Metal Additive Experts in Demand

Executive Summary
March 2019

ABOUT THE METAL ADDITIVE MANUFACTURING STUDY

Today the global Additive Manufacturing (AM) market is $7.3 billion and growing, especially in the aerospace, automotive and medical industries. While still early-stage, metal additive manufacturing/3D printing (AM/3DP) is an important part of this growth as it helps manufacturers produce stronger, lighter parts, improve efficiencies, reduce waste, lower emissions, and increase speed to market.

During the 1980s and 1990s, early adopters tapped into AM to produce prototypes, design aids and tooling equipment. Today, a number of companies are leveraging the unique capabilities to create complex structures, reducing the weight of components, simplifying assembly by combining multiple components into one, and customizing or matching to a specific need. It is allowing them to move toward on-demand manufacturing, leverage cloud computing to create more efficient designs while optimizing production schedules.

As a result, new businesses, like AM system manufacturers, material producers and software developers are finding their way into the market. For those in product development and manufacturing, the possibilities seem endless. But, there are still many barriers to wide-spread adoption.

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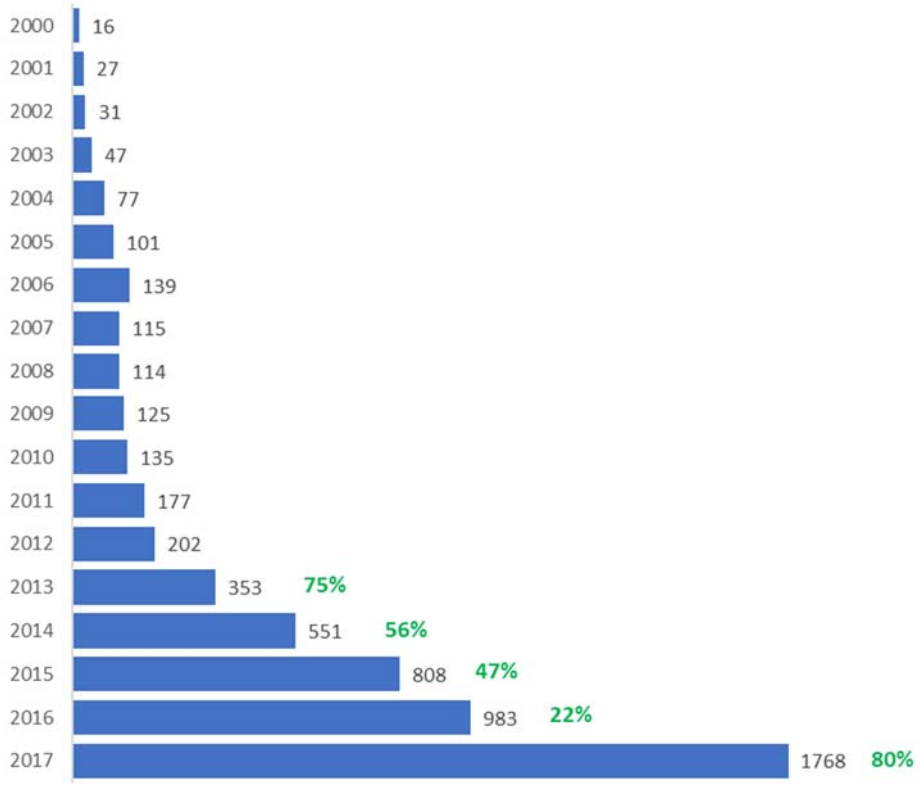
INDUSTRY GROWTH OF METAL AM/3DP

Although not a new technology, industry adoption of additive manufacturing/3D printing has significantly increased during the last decade. Its growth opportunities are increasing exponentially, particularly in the Aircraft/Aerospace, Automotive, and Medical/Surgical/Dental industries, where manufacturers are successfully integrating AM/3DP into their operations.

Year-Over-Year Growth of Metal Additive Machines Sold[1]



Over the past five years, the global metal AM/3DP market has registered a substantial increase in machines sold, increasing the number of machines sold yearly from 353 to 1,768 in five years, representing a 400% increase in sales during that time period. Over the past ten years, (2007-2017) registered over a 1400% increase in sales.[1]

Three main factors are driving metal AM/3DP's current growth: Technology development, Materials development, and Standards development.

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INDUSTRY GROWTH OF METAL AM/3DP (CONTINUED)

Technology Development

A portion of the increase in metal additive machines sold coincides with advances in technology and lower costs, which enables manufacturers to produce components by using a variety of metal powders and other metal feedstock that was impossible only a few years ago. New software is helping to optimize complex designs and print parts that are lighter and stronger, while new machines with multiple lasers are speeding up the manufacturing process.

Materials Development

One major challenge associated with metal AM/3DP is the amount of available materials and the high prices associated with it. However, advanced materials, such as titanium and a number of alloys, are now being used in the process. Powder metals available for AM/3DP include tool steels, stainless steels, titanium and alloys, aluminum alloys, nickel-based alloys, copper-based alloys, and cobalt chromium. The overall market for precious alloys in AM will become a major segment in metal AM, with material revenues forecasted to top $250 million by 2028 and overall related revenues nearing $2 billion.[2] As material prices are forecasted to become more cost-effective in the future, continued metal AM/3DP will be incorporated into production.

While this technology is still not a viable option for high-volume, repeatable mass production parts, metal AM/3DP provides immense benefits in other situations. For example:

- Production of models and prototypes during a product's development phase
- Parts for pilot series production
- Short-series production, where tooling for casting or injection molding would be too costly
- Parts of high geometrical complexity, where products can't be manufactured through conventional processes, such as molding, grinding, milling or casting

However, just as advancements in metal AM/3DP have made the technology more practical than ever before, as systems and technologies continue to advance and processing time continues to shorten, additional uses will continue to be uncovered.

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METAL AM/3DP TECHNOLOGY

In metal AM/3DP, several different technologies are used, each system classified by the energy sourced used or the way the material is joined.

Powder Bed Fusion

Composed of various techniques, such as direct metal laser sintering or electron beam melting, where a laser or electron beam melts and fuses metal powder together.

Binder Jetting

Similar to Powder Bed Fusion, but instead uses a liquid bonding agent to join the metal powders. Binder Jetting requires a secondary step which melts the binder and infuses additional metal powder in the space left by the binder.

Material Jetting

A process where droplets of liquid metal are selectively deposited, layer by layer.

Material Extrusion

Materials are drawn through a nozzle where it is heated and then deposited layer by layer. The nozzle moves horizontally, while a platform moves vertically after each new layer is deposited.

Directed Energy Deposition

A range of processes, such as laser-engineered net shaping and 3D laser cladding, both used to repair or add additional material to existing components.

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METAL AM/3DP APPLICATION AREAS

The automotive, aerospace and biomedical industries are the largest users of metal AM. Automotive uses it primarily in the development and testing phases, while aerospace engages mostly during the end-use production phase. Biomedical uses it largely for orthopedic devices like bone plates, hip and knee joint replacements and spinal cages.

Aerospace

In the aerospace, complex geometries allow component design to be optimized, which minimizes material use (and weight) while maintaining strength and other functionality of the part. This industry recognized and took advantage of opportunities available to consolidate and reduce the weight of parts and assemblies on aircraft and spacecraft. Companies such as Airbus, Boeing, GE Aviation and Honeywell Aerospace are among those that invest resources in developing and industrializing the technology.

Automotive

Car and truck manufacturers are using it to reduce spare part inventories for older model vehicles. Producing parts on-demand reduces the need to stock parts that are no longer in production. But use is still not widespread due to the cost of the materials and machines, coupled with supply chain considerations. Still, Daimler Trucks recently announced it is creating a digital warehouse of spare parts for its fleet, and BMW is using the technology to produce the mounting for the top cover of its i8 Roadster model.[3]

Medical/Dental/Surgical

The ability to produce organic shapes from biocompatible materials makes AM an attractive way of manufacturing parts that mimic the body's anatomy and allow for creating complex surface structures needed for in-bone growth of many implants. Today, manufacturers are making large investments in the technology and using it to produce a range of orthopedic products. In medical applications, it enables creation of implants in one step, instead of multiple steps, to achieve needed porous surface structures and other complex geometries.

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CHALLENGES TO METAL AM/3DP ADOPTION

Although major advancements have been made in metal AM/3DP over the past decade, which are leading to increasing usage and applications, the industry continues to face four major challenges: Regulatory issues, Funding/Capital, Technology, and Workforce.

Regulatory Issues

Legal issues are still emerging as the understating of AM/3DP technology and its' related processes continue to evolve, especially around intellectual property. Other legal and regulatory issues to note are: environmental liability, health and safety, availability of insurance for AM manufacturing processes, data protection and cyber security.

Funding/Capital

As noted previously, metal AM/3DP machines and materials are still costly. Although prices have dropped over the past few years, smaller companies still struggle to find funding/capital to invest in metal AM/3DP technology. As metal AM/3DP continues to become a more mainstream manufacturing production process, companies lacking the funding/capital to invest could find themselves at a competitive disadvantage soon.

Technology

Process speeds still needs improvement, especially in production of large-size parts. Depending on the size, it can be relatively slow compared to conventional machining. Accuracy, especially on high-volume repeatable parts also needs improvement for wide-spread adoption in industries such as automotive.

Workforce

While finding and retaining a qualified workforce is a manufacturing industry-wide challenge, it is critical that the existing workforce is trained in AM/3DP technologies. And that training must be updated frequently. This is the only way metal AM/3DP will continue to evolve.

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THE NEED FOR METAL AM/3DP EXPERTS

The industry sector has evolved in terms of skilled labor needs in response to growth of metal AM/3DP adoption. More companies are hiring Mechanical and Materials Engineers with a specialized background in AM processes and material science, AM Application and Design Engineers that can understand customer needs and leverage the AM design and manufacturing space effectively, and Manufacturing Engineers with a new mindset regarding the AM manufacturing deployment and supply chain logistics. For some smaller companies, positions may be combined (i.e. Design Engineer and Application Engineer) There are emerging specialized roles on the shop floor and in the field, such as skilled Technicians and Machine Operators and Field Service Technicians that support AM process deployment and continuous improvement. In addition, management roles in this sector require a shift in vision and strategic planning. Current job descriptions require that candidates have additional knowledge and training to cover the specialized combination of skills necessary for the metal AM/3DP segment.

SME METAL ADDITIVE MANUFACTURING COMPETENCY MODEL

To build a common language among employers and job candidates, as well as identify the necessary training competencies needed for each job requirement, the SME AM Community advisors, composed of: C-level, additive manufacturers, technology providers, research and development and faculty/educators have developed the SME Metal Additive Manufacturing Competency Model that spans several positions.

The SME Metal Additive Manufacturing Competency Model is part of efforts by industry and educational institutions to create clear career pathways for those entering the metal AM field as well as provide templates for creating positions and building training programs. As metal AM technology continues to change and evolve, more education is necessary. More degree programs that focus on AM are needed. Engineering applications, development experience and experiential AM experience in a project-based environment also are necessary.

Some of the Knowledge, Skills and Abilities (KSAs) included in the SME Metal AM competency model are:

- Design for metal AM principles
- Planning and executing 3D scanning and printing/AM processes
- Metal AM process validation
- Advanced troubleshooting of AM machines
- Metal additive process development
- Part quality measurement and assessment, including part properties geometry and tolerances
- Basic knowledge of materials selection
- Cost estimation of metal additive parts

The SME Metal Additive Manufacturing Competency Model helps with the development of job descriptions as well as curriculums and job-training programs, and is part of the process for ensuring consistency for engineers and technologists pursuing careers in metal AM.

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SME METAL ADDITIVE MANUFACTURING COMPETENCY MODEL JOB DESCRIPTION EXCEPRTS

Executive/Management

Responsible for defining the corporate vision and strategy, as well as company direction based on an intimate knowledge of the AM industry sector and AM technology business case. Executive/Management role is responsible for the development of functional or business unit strategy for the entire organization, sees the transformative impact AM can have on products and the market, and evaluates the economic impact of deployment of existing and emerging AM technologies. Develops ideas for AM products or enhancements and oversees the creation and improvement of products researched by the engineering department. Provides approval for capital expenditures, facilities and staffing.

Manufacturing Engineer

Responsible for the adoption of metal AM technologies in production facilities in terms of supply chain, production chain, planning and scheduling, QA requirements as well as coordinating the manufacturing workflow to meet production deadlines. Performs planning and scheduling operations related to AM technology deployment including metal powder handling maintenance assignments, post machining and inspection, safety and security responsibilities. Implements manufacturing plans collaboratively with materials specialists for establishing optimal build parameters and troubleshooting production quality issues.

Design Engineer

Responsible for translating customer requirements and leveraging AM technology capabilities into innovative designs to improve product performance, reduce part count and cost. Defines design optimization strategies and interfaces with materials specialists and/or manufacturing engineers, as well as leverages process simulation software tools, to validate design decisions based on AM process, part build layout and material selection. Involved with planning and executing 3D scanning and reverse engineering, assembly consolidation of components, as well as incorporating data visualization to facilitate planning for manufacturing deployment and for cost estimates.

Application Engineer

Responsible for metal additive process development based on powder bed platforms utilizing powder melting, sintering, fusion and bonding, and a strong theoretical and working knowledge of these applications. Responsible for interfacing with internal teams and clients to facilitate material and process selection, collection and dissemination of product design requirements, deployment of cost models for AM components, and planning and timelines for part production. Knowledge of part quality and performance measurement techniques and assessment to facilitate quality assurance specifications and metrics; depending on the industry, a materials science background may facilitate the evaluation of mechanical and metallurgical properties.

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SME METAL ADDITIVE MANUFACTURING COMPETENCY MODEL JOB DESCRIPTION EXCEPRTS (CONTINUED)

Technician/Operator

Responsible for the metal additive machine set up, consolidating part designs into build files and deployment of machine builds, as well as validation of parts after the manufacturing steps have completed. Responsible for parts removal and machine setup for new builds, and able to perform material changeover safely. Responsible for everyday maintenance of equipment and troubleshooting and responding to process errors or anomalies. Basic understanding of QA processes for additive manufactured parts. The technician may be required to operate, maintain and troubleshoot AM processes from CAD file to finished part.

Field Service Technician

Responsible for supporting customer requirements as it relates to installation, troubleshooting, maintenance and service of metallic additive systems at customers' sites. These activities contribute to, implementation, maintenance and repair of existing products, as well as deployment of hardware and software upgrades of such systems. Field service technicians will also visit customer sites to perform periodic calibration and diagnostics of systems. Field service technicians should maintain service records and field service reports. Responsible for following safety measures, as they relate to the manufacturing process and material handling.

[1] Wohers Associates, Wohlers Report 2018
[2] SmarTech Publishing. "Markets for Precious Metals in Additive Manufacturing: 2018-2028".
[3] Jackson, Beau. "BMW Invests e10 Million In German Additive Manufacturing Campus," 3D Printing Industry, April 16, 2018

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APPENDICIES: SME METAL ADDITIVE MANUFACTURING COMPETENCY MODEL JOB DESCRIPTIONS

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APPENDIX A: ADDITIVE METAL TECHNICIAN OPERATOR

Company: Device Manufacturer (OEM) or Hospital (POC)
Job Level: Entry-Level

Job Description:
Responsible for the metal additive machine set up, consolidating part designs into build files and deployment of machine builds, as well as validation of parts after the manufacturing steps have completed. Responsible for parts removal and machine setup for new builds, and able to perform material changeover safely. Responsible for everyday maintenance of equipment and troubleshooting and responding to process errors or anomalies. Basic understanding of QA processes for additive manufactured parts. The technician may be required to operate, maintain and troubleshoot AM processes from CAD file to finished part.

Knowledge:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
- Understanding of 3D Printers/Additive Manufacturing Machines
- Awareness of safety including: powder handling and storage requirements, auxiliary equipment, facility preparation, government regulations, personal safety best practices
- Awareness of product quality standards and product inspection criteria
- Product and process certification criteria based on customer specifications
- Influence of feedstock material quality on process performance
- Post processing technologies (e.g., powder removal, surface treatment, and finish machining) of 3D printed metal parts.
- Part quality measurement and assessment including mechanical, microstructures, etc.
- Part quality measurement and assessment including part properties geometry and tolerances
- Process signatures measurement and assessment including in situ monitoring, inspection
- Design for Metal Additive Manufacturing Principles
- Basic knowledge of metallurgy and process constraints for design
- Basic knowledge of metallurgy testing and analysis (evaluation)
- Basic knowledge of materials selection
- Knowledge of the workflow to generate and optimize a digital design for specific metal AM process
- Understanding of digital data handling, storage and Intellectual Property regarding custom designs or reverse-engineered designs
- Understanding of Design of experimental approaches for product/process optimization
- Additional engineering knowledge as required for all engineering positions within organization

Skills:
- Advanced 3D Modeling/CAD Skillset
- Troubleshoot additive manufacturing processes, and enable continuous process improvement
- Develop and/or deploy cost estimation strategies of metal additive parts
- Leverage the AM technology performance and material capabilities strategic decision-making
- Deploy performance simulation and modeling tools
- Deploy machine-specific anomaly detection tools for in-situ inspection during build process.
- Deploy defect detection tools for part inspection after build process.
- Additional engineering skills as required for all engineering positions within organization

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APPENDIX A: ADDITIVE METAL TECHNICIAN OPERATOR (CONTINUED)

Abilities:

- Advanced Troubleshooting of 3D Printing Machines
- Aptitude with design tools, computer aided modeling
- Aptitude data analysis, statistics and process design
- Ability to perform Inspection methods and types for in-process (during AM build)
- Ability to perform Inspection methods and type for post process (after AM build)
- Ability to perform data analysis after the AM build
- Ability and knowledge of programming
- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Requested Experience:

- SME Additive Manufacturing Certification

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APPENDIX B: DESIGN ENGINEER

Job Description:
Responsible for translating customer requirements and leveraging AM technology capabilities into innovative designs to improve product performance, reduce part count and cost. Defines design optimization strategies and interfaces with materials specialists and/or manufacturing engineers, as well as leverages process simulation software tools, to validate design decisions based on AM process, part build layout and material selection. Involved with planning and executing 3D scanning and reverse engineering, assembly consolidation of components, as well as incorporating data visualization to facilitate planning for manufacturing deployment and for cost estimates.

Knowledge:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Understanding of 3D Printers/Additive Manufacturing Machines
- Awareness of product quality standards and product inspection criteria
- Product and process certification criteria based on customer specifications
- Influence of feedstock material quality on process performance
- Post processing technologies (e.g., powder removal, surface treatment, and finish machining) of 3D printed metal parts.
- Part quality measurement and assessment including part properties geometry and tolerances
- Design for Metal Additive Manufacturing Principles
- Basic knowledge of metallurgy and process constraints for design
- Basic knowledge of materials selection
- Knowledge of the workflow to generate and optimize a digital design for specific metal AM process
- Understanding of digital data handling, storage and intellectual property regarding custom designs or reverse-engineered designs
- Understanding of design of experimental approaches for product/process optimization
- Additional engineering knowledge as required for all engineering positions within organization

Preferred:
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
- Awareness of safety including: powder handling and storage requirements, auxiliary equipment, facility preparation, government regulations, personal safety best practices
- Part quality measurement and assessment including mechanical, microstructures, etc.

Skills*:*
- Advanced 3D Modeling / CAD Skillset
- Develop and/or deploy cost estimation strategies of metal additive parts
- Deploy performance simulation and modeling tools
- Additional engineering skills as required for all engineering positions within organization

Preferred:
- Deploy defect detection tools for part inspection after build process.

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APPENDIX B: DESIGN ENGINEER (CONTINUED)

Abilities:

- Aptitude with design tools, computer aided modeling
- Ability to perform data analysis after the AM build
- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Preferred:

- Aptitude data analysis, statistics and process design

Requested Experience:

- Engineering Applications Development experience
- Hands-on manufacturing experience working in a project-based environment (based on job level)
- CAD experience
- Communicating & Influencing Skills: Strong oral and written communication skills, Strong interpersonal and leadership skills
- ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously
- General skills and experience, Software/controls experience, Customer support and troubleshooting

Preferred:

- Minimum of Bachelor’s Degree in Engineering, Manufacturing Material Science Engineering, Mechanical Engineering, or Industrial Systems or equivalent (Master's Preferred)
- SME Additive Manufacturing certification
- Experience across multiple disciplines with metal additive manufacturing

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APPENDIX C: EXECUTIVE/MANAGEMENT

Job Description:
Responsible for defining the corporate vision and strategy, as well as company direction based on an intimate knowledge of the AM industry sector and AM technology business case. Executive/Management role is responsible for the development of functional or business unit strategy for the entire organization, sees the transformative impact AM can have on products and the market, evaluates the economic impact of deployment of existing and emerging AM technologies. Develops ideas for AM products or enhancements and oversees the creation and improvement of products researched by the engineering department. Provides approval for capital expenditures, facilities and staffing.

Knowledge:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
- Understanding of 3D Printers/Additive Manufacturing Machines
- Understanding of digital data handling, storage and Intellectual Property regarding custom designs or reverse-engineered design
- Additional engineering knowledge as required for all engineering positions within organization

Preferred:
- Awareness of safety including: powder handling and storage requirements, auxiliary equipment, facility preparation, government regulations, personal safety best practices
- Product and process certification criteria based on customer specifications
- Influence of feedstock material quality on process performance
- Post processing technologies (e.g., powder removal, surface treatment, and finish machining) of 3D printed metal parts.
- Part quality measurement and assessment including mechanical, microstructures, etc.
- Part quality measurement and assessment including part properties geometry and tolerances
- Design for Metal Additive Manufacturing Principles
- Basic knowledge of materials selection
- Knowledge of the workflow to generate and optimize a digital design for specific metal AM process

Skills:
- Develop and/or deploy cost estimation strategies of metal additive parts
- Additional engineering skills as required for all engineering positions within organization

Preferred:
- Leverage the AM technology performance and material capabilities strategic decision-making

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APPENDIX C: EXECUTIVE/MANAGEMENT (CONTINUED)

Abilities:

- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Requested Experience:

- Communicating and influencing skills: Strong oral and written communication skills, strong interpersonal and leadership skills, ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously, ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously
- General skills and experience, software/controls experience, customer support and troubleshooting

Preferred:

- Minimum of Bachelor's Degree in Engineering, Manufacturing Material Science Engineering, Mechanical Engineering, or Industrial Systems or equivalent (Master's Preferred)
- Experience across multiple disciplines with metal additive manufacturing

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APPENDIX D: ADDITIVE METAL FIELD SERVICE TECHNICIAN

Job Description:
Responsible for supporting customer requirements as it relates to installation, troubleshooting, maintenance and service of metallic additive systems at customers' sites. These activities contribute to, implementation, maintenance and repair of existing products, as well as deployment of hardware and software upgrades of such systems. Field service technicians will also visit customer sites to perform periodic calibration and diagnostics of systems. Field service technicians should maintain service records and field service reports. Responsible for following safety measures, as they relate to the manufacturing process and material handling.

Knowledge:
- Awareness of safety including: powder handling and storage requirements, auxiliary equipment, facility preparation, government regulations, personal safety best practices
- Awareness of product quality standards and product inspection criteria
- Influence of feedstock material quality on process performance
- Additional engineering knowledge as required for all engineering positions within organization

Preferred:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
- Part quality measurement and assessment including mechanical, microstructures, etc. (validate geometric accuracy)
- Part quality measurement and assessment including part properties geometry and tolerances
- Process signatures measurement and assessment including in situ monitoring, inspection (if applicable)

Skills*:*
- Troubleshoot additive manufacturing processes, and enable continuous process improvement
- Deploy machine-specific anomaly detection tools for in-situ inspection during build process. (if applicable)
- Additional engineering skills as required for all engineering positions within organization

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APPENDIX D: ADDITIVE METAL FIELD SERVICE TECHNICIAN (CONTINUED)

Abilities:

- Advanced Troubleshooting of 3D Printing Machines
- Ability to perform Inspection methods and types for in-process (during AM build – if applicable)
- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Requested Experience:

- Experience with machine set up, operation, maintenance (based on job level)
- Communicating and influencing skills: Strong oral and written communication skills, strong interpersonal and leadership skills, ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously
- General skills and experience, Software/controls experience, Customer support and troubleshooting

Preferred:

- Experience across multiple disciplines with metal additive manufacturing

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APPENDIX E: MANUFACTURING ENGINEER

Job Description:
Responsible for the adoption of metal AM technologies in production facilities in terms of supply chain, production chain, planning and scheduling, QA requirements as well as coordinating the manufacturing workflow to meet production deadlines. Performs planning and scheduling operations related to AM technology deployment including metal powder handling maintenance assignments, post machining and inspection, safety and security responsibilities. Implements manufacturing plans collaboratively with materials specialists for establishing optimal build parameters and troubleshooting production quality issues.

Knowledge:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
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- Basic knowledge of materials selection
- Knowledge of the workflow to generate and optimize a digital design for specific metal AM process
- Understanding of digital data handling, storage and Intellectual Property regarding custom designs or reverse-engineered designs
- Understanding of Design of experimental approaches for product/process optimization
- Additional engineering knowledge as required for all engineering positions within organization

Skills:
- Advanced 3D Modeling / CAD Skillset
- Troubleshoot additive manufacturing processes, and enable continuous process improvement
- Develop and/or deploy cost estimation strategies of metal additive parts
- Leverage the AM technology performance and material capabilities strategic decision-making
- Deploy performance simulation and modeling tools
- Deploy machine-specific anomaly detection tools for in-situ inspection during build process.
- Deploy defect detection tools for part inspection after build process.
- Additional engineering skills as required for all engineering positions within organization

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APPENDIX E: MANUFACTURING ENGINEER (CONTINUED)

Abilities:

- Aptitude with design tools, computer aided modeling
- Aptitude data analysis, statistics and process design
- Ability to perform Inspection methods and types for in-process (during AM build)
- Ability to perform Inspection methods and type for post process (after AM build)
- Ability to perform data analysis after the AM build
- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Requested Experience:

- Hands-on manufacturing experience working in a project-based environment (based on job level)
- Experience with machine set up, operation, maintenance (based on job level)
- Communicating & Influencing Skills: Strong oral and written communication skills, Strong interpersonal and leadership skills
- ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously
- General skills and experience, Software/controls experience, Customer support and troubleshooting

Preferred:

- Minimum of Bachelor's Degree in Engineering, Manufacturing Material Science Engineering, Mechanical Engineering, or Industrial Systems or equivalent (Master's Preferred)
- CAD experience
- SME Additive Manufacturing certification
- Experience across multiple disciplines with metal additive manufacturing

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APPENDIX F: APPLICATION ENGINEER

Job Description:
Responsible for metal additive process development based on powder bed platforms utilizing powder melting, sintering, fusion and bonding, and a strong theoretical and working knowledge of these applications. Responsible for interfacing with internal teams and clients to facilitate material and process selection, collection and dissemination of product design requirements, deployment of cost models for AM components, and planning and timelines for part production. Knowledge of part quality and performance measurement techniques and assessment to facilitate quality assurance specifications and metrics; depending on the industry, a materials science background may facilitate the evaluation of mechanical and metallurgical properties.

Knowledge:
- Knowledge of Metal Additive Manufacturing Technologies in terms of: existing technologies and performance of such, industry sectors, use cases, success and failure modes, and general economic impact.
- Adoption of Metal AM Technologies in production facilities in terms of: supply chain, production chain (pre-, post-processing, workflow), cost models for decision-making
- Understanding of 3D Printers/Additive Manufacturing Machines
- Awareness of safety including: powder handling and storage requirements, auxiliary equipment, facility preparation, government regulations, personal safety best practices
- Awareness of product quality standards and product inspection criteria
- Product and process certification criteria based on customer specifications
- Influence of feedstock material quality on process performance
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- Part quality measurement and assessment including part properties geometry and tolerances
- Design for Metal Additive Manufacturing Principles
- Basic knowledge of materials selection
- Knowledge of the workflow to generate and optimize a digital design for specific metal AM process
- Understanding of digital data handling, storage and intellectual property regarding custom designs or reverse-engineered designs
- Additional engineering knowledge as required for all engineering positions within organization

Preferred:
- Part quality measurement and assessment including mechanical, microstructures, etc.
- Process signatures measurement and assessment including in situ monitoring, inspection
- Basic knowledge of metallurgy and process constraints for design
- Basic knowledge of metallurgy testing and analysis (evaluation)
- Understanding of design of experimental approaches for product/process optimization

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APPENDIX F: APPLICATION ENGINEER (CONTINUED)

***Skills**:*

- Advanced 3D Modeling / CAD Skillset
- Develop and/or deploy cost estimation strategies of metal additive parts
- Leverage the AM technology performance and material capabilities strategic decision-making
- Deploy performance simulation and modeling tools
- Additional engineering skills as required for all engineering positions within organization

Preferred:

- Troubleshoot additive manufacturing processes, and enable continuous process improvement
- Deploy machine-specific anomaly detection tools for in-situ inspection during build process
- Deploy defect detection tools for part inspection after build process.

Abilities:

- Aptitude with design tools, computer aided modeling
- Ability to perform Inspection methods and type for post process (after AM build)
- Ability to perform data analysis after the AM build
- Ability and knowledge of programming
- Problem solving ability to achieve root cause analysis and corrective actions
- Additional engineering abilities as required for all engineering positions within organization

Preferred:

- Advanced Troubleshooting of 3D Printing Machines
- Aptitude data analysis, statistics and process design

Requested Experience:

- Engineering Applications Development experience
- Hands-on manufacturing experience working in a project-based environment (based on job level)
- Communicating & Influencing Skills: Strong oral and written communication skills, Strong interpersonal and leadership skills
- ability to work in cross-functional teams and influence others, ability to coordinate several projects simultaneously
- General skills and experience, Software/controls experience, Customer support and troubleshooting

Preferred:

- Minimum of Bachelor’s Degree in Engineering, Manufacturing Material Science Engineering, Mechanical Engineering, or Industrial Systems or equivalent (Master's Preferred)
- CAD experience
- SME Additive Manufacturing certification
- Experience across multiple disciplines with metal additive manufacturing

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CONTRIBUTORS

Steven George – Business Intelligence Manager
Suzy Marzano – Product Development Manager

ABOUT SME

SME connects all those who are passionate about making things that improve our world. For 85 years, SME has dedicated itself to ensuring the health and competitiveness of the manufacturing industry through developing the workforce and promoting advanced technologies. As a nonprofit organization, SME has served practitioners, companies, educators, government and communities across the manufacturing spectrum for more than 80 years. Through its strategic areas of events, media, membership, training and development, and the SME Education Foundation, SME is uniquely dedicated to the advancement of manufacturing by addressing both knowledge and skills needed for the industry.

ABOUT SME BUSINESS INTELLIGENCE

SME Business Intelligence was created to focus on delivering research solutions to the manufacturing industry. Managed by experienced market research professionals, SME Business Intelligence is dedicated to delivering high-quality insights by effectively integrating market research and market intelligence. This integration of research and intelligence provides a unique approach to support and develop both advanced technologies and the workforce in the manufacturing industry.

ABOUT THE ADDITIVE MANUFACTURING COMMUNITY

The AM Community was created to promote and accelerate adoption of Additive Manufacturing within the global manufacturing community. SME's Additive Manufacturing Community Advisors provide oversight and support to develop and promote professional development products and services, technical papers, webinars, and address industry gaps. SME's Additive Manufacturing Community advisors approached ASTM to develop standards leading to the establishment of the F42 Committee.

ADDITIVE MANUFACTURING COMMUNITY ADVISORS

- Jennifer Fielding, Air Force Research Laboratory
- Mihaela Vlasea, University of Waterloo
- Chris Williams, Virginia Tech
- Brian Post, Oakridge National Lab
- Milan Brandt, RMIT
- Bryan Crutchfield, Materialise
- Zach Simkin, Senvol
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