightweight design like never before. In order to manufacture lightweight structures, used for frames and drive trains, tube forming processes can be used. But the application of modern, high strength materials to complex geometries and design requirements leads to a limited application of many processes. This challenge is increased by the consumer-driven demand of individualization, which leads to the requirement of flexible forming processes. To provide solutions, research activities are focused either on the development of fully new processes or a fundamental investigation of already known but non-conventional processes in order to make them more robust and economically viable. In this paper three non-conventional processes are presented for tube compression and expansion: spinning, hydroforming and electromagnetic forming. After a presentation of the process principals all three processes are explained in terms of applicability. Individual advantages and gaps of knowledge are mentioned comprehensively. After that some recent enhancements of all three processes partially developed by the authors are presented.

NAMRC40-7757

ORTHOGONAL CUTTING OF AISI D2 STEEL WITH TIALN COATED INSERTS: SIMULATIONS AND EXPERIMENTS

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This paper presented a finite element simulation model for the analysis of AISI D2 steel turning with TiAlN coated inserts. In this study, material constitutive model of hardened AISI D2 steel (HRC62) was built based on power law relationship, which was used in the FEM codes to describe the effect of strain, strain rate and temperature on the material flow stress. A damage model was employed to predict the chip separation. Cutting edge radius and thickness of TiAlN coating were obtained by micro-optical system and SEM, respectively. The average friction coefficients were obtained by ball-on-disc friction test using UMT-2 high speed tribometer. Numerical simulations of AISI D2 steel turning were performed using AdvantedgeTM software. The simulated results of forces and chip morphology showed good agreement with the experimental results, which validated the precision of the process simulation method. The shear stress on the interface between coating and substrate of cutting tool was analyzed. And the maximal shear stress between coating and substrate was found on the cutting edge roundness near the flank face of cutting tool.

NAMRC40-7758

PROCESS DAMPING ANALYTICAL STABILITY ANALYSIS AND VALIDATION

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This paper describes an analytical solution for turning and milling stability that includes process damping effects. Comparisons between the new analytical solution, time-domain simulation, and experiment are provided. The velocity-dependent process damping model applied in the analysis relies on a single coefficient similar to the specific cutting force approach to modeling cutting force. The process damping coefficient is identified experimentally using a flexure-based machining setup for a selected tool-workpiece pair (carbide insert-AISI 1018 steel). The effects of tool wear and cutting edge relief angle are also evaluated. It is shown that a smaller relief angle or higher wear results in increased process damping and improved stability at low spindle speeds.

NAMRC40-7759

EXPERIMENTAL STUDY OF CONVENTIONAL AND PECK DRILLING OPERATIONS

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This paper presents a comparative machinability study of conventional and peck drilling. Conventional drilling tests of Al 6061 were performed using 10 mm diameter HSS drills and the peck drilling tests were performed in three steps of 10 mm each. The generated surfaces were examined and the surface roughness values were measured and used in the comparative study. Similar drills and cutting conditions were used in both conventional and peck drilling tests. Behavior of cutting forces has also been analyzed in close reference to surface roughness. The results acquired in this work will help in understanding the complex surface roughness trends involved in different steps of peck drilling operations.

NAMRC40-7760

EMBEDDING SHAPE MEMORY ALLOW ACTUATORS IN MINIATURE ARTICULATING POLYMER STRUCTURES USING IN-MOLD ASSEMBLY

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Fabrication and assembly of highly articulating structures has been a challenge for manufacturing engineers for several years. This challenge is further enhanced when the structures are in the miniature size scales. As part of our previous work, we have developed a process called in-mold assembly to tackle this challenging manufacturing and assembly task. However, attaching the actuators to such miniature structures remains a challenging task and can be expensive in terms of costs. In this work, we will demonstrate a single step in-mold assembly method to fabricate miniature multi degree of freedom (DOF) mechanical devices with embedded SMA actuators. We have developed design optimization methods to shield the SMA actuators from the thermal cycles seen during the injection molding process. This is done to minimize thermal impact on the SMA actuators during embedding in in-mold assembled articulating joints. We have also developed experimental methods to calibrate the force and position of the embedded SMA actuators with respect to temperature. Our experimental results indicate that the SMA behavior is very repeatable with respect to temperature. Hence temperature can be used as a sensory feedback for position and force control. Using the approaches developed as part of this work, we have successfully fabricated an in-mold assembled multi DOF miniature robot with embedded SMA actuators.

NAMRC40-7761

ANALYTICAL PREDICTION OF STEPPED FEATURE GENERATION IN MULTI-PASS SINGLE POINT INCREMENTAL FORMING

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Single Point Incremental Forming (SPIF) is a new sheet metal forming process characterized by higher formability, product independent tooling and greater process flexibility. The inability of conventional single pass SPIF to form vertical walls without failure is overcome by forming multiple intermediate shapes before forming the final component, i.e., Multi-pass Single Point Incremental Forming (MSPIF). A major issue with MSPIF is significant geometric inaccuracy of the formed component, due to generation of stepped features on the base. This work proposes analytical formulations that are shown to accurately and quantitatively predict stepped feature formation in MSPIF. Additionally, a relationship is derived between the material constants used in these analytical equations and the yield stress and thickness of the blank material, so that computational effort required for calibration of these constants can be minimized. Finally, the physical effects of the yield stress and the sheet thickness on the rigid body translation are further discussed.

NAMRC40-7764

WHITE LAYER THICKNESS FORMATION IN ELECTRO DISCHARGE MACHINING OF BERYLLIUM-COPPER ALLOYS

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The Beryllium-Copper (Be-Cu) alloys are high-reliability engineered materials preferred for several applications in various industries that require usage of materials of high impact strength and excellent electrical conductivity. Electro discharge machining (EDM) is a potential method to avoid the toxicity related issues in the machining of Be-Cu alloys. The undesirable, but inevitable, white layer formation in EDM needs to be understood and accurately determined to efficiently perform post treatment processes for removing the white layer caused by the EDM process. In this study, white layer thickness data obtained from the experimental study was modeled, and analyzed by image processing technique. A second order difference equation model has been found to be statistically adequate for modeling and forecasting of white layer thickness profiles.

NAMRC40-7765

FINITE ELEMENT MODELING OF MICROSTRUCTURAL CHANGES IN TURNING OF AA7075-T651 ALLOY AND VALIDATION

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The surface characteristics of a machined product strongly influence its functional performance. During machining, the grain size of the surface is frequently modified, thus the properties of the machined surface are different to that of the original bulk material. These changes must be taken into account when modeling the surface integrity effects resulting from machining. In the present work, grain size changes induced during turning of AA 7075-T651

(160 HV) alloy are modeled using the Finite Element (FE) method and a user subroutine is implemented in the FE code to describe the microstructural change and to simulate the dynamic recrystallization, with the consequent formation of new grains. In particular, a procedure utilizing the Zener-Hollomon and Hall-Petch equations is implemented in the user subroutine to predict the evolution of the material grain size and the surface hardness when varying the cutting speeds (180 - 720 m/min) and tool nose radii (0.4 - 1.2 mm). All simulations were performed for dry cutting conditions using uncoated carbide tools. The effectiveness of the proposed FE model was demonstrated through its capability to predict grain size evolution and hardness modification from the bulk material to machined surface. The model is validated by comparing the predicted results with those experimentally observed.

NAMRC40-7766

THE EFFECT OF OVERLAP PERCENTAGE ON SURFACE QUALITY IN LASER POLISHING OF AISI H13 TOOL STEEL

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Polishing by laser beam radiation is a novel technique used to modify the initial surface geometry in order to achieve a desired level of surface finish. The performance of laser polishing (LP) is determined by its process parameters, whose optimum combination is essential for achievement of the best possible surface quality. In this regard, the overlap percentage is one of the important LP settings, which indicates the level of the overlap between two consecutive polishing tracks. In the current study, the effects of overlap percentage were experimentally investigated in the context of AISI H13 tool steel LP operations. Four surface areas were polished using four different overlap percentages but the same applied energy density. The improvement of surface quality was measured by average spatial surface roughness and material ratio function. The surface quality improvement was also analyzed by means of statistical analysis using the autospectrum and the transfer functions. Finally, the polished area created by the optimum overlap from the aforementioned analyses was further processed by an additional level of LP improving a total average surface roughness from 1.59um to 0.18um (89% improvement).

NAMRC40-7767

MAPPING MICROSTRUCTURES FROM SEVERE PLASTIC DEFORMATION IN MACHINING

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Surface generation by chip formation in machining involves unique Severe Plastic Deformation conditions characterized by superposition of large strains, strain-rates and thermomechanically coupled temperatures. Here, we use plane-strain machining itself as a test of microstructure response to create a knowledge-base of how thermomechanical conditions map to the quantitative characteristics of the deformed microstructure. To accomplish this, the mechanics of the deformation zone are characterized using digital image correlation and infrared thermography, followed by electron microscopy of the resulting chips. Ultimately, we propose Rate-Strain-Microstructure (RSM) map that is parameterized as functions of the strain, strain-rate and temperature, onto which the crystallographic characteristics of the deformed grain structure are projected. The RSM space is characterized by the x-axis as the Zener-Hollomon parameter and y-axis as the effective deformation strain. The implications of resulting mappings for microstructure prediction, control as well as for custom-designing refined surface microstructures, directly using machining are outlined.

NAMRC40-7768

CHIP MORPHOLOGY CHARACTERISTICS DURING DRY DRILLING OF AUSTEMPERED DUCTILE IRON (ADI)

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Drilling is considered as a complex three-dimensional cutting process involving variations in cutting speed and rake angle along the cutting edge. The present paper investigates the effect of cutting parameters on chip morphology characteristics, chip compression ratio and its micro-hardness during dry drilling of austempered ductile iron (ADI). The chip morphology characteristics were examined using an optical microscope and a scanning electron microscope (SEM). Shear induced lamella structure was observed at the chip-free surface at higher cutting speed. Chip micro-hardness and chip compression ratio (CCR) values were calculated for all cutting conditions to investigate the influence of cutting parameters on plastic deformation of ADI during its transformation to chips. The obtained results show good relationship between the chip micro-hardness, CCR, cutting parameters and chip morphology.

NAMRC40-7769

SPRINGBACK PREDICTION IN BENDING OF AHSS-DP 780

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Forming of AHSS creates several challenges because these materials have higher strength and lower formability compared to low carbon steels. One of these challenges is springback that leads to dimensional inaccuracy in the formed part. In the present study, the effect of unloading apparent modulus (E- modulus) variation with strain on the accuracy of springback prediction in V-die bending and U-bending of DP 780 is investigated. A reliable methodology to measure springback which is very important is developed. Load-unload tensile tests were performed to obtain unloading apparent modulus variation. Springback in V-die bending and U bending was estimated by using FEA and a variable E-modulus. Compared with experimental data, the predictions gave reasonably accurate results.

NAMRC40-7770

IMPROVEMENT OF TOOL LIFE AND PRODUCTION EFFICIENCY IN CONTINUOUS GRAIN FLOW FORGING OF DIESEL ENGINE CRANKSHAFTS

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In the face of continuing global competition, an efficient and cost competitive forging process is critical to maintain an advantage in the marketplace. Besides efficient shop-floor management, computational simulation is one of the key requirements for a) reducing lead-time to market, b) improving tool life and product quality, and c) improving material yield. The main focus of this paper is to summarize current approaches for improvement of tool life and production efficiency in continuous grain flow (CGF) forging of crankshafts using a combination of computational simulation and production validation. Ellwood National Crankshaft (ENC) has two horizontal multi-directional hydraulic presses for CGF forging. The die failure modes observed in this process tend to be primarily thermal fatigue and wear with localized plastic deformation in some regions. The root causes of die failure and quality issues were initially identified using fishbone/Ishikawa diagrams. A computational analysis approach is being developed in order to determine the die-workpiece interface conditions at a) start of production assuming a uniform pre-heat temperature on the dies and b) under steady-state production conditions. The latter approach involves repetitive simulations of discrete process steps (deformation, part transfer, lubrication, etc.). Alternative die materials are being compared on the basis of their elevated temperature thermal (thermal expansion and conductivity) and mechanical (hot hardness and hot yield strength) properties. Additionally, die stress analysis is being used for selection of die materials for production trials. Other approaches for improving tool life include optimization of the upset-offset movement profiles for reduction of contact time while ensuring required die fill. The application of computational simulation for induction heating, induction hardening and heat treatment (residual stress prediction) is also being explored. The application of these methods along with efficient shop-floor management is critical for maintaining a competitive edge in the global marketplace.

NAMRC40-7771

TOOL WEAR OF ULTRA-HARD COATINGS IN DRILLING CFRP

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This study was aimed to investigate the effect of the ultra-hard coatings on drilling forces and tool wear when drilling carbon fiber reinforced composites (CFRP). Three different types of drills were used in the drilling experiments: uncoated, boron-aluminum-magnesium (BAM) coated and diamond coated carbide (WC-Co) drills. The experimental results showed that tool wear in CFRP machining was primarily due to edge rounding. With the uncoated carbide drills, the cutting edge becomes dull as the carbide grains gradually wear flat and become thinner before finally dislodging. The diamond coating and BAM coating also have gradually worn. The diamond-coated drill has performed superior over the other drills while the BAM coating, despite of its high hardness, did not protect the tool from edge rounding. The edge rounding wear in BAM coated WC drill is relatively similar or slightly better than that of the uncoated carbide drill. Wear progression of ultra-hard coated WC drills are introduced and the tool wear mechanisms are discussed.

NAMRC40-7772

NEW DEVELOPMENTS IN THE FE SIMULATION OF CLOSED DIE FORGING PROCESSES

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Hot forging dies are exposed to a combination of cyclic thermo-mechanical, tribological and chemical loads. Both, wear on the tool surface as well as fatigue crack initiation are the most frequent causes of tool failure. An integral part of the process design and optimization is the FEA based geometry optimisation of forging tools aiming at service life maximisation. So far, the FE-based

estimation of the tool life quantity and the critical wear amount is done in a restricted manner as the cyclic die material behaviour is not described with the required accuracy. Therefore, thermo-mechanical fatigue tests were carried out in the present study in order to characterize and describe the cyclic fatigue and material behaviour of tool steels. Moreover, a model for wear estimation that considers thermal effects on the hardness of the tool material was introduced. As friction modelling plays a major role in FEA of forging processes, an improved friction model has been used. The applied model is able to represent the frictional stress between forged parts and dies realistically, since it considers the varying stress state between the contact pairs

NAMRC40-7773

A NOVEL DESIGN OF PARALLEL COMPLIANT MICRO-MOTION STAGES WITH KINEMATOTROPIC PROPERTIES

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A novel design methodology for parallel compliant micro-motion stages is presented. Conventional parallel motion-stages have permanent/unchangeable output motion states once their topological structure is determined. However, practical output motion requirements can be different for a given mechanism. Thus, a type of novel design of parallel compliant micro-motion stages with variable output motion properties is developed. The newly proposed design process can be subdivided into four steps: (1) determination of multiple output motion states according to different requirements; (2) individual design of the parallel structures corresponding to the different output motion states; (3) combinatorial variable constraint design of sub-chains with determined constraints of the different output motion states; (4) actuation and optimization of the integrated topological parallel structure in accordance with manufacturing limitations of the parallel compliant micro-motion stages. To demonstrate the applicability of the proposed design process, three illustrative cases are developed and presented.

NAMRC40-7774

PREDICTIVE MODELING FOR GLASS-SIDE LASER SCRIBING OF THIN FILM PHOTOVOLTAIC CELLS

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Laser scribing of multilayer thin films is an important process for producing integrated serial interconnection of mini-modules, used to reduce photocurrent and resistance losses in a large-area solar cell. Quality of such scribing contributes to the overall quality and efficiency of the solar cell and therefore predictive capabilities of the process are essential. Limited numerical work has been performed in predicting the thin film laser removal processes. In this study, a sequentially-coupled multilayer thermal and mechanical finite element model is developed to analyze the laser-induced spatio-temporal temperature and thermal stress responsible for SnO2:F film removal. A plasma expansion induced pressure model is also investigated to simulate the non-thermal film removal of CdTe due to the micro-explosion process. Corresponding experiments on SnO2:F films on glass substrates by 1064nm ns laser irradiation show a similar removal process to that predicted in the simulation. Differences between the model and experimental results are discussed and future model refinements are proposed. Both simulation and experimental results from glass-side laser scribing show clean film removal with minimum thermal effects indicating minimal changes to material electrical properties.

NAMRC40-7775

INVESTIGATIONS IN SUBSURFACE DAMAGE WHEN MACHINING NICKEL-BASED SUPERALLOYS

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Advanced superalloys were developed for high performance systems such as jet engines, internal combustion engines and gas turbines. Their excellent properties are given by specifically designed grain structure. Unfortunately, the structure is deformed during machining. Too much deformation generated results in components with low mechanical integrity and reduced in-service life. Experimental investigations indicated that the machining affected zone or subsurface damage formation for nickel-based superalloys is an atypical phenomenon; its dependence on the process parameters is fundamentally different from the conventional materials. This research investigates subsurface damage formation in orthogonal cutting tests performed on nickel-based superalloys, followed by empirical and numerical modeling. The simulations are used to estimate the depth of the subsurface damage and compare to the experimental results.

NAMRC40-7777

EFFECT OF APPLIED LOAD, CUTTING SPEED AND LASER POWER ON THE MATERIAL DEFORMATION AND REMOVAL OF SEMICONDUCTORS

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Semiconductors such as silicon (Si) and 4H silicon carbide (SiC) are increasingly being used for industrial applications as they are

are hard, strong, inert, light weight and have great optical and electrical properties. Manufacturing these materials without causing surface and subsurface damage is extremely challenging due to their high hardness, brittle characteristics and poor machinability. However, ductile regime machining of these materials is possible due to the high pressure phase transformation (HPPT) occurring in the material caused by the high compressive and shear stresses induced by the single point diamond tool tip. To further augment the ductile response of the machined material, traditional single point scratch tests are coupled with a micro-laser assisted machining (μ-LAM) technique. This paper discusses the effect of machining parameters such as the applied load (depth of cut), cutting speed and laser power on the material deformation and removal of single crystal Si and 4H-SiC.

NAMRC40-7779

ENERGY DISSIPATION, MICROSTRUCTURE AND HARDENING IN CRYOGENIC MACHINING

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The effects that flood-type cryogenic lubrication have on the machining of copper are investigated. Strains of 1-7, strain rates of 1 to 1000 per second and temperatures as low as 77K were used to determine the interactive effects that deformation parameters have on energy dissipation, evolution of microstructure and mechanical properties. It is shown that deformation temperature and strain had the strongest influence on the energy dissipated, while strain rate had a somewhat less significant contribution. Furthermore, a range of severe plastic deformation (SPD) microstructures were developed in the deformed copper depending on the conditions used - these include cellular, elongated, equiaxed and twinned types. These microstructure have direct consequence for understanding the resulting microstructures of the machined surface. These observations offer insight into developing an understanding of the effects that cryogenic lubrication have on the energetics of processing as well on surface integrity.

NAMRC40-7780

BALL END MILLING MECHANISTIC MODEL BASED ON A VOXEL-BASED GEOMETRIC REPRESENTATION AND A RAY CASTING TECHNIQUE

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Prediction of machining forces involved in complex geometry can be valuable information for machine shops. This paper presents a mechanistic cutting force simulation model for ball end milling processes, using ray casting and voxel representation methods used in 3D computer graphics arena. Using this method, instantaneous uncut chip cross sectional areas can be extracted, which can be used in cutting pressure coefficient extraction and machining simulation including machining forces and geometry of the workpiece. The major advantage of the proposed scheme is that it can simulate the milling processes with arbitrary cutting tool geometry on a workpiece with complex geometry without added computational cost. A series of cutting experiments were carried out to validate the model.

NAMRC40-7781

PERFORMANCE VALIDATION OF A MICRO QUICK-STOP DEVICE

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Chip removal is one of the most flexible and widely exploited processes in the microscale, but it is still not completely understood and controlled since the process cannot be effectively described simply downscaling macroscale models because of several occurring phenomena. The so-called quick-stop experiments are an invaluable support to study the tool-material interaction in the microscale, since they allow to freeze the chip formation in its regime condition by abruptly stopping the cutting action. A new quick-stop device (QSD) has been designed by the authors to be used within the typical microscale cutting requirements; an especially developed sensor has been used to validate the device by means of suitable indexes.

NAMRC40-7783

MACHINING ASSESSMENT OF NANO-CRYSTALLINE HYDROXYAPATITE BIO-CERAMIC

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Hydroxyapatite (HAP) is a widely used bio-ceramic in the fields of orthopedics and dentistry. This study investigates the machinability of nano-crystalline form of HAP (nHAP) bio-ceramic in end milling operations, using uncoated carbide tool under dry cutting conditions. Efforts are focused on the effects of various machining conditions on surface integrity. A first order surface roughness model for the end milling of nHAP was developed using response surface methodology (RSM), relating surface roughness to the cutting parameters: cutting speed, feed and depth of cut. Model analysis showed that all three cutting parameters have significant effect on surface roughness. However the current model has limited statistical predictive power and a higher order model is desired. Furthermore, tool wear and chip morphology was studied. Machined surface analysis showed that the surface integrity was good, although material removal is caused by brittle fracture without plastic flow.

NAMRC40-7784

JOINT DYNAMICS MODELING AND IDENTIFICATION

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Complex structures, such as machine tools and automotive and aerospace structures, are comprised of several substructures connected to each other through joints to fabricate the assembled structures. Joints can have significant contributions on the behavior of the overall assembly: ignoring joint effects in the design stage may result in considerable deviations from the actual behavior. The identification of joint dynamics enables us to accurately predict overall dynamics by mathematically combining substructure dynamics through the equilibrium and compatibility conditions at the joint. The essence of joint identification is the determination of the difference between the measured overall dynamics and the rigidly coupled substructure dynamics. In this study, we investigate the inverse receptance coupling (IRC) method and the point-mass joint model, which considers the joint as lumped mass, damping and stiffness elements. The dynamic properties of the joint are modeled using both methods and investigated through simulations. Experimental verification tests are performed on cylindrical modular tools.

NAMRC40-7785

INVESTIGATION OF THE EFFICIENCY OF JOINT DESIGNS FOR THE ELECTRO-MAGNETIC WELDING (EMW) OF THE RING-SHAFT ASSEMBLY

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In this study, the joint efficiency of electro-magnetic welding (EMW) for dissimilar materials was investigated. Two different joint designs, single- and double-flared lap joints, were studied for EWM. Both aluminum 6061-T4 and chromium copper alloy, C40, were used for the driver ring material on the steel shaft that was stationary. The performance of joint was evaluated by push-off testing. Analytical modeling was conducted to estimate the magnetic pressure between the coil and the ring. In experiments, the double-flared lap joint showed better joint efficiency than single-flared lap joint and the copper showed better adhesion than aluminum at same discharge voltages. A double-flared copper ring at 45 KJ gave the best performance of joint, and exceeded the required axial thrust load requirement. From the metallographic analysis, the interface of joint did not show the metallurgical bonding, however, strong mechanical interlocking was achieved.

NAMRC40-7787

FLEXIBILITY IN MANUFACTURING AUTOMATION: A LIVING LAB CASE STUDY OF NORWEGIAN METALCASTING SMES

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Flexibility can be defined as the ability to respond efficiently to the changing demands of the customer and is different in SMEs (Small-to-Medium manufacturing Enterprises) than the traditional OEMs (Original Equipment Manufacturers). Costs involved in implementing manufacturing flexibility to meet customer demand are more important in the SMEs, especially that are labor intensive for example metalcasting companies, when located in a high cost country like Norway. Therefore the Norwegian Research Council initiated the Autocast project to promote SME business cooperation and flexibility by automating the manufacturing processes within the Norwegian casting/foundry SMEs. The project intends to identify and improve the areas crucial for flexible manufacturing to help SMEs stay competitive in global competition. This paper is a review of the current literature of the technological-machine and plant level flexibility parameters in a metalcasting/foundry living lab setup. Although quite a number of flexibility definitions and mechanisms can be found in the literature, there is a lack of standard terms about flexibility. The findings from the living lab case study reveal the use of flexible automation in a consortium collaborative environment could allow for better response to customer needs and support on-the-move interaction collaboration. This paper helps in identifying areas for flexible automation tailored to the needs to foundry SMEs, in which the number of published studies is very limited.

NAMRC40-7789

EXPERIMENTAL INVESTIGATION AND CHARACTERIZATION OF NANO-SCALE DRY ELECTRO-MACHINING

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Present study investigates and characterizes a novel technique of nanoscale electro-machining (EM) in atmospheric air, named dry nano-EM, by using scanning tunneling microscopy (STM) as the platform for nanomachining. The electro-machining has been conducted in near field by maintaining a gap distance of 1-2 nm between the Platinum-Iridium [Pt-Ir (80:20)] tool electrode and atomically flat gold substrate with the air as dielectric medium. An in-situ process of evaluating the tool quality before and after machining has been used by monitoring the current–displacement (I-Z) spectroscopy curves. The mechanism of dry nano-EM has been presented as well as the machining performance of the process has been evaluated. Based on the observations, it has been established that field induced evaporation due to intense heat generated at the gap width is the primary mechanism of material removal in dry nano-EM. The experimental results show that dry

nano-EM is capable of fabricating consistent nano-features with good repeatability. The volume of material removal increases almost linearly with increasing number of features machined and machining time, indicating the consistency in the dimensions of the nano-features. Finally, dry nano-EM is established as a technique capable of machining 50 – 100 features in a pre-defined manner with average feature size of 7.5 – 10 nm in a single shot, thus suitable for nano-patterning in atomically flat conducting surfaces.

NAMRC40-7790

MULTI SENSOR DATA FUSION IN SURFACE AND DIMENSIONAL METROLOGY DOMAINS

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Miniaturization has led to the development of components with micro-scale features which need to be characterized with respect to datum features separated by macro scale distances. This has resulted in a need to combine measurements obtained from multiple magnifications or technologies. Multi-sensor data fusion is used to get more accurate reliable information based on multiple measurements from same sensor or multiple sensors. In this paper, fusion of datasets obtained from coherence scanning interferometer using two different lighting settings is described. Feasibility of fusion of different magnification datasets obtained from a vision system and a coherence scanning interferometer is demonstrated. The advantages of data fusion in characterizing surfaces as well as performing dimensional measurements from a single dataset are detailed.

NAMRC40-7791

TOWARDS CONTROL OF CARBON NANOTUBE SYNTHESIS PROCESS USING PREDICTION-BASED FAST MONTE CARLO SIMULATIONS

Changqing Cheng — Oklahoma State University
Satish Bukkapatnam — Oklahoma State University
Lionel Raff — Oklahoma State University
Ranga Komanduri — Oklahoma State University

Effective control of carbon nanotube (CNT) lengths is important for various industrial applications. The current in situ measurement techniques are expensive, and mostly provide intermittent (~ 1 min) recordings. Atomistic Monte Carlo (MC) simulation of CNT synthesis process can be used to supplement these intermediate measurements with continuous growth estimates, necessary for precise control over lengths and other geometric features. However the current MC models can only simulate early growth stage due to the computational overhead involved. We present an approach to accelerate this MC simulation from a chemical vapor deposition process through predicting the nonlinear and nonstationary growth evolution. The fast MC simulation can be used to monitor length variation of CNTs during synthesis process, and detect the synthesis end-point for desired CNT length. Extensive simulation studies indicate that over 88% of the generated CNTs are within the 95% confidence interval of length specification.

NAMRC40-7792

MICRO FABRICATION ON CYLINDER SURFACE FOR CONTROL OF WETTABILITY

Takashi Matsumura — Tokyo Denki University
Hitoshi Sadakata — Tokyo Denki University
Hiroshi Makihata — Tokyo Denki University

A micro fabrication is presented to control wettability on cylinder surface. A machine tool is developed to machine the micro-scale structure in forming. The stamping tool is manufactured to fabricate the micro-scale structure on the top of the tool in FIB sputtering. The micro forming is repeated with linear and rotational motions. The rotation is controlled by the friction drive on the machine table because of the stable stamping with reducing bending of the workpiece. The critical stamping depth, the minimum depth at which the structures can be formed, is determined in the forming tests using the structured tool. Then, a stripe type structure is formed to change wettability on the cylinder surface. Anisotropic wettability appears on the structured surface.

NAMRC40-7793

EFFECT OF SPECIMEN PLANAR AREA ON ELECTROMAGNETIC FLANGING

Reid VanBenthysen — University of New Hampshire
Brad Kinsey — University of New Hampshire

The specimen parameter that is often mentioned with respect to the ability to achieve electromagnetic forming (EMF) is the specimen thickness. If the skin depth is less than this parameter, deformation will be achieved. However, another parameter that may affect the ability to achieve EMF is the specimen's planar area, i.e., the length and width of the specimen. This would particularly become an important factor if EMF is used to fabricate meso/microscale components. In this research, a flat spiral coil was used to flange 0.508 mm thickness, CuZn30 specimens of varying widths (i.e., 10, 14, 18, 22, 35, and 47 mm). These widths were determined in order to vary the number of coils that are covering the specimen. Since the flat spiral coil isn't symmetric (i.e., one side consists of an additional half coil due to the spiral nature of the geometry), material was overhung on both sides of the die to assess if this caused any differences in flanging. This yielded an extra half coil on the left side of the specimen. Results showed that an increase in the specimen width was generally associated with an increase in forming (i.e., higher flanging angle). Thus, in order to achieve

meso/microforming with EMF, attention to the interaction between coil design and specimen dimensions is required.

NAMRC40-7795

INVESTIGATION OF CARBON NANOTUBE (CNT) NANOCOMPOSITES THROUGH MICRO SCRIBING AND INDENTATIONS

Chaneel Park — University of Calgary
Golam Mostofa — University of Calgary
Mehdi Mahmoodi — University of Calgary
Simon Park — University of Calgary

Polymeric carbon nanotube (CNT) nanocomposites have unique mechanical, electrical, and thermal properties. In this study, a micro indenter-scriber system was developed to perform scribing and indentation experiments on multi-walled carbon nanotube-polystyrene (MWCNT-PS) composites. MWCNT-PS samples with varying CNT concentrations were prepared through the micro injection molding process where injection enabled the partial alignment of CNTs in the flow direction through high shear stress. Scribing experiments were performed in the parallel and perpendicular directions to the CNT alignment. Cutting and thrust forces were measured and investigated the apparent friction coefficients with respect to the CNT concentrations. Small amount of CNT loading (i.e. 0.5 wt.%) on the polymer matrix reduced the apparent friction coefficient compared to the pure and higher concentration CNT composites. We also observed slightly higher forces when we scribed 5 wt.% CNT nanocomposites in the cross-flow direction compared to the in-flow direction. The hardness and modulus of elasticity were obtained from the micro indentation experiments. A mechanistic scribing force model was proposed based on the parameters obtained from the indentation tests and verified with the experimental scribing results.

NAMRC40-7796

INFLUENCE OF PROCESS VARIABLES ON PREFORM DESIGN FOR TUBE HYDROFORMING BASED ON WRINKLE EVOLUTION

Gracious Ngaile — North Carolina State University
Chen Yang — North Carolina State University

A two-stage preforming process based on wrinkle formation is discussed for the tube hydroforming process to accumulate material in the forming zone, thus reducing the thinning rate and improving the formability. In preforming stage one, the wrinkle onset is triggered with limited axial compression. In preforming stage two, the wrinkle grows stably and uniformly to a certain height. Then the preformed wrinkles are flattened to conform to the die shape in the final tube hydroforming process. Understanding the variables that influence the number of wrinkles in a specific die cavity is important in optimizing the preform die geometry. Thus, the influence of internal pressure, strain hardening exponent, tube thickness, and die cavity length on wrinkle evolution was investigated. The study has shown that wrinkle wave length increases with increase in internal pressure as well as with increase in the tube thickness. The study has also shown that wrinkle wave length increases with decrease in the strain hardening exponent. As a case study, preform design based on wrinkle evolution was used to hydroform an axi-symmetric bulge from AL6061. Through this method a significant increase in the expansion rate was achieved.

NAMRC40-7797

DESIGN AND EVALUATION OF AN ATOMIZATION-BASED CUTTING FLUID SPRAY SYSTEM IN TURNING OF TITANIUM ALLOY

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Shiv G. Kapoor — University of Illinois at Urbana-Champaign
Richard E. DeVor — University of Illinois at Urbana-Champaign
Anil K. Srivastava — Techsolve, Inc.,

Tool life has been a vital issue in machining titanium alloys. Recently, an atomization-based cutting fluid (ACF) application has been found to be an effective approach for cooling and lubrication in micro-machining operations. In this study, an ACF spray system is developed for macro-scale turning of Ti-6Al-4V. The spray system is designed to minimize interaction between the fluid droplets, and the gas nozzle to control the divergence of the fluid droplets. Experiments are conducted to study the effect of five specific ACF spray parameters including fluid flow rate, spray distance, impingement angle, and type and pressure level of the mist carrier gas on tool life, friction coefficient, and chip characteristics. It has been observed that the combination of low pressure (150 psi) air-mixed CO2 with a high flow rate (20 ml/min) produces a significantly longer tool life and broken chips. The results also reveal that the ACF spray system can extend tool life up to 40-50% over flood cooling.

NAMRC40-7798

AN EVALUATION INTO THE CAUSE OF CORROSIVE FAILURE IN AUTOPHORETIC COATED MATERIAL

Sean Derrick — Western Michigan University
David Meade — Western Michigan University
Gary Nola — Western Michigan University
Margaret Joyce — Western Michigan University
Matt Johnson — Western Michigan University

This paper documents a study of performance failures in Autophoretic® (A-coat or AP) coatings. As AP is a proprietary process and coating material, limited research has been published regarding the field performance of this coating technique. The

specific failure under analysis in this study was corrosion. The study was performed at the request of a manufacturer that was experiencing pre-mature failures in the field on product coated using this process and material. Prepared samples were evaluated using several analysis techniques including, BET Gas Absorption Testing, Optical Microcroscopy, FE-SEM, and Corrosion-Rate Analysis. Samples were subjected to the Society of Automotive Engineers (SAE) – Surface Vehicle Standard, J2334 Cosmetic Cyclical Corrosion Lab Test to accelerate the corrosion process, simulating long-term field conditions. Micro-cracks and pores were identified in the final finished surface that proved to be the point of origin of extensive corrosion that was the result of creep under the surface of the finish and ultimate delimitation.

NAMRC40-7799

SELECTIVE WELDING REINFORCEMENT WITHIN THREE-DIMENSIONAL FABRIC

Timothy Rodts — University of Notre Dame
Steven R. Schmid — University of Notre Dame
Miguel A. Selles — Universitat Politecnica de Valencia
Samuel Sanchez-Caballero — Universitat Politecnica de Valencia

Laser welding of three-dimensional polymer fabrics using the commercially available Clearweld® coating was demonstrated as a new, through-thickness reinforcement mechanism. Two processes for applying the Clearweld® coating were developed. The Soak-Deposition method allows for targeted coating delivery with the potential of functionally grading the residual coating density on the yarns within the fabrics. The Direct Application method is a uniform deposition of the coating. A 50 W fiber laser was used to create surface and subsurface reinforcing welds. Micro-computed tomography was used to nondestructively image the entire three-dimensional fabric after welding. An automated image analysis algorithm was developed to test for subsurface, interior weld zones. The ability to create surface and subsurface welds was demonstrated and confirmed with the nondestructive analysis.

NAMRC40-7800

INTEGRATION OF ECONOMIC AND ENVIRONMENTAL CONSIDERATIONS INTO PROCESS SELECTION AND PLANNING

Vance Murray — Purdue University
Fu Zhao — Purdue University
John W. Sutherland — Purdue University

Due to mounting environmental concerns, the need for methods that improve the sustainability of manufacturing has never been higher. Often, the environmental footprint of a product being manufactured is largely determined by the process plan. Little research has been conducted on the development of process planning methods that consider environmental factors. In this paper, a new process planning method is developed that integrates both economic and environmental considerations. The proposed method has seven steps: (1) obtain a master process plan, (2) calculate the manufacturing cost and environmental impact of the plan, (3) identify the impactful processes, (4) identify the features realized by the impactful processes, (5) create alternative process plans, (6) calculate the manufacturing cost and environmental impact of the alternative process plans, and (7) identify the Pareto-optimal process plans. The proposed method is demonstrated by developing alternate process plans for a prosthetic hip shell.

NAMRC40-7803

PERSPIRABLE SKIN: THERMAL BUCKLING ACHIEVED BY COMPLEX FUNCTIONALLY GRADED MATERIALS

Mingang Wang — Michigan State University
Matt Lempke — Michigan State University
Patrick Kwon — Michigan State University

A perspirable skin design was proposed as a thermal protection system to autonomously reduce the surface temperature in many applications such as reentry vehicle. This can be achieved with a unique design featuring an arrangement of tiles that buckles upon heating. Potentially a large gap can be generated through the buckling action. These tiles will be assembled and shrink-fitted within the opening of Reinforced Carbon-Carbon Composite (RCC) in the case of reentry vehicle. Each tile needs to have a unique CTE variations, which expand radially and shrinking tangentially, causing the structure to buckle. This paper concentrates on the fabrication of these tiles made of complex Functionally Graded materials (FGMs). This paper presents our effort to fabricate and optimize the designed tiles. To validate our idea, a series of simulations was performed to verify this buckling action of the assembly.

NAMRC40-7804

CURRENT ENVELOPE ANALYSIS FOR DEFECT IDENTIFICATION AND DIAGNOSIS IN INDUCTION MOTORS

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Shaopeng Liu — University of Connecticut
Robert Gao — University of Connecticut
Ruqiang Yan — University of Connecticut

Increasing demand in reliable manufacturing systems has been accelerating research in condition monitoring and defect diagnosis of vital machine components. This paper investigates defect diagnosis of induction motors, which are widely used in manufacturing systems as a source of actuation. A new approach, based on feature extraction from the envelope of the motor current instead of the motor current itself, has been investigated. This is based on the consideration that motor current envelope is effective in revealing the amplitude-modulated nature of the motor current

signal. Three pattern classifiers - Naïve Bayes, k-nearest neighbor, and Support Vector Machine, have been investigated for defect classification. Experimental results have demonstrated that the new feature extraction and selection method yields a higher degree of accuracy than the traditional method for motor defect classification.

NAMRC40-7806

DEFORMATION OF OFHC COPPER DURING CUTTING

Sreedhar Vasomsetti — Wichita State University
Madhavan Vis — Wichita State University

The study is aimed at understanding the nature of high strain rate deformation of a highly ductile and workhardening material, namely, OFHC copper. Experimental measurements of the strain rate distribution over the primary shear zone (PSZ) have been carried out using digital image correlation (DIC) of ultra high-speed photographic images. A large depth of cut of 300um has been used to increase the width of the shear zone and resolve the deformation clearly. The PSZ is found to be narrower near the tool tip and wider near the free surface. The width of the PSZ increases over the first half of its length near the cutting edge and then remains constant over the second half to the free surface. Correspondingly, the strain rate is higher near the tool tip and lower near the free surface. The PSZ is comprised of multiple shear bands, which are linear regions of material along which the strain is higher than in adjacent regions. Shear bands are observed to initiate near the entrance of the PSZ and remain active till they exit the PSZ. The strain rate over a band increases as it moves towards the middle of the PSZ and then decreases as it moves to the exit of the PSZ. The mean spacing between bands near the free surface is about 25um, which corresponds to the wavelength of the ripples along the back surface of the chip. Typically, the strain rate along each shear band decreases from the cutting edge to the free surface. A single intense shear band near the cutting edge is often observed to branch into multiple bands. In a few cases, shear bands are observed to develop additional branches closer to the free surface. The fact that shear bands become noticeable even at small strains of the order of 0.22 within this highly ductile, work hardening and conductive material indicates that the shear bands are not caused by damage or adiabatic deformation. These likely correspond to the strain inhomogeneity usually observed at the level of the grain size, as evidenced by the fact that the free surface of chips is always observed to be rippled.

NAMRC40-7807

THE EFFECT OF PITTING CORROSION ON SPLIT SLEEVE COLD HOLE EXPANDED: BARE 7075-T651 ALUMINIUM ALLOY

Glenn J. Stephen — AUT University
Timotius Pasang — AUT University
Benjamin P. Withy — Defence Technology Agency

As part of an aircraft fleet fatigue life improvement programme, investigation has been carried out into the effect pitting corrosion has on bare 7075-T651 which had undergone split sleeve cold hole expansion. Constant amplitude sinusoidal loading was applied to fatigue test coupons which had pitting corrosion induced upon them by a modified cyclic immersion process using a 3.5% NaCl solution. A pit depth of 39-58μm was found to significantly reduce the increased fatigue life gains achieved by carrying out cold hole expansion. At 137.9MPa fatigue life was reduced from achieving run out of ten million cycles to an average $371x10^3$ cycles, while at 165.5Pa average fatigue life was reduced from $810x10^3$ to $65x10^3$ cycles. The fracture surfaces were analyzed under a scanning electron microscope where each displayed an individual crack initiation site located on the material surface within the zone of residual circumferential stress.

NAMRC40-7811

A PROTOTYPE PRINTER FOR LASER DRIVEN MICRO-TRANSFER PRINTING

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Reza Saeidpourazar — University of Illinois at Urbana-Champaign
Michael D. Sangid — University of Illinois at Urbana-Champaign
John A. Rogers — University of Illinois at Urbana-Champaign

This paper demonstrates a new mode of automated micro transfer printing called laser micro transfer printing (LmTP). As a process, micro-transfer printing provides a unique and critical manufacturing route to extracting active microstructures from growth substrates and deterministically assembling them into a variety of functional substrates ranging from polymers to glasses and ceramics and to metallic foils to support applications such as flexible, large-area electronics, concentrating photovoltaics and displays. Laser transfer printing extends micro-transfer printing technology by providing a non-contact approach that is insensitive to the preparation and properties of the receiving substrate. It does so by exploiting the difference in the thermo-mechanical responses of the microstructure and transfer printing stamp materials to drive the release of the microstructure or 'ink' from the stamp and its transfer to substrate. This paper describes the process and the physical phenomena that drive it. It focuses on the use of this knowledge to design and test a print head for the process. The print

head is used to demonstrate the new printing capabilities that LmTP enables.

NAMRC40-7813

STRINGER SHEET FORMING

Frederic Bäcker — Technische Universität Darmstadt
Peter Groche — Technische Universität Darmstadt
Scholeh Abedini — Technische Universität Darmstadt

Load carrying sheet structures are often stiffened by stringers or ribs. If they are also required to feature complex curvatures their manufacture becomes quite elaborate. Either spatially curved joints or time and energy consuming manufacturing processes have to be put up with. Sheet metal hydroforming is a deep drawing process in which the punch is replaced by a pressurized liquid medium forming the workpiece into a die. Since the pressure side of the workpiece is in no contact to solid parts of the tool, hydroforming can be applied to the forming of already stringer-stiffened sheets. The presented article addresses chances and challenges of this novel process chain and discusses architecture as a possible field of application.

NAMRC40-7814

SIMULATIVE TESTING OF FRICTION AND LUBRICATION IN COLD FORGING OF STEEL AND ALUMINUM

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Niels Bay — Technical University of Denmark
Tetsuo Aida — Toyama University
Kuniaki Dohda — Northwestern University
Tor Erik Nicolaisen — Steertec Raufoss AS

A new, simulative test of friction and lubrication in cold forging is developed by the authors. The test is based on a backward can extrusion process in which the workpiece rotates relatively to the conical punch. An analytical model is presented determining the friction stress from the measured torque during testing combined with an analysis of the sliding velocity distribution along the punch nose. The latter is determined by FE analysis of the test. Results show friction stress for unalloyed low C-steel provided with different types of lubricants, i.e. phosphate coating plus soap, phosphate coating plus MoS2 and single bathe lubrication with PULS and aluminum provided with 6 different lubricants. The new test is so severe, that it is possible to break down the best lubrication systems for cold forging of steel and aluminum.

NAMRC40-7815

SINGLE STEP CHANNELING IN GLASS INTERIOR BY FEMTOSECOND LASER

Panjawat Kongsuwan — Columbia University
Hongliang Wang — Columbia University
Y. Lawrence Yao — Columbia University

Channeling inside a transparent material, glass, by femtosecond laser was performed by using a single step process rather than hybrid processes that combine the laser irradiation with an additional tool or step to remove the material. Tightly focusing of a single femtosecond laser pulse using proper optical and laser processing parameters could induce the micro-explosion and could create voids inside transparent materials, and the effects of these parameters on the resultant feature geometry and channel length were studied. Understanding of the channel length variation at different locations from the specimen surface could enhance prediction capability. Taking into account of the laser, material, and lens properties, numerical models were developed to predict the absorption volume shape and size at different focusing depths below the surface of a specimen. These models will also be validated with the variation in feature and channel lengths inside the specimen obtained from the experiments. Spacing between adjacent laser pulses and laser parameters were varied to investigate effects of channel overlapping and its influence on long channel formation.

NAMRC40-7816

INERTIA WELDING FOR ASSEMBLY OF COPPER SQUIRREL CAGES FOR ELECTRIC MOTORS

John Agapiou — General Motors, R&D Center

Automotive is developing designs and manufacturing processes for new generations of electric motors intended for use in hybrid and electric vehicles. There is interest in replacing the aluminum traditionally used in induction motor rotors with copper to improve motor capability. This paper focused on the solid-state welding to join copper end rings to copper spokes in the fabrication of copper rotors. Inertia friction welding was explored to examine weldability of these copper components. A better understanding of inertia welding characteristics will help the advancements in its application for induction rotors. The limitations of this application will be discussed.

NAMRC40-7819

DEFLECTION FOR A MAGNETOSTRICTIVE THIN FILM BIMORPH IN A MAGNETIC FIELD

Xiaoli Wang — Northwestern University
M. P. Ulmer — Northwestern University
Michael E. Graham — Northwestern University
Semyon Vaynman — Northwestern University
Julia Savoie — Northwestern University
Lien Hoffmann — Northwestern University
Jian Cao — Northwestern University

Magnetostrictive materials were investigated as a means to correct the shape of a thin-wall X-ray telescope surface. Sputter-deposited magnetostrictive films on the glass and Ni substrate were prepared to realize the requirement of deformation under an external magnetic field. The profiles of thin-film specimens were measured under an external magnetic field with White Light Interferometry. The distribution of the external magnetic field around the specimen in the experiments was discussed. In addition, a theoretical analysis was conducted to calculate the residual stress in the specimen and the possible deformation generated by the magnetic field. Preliminary experimental results confirmed that the magnetic field had an effect on the deformation of the magnetostrictive thin film bimorph prepared by sputter-deposition. Directions for future work were presented towards the goal of enabling the application of magnetostrictive thin film as an adaptive optics for X-ray mirrors.

NAMRC40-7820

HERMETIC JOINING OF 316L STAINLESS STEEL USING A PATTERNED NICKEL NANOPARTICLE INTERLAYER

Ravindranadh Tagore Eluri — Oregon State University
Brian K. Paul — Oregon State University

This paper evaluates the use of a nickel nanoparticle (NiNP) interlayer for making hermetic joints in 316L stainless steel substrates via diffusion brazing. Nickel nanoparticles were synthesized in ethylene glycol by the reduction of NiCl2.6H2O in the presence of hydrazine (N2H4) as a reducing agent. X-ray diffraction (XRD) analysis and transmission electron microscopy (TEM) results confirm the presence of pure fcc-Ni with an average particle size of 5.4 nm. An as-synthesized suspension of NiNPs was patterned onto 316L stainless steel laminae to a thickness of ~3 μm and bonded at 900ºC for 30 min at a pressure of 2 MPa via transient liquid phase bonding (TLP). The diffusion-brazed test article was found to be hermetic up to 70 psi. An examination of the bond line using scanning electron microscopy (SEM) showed good uniformity and continuity.

NAMRC40-7822

FAILURE ANALYSIS OF HYDROFORMING OF SANDWICH PANELS

Jyhwen Wang — Texas A&M University
Cheng-Kang Yang — Texas A&M University

Sandwich panels are commonly used in various applications to improve the stiffness-to-weight ratio of structure components. While producing flat sandwich panel is relatively straightforward, manufacturing of shaped sandwich components can be a challenging task. This paper presents the use of hydroforming technique in forming bi-layered and sandwich materials with an open-cell foam core. Hydraulic bulge experiments were conducted to form bi-layered and sandwich blanks into a dome shape. Various failure modes were observed from the experiments. Finite element simulations were conducted to understand the different failure mechanisms that could occur during the deformation process. The investigation can facilitate the selection of geometry and property of the constituents of the sandwich material for successful hydroforming.

NAMRC40-7823

APPLYING AXIOMATIC DESIGN TO ORTHOGONAL METAL CUTTING CREATES A NEW SHEAR STRAIN EQUATION

J T. Black — BRC

The first axiomatic design rule is to keep functional requirements independent. When applied to orthogonal metal cutting, the rule suggests keeping the lower boundry, defined by ϕ, independent from the direction of shear, defined by ψ. Experiments using metal hardness as a controlled variable prove the Black-Huang theory is the correct shear strain equation.

NAMRC40-7824

DAMAGE DIAGNOSIS AND FIXTURE CLASSIFICATION USING IMPEDANCE-BASED SENSORS

Jeremy Rickli — Virginia Tech
Charles Crawford — Virginia Tech
Sudipto Aich — Virginia Tech
Jaime Camelio — Virginia Tech

Assembly fixtures are commonly used to locate rigid and compliant components for joining operations. Variability in a component's location caused by damaged fixtures can lead to costly rework, scrap, and process repair. Piezoelectric (PZT) impedance sensors can be used to individually monitor assembly fixtures and have been proven effective for structural health monitoring applications. The sensors rapidly record significant quantities of data, but must be bonded to a fixture in order to transmit an input signal and record the corresponding output signal. Thus, PZT impedance sensors become a permanent feature of an assembly fixture and may create unique systems defined by the Assembly Fixture and Impedance Sensor (AFIS). Previous research has shown success in detecting fixture damage using PZT impedance sensors. This paper extends previous fixture damage detection work to damage diagnosis through the use of data mining classifiers. Classifiers were used in three studies; the first was to show that classifiers can be trained to classify a healthy fixture, general fixture damage, and multiple severities of fixture damage in an isolated AFIS. In the second study, classifier generalization was tested by simulating an unknown damage. Lastly, classifiers were used to study the uniqueness (fixture classification) of two AFIS, which could have implications related to the application of classifier models to any AFIS.

NAMRC40-7825

IMPROVED REDUCED ORDER MODELING OF MACHINE TOOL STRUCTURES

Mohit Law — University of British Columbia
Yusuf Altintas — University of British Columbia
A. Srikantha Phani — University of British Columbia

Dynamic response of a machine tool structure varies along the tool path depending on the changes in its structural configurations. The productivity of the machine tool varies as a function of its Frequency Response Function (FRF) which determines its dynamic response and chatter stability. This paper presents a computationally efficient reduced order model to simulate the FRF at the tool centre point of a machine tool for any position within its work volume. The machine tool is represented by its time invariant components or substructures. The substructures are assembled by modeling the contacts at assembly joints. As the machine tool moves, the contact points are updated to predict the FRFs efficiently without having to use the computationally costly full order Finite Element or Modal models. To facilitate dynamic substructuring, improved variants of reduced order models are developed which automate reduced order determination via retaining only the important modes of the subsystems. Position-dependent dynamic behavior and stability is successfully simulated for the case of virtual three axis milling machine, using the developed substructurally synthesized reduced order model.

NAMRC40-7826

SIMULATIONS AND EXPERIMENTS IN PUNCHING SPRING-STEEL DEVICES WITH SUB-MILLIMITER FEATURES

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A. Ravi Kumar — Indian Institute of Science
G. K. Ananthasuresh — Indian Institute of Science

This work demonstrates the feasibility of meso-scale (100 micrometer to mm) punching of multiple holes of intricate shapes in metals. Analytical modeling, finite element (FE) simulation, and experimentations are used in this work. Two dimensional FE simulations in ABAQUS were done with an assumed material modeling and plane-strain condition. A known analytical model was used and compared with the ABAQUS simulation results to understand the effects of clearance between the punch and the die. FE simulation in ABAQUS was done for different clearances and corner radii at punch, die, and holder. A set of punches and dies were used to punch out a miniature spring-steel gripper. Comparison of compliant grippers manufactured by wire-cut electro discharge machining (EDM) and punching shows that realizing sharp interior and reentrant corners by punching is not easy to achieve. However, the promise of realizing meso-scale parts with complicated shapes through punching is demonstrated in this work; and further work is identified and some strategies are suggested for improvement.

NAMRC40-7827

MODELING MACHINING DISTORTION USING THE FINITE ELEMENT METHOD: APPLICATION TO ENGINE DISK

Marko Knezevic — Los Alamos National Laboratory
Byung Kwan Chun — Scientific Forming Technologies Corporation
Jin Yong Oh — Scientific Forming Technologies Corporation
Wei-Tsu Wu — Scientific Forming Technologies Corporation
Robert A. Ress III — Rolls-Royce Corporation
Michael G. Glavicic — Rolls-Royce Corporation
Shesh Srivatsa — GE Aviation

Distortion of an aircraft engine disk is modeled using the Finite Element Method (FEM). The disk is machined from pancake shaped forgings of nickel based IN718 alloy. The starting material for machining has a distribution of bulk residual stresses resulting from forging and heat treatment processes. During subsequent machining the disk distorts as material is removed, while bulk residual stresses evolved to reach a new equilibrium. An automated procedure using the FEM is developed to simulate the distortion due to material removal in the presence of bulk residual stresses. To validate the numerical procedure, multiple disks are manufactured and the dimensions after machining are measured using a coordinate measuring machine (CMM). Excellent agreement is observed between the CMM measurements and the FEM predictions. The procedure and results are presented and discussed in this paper.

NAMRC40-7828

NEW DEVELOPMENTS IN SHEET METAL FORMING OF STAINLESS STEEL: CURRENT INVESTIGATIONS AND FUTURE CHALLENGES

Philipp Schmid — FGU mbH Stuttgart
Mathias Liewald — University of Stuttgart, Institute for Metal Forming Technology

The stainless steel market showed a growing volume of 3-5% p.a. during the last decades and is supposed to continue growing especially in China. Due to the high nickel price the austenitic grades are losing market shares to ferritic or 200-series grades, but still playing the most important role within the stainless steel market. The substitution of austenitic with ferritic grades is generating high demands on the process technology. Austenitic stainless steel is characterised by the strain-induced martensite formation, causing the TRIP-effect which is responsible for the good formability and high strength. The TRIP-Effect itself is highly dependent on the forming temperature, the strain as well as the chemical composition which has a direct influence on the stability of the austenite. For an ideal utilization of the TRIP-effect and the possibility to create new innovative sheet metal parts, a better understanding of the phase transformation, influence of the temperature on the effect and enhanced processing technologies are necessary. Therefore advanced material models are required, parameters determined and FEM-simulations validated via practical tests. Adjustable tool temperature control systems are playing an important role to steer locally the material properties during and after the forming process as well as allowing abolishing the influence of heat development during the metal forming process.

Author and Presenter Index

Index of Session Chairs and Co-Chairs

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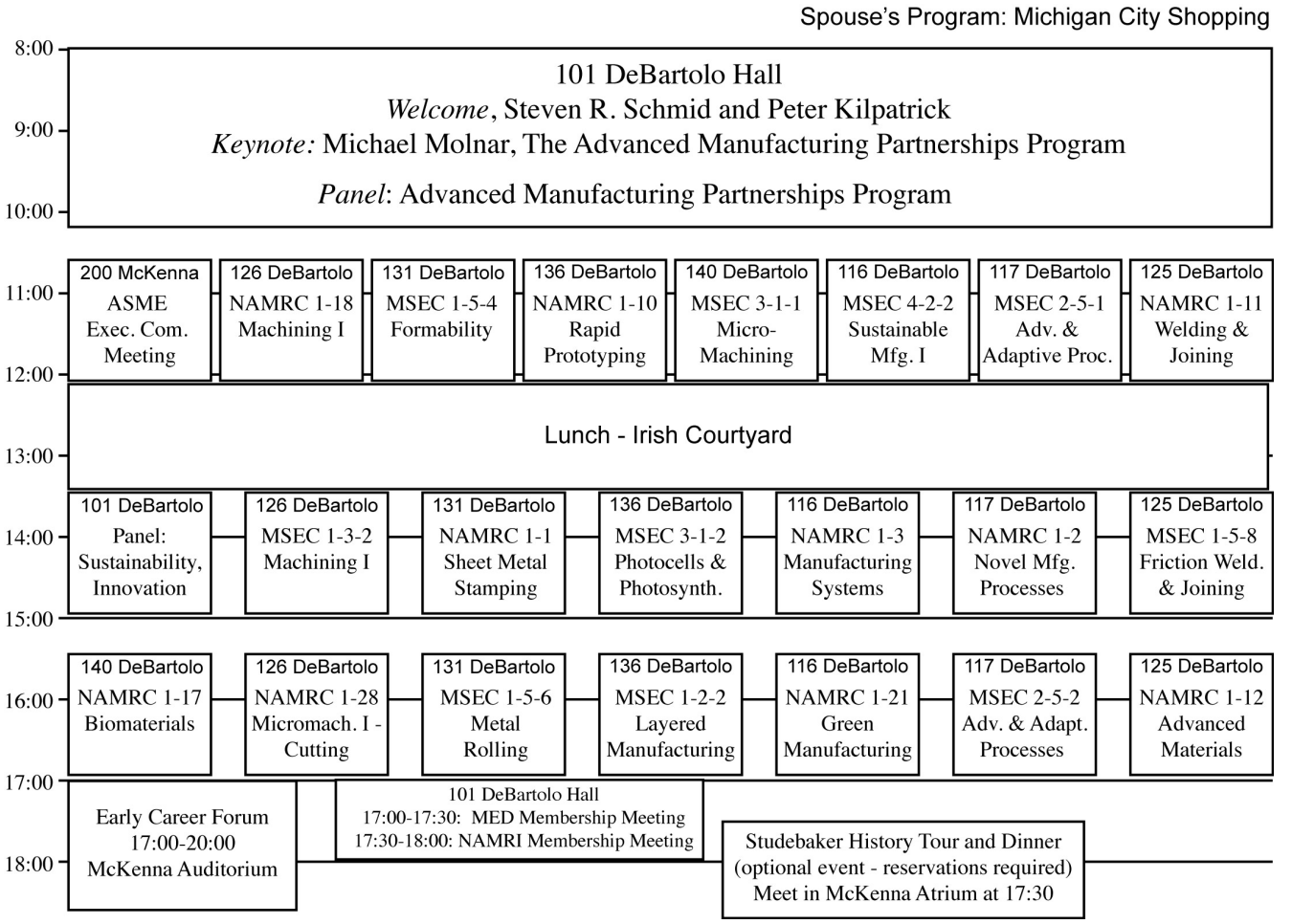
A joint oversight committee of NAMRI/SME and ASME reviews proposals annually. Host site selections are usually made two to three years in advance to allow for adequate planning and promotion. Submission of a written proposal and formal presentation of the proposal at a NAMRI/SME Board of Directors meeting is required. If the proposal is selected, the host institution will enter into a conference agreement with SME and ASME. The NAMRI/SME Board of Directors requires conference planning updates at its semi-annual meetings. For additional information, contact:

Mark Stratton
Member and Industry Relations Manager
Society of Manufacturing Engineers
One SME Drive
Dearborn, MI 48121-0930
Phone: 313.425.3307
E-mail: mstratton@sme.org

TECHNICAL PROGRAM - TUESDAY, JUNE 5, 2012

Overview



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00-8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00-17:00.
3. Lunch will be moved to South Dining Hall in case of inclement weather.

Conference Opening Ceremony
101 DeBartolo Hall 8:00 – 10:15

Opening Remarks
Steven R. Schmid**,** *University of Notre Dame, Notre Dame, IN, United States.*

Welcome
Peter Kilpatrick**,** *Dean, College of Engineering, University of Notre Dame, Notre Dame, IN, United States.*

Keynote: The Advanced Manufacturing Partnerships Program
Michael Molnar*, Chief Manufacturing Officer, National Institute of Standards and Technology Gaithersburg, MD, United States.*

Panel Session: Advanced Manufacturing Partnerships
Moderator: ***Steven Hayashi****, GE Global Research.*
Panel: ***S. Jack Hu,*** *University of Michigan.*
David Dornfeld*, University of California at Berkeley.*
Karen Huber, *Caterpillar Inc.*
Robert W. Ivester, *National Institute of Standards and Technology.*

Break, McKenna Atrium
10:15-10:45

CONCURRENT TECHNICAL SESSIONS
10:45-12:15

ASME Executive Committee Meeting
200 McKenna Hall

NAMRC 1-10 Rapid Prototyping
136 DeBartolo Hall 10:45 - 12:15

Session Chair: **Yong Chen**, *University of Southern California, Los Angeles, CA, United States*
Session Co-Chair: **Sam Anand**, *University of Cincinnati, Cincinnati, OH, United States*

Optimum Part Orientation in Rapid Protopyping Using Genetic Algorithm
NAMRC40-7710
***Amar Phatak, Sanjay Pande**, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India*

Smooth Surface Fabrication in Mask Projection Based Stereolithography
NAMRC40-7715
***Yayue Pan, Xuejin Zhao, Chi Zhou, Yong Chen**, University of Southern California, Los Angeles, CA, United States*

Process Energy Analysis and Optimization in Selective Laser Sintering
NAMRC40-7738
***Ratnadeep Paul, Sam Anand**, University of Cincinnati, Cincinnati, OH, United States*

NAMRC 1-11 Welding and Joining
125 DeBartolo Hall 10:45 - 12:15

Session Chair: **John Agapiou**, General Motors R&D Center, Warren, MI, United States
Session Co-Chair: **Tim Rodts**, *University of Notre Dame, Notre Dame, IN, United States*

On the Choice of Tool Material in Friction Stir Welding of Titanium Alloys
NAMRC40-7717
***Gianluca Buffa, Livan Fratini, Fabrizio Micari**, University of Palermo, Palermo, Italy*, ***Luca Settineri**, Polytechnic University of Turin, Torino, Italy*

A Combined Experimental Simulative Method for Studying the Material Bonding of Different Aluminum Alloys
NAMRC40-7725
***Gianluca D'Urso, Michela Longo, Claudio Giardini**, University of Bergamo, Dalmine (BG), Italy*, ***Elisabetta Ceretti**, University of Brescia, Brescia, Italy*

Inertia Welding for Assembly of Copper Squirrel Cages for Electric Motors
NAMRC40-7816
***John Agapiou**, General Motors, R&D Center, Warren, MI, United States*

NAMRC 1-18 Machining I
126 DeBartolo Hall 10:45 - 12:15

Session Chair: **Steven Liang,** *Georgia Tech, Atlanta, GA, United States*
Session Co-Chair: **Mohamed El Mansori**, *Arts et Métiers ParisTech, Châlons-en-Champagne, France*

Process Damping Analytical Stability Analysis and Validation
NAMRC40-7758
***Chris Tyler, Tony Schmitz**, University of North Carolina at Charlotte, Charlotte, NC, United States*

Chip Morphology Characteristics During Dry Drilling of Austempered Ductile Iron (ADI)
NAMRC40-7768
***Anil Meena, Mohamed El Mansori**, Arts et Métiers ParisTech, Châlons-en-Champagne, France*

Mapping Microstructures From Severe Plastic Deformation in Machining
NAMRC40-7767
***Sepideh Abolghasem, Saurabh Basu, Shashank Shekhar, Jiazhao Cai, M. Ravi Shankar**, University of Pittsburgh, Pittsburgh, PA, United States*

MSEC 1-5-4 Formability
131 DeBartolo Hall 10:45 - 12:15

Session Chair: **Edmund Chu**, *Alcoa Inc, Alcoa Center, PA, United States.*
Session Co-Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States*

M-K Analysis of Forming Limit Diagram under Stretch-Bending
MSEC2012-7401
***Ji He**, Shanghai Jiao Tong University, Shanghai, China*, ***Z. Cedric Xia**, Ford Motor Company, Dearborn, MI, United States*, ***Shuhui Li**, Shanghai Jiao Tong University, Shanghai, China*, ***Danielle Zeng**, Ford Motor Company, Dearborn, MI, United States.*

Numerical and Experimental Investigations of Key Assumptions in Analytical Failure Models for Sheet Metal Forming
MSEC2012-7319
***Raed Hasan**, GE Aviation, Vandalia, OH, United States*, ***Tugce Kasikci, Igor Tsukrov, Brad Kinsey**, University of New Hampshire, Durham, NH, United States.*

Biaxial Work Hardening Characteristics of 6000 Series Aluminum Alloy Sheet for Large Strain Range
MSEC2012-7288
***Daisaku Yanaga, Toshihiko Kuwabara**, Tokyo University of Agriculture and Technology, Tokyo, Japan*, ***Naoyuki Uema, Mineo Asano**, Sumitomo Light Metal Industries Ltd, Nagoya, Japan.*

MSEC 2-5-1 Advanced and Adaptive Manufacturing Systems
117 DeBartolo Hall 10:45 - 12:15

Session Chair: **Zhuming Bi**, *IPFW, Fort Wayne, IN, United States.*
Session Co-Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden.*

Web Based Monitoring and Control of Distant Robotic Operations
MSEC2012-7296
***Magnus Holm, Mohammad Givehchi, Abdullah Mohammed, Lihui Wang**, University of Skövde, Skövde, Sweden.*

Robust Work Planning And Development of a Decision Support System for Work Distribution on a Mixed-Model Automotive Assembly Line
MSEC2012-7350
***Kavit Antani**, **Alireza Madadi, Mary E. Kurz**, **Laine Mears**, **Maria E. Mayorga**, Clemson University, Clemson, SC, United States*, ***Kilian Funk**, BMW Manufacturing Co., Greer, SC, United States.*

Dynamic Strategies for Preventive Maintenance Scheduling with Throughput Target Variation
MSEC2012-7384
***Xiaoning Jin, Jun Ni**, University of Michigan, Ann Arbor, MI, United States.*

MSEC 3-1-1 Micro-Scale Machining I
140 DeBartolo Hall 10:45 - 12:15

Session Chair: **Qingwei Zhang**, *Drexel University, Philadelphia, PA, United States.*
Session Co-Chair: **Jack G. Zhou**, *Drexel University, Philadelphia, PA, United States.*

Fabrication of Textured 3D Microstructures Using 'Bulk Lithography'
MSEC2012-7357
***Prasanna Gandhi**, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India*, ***Kiran Bhole**, IIT Bombay, Mumbai, Maharashtra, India*, ***Naresh Chaudhari**, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, India.*

Micropatterning of Porous Polymer Structures
MSEC2012-7408
***Wei Zhang**, Georgia Institute of Technology, Atlanta, GA, United States*, ***Min Li, Chaosheng Wang**, Donghua University, Shanghai, China*, ***Jack Zhou**, Drexel University, Philadelphia, PA, United States*, ***Donggang Yao**, Georgia Institute of Technology, Atlanta, GA, United States.*

A Microlens Array on Curved Substrates by 3D Micro Projection and Reflow Process
MSEC2012-7409
***Hao Zhang, Lei Li, David McCray**, The Ohio State University, Columbus, OH, United States*, ***Donggang Yao**, Georgia Institute of Technology, Atlanta, GA, United States*, ***Allen Yi**, The Ohio State University, Columbus, OH, United States.*

MSEC 4-2-2 Sustainable Manufacturing Systems
116 DeBartolo Hall 10:45 - 12:15

Session Chair: **Mahesh Mani**, *NIST, Gaithersburg, MD, United States.*
Session Co-Chair: **John Michaloski**, *NIST, Gaithersburg, MD, United States.*

Discovering Material Recovery Scenarios for Industrial Machinery: A Case-Based Approach
MSEC2012-7306
William Z Bernstein, Devarajan Ramanujan*, Purdue University, West Lafayette, IN, United States*, ***Mikko Koho****, Tampere University of Technology, Tampere, Finland*, ***Karthik Ramani, Fu Zhao****, Purdue University, West Lafayette, IN, United States.*

Scheduling of Machine Startup and Shutdown to Reduce Energy Consumption in Bernoulli Production Lines
MSEC2012-7342
Guorong Chen, Liang Zhang*, University of Wisconsin-Milwaukee, Milwaukee, WI, United States*, ***Jorge Arinez, Stephan Biller****, General Motors, Warren, MI, United States.*

Ultrasonic-Vibration Assisted Pelleting for Cellulosic Ethanol Manufacturing: Effects of Particle Size and Moisture Content on Power Consumption
MSEC2012-7211
Qi Zhang*, Kansas State University, Kansas, United States*, ***Pengfei Zhang, Graham Pritchett, Z.J. Pei, Xiaoxu Song, Meng Zhang, T.W. Deines****, Kansas State University, Manhattan, KS, United States.*

Lunch, Irish Courtyard
12:15 - 13:30

CONCURRENT TECHNICAL SESSIONS
13:30-15:00

Panel: Sustainability, Innovation and the Education of Engineering Methodologies
101 DeBartolo 13:30 - 15:00

Moderator: ***Dr. Wenwu Zhang*****,** *GE Global Research Center, Schenectady, NY, United States.*

Panelists:

Ronald J. Bennett, Ph.D., *University of St. Thomas, St. Paul, MN, United States.*
Steve Hayashi**,** *GE Global Research Center, Niskayuna, NY, United States.*
Kevin W. Lyons**,** *NIST, Gaithersburg, MD, United States.*

John W. Sutherland**,** *Purdue University, West LaFayette, IN, United States.*

NAMRC 1-1 Sheet Metal Stamping
131 DeBartolo Hall 13:30 - 15:00

Session Chair: **Livan Fratini***, University of Palermo, Palermo, Italy*
Session Co-Chair: **Rajiv Shivpuri***, The Ohio State University, Columbus, OH, United States*

A Combined Dynamic Programming / Finite Element Approach for the Analysis and Optimization of Multi-Stage Deep Drawing of Box-Shaped Parts
NAMRC40-7741
Tamer F. Abdelmaguid*, Cairo University, Giza, Egypt*, ***Ragab K. Abdel-Magied****, Beni-Sueif University, Beni-Sueif,Egypt*, ***Mostafa Shazly****, the British University in Egypt, ElShorouk,Egypt*, ***Abdalla Wifi****, Cairo University, Giza, Egypt*

Effect of Specimen Planar Area on Electromagnetic Flanging
NAMRC40-7793
Reid VanBenthysen, Brad Kinsey*, University of New Hampshire, Durham, NH, United States*

Simulations and Experiments in Punching Spring-Steel Devices With Sub-Millimeter Features
NAMRC40-7826
Rakesh Kumar Pathak, A. Ravi Kumar, G. K. Ananthasuresh*, Indian Institute of Science, Bangalore, KA, India*

NAMRC 1-2 Novel Manufacturing Processes
117 DeBartolo Hall 13:30 - 15:00

Session Chair: **Z.J. Pei***, Kansas State University, Manhattan, KS, United States*
Session Co-Chair: **Steve Hayashi***, GE Global Research, Niskayuna, NY, United States*

Printed Energy Storage: From Prototype Towards Large-Scale Manufacturing
NAMRC40-7711
Paul K. Wright, David A. Dornfeld, Zuoqian Wang, Alic Chen*, UC Berkeley, Berkeley, CA, United States*, ***Rei-Cheng Juang****, Industrial Technology Research Institute, Hsinchu,Taiwan*, ***James W. Evans****, UC Berkeley, Berkeley, CA, United States*

Embedding Shape Memory Alloy Actuators in Miniature Articulating Polymer Structures Using In-Mold Assembly
NAMRC40-7760
Arvind Ananthanarayanan*, Massachusetts Institute of Technology, Cambridge, MA, United States*, ***Leicester Ehrlich, Mingyen Ho, Jaydev P. Desai, Satyandra K. Gupta****, University of Maryland College Park, College Park, MD, United States*

A Prototype Printer for Laser Driven Micro-Transfer Printing
NAMRC40-7811
***Placid Ferreira, Reza Saeidpourazar, Michael D. Sangid, John A. Rogers**, University of Illinois at Urbana-Champaign, Urbana, IL, United States*

NAMRC 1-3 Manufacturing Systems
116 DeBartolo Hall 13:30 - 15:00

Session Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden*
Session Co-Chair: **Dragan Djurdjanovic**, *University of Texas, Austin, TX, United States*

Hierarchical Decomposition Based Approach to Process Design of Aeroengine Disk in Presence of Defects
NAMRC40-7723
***Kuldeep Agarwal, Rajiv Shivpuri**, The Ohio State University, Columbus, OH, United States*

A Study on Optimal Machine Setups Using an Energy Modeling Approach
NAMRC40-7743
***Zhuming Bi**, Indiana University Purdue University Fort Wayne, Fort Wayne IN, United States*, ***Lihui Wang**, University of Skövde, Skövde, Sweden*

Flexibility in Manufacturing Automation: A Living Lab Case Study of Norwegian Metalcasting SMEs
NAMRC40-7787
***Rhythm Wadhwa**, NTNU Valgrinda, Trondheim, Norway*

MSEC 1-3-2 Machining I
126 DeBartolo Hall 13:30 - 15:00

Session Chair: **Ihab Ragai**, *Hitachi, Guelph, ON, Canada.*
Session Co-Chair: **Arif S. Malik**, *Saint Louis University, St. Louis, MO, United States.*

Optimization of Machining Parameters in CFRP/Ti Stacks Drilling
MSEC2012-7216
***Krishnaraj Vijayan, Prabu Karthi Arumugam, Santhosh Murugan**, PSG College of Technology, Coimbatore, Tamilnadu, India*, ***Redouane Zitoune**, Clement Ader Institute, Toulouse, France*, ***Senthil Kumar Mouleeswaran**, PSG College of Technology, Coimbatore, India.*

Optimization of Double Cone Drill Geometry During Drilling of Carbon Fibre Reinforced Plastic (CFRP)
MSEC2012-7244
***Redouane Zitoune**, Clement Ader Institute, Toulouse, France*, ***Sofiane AlmaBouacif**, ICA- Toulouse University, Toulouse, France*, ***Vijayan Krishnaraj**, PSG College of Technology, Coimbatore, India*, ***Francis Collombet**, ICA- Toulouse University, Toulouse, France*, ***Michel Matchoro**, Stoc Production, Toulouse, France.*

Investigation on the Important Factors in Determining Aerodynamic Noise in Face Milling Cutters
MSEC2012-7250
***Chunhui Ji**, North Dakota State University, Fargo, ND, United States*, ***Zhanqiang Liu**, Shandong University, Jinan, Shandong, China*, ***Jing Shi**, North Dakota State University, Fargo, ND, United States.*

MSEC 1-5-8 Friction Based Welding and Joining
125 DeBartolo Hall 13:30 - 15:00

Session Chair: **Aashish Rohatgi**, *Pacific Northwest National Laboratory, Richland, WA, United States*

Spiral Friction Stir Processing (SFSP) for the Extrusion of Lightweight Alloy Tubes
MSEC2012-7358
***Fadi Abu-Farha**, Clemson University, Greenville, SC, United States.*

Characterization of Ultrasonic Metal Weld Quality for Lithium-Ion Battery Tab Joining
MSEC2012-7410
***Tae Hyung Kim, S. Shawn Lee**, **S. Jack Hu**, University of Michigan, Ann Arbor, MI, United States*, ***Wayne Cai**, GM Global R&D, Warren, MI, United States*, ***Jingjing Li**, University of Hawaii, Honolulu, HI, United States*, ***Jeffrey Abell**, GM Global R&D, Warren, MI, United States.*

Tool-Workpiece Interface Temperature Measurement in Friction Stir Welding
MSEC2012-7326
***Axel Fehrenbacher, Joshua R. Schmale, Michael R. Zinn, Frank E. Pfefferkorn**, University of Wisconsin - Madison, Madison, WI, United States.*

MSEC 3-1-2 Photocells and Photosynthesis
136 DeBartolo Hall 13:30 - 15:00

Session Chair: **Xugang Zhang**, *Johnson Controls, Milwaukee, WI, United States.*
Session Co-Chair: **Chris Yuan**, *University of Wisconsin, Milwaukee, Milwaukee, WI, United States.*

Nano Finishing of Brass Tubes by Using Mechanically Alloyed Magnetic Abrasives
MSEC2012-7264
***Sehijpal Singh Khangura**, Guru Nanak Dev Engg College, Ludhiana, India*, ***Lakhvir Singh Sran**, BBSB Engg College, Fathegarh Sahib, India*, ***Amarjit Singh**, Bureau of Indian Standards, Chandigarh, India.*

Fabrication of Aluminum Composites with Patterned Silicon Carbide Reinforcement Architecture by Semi-solid Processing
MSEC2012-7352
***Can Zhu, Yufeng Wu, Gap-Yong Kim**, Iowa State University, Ames, IA, United States.*

Micro and Nano Design and Fabrication of a Novel Artificial Photosynthesis Device
MSEC2012-7394
***Xiang Ren, Qingwei Zhang, Ho-lung Li, Jack Zhou**, Drexel University, Philadelphia, PA, United States.*

Coffee Break, McKenna Hall Atrium
15:00-15:30

CONCURRENT TECHNICAL SESSIONS
15:30-17:00

NAMRC 1-17 Biomaterials
140 DeBartolo Hall 15:30-17:00

Session Chair: **Albert Shih,** *University of Michigan, Ann Arbor, MI, United States*
Session Co-Chair: **Michael Hawkins**, *Zimmer Inc., Warsaw IN, United States*

Machining Assessment of Nano-Crystalline Hydroxyapatite Bio-Ceramic
NAMRC40-7783
***Sanket Kulkarni**, AGCO Corporation, Hesston, KS, United States*, ***Yaowei Yong**, Ningxia University, Yinchuan, Ningxia, China*, ***Malgorzata Rys, Shuting Lei**, Kansas State University, Manhattan, KS, United States*

Selective Welding Reinforcement Within Three-Dimensional Fabric
NAMRC40-7799
***Tim Rodts, Steven R. Schmid**, University of Notre Dame, Notre Dame, IN, United States*, ***Miguel A. Selles, Samuel Sanchez-Caballero**, Universitat Politecnica de Valencia, Alcoy, Spain*

Multi-Material Fabrication of Tissue Engineering Scaffold
NAMRC40-7742
***Chuang Wei**, NCSU, Raleigh, NC, United States*, ***Lei Cai, Shanfeng Wang**, The University of Tennessee, Knoxville, Knoxville, TN, United States*, ***Jingyan Dong**, North Carolina State University, Raleigh, NC, United States*

NAMRC 1-21 Green Manufacturing
116 DeBartolo Hall 15:30 - 17:00

Session Chair: **John W. Sutherland**, *Purdue University, West Lafayette, IN, United States*
Session Co-Chair: **Barbara S. Linke**, *University of California, Berkeley, Berkeley, CA, United States*

Effect of Green Machining on Distortion and Surface Finishing in Advanced Ceramic
NAMRC40-7734
***Luiz Sanchez, Arthur Fiocchi, Gill Bukvic**, Sao Paulo State University - Unesp, Bauru, Sao Paulo, Brazil*, ***Carlos Fortulan**, University of Sao Paulo - USP, Sao Carlos, Sao Paulo, Brazil*, ***Ioan Marinescu**, University of Toledo, Toledo, OH, United States*

Application of Axiomatic Design Principles to Identify More Sustainable Strategies for Grinding
NAMRC40-7735
***Barbara S. Linke**, **David A. Dornfeld**, University of California, Berkeley, Berkeley, CA, United States*

Integration of Economic and Environmental Considerations Into Process Selection and Planning
NAMRC40-7800
***Vance Murray, Fu Zhao, John W. Sutherland**, Purdue University, West Lafayette, IN, United States*

NAMRC 1-28 Micromachining I - Cutting
126 DeBartolo Hall 15:30 - 17:00

Session Chair: **Simon Park**, *University of Calgary, Calgary, AB, Canada*
Session Co-Chair: **Lara Rebaioli,** *Politecnico di Milano, Milano, Italy*

Finite Element Modeling and Simulation of Micro-Milling
NAMRC40-7745
***Thanongsak Thepsonthi, Tugrul Özel**, Rutgers University, Piscataway, NJ, United States*

Parametric Glass Milling With Simultaneous Control
NAMRC40-7749
***Takashi Matsumura, Mitsuo Kakishita**, Tokyo Denki University, Tokyo, Tokyo, Japan*

Performance Validation of a Micro Quick-Stop Device
NAMRC40-7781
***Massimiliano Annoni, Lara Rebaioli, Quirico Semeraro**, Politecnico di Milano, Milano, Italy*

MSEC 1-2-2 Layered Manufacturing
136 DeBartolo Hall 15:30 - 17:00

Session Chair: **Sam Anand,** *University of Cincinnati, Cincinnati, OH, United States*
Session Co-Chair: **Yong Chen**, *University of Southern California, Los Angeles, CA, United States.*

Rapid Manufacturing in Minutes: The Development of a Mask Projection Stereolithography Process for High-speed Fabrication
MSEC2012-7232
***Yayue Pan**, **Chi Zhou, Yong Chen**, University of Southern California, Los Angeles, CA, United States.*

Analysis of Voxel Size during Two-Photon Polymerization
MSEC2012-7374
***Serge Gregory, Elijah Kannatey-Asibu**, University of Michigan, Ann Arbor, MI, United States.*

Initial Investigation into Helical Milling of Laminated Stacks of Electrical Steel
MSEC2012-7239
***Howard Liles, J. Rhett Mayor**, Georgia Institute of Technology, Atlanta, GA, United States.*

MSEC 1-5-6 Metal Rolling
131 DeBartolo Hall 15:30 - 17:00

Session Chair: **Gracious Ngaile**, *North Carolina State University, Raleigh, NC, United States*
Session Co-Chair: **Yannis Korkolis**, *University of New Hampshire, Durham, NH, United States.*

Development of Statically Determinate Plate Rolling Mills based on Micro-scale Parameters
MSEC2012-7311
***Guangxian Shen, Yongjiang Zheng, Ming Li**, Yanshan University, Qinhuangdao, Hebei, China.*

Mixed Lubrication Model for Cold Rolling Considering the Inlet and Deformation Zones
MSEC2012-7245
***Martin Bergmann, Klaus Zeman, Alexander Kainz**, Johannes Kepler University, Linz, Upper Austria, Austria*, ***Konrad Krimpelstätter**, Siemens VAI Metals Technologies GmbH, Linz, Upper Austria, Austria*, ***Dieter G. Paesold**, voestalpine Stahl GmbH, Linz, Upper Austria, Austria*, ***Peter Schellingerhout, Bas Smeulders**, Quaker Chemical B.V., Uithoorn, Netherlands.*

Formation Condition of Scale Layer on Work Roll in Hot Steel Rolling
MSEC2012-7235
***Kento Nakazawa, Akira Azushima**, Yokohama National University, Yokohama, Kanagawa, Japan.*

MSEC 2-5-2 Advanced and Adaptive Manufacturing Systems II
117 DeBartolo Hall 15:30 - 17:00

Session Chair: **Lihui Wang**, *University of Skövde, Skövde, Sweden.*
Session Co-Chair: **Zhuming Bi**, *IPFW, Fort Wayne, IN, United States.*

Real-Time Error Prediction for High-Precision Operation of Parallel Kinematic Machines
MSEC2012-7201
***Zhuming Bi**, **Guoping Wang**, Indiana University Purdue University Fort Wayne, Fort Wayne, IN, United States.*

Research on Intelligent Retrieval System for Networked Manufacturing Resources
MSEC2012-7266
***Defang Liu, Bin Wang**, Yancheng Institute of Technology, Yancheng, Jiangsu, China*, ***Congdong Ji**, Jiangsu University, Yancheng, Jiangsu, China.*

Reduction of Vibrations in Ball Screw Driven Machine Tools by the Optimal Selection of Nut Parameters
MSEC2012-7283
***Chinedum Okwudire, Peng Zhao**, University of Michigan, Ann Arbor, MI, United States.*

ADDITIONAL AND OPTIONAL EVENTS

MED Membership Meeting
101 DeBartolo Hall 17:00 - 17:30

NAMRI/SME Membership Meeting
101 DeBartolo Hall 17:30 - 18:00

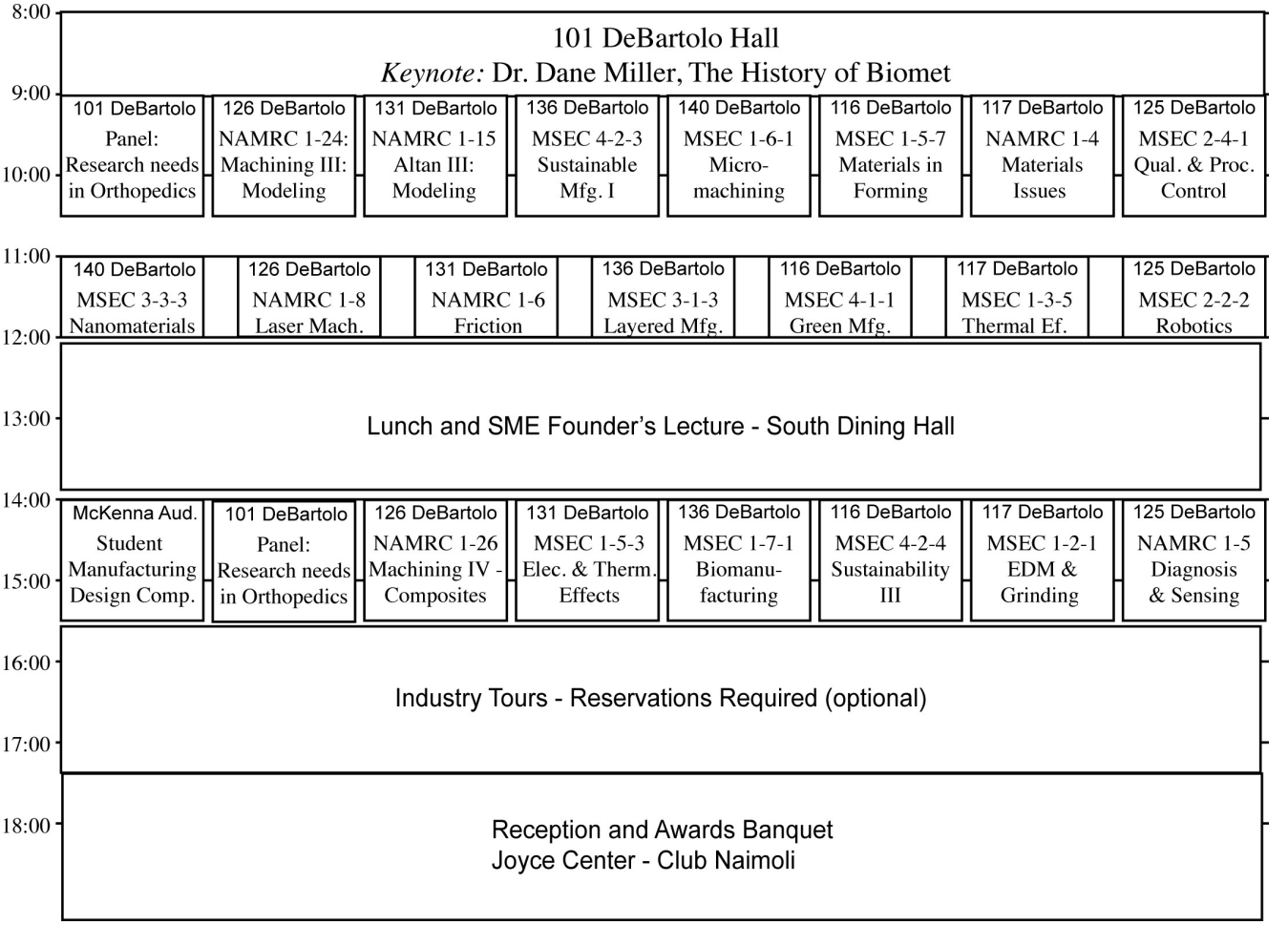
Early Career Forum
McKenna Auditorium 17:00 - 20:00

Studebaker History Tour (optional dinner – reservations required)
Meet in McKenna Atrium at 18:00

TECHNICAL PROGRAM - WEDNESDAY, JUNE 6, 2012

Overview

Spouse's Program: Fernwood Botanical Gardens & South Bend Chocolate Co.



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00-8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00-17:00.
3. Industry tours require reservations; space is limited. Sign up at the Registration Desk if you didn't pre-register. Options are:
    a. Zimmer, Inc. (Orthopedic Implants)
    b. DePuy, Inc. (Orthopedic Implants)
    c. Jayco, Inc. (Recreational Vehicles)

Keynote: Dr. Dane Miller, The History of Biomet
101 DeBartolo Hall 8:00 - 9:00

CONCURRENT TECHNICAL SESSIONS
9:00-10:30

Panel: Manufacturing Research Needs for the Orthopaedics Industry
101 DeBartolo 9:00 - 10:30

Moderators**: *Glen Niebur, Diane Wagner**, University of Notre Dame, Notre Dame, IN, United States.*

Panelists:

Toby Buck**,** *Paragon Medical, Pierceton, IN, United States.*

Joseph Budzinski**,** *DePuy Orthopaedics, A Johnson & Johnson Company, Raynham, MA, United States.*

Michael Hawkins**,** *Zimmer Orthopedics, Inc., Warsaw, IN, United States.*

NAMRC 1-4 Materials Issues
117 DeBartolo Hall 9:00 - 10:30

Session Chair: **Jaime Camelio***, Virginia Tech, Blacksburg, VA, United States*
Session Co-Chair: **Tim Rodts***, University of Notre Dame, Notre Dame, IN, United States*

An Evaluation into the Cause of Corrosive Failure in Autophoretic Coated Material
NAMRC40-7798
Sean Derrick, David Meade, Gary Nola, Margaret Joyce, Matt Johnson*, Western Michigan University, Kalamazoo, MI, United States*

The Effect of Pitting Corrosion on Split Sleeve Cold Hole Expanded: Bare 7075-T651 Aluminium Alloy
NAMRC40-7807
Glenn J. Stephen, Timotius Pasang*, AUT University, Auckland, New Zealand*, ***Benjamin P. Withy****, Defense Technology Agency, Auckland, New Zealand*

Hermetic Joining of 316L Stainless Steel Using a Patterned Nickel Nanoparticle Interlayer
NAMRC40-7820
Ravindranadh Tagore Eluri, Brian K Paul*, Oregon State University, Corvallis, OR, United States*

NAMRC 1-15 Altan Symposium III: Modeling
131 DeBartolo Hall 9:00 - 10:30

Session Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States*
Session Co-Chair: **Steven R. Schmid,** *University of Notre Dame, Notre Dame, IN, United States*

Advances in Predicting Damage Evolution and Fracture Occurrence in Metal Forming Operations
NAMRC40-7736
***Paolo F. Bariani, Stefania Bruschi, Andrea Ghiotti**, University of Padova, Padova, Italy*

Analytical Prediction of Stepped Feature Generation in Multi-Pass Single Point Incremental Forming
NAMRC40-7761
***Dongkai Xu**, **Rajiv Malhotra, Jian Cao**, Northwestern University, Evanston, IL, United States*, ***N.V. Reddy**, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh, India*, ***Jun Chen**, Shanghai Jiao Tong University, Shanghai, Shanghai, China*

Springback Prediction in Bending of AHSS-DP 780
NAMRC40-7769
***Nimet Kardes Sever, Osman H. Mete, Yurdaer Demiralp, Changhyok Choi, Taylan Altan**, The Ohio State University, Columbus, OH, United States*

NAMRC 1-24 Machining III - Modeling
126 DeBartolo Hall 9:00 - 10:30

Session Chair: **Christopher Saldana**, *Pennsylvania State University, University Park, PA, United States*

Finite Element Modeling of Microstructural Changes in Turning of AA7075-T651 Alloy and Validation
NAMRC40-7765
***Giovanna Rotella**, Politecnico di Torino, Torino, TO, Italy*, ***O.W. Dillon**, University of Kentucky, Lexington, KY, United States*, ***Domenico Umbrello**, University of Calabria, Rende, Cosenza, Italy*, ***Luca Settineri**, , Politecnico di Torino, Torino, TO, Italy*, ***I.S. Jawahir**, University of Kentucky, Lexington, KY, United States*

Ball End Milling Mechanistic Model Based on a Voxel-Based Geometric Representation and a Ray Casting Technique
NAMRC40-7780
***Jason Wou**, Bishop Steering Technology, Indianapolis, IN, United States*, ***Yung Shin**, Purdue University, West Lafayette, IN, United States*, ***Hazim El-Mounayri**, Indiana University-Purdue University Indianapolis, Indianapolis, IN, United States*

Applying Axiomatic Design to Orthogonal Metal Cutting Creates a New Shear Strain Equation
NAMRC40-7823
***J T Black**, BRC, Auburn, AL, United States*

MSEC 1-5-7 Materials
116 DeBartolo Hall 9:00 - 10:30

Session Chair: **Aashish Rohatgi**, *Pacific Northwest National Laboratory, Richland, WA, United States*
Session Co-Chair: **Justin Milner,** *Clemson University, Greenville, SC, United States*

Modeling Mechanical Behavior of Materials Processed by Accumulative Roll Bonding
MSEC2012-7233
***Justin L. Milner, Cristina J. Bunget, Thomas R. Kurfess**, Clemson University, Greenville, SC, United States*, ***Vincent H. Hammond**, US Army Research Laboratory, Aberdeen Proving Ground, MD, United States.*

Study of Size Effects on Deformation Behavior and Formability in Micro Metal Forming of Ti Foil
MSEC2012-7411
***Xu Jie, Guo Bin, Shan Debin, Li Baishun**, Harbin Institute of Technology, Harbin, China.*

A New Approach to Predict Machining Force and Temperature with Minimum Quantity Lubrication
MSEC2012-7221
***Xia Ji, Xueping Zhang**, Shanghai Jiao Tong University, Shanghai, China*, ***Y. Steven Liang**, Georgia Institute of Technology, Atlanta, GA, United States.*

MSEC 1-6-1 Micromachining
140 DeBartolo Hall 9:00 - 10:30

Session Chair: **Wenwu Zhang**, *GE Global Research Center, Schenectady, NY, United States.*
Session Co-Chair: **Gary J. Cheng**, *Purdue University, West Lafayette, IN, United States.*

Microvia Formation for Multi-layer PWB by Laser Direct Drilling: Improvement of Drilled Hole Quality of GFRP Plates
MSEC2012-7219
***Keiji Ogawa**, University of Shiga Prefecture, Hikone-shi, Japan*, ***Toshiki Hirogaki, Eiichi Aoyama**, **Tsukasa Ayuzawa**, Doshisha University, Kyotanabe, Japan.*

Microfluidic Channel Fabrication with Tailored Wall Roughness
MSEC2012-7328
***Jing Ren, Sriram Sundararajan**, Iowa State University, Ames, IA, United States.*

Laser Shock Induced Nano-Patterning of Graphene
MSEC2012-7378
***Ji Li**, Purdue University, West Lafayette, IN, United States*, ***Rongjun Zhang, Hanqing Jiang**, Arizona State University, Tempe, AZ, United States*, ***Gary J. Cheng**, Purdue University, West Lafayette, IN, United States.*

MSEC 2-4-1 Quality and Process Control
125 DeBartolo Hall 9:00 - 10:30

Session Chair: **Dragan Djurdjanovic**, *University of Texas at Austin, Austin, TX, United States.*
Session Co-Chair: **Jeonghan Ko**, *University of Nebraska-Lincoln, Linoln, NE, United States.*

Characterization of Cutting Force Induced Surface Shape Variation Using High-Definition Metrology
MSEC2012-7276
***Hai Nguyen, Hui Wang, S. Jack Hu**, University of Michigan, Ann Arbor, MI, United States.*

Kernel Density Estimation and Metrolopis-Hastings Sampling in Process Capability Analysis of Unknown Distributions
MSEC2012-7299
***Wenzhen Huang**, University of Massachusetts Dartmouth, North Dartmouth, MA, United States*, ***Ankit Pahwa, MS**, Surgical Monitoring Associates Inc., Springfield, PA, United States*, ***Dr. Zhenyu Kong**, Oklahoma State University, Stillwater, OK, United States.*

Joint Maintenance and Production Operations Decision Making in Flexible Manufacturing Systems
MSEC2012-7258
***Merve Celen**, **Dragan Djurdjanovic**, University of Texas at Austin, Austin, TX, United States.*

MEC 4-2-3 Sustainable Manufacturing Methods I
136 DeBartolo Hall 9:00 - 10:30

Session Chair: **Chris Yuan**, *University of Wisconsin, Milwaukee, Milwaukee, WI, United States.*
Session Co-Chair: **Liang Zhang**, *University of Wisconsin-Milwaukee, Milwaukee, WI, United States.*

Synthesis of Manufacturing and Facility Data for Sustainability Analysis
MSEC2012-7294
***John Michaloski, Guodong Shao, Frank Riddick, Swee Leong**, NIST, Gaithersburg, MD, United States*, ***Jonatan Berglund**, Chalmers University of Technology, Gothenburg, Sweden*, ***Jorge Arinez, Stephan Biller**, General Motors, Warren, MI, United States.*

A Computer Aided System for Sustainability Analysis for Die-Casting Processes
MSEC2012-7303
***Jatinder Madan**, System Integration Division, National Institute of Standards and Technology, Gaithersburg, MD, United States*, ***Princepal Singh**, Lovely Professional University, Phagwara, Punjab, India*, ***Amrik Singh**, Sant Longowal Institute of Engg. and Tech., Sangrur, Punjab, India*, ***Mahesh Mani**, National Institute of Standards and Technology, Gaithersburg, MD, United States.*

A Process-Based Approach for Cradle-to-Gate Energy and Carbon Footprint Reduction in Product Design
MSEC2012-7405
***Ahmed J. Alsaffar, Karl Haapala**, Oregon State University, Corvallis, OR, United States*, ***Kyoung-Yun Kim**, Wayne State University, Detroit, MI, United States*, ***Gul Okudan Kremer**, Pennsylvania State University, University Park, PA, United States.*

MSEC 5-1-1 Technical Poster Presentations
McKenna Atrium 9:00 - 10:30

Session Chair: **Hitomi Yamaguchi**, *University of Florida, Gainesville, FL, United States.*
Session Co-Chair: **Laine Mears**, *Clemson University, Greenville, SC, United States.*

An Experimental Device for Cyclic Tension and Compression Tests
MSEC2012-7426
***Fuh-Kuo Chen, Heng-Kuang Tsai, Chih-Hsun Lin**, National Taiwan University, Taipei, Taiwan.*

Reheating Effect on the Strength and Formability of DP980
MSEC2012-7416
***Jorge Cisneros, Xin Wu**, Wayne State University, Detroit, MI, United States.*

Time-Resolved Study of Alginate Spheroid Formation in Inkjetting
MSEC2012-7417
***C. Leigh Herran, Yong Huang, Nicole Coutris, Changxue Xu**, Clemson University, Clemson, SC, United States.*

Scaffold-Free Fabrication of Three-Dimensional Cellular Tubes
MSEC2012-7418
***Changxue Xu, Yong Huang, Wenxuan Chai**, Clemson University, Clemson, SC, United States.*

Active Compliant Microassembly Platform with Integrated Force Measurement
MSEC2012-7419
***Paul Moore, Gloria Wiens**, University of Florida, Gainesville, FL, United States.*

Ultra High-Speed Micro-Milling and Micro-Grinding
MSEC2012-7420
***Said Jahanmir, Hooshang Heshmat, Michael Tomaszewski, David Slezak**, Mohawk Innovative Technology, Inc, Albany, NY, United States.*

Synthesis of Carbon Nanotube-Nanodiamond Hybrid Structures and Their Effect on the Mechanical Property of Polymer Composites
MSEC2012-7421
Dae-Soon Lim, Seung-Koo Lee, Yang-Bok Lee, Kyung-Min Kim, Young-Kyun Lim, Seo-Hyun Yoon*, Korea University, Seoul, Seoungbuk-Ku, Korea (Republic).*

Experimental Study on the Cooled Air Effect for Hard Turning
MSEC2012-7422
Hyung Wook Park, Dong Min Kim*, UNIST, Ulsan, Ulju-gun, Korea (Republic).*

Life Cycle Analysis of Diamond Coating of Machining Tools
MSEC2012-7423
Carlos Wilfong, Humberto A Gomez, Delcie R Durham*, University of South Florida, Tampa, FL, United States.*

RFID-Based 3D Indoor Real-Time Localization System
MSEC2012-7424
Jiaqing Wu, Lianlin Zhao, Lance Pérez, Robert Williams*, University of Nebraska-Lincoln, Lincoln, NE, United States.*

Coffee Break, McKenna Hall Atrium
10:30-11:00

CONCURRENT TECHNICAL SESSIONS
11:00-12:00

NAMRC/ICTMP 1-6 Friction
131 DeBartolo Hall 11:00 - 12:00

Session Chair: **Stefania Bruschi***, DIMEG, University of Padova, Padova, Italy*
Session Co-Chair: **Akira Azushima***, Yokohama National University, Yokohama, Jordan*

Flatness Defects in Thin Strip Cold Rolling and the Friction Impact on It
NAMRC40-7728
Rebecca Nakhoul, Pierre Montmitonnet*, MINES Paristech - CEMEF, Sophia Antipolis, France*, ***Sami Abdelkhalek****, ArcelorMittal, Maizieres-les-Metz, France*

Simulative Testing of Friction and Lubrication in Cold Forging of Steel and Aluminum
NAMRC40-7814
Ermanno Ceron, Niels Bay*, Technical University of Denmark, Kgs. Lyngby,Denmark*, ***Tetsuo Aida****, Toyama University, Toyama, Japan*, ***Kuniaki Dohda****, Northwestern University, Evanston, IL, United States*, ***Tor Erik Nicolaisen****, Steertec Raufoss AS, Raufoss, Norway*

NAMRC 1-8 Laser Machining
126 DeBartolo Hall 11:00-12:00

Session Chair: **Abdullah Khalid Hafiz,** *University of Western Ontario, London, ON, Canada*
Session Co-Chair: **Jack Jeswiet,** *Queen's University, Kingston, ON, Canada*

The Effect of Overlap Percentage on Surface Quality in Laser Polishing of AISI H13 Tool Steel
NAMRC40-7766
***Abdullah Khalid Hafiz**, The University of Western Ontario, London, ON, Canada*, ***Evgueni Bordatchev**, NRC-IMI-CAMM, London, ON, Canada*, ***Remus Tutunea-Fatan**, The University of Western Ontario, London, ON, Canada*

Predictive Modeling for Glass-Side Laser Scribing of Thin Film Photovoltaic Cells
NAMRC40-7774
***Hongliang Wang, Shan-Ting Hsu, Huade Tan, Y. Lawrence Yao**, Columbia University, New York, NY, United States*, ***Hongqiang Chen, Magdi N. Azer**, GE Global Research, Niskayuna, NY, United States*

MSEC 1-3-5 Thermal Effects
117 DeBartolo Hall 11:00 - 12:00

Session Chair: **Cristina J. Bunget**, *Clemson University, Greenville, SC, United States.*
Session Co-Chair: **Arif S. Malik**, *Saint Louis University, St. Louis, MO, United States.*

Hook Shaped Residual Stress, The Effect of Tool Ploughing, and the Analysis of the Mechanical and Thermal Effects
MSEC2012-7220
***Xueping Zhang, Shenfeng Wu**, Shanghai Jiao Tong University, Shanghai, China*, ***C. Richard Liu**, Purdue University, West Lafayette, IN, United States.*

Thermal Modeling of Electron Beam Additive Manufacturing Process - Powder Sintering Effects
MSEC2012-7253
***Ninggang Shen**, **Kevin Chou**, University of Alabama, Tuscaloosa, AL, United States.*

MSEC 2-2-1 Robotics in Manufacturing
125 DeBartolo Hall 11:00 - 12:00

Session Chair: **Martin Jun**, *University of Victoria, Victoria, BC, Canada.*
Session Co-Chair: **Johnson Samuel**, *Rensselaer Polytechnic Institute, Troy, NY, United States.*

Contour Detection for Robotic Chamfering Based on Optical Measurement Technologies: Fringe Projection vs. Profile Sensor
MSEC2012-7247
***Richard Münder**, **Bernhard Karpuschewski**, University of Magdeburg, Magdeburg, Germany.*

Study of Pressure Distribution in Compliant Coated Abrasive Tools for Robotic Polishing
MSEC2012-7396
***Umer Muhammed, Kushendarsyah Saptaji, Sathyan Subbiah**, Nanyang Technological University, Singapore, Singapore.*

MSEC 3-1-3 Layered Manufacturing
136 DeBartolo Hall 11:00 - 12:00

Session Chair: **Jack G. Zhou**, *Drexel University, Philadelphia, PA, United States.*
Session Co-Chair: **Haibo Gong**, *Drexel University, Philadelphia, PA, United States.*

Deposition of Al-doped Zinc Oxide by Direct Pulsed Laser Recrystallization at Room Temperature on Various Substrates for Solar Cell Applications
MSEC2012-7381
***Martin Y. Zhang, Qiong Nian, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States.*

A Note on the High Aspect-Ratio SU-8 Micromechanical Structures Using Mask-Less Direct Laser Writing
MSEC2012-7413
***Siddharth Ghosh**, University of Birmingham, Birmingham, United Kingdom*, ***G.K. Ananthasuresh**, Indian Institute of Science, Bangalore, Karnataka, India.*

MSEC 3-3-3 Nanomaterials
140 DeBartolo Hall 11:00 - 12:00

Session Chair: **Xiaoping Yang**, *Cummins Inc., Columbus, IN, United States*
Session Co-Chair: **Jack Zhou**, *Drexel University, Philadelphia, PA, United States*

Nanoparticles Embedding into Metallic Materials by Laser Direct Irradiation
MSEC2012-7379
***Dong Lin, Sergey Suslov, Chang Ye, Yiliang Liao, C. Richard Liu, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States.*

Nanodiamond Reinforced PLLA Nanocomposites for Bone Tissue Engineering
MSEC2012-7393
***Qingwei Zhang, Yury Gogotsi, Peter Lelkes, Jack Zhou**, Drexel University, Philadelphia, PA, United States.*

MSEC 4-1-1 Green Energy Product Research
116 DeBartolo Hall 11:00 - 12:00

Session Chair: **Lin Li**, *University of Illinois at Chicago, Chicago, IL, United States.*
Session Co-Chair: **Xiaoning Jin**, *University of Michigan, Ann Arbor, MI, United States.*

Simulation-Based Energy Efficiency Improvement for Sustainable Manufacturing Systems
MSEC2012-7242
***Lin Li, Zeyi Sun, Haoxiang Yang**, University of Illinois at Chicago, Chicago, IL, United States*, ***Fangming Gu**, General Motors, Warren, MI, United States.*

Performance Analysis and Optimization of Remanufacturing Systems with Stochastic Returns
MSEC2012-7383
***Guoxian Xiao**, General Motors R&D Center, Warren, MI, United States*, ***Xiaoning Jin**, University of Michigan, Ann Arbor, MI, United States*, ***Qing Chang**, Stony Brook University, Stony Brook, NY, United States*, ***Stephan Biller**, General Motors, Warren, MI, United States*, ***Jun Ni**, **S. Jack Hu**, University of Michigan, Ann Arbor, MI, United States.*

Lunch and SME Founder's Lecture, South Dining Hall 12:00-14:00

CONCURRENT TECHNICAL SESSIONS 14:00-15:30

NAMRC 1-5 Diagnosis and Sensing
125 DeBartolo Hall 14:00 - 15:30

Session Chair: **John Morehouse,** *Georgia Institute of Technology, Atlanta, GA, United States*
Session Co-Chair: **Jaime Camelio**, *Virginia Institute of Technology, Blacksburg, VA, United States*

Multi Sensor Data Fusion in Surface and Dimensional Metrology Domains
NAMRC40-7790
***Suresh Kumar Ramasamy**, **Jayaraman Raja, Brian Boudreau**, University of North Carolina at Charlotte, Charlotte, NC, United States*

Current Envelope Analysis for Defect Identification and Diagnosis in Induction Motors
NAMRC40-7804
***Jinjiang Wang, Shaopeng Liu, Robert Gao, Ruqiang Yan**, University of Connecticut, Storrs, CT, United States*

Damage Diagnosis and Fixture Classification Using Impedance-Based Sensors
NAMRC40-7824
***Jeremy Rickli, Charles Crawford, Sudipto Aich, Jaime Camelio**, Virginia Institute of Technology, Blacksburg, VA, United States*

NAMRC 1-26 Machining IV - Machining of Composites
126 DeBartolo Hall 14:00 - 15:30

Session Chair: **Jason Wou,** *Bishop Steering, Indianapolis, IN, United States*
Session Co-Chair: **Patrick Kwon,** *Michigan State University, East Lansing, MI, United States*

Effect of Machining on Tensile Strength of Composite Laminates
NAMRC40-7750
***Jamal Sheikh-Ahmad**, The Petroleum Institute, Abu Dhabi, United Arab Emir.*, ***Abdul Hamid Shahid**, The Petroelum Institute, Abu Dhabi, United Arab Emir.*

Tool Wear of Ultra-Hard Coatings in Drilling CFRP
NAMRC40-7771
***Xin Wang, Patrick Kwon**, Michigan State University, East Lansing, MI, United States*, ***Caleb Sturtevant, Dave (Dae-Wook) Kim**, Washington State University Vancouver, Vancouver, WA, United States*, ***Jeff Lantrip**, Boeing Co, Seattle, WA, United States*

Development of Hole Making Apparatus Based on Double Eccentric Mechanism and its Capability in the Case of Bi-Layer Composite Materials Consisting of CFRP Laminates and Titanium Alloys
NAMRC40-7701
***Hukuzo Yagishita**, Numzu National College of Technology, Numazu, Shizuoka, Japan*

NAMRC 1-27 MICROFABRICATION
140 DeBartolo Hall 14:00 - 15:30

Session Chair: **Brian K Paul**, *Oregon State University, Corvallis, OR, United States*
Session Co-Chair: **Masahiko Yoshino**, *Tokyo Institute of Technology, Tokyo, Japan*

Towards Control of Carbon Nanotube Synthesis Process Using Prediction-Based Fast Monte Carlo Simulations
NAMRC40-7791
***Changqing Cheng, Satish Bukkapatnam, Lionel Raff, Ranga Komanduri**, Oklahoma State University, Stillwater, OK, United States*

Micro Fabrication on Cylinder Surface for Control of Wettability
NAMRC40-7792
***Takashi Matsumura, Hitoshi Sadakata, Hiroshi Makihata**, Tokyo Denki University, Tokyo, Japan*

Investigation of Carbon Nanotube (CNT) Nanocomposites Through Micro Scribing and Indentations
NAMRC40-7795
Chaneel Park, Golam Mostofa, Mehdi Mahmoodi, Simon Park*, University of Calgary, Calgary, AB, Canada*

MSEC 1-2-1 Electrical Discharge Machining and Grinding
117 DeBartolo Hall 14:00 - 15:30

Session Chair: **Avanish Kumar Dubey***, Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India.*
Session Co-Chair: **Albert W.J. Hsue***, National Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan.*

Intelligent Modeling and Optimization of Material Removal Rate in Electric Discharge Diamond Grinding
MSEC2012-7252
Pankaj Kumar Shrivastava*, Vindhya Institute of Technology & Science, Satna, India*, ***Avanish Kumar Dubey****, Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India.*

Experimental Characterization of Vibration-Assisted Reverse Micro Electrical Discharge Machining (EDM) for Surface Texturing
MSEC2012-7314
Sachin Mastud*, Veermata Jijabai Technologial Institute, Matunga, Maharashtra, India*, ***Mayank Garg****, IIT Bombay, Powai, India*, ***Ramesh Singh****, Indian Institute of Technology Bombay, Mumbai, India*, ***Johnson Samuel****, Rensselaer Polytechnic Institute, Troy, NY, United States*, ***Suhas Joshi****, Indian Institute of Technology Bombay, Mumbai, India.*

Milling Tool of Micro-EDM by Ultrasonic Assisted Multi-axial Wire Electrical Discharge Grinding Processes
MSEC2012-7415
Albert W.J. Hsue*, National Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan*, ***Jun-Jie Wang, Chia-Hung Chang****, Kaohsiung University of Applied Sciences (KUAS), Kaohsiung, Taiwan.*

MSEC 1-5-3 Electrical and Thermal Effects
131 DeBartolo Hall 14:00 - 15:30

Session Chair: **Cristina J. Bunget***, Clemson University, Greenville, SC, United States.*

Electro-Hydraulic Forming of Advanced High-Strength Steels: Deformation and Microstructural Characterization
MSEC2012-7322
***Aashish Rohatgi, Elizabeth V. Stephens, Danny J. Edwards, Mark T. Smith, Richard W. Davies**, Pacific Northwest National Laboratory, Richland, WA, United States.*

Thermal Response Characterization of Sheet Metals During Electrically-Assisted Forming (EAF)
MSEC2012-7349
***Joshua Jones**, **Laine Mears**, Clemson University, Greenville, SC, United States.*

Friction and Deformation-Induced Heating During Sheet Metal Stamping
MSEC2012-7278
***Michael P. Pereira, Bernard F. Rolfe**, Deakin University, Geelong, Victoria, Australia.*

MSEC 1-7-1 Advances in Biomanufacturing
136 DeBartolo Hall 14:00 - 15:30

Session Chair: **Wei Li**, *University of Texas at Austin, Austin, TX, United States.*
Session Co-Chair: **Binil Starly,** *University of Oklahoma, Norman, OK, United States.*

Force Model for Needle-Tissue Interaction
MSEC2012-7257
***Peidong Han, Kumar Pallav, Kornel Ehmann**, Northwestern University, Evanston, IL, United States.*

Laser Micromachining Modeling and Laser Machined Surface Errors Prediction for Biomedical Applications
MSEC2012-7370
***Yuan-Shin Lee**, North Carolina State University, Raleigh, NC, United States*, ***Plawut Wongwiwat**, North Carolina State University, College of Engineering, Raleigh, NC, United States*, ***Roger J. Narayan**, University of North Carolina, Raleigh, NC, United States.*

Effects of Lubricant on the Mechanical Properties and Microstructural Evolution of Aluminum 6063 Alloy after ECAE
MSEC2012-7223
***Joseph S. Ajiboye, Saheed A. Adebayo, Temitayo M. Azeez**, University of Lagos, Lagos, Nigeria.*

MSEC 4-2-4 Sustainable Manufacturing Methods II
116 DeBartolo Hall 14:00 - 15:30

Session Chair: **Yuebin Guo**, *University of Alabama, Tuscaloosa, AL, United States.*
Session Co-Chair: **Xiaoning Jin**, *University of Michigan, Ann Arbor, MI, United States.*

Life Cycle Analysis of Diamond Coating of Machining Tools
MSEC2012-7206
***Carlos Wilfong, Humberto A Gomez, Delcie R Durham**, University of South Florida, Tampa, FL, United States.*

Experimental Measurement of Nano-Particle Emissions from Atomic Layer Deposition
MSEC2012-7320
***Jingwan Huo, Xiu Lin**, **Chris Yuan**, University of Wisconsin-Milwaukee, Milwaukee, WI, United States.*

Electric Power Resource Planning: A Case Study of Norway
MSEC2012-7215
***Rhythm Wadhwa**, NTNU, Trondheim, Norway.*

MSEC 5-1-2 Student Manufacturing Design Competition
McKenna Auditorium 14:00 - 15:30

Session Chair: **Xiaoping Yang**, *Cummins Inc., Columbus, IN, United States*

Industry Tours
15:30-18:30

Space is limited, reservations are required. Please sign up for industry tours at the registration desk. Meet at the Atrium in McKenna Hall.

Options are:

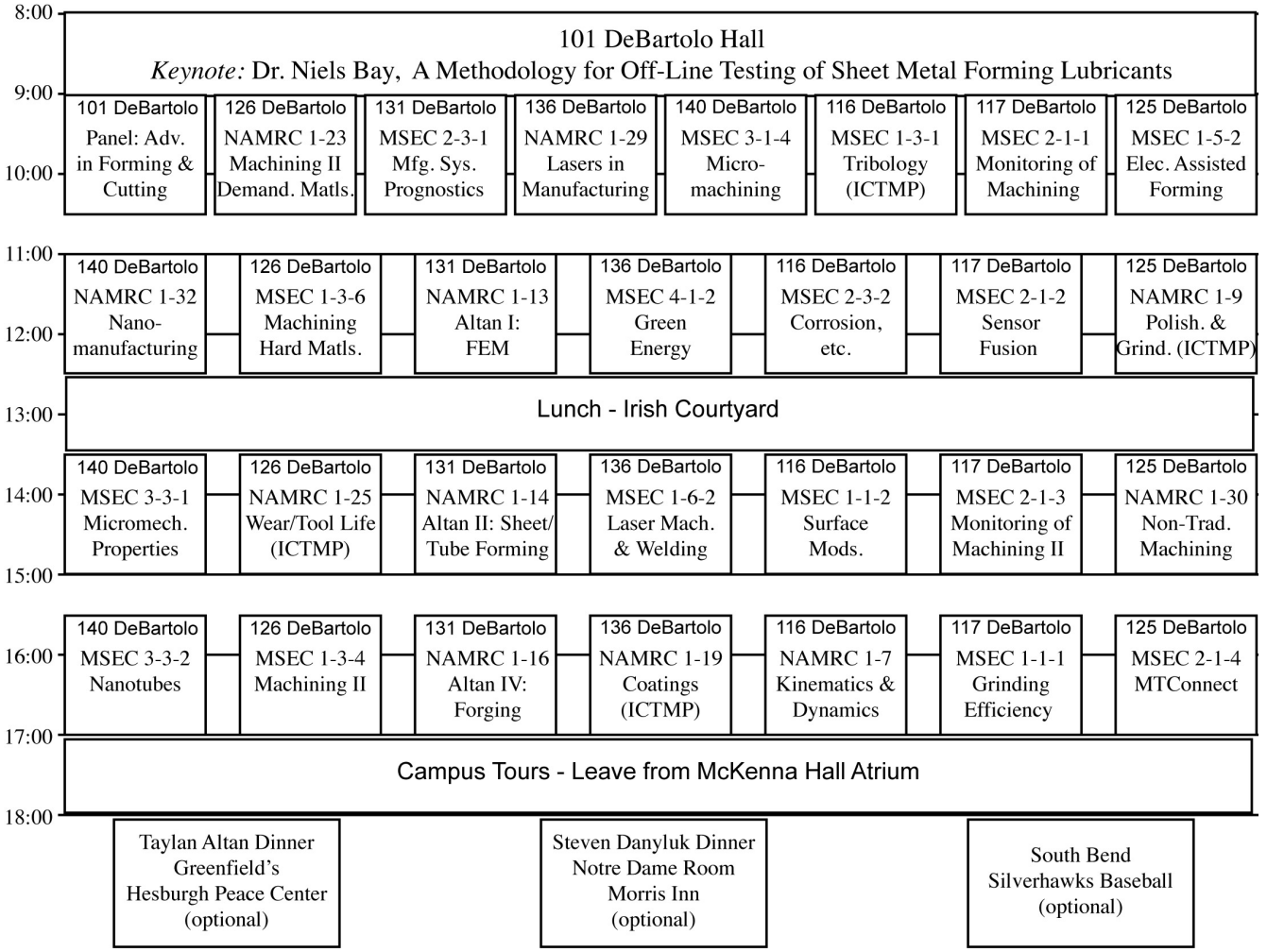
a. Zimmer Inc. (orthopedic implants)
b. DePuy, a Johnson & Johnson Company (orthopedic implants)
c. Jayco, Inc. (recreational vehicles)

Reception and Awards Banquet, Club Naimoli
18:30-22:00

TECHNICAL PROGRAM - THURSDAY, JUNE 7, 2012

Overview

Spouse's Program: Shipshewanna



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00-8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00-17:00.
3. Lunch will be moved to South Dining Hall in case of inclement weather.

Keynote: Dr. Niels Bay, A Methodology for Off-Line Testing of Sheet Metal Forming Lubricants
101 DeBartolo Hall 8:00 - 9:00

CONCURRENT TECHNICAL SESSIONS
9:00-10:30

Panel: Advances in Metal Forming & Machining Through Global Collaborations: A Panel in Honor of Dr. Taylan Altan

101 DeBartolo 9:00 - 10:30

Moderator: ***Taylan Altan****, Ohio State University, Columbus, OH, United States.*

Panelists:

Yusuf Altintas**,** *University of British Columbia, Vancouver, BC, Canada*
Niels Bay**,** *Technical University of Denmark, Lyngby, Denmark*
Erman Tekkaya**,** *Technische Universität Dortmund, Dortmund, Germany*
Reiner Kopp, *RWTH Aachen University, Aachen, Germany*

NAMRC 1-23 Machining II

126 DeBartolo Hall 9:00 - 10:30

Session Chair: **I.S. Jawahir***, University of Kentucky, Lexington, KY, United States*

Investigations in Subsurface Damage When Machining Nickel-Based Superalloys
NAMRC40-7775
Yujie Chen, Cristina Bunget, Thomas R. Kurfess*, Clemson University, Greenville, SC, United States*

Deformation of OFHC Copper During Cutting
NAMRC40-7806
Sreedhar Vasomsetti, Madhavan Vis*, Wichita State University, Wichita, KS, United States*

Experimental Study of Conventional and Peck Drilling Operations
NAMRC40-7759
Salman Pervaiz, Ibrahim Deiab*, American University of Sharjah, Sharjah, United Arab Emir.*, ***Hossam Kishawy****, University of Ontario Institute of Technology, Oshawa, ON, Canada*

1-29 MICROMACHINING II - LASERS IN MICROMACHINING
136 DeBartolo Hall 9:00 - 10:30

Session Chair: **Frank Pfefferkorn,** *University of Wisconsin, Madison, WI, United States*

Nanosecond Pulsed Laser Micro-Machining of PMMA-Based Microfluidic Channels
NAMRC40-7746
Daniel Teixidor, Joaquim Ciurana*, University of Girona, Girona, Spain*, ***Thanongsak Thepsonthi, Tugrul Özel****, Rutgers University, Piscataway, NJ, United States*

Single Step Channeling in Glass Interior by Femtosecond Laser
NAMRC40-7815
Panjawat Kongsuwan, Hongliang Wang, Y. Lawrence Yao*, Columbia University, New York, NY, United States*

Effect of Applied Load, Cutting Speed and Laser Power on the Material Deformation and Removal of Semiconductors
NAMRC40-7777
Deepak Ravindra, John Patten, Muralidhar Ghantasala*, Western Michigan University, Kalamazoo, MI, United States*

MSEC/ICTMP 1-3-1 Tribology I
116 DeBartolo Hall 9:00 - 10:30

Session Chair: **Arif S. Malik***, Saint Louis University, St. Louis, MO, United States.*
Session Co-Chair: **Ihab Ragai***, Hitachi, Guelph, ON, Canada.*

A Methodology to Determine Friction in Orthogonal Cutting with Application to Machining Titanium and Nickel Based Alloys
MSEC2012-7275
Durul Ulutan, Tugrul Özel*, Rutgers University, Piscataway, NJ, United States.*

Evidence of Phase Dependent Tool Wear in Ti-6Al-4V Turning Experiments Using PCD and Carbide Inserts
MSEC2012-7332
David Schrock, Patrick Kwon*, Michigan State University, East Lansing, MI, United States.*

The Correlation of Volumetric Tool Wear and Wear Rate of Machining Tools with the Material Removal Rate of Titanium Alloys
MSEC2012-7338
***Mathew Kuttolamadom**, **Parikshit Mehta**, **Laine Mears**, **Thomas R. Kurfess**, Clemson University, Greenville, SC, United States.*

MSEC 1-5-2 Electrically Assisted Forming
125 DeBartolo Hall 9:00 - 10:30

Session Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States.*
Session Co-Chair: **Scott W. Wagner**, *Michigan Technological University, Houghton, MI, United States*

Modeling the Electroplastic Effect During Electrically-Assisted Forming of 304 Stainless Steel
MSEC2012-7241
***Wesley A. Salandro**, **Cristina J. Bunget**, **Laine Mears**, Clemson University, Greenville, SC, United States.*

Sensitivities when Modeling Electrically-Assisted Forming
MSEC2012-7334
***Cristina J. Bunget**, **Wesley A. Salandro**, **Laine Mears**, Clemson University, Greenville, SC, United States.*

Effects of Continuous Direct Current on the Yield Stress of Stainless Steel 304 Micro Tubes During Hydroforming Operations
MSEC2012-7309
***Scott W. Wagner**, **Kenny Ng**, Michigan Technological University, Houghton, MI, United States*, ***William J. Emblom**, University of Louisiana at Lafayette, Lafayette, LA, United States*, ***Jaime A. Camelio**, Virginia Tech, Blacksburg, VA, United States.*

MSEC 2-1-1 Monitoring of Machining I
117 DeBartolo Hall 9:00 - 10:30

Session Chair: **Robert Ivester**, *National Institute of Standards and Technology, Gaithersburg, MD, United States.*
Session Co-Chair: **Mike Vogler**, *Caterpillar Inc., Peoria, IL, United States.*

Estimation of Cutting Force Model Coefficients to Track Wear in Milling Using Bayesian Analysis
MSEC2012-7259
***Mehdi Nouri**, **Barry K. Fussell**, **Robert B. Jerard**, **Ernst Linder**, University of New Hampshire, Durham, NH, United States*, ***Lei Gao**, George Mason University, Fairfax, VA, United States.*

Machining Process Power Monitoring: Bayesian Update of Machining Power Model
MSEC2012-7277
***Parikshit Mehta**, **Mathew Kuttolamadom**, **Laine Mears**, Clemson University, Greenville, SC, United States.*

Surface Variation Reduction for Face Milling Based on High-Definition Metrology
MSEC2012-7208
***Bruce L. Tai, Hui Wang, Hai Nguyen, S. Jack Hu, Albert Shih**, University of Michigan, Ann Arbor, MI, United States.*

MSEC 2-3-1 Manufacturing System Prognostics
131 DeBartolo Hall 9:00 - 10:30

Session Chair: **Sang Won Lee**, *Sungkyunkwan University, Suwon, Korea (Republic).*
Session Co-Chair: **Seungchul Lee**, *University of Michigan, Ann Arbor, MI, United States.*

Degradation-based Swapping Policy with Application to System-level Manufacturing Utilization
MSEC2012-7280
***Ahmad Almuhtady, Seungchul Lee, Jun Ni**, University of Michigan, Ann Arbor, MI, United States.*

Dissimilarity Measures for ICA-based Source Number Estimation
MSEC2012-7340
***Wei Cheng**, **Seungchul Lee**, University of Michigan, Ann Arbor, MI, United States*, ***Zhousuo Zhang, Zhengjia He**, Xi'an Jiaotong University, Xi'an, China.*

Extension of Maintenance Opportunity Windows to General Manufacturing Systems
MSEC2012-7346
***Xi Gu, Seungchul Lee, Xinran Liang, Jun Ni**, University of Michigan, Ann Arbor, MI, United States.*

MSEC 3-1-4 Micro-scale Machining II
140 DeBartolo Hall 9:00 - 10:30

Session Chair: **Jack G. Zhou**, *Drexel University, Philadelphia, PA, United States.*
Session Co-Chair: **Xiang Ren**, *Drexel University, Philadelphia, PA, United States.*

Experimental Investigation of the Machinability of Epoxy Reinforced with Graphene Platelets
MSEC2012-7204
***Ishank Arora, Johnson Samuel, Nikhil Koratkar**, Rensselaer Polytechnic Institute, Troy, NY, United States.*

Mathematical Modeling of Cutting Forces in Micro-Drilling
MSEC2012-7399
***Kumar Sambhav**, Indian Institute of Technology, Kanpur, Kanpur, Uttar Pradesh, India*, ***Puneet Tandon**, PDPM IIITDM Jabalpur, Jabalpur, Madhya Pradesh, India*, ***Shiv G. Kapoor**, University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ***Sanjay G. Dhande**, Indian Institute of Technology, Kanpur, Kanpur, Uttar Pradesh, India.*

Process Stability and Energy Efficiency of the Grinding Process of High Performance Materials
MSEC2012-7297
***Eckart Uhlmann, Christoph Sammler, Fiona Sammler, Florian Heitmüller, Leif Hochschild**, Technische Universität Berlin, Berlin, Germany.*

CONCURRENT TECHNICAL SESSIONS
11:00-12:30

NAMRC/ICTMP 1-9 Polishing and Grinding
125 DeBartolo Hall 11:00 - 12:30

Session Chair: **Hitomi Yamaguchi**, *University of Florida, Gainesville, FL, United States*

Characterization of Surfaces Produced by Abrasive Flow Machining Under Magnetic Field Assistance
NAMRC40-7702
***Balkar Singh**, Punjab Technical University, Jallandhar, India*, ***Sehijpal Singh**, Guru Nanak Dev Engineering College, Ludhiana, India*, ***Pradeep Kumar**, IIT Roorkee, Roorkee, India*, ***Harbhajan Singh Shan**, Swift Institution of Engineering and Technology, Chandigarh, India*

A Case for 2-Body Material Removal in Prime LED Sapphire Substrate Lapping and Polishing
NAMRC40-7714
***John J Gagliardi, Dr. Matt R. Atkinson, Dr. Jennifer J Sokol**, 3M, St. Paul, MN, United States*, ***Don Kim**, 3M, Dongtan, Korea (Republic)*, ***Vincent D Romero, Larry Zazzera**, 3M, St. Paul, MN, United States*, ***Faisal Nabulsi**, Rubicon, Franklin Park, IL, United States*, ***Harry Zhang**, Rubicon, Chicago, IL, United States*

Highly-Efficient Polishing Technology for Glass Substrates Using Tribo-Chemical Polishing With Electrically Controlled Slurry
NAMRC40-7731
***Yoichi Akagami, Hiroshi Ikeda**, Akita Industrial Technology Center, Akita, Japan*

NAMRC 1-13 Altan Symposium I: Finite Element Method
131 DeBartolo Hall 11:00 - 12:30

Session Chair: **Thomas R. Neitzert**, *Auckland University of Technology, Auckland, New Zealand*
Session Co-Chair: **Tugrul Özel**, *Rutgers University, Piscataway, NJ, United States*

Algorithm for Tool Geometry Updating in 3D FEM Environment Considering the Tool Wear
NAMRC40-7727
***Aldo Attanasio, Elisabetta Ceretti, Cristian Cappellini**, University of Brescia, Brescia, Italy*, ***Claudio Giardini**, University of Bergamo, Dalmine (BG), Italy*, ***Gérard Poulachon**, Arts et Metiers ParisTech, Cluny, France*

New Developments in the FE Simulation of Closed Die Forging Processes
NAMRC40-7772
***Bernd-Arno Behrens**, Institute of Forming Technology and Machines, Leibniz Universität Hannover, Garbsen, Lower Saxony, Germany*

Modeling Machining Distortion Using the Finite Element Method: Application to Engine Disk
NAMRC40-7827
***Marko Knezevic**, Los Alamos National Laboratory, Los Alamos, NM, United States*, ***Byung Kwan Chun, Jin Yong Oh, Wei-Tsu Wu**, Scientific Forming Technologies Corporation, Columbus, OH, United States*, ***Robert A. Ress III, Michael G. Glavicic**, Rolls-Royce Corporation, Indianapolis, IN, United States*, ***Shesh Srivatsa**, GE Aviation, Cincinnati, OH, United States*

NAMRC 1-32 Nanomanufacturing
140 DeBartolo Hall 11:00 - 12:30

Session Chair: **Placid Ferreira**, *University of Illinois at Urbana-Champaign, Urbana, IL, United States*
Session Co-Chair: **Sathyan Subbiah,** *Nanyang Technological University, Singapore*

Ultrasonic Vibration Assisted Nanomachining on PMMA with an AFM
NAMRC40-7737
***Li Zhang, Jingyan Dong**, North Carolina State University, Raleigh, NC, United States*

Effects of Process Conditions on Nano-Dot Array Formation by Thermal Dewetting
NAMRC40-7740
***Masahiko Yoshino**, Tokyo Institute of Technology, Tokyo, Japan*, ***Hiroki Osawa**, Sharp, Nara, Japan*, ***Akinori Yamanaka**, Tokyo Institute of Technology, Tokyo, Japan*

Experimental Investigation and Characterization of Nano-Scale Dry Electro-Machining
NAMRC40-7789
***Muhammad Jahan, Ajay Malshe**, University of Arkansas, Fayetteville, AR, United States*, ***K.P. Rajurkar**, University of Nebraska-Lincoln, Lincoln, NE, United States*

MSEC 1-3-6 Hard Materials
126 DeBartolo Hall 11:00 - 12:30

Session Chair: **Cristina J. Bunget**, *Clemson University, Greenville, SC, United States.*
Session Co-Chair: **Ihab Ragai**, *Hitachi, Guelph, ON, Canada.*

Experimental Investigation of Hard Turning Mechanisms by PCBN Tooling Embedded Micro Thin Film Thermocouples
MSEC2012-7262
***Linwen Li**, Northwestern University, Evanston, IL, United States*, ***Bin Li**, Huazhong University of Science and Technology, Wuhan, Hubei, China*, ***Xiaochun Li**, University of Wisconsin-Madison Madison, Madison, WI, United States*, ***Kornel Ehmann**, Northwestern University, Evanston, IL, United States.*

Minimized Wear and Debris Generation through Optimized Machining of Co-Cr-Mo Alloys for Use in Metal-on-Metal Hip Implants
MSEC2012-7260
***Ashish Deshpande, Shu Yang, Dave Puleo, David Pienkowski, Oscar Dillon**, University of Kentucky, Lexington, KY, United States*, ***Jose Outeiro**, Portuguese Catholic University, Rio de Mouro, Lisbon, Portugal*, ***I.S. Jawahir**, University of Kentucky, Lexington, KY, United States.*

Robust Shearing Process for Improving AHSS Edge Stretchability
MSEC2012-7318
***Hua-Chu Shih, Ming F. Shi**, United States Steel Corporation, Troy, MI, United States.*

MSEC 2-1-2 Sensors and Sensor Fusion
117 DeBartolo Hall 11:00 - 12:30

Session Chair: **Yuebin Guo**, *University of Alabama, Tuscaloosa, AL, United States.*
Session Co-Chair: **Kang B Lee**, *NIST, Gaithersburg, MD, United States.*

Detection of Cutting Phenomena Using Sensor Fusion
MSEC2012-7307
***John A. Slotwinski, Ph.D., Gregory Vogl, Robert Ivester, Ph.D.**, National Institute of Standards and Technology, Gaithersburg, MD, United States*, ***Ian Younker**, Lebanon Valley College, Annville, PA, United States.*

Process Monitoring During Micro-drilling via Acoustic Emission, Ultrasonic Sound, and Spindle Load Sensors
MSEC2012-7341
***Keith Bourne, Shiv G. Kapoor**, University of Illinois at Urbana Champaign, Urbana, IL, United States.*

Classifier Fusion for Acoustic Emission Based Tool Wear Monitoring
MSEC2012-7380
***Juil Yum, Tae Hyung Kim**, **Elijah Kannatey-Asibu**, University of Michigan, Ann Arbor, MI, United States.*

MSEC 2-3-2 Corrosion/Electrolytic Effects
116 DeBartolo Hall 11:00 - 12:30

Session Chair: **Seungchul Lee**, *University of Michigan, Ann Arbor, MI, United States.*
Session Co-Chair: **Daniel Peters**, *Nu-Iron Unlimited, Point Lisas, Trinidad/Tobago.*

Battery Prognostics: SoC and SoH Prediction
MSEC2012-7345
***Seungchul Lee**, **Harry Cui**, University of Michigan, Ann Arbor, MI, United States*, ***Mohammad Rezvani**, University of Cincinnati, Cincinnati, OH, United States*, ***Jun Ni**, University of Michigan, Ann Arbor, MI, United States.*

Application of OLI Electrolyte Simulation to the Resolution of Corrosion Concerns Within a Reciprocating Compressor
MSEC2012-7224
***Diane Stewart, P.E.**, Praxair, Geismar, LA, United States*, ***Anthony J. Gerbino, Ph.D.**, AQSim, Aqueous Process Simulations, Denville, NJ, United States*, ***Tony Scribner**, Becht Engineering, Gilbert, SC, United States.*

An Integrated Design Strategy for Dust Collection and Slurry Transport Systems and Implementation in a Steel Plant
MSEC2012-7390
***Daniel Peters, Aquelius Young**, Nu-Iron Unlimited, Point Lisas, Trinidad and Tobago.*

MSEC 4-1-2 Green Energy Product Manufacturing Research
136 DeBartolo Hall 11:00 - 12:30

Session Chair: **Hui Wang**, *University of Michigan, Ann Arbor, MI, United States.*

Ultrasonic-Vibration Assisted Pelleting for Cellulosic Biofuel Manufacturing: Investigation on Power Consumption with Design of Experiment
MSEC2012-7212
***Qi Zhang**, **Pengfei Zhang, Graham Pritchett, Z.J. Pei, Meng Zhang, Xiaoxu Song, T.W. Deines**, Kansas State University, Manhattan, KS, United States.*

Effects of Water Soaking on Biomass Particle Size in Cellulosic Biofuel Manufacturing
MSEC2012-7227
***Hera Wu**, University of California-Berkeley, Berkeley, CA, United States*, ***Pengfei Zhang**, **Qi Zhang**, **Z.J. Pei**, Kansas State University, Manhattan, KS, United States.*

Sugar Yield Comparison of Wheat Straw Processed by Two Pelleting Methods for Cellulosic Biofuel Manufacturing
MSEC2012-7228
***Qi Zhang**, **Pengfei Zhang**, Kansas State University, Manhattan, KS, United States*, ***Kangqi Fan**, Xidian University, Manhattan, KS, United States*, ***Meng Zhang, Xiaoxu Song, Z.J. Pei, Obair Siddiqui**, Kansas State University, Manhattan, KS, United States.*

Lunch, Irish Courtyard
12:30-13:30

CONCURRENT TECHNICAL SESSIONS
13:30-15:00

NAMRC 1-14 Altan Symposium II: Sheet Metal and Tube Forming
131 DeBartolo Hall 13:30 - 15:00

Session Chair: **Elisabetta Ceretti**, *University of Brescia, Brescia, Italy*
Session Co-Chair: **William J. Emblom**, *University of Louisiana at Lafayette, Lafayette, LA, United States*

The Development of a Simple Method for Micro Strain Measurement Applied to Bulge Microhydroforming
NAMRC40-7706
***Richard J. Jones**, Caterpillar, Peoria, IL, United States*, ***William J. Emblom**, University of Louisiana at Lafayette, Lafayette, LA, United States*, ***Gary A. Glass**, University of North Texas, Denton, TX, United States*

Recent Developments in Non-Conventional Tube Forming
NAMRC40-7756
***Lukas Kwiatkowski**, **O. Koray Demir**, **Soeren Gies, A. Erman Tekkaya**, Technische Universität Dortmund, Dortmund, NRW, Germany*

New Developments in Sheet Metal Forming of Stainless Steel: Current Investigations and Future Challenges
NAMRC40-7828
***Philipp Schmid**, FGU mbH Stuttgart, Stuttgart, Baden-Wuerttemberg, Germany*, ***Mathias Liewald**, University of Stuttgart, Stuttgart, Germany*

NAMRC/ICTMP 1-25 Machining IV - Wear and Tool Life
126 DeBartolo Hall 13:30 - 15:00

Session Chair: **Pierre Montmitonnet**, *MINES Paristech - CEMEF, Sophia Antipolis, France*
Session Co-Chair: **Kevin Chou**, *The University of Alabama, Tuscaloosa, AL, United States*

Spindle Speed Selection for Tool Life Testing using Bayesian Inference
NAMRC40-7703
***Jaydeep Karandikar, Tony Schmitz**, University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Ali Abbas**, University of Illinois at Urbana-Champaign, Urbana, IL, United States*

Updated Mechanistic Force Model to Account for Rapid Tool Wear when Milling Nickel-Based Superalloys
NAMRC40-7744
***Andrew Henderson, Cristina Bunget, Thomas R. Kurfess**, Clemson University, Greenville, SC, United States*

Design and Evaluation of an Atomization-Based Cutting Fluid Spray System in Turning of Titanium Alloy
NAMRC40-7797
***Chandra Nath, Shiv G. Kapoor, Richard E. DeVor**, University of Illinois at Urbana-Champaign, Urbana, IL, United States*, ***Anil K. Srivastava**, Techsolve, Inc., Cincinnati, OH, United States*

NAMRC 1-30 Non-traditional Machining
125 DeBartolo Hall 13:30 - 15:00

Session Chair: **Murali Sundaram**, *University of Cincinnati, Cincinnati, OH, United States*
Session Co-Chair: **K. Rajurkar,** *University of Nebraska-Lincoln, Lincoln, NE, United States*

Comparison of Different Approaches to Force Controlled Precision Honing of Bores
NAMRC40-7724
***Dirk Bähre, Christina Schmitt, Uwe Moos**, Saarland University, Saarbrücken, Germany*

White Layer Thickness Formation in Electro Discharge Machining of Beryllium-Copper Alloys
NAMRC40-7764
***Yakup Yildiz**, Dumlupinar University, Kutahya,Turkey*, ***Murali Sundaram**, University of Cincinnati, Cincinnati, OH, United States*, ***K.P. Rajurkar**, University of Nebraska-Lincoln, Lincoln, NE, United States*

Energy Dissipation, Microstructure and Hardening in Cryogenic Machining
NAMRC40-7779
***Christopher Saldana**, Pennsylvania State University, University Park, PA, United States*

MSEC 1-1-2 Surface Modification
116 DeBartolo 13:30 - 15:00

Session Chair: **Barbara S. Linke**, *University of California, Berkeley, Berkeley, CA, United States.*
Session Co-Chair: **John Webster**, *Cool-Grind Technologies, Ashford, CT, United States.*

An Analysis of Polishing Forces in Magnetic Field Assisted Finishing
MSEC2012-7256
***Vasishta Ganguly, Tony Schmitz, Ph.D.**, University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Arthur Graziano, Hitomi Yamaguchi**, University of Florida, Gainesville, FL, United States.*

Tribological Conditioning of Cylinder Running Surfaces
MSEC2012-7237
***Florian Welzel, Bernhard Karpuschewski**, University of Magdeburg, Magdeburg, Germany.*

Observations During Vortex Machining Process Development
MSEC2012-7272
***Stephen C. Howard, Jacob Chesna, Brigid Mullany, Stuart T. Smith**, UNC Charlotte, Charlotte, NC, United States.*

MSEC 1-6-2 Laser Machining and Welding
136 DeBartolo Hall 13:30 - 15:00

Session Chair: **John Patten**, *Western Michigan University, Kalamazoo, MI, United States.*
Session Co-Chair: **Avanish Kumar Dubey**, *Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India.*

Modeling and Optimization of Kerf Taper in Pulsed Laser Cutting of Duralumin Sheet
MSEC2012-7243
***Arun Kumar Pandey, Avanish Kumar Dubey**, Motilal Nehru National Institute of Technology, Allahabad, Uttar Pradesh, India.*

Laser Joining of Continuous Glass Fiber Composite Pre-forms
MSEC2012-7304
***Huade Tan, Lawrence Yao**, Columbia University, New York, NY, United States.*

Studying the Temperature Effect during the High-Pressure Phase Transformation of Silicon via Indentations
MSEC2012-7323
***Deepak Ravindra, John Patten, Muralidhar Ghantasala**, Western Michigan University, Kalamazoo, MI, United States.*

MSEC 2-1-3 Monitoring of Machining II
117 DeBartolo Hall 13:30 - 15:00

Session Chair: **Shreyes N. Melkote, Ph.D.**, *Georgia Institute of Technology, Atlanta, GA, United States.*
Session Co-Chair: **Kevin Chou**, *University of Alabama, Tuscaloosa, United States.*

A Two-Parameter Method to Monitor and Characterize Tool Wear in End Milling Inconel 718
MSEC2012-7362
***Yuebin Guo, W. Li**, University of Alabama, Tuscaloosa, AL, United States.*

End Milling Force Model Calibration using Measured Force Profiles
MSEC2012-7385
***Barry K. Fussell, Yong Zhao, Robert B. Jerard**, University of New Hampshire, Durham, NH, United States.*

Calibration and Characterization of a Low-Cost Wireless Sensor for Applications in CNC End Milling
MSEC2012-7386
***Barry K. Fussell, Andrew Harmon, Robert B. Jerard**, University of New Hampshire, Durham, NH, United States.*

MSEC 3-3-1 Micromechanical Properties
140 DeBartolo Hall 13:30 - 15:00

Session Chair: **Xinnan Wang**, *North Dakota State University, Fargo, ND, United States.*
Session Co-Chair: **Gary J. Cheng**, *Purdue University, West Lafayette, IN, United States.*

Extension of a Microscale Indentation Fracture Model to Nanoscale Contact in Purview of Mechanical Nanofabrication Processes
MSEC2012-7336
***Jared Hann, Raul E. Riveros, Hitomi Yamaguchi, Curtis Taylor**, University of Florida, Gainesville, FL, United States.*

AFM-Based Nanoindentation Process: A Comparative Study
MSEC2012-7356
***Rapeepan Promyoo, Hazim El-Mounayri, Kody Varahramyan**, Indiana University - Purdue University Indianapolis, Indianapolis, IN, United States.*

Micro Characterization of Mg and Mg Alloy for Biodegradable Orthopedic Implants Application
MSEC2012-7395
***Haibo Gong, Yoontae Kim, Qingwei Zhang, Kavan Hazeli, Antonios Kontsos, Peter Lelkes**, Drexel University, Philadelphia, PA, United States*, ***Donggang Yao**, Georgia Institute of Technology, Atlanta, GA, United States*, ***Jack Zhou**, Drexel University, Philadelphia, PA, United States.*

CONCURRENT TECHNICAL SESSIONS
15:30-17:00

NAMRC 1-7 Kinematics and Dynamics
116 DeBartolo Hall 3:30 - 5:00

Session Chair: **Tony Schmitz**, *University of North Carolina at Charlotte, Charlotte, NC, United States*
Session Co-Chair: **John Ziegert**, *University of North Carolina at Charlotte, Charlotte, NC, United States*

A Novel Design of Parallel Compliant Micro-Motion Stages With Kinematotropic Properties
NAMRC40-7773
***Qiang Zeng, Kornel F. Ehmann**, Northwestern University, Evanston, IL, United States*

Joint Dynamics Modeling and Identification
NAMRC40-7784
***Majid Mehrpouya, Eldon Graham, Simon Park**, University of Calgary, Calgary, AB, Canada*

Improved Reduced Order Modeling of Machine Tool Structures
NAMRC40-7825
***Mohit Law, Yusuf Altintas, A. Srikantha Phani**, The University of British Columbia, Vancouver, BC, Canada*

NAMRC 1-16 Altan Symposium IV: Forging
131 DeBartolo Hall 3:30 - 5:00

Session Chair: **Gracious Ngaile**, *North Carolina State Unv, Raleigh, NC, United States*

Investigation of the Fishtail Defect in Ring Rolling by a FEM Approach
NAMRC40-7753
***Luca Giorleo, Elisabetta Ceretti**, University of Brescia, Brescia, Italy*, ***Claudio Giardini**, University of Bergamo, Dalmine (BG), Italy*

Improvement of Tool Life and Production Efficiency in Continuous Grain Flow Forging of Diesel Engine Crankshafts
NAMRC40-7770
***Manas Shirgaokar, Gerhard Epp**, Ellwood National Crankshaft, Irvine, PA, United States*, ***Brian Taylor**, Ellwood Crankshaft Group, Hermitage, PA, United States*

Investigation of the Efficiency of Joint Designs for the Electro-Magnetic Welding (EMW) of the Ring-Shaft Assembly
NAMRC40-7785
***Hyunok Kim**, Edison Welding Institute (EWI), Columbus, OH, United States*, ***Jianhui Shang**, American Trim, Lima, OH, United States*, ***Jerry Gould**, Edison Welding Institute (EWI), Columbus, OH, United States*, ***Ajay Yadav, Robert Meyer**, Caterpillar Inc., Mossville, IL, United States*, ***Menachem Kimchi**, Edison Welding Institute (EWI), Columbus, OH, United States*

NAMRC/ICTMP 1-19 Coatings
136 DeBartolo Hall 3:30 - 5:00

Session Chair: **Miguel A. Selles**, *Universitat Politecnica de Valencia, Alcoy, Spain*
Session Co-Chair: **Amy Libardi,** *University of Notre Dame, Notre Dame, IN, United States*

Analysis of Orthogonal Cutting Experiments Using Diamond-Coated Tools With Force and Temperature Measurements
NAMRC40-7718
***Robert Ivester, Eric Whitenton**, NIST, Gaithersburg, MD, United States*, ***Jill Hershman, Kevin Chou**, The University of Alabama, Tuscaloosa, AL, United States*, ***Qiang Wu**, Kennametal Inc., Latrobe, PA, United States*

PVD Coated Mill Rolls for Cold Rolling of Stainless Steel Strips: Tribological and Mechanical Laboratory Tests
NAMRC40-7720
***Choumad Ould**, CEMEF Ecole des mines de paris, Sophia-Antipolis, France*, ***Xavier Badiche**, HEF R&D, Andrézieux-Bouthéon, France*, ***Pierre Montmitonnet**, MINES Paristech - CEMEF, Sophia Antipolis, France*, ***Yves Gachon**, HEF R&D, Andrézieux-Bouthéon, France*

Orthogonal Cutting of AISI D2 Steel With TiAlN Coated Inserts: Simulations and Experiments
NAMRC40-7757
***Lan Yan, Feng Jiang, Yiming Rong**, Tsinghua University, Beijing, Beijing, China*

MSEC 1-1-1 Grinding Efficiency
117 DeBartolo Hall 15:30 - 17:00

Session Chair: **John Webster**, *Cool-Grind Technologies, Ashford, CT, United States.*
Session Co-Chair: **Brigid Mullany**, *UNC Charlotte, Charlotte, NC, United States.*

Higher Competitiveness of Speed-Stroke Grinding by Using Increased Wheel Speeds
MSEC2012-7240
***Michael Duscha**, RWTH Aachen University, Aachen, NRW, Germany*, ***Barbara S. Linke**, University of California, Berkeley, Berkeley, CA, United States*, ***Fritz Klocke**, RWTH Aachen University, Aachen, NRW, Germany*, ***David Dornfeld**, University of California, Berkeley, Berkley, CA, United States.*

Design and Analysis of Helical Needle Tip Grinding Process
MSEC2012-7274
***Demeng Che, Ping Guo, Kornel Ehmann**, Northwestern University, Evanston, IL, United States.*

In Vitro Dental Cutting of Feldspar and Leucite Glass Ceramics Using an Electric Handpiece
MSEC2012-7290
***Xiao Fei Song, Jianhui Peng**, Tianjin University, Tianjin, China*, ***Ling Yin**, James Cook University, QLD, Australia*, ***Bin Lin**, Tianjin University, Tianjin, China.*

MSEC 1-3-4 Machining II
126 DeBartolo Hall 15:30 - 17:00

Session Chair: **Arif S. Malik**, *Saint Louis University, St. Louis, MO, United States.*
Session Co-Chair: **Ihab Ragai**, *Hitachi, Guelph, ON, Canada.*

High Speed Non-Linear Micro-Milling Dynamics
MSEC2012-7287
***Eric Halfmann, C. Steve Suh**, Texas A&M University, College Station, TX, United States.*

A Metallo-Thermo-Mechanically Coupled Analysis of Orthogonal Cutting of AISI 1045 Steel.
MSEC2012-7300
***Hongtao Ding, Yung Shin**, Purdue University, West Lafayette, IN, United States.*

Finite Element Analysis of Residual Stresses in High-Speed Dry Cutting of Biodegradable Magnesium-Calcium Alloy
MSEC2012-7361
***M. Salahshoor, Yuebin Guo**, University of Alabama, Tuscaloosa, AL, United States.*

MSEC 2-1-4 Applications of MTConnect
125 DeBartolo Hall 15:30 - 17:00

Session Chair: **Radu Pavel**, *TechSolve Inc., Cincinnati, OH, United States.*
Session Co-Chair: **John A. Slotwinski**, *National Institute of Standards and Technology, Gaithersburg, MD, United States.*

PNEUVIZ: MTConnect Compliant Compressed Air Monitoring Application
MSEC2012-7389
***Sri Atluru**, University of Cincinnati, Cincinnati, OH, United States*, ***Amit Deshpande, Ron Pieper**, TechSolve Inc., Cincinnati, OH, United States*, ***Sam Huang**, University of Cincinnati, Cincinnati, OH, United States.*

Integration of MTConnect and Standard-based Sensor Networks for Manufacturing Equipment Monitoring
MSEC2012-7398
***Kang B Lee, Eugene Y. Song, Peter Gu**, NIST, Gaithersburg, MD, United States.*

Statistical Process Monitoring with MTConnect
MSEC2012-7344
***Sri Atluru**, University of Cincinnati, Cincinnati, OH, United States*, ***Amit Deshpande**, TechSolve Inc., Cincinnati, OH, United States.*

MSEC 3-3-2 Nanotube Applications
140 DeBartolo Hall 15:30 - 17:00

Session Chair: **Curtis Taylor**, *University of Florida, Gainesville, FL, United States.*
Session Co-Chair: **Jing Shi**, *North Dakota State University, Fargo, ND, United States.*

In-Situ Characterization of MWCNTs Reinforced Epoxy Nanocomposite under Mechanical Load
MSEC2012-7397
***Xinnan Wang**, **Peng Cui**, **Annie Tangpong**, North Dakota State University, Fargo, ND, United States.*

Estimating the Cohesive Zone Model Parameters for Carbon Nanotube-Polymer Interface Using Inverse Finite Element Analysis
MSEC2012-7400
***Lingyun Jiang**, **Chandra Nath**, University of Illnois at Urbana-Champaign, Urbana, IL, United States*, ***Johnson Samuel**, Rensselaer Polytechnic Institute, Troy, NY, United States*, ***Shiv G. Kapoor**, University of Illinois at Urbana-Champaign, Urbana, IL, United States.*

Titanium Oxide Nanotubes Doped for Use in a Visible-Light Biophotofuel Cell
MSEC2012-7255
***Evan Clark, Yong Gan, Chao Xue**, University of Toledo, Toledo, OH, United States.*

ADDITIONAL AND OPTIONAL EVENTS

Campus Tours
Meet in McKenna Hall Atrium 17:00 – 18:00

Taylan Altan Dinner

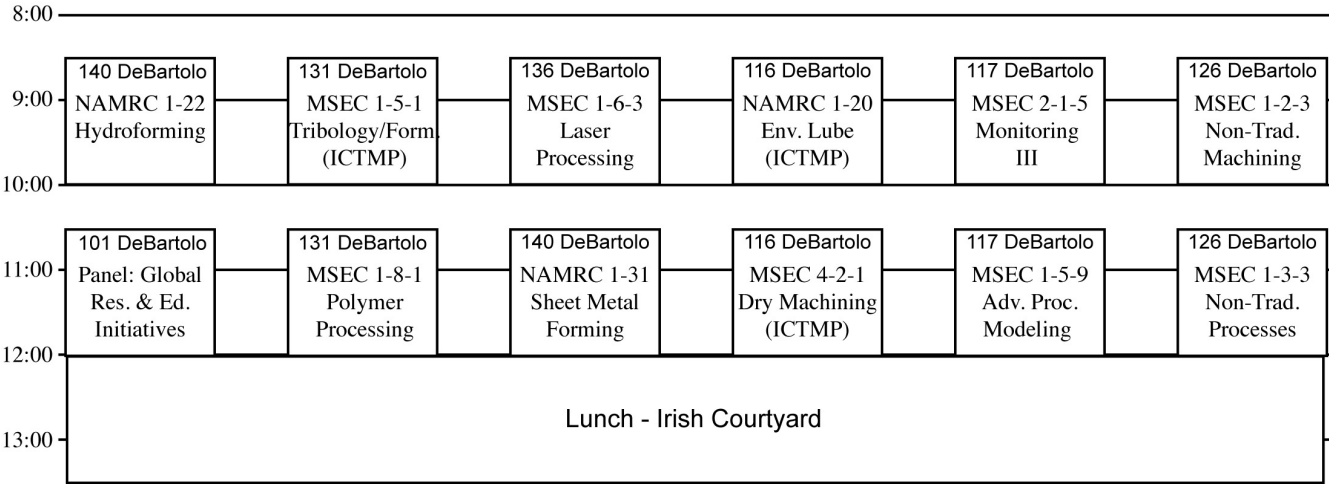
Greenfield's, Hesburgh Peace Center, 18:00-21:00. (Optional dinner – reservations required.)

Steven Danyluk Dinner
Notre Dame Room, Morris Inn, 18:00-21:00. (Optional dinner – reservations required.)

South Bend Silverhawks Baseball Excursion
Meet in McKenna Hall Atrium, 18:00 (Optional dinner – reservations required.)

TECHNICAL PROGRAM - FRIDAY, JUNE 8, 2012

Overview



Notes:

1. Breakfast is available in the McKenna Hall Atrium from 7:00-8:00.
2. The Registration Desk in the McKenna Hall Atrium will be open from 8:00-17:00.
3. Lunch will be moved to South Dining Hall in case of inclement weather.

CONCURRENT TECHNICAL SESSIONS
8:00-9:30

NAMRC/ICTMP 1-20 Environmentally Friendly Lubrication
116 DeBartolo Hall 8:30 - 10:00

Session Chair: **David Adams,** *Queen's University, Kingston, ON, Canada*
Session Co-Chair: **Kuniaki Dohda,** *Northwestern University, Evanston, IL, United States*

Feasibility of Vegetable Oil in Water Emulsion Achieved Through Ultrasonic Atomization as Cutting Fluids
NAMRC40-7707
***Geoff Burton**, University of Victoria, Victoria, BC, BC, Canada*, ***Chan-Seo Goo**, LG Electronics, Seoul, Korea (Republic)*, ***Martin Jun**, University of Victoria, Victoria, BC, BC, Canada*

Evaluation of Environmentally Friendly Lubricant for Aluminum Cold Forging Using Friction Test Based on Spline Extrusion
NAMRC40-7709
***Yoshihiro Sagisaka**, Industrial Research Institute of Shizuoka Prefecture, Shizuoka, Japan*, ***Tamotsu Nakamura, Kunio Hayakawa**, Shizuoka University, Hamamatsu, Japan*, ***Itaru Ishibashi**, Sumico Lubricant, Inabe, Mie, Japan*

An Assessment of Environmentally Benign Lubricants With the Ring Test and Upset Forming
NAMRC40-7712
***Tristan J. Koivisto**, Queen's University, Kingston, ON, Canada*, ***Dustin L. Campbell**, Chinook Mobile Heating and Deicing, Nepean, ON, Canada*, ***Jack Jeswiet**, Queen's University, Kingston, ON, Canada*, ***Jessica R. Larmer**, Conestoga-Rovers and Associates Ltd, Waterloo, ON, Canada*

NAMRC 1-22 Hydroforming
140 DeBartolo Hall 8:30 - 10:00

Session Chair: **Jyhwen Wang,** *Texas A & M University, College Station, TX, United States*
Session Co-Chair: **Frederic Bäcker,** *Technishche Universität Darmstadt, Darmstadt, Germany*

Influence of Process Variables on Preform Design for Tube Hydroforming Based on Wrinkle Evolution
NAMRC40-7796
***Gracious Ngaile**, **Chen Yang**, North Carolina State University, Raleigh, NC, United States*

Stringer Sheet Forming
NAMRC40-7813
***Frederic Bäcker, Peter Groche, Scholeh Abedini**, Technische Universität Darmstadt, Darmstadt, Germany*

Failure Analysis of Hydroforming of Sandwich Panels
NAMRC40-7822
***Jyhwen Wang, Cheng-Kang Yang**, Texas A&M University, College Station, TX, United States*

MSEC 1-2-3 Nontraditional Machining
126 DeBartolo Hall 8:00 - 9:30

Session Chair: **Mehdi Asgharifar**, *Southern Methodist University, Dallas, TX, United States.*
Session Co-Chair: **Murali M. Sundaram**, *University of Cincinnati, Cincinnati, OH, United States.*

Pulse Electrochemical Micromachining of Tungsten Carbide
MSEC2012-7238
***Abishek Balsamy Kamaraj, Rachael Dyer, Murali M. Sundaram**, University of Cincinnati, Cincinnati, OH, United States.*

Wettability Enhancement of Aluminum Alloys via Plasma Arc Discharge
MSEC2012-7331
***Mehdi Asgharifar, Joshua Abramovitch, Fanrong Kong, Radovan Kovacevic**, Southern Methodist University/RCAM, Dallas, TX, United States*, ***Blair Carlson**, GM Global R&D, Warren, MI, United States.*

Characteristics of Cobalt Chromium Alloy Surfaces Finished using Magnetic Abrasive Finishing
MSEC2012-7367
***Arthur Graziano**, University of Florida, Gainesville, FL, United States*, ***Vasishta Ganguly**, University of North Carolina at Charlotte, Charlotte, NC, United States*, ***J. Whittaker Bullard**, University of Florida, Gainesivlle, FL, United States*, ***Tony Schmitz, Ph.D.**, University of North Carolina at Charlotte, Charlotte, NC, United States*, ***Hitomi Yamaguchi**, University of Florida, Gainesville, FL, United States.*

MSEC/ICTMP 1-5-1 Tribology in Metal Forming
131 DeBartolo Hall 8:00 - 9:30

Session Chair: **Cristina J. Bunget**, *Clemson University, Greenville, SC, United States.*

A Study on the Performance of Rolling Oil During Cold Rolling of Stainless Steel simulating Industrial Condition
MSEC2012-7373
***Rajendra Mahapatra, Jaspal Singh Rait, Samuel Pappy, Inder Singh Sudhir, Ajay Kumar Harinarain**, **Deepak Saxena**, **Vincent Martin**, **R. K. Malhotra**, Indian Oil Corporation R&D, Faridabad, Haryana, India.*

Tribological Investigation of Deep-Drawing Processes using Servo Presses
MSEC2012-7292
***Peter Groche, Norman Moeller**, Institute for Production Engineering and Forming Machines, Technische Universitaet Darmstadt, Darmstadt, Germany.*

Numerical Investigation of Residual Formability and Deformation Localization during Continuous-Bending-Under-Tension
MSEC2012-7302
***Chetan Nikhare, Yannis Korkolis, Brad Kinsey**, University of New Hampshire, Durham, NH, United States.*

MSEC 1-6-3 Laser Processing
136 DeBartolo Hall 8:00 - 9:30

Session Chair: **Benxin Wu**, *Illinois Institute of Technology, Chicago, IL, United States.*
Session Co-Chair: **Gary J. Cheng**, *Purdue University, West Lafayette, IN, United States.*

Effect of Warm Laser Shock Peening on the Tensile Strength and Ductility of Aluminum Alloys
MSEC2012-7371
***Chang Ye, Dong Lin, Yiliang Liao, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States.*

Enhanced Laser Shock by an Active Liquid Confinement
MSEC2012-7372
***Yiliang Liao, Gary J. Cheng**, Purdue University, West Lafayette, IN, United States.*

Nanotwins in Copper Nanowires Controlled by Laser Assisted Electrochemical Deposition
MSEC2012-7391
***Zhikun Liu, Gary J. Cheng, Yuefeng Wang, Yiliang Liao**, Purdue University, West Lafayette, IN, United States.*

MSEC 2-1-5 Monitoring and Sensing III
117 DeBartolo Hall 8:00 - 9:30

Session Chair: **Amit Bagchi,** *Naval Research Laboratory, Washington DC, United States*
Session Co-Chair: **Anil K. Srivastava**, *TechSolve, Inc., Cincinnati, OH, United States.*

Thin-Film PVDF Sensor Based Monitoring of Cutting Forces in Peripheral End Milling
MSEC2012-7217
***Lei Ma, Shreyes N. Melkote, Ph.D., John Morehouse**, Georgia Institute of Technology, Atlanta, GA, United States*, ***James Castle, James Fonda**, The Boeing Company, St. Louis, MO, United States*, ***Melissa Johnson**, The Boeing Company, Seattle, WA, United States.*

Enabling Machining Vision using STEP-NC
MSEC2012-7310
***Martin Hardwick**, RPI Department of Computer Science, Troy, NY, United States*, ***David Loffredo**, STEP Tools, Inc., Troy, NY, United States*, ***Fred Proctor**, NIST, Gaithersburg, MD, United States*, ***Sid Venkatesh**, The Boeing Company, Tukwila, WA, United States.*

Remote Tool Health Monitoring Using Wireless Sensors on Rotational Machinery
MSEC2012-7335
***David Loker, Mark Rynders, John Roth**, Penn State Erie, The Behrend College, Erie, PA, United States.*

CONCURRENT TECHNICAL SESSIONS

10:00-11:30

Panel: Global Research and Education Collaborations
101 DeBartolo 10:00 - 11:30

Moderator: ***Jian Cao****, Northwestern University, Evanston, IL, United States.*

Panelists:

Christine Furstoss**,** *GE Research, Niskayuna, NY, United States.*
Thomas Neitzert**,** *AUT University, Auckland, New Zealand.*
Elena Pérez-Bernabeu, *Universitat Politècnica de Valencia, Campus of Alcoy, Spain.*

NAMRC 1-31 Sheet Metal Forming
140 DeBartolo Hall 10:00 - 11:30

Session Chair: **Gracious Ngaile***, North Carolina State University, Raleigh, NC, United States*
Session Co-Chair*:* **Chetan Nikhare,** *University of New Hampshire, Durham, NH, United States*

Energy Consumption in Single Point Incremental Forming
NAMRC40-7704
David Adams, Jack Jeswiet*, Queen's University, Kingston, ON, Canada*

Optimization of the Design of Roll-Formers
NAMRC40-7705
Florian M. Kern, Thomas R. Neitzert*, Auckland University of Technology, Auckland, New Zealand*

Influences of Clamp Die Geometry and Friction on the Clamping Process in Rotary Draw Bending
NAMRC40-7732
Markus Hinkel, Bernd Engel*, University of Siegen, Siegen, Germany*

MSEC 1-3-3 Materials and Nontraditional Processes
126 DeBartolo Hall 10:00 - 11:30

Session Chair: **Ihab Ragai***, Hitachi, Guelph, ON, Canada.*
Session Co-Chair: **Arif S. Malik***, Saint Louis University, St. Louis, MO, United States.*

Real Time Dispatching Control of Multi-Dollies Material Handling systems in General Assembly Lines
MSEC2012-7333
***Chaoye Pan, Jun Ni**, University of Michigan, Ann Arbor, MI, United States*, ***Qing Chang**, Stony Brook University, Stony Brook, NY, United States.*

Application of Multiple Regression and Adaptive Neuro-Fuzzy Inference System for Prediction of Surface Roughness in EDM
MSEC2012-7273
***Sunil Baraskar**, **Sukhwant Singh Banwait**, National Institute of Technical Teachers Training & Research, Chandigarh, India.*

A Reliability-Based Approach to Flatness Actuator Effectiveness in 20-High Rolling Mills
MSEC2012-7281
***Arif S. Malik, John Wendel**, Saint Louis University, St. Louis, MO, United States*, ***Mark Zipf**, Tenova I2S, LLC, Yalesville, CT, United States*, ***Andrew Nelson**, Saint Louis University, St. Louis, MO, United States.*

MSEC 1-5-9 Advances in Process Modeling
117 DeBartolo Hall 10:00 - 11:30

Session Chair: **Edmund Chu**, *Alcoa Inc, Alcoa Center, PA, United States.*
Session Co-Chair: **Brad Kinsey**, *University of New Hampshire, Durham, NH, United States.*

Twist in Incremental Forming
MSEC2012-7402
***Venkata Reddy, Javed Asghar, Shibin E., Anirban Bhattacharya**, IIT Kanpur, Kanpur, India.*

A Preliminary Numerical Study of the Slurry Wire Sawing Process
MSEC2012-7289
***Chunhui Chung**, National Taiwan University of Science and Technology, Taipei, Taiwan.*

Finite Element Modeling of Pad Deformation Due to Diamond Disc Conditioning in Chemical Mechanical Polishing (CMP)
MSEC2012-7364
***Emmanuel Baisie**, **Zhichao Li**, North Carolina Agricultural & Technical State University, Greensboro, NC, United States*, ***X.H. Zhang**, Seagate Technology, Minneapolis, MN, United States.*

MSEC 1-8-1 Mechanical Polymer Processing
131 DeBartolo Hall 10:00 - 11:30

Session Chair: **Donggang Yao**, *Georgia Institute of Technology, Atlanta, GA, United States.*

Investigation of the Machinability of PA-6/NANO-CACO3 Composite
MSEC2012-7203
***Reza Farshbaf Zinati, Mohammad Reza Razfar**, AmirKabir University of Technology, Tehran, Iran*, ***Mehdi Haghi**, Tabriz University, Tabriz, Azarbyjan Sharghi, Iran.*

Development of a Fiber Orientation Measurement Methodology for Injection Molded Thermally-Enhanced Polymers
MSEC2012-7291
***Timothy Hall, Arumugham Subramoniam, Hugh Bruck, Satyandra Gupta**, University of Maryland, College Park, MD, United States.*

Characteristics of the Exfoliated Graphite Nanoplatelets-Polyamide12 Nanocomposites Processed by Extrusion Injection Molding
MSEC2012-7388
***Mehdi Karevan, Kyriaki Kalaitzidou**, Georgia Institute of Technology, Atlanta, GA, United States.*

MSEC/ICTMP 4-2-1 Sustainable Manufacturing - Lubricants and Dry Machining
116 DeBartolo Hall 10:00 - 11:30

Session Chair: **Delcie R Durham**, *University of South Florida, Tampa, FL, United States.*
Session Co-Chair: **Fu Zhao**, *Purdue University, West Lafayette, IN, United States.*

Designing Green Lubricants for Manufacturing Industry Using Renewable Base Materials
MSEC2012-7254
***Joseph P. V., Deepak Saxena, Pankaj Bhatnagar, Rajan Mookken, R. K. Malhotra**, Indian Oil Corporation R&D Center, Faridabad, Haryana, India.*

Residual Stress and Fatigue Properties of AISI H13 Steel by Sustainable Dry Milling
MSEC2012-7363
***Yuebin Guo, W. Li**, The University of Alabama, Tuscaloosa, AL, United States.*

Multi-Scale Friction Modeling for Manufacturing Processes: The Boundary Layer Regime
MSEC2012-7298
***J. Hol, D.K. Karupannasamy**, Materials innovation institute (M2i), Delft, Netherlands*, ***T. Meinders**, University of Twente, Enschede, Netherlands.*

Microfracturing Ceramic Abrasive in Grinding
MSEC2012-7324
***Jeffrey Badger**, The Grinding Doc Consulting, Bulverde, TX, United States.*

Lunch, Irish Courtyard
11:30-13:00