Break the mold

Amid ever-expanding tire product ranges and more complex tread pattern designs, 3D-printing technology is changing the face of tire mold production, providing a breakthrough in both factory productivity levels, as well as mold functionality

by Rachel Evans | Illustration by Sean Rodwell

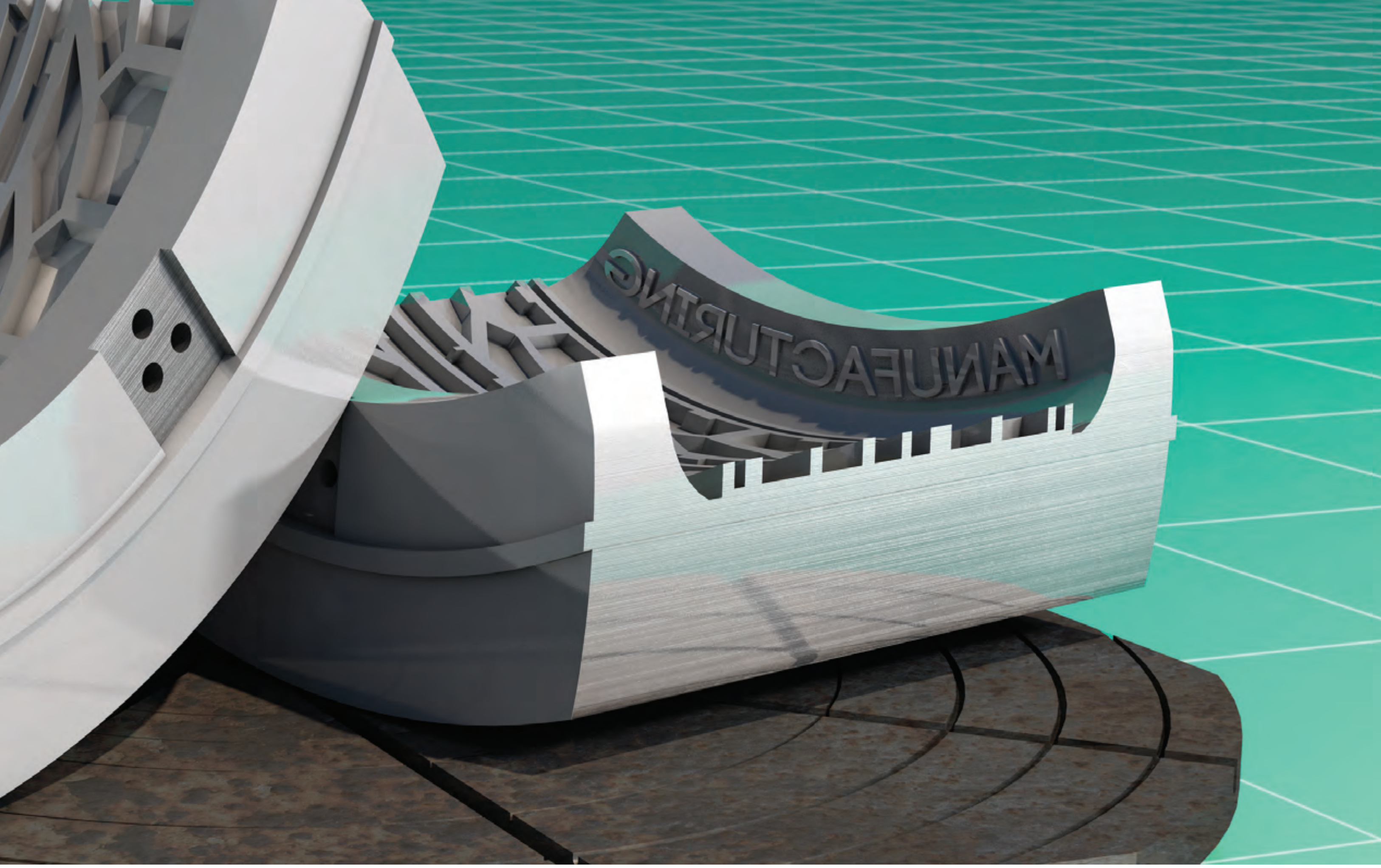
In the production of tire molds, additive manufacturing is transforming the way segments are made, making revolutionary new tread pattern designs conceivable. Although the technology, perhaps more widely known as 3D printing, has been around for over three decades, tire manufacturers and mold developers are now discovering the benefits it has to offer in this new area of application.

Michelin, for example, is one industry player to advocate the technology, and in 2015 announced the establishment of its joint venture company, AddUp (formerly known as Fives Michelin Additive Solutions), which sells 3D-printing equipment to various industries for different purposes. It is thought the tire maker is successfully using the technology in mass production of tire molds in its factories worldwide, with a suite of in-house-developed machines. The OEM first explored its application around 10 years ago.

Bruno Bernard, former CEO at Safran Engineering Services, who more recently served as CEO of AddUp, says, "In the beginning it was about learning and making sure an opportunity was not about to be missed, so there was no precise idea of the potential benefits. Now, however, the benefits have become very clear."

Through additive manufacturing via selective laser melting, thanks to the layer-by-layer build process carried out by lasers, highly intricate tread designs with extremely fine gaps and 3D geometries are made possible. Bernard comments, "This ability enables new types of tire profiles and tread features – such as the 3D self-locking sipes on the Michelin Cross-Climate. You can manufacture virtually any design or shape, which is not the case with traditional solutions that rely on specific tools."

In particular, additive manufacturing has enabled production of complex winter tire designs, with sipes and blades of as little as 0.3mm thickness printable using today's equipment. Creating these sipes and integrating them into the mold is a challenging task via commonly used mold manufacturing techniques such as die-casting and EDM.



> **"The customer must learn to work with the technology and understand how to design the mold, such as with the twin shell system and by splitting segments in different ways"**
>
> Ralf Frohwerk, global head of business development, SLM Solutions

Furthermore, lead time for the preparation of the mold is greatly reduced, as Bernard notes, "With traditional manufacturing solutions, making a mold is a very time-consuming process that can typically take four to five months, from the conception stage to introduction of the mold in the factory. Using 3D printing, you can reduce this time to as little as one month in some cases."

Suppliers of 3D-printing machinery, such as SLM Solutions and EOS Technologies, also wax lyrical about the advantages provided by the technology. Ralf Frohwerk, global head of business development at SLM Solutions, a developer of 3D-printing equipment, says that in recent years, much of the company's R&D has focused on this new area of application.

Following a presentation on the technology at the 2017 Tire Technology Expo Conference, he affirms, "The main benefit 3D printing offers is that there are almost no limitations to the method. If you are looking to produce an extremely complex mold, then our systems can offer huge advantages in terms of production time and mold functionality, as well as cost-effectiveness."

According to Frohwerk, tire mold segments, of which there are typically between 8 and 16 per mold, fit well in the SLM machine chambers. SLM recommends a groundbreaking concept for a tire mold printed using additive manufacturing, a so-called twin shell design. The outer shell is a machined ring providing strength, stability and roundness to support the inner profile. Inside the supporting outer ring is the 3D-printed shell forming the tire tread profile. This can be made extremely thin in order to reduce costs.

Recent upgrades to SLM's 280 2.0 additive manufacturing machine are designed to enable improved productivity levels and reduced energy consumption

"In order to achieve the highest level of accuracy, it is important to adjust the scan parameters, of which there can be up to 180 for every material," Frohwerk adds. "It's a combination of how you split the design with the twin-shell system and then how you orientate the segment in the machine, and this requires collaboration between the end user, the tire mold producer and the machine maker."

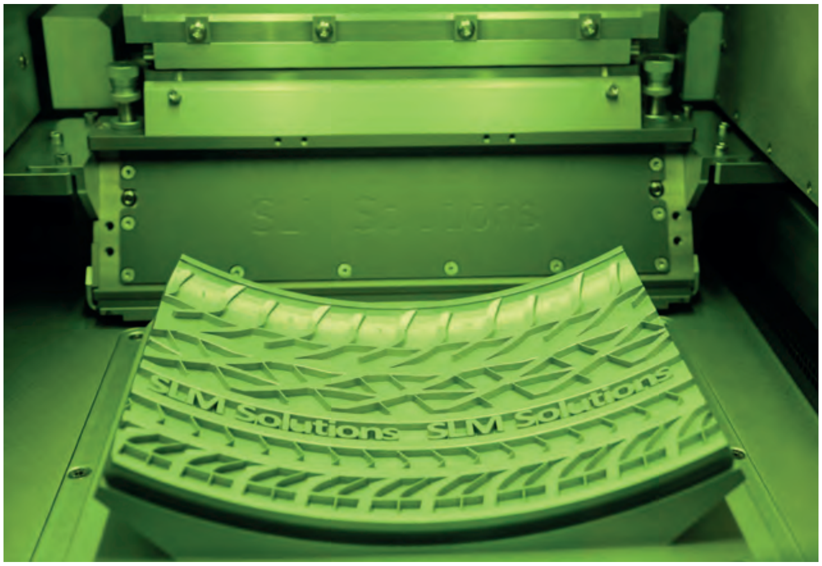
A new dimension

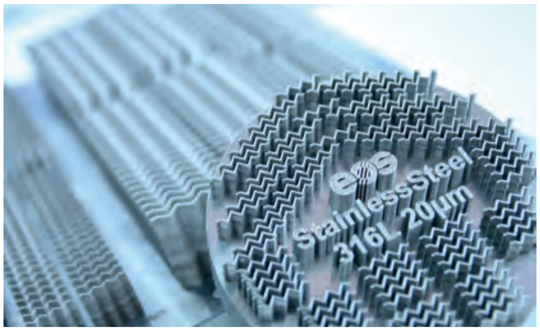
With the application in its infancy, some tire mold makers are skeptical. Since 2016, D-Company, a mold producer from Serbia, has been refining the process with the creation of concept molds for R&D purposes. Technical manager Bojan Mančić notes, "When this technology presented

THREE IS A MAGIC NUMBER

Additive manufacturing is believed by many to be a game-changer in numerous areas of the industry. For example, earlier in 2017, Goodyear revealed its spherical tire concept incorporating 3D-printed parts. According to Carlos Cipollitti, VP for EMEA product development and general director of Goodyear Innovation Center Luxembourg, the OEM is also in the process of assessing its potential usage in the mold production arena.

He says, "We continuously look at how we can tap into those opportunities and we are currently considering the technology for printing of molds and parts. There's been a lot of research into how to achieve the accuracies required for mold printing. It's hard to estimate when, because it depends on many factors, such as the development of metals and 3D printers, including which ones will be suitable for this type of application, but we expect the technology to find its way into production in the next few years." ■





itself in the market, everybody thought it was like a regular printer – you press the button and the machine will print – but that is not the case.

"All our competitors have acquired the technology, but it is crystal clear to us that it's not suitable for use in serial production yet because you cannot produce the quantities needed. For around a year we have been in the testing phase, making mistakes along the way in order to learn."

Mančić believes it will be some time yet before machine suppliers are able to develop a 3D-printing system suitable for industrial production, due to the time it takes to produce parts. According to the engineer, segments must be left to thermally stabilize after production, which adds a considerable amount of time to the process.

Above: The 3D-printing technique enables construction of delicate tire blades, which usually have to be integrated in the mold individually

Above right: EOS attended Tire Technology Expo this year and highlighted its AM technology as a complementary alternative to established production systems

IMPROVEMENTS ALL-AROUND

In traditional mold production, the machining of each mold segment can be a huge challenge, with as many as 12 different pitched segments in one complete mold circle. Here, machining accuracy is absolutely critical. In a recent case study, Reinshaw was able to greatly improve machining productivity and product quality for one customer, through application of its OMP400 high-accuracy inspection probe.

Focusing on process setting, the system has enabled rapid, automated on-machine part setup, removing the need for manual intervention. Overall, a 50% reduction in the production time for one segment was achieved, while time previously spent setting the part by the operator has now been totally eliminated – time that can now be used elsewhere. Thanks to the Reinshaw inspection probe, production throughput has been increased by 100% using existing systems. Furthermore, scrap has been reduced by 91.7%, enabling the company to save US$68,400 in the first year of installation.

Ultimately, the new capability has delivered an improvement in machine capability, increased automation, and as a result, a reduction in human intervention, and has also enabled Reinshaw's customer to reduce delivery times of its molds. ■

Meanwhile, Bernard, who is currently seeking a new opportunity in the additive manufacturing arena, identifies cost as another hurdle to be overcome, as the price of the process remains relatively high. In order to decrease costs, he says the speed of the process must be further accelerated. This will directly reduce the price of parts and, as a result, the price of the material.

"Furthermore, handling of very fine powders is a complicated practice due to the health risks involved and the infrastructure required. This means additional costs because you need to have air- and pressure-conditioning around the machines. It is also uncomfortable for employees who have to wear full-body protective clothing," adds Bernard.

Post-processing can also be a challenge and differs from case to case. Typically, after a part is made, excess powder must be eliminated, then once the segment is removed from the plate, it is sand-blasted to polish the surface. Any leftover powder residue can be recycled for new segment build jobs.

Print run

In the future, Frohwerk expects further improvements in the method, as well as a reduction in the amount of secondary post-processing required, with the extremely high requirements for dimensional accuracy and surface quality of the molds the greatest challenge.

He adds that close cooperation between the machinery supplier, the mold manufacturer and the tire maker will be key to implementation of the technology on a mass scale.

"Everyone has tried to compare a 3D die-cast part with the SLM design, but they are not comparable. The customer must learn to work with the technology and understand how to design the mold, such as with the twin-shell system and by splitting segments in different ways. One of the top-five players in the world has been using the technology for years because they are 100% convinced that it is the right path."

Despite an initially cautious approach, D-Company's Mančić recognizes it as a key production technique for the future. He comments, "Machine suppliers will work to improve their processes, and together, in a couple of years, I believe we will have a system that is industrially ready. We will welcome it because the limitations are far fewer than any other method of mold production available today." **tire**