DE
Digital Engineering

MAKING THE CASE FOR BUILDING AN AM TEAM

Take a holistic approach to implementing metal additive manufacturing by partnering with experts

A SPECIAL SUPPLEMENT IN PARTNERSHIP WITH

SLM SOLUTIONS

MAKE THE LEAP

So you think metal additive manufacturing is right for you ... now what?

Given all the recent hype surrounding 3D printing, it's easy to forget that the technology isn't some relative newcomer or unknown bit player. Rather, 3D printing, including metal additive technology, has increasingly become a principal actor on the manufacturing stage, used as a cost-effective production alternative for countless applications across myriad industries for the better part of a decade.

Metal additive manufacturing (AM), while commanding less of the current spotlight than thermoplastic 3D printing technologies, has become a proven production method in the last few years. The technology has gained significant traction in industries such as aerospace, automotive, medical, and dental, where there is outsized demand for relatively low volumes of parts, and where customization and the ability to combine parts for optimization purposes can play a significant role in differentiating a product or driving cost efficiencies throughout its lifecycle.

Metal AM systems vary based on the technology employed, but one of the most popular technologies, selective laser melting (SLM), spreads a layer of metal powder onto a substrate plate, and then a high-power laser selectively melts the powder to create the first layer of the build. A fresh layer of metal powder is then evenly distributed over the build surface, and the lasers melt each successive layer until the desired component is produced.

While AM technologies like SLM have been part of leading aerospace and automotive companies' manufacturing playbooks for the last few years, usage has been limited, in part because of the high cost of the additive manufacturing systems and materials, in addition to a general lack of knowledge and expertise in how to fully use additive methods. Thanks to advances in technology and manufacturers' growing familiarity with additive manufacturing, the industry is rapidly expanding. Worldwide revenues increased 17.4% in 2016, according to the 2017 *Wohlers Report*. Metal AM, in particular, is enjoying significant traction with nearly half of all service providers in the market running AM systems able to produce metal parts—an indication of increased customer demand.

Widespread interest in AM, and metal AM in particular, has been stoked by success stories from a range of industries, but particularly in the aerospace and defense sector. NASA, for example, leveraged selective laser melting 3D printing technology to output turbo pumps,

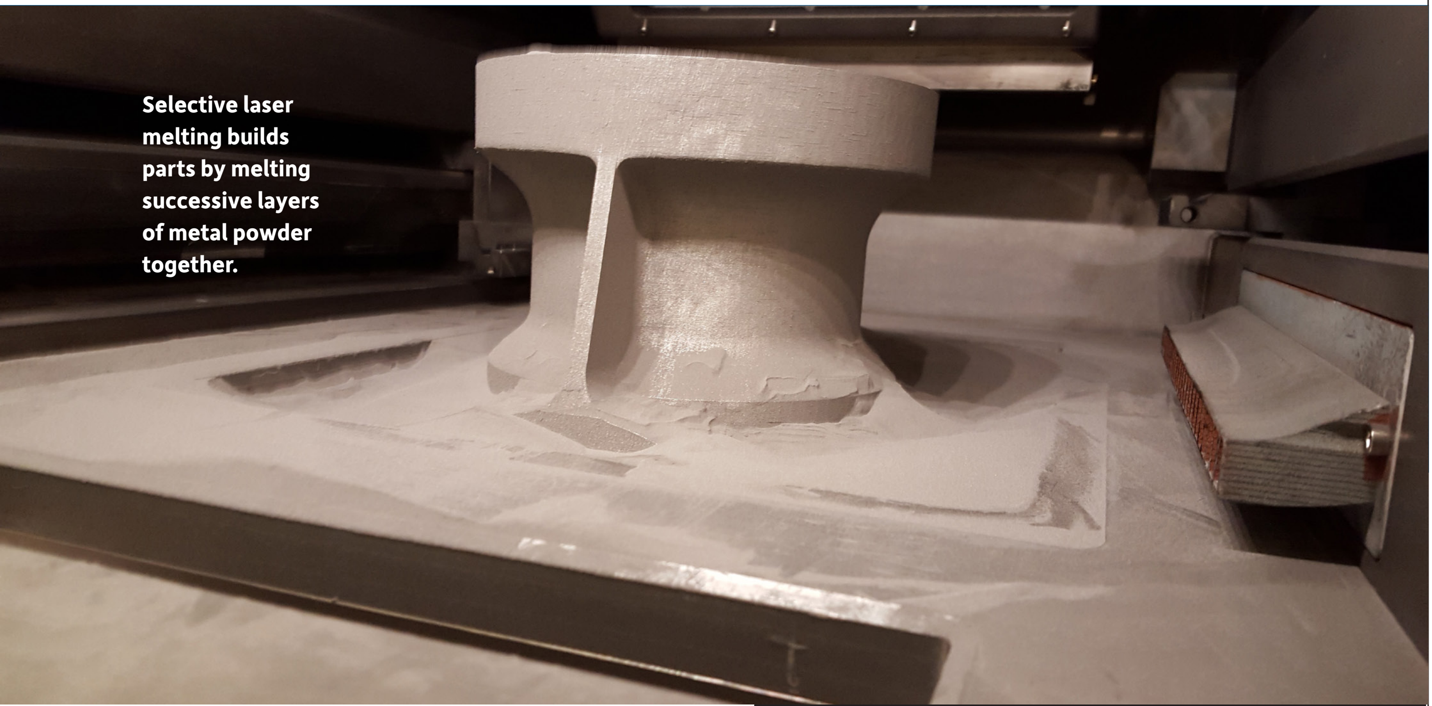
WORKING LAB

As part of its commitment to partner with customers, SLM Solutions has built a new office and development lab in Wixom, MI, adding new capabilities to foster collaboration on metal AM projects.

The new space, almost double the size of the company's previous office, has a large demonstration area outfitted with up to seven machines, a dedicated lab and post-processing room, along with customer meeting rooms specifically designated for training.

The demonstration lab encompasses:

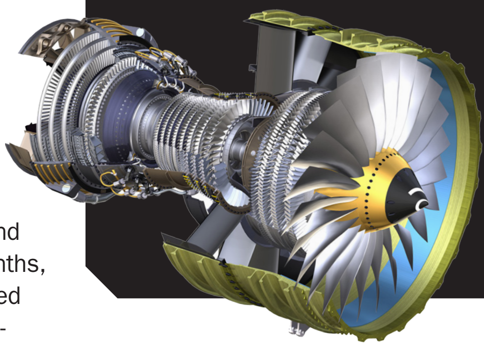
- Post-processing equipment, including heat treating oven, milling machine, and large band saw
- An array of SLM machines, including SLM 280, 500, and 125 models in addition to powder Sieves
- A CMM used for laser scan field calibration
- Over $5 million in inventory of spare parts and consumables



Selective laser melting builds parts by melting successive layers of metal powder together.

injectors, and valves (75% of the necessary parts for a fully 3D printed rocket engine) and tested all three individually with great results. By leveraging SLM technology, NASA was able to design each part with fewer components—for example, the injector was produced in just two pieces compared to the more than 200 parts for a similar, traditional component—and the team was able to construct the components in months, not years. More recently, NASA connected the 3D printed parts together as a traditional rocket engine, which produced more than 20,000 pounds of thrust while withstanding temperatures of 6,000°F.

GE also used metal AM to create its redesigned Leap engine fuel nozzle. Whereas it historically took 20 parts to complete the fuel nozzle's complex geometry, 3D printing allowed for a simplified fuel nozzle design that can be produced as a single unit and is five times more durable than its predecessor, according to the company. Others in and outside of the aerospace industry are catching on to the cost efficiencies and part optimization benefits of AM technologies. According to a study funded by the U.S. Department of Energy Advanced Manufacturing Office, aircraft weight can be reduced by 7% by replacing conventional manufacturing methods with AM technologies. With fuel expenses now ranging from 25 to 40% of total airline operating costs, every percentage of weight reduction equals huge cost savings. For example, in 2014, researchers at MIT estimated that cost of each passenger carrying a cellphone costs Southwest Airlines $1.2 million a year in weight-related fuel expenses.



With 3D printing, GE consolidated 20 parts into one Leap engine fuel nozzle that is 5x more durable than before.

AM technologies are also getting more air time as talk of industry 4.0 or digital manufacturing takes hold. As part of the vision for next-generation manufacturing, 3D printing joins technologies like big data analytics, simulation, autonomous robots, and the industrial Internet of Things (IIoT), to deliver new levels of intelligence and automation, enabling faster, more flexible manufacturing processes that allow companies to produce high-quality goods at reduced costs. AM technologies, in particular, let manufacturers produce smaller batches of customized products more cost-efficiently while also supporting more complex, lightweight designs that aren't possible to create with conventional tooling or injection modeling processes.

Perception vs. Reality

While the race is on, there are still plenty of hurdles to overcome before AM technologies can be leveraged effectively. One of the biggest is the misperception that 3D printing has evolved to a point where it is dead simple to use. The recent influx of low-cost thermoplastic 3D printers has fed a narrative that the technology is push-button-ready in the same genre as traditional office-style printers. Indeed, while plastic 3D printing has become far more accessible from both a price point and usability factor, and has been widely embraced by engineers for prototyping, it is still not a turnkey practice. In fact, plastic 3D printing, like metal AM technologies, requires plenty of specialized knowledge, including expertise in the specific 3D printing technology, post-processing procedures, and most importantly, how to prepare a 3D CAD model so it can be effectively translated and reproduced on a 3D printer.

Those with limited 3D printing experience who are focused primarily on prototyping are more likely to miscalculate the intricacies of tapping metal AM technologies for production purposes. Just like traditional manufacturing processes like casting, machining, forming, and injection modeling, metal AM is a specialized discipline that requires the expertise of trained professionals. While the primary metal AM technologies predominantly use the same basic melting process, there are critical differences in how the actual machines are designed and operated. As a result, professionals need to be properly trained in the nuances of the system so they can optimize the build accordingly.

TEAM WORK MAKES AM WORK

Metal AM technology isn't necessarily new, but it is a relative newcomer in most organizations as a routine alternative to traditional manufacturing processes for low volume, high-value customized components. Many companies ready to embrace the technology begin by working with service providers.

When the decision has been made to bring a solution in-house, rather than contracting all AM runs through a service provider, companies can maximize their metal AM usage on several levels. For one thing, the AM vendor takes a vested interest in a company's long-term success with metal AM, providing support and knowledge sharing that elevates use of the technology to the next level. In addition, the vendor will work with the engineering organization at each stage of design, ensuring the return on investment in the solutions are maximized.

At the same time, the engineering organization benefits from having metal AM capabilities at their disposal. The metal AM vendor can provide regular training and learning opportunities to expose engineering to the full capabilities of the printer, as well as best practices for AM metal printing. In addition, having the technology at the ready allows engineers to experiment, which has a dramatic impact on their learning curve and results in better designs, productivity increases, and optimized adherence to safety and regulatory standards.

Choosing the right AM technology is critical, but forging partnerships with the optimal AM provider is the fastest path to success.

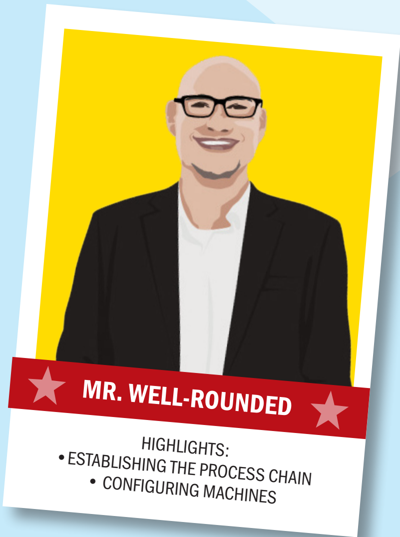
For more information on SLM Solutions metal AM technologies, go to SLM-Solutions.us.

PARTNER PROFILES

When choosing a metal AM vendor, make sure you're setting yourself up for success by choosing a partner that has a knowledgeable team in place to help you. Four key players to look for in a metal AM vendor partner are the applications engineer, the systems engineer, the metallurgist and the service engineer.

The Applications Engineer

This well-rounded player starts by working with design engineers to figure out how to create a component that fully exploits the capabilities of metal AM. They also spend time setting up and configuring machines so they are productive as well as establishing the process chain that supports metal AM production from the initial design stage all the way through final inspection.



At the same time, manufacturers need to understand how to design parts for metal AM production so they can fully capitalize on the technology. For example, metal AM allows for customization of parts and complex lattice structures that are critical for lightweighting and aren't possible with traditional manufacturing methods. There are also design requirements specific to the behaviors and characteristics of the metal materials supported by particular machines. All of these considerations need to be factored in at the earliest design stages. Finally, metal AM is not a one-sized-fits-all solution, so manufacturers need to closely map their requirements to specific machine capabilities and system configurations, including things like build envelope size, range of materials supported, and the number of lasers in place.

There's no question that metal AM technology has arrived at the point where it's a viable production alternative for companies of all sizes, across many industries. Manufacturers just need to do the proper due diligence to ensure they choose the right metal AM technology for their application. At the same time, they also need to align with a trusted and expert partner that can help navigate the inevitable twists and turns in what's likely to be a rewarding and transformative journey.

The Systems Engineer

This person is responsible for taking a holistic view of the entire process chain from design to end product, determining how to best integrate metal AM technology into existing production processes. The systems engineer will handle everything from how the AM system is installed in the customer facility (including things like HVAC and power sources) as well as how to maintain infrastructure with an emphasis on safety.

The Service Engineer

This role may vary depending on the hardware provider, but it typically handles an array of functions, from installation, on-site maintenance and repair of machines, to delivering basic operational training to doing whatever it takes to remove doubt from customers' minds.

The Metallurgist

Given that products produced with metal AM technologies are high-value items, there needs to be focus on materials properties and characteristics—hence the job of the metallurgist. This role maintains oversight of mechanical properties (requirements related to resistance or hardness or impact of porosity, for example) and ensures that parts produced meet all certification standards.

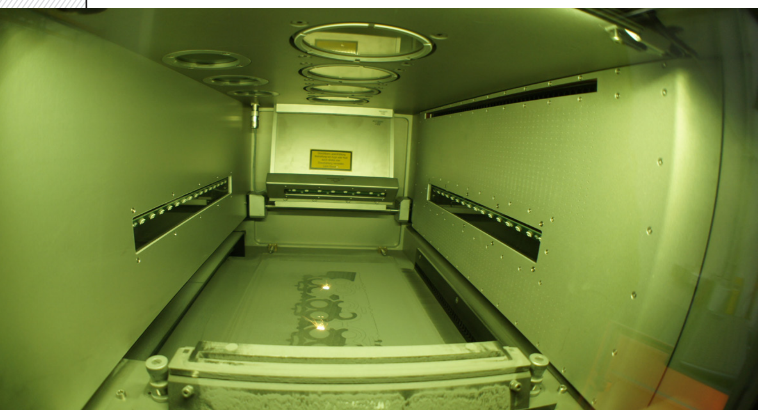
SLM Solutions' global headquarters and manufacturing is located in Lübeck, Germany. In addition to this global network, SLM Solutions North America has offices in Metro-Detroit with a full team of these professionals to help companies fully capitalize on the promise of metal additive manufacturing technologies.

BEYOND SPEEDS AND FEEDS

Metal AM technology can deliver plenty of benefits for the production of limited run, highly customized parts, yet choosing the right solution is more involved than selecting the optimal hardware configuration. Instead, companies need to balance technical requirements with the accessibility of metal AM expertise, aligning with a solution provider that will function in a collaborative role, not just as a vendor.

By partnering with a trusted AM provider to bring metal AM solutions in house, companies gain a leg up leveraging the technology for optimal output. Many companies in the aerospace, medical, and dental industries produce metal AM parts by contracting with service bureaus, but this on-demand approach actually limits the scope of how the technology is deployed because there is little exposure to engineering. If engineers aren't versed in the nuances of metal AM, they don't understand how to effectively design new kinds of parts that take advantage of additive manufacturing technology.

"For most companies, metal AM is relatively new and there's not usually a lot of knowledge about it within any given company," notes Richard Grylls, technical director for SLM Solutions, North America. "It's enormously valuable to have the technology in-house to keep it close to engineers, serving as an educational tool to understand what's possible."



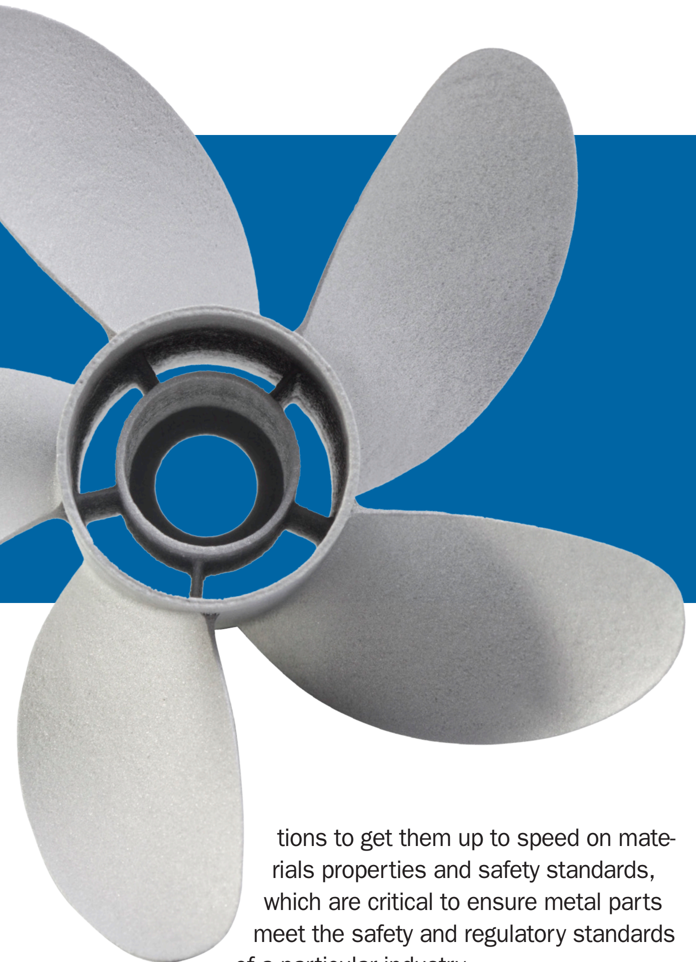
An inside view of the SLM additive manufacturing process.

Beyond pushing the envelope in design, bringing metal AM systems in house via a partnership with a hardware provider can foster the safety and compliance requirements critical for industries like aerospace and medical. In those sectors, metal AM-produced parts are highly regulated and have to meet stringent safety and certification requirements given that they might be part of a jet engine or a surgical implant where failure is not an option. Installing AM metal printers on-site allows in-house engineers to lean on their hardware partner to learn the intricacies of the system so they have the authority to certify how equipment is calibrated, what is required for a part to pass inspection, or make judgments about the quality of a finished part. That direct level of input isn't possible if the metal parts are outsourced to a metal AM service bureau.

Making metal parts in house also helps companies maintain control over their design intellectual property (IP). Many standard-looking metal AM components have really creative internal features such as intricate channels for gas or fluid flow that aid in part performance. "If you send a drawing of a part to a casting vendor, they know what you are doing," Grylls says. "The ability to make components in house provides an opportunity to retain all of your own IP."

Creating the Workflow

Like traditional manufacturing, metal AM involves a series of steps from initial design through outputting files and machine preparation. For example, engineers need to know how to design effectively for metal AM technologies, set up files for optimal output, and effectively perform powder handling and post-processing steps—all areas where a solutions partner can deliver training and hands-on expertise. The right hardware partner can also work with engineering organiza-



tions to get them up to speed on materials properties and safety standards, which are critical to ensure metal parts meet the safety and regulatory standards of a particular industry.

When evaluating AM solutions, there are a variety of considerations on both the hardware and vendor front. From a speeds and feeds perspective, size of the build envelope, support for multiple lasers, and the power of the lasers are key differentiators as are powder handling capabilities. For example, SLM Solutions' mid-size metal AM printer features a 280 x 280mm build envelope, which is significantly larger than the standard 250 x 250 size, accommodating 30% more components. SLM Solutions printers' file preparation techniques, which are preprogrammed to load and run compared with other systems that pause for extended periods of time in between layers, are also key to boosting productivity. Safety is another big area of differentiation, addressed with a variety of features, including a powder sieve station that eliminates any contact between the operator and the metal materials.

In addition to the actual feature set, organizations should align with an AM hardware provider that has a focus beyond equipment sales. It's important to collaborate with a trusted provider willing to dig deep into a company's design goals and workflow challenges while having expert guidance to direct internal engineering teams. By fostering this type of collaborative relationship over the long term, companies are assured of maximizing the impact of metal AM technologies.

LARGE TITANIUM PARTS PREPARE FOR TAKE OFF

Titanium is a favorite for aerospace applications due to the material's properties for producing strong and lightweight parts. Yet leveraging titanium for additive manufacturing (AM) processes has been a challenge due to the size limitations of many metal-based AM printers as well as other issues related to building large-scale parts.

SLM Solutions put those concerns to rest with its effort to produce a 3D printed titanium aircraft component that measures 12 in. tall x 9 in. in diameter —the largest titanium part to date built in the company's SLM 280 printer using dual 400W lasers. This configuration, which has an increased build plate size of 280x280mm (compared to the 250x250mm build envelope of most AM machines this class) made it possible to build such a large-scale part in a relatively short time frame compared to what would be possible with conventional manufacturing.

Advances in SLM Solutions' selective laser melting (SLM) technology made it possible to overcome the obstacles typically encountered building large titanium parts. Titanium is normally very hard and thus subject to cracking due to high residual stresses.

SLM Solution's dual, overlapping laser technology was crucial for building the larger part in an accelerated fashion—specifically, six and a half days with no process interruptions. In comparison, it would have taken many setups and several weeks to machine conventionally. Casting the part would have taken even longer since tooling would have had to be built (a process that could take as long as six months).

"We were far faster even though the cost was more," said Richard Grylls, head of the applications engineering department/North America Technical Director and a Ph.D. metallurgist. "Still, in terms of the total time saved, the cost is worth it for a critical part of this size."

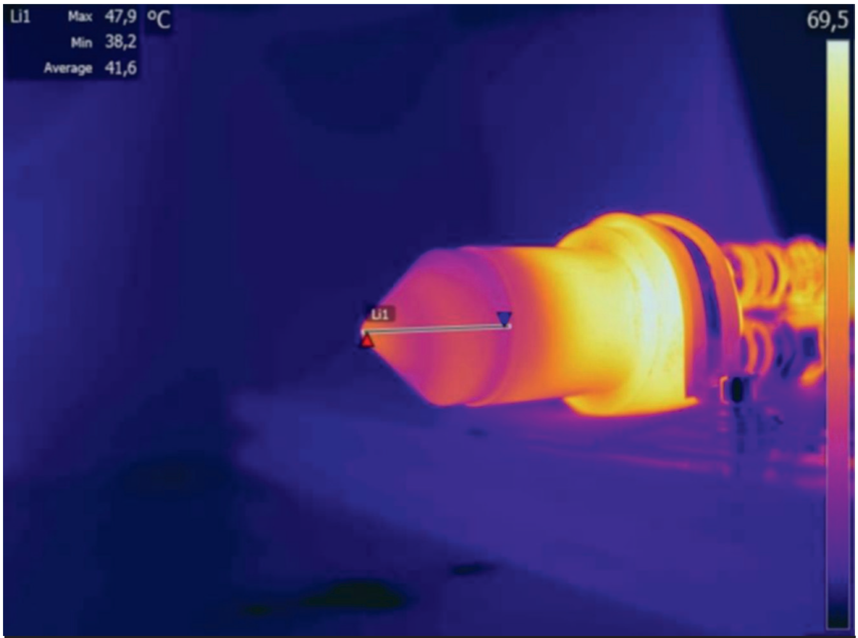
SLM-BUILT TOOLING SLICES CYCLE TIME FOR ABB CABLING GROMMETS

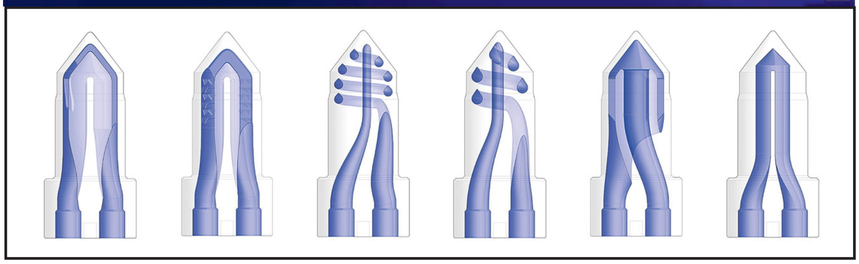
ABB OY, Drives and Controls, which produces millions of cabling grommets each year, was looking for a way to reduce cycle time and minimize scrap parts as part of its production.

The high-volume component, made of thermoplastic elastomer (TPE), was produced by ABB using an injection molding tool, which didn't feature any cooling inserts. The result was a cycle time of around 60 seconds to produce each grommet, which included a cooling period of around 30 seconds.

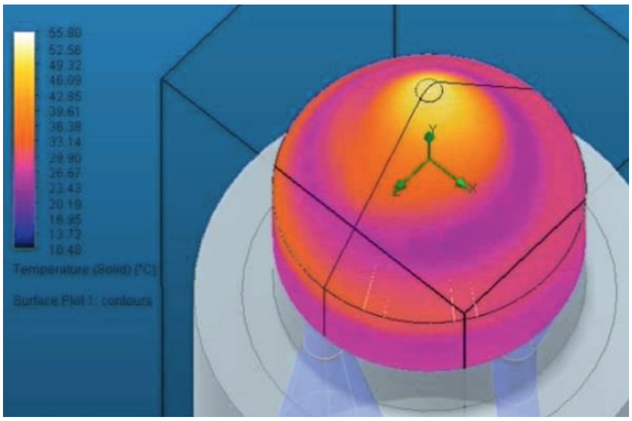
By leveraging SLM Solutions' Selective Laser Melting (SLM) AM technology to redesign and optimize its tooling, ABB was able to achieve its cycle time reduction goals. The company, along with partner SLM Solutions, created six different channel profiles for the tooling insert, including one mimicking conventional cooling, so it could make a proper comparison to conventional manufacturing. The channel profiles were optimized for SLM technology—for example, surface angles were positioned to minimize the need for supports and there was a minimum wall thickness between channels. The team also simulated water flow and thermal conductivity on the various cooling channel profiles to determine optimal behavior.

The foundation and U-profile channel configurations were determined to show the most potential for a conformal cooling insert in the injection molding tool in addition to having a dramatic impact on manufacturability and production. These profiles were able to achieve a TPE cooling time of approximately six seconds, resulting in a full production cycle time of 14.7 seconds, which is a dramatic improvement from the original 60.5 seconds. In addition to the savings in production time, the experiment produced less defective products due to more equal cooling on the surface.



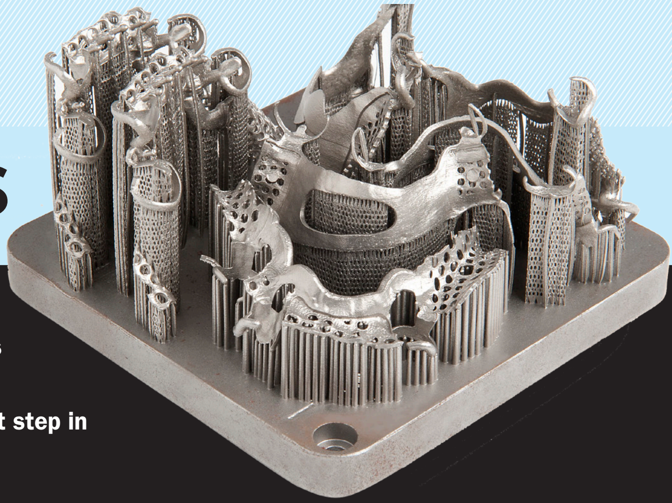


Six different channel profiles were designed for the tooling insert, including one resembling a part with conventional cooling to provide a comparison to conventional manufacturing.



To test the cooling, the parts were heated to a temperature of 70°C with a tempering system and cooled to 20°C to mimic the cooling of the TPE in the injection molding process.

TAKE THE NEXT STEPS



SLM Solutions provides a number of resources for companies that want to learn more about metal additive manufacturing capabilities. Online, on the phone, or in person, take the next step in your metal AM education via the resources below.

Videos

See how selective laser melting works via videos on SLM Solutions' YouTube channel. Get an overview of the company and its products, as well as examples of how customers are using SLM to manufacture more innovative products.

youtube.com/c/slmsolutionsus

Events

Industry events are a great way to see metal 3D printing live and discuss the benefits of additive manufacturing with SLM Solutions' industry experts.

slm-solutions.us/events

White Papers, Case Studies and More

Download the "7 Questions Every Manufacturing Professional Must Ask Before Buying a Metal 3D Printing System" and "The Effect of Additive Manufacturing on the Bottom Line," as well as case studies that show the challenges customers solved by partnering with SLM Solutions. SLM Solutions even has podcasts you can listen to as you work.

slm-solutions.us/resources

Customer Training

SLM Solutions offers training courses at its new Wixom, MI location. Book one of the company's offered courses, or a dedicated session for your group. Either way, you'll gain access to the entire SLM team, its facility, additive manufacturing and post-processing equipment and best-practices together with dedicated training. All training dates accommodate a maximum of four trainees, providing ample time to interact with the trainer and answer all of your questions.

slm-solutions.us/resources/#Training

Service Providers

Looking for contract metal 3D printing service providers with printing services? New to additive manufacturing and need consultation on selective laser melting and if it is a good fit for your component? Check out these service bureaus that feature SLM Solutions equipment.

slm-solutions.us/resources/#Service-Providers

Contact

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