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SERVICE PROVIDERS

How automation can
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MEDICAL TECHNOLOGY

Antonius Köster creates extraordinary textures –
and the data that makes them possible

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mesago

formnext

When digital transformation is done right, it's like a caterpillar turning into a butterfly, but when done wrong, all you have is a really fast caterpillar.



George Westerman, author and founder of the Global Opportunity Forum

Cover: 3Faktur

The typical business cycle doesn't make things easy, does it? Instead of following a nice upward trajectory, it looks more like a wave on paper – peaks and valleys, in other words. The latter is what a number of sectors are going through right now, especially the mechanical engineering and automotive industries. The reasons why have to do with economics, related policies, and geopolitical factors in Germany, greater Europe, and the world at large.

Here in Germany, some of these matter are of our own making – standards and requirements with regard to electromobility or climate protection, for example. Others, meanwhile, are external in nature, such as the ongoing war in Ukraine and the growing distance among major political players like Europe, China, and the United States. These things also have a negative effect on sales and orders in the AM market, of course. Right now, the glimmers of light offered by user industries like medical and dental technology, and aerospace can't quite brighten the overall picture. Whether things will start looking up again in the second half of the year remains to be seen.

One thing that's certain, however, is that Formnext 2024 will once again serve as the event highlight of the global AM community this November. A strong market presence is essential for companies interested in staying up to speed with their customers and gaining new ones, as well.

On the technological side, innovations are always finding their way into new systems and processes, and the world's most prominent trade show in AM is the best place to check them out.

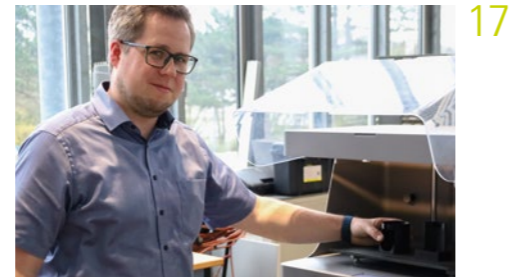
Having that proverbial leg up on the competition can be absolutely critical, particularly in times of economic uncertainty. That also applies to our own international efforts, by the way: Following our forays into Japan and China, we'll be bringing Formnext to Chicago next year with another very special concept that's sure leave our own competitors' jaws on the floor.

Before signing off, I'd also like to thank you all for the many constructive responses we received to our reader survey. Your suggestions have already resulted in a change you'll see right away in this issue: To make it easier to read, we've modified our font and made some slight adjustments to the page layout. Stay tuned for other future developments, as well!

Sincerely, Sascha F. Wenzler
Vice President Formnext



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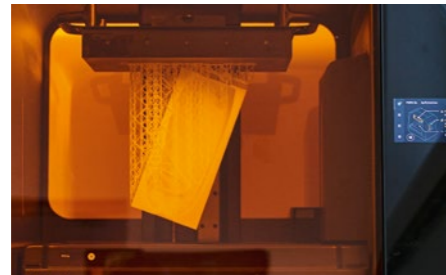


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Formnext gives talented people the stage they deserve

- **Sustainability Award:** AM use cases and products, that will be assessed and judged on their full life-cycle
- **Design Award:** for exceptional design of AM parts and products (aesthetically and functionally)
- **R)Evolution Award supported by 3D Printing Industry:** products, technologies or services that are groundbreaking and hold real merit for the AM end users
- **AMBassador Award:** for individuals or organizations who provide real impact on the industry through training and educational programs or their personal advocacy

NEW FORMNEXT AWARD LOOKING FOR ROOKIES, REVOLUTIONARIES, AND MORE

The AM world shines thanks to talented, motivated people who continue to advance the technology and thus drive the entire surrounding industry. It's therefore only fitting that their ideas should receive the time in the spotlight that they deserve – for the good of the industry and the forward-thinking development of modern production itself.

From its very start, Formnext has used the Formnext Start-up Challenge to promote innovative and creative companies and help pave the way for key technical and entrepreneurial progress. Meanwhile, the AM sector continues to evolve in increasingly complex ways and expand into new areas of expertise. That means it's time for Formnext to step up its own efforts to recognize excellence. Enter the new Formnext Award, which will be conferred on innovative young firms, sustainable business ideas, groundbreaking technologies, and much more starting this year.

»Especially for start-ups and other up-and-coming companies, it's important to share ideas, raise one's profile, and

establish contact with potential customers, partners, and investors. We want to offer newcomers to AM even more support in doing just that by introducing the Formnext Award and continuing to develop it going forward,« explains Sascha F. Wenzler, Vice President of Formnext at event organizer Mesago Messe Frankfurt GmbH. »At the same time, we also want to recognize and encourage achievements outside of our existing product categories with accolades like the Design and Ambassador Awards.«

THE FORMNEXT AWARD WILL BE PRESENTED IN THE FOLLOWING CATEGORIES:

- **Start-up Award supported by AM Ventures:** for inspiring young companies with viable business models
- **Rookie Award:** for young individuals with promising business ideas who have not yet founded a company (or have done so no more than one year ago)

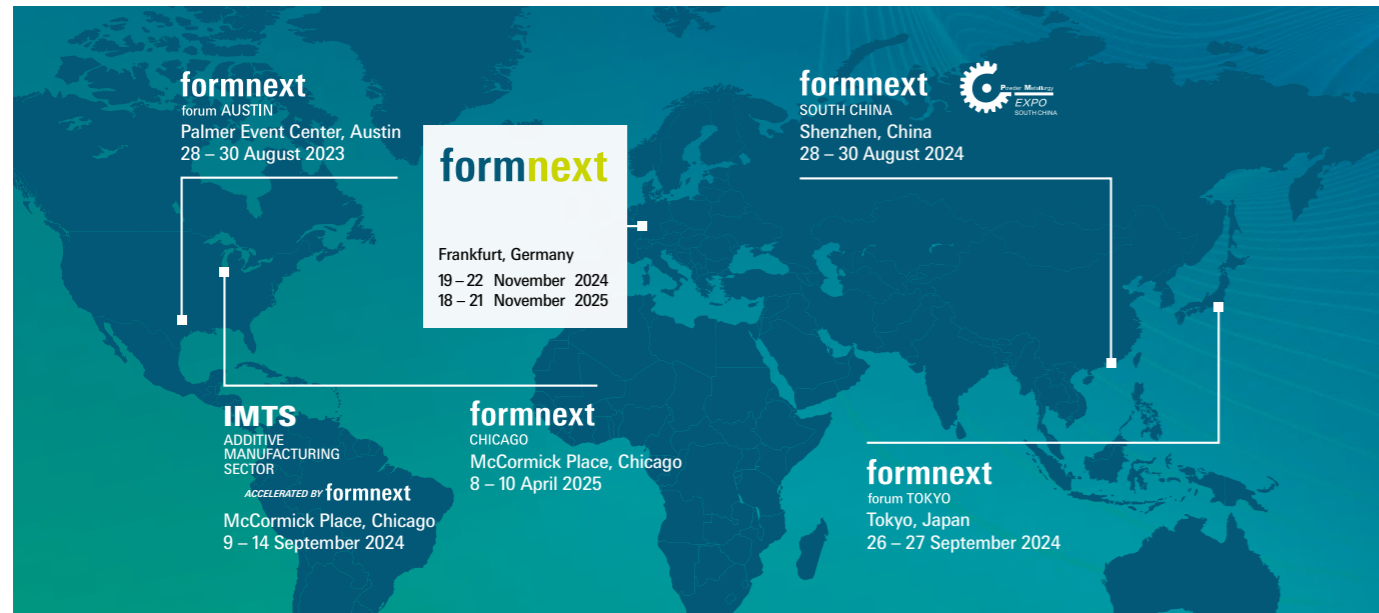
A sterling jury of renowned industry representatives will evaluate every inspiring nominee, determine who the finalists are, and choose the winners with the help of a public vote. The winners will then be announced at an awards ceremony to be held on the evening of Thursday, 21 November 2024.

The finalists' submissions and exhibits will be presented at Formnext as part of a special showcase. The public vote will give Formnext attendees the chance to help determine the eventual results by supporting a finalist in each of the six categories either online or at the trade show.

Along with a high-quality, intricately designed trophy sponsored by Voxeljet, the winners will receive cash and other prizes (such as business coaching).

Nominations can be submitted starting this June.

» formnext.com/awards



THREE CONTINENTS... AND COUNTING

The year 2023 was a very international one for Formnext. In addition to its flagship event in Frankfurt in November, the Formnext family had a great deal of success representing the brand in China, Japan, and the United States.

Formnext + PM South China, for example, welcomed an impressive 275 exhibitors and 13,183 attendees to a 20,000-square-meter event space in Shenzhen from 29–31 August 2023. It also attracted some 50,000 online visitors. Just one month later on 28–29 September, the Tokyo Metropolitan Industrial Trade Center Hamamutsucho-Kan hosted the Formnext Forum Tokyo. Its conference format also proved highly successful, drawing 67 exhibitors and 1,185 attendees. And finally, another conference saw Formnext plant its flag in the US for the first time: The Formnext Forum Austin featured 82 exhibitors and 1,076 visitors while showcasing 24 countries (along with its host nation). From 28–30 August, the event thus succeeded in laying the groundwork for next year's Formnext Chicago, the newest Additive Manufacturing trade fair in the United States.

POTENT PARTNERS

In another foray into the US, Formnext will be presenting itself in an AM area at IMTS – North America's biggest trade show in manufacturing technology – from 9–14 September 2024. Formnext Chicago will then take place from 8–10 April 2025 (for more, check out the interview on page 7). With that, Formnext is set to bring its highly successful trade fair concept to the world's largest AM market and offer innovative solutions for countless users all along the AM process chain. For this major US event, Mesago Messe Frankfurt (the event company behind Formnext) will have two potent partners by its side: the Association for Manufacturing Technology (AMT), which organizes the aforementioned IMTS, and Gardner Business Media, the leading media company in North America that focuses on machining, plastic processing, and other production technologies.

With its international events and brands, Mesago Messe Frankfurt is seeking to »bring Formnext's brand promise and unique selling points to relevant AM markets around the world through select local partnerships and tailored concepts,« explains Sascha F. Wenzler, Vice President of Formnext. »This will enable us to reach market participants that only operate locally. Those who develop an interest in more international relationships and mar-

kets and everything else we have to offer can then come to our flagship event in Frankfurt or other Formnext brands in their region.«

A GUARANTEE OF QUALITY REGARDLESS OF LOCATION

All these efforts point to the truly global presence Formnext is developing to address every key AM market alongside its international exhibitors. »Meanwhile, we continue to maintain a level of quality that everyone can count on, be it our customers, exhibitors, or attendees. That's increasingly becoming a hallmark of Formnext as parts of the world are disengaging somewhat and operating more independently,« reports Wenzler. For further examples of this strategy's success, look no further than the outstanding international development of Mesago Messe Frankfurt's other trade fairs, such as Light + Building or Automechanika, the latter of which now holds 17 compelling events across the globe.

UPCOMING DATES:

- Formnext + PM South China**
28–30 August 2024
- Formnext Stage at IMTS Chicago**
9–14 September 2024
- Formnext Forum Tokyo**
26–27 September 2024
- Formnext Chicago** 8–10 April 2025

FORMNEXT CHICAGO: A KICK-OFF IN STORMY TIMES

Formnext Chicago is set to arrive next year. AMT President Doug Woods and Sascha Wenzler, Vice President at Mesago Messe Frankfurt, talked to Peter Zelinski, (Editor-in-Chief of Additive Manufacturing Media, about the long road to this event, the importance of Formnext coming to Additive Manufacturing's biggest market, and the 2025 event landscape in a highly competitive market.

There are U.S. trade shows that already address the 3D Printing industry, like Rapid + TCT and IMTS. For current and future users of Additive Manufacturing, what is the purpose and promise of Formnext Chicago?

DOUG WOODS First, this is an additional location for what has become the best-known, most attended, and most important additive show in the world – Formnext. Until now, the only U.S. trade show showcasing 3D Printing technology

for industry – a show that, to its credit, has run for over 30 years – was Rapid + TCT, which began as Rapid. The show started as a rapid manufacturing show and morphed over time. It has started paying attention to the maker movement and 3D Printing applications beyond industrial production, including by offering additive solutions to manufacturing. Meanwhile, IMTS is the best place to find all things manufacturing technology. But Formnext offers something different from both of these events. What we're all missing is the concept that makes Formnext the most successful additive show in the world: the way it brings together the entire AM value chain. It's not just 3D Printing; AM as an innovative production solution involves much more. Formnext provides a venue for everything involved in AM, from the materials providers to additive equipment, post-processing solutions, engineering, inspection, and software needs.

Sascha, since 2015, you and your team have developed Formnext in Germany. It has become the largest and arguably the most important AM event worldwide. Why do you now want to bring Formnext to the United States?

SASCHA WENZLER With international Formnext-brand events, we're following a strategy of holding locally adapted Formnext formats in relevant AM markets based on our highly successful flagship event in Frankfurt. That's why we have a Formnext expo format in Shenzhen, China, and a Formnext Forum in Tokyo, Japan, for instance. As Doug said, in the United States – the largest marketplace for AM – we see a huge need for a professional B2B trade fair for investment goods that focuses clearly on the whole industrial process of Additive Manufacturing and the needs of the various industries using this fascinating technology. With Formnext in Chicago, we and our partners can leverage AM in the United States to reach the next level of innovative manufacturing technologies. There's huge potential among U.S. companies that still haven't encountered or taken advantage of AM. Together with our partners AMT and Gardner Business Media, our approach is to exploit this potential just as we've done very successfully since founding Formnext in Frankfurt. This is the only way to expand the application of AM beyond the core of professionals into a broad range of industries and ultimately significantly increase the business contacts of our exhibitors. »



Image: Mesago / Marc Jacquemin

Doug Woods and Sascha Wenzler sign an official agreement to collaborate on Formnext Chicago



Formnext Chicago is set to make the City of Big Shoulders the leading hub of AM in the United States

The organizers of Rapid + TCT 2025 have decided to hold their trade fair on the same dates that have been announced for Formnext Chicago. What does AMT think about this?

DOUG WOODS It's important to understand the sequence of steps. When Mesago began considering its entry into the U.S. market – when the partnership had begun, but we hadn't decided on a date for a U.S. event – we went directly to SME and the Additive Manufacturing Users Group (AMUG) to look for ways to collaborate. Unfortunately, these discussions did not lead to a collaboration. I can appreciate the difficulty for an exhibitor wondering how to handle this. Unfortunately, we now find ourselves in a situation in which many market participants have to make a decision. There's always competition, especially in the United States. In a market as large as the United States and with a technology as important

as Additive Manufacturing, there's room for more than one format, but we're consciously positioning ourselves in this environment with the unique selling proposition of a dedicated technology trade fair like Formnext.

There is also the Additive Manufacturing Users Group (AMUG) Conference. In 2025, the date of Formnext Chicago is close to that of this conference, also in Chicago. Sascha, what is your perspective on this?

SASCHA WENZLER You're right, and Doug already mentioned it regarding Rapid + TCT. It's a really unfortunate situation when you look at 2025. We were the first ones to announce our date back in 2021. Now, with 2025 coming up very soon, there are three events scheduled close together, or even on the same date. In this context, AMUG is a very different format compared to Formnext.

This makes 2025 a real challenge for all the players, be they exhibitors, visitors, or organizers. However, AMUG is a conference in a hotel atmosphere where the users of AM meet and share their ideas. It's not a traditional trade fair with a much wider reach and range that's also designed for showing and selling machines, products, and solutions to customers. Both formats create value for the community. In our group of partners, we've always been open to discussing possible ways to realize synergies with AMUG or support each other. I'm always more about looking to the future than dwelling on the past. That's why I'm convinced there are opportunities if everybody moves out of their comfort zone and thinks about how a full year can offer possibilities for different events and formats that benefit the industries we serve and create added value. This is where AMUG and Formnext can complement each other very well.

Image: iStock/ibsky

LOWER EMISSIONS THAN DIE CASTING

The BMW Group is testing the wire arc Additive Manufacturing (WAAM) process at its Additive Manufacturing Campus in Oberschleissheim to produce metallic vehicle components and tools. The campus brings together production, research, and training in this area under one roof. The BMW Group has been working with the WAAM process since 2015, and a WAAM cell has

been used there for the production of test components since 2021. One such component is a suspension strut support that is being compared to a corresponding series part made of die-cast aluminum in extensive test runs. »Even at this early stage of technology validation, it's clear that the WAAM process can lead to lower emissions in the production process. Components can be produced more

efficiently thanks to their lower weight, the favorable material usage ratio, and the possibility of using green electricity,« reports Jens Ertel, head of BMW Additive Manufacturing. The next development step on the way to series production is testing components in vehicles, which will begin in the foreseeable future. In contrast to laser beam melting, which is already used in prototype and small-series production at the BMW Group, WAAM is particularly suitable for larger parts. The typical wall thicknesses are well suited to body, drive, and chassis components. However, tools and devices can also be produced using this process. »It's impressive to see how WAAM technology has developed from research into a flexible tool for not only test components, but series components, as well,« says Karol Virsik, head of vehicle research at the BMW Group. Initially, the BMW Group is planning to use WAAM to produce components centrally in Oberschleissheim, but it may be rolled out to other locations and suppliers in the future.



RICH SOUNDS FROM MUSHROOM CASINGS

Mushroom mycelium can serve as a renewable and sustainable replacement for various materials, such as animal leather; packaging material made of wood, cardboard, or polystyrene; and insulating wool. Now, a team of researchers at Fraunhofer IWU has opened up another area of application for mushroom mycelia: 3D-printed components that make high-quality transmission line loudspeakers sound even better. The researchers' findings regarding the programmability of mushroom mycelium material for loudspeaker construction are particularly promising. The desired material properties can be specifically adjusted in the cultivation of mycelium. This results in foam-like structures that are particularly suitable for sound absorption or damping, or solid and smooth structures that are ideal for

sound reflection. Mycelium can therefore be used both as an insulating material and for housings. To ensure good low bass frequencies and as little resonance



(natural vibrations) as possible, transmission line loudspeakers rely on a sound outlet that is connected to a tube up to three meters long inside their enclosure. This tube has to be folded several times in the speaker cabinet in order to find space, which results in complex geometry. The high manufacturing costs alone deter many manufacturers from using this design principle. The 3D Printing of functional components and loudspeaker enclosures has solved this issue while also reducing the number of glued and other joints. Fungal mycelium is found in large quantities in the soil. It can also be obtained from the organic residue of materials such as straw, wood, sawdust, reeds, or spent grains (from brewing beer). The material is completely non-toxic, comparable to edible mushrooms, and completely biodegradable.

Images: BMW, Fraunhofer IWU

STREAMLINING DESIGN PROCESSES

EOS and 1000 Kelvin have announced the integration of Amaize into the EOS software suite in order to speed up production workflows and improve the development process. 1000 Kelvin is thus

hoping to enable users in industries such as aerospace, energy, and contract manufacturing to use artificial intelligence to streamline design processes. »Amaize’s predictive AI capabilities enable a para-

digim shift from physical to digital iteration. This is an important step towards the industrialization of Additive Manufacturing,« says Martin Steuer, SVP of the software division at EOS.

FASTER REPAIR OF TURBINE BLADES

In the Lasermeister LM300A, Nikon Corporation has presented its new DED system for metal Additive Manufacturing. The system is complemented by the Lasermeister SB100 3D scanner. The Lasermeister 100A system series was primarily introduced for research purposes and has now been developed further for industrial applications. Building on the predecessor system, the 1,350-kg LM300A offers an extended build area of 297 mm x 210 mm x 400 mm. The Lasermeister SB100 3D scanner supports auto-

mation and, according to Nikon, is particularly suitable in combination with the LM300A for applications such as repairing turbine blades and molds. In the conventional repair of worn turbine blades, the damaged area of each individual blade is cut out and scraped. The blade is then manually welded and ground for repair. With its new system, Nikon aims to eliminate the numerous challenges in the conventional repair process and promises up to 65% shorter throughput times, as well as minimized post-processing require-

ments. The company also sees potential applications in the automotive, railroad, and mechanical engineering industries.



»WAIT AND SEE WHAT THE PRACTICAL IMPLEMENTATION LOOKS LIKE«

When the European Court of Justice (ECJ) ruled a few weeks ago that a standard on toy safety must be made publicly available free of charge, some legal experts feared the collapse of the existing standardization system. After all, the German Institute for Standardization (DIN) gets around 60 percent of its funding from the sale of such standards. In its ruling, the ECJ stated that the publication of documents cannot be impeded if there is an »overriding public interest.« Put simply, if standards are of a legislative nature, they should also be publicly accessible. While the dust has settled somewhat in the meantime, the topic »remains exciting,« explains Prof. Christian Seidel, who has accompanied the development of numerous standards in the AM industry for many years as chairman of ISO TC 216. To see what impact the ECJ’s ruling will have

on the AM industry, however, »we need to allow some time to pass and wait and see what the practical implementation looks like.« The website of Beuth-Verlag, which belongs to DIN and is responsible for marketing its standards, now offers more than 70 standards on Additive Manufacturing, as well as around 20 draft standards and 40 technical rules. The cost of the individual works ranges from €41.90 to €190.80. While the standards »have a normative character« and are mandatory for certain procedures and processes, the »technical rules have more of an informative character,« says Seidel, who works for the Munich University of Applied Sciences and the Bavarian Doctoral Center, as well as for Wohlers Associates as a strategic implementation consultant. Accordingly, only the explicit standards are likely to be affected by the ECJ ruling. With regard to Additive Manu-

facturing, a wide range of topics are described, from the additive production of printed parts to the design and production of test specimens to process requirements and qualifications. However, Seidel also warns that the »technical depth of many standards in the AM sector should be increased.« As Additive Manufacturing is still a very young technology, there was a great deal of pressure and need to launch as many standards as quickly as possible, which was »not conducive to the depth of technical consensus that could be achieved.« Still, Seidel is very pleased that a large number of standards for Additive Manufacturing are now available. »This helps the entire industry and all its players,« he says. And in any case, all standards are reviewed every five years at minimum. (tm)

Image: Nikon

FINE PRINTING FOR JEWELRY AND FASHION

With its new 3D Printing service for metal components, Legor Group SPA wants to harness the possibilities of Additive Manufacturing for the production of jewelry and fashion accessories. Headquartered in Vicenza, Italy, the company is a manufacturer of metal alloys, coating solutions, and pre-

cious metal powders for the jewelry, luxury goods, and fashion industries. Legor, which founded the 3D Metal Hub two years ago, relies on binder jetting technology (BJT) in cooperation with HP. Their 3D metal jet printing service is part of the 3D Metal Hub. As Legor also anticipates further growth in Additive Manufacturing in the

jewelry and fashion industry, the company has developed its own range of metal powders under the Powmet brand. Legor can currently produce parts from steel, bronze, silver, and platinum and also plans to 3D-print 18-carat gold in the future.

ONGOING DOUBLE-DIGIT GROWTH DESPITE CONSOLIDATION

Even though some major AM players have recently scaled back their forecasts, the overall Additive Manufacturing market continued to see double-digit growth last year. The leading market reports in the additive world, Wohlers Report and the Ampower Report, put the market’s growth at 11.1% and 10.3%, respectively. The user industries driving this expansion include the aerospace and defense sectors.

The market researchers are also confident about the future: although the growth forecasts have also been reduced to some extent, they are still clearly in the double-digit range. Wohlers Report 2024 forecasts average annual market growth of 17% over the next ten years, while the Ampower Report projects 13.9% for each of the next five years.

SIGNIFICANTLY MORE MERGERS AND ACQUISITIONS

According to Wohlers Report, the AM industry could generate revenue of USD 20.035 billion in 2023, exceeding the 20-billion mark for the first time. Nevertheless, Terry Wohlers also sees consolidation in the industry: »33 mergers and acquisitions occurred from March 2023 to February 2024. This compares to 21 transactions in 2022. I expect this trend to continue because many companies in AM are interesting, creating good value, and are targets for acquisition.«

According to the Hamburg-based consulting firm Ampower, the global market for industrial Additive Manufacturing (metals and polymers) reached a volume of EUR 10.5 billion in 2023. The business of equipment suppliers developed more

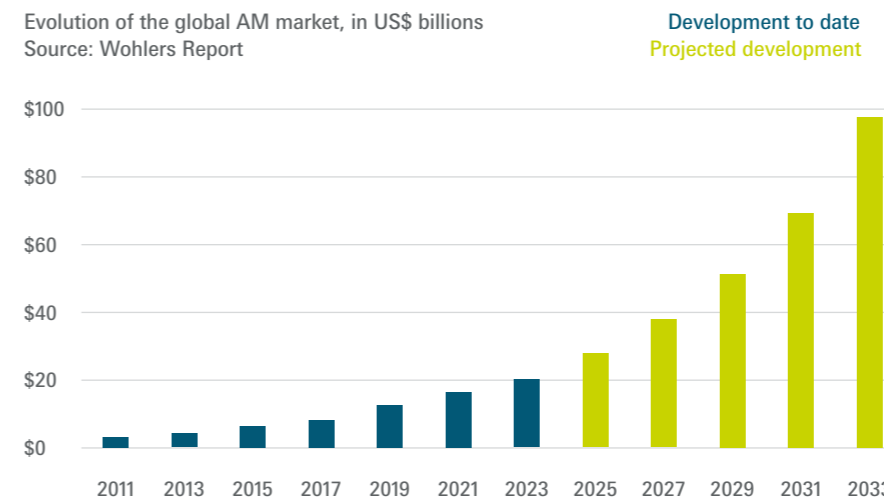
slowly than expected, growing by around 5% in 2023. However, this segment is expected to grow at a higher annual rate of around 16% in the future – thanks in particular by the APAC region. Ampower also anticipates further growth due to ongoing improvements in post-processing methods, new materials, and the certification of new designs in combination with industry standards.

A VERY DYNAMIC AEROSPACE SECTOR

While Additive Manufacturing continues to grow strongly in the aerospace industry, investment in AM systems in the automotive sector is stagnating according to the Ampower Report. Prototyping, toolmaking, production equipment, and fixtures have found their place here, but there are too few large-scale production applications. In order to generate further growth, AM technologies for large-scale manufacturing, such as binder jetting, must reach the necessary level of industrial maturity. Ampower also continues to see a high level of acceptance of AM in the dental industry in both the polymer and metal segments. Here, the technology is used in particular to produce molds for aligners and metal dental prostheses.

According to our research for Wohlers Report 2024, automotive, consumer products, and medical/dental are the three largest markets for AM products and services worldwide. Meanwhile, aerospace and national defense were among the most vibrant sectors over the past year. The use of AM in producing rocket engine parts has been particularly interesting and dynamic.

Evolution of the global AM market, in US\$ billions
Source: Wohlers Report



MORE INNOVATIONS FOR A FAST-MOVING WORLD

How Unilever and Serioplast are using 3D Printing to create new bottle designs

As one of the world's largest fast-moving consumer goods (FMCG) companies, Unilever is constantly developing new products for everyday use – from personal care to home care, nutrition, and more. FMCG is an industry in which constant consumer demand drives fierce competition, which is why brands have to continuously innovate and adapt their product strategies. One important area of innovation is packaging: the design of a bottle can sometimes affect customer perception as much as what's inside.

Even with »simple« plastic bottles, however, it used to take months for a design to make it from the computer screen to an actual bottle being filled on the production line. With the help of Addi-

tive Manufacturing, this process has now been significantly shortened. In cooperation with Formlabs, molds were 3D-printed to produce sample parts for consumer tests. »You can have a real bottle before you do the real mold, so you can identify immediately if you're on the right path in your development or need to change something to avoid mistakes that can cost more,« explains Stefano Cademartiri, owner of CAD and prototyping at Unilever.

MASS PRODUCTION USING THE BLOW MOLDING PROCESS

Plastic products such as food and beverage containers, cosmetic packaging, and medical packaging are most commonly produced with blow molding,

which refers to a set of long-established methods for the rapid mass production of high-quality, thin-walled parts. Blow molding has very short cycle times – typically between one and two minutes – and is extremely cost-effective for high-volume production. It is usually employed to produce millions of identical parts at low unit costs.

One of Unilever's major partners in developing and producing packaging for the home and personal care market is Serioplast Global Services. Founded in Seriate (Bergamo, Italy) in 1974, Serioplast is a global producer of rigid plastic packaging for the FMCG industry that produces four billion PET, HDPE, and PP bottles per year.

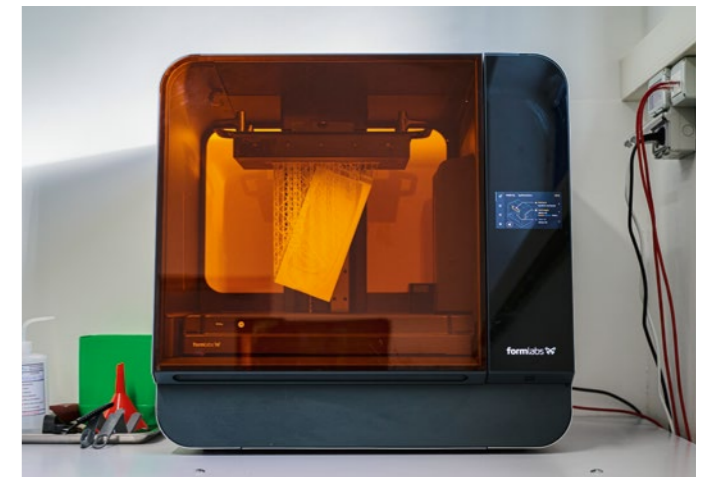
After being 3D-printed from Rigid 10K Resin, this mold is polished manually and then inserted into a metal frame



Images: Formlabs



At left: A two-part, 3D-printed mold and a bottle it was used to produce, standing next to a steel mold and a labeled prototype for consumer tests
Below: SLA 3D Printing makes it possible to produce molds in just two days



NOT ROBUST ENOUGH OR TOO EXPENSIVE

Typically, Serioplast would either 3D-print mockups for prototypes directly or produce them through blow molding, but most 3D-printed mockups lacked the right feel or transparency and were not reliable enough to be sent to consumers. Blow-molding prototypes, on the other hand, is expensive and time-consuming, as a metal tool is required. Such a mold is machined conventionally, which usually takes four to eight weeks and costs from €2,000 to over €100,000 depending on the complexity of the part.

The right material is crucial for 3D Printing a blow mold because it has to withstand the internal pressure and tem-

perature of the blow molding process while providing good dimensional accuracy and stability. Rigid 10K Resin is the material recommended by Formlabs for stretch blow molding. This is a highly glass-filled, industrial-grade material with a heat deflection temperature (HDT) of 218 degrees Celsius at 0.45 megapascals and a tensile modulus of 10,000 megapascals.

After 3D Printing, the mold is reworked with a polishing machine or by means of manual grinding in order to maintain its exact dimensions. With SLA 3D Printing, molds can be produced in just two days, which »saves us up to 70 percent in time and 90 percent in costs compared to a standard mold,« explains

Flavio Migliarelli, R&D design manager at Serioplast. »In the past, clients had to wait up to 12 weeks just for a single design. Now we can make five!«

+ FURTHER INFORMATION:

- » formlabs.com
- » unilever.com
- » serioplast.com
- » formnext.com/fonmag

BEYOND SORTING AND POST-PROCESSING

The AM service provider 3Faktur has leveraged automation to establish itself as a leading manufacturer of finished components



When Markus May and his business partner Johannes Zaremba founded the AM service firm 3Faktur around 10 years ago, their intention was to focus on manufacturing prototypes. After a few years, however, the 42-year-old May could no longer see a future in that line of work. The competition was only getting more intense, prices were falling, and more and more companies were acquiring their own in-house 3D printers. »How can a service provider offer real added value that customers can't find anywhere else?« May found himself wondering at the time.

»For us, series production of prefabricated parts has proven to be the solution,« he says today. Implementing an efficient production process with printers

from the same manufacturer and automating it in a holistic manner were key steps along the way. According to May, these changes were also necessary in order to survive in the marketplace as a service provider for finished components. »If it weren't for automation, our production methods wouldn't be competitive,« he points out.

3Faktur automated its operations in 2021 along with AM Flow, a Dutch company that specializes in automation solutions for Additive Manufacturing. This effort involved integrating component recognition, sorting, and packaging. The resulting system now complements other automation solutions in manufacturing at 3Faktur, which come from the likes of HP, Rösler, and MHG.

Text: Thomas Masuch

Images: 3Faktur

Meanwhile, 3Faktur wouldn't have been able to pull off this automation upgrade without overhauling its entire IT landscape. »For that purpose, we created our own production management software, which enables us to monitor and control data on every essential production step,« May explains. This made the company a pioneer in its industry and one of AM Flow's first customers. It also reflects the corporate philosophy of 3Faktur's co-founder: »For us, it was always important to have the newest technologies at the

company,« May affirms. That remains a high priority at 3Faktur, which is currently working as a beta tester alongside another manufacturer on the development of a new machine for cleaning AM parts – one of the innovations set to be unveiled at Formnext 2024.

HOUSING COMPONENTS, MECHANISMS, FIXTURES, AND MORE

Since its foundation in 2014, 3Faktur's workforce has grown to 12 employees. The company, which is based in Jena,

Germany, began making exclusive use of HP printers in 2017 (it now has four) and produces its parts largely from polyamide. The some 2,500 customers it currently serves hail primarily from the mechanical engineering, vehicle construction, and medical equipment sectors. 3Faktur manufactures plastic industrial components like housing parts, mechanisms, and fixtures for them. These days, it rarely produces prototypes. »Our parts are usually built into other things,« May says.

GEOMETRIC VARIANCE

As for the matter of when automation makes sense for a service provider, May explains that it's mainly a question of how much variance there is among the parts in question; the quantities produced aren't all that critical. »When you make 30 to 50 different geometries on your printers, it starts paying off,« he reveals, adding that once a process is stable, orders for additional components are almost sure to follow. »



The automation provided by AM Flow is complementing other automation solutions 3Faktur uses in production, which come from the likes of HP, Rösler, and MHG



At 3Faktur, every print run results in around 200 parts, which puts the company's daily production at roughly a thousand. Each individual build contains approximately 15 different geometries. »We mix components of different sizes together for quality reasons,« May points out. »Ideally, parts are arranged so that roughly the same surface area gets illuminated in each layer. That's difficult to pull off with large components, so we insert smaller parts in between.« This is precisely where May thinks a service provider like 3Faktur has an edge: After all, other companies typically don't deal with this degree of component variance. As he goes on to explain, however, the trick further down the production line lies in separating parts in an efficient manner. This is no longer a problem thanks to 3Faktur's automation efforts, which have included implementing a camera-based system for part recognition.

»A LOT HAS CHANGED«

After using the company's new systems for three years, May has nothing but good things to say about automation – in spite of the cost of acquisition and the monthly fees 3Faktur pays. »For a rather small company like ours, it was a major investment, but we're reaping major benefits, as well,« he states. 3Faktur's production operations have become more efficient, and its fully automated process also makes it possible to compile end-to-end quality reports for customers.

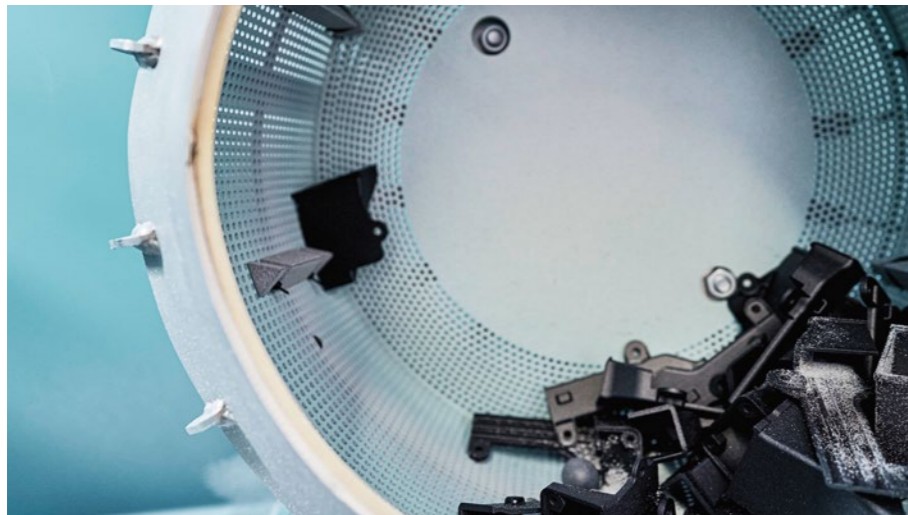
»A lot has changed at the company overall as a result; there's so much more we can do,« reports May, who also points out that automation has paid off in another way, as well. »For the most part, customers are placing their orders on shorter notice, and the number of batches is getting smaller.« May says this makes the capacity to accommodate peaks while maintaining a consistent level of quality –

including over extended periods of time – all the more important. »If a customer contacts us again after a few months and wants to order the same parts as before, there can't be any differences to the previous batches,« he explains.

For May, this is how automation opens the door to more efficient growth. »With systems like these, you can significantly expand production without having to hire more people.«

+ FURTHER INFORMATION:

- » 3faktur.com
- » formnext.com/fonmag



Thanks to its fully automated process, 3Faktur can produce end-to-end quality reports for its customers

Text and Images: Thomas Masuch

LIGHT FACTORY ACHIEVES SHORTER PROCESS CHAIN

In just under two years, 3D Printing has turned into a real success story at Erco.

Erco's first attempt at 3D Printing came to a rather sobering end. »Almost 10 years ago, we'd already taken a look at whether we might be able to use AM to produce components for our lights,« recalls Stephan Jungkurth, head of tool engineering at the company. Erco, which specializes in high-quality architectural lighting, does seem like a prime candidate for 3D Printing: There's a great deal of variance in its products, and it produces different quantities depending on the order at hand. »In the end, however, it didn't make economic sense. For the products we make for the premium

segment, we need really high-quality surfaces – the kind you can only get with printed parts if you spend a lot of time on post-processing,« Jungkurth reveals.

After its initial foray, Erco nonetheless kept a constant eye on this innovative manufacturing technology. Its next attempt to establish AM at the company started in 2021 – not in the production of components for finished products, but in connection with equipment and operating facilities that fall within the 37-year-old Jungkurth's purview.

Erco took the first steps along with a service provider from its region that sup-

plied it with some initial sample parts. Meanwhile, the specialists in Erco's design engineering department were able to learn more and more from the provider about dealing with supporting structures, overhangs, and infills. »We're still learning, but that was the period when the learning curve was the steepest,« Jungkurth says before adding in summary: »It was definitely the right decision to work with a service provider first. I'd do it again any time we were introducing a new technology.«



Stephan Jungkurth, 37, has been at Erco since 2007. After completing his training as a tool engineer and studying mechanical engineering at the South Westphalia University of Applied Sciences, he began working at the company as a process developer. He then took over as head of the tool engineering department in 2022.

Since May 2022, this Markforged X3 has been in use in Erco's tool engineering department in Lüdenscheid



COST RECOUPED IN JUST A YEAR

Erco's 3D-printed parts made a compelling case more or less straightaway. As the demand for them grew, purchasing a printer for in-house use was the obvious next move. Jungkurth drew up a »very conservative« amortization plan that projected Erco would recoup its investment in three to four years at the latest.

A Markforged X3 then made its debut in Erco's tool engineering department in Lüdenscheid (western Germany) in May 2022. »Since then, we've churned out so many parts that the printer paid for itself in one year,« Jungkurth reports. He's talking about around 1,500 components, and the X3's display bears that out, reporting an impressive 11,400 hours of use. The unit typically produces layers and infills 18 hours a day, which makes it one of the most utilized machines at the company.

ESD MATERIAL IS KEY

In its production operations, Erco has to pay continuous attention to the issue of static discharge in order to protect the sensitive electronics in its lights. Its employees even wear shoes and clothing

interwoven with carbon fibers that help them conduct electricity. Erco's 3D-printed parts also need to be conductive, of course. In his search for suitable synthetic materials, Jungkurth says Markforged was the only company offering something with the right ESD (electronic static discharge) properties.

Once Erco's design engineers send their creations to its tool engineering department, they find their way to the 3D printer. »Thanks to the experience we gathered with our service provider, we didn't have much trouble getting started,« Jungkurth says. Printed components are usually taken out of the printer during the morning shift and then assembled. »On the whole, we've not only saved a lot of money, but significantly shortened our entire process chain, as well,« Jungkurth explains, gesturing toward an area of the production hall in which injection-molding machines are being stored on a row of wooden pallets. »That used to be where we kept the semi-finished products we milled into parts for fixtures. These days, we basically don't need them anymore.«

About Erco

Erco is an international company that specializes in high-quality digital architectural lighting. Founded in 1934, this family-managed business now operates in 55 countries around the world through independent sales organizations and partners. Erco views light as the fourth dimension of architecture. At its production facility in Lüdenscheid, Germany, it designs and manufactures lights with a focus on technical optical characteristics, electronics, and sustainability. Erco creates its lighting tools in close collaboration with architects and specialists in light and electrical planning.

EXPERTISE IN LIGHTING

Echoing a common theme, Erco's tool engineering department features tall windows that let plenty of light in. The adjacent foyer includes a type of showroom in which Erco presents various types of lighting that are designed to provide just the right illumination, whether for works of art at museums, workspaces at offices, or the facades of buildings. For shops and the retail sector in general, the company also offers technical accessories such as filters that modify the light spectrum and lend products like fish or meat a fresher appearance.

Meanwhile, every new product requires new fixtures. The same need also arises when production processes are optimized or certain lights prove so popular that Erco has to set up a second pro-

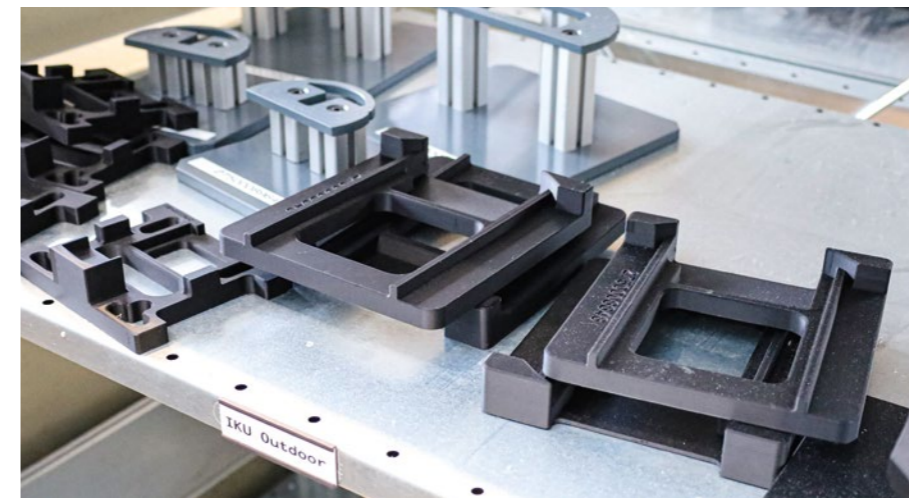
duction line. Its 3D-printed components go into not just a wide variety of test and mounting fixtures, but various gripper elements and handling systems, as well.

SOME 250 FIXTURES

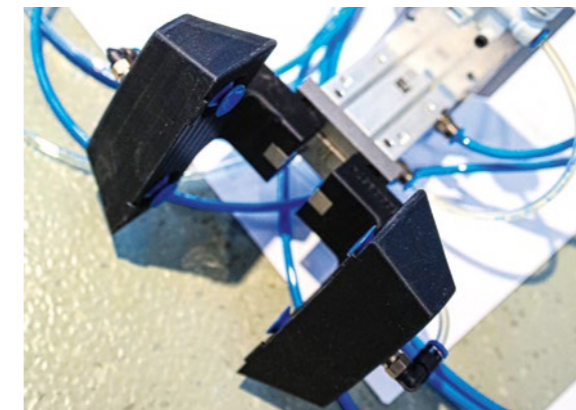
Last year, Jungkurth and his team produced a total of around 250 such fixtures. »What's helped us a lot is the way 3D Printing has really streamlined the process and enabled us to work more efficiently,« he points out.

Having had such a positive experience with the technology, Jungkurth is now keen to leverage it in other areas at the company. »We're looking for new opportunities,« he affirms, citing hand samples for product development and the masking of holes and screw threads for painting purposes as examples. He also sees

potential in 3D-printed inserts for injection molds. These make several dozen shots possible in some cases, which Jungkurth says covers Erco's requirements for an entire year for certain products. This would enable the company to offer efficient solutions for even more customer-specific needs – including in situations where traditional toolmaking wouldn't be cost-effective. Someday, Erco might even print parts for its actual lights. Jungkurth is convinced that 3D Printing technology »has the potential to advance to that point in the future.«



In 2023, Jungkurth and his team produced a total of 250 fixtures with the help of 3D Printing



+ FURTHER INFORMATION:

- » erco.com
- » formnext.com/fonmag

»MORE IMPRESSIVE THAN A 3D-PRINTED ROCKET ENGINE«

Antonius Köster combines digitalization and medical technology with the spirit of a pioneer – while still keeping his feet on the ground.



Text: Thomas Masuch

Images: Antonius Köster, Thomas Masuch



In addition to medical technology, Antonius Köster GmbH & Co. KG specializes in creating data for high-quality textures

The collection of products decorating our meeting room reflects the rich variety of Antonius Köster's creations. A car's gear stick amicably shares the space with a designer lamp, numerous prostheses mingle with an erotic toy, and slate-look porcelain plates offer a cool counterpoint to a leopard-print mug. Most of these works were 3D-printed, and for some, the product development process was driven by Köster himself. For almost every one of them, the man can tell a story about combining modern technology with traditional artisanry in a creative way.

The 59-year-old Köster, a model builder by training, specializes in working with design data. That's why the beating heart of Antonius Köster GmbH & Co. KG isn't its workshop (which houses four FDM 3D printers), but a room one floor up that features around a dozen top-quality scanners and sees use as a space for

training courses. A bold mission statement adorns one of the walls: »We can make any shape production-ready« – »...but the data is essential,« Köster adds with a smile.

The leopard-print mug was something Köster 3D-printed over a decade ago for a TV commercial in which the German comedian Hape Kerkeling extolled the virtues of Krüger-brand coffee. One of his much more recent accomplishments involved producing release samples for a new series of porcelain creations from Villeroy & Boch. In the space of just one week, Köster provided the company with 3D-printed samples that eventually evolved into a highly successful collection. The plates, cups, and saucers in it are still shaped by the design data he created. »That's our concept of creativity – taking new ideas and making them ready for production,« Köster explains. One particular aspect of his company's crea-

tive expertise relates to mapping decorative surfaces in the digital realm, often with an eye toward 3D Printing them in the real world. In some instances, Köster's innovations have even resulted in patents, as he explains with a wry smile. »Unfortunately, there's no mention of us in those patents even though a lot of our know-how has gone into the corresponding products. That's just how it goes for service providers like us.«

A FIRST RESPONDER OF SORTS

»We've carved out a niche as a first responder of sorts,« says Köster, who favors medical metaphors and technical jargon (we'll explain why later). »In other words, we're the ones companies call when they're in some kind of fix.« Along with creative support, the emergency services the firm provides include 3D Printing.

Köster – a native of Sauerland (western Germany) – got his business off the ground 30 years ago in the city of Meschede, where his first »office« also happened to be his kitchen. Today, the company has 10 employees and is headquartered on Köster family property. In one of its offices, which is only separated from the building's private residential portion by a single wall, Christian Alexander sits at a computer working on some design engineering for a customer. He was Köster's first employee and has now been with the company for 27 years. With his down-to-earth manner, Alexander's boss seems to have little in common with start-ups from the United States, whose investors dream of rapid scalability. »

THE IMPORTANCE OF DATA

Köster has actually been exploring 3D Printing since all the way back in 1991. His company's workshop still has an Objet Polyjet printer from 2009, which Köster claims still works as well as plenty of new printers. That said, he also relies on new technologies when doing so makes sense. The man is bursting with practical ideas, but doesn't jump on every hype train and takes a critical view of some developments in the industry.

Köster has seen a great many companies struggle to introduce and utilize such innovations. »Some of them buy a 3D printer after being taken in by the manufacturer's sales representatives, only to realize that they don't have any corresponding data,« he explains. He goes on to cite the development of the aforementioned porcelain collection as an example. »3D Printing helps us offer demo products, but the data involved eventually serves as a basis for an entire production setup. The data is where real value is created.«

FOCUS AREA: ORTHOPEDICS

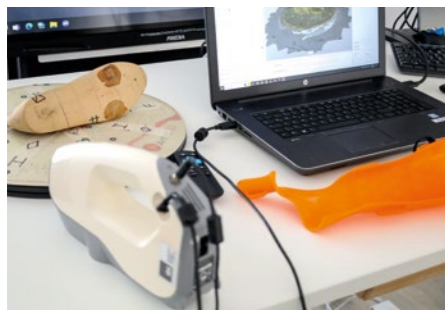
Data also plays an integral role in the second mainstay of Köster's business – the one that's even more critical to its balance sheet. Since 2003, Antonius Köster GmbH & Co. KG has been a sales partner of 3D Systems and Oqton (for their Touch hardware and Freeform software, respectively). The company serves the German-speaking and Benelux countries and select customers in other regions, which amounts to around 600 active clients in total. Of that number, 80 percent operate in the field of orthopedics or other areas of medicine, where 3D Printing is used for purposes like planning operations.

According to Köster himself, Freeform is particularly well suited to organic shapes. A haptic pen makes it quite easy to »take hold« of digital models and make modifications. »In this respect, we're a lot faster than parametric software solutions,« he explains. There are numerous potential applications, particularly in

orthopedics. As Köster points out, you can't just scan a foot and print an orthosis; there needs to be space around the toes, or else someone is going to feel the pinch when walking. »That's the difference between a form that fits and one that actually works. It's something we've learned from orthopedic technicians.« To that end, digital scans need to be adjusted accordingly. In doing so, Köster does his best to incorporate the technicians' more traditional knowledge and marry it to digitalization.

TRAINING IS KEY

»At the end of the day, it's about enabling a craft business to work with new technologies,« Köster offers in summary. In a highly traditional industry like this, he says this often takes a lot of convincing, especially when tried-and-true business processes are to change. »The best approach is to work with young people that haven't gotten so used to the conventional way of doing things.«



In his company's online courses, Antonius Köster demonstrates things like efficient ways to scan objects

Another prerequisite is having orthopedic technicians that are able to acquire the necessary expertise, which is why training is another essential component of the work done by Köster and his team. He can explain, for example, how to optimize the scanning process, the best way to combine TPU and PA 12 in a prosthesis, or how thick a sole needs to be based on the patient's weight and the length of the limb in question. This results in products that »have a real impact on people's lives,« an enthusiastic Köster says, recalling a four-year-old boy who was able to walk for the first time thanks to a 3D-printed prosthesis. »Things like that impress me more than a 3D-printed rocket engine!«

A PAST LIFE SPENT IN HOTEL ROOMS

Before the pandemic, Köster was on the road visiting customers around half the time; he racked up around 180 hotel stays every year, and one of his employees added as many as 120. These days, the company's training program is largely online. »It works really well this way, too,« Köster affirms. And of course, not traveling as much anymore means being able to spend more time with his family and explore the forests around Meschede on his bike.

Meanwhile, doing things digitally has led to advancements in Köster's training courses, as well. Instead of being arranged in hefty blocks, they now comprise shorter units that can be completed over a longer period of time. »Customers can also send in products for us to scan and process on the computer,« Köster adds. The training program takes longer now on the whole – two or three weeks in some cases. »It enables employees to start working productively much more quickly, though,« Köster points out.

ORTHOPEDICS COMPANIES AND CLINICS

The company's clients also include quite a few clinics in places like Münster, Basel, and Salzburg. In some of these locations, there are AM centers with large numbers of printers that produce haptic models for surgical preparation, which shorten the duration of such procedures



High-quality scanning technology is essential to achieving good results during data creation, as well

and can help surgeons achieve better results. Custom medical devices are also developed, such as 3D-printed ventilation masks for preterm babies. A tiny pacifier of this kind with built-in tubes was made at the Charité hospital in Berlin, where it has also been put to successful use. This is an area where Köster believes 3D Printing is just getting started. »Development is proceeding slowly,« he says. »It would help if things that have turned out well were collected in some kind of official way as evidence of the benefits of new technologies.«

In contrast, Additive Manufacturing is already much more widely established in orthopedic technology. Köster's most important customer segment comprises both small trade businesses and large orthopedics companies with hundreds of employees. »Two-thirds of our clients use 3D Printing,« the company's owner and CEO estimates. He says that although

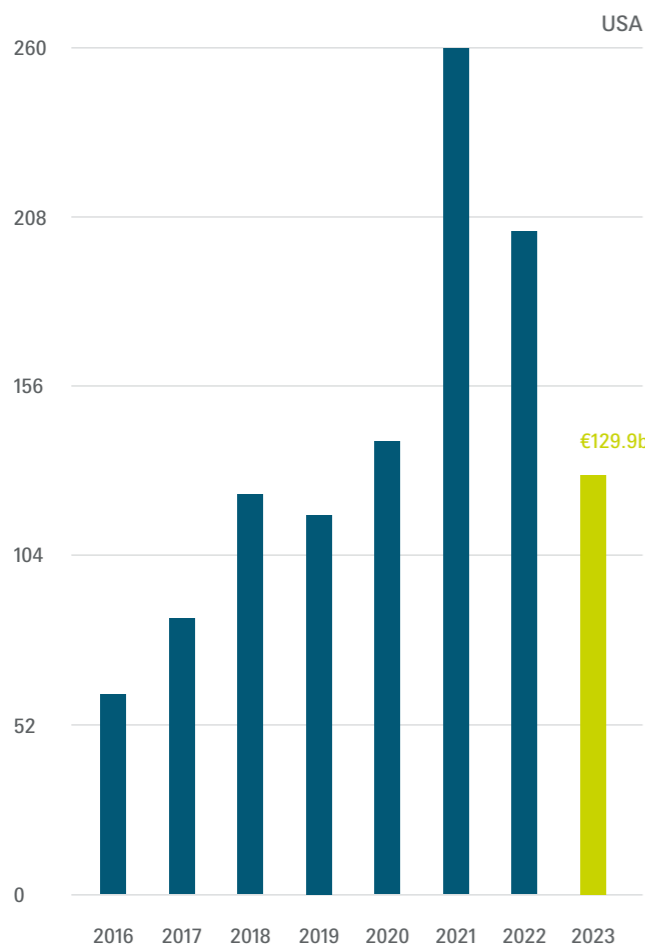
Additive Manufacturing will always be a complementary technology in this field, »the scope of the 3D-printed products used by orthopedists and dental technicians is huge.« According to Köster, some of his company's customers print three to four thousand orthoses each year. »It's a level of potential a lot of people just aren't aware of,« he adds. At the same time, Köster laments the lack of specialized personnel that would enable him to increase his sales considerably. »We'd be generating more revenue if we could deliver operators along with our products!«

+ FURTHER INFORMATION:
 » innovative-cad-cam-solutions.de
 » formnext.com/fonmag

THE END OF OVER-PROMISING

The gold-rush mentality that surrounded start-ups in years past has given way to a more somber mood among founders and investors. In fact, the valuation of such firms has practically fallen off a cliff as of late according to a study by Ampower and AM Ventures, who have analyzed the development of start-ups and investments over the past decade. Ampower founder and CEO Matthias Schmidt-Lehr believes that the corresponding consolidation points to conclusions that can be drawn for the AM market as a whole.

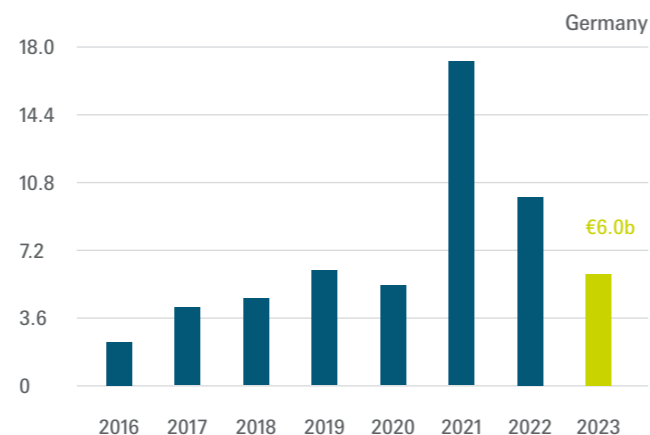
Financing of start-ups, in € billions.
Sources: Handelsblatt, EY



From his own projects and conversations with numerous investors, Schmidt-Lehr knows that valuations of start-ups are often based on the stock market valuations of established companies. »Share prices have declined significantly and money stopped being so cheaply available long ago, which is why start-up valuations have fallen considerably as well,« he explains.

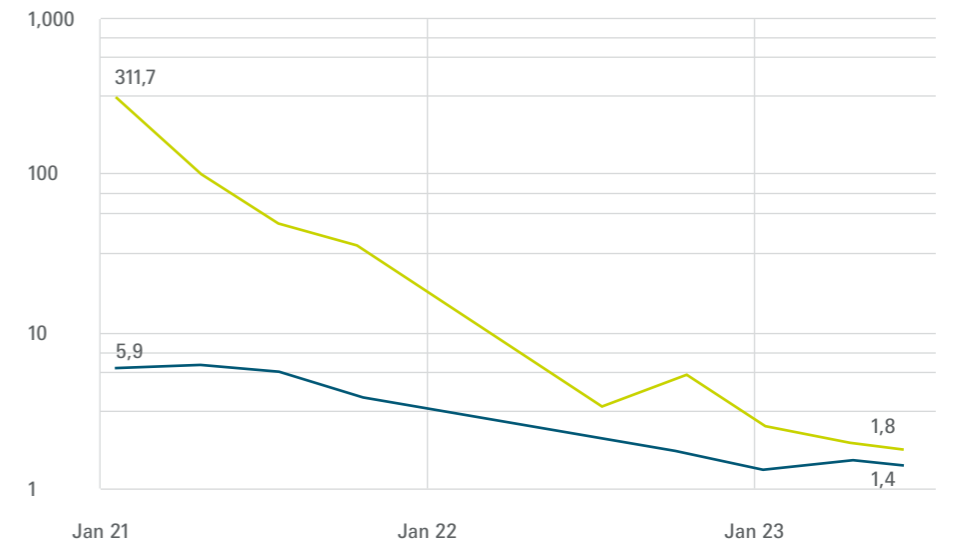
»SECOND WAVE OF AM HYPE«

According to the recent study conducted by Ampower and AM Ventures, valuations of »AM newcomers« have plummeted from 311 times revenue to just 1.8 times revenue in the past two years. Valuations of established AM companies



Text: Thomas Masuch

Valuation development of Additive Manufacturing companies
Quarterly EV / Revenue multiples since 2021 (logarithmic)



Source: Ampower AM Ventures, Finbox.com: »AM Newcomer« includes Desktop Metal, Markforged, Velo3D, Xometry, Fathom, Shapeways; »Established AM Players« include 3D Systems, Stratasys, Voxeljet, Materialise, Proto Labs

have also been on the decline since 2021 – from 5.9 times revenue to 1.4. Ampower sees one of the reasons for this trend in an »overestimation of the available market.« The firm also points out that in spite of the advancements made, additive technologies remain more expensive than traditional production methods in many areas, and the implementation of such innovations is often hardly trivial. Meanwhile, the »second wave of AM hype« has run up against an economic environment that has only gotten more difficult. That said, the wane in valuations hasn't been limited to companies in AM; the same has been seen in connection with other growth technologies.

THE HIGH COST OF RAPID GROWTH

For Schmidt-Lehr, the evolution of the VC market for start-ups in AM portends the consolidation of the entire surrounding industry. »A number of things are going to change for young companies, especially if there's no longer so much cheap money available,« he predicts, citing sales and marketing as an example. »Lots of AM companies are spending a lot on this area right now – 20 to 30 percent of their turnover in many cases.« In the past, there was a good reason to do so: It was the only way firms could meet the lofty expectations they faced with respect

to their rapid global growth. As another driver of high sales expenditures, Schmidt-Lehr points to the fact that AM systems frequently require a great deal of explanation. »With large industrial systems, it often takes a year to turn a lead into an actual sale.« Particularly in comparison with other branches of industry (such as CNC machining), the difference is dramatic. »In those areas, customers are usually familiar with the technology and know what they're getting. That makes the process of selling systems much simpler and more efficient,« Schmidt-Lehr says.

FOCUSING ON SPECIFIC APPLICATIONS

At the same time, Ampower's CEO thinks consolidation offers many benefits, as well. »It will help the whole industry if we can let some air out of the bubble and get on the path to healthy growth,« Schmidt-Lehr declares. He's already seeing corresponding signs: »Even really promising start-ups are being a bit more modest about how they present themselves and focusing on specific applications. The times when AM companies claimed they were going to revolutionize production are over.« That's why Schmidt-Lehr advises start-ups to zero in on clear-cut use cases and learn as much as they

can about the needs of their respective target groups.

The engineer and industry analyst in him also foresees a »future in which there are going to be more mergers of AM companies that offer similar products.« As for whether this will result in fewer new technologies finding their way to the market, Schmidt-Lehr says it's difficult to say at present. After all, for example, universities continue to conduct a large number of new research projects. »Ultimately, though, it's definitely going to be harder for company founders that want to establish new technologies,« he explains, alluding to both the increased cost of borrowing money and to how mature the AM market has become. »There's less potential for radical improvements all the time,« Schmidt-Lehr adds. »And when you have 40 different technological approaches, the niches in which many companies do business get smaller.«

- + FURTHER INFORMATION:**
- » ampower.eu
 - » amventures.com
 - » formnext.com/fonmag

A path to success – or perhaps a dead end?

In my circle of friends, we've taken to giving each other nicknames that usually relate to a unique personal characteristic or a life event that was amusing in some way. In one case, it didn't take us long to come up with the right moniker. The fellow in question is the type who takes a critical view of just about everything. No matter what you tell him, he never really agrees or responds in any kind of positive way. Now matter how good the soup is, he's always going to find a hair in it. If our friend – whom we've affectionately dubbed »Negativo« – ever won the lottery, he'd probably complain about having to find a sensible way to invest the money.

A few days ago, however, I started to think that we might have treated Negativo unfairly. I was listening to a podcast on the topic of investment that was espousing a strategy called »Via Negativa.« This apparently means that successful investors don't necessarily need to have a nose for diamonds in the rough; they mainly have to avoid making mistakes. Indeed, noted billionaire Warren Buffett believes that you »only have to do a very few things right in life so long as you don't do too many things wrong.« The »Via Negativa« philosophy seems to have taken hold in other areas, as well. Broadly speaking, we usually have a good idea of what we don't want, while the objects of our desire often refuse to come into focus in the tangle of our inner emotions. Or consider basically any popular team sport, where the would-be experts will tell you that offense wins games, but defense wins championships. Those who stop the other team from scoring – avoid mistakes, in other words – have the most long-term success.

This mindset can be traced all the way back to one of ancient Greece's most famous thinkers, Plato. Even then, people were always trying to capture the essence

of the divine in this way. After all, no one had actually seen a deity or knew what one looked like, so they attempted to describe what one was not. Is it possible that our friend Negativo isn't an overly critical soul at all, but a misjudged philosopher in his own right?

Many successful people benefit from a certain kind of negativism. Instead of just avoiding poor decisions, they eliminate anything that does not do them good from their lives. Mark Zuckerberg doesn't struggle with the choice of what to wear every morning; he simply wears the same thing. Similar things have been said of Steve Jobs or Barack Obama. Experts in brain research even recommend this type

of mental »decluttering« as a way to improve one's focus or achieve a state of relaxation.

Come to think of it, the AM industry seems to have slipped into its own decluttering phase to a certain extent. The era of boundless growth appears to be over for some companies, at least for now. Even the most lavish U.S. investors are tightening their belts, having perhaps discovered the »Via Negativa« for themselves. But then again, other AM companies continue to expand unabated, and are even turning a profit in the process. How? Don't ask me – it probably has to do with something positive.



Text: Thomas Masuch

Illustration: feedbackmedia.de, iStock/EgudinKa, eLenabs, Kristina Velickovic



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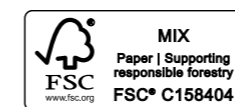
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