Simulation in manufacturing is pervasive, with highly realistic 3D visualizations used to prove out manufacturing processes in advance of cutting metal, laying out a factory assembly line, or even buying an expensive piece of manufacturing equipment.

Today’s manufacturers use highly accurate NC-level machining simulations to view any potential metalcutting process problems, and the latest digital manufacturing simulations help manufacturing engineers design and validate or commission assembly lines and entire factories—before they’re built. Along with these critical simulations, engineers and others involved throughout the product development design cycle increasingly collaborate using CAE and multiphysics solutions to ensure that the materials used will withstand thermal or fatigue stresses and meet standards for product safety and longevity.
The push for simulation at all levels of manufacturing has gained some momentum last year with the creation of the Digital Manufacturing & Design Innovation Institute (DMDII; Chicago) by the US government. Part of the Obama Administration’s efforts to help rebuild manufacturing, the DMDII aims to build new digital systems and meld the efforts of top manufacturing companies and software developers to find new and innovative digital manufacturing methodologies.

On the Cutting Edge

Being able to accurately simulate the metalcutting process before ever cutting metal is critical to manufacturing success. With the latest high-end NC simulation solutions, manufacturers ensure that the programming for their very complex multitasking machines and five-axis machining processes are completely accurate, with no risks of harming expensive equipment or workpieces with collisions during the NC metalcutting process.

Using true G-code simulation in the NC cutting process provides manufacturers with the most realistic visualizations possible, simulating the action of the machine tool, tooling and workpiece with 100% accuracy.

“Simulating NC programs in a virtual machining environment prior to running them in the physical workshop is endemic and spans manufacturing automation from process concept to shop floor,” said Bill Hasenjaeger, product marketing manager, CGTech (Irvine, CA), developer of the Vericut NC simulation, verification and optimization software. “Our customers use Vericut’s platform-independent simulation for process design tasks such as CNC equipment concept design and evaluation prior to purchase, CAM programming system evaluation, design-for-manufacturing review sessions, machining strategy analysis and decision-making, and as an aid in workholding design, all prior to production NC programming activities.

Suppliers of factory equipment are now acknowledging and rushing to fill the needs for pre-process simulation as

The Spring Technologies’ NCSIMUL Machine 9.2 simulation software runs embedded on a Panasonic Toughpad IP65 tablet mobile system.

“The design, tooling and fixturing are set then the usual simulation production benefits of machine/tool(fixture/workpiece collision-checking, workpiece dimensional validation, and machining optimization are realized,” Hasenjaeger said. “Then downstream in the workshop, the results of Vericut’s simulation are used to document the machining process and as an aid for part inspection for shop floor personnel.”

Suppliers of factory equipment are now acknowledging and rushing to fill the needs for pre-process simulation as
well, Hasenjaeger said, making 3D models of their products generally available to end users. “This includes machine tool manufacturers, makers of workholding devices such as vises, clamps and tooling components, cutting tool and toolholder suppliers, and those making other auxiliary equipment such as spindle probes, part transfer grippers, and other optional machine attachments,” he said. “While this trend is influenced by the increased use of simulation technology throughout the manufacturing process chain, the biggest business motivation has been from end users who demand these models as a condition of purchase from the suppliers.”

With the latest Version 7.3 Vericut, users can simulate any metalcutting CNC process and Vericut for Composites is used widely by aerospace customers in simulating, verifying and optimizing programming of composite cutting processes. Machine tool movements can be simulated while stepping or playing backwards in Vericut’s Reviewer, which is also playable on an iPad.

“Simulation system end users are becoming more sophisticated and beginning to recognize that process analysis features within the simulation are extremely important, maybe the most important feature of any simulation system,” Hasenjaeger said. “It’s easy to lose sight of this important fact in the very visual world of machining simulation and the animation of the machine. Pretty pictures are nice, but process simulation is an engineering analysis tool. It doesn’t matter how nice the images look if the simulation is unable to alert the user of process problems, such as small-but-disastrous workpiece gouges. Unfortunately, some software simulation methods reduce accuracy for faster simulation speed while hiding unrealistic flaws with graphics shading ‘tricks’—not only are the flaws hidden, but so are process errors.”

An additional detailed analysis feature recently introduced in Vericut is the Force method of cutting analysis and feed rate optimization, Hasenjaeger said. “Based on years of research at one of our large aerospace manufacturing customers, Force evaluates the cutting conditions for each machining cut and predicts cutting forces, torque and chip load,” he said. “Difficulties can be quickly identified and feed rates automatically adjusted to bring the conditions within a range of optimal machining behavior.”

Mobile Verification, Optimization

Taking NC verification onto the shop floor, Spring Technologies (Paris), developer of NCSIMUL Machine 9.2 simula-
tion and verification software, recently introduced its mobile system, called WYSIWYC (What You See is What You Cut), that runs its flagship software embedded on a fully rugged Panasonic Toughpad IP65 tablet.

The WYSIWYC is fully synchronized in real time with the machine tool, noted Silvere Proisy, US general manager, Spring Technologies Inc. (Boston), allowing users to slow down the machine on the shop floor with the handheld mobile device. The rugged tablet version of the software was first developed with FANUC controls, Proisy said, and it can now operate using the virtual NC kernel (VNCK) in Siemens Sinumerik controls.

In addition to verification, Spring’s solutions include an optimization module, Optitool, that can significantly improve feeds and speeds on metalcutting processes. “To optimize efficiencies, you can improve the cutting times of your machine tool by 6, 10 or 20%, which is a significant process improvement,” Proisy said. An optional module, Optitool is currently being used by about 30-40% of Spring Technologies’ customers, he added. “If it saves some time on their machine, it makes sense even if you make a gain of only a few minutes on repetitive production parts.”

Another development in NC simulation/verification is the use of physics-based technology for analysis, verification and optimization of NC cutting processes. At IMTS 2014, Manufacturing Automation Labs Inc. (MAL; Vancouver, BC, Canada) previewed its new NPro advanced physics-based process simulation and toolpath optimization software developed as a plug-in module for Siemens PLM Software’s (Plano, TX) NX CAM software. In contrast to geometry-based solutions, which adjust purely on the volume of material removed, the Npro software considers the geometry of the chip being removed, workpiece material properties, tool geometry and tool motion (kinematics), and machine-tool limitations and dynamics.

The NC simulation in Siemens NX CAM is an internally developed system that does full G-code simulation, said Aaron
Frankel, Siemens PLM Software’s director of product marketing. “We also have the ability to use the actual controller software from Sinumerik controllers’ VNCK, which gives the best fidelity simulation possible. We’re partnering with different companies like MAL, using a physics-based approach. We’re looking at the routing of the cutting tools and forces, and we’ve optimized the path for speed and quality. It’s relatively new.”

Moving Toward the Digital Factory

Digital manufacturing tools can help manufacturers prove out processes in advance of finalizing plant-floor layouts in new and existing manufacturing facilities. With simulation software in the 3DEXperience platform from Dassault Systèmes, manufacturers can easily view and share product designs and simulations for collaboration among global manufacturing locations.

“We’ve been a big promoter of 3D. It started in aerospace and defense, and we’re now starting to see it more in transportation,” said Patrick Michel, vice president, Delmia Digital Manufacturing, Dassault Systèmes (Paris and Auburn Hills, MI). “It’s not that the high-volume automotive OEMs weren’t using simulation. Automotive was the first to adopt 3D work instructions.”

The latest Dassault 3DEXperience Release 2015 gives users stronger bond between 3D simulations and their connection with the shop floor. “It’s basic but very powerful visibility,” Michel said of the most recent R2015 platform. “You can connect in what I call ‘near real time—it’s 15-minutes-old data. In terms of real time for the shop floor, that’s real time.”

With globalization, simulation has made an even greater impact on manufacturers that have more globalized operations than ever before, Michel noted. “One thing we see in digital manufacturing is the virtualization of things—almost all companies are integrating their work with global teams. Some of the Japanese companies are making decisions now in the US, and that was unheard of before,” Michel said.

While automotive manufacturers have heavily adopted simulation for robotics, the technologies offered by digital manufacturing solutions like Siemens’ Tecnomatix line are spreading to many other industry segments, noted Ulrich Rossgoderer, director, product management, Siemens PLM Software (Plano, TX). “Nike wants to shorten the cycle between design and production,” Rossgoderer said. “In aerospace, what we see is the need for simulation is growing on the factory floor for the amount of engines that Rolls Royce needs to build. They have to apply some of the methods that automotive has applied,

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and they cannot afford all of the time it’s taken in the past, so they’re doing more simulations today as well.”

Many digital manufacturing applications need more effective simulations related to shop-floor ergonomics, and employing the Tecnomatix Jack and Jill manikins in simulations gives builders key insights into potential ergonomic risks in any particular process. “It was a bigger trend in automotive in the 90s, and it’s coming back with the aging workforce,” Rossgoderer said. “They have a shift in age on the shop floor they have to be sensitive to, especially in places like Germany where they’ve raised the retirement age to 67.”

Melding simulations with technologies like augmented reality, and with Google Glass, also are starting up, albeit in incubation form, added Frankel. Another trend is the support of point cloud data in visualizations recently added in Tecnomatix solutions, which narrows the gap between the factory and simulations. “With the support of point clouds, there is a greater fidelity between the product and the 3D world,” Frankel said, noting that with any new changes, scans can be quickly added in for a more complete model. “We’re ultimately trying to enable companies to make a virtual twin.”

**Adopting New Digital Tools**

The payoff of digital manufacturing isn’t always readily apparent to many manufacturers. “A lot of companies are simply not aware of virtual simulation or a ‘digital factory’ and how it can help them,” said Helmut Ziewers, vice president, Digital Factory Solutions, Cenit AG (Stuttgart, Germany, and Auburn Hills, MI). “As awareness grows, manufacturing businesses are figuring out different ways to utilize this new tool.”

With its recently updated FastSuite Edition 2, Cenit offers a digital manufacturing software platform for small to large manufacturers for automating robotics applications. With Cenit’s FastSuite, manufacturers can maximize factory throughput, Ziewers said. “Not only does it offer a simulated test and way to configure...
your manufacturing environment better, but it will help save on costs," he said. "Doing something digitally will prove out the process, and it's a lot easier to change things on the computer screen than it is to reconfigure them on the shop floor.

“Digital manufacturing thus becomes an enabler for automation technology. Thanks to early feasibility studies, by testing the reach and limits of various robots for certain applications, it provides a higher maturity during the decision-making process," Ziewers said. “Simulation and validation capabilities ensure a short go-life phase, and powerful offline-programming functions are speeding up the daily use of robot-based applications and opens the door for getting the most out of a real factory environment.”

With hundreds of installations of FastSuite, Cenit has customers including Boeing, Lockheed Martin, and Ford Motor Co. in production applications such as spray paint, laser cutting of sheet metal, and automated robotic riveting, Ziewers said. “Cycle time enhancements using real-time emulation in the virtual world before commissioning them to the shop floor is a major way to improve efficiency in any factory that has automation," he said. “Virtual factory simulation gives a company the ability to truly optimize the automation components and layout of the factory to achieve the highest efficiency possible, while also helping to cut down on the lead time for upstart. Lengthy downtimes can also be prevented because the ability to make virtual corrections in advance is much easier to accomplish.”

**Leveraging CAE Simulations**

More widespread use of CAE and multiphysics simulations is also making inroads in manufacturing, as “non-expert” users become more involved with these simulations early in design cycles that have a major effect downstream on product development and manufacturing processes.

“The large majority of use is around product design,” said Barry Christenson, director of product marketing, Ansys Inc. (Canonsburg, PA). But across industry in general, there has been high growth for the company outside of its traditional users, he said. “It’s important in areas like forming for automotive, where you have concerns about metal thinning and stresses on a product,” Christenson said. “For a deep-drawing process, you’d want to go through simulations, if there’s a concern about tearing.”

Designers of cutting tools also simulate their designs with the software. “One of the problems is heat tends to destroy cutting tools,” Christenson said. A lot of CFD work is in traditional manufacturing areas, with metalcutting, metalforming and high-speed machinery users concerned with motion, he said. In its most recent release, Ansys 16, the company addressed areas including wave loading, analyzing the effects of forces from large waves hitting oil platforms. “We’ve had significant growth in pharmaceutical, and in oil & gas,” Christenson said, “where they’re studying how chemicals mix or combust, if that’s part of the process.”

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