Core competence

3D printing in metal offers incredible opportunity, but, as Star Rapid's Gordon Styles tells **Alistair Welch**, for designers to get the most out of the process they need to understand the technology

Gordon Styles' message is clear: metal 3D printing is an amazing technology, but the design and manufacturing industries need to be realistic about its application. "There is no point considering metal 3D printing for a part that is price sensitive," he says. "The only time you use metal 3D printing is when you are trying to manufacture something that simply cannot be made by any other manufacturing process."

Alongside more traditional manufacturing techniques such as CNC machining and injection moulding, Styles' company Star Rapid is equipped to offer clients Direct Metal Laser Melting (DMLM) 3D printing. Star Rapid's factory in Guangdong Province, China has a Renishaw AM250 machine that enables the printing of metal parts directly from CAD data.

Styles has been involved in the engineering industry since the age of 18 and in 1993 (at 28) he was running Styles RPD, an early adopter of 3D printing, and eventually the company grew to become one of the UK's largest rapid prototyping companies. He sold the business in 2000 and set up a new company, this time specializing in low-volume production. However, the timing was unfortunate: by 2003 low-cost Chinese manufacturing was undercutting the UK market and the company found contracts hard to come by. When two months elapsed in 2005 with no new work whatsoever, Styles made the decision to close down the business.

However, rather than dwelling on adversity, Styles saw opportunity in China. In May 2005, he travelled to China to assess the market and by July 2005 he had established Star Rapid (then called Star Prototype). Setting up in China was, Styles admits, a leap of faith, but his ambition paid off: Star Rapid now employs 250 people and engages with clients throughout the world.

After building the business predominantly around CNC machining and moulding, Styles decided to develop a metal 3D printing offer as he felt it would provide significant added value to the company's business model.

Like 3D printing in plastic, metal 3D printing is an additive manufacturing process that builds parts in successive layers. The DMLM process offered by Star Rapid uses a high-powered laser to melt and fuse powdered metal into solid parts. The technology is capable of producing complex and feature-rich components.

Star Rapid has completed metal 3D printing projects for clients in the aerospace, defence, industrial, and medical (that's both implants and clinical devices) sectors. However, Styles reports that a key market is conformal cooling cores. These are part of a mould tool used in the moulding of high-volume products, such as bottle caps or low-volume but highly sophisticated parts where efficient cooling is more important than volume savings. The metal 3D printed conformal cooling channels greatly increase cooling efficiency and reduce cycle times while improving finished part quality.

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Whilst metal 3D printing a core might be more expensive than using a conventional manufacturing method, the cost is essentially irrelevant compared to the enormous savings offered by the reduced cycling times in moulding tens of millions of parts per year.

As Styles asserts, metal 3D printing is not a prototyping technology – the market is low-volume production for niche applications. "Anyone who thinks they can build a business doing metal prototyping by 3D printing is in for a very rude awakening," he says.

In contrast to its plastic cousin, metal 3D printing is a highly specialized, highly industrial technology. Plastic 3D printers sit on desktops and in design studios and given a reasonable level of training and experience can be used safely, predictably, and productively. Metal 3D printing is more complex and, according to Styles, requires the input of specialists to produce reliable, useful results.

"At Star Rapid, we employ someone who

Below | Star Rapid founder Gordon Styles with some of his team members

really knows her metallurgy," says Styles. "Chloe Kow is very senior in the industry having had ten years' experience in metal 3D printing in the UK. Finding such a person to run your factory's metal 3D printing is critical. With plastics, frankly, you can take a graduate engineer and with a couple of months training they are good to go. That's not the case in metal; metal is a whole step change and is more difficult."

On top of the metallurgical aspect there is the issue of geometry. In using metal 3D printing there are a number of constraints and limitations that it is important the designer understands. "You can't have an overhanging angle more acute than 45 degrees to the horizontal otherwise you have to start adding difficult to remove supports, for example," says Styles. "Also, the supports need to be designed in. There are automatic support programmes for plastics and metals, but the ones for metals are not very intuitive and therefore we need to design in the supports manually. With plastics, you can put in as many supports as you want because you can tear the supports off with your hands after the build, it's really not that big a deal. But with metal you've got to be very frugal – all supports need to be connected with tear strips and getting the supports off is a full on hardcore engineering job."

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As far as Styles is concerned the fact that metal 3D printing is difficult to get right is good. "My business model is based around having humans – highly-skilled humans – that offer added value," he says. "If your business model is about skills then it's a difficult model to copy."

Star Rapid's business is 97 percent export. The US and the UK are the two largest individual markets and last year the company did business

additivemanufacturing

Opposite top | Inside Star Rapid's workshop in Guangdong Province, China
Opposite bottom | A part produced using metal 3D printing
Below | Star Rapid's quality control team at work

in over 60 countries. Styles explains that the company receives a large number of enquiries about metal 3D printing but he admits that "90 percent do not suit" the technology.

He continues: "A reason why a lot of people come to us is that they have designed something and they have been to a lot of different companies trying to get a quote for CNC machining or die casting and they have run out of options because they've got a design that can't be made. What they should have done was design according to the rules of CNC machining. Yet they are adamant that they are going to have their design produced somehow and they think metal 3D printing is the answer."

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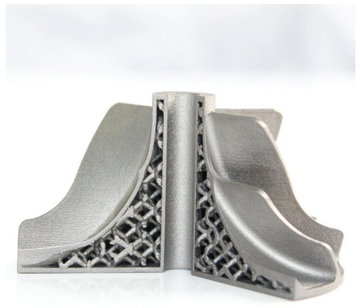
Large, chunky parts in particular are not best suited to metal 3D printing. Large blocks can be subject to twisting, buckling and deformation during the print process.

So, how might designers better conceive parts for metal 3D printing? Styles suggests that a key concern should be to reduce the amount of material that needs to be melted to as little as possible. "Hollow structures are really cool," he says. "A client needs to think about removing material. One of the benefits of metal 3D printing is that you can have hollow parts or parts filled by a mesh. It's a case of learning to design for the process and then opening your mind to start designing amazing stuff based on those principles."

Star Rapid offers a consultancy service to help clients derive the most benefit from metal 3D printing. Furthermore, the company is planning to organize free training sessions at its factory later this year. These week-long courses will train delegates in best practices in designing for the process and will allow them to build and print their own parts. "Getting into the factory really drums in just how laborious the process is if you design a part that needs loads of supports," comments Styles. "The perfect design of a 3D printed metal part is one that needs only a single support. If you can do that it is extremely efficient to build and extremely efficient to remove [the supports] and lowers the cost dramatically. We want people to develop an instinctive knowledge around metal 3D printing. Offering practical training teaches people and will build really good relationships in the long term."



Although located in China, Styles explains that it has always been his intention to run a 'European-style' business. From the beginning he has ensured that the Star Rapid factory operates in accordance with European standards around sustainability and health and safety. "Now ten years later China has effectively co-opted most EU laws on the environment, health and safety, and workers' rights," he reflects. "China's standards have come up to meet mine."

"We are still very much in the early days of this industry," says Styles. Over the coming years, Styles expects metal 3D printing's ability to deal with larger parts to develop. At the moment, large parts can buckle or even tear themselves off the build plate. One possible solution is for the machines to 'run hot' with the powder bed kept at between 400 and 600 degrees Celsius.

This reinforces the fact that metal 3D printing is an industrial process – we won't be talking about having a metal 3D printer in your home or office anytime soon. "These big metal 3D printing machines are serious industrial equipment," adds Styles. "They require an awful lot of insulation and thermal control, plus if you're using titanium the risk of explosion is enormous. The process creates a lot of dust, super fine titanium powder, that if you so much as let normal air get to it, it will explode."

The other development Styles is keeping a close eye on is hybridization – that is machines that will combine metal 3D printing with milling and turning. "The machines use a conical flow of powder and a laser to build up a partial metal 3D printed part and then can do some machining on that part before going back to doing more 3D printing," he says. "That's really the future for me. We are going to see a lot of hybrid machines coming into the mainstream."

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