BY ANDREW BROOKS

A Material Difference

As additive manufacturing matures, new processes, powers and powders enter the market

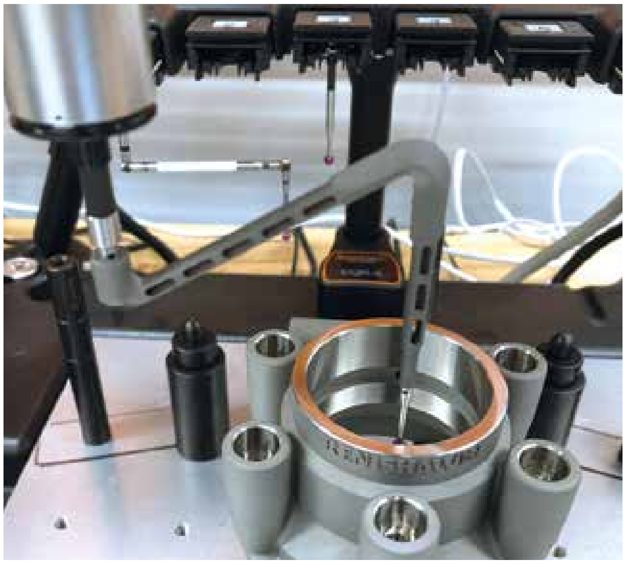
It seems odd to talk about the 'early days' of metal additive manufacturing, considering that the technology is so new. But it's an indicator of how fast the field is progressing that we're already entering an 'AM 2.0' phase, where the expectations of potential customers have become more sophisticated and suppliers of AM equipment, supplies and services are coming to market with solutions designed to make the most of metal AM's unique potential—while making it easier for even small companies to take their first steps in what used to be a financially and technologically intimidating field.

"You still need to think carefully about your business case if you're thinking of getting into metal 3D printing," says Mark Kirby, additive manufacturing business manager for Renishaw Canada. Kirby believes that AM machines with smaller footprints and a higher degree of automation of complex—and even potentially dangerous—processes can make it easier for new entrants to embrace AM without disrupting their existing operations.

Renishaw's new RenAM 500Q is one example, Kirby says. The 500Q has a small footprint and with four 500W lasers, each of which can access the entire powder bed simultaneously, the machine is significantly faster than a single-laser system. "The machine operates faster, but the powder handling is also automated," Kirby says. "The first generation of machines required an operator to handle the powder manually, but by automating that process we not only speed up operation but also increase operator safety and separate the powder handling from other parts of the shop floor. It makes it easier to start out in additive manufacturing because the disruption to the rest of your operations is much less."

The evolution of raw materials is further evidence of the maturing of AM. In those far-off "early" days (i.e. a couple of years ago) what excited the industry most about AM was what it could do for existing products and processes, with existing materials. The powders used were still made from standard industry alloys. But as the transformational nature of AM became more and more apparent, a revolution in raw materials also got underway.

"Today the powder quality is much more uniform than it used to be," says John Manley, president of distributor Machine Tool Systems, which distributes AM systems by EOS. "Also, there are more blends of powder available."



AM enables Renishaw to produce styli of any configuration in a single piece of metal as shown here. A conventionally assembled crank stylus is visible in the background.

EOS, like other AM system OEMs, provides metal powder materials for direct metal laser sintering (DMLS) systems. But a major game-changer for the company was its decision to "unlock" its technology with "open laser parameter sets." This allows customers to customize laser scanning strategies, allowing both customer-specific material development, as well as sophisticated build strategies. It's a sign that the market is maturing, but also that in the absence of decades of accumulated experience, the industry needs to be able to experiment freely with the additive process.

The "unlocking" was gradual, starting with schools and moving on to large corporate clients and now SMEs. "Today," Manley says, "there's a huge community out there developing powders for EOS, and developing laser parameters to

Sandvik Creates 3D Printed Diamond Composite

Sandvik Additive Manufacturing has announced the development of a process for 3D printing using a diamond composite material. Sandvik says the new process means this super-hard material can now be additively manufactured in complex shapes, representing a revolutionary advance in how industry can use the hardest natural material on the planet.

While it has been possible to produce synthetic diamond since 1953, up to now only a few simple geometric configurations were possible. Using stereolithography, Sandvik has successfully manufactured complex parts from a slurry consisting of diamond powder and polymer under ultraviolet light.

The crucial part of the process is Sandvik's proprietary post-processing method where the exact properties of the super-hard diamond composite are achieved.

"This step was extremely complicated," said Mikael Schuisky, head of R&D and Operations at Sandvik Additive Manufacturing. "However, after extensive R&D efforts and several trials we managed to take control over the process and made the first 3D printed diamond composite."

Testing has demonstrated that the composite has very high hardness, higher heat conductivity than copper, low density, thermal expansion close to Invar, three times the stiffness of steel and excellent corrosion resistance.

"We predict it will be used in many different industries where there is a need for wear resistance, extremely durable parts, very efficient cooling, and complex shapes – for example internal coolant channels, advanced nozzles or brackets etc.," says Schuisky.

"The properties of the diamond material make it suitable for parts subject to high wear – which can be found in basically any industry. Another general application is to use it as a 'heat sink,' i.e. use it to extract heat away from hot sensitive components such as electronics, computer processors and similar. When the light density of the material is also considered, it makes it even more interesting to use it in aerospace and space applications."

Sandvik already has development projects underway in different industries, but can't say anything publicly yet.

While additive manufacturing already represents a huge advance over conventional manufacturing techniques when it comes to reducing waste, the new process goes a step further: excess slurry can be reused and the diamond powder can even be extracted from the slurry after use and reused for another printing job.

Sandvik unveiled the new process at the RAPID + TCT Show in Detroit May 21-23, North America's top additive manufacturing event.

More information at https://www.additive.sandvik/en/.

match their recipe. The global industry is going to develop way more powders than the OEM ever will."

Manley uses the example of aerospace manufacturing, where an A357 grade aluminum has traditionally been the alloy offered for AM. Recently, Manley says, Elementum 3D, an EOS user, announced four new grades of A6061 aircraft aluminum that run on the platform.

Traditionally the "holy grail" of powder metallurgy has been to attain 100 per cent density, but even that conventional wisdom is now being challenged. Manley offers the example of GKN Metals partnering with EOS to develop Stainless Steel 316L VPro, which is deliberately closer to as-cast density, say around 95 per cent, making it possible to create a high performance part designed for series production.

"This reduced density represents a massive cost savings for two reasons. First, the material is far less expensive, because it doesn't have to be sieved as fine any longer. But more importantly, the AM process runs much faster. Combine these benefits with a quad-laser system, and suddenly you're not simply prototyping anymore; this could become a viable production process. This is the rapidly changing direction of industrial grade AM."

Traditional production metrics are starting to come into play, agrees Aaron Lalonde, director of applications engineering, SLM Solutions. "The 'wow' factor is still there, even for people who have been doing AM for a while. But now people are starting to ask different questions; can you make that ten, 20, 100 times in a row reliably and repeatably? Can you do it faster and more accurately?"

Getting there means defining manufacturing processes more closely, and defining areas of error and tolerance, Lalonde says. "We put lot of focus into developing high productivity process parameters, including higher laser powers and larger linear thicknesses. But it's more than increasing thickness. You have to increase the power of the laser, you have to modify the speed of the laser, you need to make sure the material structure is still good. There's a lot of development that goes into making the process parameters more productive."

Getting a production quality finish is still one of the biggest challenges in additive manufacturing, especially in specialized applications such as aerospace and medical work. This is an area of expertise at CRIQ in Quebec City. CRIQ ("Quebec Industrial Research Centre" in English) is a provincially funded research centre that cooperates with private companies to provide services such as research, prototyping, feasibility studies, testing and short-run production.

Several years ago, CRIQ purchased an EOS M 290, and one of the research areas, says director of productivity and industrial systems Francois Gingras, is finish quality, especially with the work CRIQ is doing with companies in the medical field, where finish for implants is critical.

"Finish is still a challenge in additive manufacturing because it adds steps to the process and also cost," Gingras says. "CNC machining is an option, but it's not the only option. We've been buying a lot of different equipment over last few years. Some are classic shot peening or sandblasting equipment, but we're also installing barrel equipment with stones and different materials, and we also acquired an electropolishing machine recently."

A Bugatti brake caliper built on an SLM500 quad laser is one example of the larger workpieces it is now possible to build additively. Titanium, build time 45 hours.

To improve AM's finishing capabilities, EOS's AMCM (Additive Manufacturing Custom Machines) division offers a system called Fine Detail Resolution (FDR) that delivers a very small 40-micron laser spot size, as well as both dual-laser format and large work envelopes.

"This lets you get into very fine detail and latticework structures as required by both the biomedical and heat sink sectors," Manley says. "You can work with titanium and pure copper in very fine detail. In parallel, improving the surface finish to reduce post-processing is a high growth opportunity."

Higher power lasers, smaller—and even variable—laser spot sizes, thicker deposition layers… it all sounds like a tough technical challenge. But there's more to it than just the technology, says Renishaw's Kirby.

CRIQ (Quebec Industrial Research Centre) uses an EOS M 290 in its AM research. Photo at right shows a workpiece printed at CRIQ on the EOS M 290.

"People are beginning to realize metal printing isn't just about metal printing. It's about the upfront business case and how you improve that business case using design engineering. When I understand what can be done, I can start deciding what I need to do, what markets I'd like to get into.

"Additive is much more about the entrepreneurial design and manufacturing discussion. They all need to go on together, and that's what makes it so exciting." SMT

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