

02/2021 | EN

fon

formnext magazine

Foundries:
A forward-thinking concept in 3D-printed molds
» Page 08

Fittings:
Grohe 3D-prints faucets for the luxury set
» Page 14

Aerospace:
How the satellite industry is using AM
» Page 16

by **formnext**

If you
compromise
bold decisions
you lose.



[Jonas Brennwald, Co-CEO Grohe AG and Leader Lixil Emena]

Cover: Gienanth Group

EDITORIAL

Humankind has always been driven to come up with new developments and make new discoveries.

For a prime example, look no further than the latest NASA mission to Mars, where the helicopter Ingenuity recently rose from the surface of the red planet. Past journeys of discovery might not have made it quite that far, but were no less spectacular: Around 3,400 years ago, the famed Greek hero Odysseus experienced so much adventure, hardship, and revelation on his travels from Troy back home that Homer's account of his story (the Iliad) went on to become an international bestseller.

Since the people of the ancient world had decidedly less digital processing power at their disposal to plan for every eventuality of their trips, they sought out the wisdom of an oracle. The ruins of the most well-known temple where travelers could solicit such advice can still be found in Delphi today. An oracle's cryptic prophecies offered clues as to how wars would end and whether entire civilizations would survive.

Due to the coronavirus pandemic, we've essentially been on an uncertain journey of our own for more than a year now. At this point, we wouldn't be above consulting an oracle ourselves given the choppy waters we find ourselves navigating as trade fair organizers.

Still, there are plenty of signs that augur a return to the fertile economic terrain we'd grown accustomed to. Vaccination efforts are picking up speed in many countries, especially in Israel, the United Kingdom, and the United States. Some international companies want to start allowing business travel again as soon as May. Here in Central Europe, the

bulk of the population is very likely to be inoculated by the end of the summer at the latest.

The resulting upswing in the general mood is also evident in the feedback we've received from exhibitors regarding this year's Formnext. We already have almost every key player on board, along with an entire array of small and midsize companies – many of them first-time exhibitors from various countries. With more than 55 percent of our exhibitors set to arrive from outside of Germany on 16–19 November, it's clear that Formnext 2021 will draw attendees from all corners of the world.

As the organizers behind this event, we will nevertheless continue to keep a close eye on the ongoing development of the pandemic and adjust our concept. Meanwhile, we plan to heed the famous inscription at the temple in Delphi – »know thyself« – by leveraging the experience we have gained from these challenging times to forge ahead with new vigor. After all, the team behind Formnext and the entire AM industry still have a long and thrilling journey ahead of us.

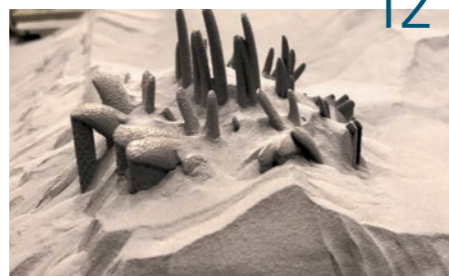
Sincerely, Sascha F. Wenzler
Vice President Formnext



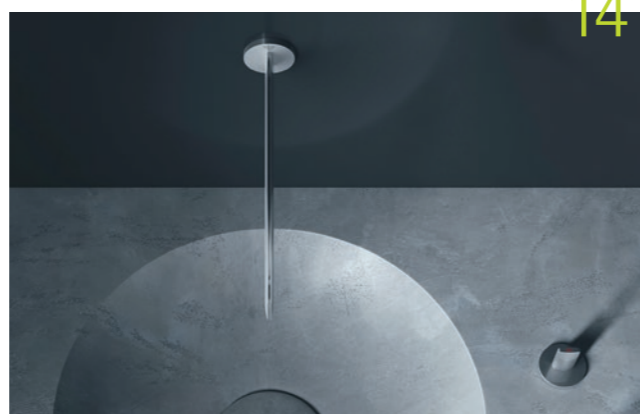
CONTENTS



16



12



14



08

08 »THINGS ARE STARTING TO GET ROLLING«
 » 3D-printed molds: a forward-thinking concept for foundries

12 TAPPING INTO NEW MARKETS
 » Automotive supplier Burgmaier hoping to tap into new markets with AM

14 LUXURY DESIGNS FOR OASES OF WELLNESS
 » Grohe marks two years of 3D-printing exclusive faucets

16 OUT OF THIS WORLD
 » Space series, part II: The role of AM in satellite construction

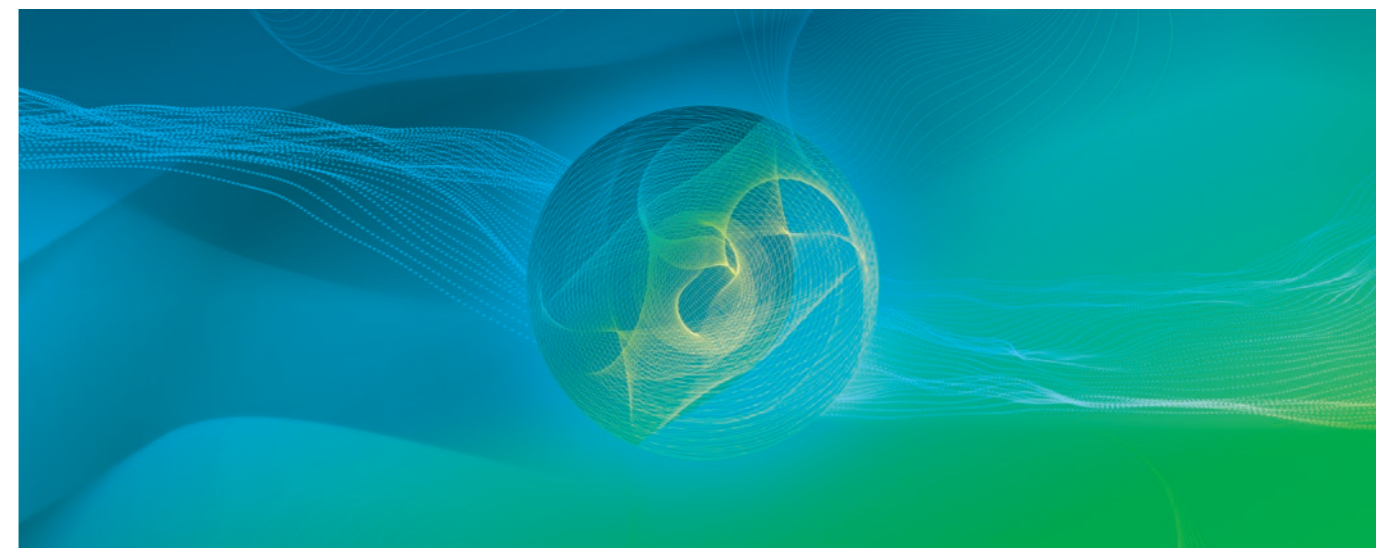
05 FORMNEXT NEWS
 » Real-life encounters and fresh new colors

06 NEWS
 » Lithoz · Nikon · Trumpf · Wohlers

20 TRENDS
 » Hansgrohe/EOS · Holo · SLM Solutions · Makerbot

22 OUTSIDE THE BOX
 » In pecunia veritas

FORMNEXT NEWS



REAL-LIFE ENCOUNTERS AND FRESH NEW COLORS

Following a year in which trade fairs all across the world went almost entirely digital, Formnext 2021 now promises to combine such elements with a return to real-life encounters in a hybrid concept. To symbolize progress and new beginnings Formnext is launching a brand-new key visual.

The event will enable the world of additive manufacturing to finally come together again in Frankfurt on 16 – 19 November 2021 »The feedback we've received from exhibitors, attendees, and the exhibitor advisory board has made it clear that a genuine in-person event is essential to this industry. Everyone is longing to visit some real booths and have some face-to-face conversations,« reports Sascha F. Wenzler, Vice President of Formnext at Mesago Messe Frankfurt GmbH.

Since the health and safety of all attendees remains priority one, the plans for Formnext 2021 are being made on the basis of a health concept that at minimum meets the corresponding legal requirements. The overall event concept will also be adapted to reflect the latest developments in the pandemic. Here, the

Formnext-team is counting on a positive trend, which should enable more people to undertake business trips as the year progresses.

AS MUCH FLEXIBILITY AS POSSIBLE

To provide Formnext's exhibitors with as much flexibility as possible in their planning, both the related deadlines and the event's general terms and conditions have been adjusted. Exhibitors can, for example, cancel their bookings free of charge until the end of June. In light of the current situation, Formnext 2021 is also offering modified, turnkey booth concepts that make planning an entire trade-fair appearance a simple affair without any major additional effort.

In terms of its subject matter, Formnext will continue to focus on the entire process chain involved in industrial 3D printing. »An array of highly innovative companies from the various sectors of this industry can't wait to present their latest developments to our audience in person,« Wenzler says.

To offer a counterpart to the in-person event for the very first time, the Formnext Digital Days are being planned two weeks later (30 November – 1 December 2021). These two days are to provide an intriguing digital platform, especially for attendees and exhibitors who can't make it to Frankfurt in November due to travel restrictions.

A NEW LOOK FOR FORMNEXT

At the heart of Formnext's new key visual is a sphere made up of lots of lines, all of which interlace and merge to create an intricate whole – a nod to the intelligent design that is only made possible by additive manufacturing. The slogan »Where ideas take shape« is therefore reflected in the visual language of the new design. The new look also puts the spotlight on Formnext's key objective of bringing the whole world and all the process steps involved in innovative manufacturing together in one place, in order to identify new potential for industrial production.

Formnext's existing color scheme provided the foundation for the blue-green color palette, although the new colors are fresher and more modern. The blue stands for an event that can be relied on and is associated with technology, innovation, and communication. And the fact that Formnext is a modern, forward-looking platform is reflected in the fresh new shade of green.

+ FURTHER INFORMATION:
 » formnext.com

NEWS

LOWERING THE ENTRY-LEVEL FOR 3D PRINTING CERAMICS

Lithoz, a specialist for ceramic 3D printing, has launched its 3D printer Cerafab Lab L30 which has been developed for those new to ceramic 3D printing and is suited to shop floors, research purposes and small-series production, as Lithoz reports. The new machine will enable more companies to adopt 3D printing as a manufacturing technique and drive the growth of this technology.

According to Lithoz, the new Cerafab L30 contains the full manufacturing power of the Cerafab 7500, Lithoz's original 3D printer. The new entry-level machine also enables the development and use of own materials, making it well-suited for use in research and labs.

Founded in 2011, the Austrian company has an export share of almost 100 percent, employs more than 80 employees and, since 2017, has a subsidiary in the USA.



NEW GROWTH AREA FOR NIKON

Nikon Corporation has acquired majority ownership of Californian AM startup Morf3D Inc. Founded in 2015, the young company is headquartered in El Segundo and specializes in metal components for the aerospace sector, using AM technology to produce aluminum and titanium components for Boeing helicopters and satellites, for example. The size of the investment has not been officially released, although the industry estimate is around \$90 million.

International technology group Nikon was founded in 1917 and is internationally renowned as a pioneer of optical technologies, but recently was forced to announce its camera business has been ailing due to the pandemic. In the interest of tapping into new growth areas such as materials processing technologies, Nikon established its Next Generation Project Division in July 2019.

»Morf3D has proven leadership in metal additive technology, a strong innovation pipeline and highly specialized aerospace manufacturing qualifications. It also brings a team of experts accustomed to partnering with customers to achieve their unique requirements. This combination is well aligned with Nikon's vision for accelerating industrialization of AM through innovation,« said Yuichi Shibazaki, Corporate Vice President and General Manager of Nikon's Next Generation Project Division.

Purchasing this stake in Morf3D, which Boeing itself has invested in in recent years via its venture capital arm Boeing HorizonX Ventures, could also open the door to the satellite market for Nikon (see feature starting on page 16). Japanese competitor Canon set a precedent for this move when it built a small Earth observation satellite and had it launched into space back in 2017.

NICKEL-BASE ALLOYS, STEELS, TITANIUM AND ALUMINIUM

Trumpf GmbH & Co. KG, Germany, recently unveiled its new TruPrint 3000 metal Additive Manufacturing machine. The medium-format machine uses Laser Beam Powder Bed Fusion (PBF-LB) technology to produce parts with a diameter of up to 300 mm and a height of up to 400 mm. It can reportedly handle all weldable materials including steels, nickel-base alloys, titanium and aluminium. Klaus Parey, Managing Director of Trumpf Additive Manufacturing, stated, »We've improved key aspects of the TruPrint 3000 to tailor it even more closely to the quality requirements, certifications and production processes of various industries.«

The new AM machine can be equipped with a second 500-watt laser that is said to almost double its productivity and to facilitate the move into mass production.

Trumpf also has transformed the movement of inert gas. The way in which it flows through the machine from back to front is now steadier and more uniform which, according to Trumpf improves the quality of additively manufactured parts. In addition, the new machine concept allows the operator to remove excess powder from the part while it is still inside the machine. Previous models required the operator to take the part out and remove the powder at a separate station. The new machine is designed to process the powder in a shielded environment, using inert gas to prevent the powder from becoming contaminated during the build. A crucial advantage for sensitive industries such as medical device manufacturing notes Trumpf.



Photos: Lithoz, Trumpf

Infographic: feedbackmedia.de, Source: Wohlers Associates, Inc.

NEWS

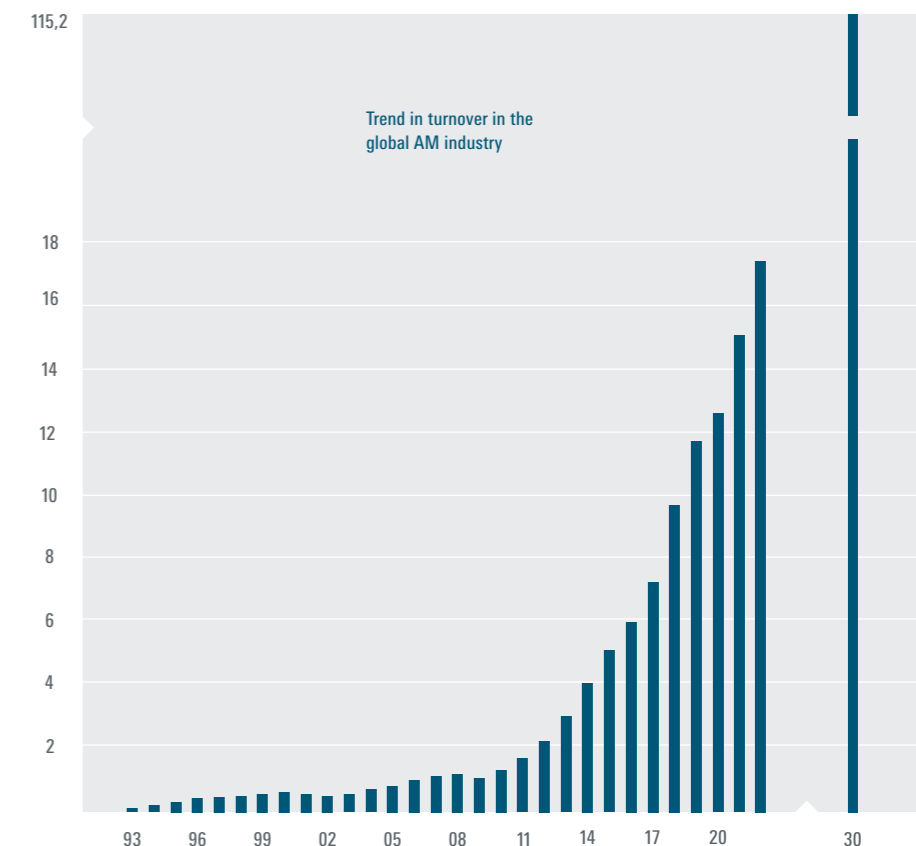
WINNERS, LOSERS, AND INTERESTING FIELDS FOR THE FUTURE

The Wohlers Report analyzes the consequences of the pandemic for the AM industry and predicts a continued high growth rate. Although the AM industry was another sector hit particularly hard by the Covid-19 pandemic, it remains on track for growth. That is the conclusion of the recently published Wohlers Report 2021. The 375-page report published by Wohlers Associates found industry expansion of 7.5% to nearly \$12.8 billion in 2020. However, compared to average annual growth of 27.4% over the previous 10 years, this growth was down considerably.

At the same time, the pandemic also produced winners and losers within the AM industry: In the first half of 2020, smaller AM companies and service providers in particular were the ones who suffered, while opportunities for investments and acquisitions rose from the second half of 2020 onwards. The latter was reflected in large acquisitions such as those involving Origin (bought in December 2020 for around \$100 million by Stratasys), 3D Hubs (bought in January 2021 for \$280 million by Protolabs), and Envisiontec (bought in February 2021 for \$300 million by Desktop Metal).

»The growth we saw in 2020 was surprising. We expected it to be much worse,« Terry Wohlers explains in an interview with Formnext magazine. He gives an optimistic forecast for the years ahead: »We believe the AM industry will begin to recover this year, with much stronger growth next year. We predict the market will grow to \$17.7 billion in 2022.« This would imply a return to annual growth rates of more than 20%.

Wohlers sees no end to the AM industry's continued remarkable growth in years to come either: By 2030, sales of AM products and services are expected to rise to \$115.2 billion. This corresponds to a roughly tenfold increase from the current level. Overall, the AM industry's share of the total global economy (currently \$80 trillion) and global industrial production (\$12.8 trillion) is still quite manageable. But Wohlers is right that the AM industry »will eventually account for a 5% share of global



industrial manufacturing and generate \$640 billion in revenue.« Exactly when, however, remains to be seen.

The highly dynamic nature of the AM market also comes from the continuing development of innovative technologies, which means new, pioneering additive manufacturing technologies are still being developed every year. According to Wohlers, many of these innovative startups do not sell machines, materials, or software, but produce parts as a service. This is mostly because the barriers to entry are relatively low: If you have a machine, a website, and the relevant knowhow, you can make a start in this business.

The Wohlers Report singles out 3D printing of food, medicines, and electronics as particularly interesting fields for the future of the AM industry. For the electronics sector, 3D printing is a revolutionary way of producing compo-

nents, where the combination of metal and plastic is proving extremely useful and is now, thanks to the development of new manufacturing methods, becoming a reality, says Wohlers. 3D printing of medicines is also a very young field; designing tablets in a certain way can make them more effective and tailored to each specific patient, which opens the door to new treatments.

3D printing of food (3DPF) has already been a reality for several years, albeit currently as a niche application. However, many different research projects are currently underway. For example, creating meat substitutes (from proteins or living cells) via 3D printing is one way of getting involved in the trend toward sustainable nutrition. The authors of the Wohlers Report therefore anticipate significant market growth as advances are made over time.

»THINGS ARE STARTING TO GET ROLLING«

The gradual electrification of the automotive industry is impacting many sectors, but perhaps nowhere are the effects being felt as strongly as in the foundry industry. At the moment, more than half of the metal components cast in Germany are built into road vehicles, but many of them will no longer be needed in future electric vehicles. Of course, e-mobility does present new business opportunities in this regard. However: »There won't be enough alternative business to go around in the foundry industry in the years ahead,« predicts Simon Geib, head of project management and business development at Gienanth Group GmbH. This is why Gienanth, which boasts a centuries-long history in the aptly named town of Eisenberg (western Germany), has already adapted its strategy to the new challenges ahead – and could thus be blazing a trail for its entire industry. The 3D printing of sand molds plays a key role in its approach.



Photos: Gienanth

At left:
Gienanth has been casting iron since 1735.
Above:
Sand cores are traditionally manufactured using a core shooting machine.



Text: Thomas Masuch

Gienanth Group GmbH
Founded as the »Hammerwerk« in Eisenberg (western Germany) in 1735, Gienanth is now one of the longest-standing companies in Germany. One of its locations in Bavaria even dates all the way back to the year 1449. Gienanth has since evolved into an international corporate group that employs some 1,800 people and generates around €250 million in turnover each year. Its products and solutions include highly complex cylinder crankcases and cylinder heads designed for heavy-duty engines with between 1,000 and 15,000 horsepower. Among other settings, these engines see use in power generators, locomotives, and ships.

The drivetrains of electric cars require only around half the parts of vehicles that run on conventional combustion engines.

»As e-mobility continues to gain significance, you're going to see more and more excess capacity in this regard,« Geib reveals. »That makes for a very challenging future – especially for foundries that mainly supply the automotive industry.« On the one hand, he believes this trend hasn't yet arrived in the marketplace, and that the spare parts trade will mitigate its effects to some extent in the coming years. »Over the long term, however, there's going to be a kind of natural selection in the casting market, and companies that only supply parts for combustion engines will inevitably leave.«

Founded all the way back in 1735, the Gienanth Group now does 20-25 percent of its business in the automotive sector, which means the impact of this development has been rather moderate. It has nevertheless already realigned its strategy to prioritize products that aren't connected to the drivetrains of combustion vehicles. At the same time, Gienanth's iron casting division is exploring the possibilities afforded by 3D-printed sand

molds and cores¹ with a focus on new component designs and smaller lot sizes.

MORE EFFICIENT COMBUSTION

Elsewhere, Gienanth recently provided metal casting support to the Austrian engine developer AVL List GmbH in a research project to make heavy-duty engines even more efficient. The two partners wanted to optimize the combustion of these units – many of which weigh tons and see use in naval and power-generation operations – by achieving higher levels of ignition pressure with diesel, natural gas, and alternative fuels. Besides increasing efficiency, this reduces consumption, and emissions and operating costs along with it.

What might sound simple enough involved some profound technological challenges: Increasing ignition pressure beyond the maximum allowed by the current state of the art puts a great deal more stress on an engine, and in particular on its cylinder head. If the

¹ In metal casting, a core is the part of a mold that prevents metal from filling the entire mold



This innovative cylinder head is designed to make heavy-duty engines more efficient.



Binder Jetting

For further information on this procedure, check out the AM Field Guide at formnext.com/amfieldguide

engine's design is not modified, its useful life will be considerably shorter. To counteract this issue, the research project devised a new type of cylinder head with much better cooling properties and improved stability.

The cylinder head features reduced thickness and narrower conduits that optimize the flow of coolant and are thus capable of dispersing more heat. This innovative design, which AVL has since patented, used to be »technically impossible to realize in this way, but it can now be done by 3D-printing sand cores,« explains Benjamin Heil, head of hand-molded casting projects at Gienanth. Heil has thus grown to appreciate 3D printing as a »tool that takes engineering to the next level.«

With AVL heading up this research project, Gienanth handled the development of the cast and the actual production of 10 cylinder heads. Some of the challenges involved had to do with achieving a very precise level of surface quality – and removing all the sand residue from the cast pieces.

Gienanth acquired the casting molds and cores it needed to form liquid iron at over 1,370 degrees Celsius from the service provider voxeljet. For the moment, the Eisenberg-based company is not planning to run its own 3D-printing equipment. »Placing orders with service providers gives us flexibility with regard to sizes and unit quantities,« Simon Geib points out.

JUST A FEW MINUTES

For the casting experts at Gienanth, lot sizes in the single digits are rare; indeed, it usually deals in quantities that are many times greater. The group, which generates around €250 million in annual turnover, produces more than 15 million brake parts each year. According to Geib, this gives Gienanth a sizable share of the corresponding market in Europe.

For mass production purposes, the sand cores used in making the aforementioned cylinder heads will be manufactured using core shooting machines. Depending on the design in question, this takes between three and seven minutes. The production time on a 3D printer is much, much longer, but the traditional method requires tools that are very complicated to manufacture and can cost several hundred thousand euros. As a result, 3D-printed sand cores can be much more cost-effective when dealing with small lot sizes. That said, time is a factor: While 3D-printed cores can be made available in a matter of days, assembling the tools for a core shooting machine sometimes takes several months.

The use of 3D-printed sand cores in production processes nevertheless remains rather marginal, which Gienanth's experts mainly attribute to the »considerably higher costs compared to traditional manufacturing.« At the same time, it is possible to incorporate 3D-printed sand cores into mold consisting of other

cores produced the conventional way. »This means 3D printing can be a useful addition in the production of large quantities,« Geib affirms.

»A LOT OF MOMENTUM IN ELECTRIC VEHICLES«

Meanwhile, the quantity at which 3D-printed sand cores make economic sense appears to be constantly rising thanks to the development of new 3D printers. Small series (meaning those of less than 1,000 units) and very small series (less than 20 units) have become the norm for service providers like voxeljet in recent years, but CEO Ingo Ederer could imagine six-figure amounts being produced in a cost-effective manner. »That would require things like automated unpacking solutions, though,« he says.

At voxeljet, Bavaria's pioneer in 3D sand printing, the upheaval brought on by the electrification of the automotive industry is already having a tangible impact. »We're definitely seeing a decline – or at least a shift – in orders from the automobile industry,« Ederer reports. »We've already been noticing a significant reduction in requests from projects involving

combustion engines for some time. Meanwhile, we handled a number of major orders last year that showed us there's a lot of momentum in e-mobility.« In one example, voxeljet has 3D-printed molds for body components on behalf of larger manufacturers of electric vehicles. Ederer suspects these molds were initially used in the production of smaller lot sizes before being replaced by die casting tools.

PRESSURE TO OPTIMIZE PROMPTING A CHANGE IN MINDSETS

Back at Gienanth, the people in charge can foresee their new cylinder heads being manufactured with the help of 3D-printed sand cores – assuming the tests currently being conducted yield positive results, of course. If they do, a small production series will be the next step. Depending on the number of cylinders at hand, up to 24 cylinder heads can be screwed onto a heavy-duty engine one by one. Corresponding demand is on the rise with regard to both new engines and replacement parts.

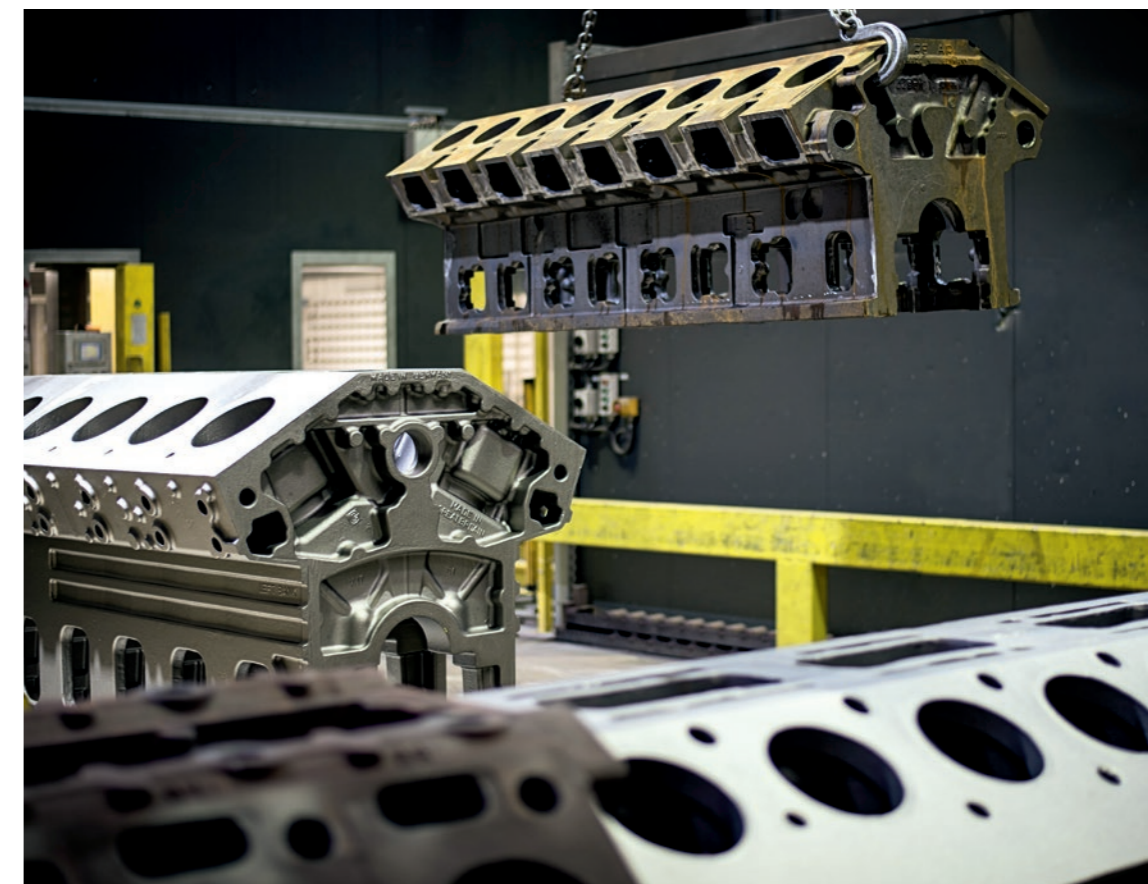
The megatrend toward customization – and thus to relatively small lot sizes – is also evident in the casting industry, which Simon

Geib says was almost never the case in the past. After all, larger series were (and still are) more profitable most of the time. Geib reports that this is another area where mindsets are changing, however, and 3D printing could play a more prominent role going forward. As for other applications in the casting industry, Geib and Benjamin Heil believe additive manufacturing has potential in the ongoing pursuit of greater environmental awareness and energy efficiency, which is what has led to more pressure to optimize things like heavy-duty engines. They say this is changing the way people think about design and manufacturing processes, as well. »The development cycles in these industries are relatively long, though: For heavy-duty engines, they're several times longer than for utility vehicles or passenger cars,« Geib explains. »Still, things are starting to get rolling.«

+ FURTHER INFORMATION:

» fon-mag.com

» gienanth.com



Cast and finished engine blocks

TAPPING INTO NEW MARKETS

Photo, page 12:
Burgmaier is combining its experience in milling with its new additive expertise.

Top photo, page 13:
Metal components on a powder bed

Bottom photo, page 13:
A nozzle support manufactured using both additive and subtractive methods

As if struggling with the coronavirus pandemic weren't enough, the traditional automobile industry had to contend with the transformation to alternative drive systems in 2020. This transition is also putting automotive suppliers under considerable pressure to respond. Burgmaier, however – a family-owned company based in Allmendingen (southwest Germany) that employs around 800 people – already began setting the wheels in motion to leverage new technologies like additive manufacturing and tap into further markets two years ago.

Compared to the 280 machining centers in use at Burgmaier's four plants, the company's single powder bed unit is definitely playing more of a minor role. Ken Krauß, who has been heading up the AM division at Burgmaier for two years now, nonetheless reports that this twin-laser SLM 280 is already producing series of more than a thousand components in a dedicated AM environment. To continue ramping up these production runs over the long term, Krauß and his colleagues are also taking a look at additive technologies beyond powder bed fusion.

Outside of Burgmaier's neatly isolated AM operations, dozens of milling and turning machines send plenty of metal shavings flying as they produce thousands of parts every day. »We're advancing into a new production environment with additive manufacturing.« Krauß says, referring to the application-oriented way in which Burgmaier closely combines AM with post-pro-

cessing. It's here that the company sees one of its particular strengths: Since its foundation in 1931, Burgmaier has amassed decades of experience in cutting and surface treatment.

Through AM, it is now also reaching out to new customer groups outside of the automotive industry – manufacturers of cutting tools, for instance. With 16MnCr5, a material the company has certified specifically for additive manufacturing, it is 3D-printing things like mounts for the sharp working edges found in milling and turning machines. The cooling channels Burgmaier is integrating into these mounts are more efficient at dispersing process heat. Meanwhile, the company's product portfolio now includes 3D-printed grippers, as well. Here, AM produces rougher surfaces that offer improved hold. Krauß also sees a great deal of potential in gearwheels, which are used in many industries and are highly compatible with additive manufacturing.

Text: Thomas Masuch

Photos: Burgmaier



»AM IS THE RIGHT STEP FORWARD«

A businessman by training, Krauß leads a team of five employees that includes two application engineers. »Still, I like putting the mask and lab coat on myself now and then to lend a hand in our AM operations,« he reveals. Although just 36 years old, Krauß is the most senior member of his dynamic AM department, which reports directly to managing partner Karl-Hugo Schick. »Burgmaier's ownership group is convinced that additive manufacturing technology is the right step forward in leading the company into the next generation,« Krauß says, citing the family-run company's flat hierarchy as a further advantage that »enables us to operate with agility and flexibility«.

While AM is a key aspect of Burgmaier's future technological plans, it has set some specific short-term business goals in this field, as well. Krauß reports that his department was already expected to turn a profit in 2020 before the coronavirus set it back a year.

BURGMAIER'S FUTURE ACE IN THE HOLE: A NEW MATERIAL

Luckily, Burgmaier has used the pandemic as an opportunity to lay the foundation for its next big push. In completing its internal certification of the aforementioned material 16MnCr5 for selective laser melting in the summer of 2020, the company achieved a significant technological advancement – one it believes gives it a unique selling proposition in the AM

market. Well-known for its versatile properties in metal cutting, this material has already passed the test in a wide variety of applications in the automotive sector, mechanical engineering, and the manufacture of tools and clamping devices. Burgmaier purchases the powder required, but developed the production parameters itself. »At a thickness of 50 micrometers, we're producing components with a density of up to 99.9 percent,« Krauß proudly states. At the same time, the heat treatment cycles involved can be fine-tuned to make this case-hardening steel rigid and wear-resistant on the outside, while the inside remains tensile rather than brittle.

Since additive manufacturing doesn't begin and end with 3D printers, Krauß and his team have adopted the same quality standards Burgmaier maintains in series production, but adapted some aspects to the particularities of AM (which deals in much smaller production runs). Among other things, they conduct inspections of their process and make use of test pieces. Burgmaier also provides measurement reports when requested by its customers, some of whom have also audited the company's AM operations themselves. Here, Krauß underscores the special attention Burgmaier pays to quality assurance. »For AM start-ups in particular, it's a subject that can really sneak up on you,« he points out. A long-standing organization like his, on the other hand, can take advantage of its decades of related experience.

Burgmaier Technologies GmbH + Co KG
Headquartered in Allmendingen (near Ulm), Germany, Burgmaier is one of the leading manufacturers of precision components. It employs over 800 people in development, construction design, production, assembly, and quality assurance at four plants in Germany, France, and Slovakia. According to the company's own figures, around 350,000 parts roll off the line at these facilities every day. In statistical terms, every European automobile contains an average of five Burgmaier components.

PARTNERS ON EQUAL FOOTING

In establishing its own AM operations, Burgmaier was always looking to find customers in other companies and industries outside of automotive supply. It has since discovered that along with manufacturing knowledge, many clients need guidance with regard to development. »A good portion of our customers already have AM expertise, but are searching for a production partner that will discuss their developments with them on equal footing – and ask some critical questions, as well,« Krauß explains. He also points to other customers who want to incorporate the advantages of AM into their products despite having just gotten started with the technology themselves. In these cases, Burgmaier works with them on developing designs for components. Krauß says the company rarely handles just the 3D printing of parts designed for AM. »We typically only do that when the production process is difficult or post-processing is required,« he reports.



+ FURTHER INFORMATION:

- » fon-mag.com
- » burgmaier.com

LUXURY DESIGNS FOR OASES OF WELLNESS

They're elegant, exclusive, puristic in their design – and definitely not for everyone's budget: In the Allure Brilliant and Atrio Icon 3D, the bathroom fixture manufacturer Grohe AG has added 3D-printed faucets to its product range for the first time over the past two years. These luxury items, which weigh in at around €12,000 apiece, are made at Grohe's main production site in Hemer, Germany, and represent just the first step in the company's additive journey.



Grohe

Grohe is a brand known around the world for its comprehensive bathroom solutions and kitchen fixtures. Grohe AG employs a total of more than 6,500 employees in 150 countries around the world – 2,600 of them in Germany. Since 2014, the company has belonged to the brand portfolio of Lixil, a Japanese manufacturer of water- and housing-related technologies.



Powder Bed Fusion
For further information on this procedure, check out the AM Field Guide at formnext.com/amfieldguide

Grohe AG prefers not to reveal how many 3D-printed faucets it has already sold, but does say it hopes to increase the number in the future. To that end, head of industrial engineering Thorsten Schollenberger wants to make the company's additive manufacturing operations much more efficient, which should ultimately reduce the price of these refined fixtures. At the same time, Schollenberger also wants to keep an eye out for other products that could be compatible with 3D printing.

Grohe's product categories include everything from moderately priced appointments to the premium segment, and its 3D-printed,

stainless-steel water faucets are at the very top of the line. The new owners of these eye-catching items are similarly exclusive: The Atrio Icon 3D can be found, for example, at the world's largest underwater restaurant, Under, which resides below the frigid tides off the southern coast of Norway. Grohe has also sold these fixtures to numerous private individuals with an eye for design, but Schollenberger would still like to find a lot more customers for them. He says the production costs need to be significantly reduced to make that possible. »We've got to bring the costs down; otherwise we can't make these products accessible to a larger target market,« Schollenberger affirms. He has

Text: Thomas Masuch

Photo, page 14:
The Atrio Icon 3D
Left photo, page 15:
The Grohe Allure Brilliant
Top-right photo, page 15:
At the Norwegian restaurant
Under, patrons can wash their
hands at 3D-printed faucets.
Bottom-right photo, page 15:
Thorsten Schollenberger,
Grohe's head of industrial
engineering



already come up with a plan to slash the production time needed to 3D-print a faucet from the current 52 hours to just over 12. There's still quite a difference between that and conventional manufacturing, though: Using low-pressure casting, Grohe's plant in Hemer produces brass fixtures every 10 to 15 minutes.

For the Atrio and Allure Brilliant Icon 3D, the company's designers envisioned a much smaller production volume. Thanks to additive manufacturing, the faucets' internal water channels are considerably narrower, which opens the door to elegant designs that wouldn't be possible with standard methods. By selling more 3D-printed fixtures, Schollenberger also wants to achieve better capacity utilization in AM production at the Hemer facility, which can currently turn out 400 water faucets per year.

»NOT A GOOD FIT FOR HIGH-END PRODUCTION«

Grohe's AM department is based around two Trumpf TruPrint 3000 units and a four-person team that works on design, machine operations, and post-processing. After being 3D-printed, components go straight to post-processing, where their support structures are removed and the fixtures are ground, drilled, and polished. Schollenberger describes this step as particu-

larly important in ensuring a high-quality product with a flawless surface – and one that could be made a great deal more efficient at Grohe. »Grinding and drilling still involves a lot of manual work, which can be time-consuming and isn't a good fit for high-end production,« he points out.

Meanwhile, Grohe is currently only using one of its Trumpf machines to 3D-print faucets. The other is producing tool inserts with conformal cooling elements made of brass. Grohe has secured a patent on the AM production of this material, which features a high degree of thermal conductivity. Having passed a round of initial tests, its new tool inserts for injection molding machines are now proving their ability to stand up to long-term operations at Grohe's Porta Westfalica plant, where they are already facilitating more efficient production. »The conformal cooling aspect enabled us to reduce cycle times by 20 percent,« says a pleased Thorsten Schollenberger. »With the brass tools, we're now around 50 percent faster.«

THE »WELLNESS OASIS« TREND

Despite the rather modest contribution they make to Grohe's bottom line, these elegant 3D-printed fixtures have already left their mark on the company – thanks in part to the atten-

tion they attract and the considerable value they offer in terms of marketing. Grohe has gained a good deal of expertise and experience in additive manufacturing, as well.

Meanwhile, its 3D-printed faucets represent Grohe's response to a trend it has observed in which the bathroom is no longer viewed as closed-off space meant solely for hygiene purposes, but an »oasis of wellness« that integrates seamlessly into the rest of the home. Another future trend Grohe has identified – and one that is playing an increasingly significant role for this subsidiary of Japan's Lixil group – has to do with customization. So far, this aspect has been evident in the demand for a wider variety of colors in bathrooms, for example. According to Schollenberger, Grohe wants to continue following this trend with its 3D-printed fixtures. In the future, he can see the company offering basic versions of certain products that can then be customized. Customers will thus be able to put the finishing touches on their fixtures themselves or with the help of a designer.

+ FURTHER INFORMATION:

- » fon-mag.com
- » grohe.com

Photos: Grohe

OUT OF THIS WORLD



It is as if additive manufacturing was tailor-made for the satellite construction industry, which is all about very small quantities, complex designs, and a quest to reduce weight: all demands that suit additive manufacturing to a T. No wonder, then, that satellites containing 3D-printed components have already been orbiting the earth for several years now. In this second part of our »AM in the Space Industry« series, we look behind the scenes to find out how widespread AM is in satellite construction at the moment, what market potential it has, what trends are driving the industry, and what challenges satellite manufacturers and their service providers still face.

Text: Thomas Masuch

Photos: Airbus Defence and Space, OHB System AG

Airbus Defence and Space is currently manufacturing two Hotbird satellites for its customer Eutelsat, which will be fitted with a total of 500 3D-printed components. These parts are made from an aluminum-silicon-magnesium alloy (AlSi10Mg) and produced by certified partners using the selective laser melting (SLM) process. »There are more than 100 different waveguide designs, together with other network designs. The waveguides conduct the RF signals around the spacecraft. The components come in sizes ranging from about 100 mm [4"] to about 300 mm [12"],« explained Andrew Neal, an expert in additive layer manufacturing at Airbus in Portsmouth, UK, when he spoke to Formnext Magazine.

Aerospace company OHB System AG has also been engaged in additive manufacturing for more than six years now. »At first, it was a development project. Now we are at the stage of not only replacing existing components, but optimizing them in a really targeted way,« said Marco Mulser, a technology manager for additive manufacturing at OHB. Next year, after several years of development, the first metallic AM part installed by OHB System will launch into space.

AM has also been high on the agenda for another industry heavyweight, Thales Alenia Space, for years now. The French company built a 3D-printed aluminum antenna into the TurkmenAlem communications satellite way back in

2015, before installing additively manufactured parts in 45 other communications satellites in 2017. Today, all Thales Alenia Space communications satellites use 3D-printed antenna brackets and reflector sleeves.

PURCHASED FROM SERVICE PROVIDERS

Both OHB System AG and Airbus Defence and Space purchase their 3D-printed components from suppliers, but only once they have »gone through a complete supplier and qualification process,« according to Neal. OHB System decided four years ago to purchase 3D-printed parts solely from suppliers – the same approach the company takes to most of the other parts and components it uses to make its satellites. »We want to be able to rely on service providers having stable processes,« said Mulser. And the engineer considers established companies in particular to be at an advantage here, »because it's not so easy to just catch up on years of experience.« OHB System turns to external partners for quality assurance too, »although we choose specifically which technology and which type of quality inspection is used.«

RELIABILITY IS A PRIORITY

Generally speaking, the satellite production industry has extremely high demands when it comes to reliability, which means redundant solutions are sometimes required. »Our job is very different to working in the automotive

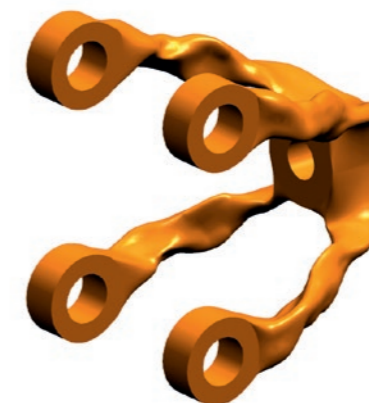
industry or even in aviation. After all, we cannot repair a faulty part or recall a product,« said Mulser. »This means that the manufacturing process must be stable and consistently deliver reproducible results.« This excludes the possibility of developing the process over time, a »learning by doing« approach, so to speak. Engineers at OHB System therefore work with fixed process parameters that have been verified in advance and use these as a basis for deciding where additive manufacturing could be a suitable production method, then designing components accordingly. »By now we have a very clear picture of which applications this works for,« according to Mulser.

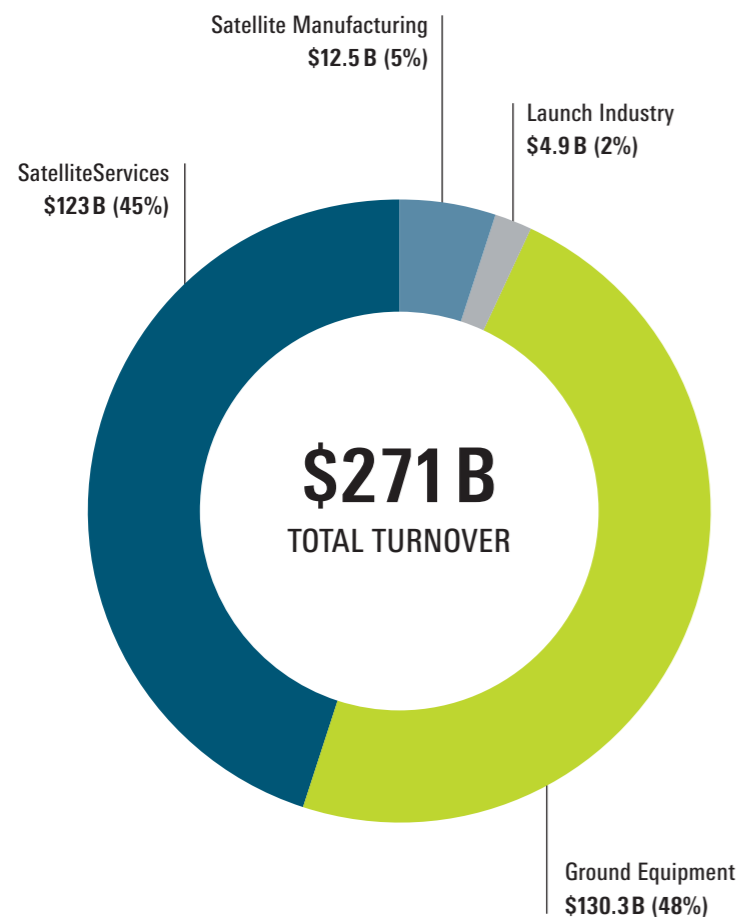
A PRETTY ROBUST SECTOR SO FAR

With its extraordinarily complex technology and long development times, satellite production has actually been a pretty robust sector in the past. Although the market did fluctuate depending on what was happening with certain major projects, it showed quite steady single-digit growth overall. In the years 2014 to 2018, satellite production revenues stood at \$16.2 billion (source: Satellite Industry Association, SIA), with more than half that amount attributable to the USA. According to the SIA, 62.4 percent of global satellite production in 2019 took place in the USA. (See SIA chart.)

Overall, satellite production makes only a small contribution to the entire satellite sector of the aerospace industry. According to Bryce-»

At left:
3D concept of a cleat for connecting sandwich panels
At right:
Integration of an MTG satellite in the OHB System AG cleanroom





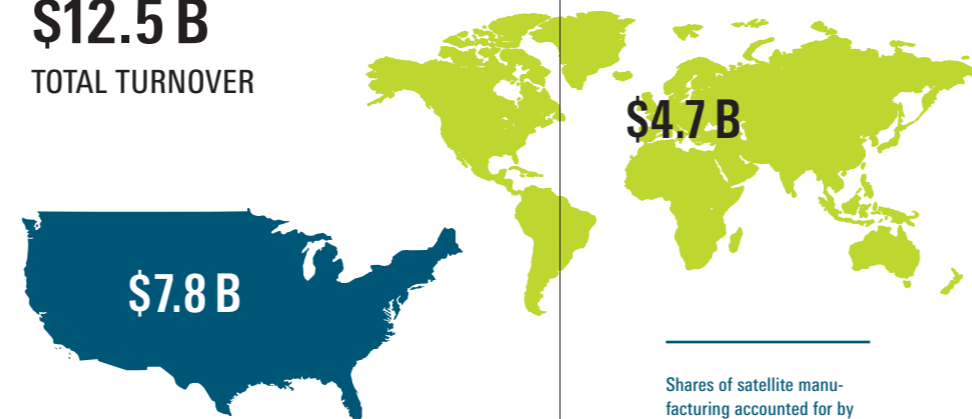
Turnover by sector in the global satellite industry (2019)

tech, this satellite sector generated revenues of \$217 billion in 2019, but that figure also includes ground equipment, TV, mobile services, and launch services.

Some 8,900 satellites have been launched into space since 1957, with 5,000 still orbiting the Earth and 1,900 of those still operational. Having ushered in a new era of rocket engineering, Elon Musk and SpaceX are now set to do the same for the satellite industry: The Starlink project, which aims to bring high-speed broadband internet even to rural areas (for a fee), has launched 1,318 satellites into the Earth's orbit at an altitude of around 270 km [168 miles] since May 2019 (data correct as of March 24, 2021). This led to SpaceX becoming the world's largest satellite operator very quickly indeed. One Falcon 9 delivers 60

Starlink satellites into orbit. But despite its large number of satellites, Starlink has not significantly increased the volume of the exclusive satellite construction market. That's because, with estimated manufacturing costs of \$250,000 to \$500,000 per unit, the 260 kg [570 lb] Starlink satellites are positioned toward the lower end of the market's price range. Other satellites, such as those used in Earth observation, are competing in a whole other weight class due to their size alone. One of the largest satellites ever launched was the TerreStar-1 back in 2009, which weighs 6,910 kg [15,230 lb] and has solar panels with a span of 32 m [105 ft]. According to estimates from satellite phone provider Globalcom, a typical weather satellite costs around \$290 million.

\$12.5 B
TOTAL TURNOVER



\$4.7 B

Shares of satellite manufacturing accounted for by the United States and the rest of the world (2019)

1.900
IN OPERATION



8.900
SATELLITES
IN SPACE

TREND TOWARD SMALLER SATELLITES

In addition to Starlink, the trend toward ever smaller satellites is giving the industry a boost too. Fired up by new applications in agriculture, energy, civil defense, or oil and gas, for example, the market for small satellites weighing under 500 kg [1,000 lb] is expected to grow strongly in the coming years. Allied Market Research analysts predict that this sector will grow from \$3.6 billion in 2018 to \$15.7 billion by 2026, an annual increase of about 20 percent. Contributing to this growth will be the Lightspeed project by Canadian satellite operator Telesat, which intends to launch a fleet of 298 satellites, each weighing 700 – 750 kg [1,543 – 1,653 lb], into orbit around the Earth over the next few years – Thales Alenia Space was awarded the contract for this work in February 2021.

Infographic: feedbackmedia.de, Source: Satellite Industry Association, SIA

a few ounces on a large satellite does not really have much impact on its overall weight. No, where additive manufacturing actually offers a great advantage is in the design process. Improvements can be made to individual components much more easily and quickly than to milled parts, for example, which significantly reduces development time and costs. Mulser also appreciated the opportunity »to practice integral construction, that is, to integrate different functions into one component and thus save on joining and assembly steps.«

Airbus expert Neal also highlighted this bonus of faster production: »We have speeded things up considerably compared to existing conventional waveguides. On average, we have halved the time it takes to produce waveguides with AM.« Where a little over two years were spent working on the initial AM components, now the processes have been industrialized at Airbus Defence and Space it takes just a matter of months.

THE CHALLENGE OF EXTREMELY CLEAN SURFACES

In order to reap the benefit of these faster times, incredibly stringent demands must be met, especially in postprocessing. As an example of this, Neal referred to the smooth surface that waveguides need to have in order to achieve the required RF power. »Satellites are assembled in a cleanroom, the surfaces must be clinically clean,« added Mulser. This means even the tiniest powder residues need to be removed, which requires scrupulous cleaning, especially of internal surfaces.

But the additively manufactured components also need to have technical characteristics that meet the very particular requirements of space travel. These include the huge loads encountered during lift-off and the enormous temperature fluctuations that occur when satellites or parts thereof are illuminated by the sun or situated in the shade. OHB System, for instance, has developed connecting elements called cleats, which connect two sandwich panels and compensate for thermal deformations, to deal with this issue. »Their structural design means these cleats can only be manufactured additively,« explained Mulser.

OUTLOOK: FIVE BECOME ONE

For Marco Mulser, stable manufacturing processes are the key to unlocking all the future potential for the satellite construction

Airbus Defence and Space
Airbus Defence and Space is a division of the Airbus Group, which generates revenues of around 10 billion euros and has approximately 34,000 employees. Its business areas cover military aviation and space systems, as well as sensors and communications technology. It is headquartered in Taufkirchen near Munich.

OHB System AG
OHB System AG is one of Europe's three leading aerospace companies. The systems provider belongs to the listed high-tech group OHB SE, where around 2,900 specialists and executives work on key European space programs. With two locations in Bremen and Munich and around 40 years of experience, OHB System AG specializes in high-tech solutions for space travel. These include low-orbiting and geostationary satellites for Earth observation, navigation, telecommunications, science, and space exploration, as well as systems for manned space flight, aerial reconnaissance, and process control systems.

sector that is offered by additive manufacturing. »This includes, for example, establishing lattice structures in the components and forging ahead with functional integration.« Airbus expert Andrew Neal also considered additive manufacturing to be vitally important for satellite production in the coming years. On the one hand, »the technology can now also be used as the basis for adjusting the payload.« And, as well as providing new ways to speed things up, additive manufacturing enables production and assembly costs to be lowered even further. »Because, on average, one AM component will replace a part that was previously made up of five separate components.«

- + FURTHER INFORMATION:**
- » fon-mag.com
 - » ohb-system.de
 - » airbus.com/space.html

TRENDS

A SHOWER THAT EVEN DOGS WILL ENJOY

It's not unusual for man's best friend to dislike the shower. But what if it were possible to clean dogs that are afraid of water simply by stroking them? EOS worked with Hansgrohe, a fittings and shower specialist based in Germany's Black Forest, to come up with an internally tested, sellable product in just five and a half months: a shower designed specifically for dogs.

As far as the Furlly canine shower head was concerned, there were two major issues to solve: First, to make the relationship between dog and owner even better. And second, the product in question had to be brought from idea to series production within a tight timeframe and with a keen eye on cost. So the project came with requirements that are really more familiar in the field of IT startups, but which also form part of the Hansgrohe think tank's arsenal: be agile, test fast, identify errors fast, learn fast.

Hansgrohe and EOS worked closely together to obtain the drinking water certification needed for the material used in additive manufacturing (AM): EOS submitted the powdered material PA 2200 and the relevant extracts from EOS's very own patented recipe to several laboratories. Once approval had been granted,

Hansgrohe began making the Furlly prototype and the first batch of 5,000 units on an EOS P 396 3D printer.

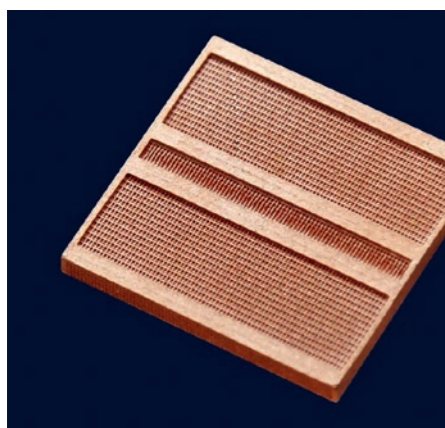
Thanks to the AM-optimized design, there was no need for any complex welding of individual parts. Only the switchover valve for changing the jets, which was based on an in-house large-batch product, is installed separately. Dog owners can use the switchover valve to choose whether the water will flow out of the shower head nubs gently or as a powerful, compact jet.



So this special shower head will be hours of fun for both owner and furry friend alike!



BIG PLANS THAT ARE VERY COOL



Californian company Holo recently launched its PureForm platform, which is set to produce high-resolution components from pure copper. Soon enough, thousands of components per month will be manufactured on this platform at Holo's newly opened 1,900 m² [20,500 sq ft] production facility in the Bay Area. The young company is focusing on selling 3D-printed components, not 3D printers themselves, and thus lowering the barriers to adoption in this technological field.

By using pure copper, Holo is able to concentrate on cooling solutions for high-per-

formance computers, electric vehicles, RF antennae, or heat exchangers, for example. Stainless steel is also set to be added to the material portfolio soon, which would open up even more applications.

Holo has developed a sinter-based platform for additive manufacturing using high-resolution imaging technology and a backend process based on the Vat Photopolymerisation (VPP). The company, which was founded as a spinout of Autodesk along with other AM companies, is backed by top-tier Silicon Valley investors such as Prelude Ventures and Lightspeed.

Photos: EOS, Holo

TRENDS

FIRST AM COMPONENT OF A NOSE LANDING GEAR OF A BIZJET



In a joint project, Safran Landing Systems and SLM Solutions tested Selective Laser Melting for the first time to produce a component of a nose landing gear for a bizjet. The joint objective of the project is to demonstrate the feasibility to produce a main fitting by Selective Laser Melting process. The component was therefore redesigned for metal-based additive manufacturing allowing time saving in the whole process, and weight reduction about 15 percent of the component. Due to the stringent requirements of this component, which is one of the parts that transfers the loads from the wheel to the aircraft structure and is retracted after take-off, Safran selected a titanium alloy with excellent mechanical properties that is naturally resistant to corrosion and does not require any surface treatment. The component was produced on an SLM800 system.

FROM THE WORKSHOP TO THE DESERT

With off-road legend Nani Roma the Bahrain Raid Xtreme Team (BRX) finished 5th in this year's Dakar Rally with – also supported by the mobile use of 3D printing. The BRX team, led by the company Prodrive, produced more than 30 car parts for the Hunter T1 race car from nylon carbon fiber. To do so, the team had a Makerbot 3D printer installed in its service truck.

This year Dakar Rally took place over two weeks, with stages covering hundreds of miles across Saudi Arabia. With two Method X 3D printers, the BRX team was able to engineer some parts at the factory in the UK as well as on site at the Rally. »We printed remotely in the middle of nowhere; literally where you can't see traces of civilization«, reported Paul Doe, chief engineer at Prodrive.

The BRX team 3D-printed over 30 parts on the Hunter T1, including a mount for a suspension position sensor and a sculpted nozzle mount for the cockpit's fire suppression system.



»There are quite a bit of parts in the car, such as the engine bays and wheel side near the brakes, where the environments reach up to 120°C and where traditional FDM materials

start to struggle, forcing us to revert to aluminum which is costly. In this case, we were able to print parts in nylon carbon fiber which is able to reach very high temperatures«, said Doe.

Photos: SLM Solutions, Makerbot

»OUTSIDE THE BOX«



In pecunia veritas

A few days ago, my bank sent me three bottles of wine (red, white, and rosé) from a vineyard on Lake Constance. I was meant to partake in this Lucullan largesse at an online wine-tasting that the bank was planning as a substitute for its annual client get-together. When it came time to enjoy these select vintages in the glow of my laptop's screen at home, the topics of conversation with my fellow customers drifted away from wine and eventually settled on the type of matters that make a bank what it is: investment opportunities – or ways to make my hard-earned cash more »full-bodied«, if you like.

Just like your preferred bottle of merlot has a certain alcoholic content, the world of finance has its percentages in the form of rates of return. To achieve better returns over the long term, more and more funds are now investing in sustainability. E-mobility and the future of food are trending topics in this regard, but upon closer inspection, some things don't have nearly the same sustainable sheen. Elon Musk, for example – who otherwise styles himself as the world's eco-friendly savior – recently cast his lot with Bitcoin. The mining of this cryptocurrency is projected to consume as much electricity as the entire nation of Italy by the year 2023. According to the Bitcoin Energy

Consumption Index, a single Bitcoin transaction sucks up 935.9 kilowatt-hours, which would be enough to power a Tesla for around 8,500 kilometers. As the ancient Romans once said, though, pecunia non olet; money doesn't stink. These days, you might say that even if your methods aren't green, dollar signs certainly are.

Billions are also being poured into vertical farming, which is what they call the herbs and salads you now see growing on futuristic supermarket shelves – or in entire factory buildings where thousands of LED lamps hang from the ceiling. The plants grow in plastic pots with their roots swimming in a nutrient solution. The principle is basically the same as in an illuminated greenhouse, only the roof is made of metal instead of glass. The U.S. company Hydrofarm, which is now valued at €1.7 billion (as of April 16, 2021), sells all the equipment required, including fans, climate-control units, fertilizer, lights, and plastic pots with fancy names like »Active Aqua Grow Flow« and »Active Aqua Root Spa«.

Meanwhile, the U.S. scientists Ermias Kebreab and Breanna Roque recently came up with a truly sustainable innovation by mixing seaweed into cattle feed, which reduced their cows' methane emissions by 82 percent. Apply that to the world's 1.5 billion cows and the 300 billion liters of pollution they produce every day

and you'll really be getting somewhere! Someone who has already changed our planet in a sustainable way is Yacouba Sawadogo, a farmer from Burkina Faso who uses an intelligent and natural method to make trees flourish in the desert. His technique has since spread to other countries, and the resulting accomplishments can now be seen from space.


While Elon Musk, Hydrofarm, and other hip green start-ups make their billions, it's hard to believe that those who really are making the world a better place are reaping the financial benefits of their developments. Helping cows burp cleaner doesn't exactly make for a sexy IPO, after all. Yacouba Sawadogo, for instance, didn't have the money to buy the forest he himself had planted when it was reclassified as valuable building terrain.

This is part of the reason why I appreciate the world of AM, which – sometimes in spite of itself – has a sustainable streak thanks to its constant pursuit of reductions in weight and material. Our industry also shows that you can make a solid living while doing our world some good, even without marketing philosophies that are only green on the surface. Plus, AM gives us the chance to raise a glass of wine together now and then – at Formnext in Frankfurt this November, for example!

Text: Thomas Masuch

Infographic: iStock/Mykyta Dolmatov

END OF ISSUE – CONTENT CONTINUES



AM Field Guide

The AM Field Guide is a hands-on introduction and provides an initial, structured overview of the complex, multilayered world of additive manufacturing processes.

+ Deepen your AM knowledge: formnext.com/amfieldguide

Formnext.TV

Insights behind otherwise closed doors, technologies, that are revolutionizing industrial production, experts-talks and interviews. It's the AM industry, brought to you in entertaining videos.

+ Have fun watching: Formnext.TV

Fon-Mag.com

Looking for more FON Mag? The digital version of the Formnext Magazine offers up-to-date reports from the AM community all year round.

+ Continue reading: Fon-Mag.com

+ **formnext**

» 16–19 November 2021
 » Messe Frankfurt
 » Further information: formnext.com

@ **CONTACT:**

» Hotline: +49 711 61946-810
 » formnext@mesago.com

📅 **SAVE THE DATE 2022:**

» 15–18 November 2022

IMPRINT fon | formnext magazine Issue 02/2021

PUBLISHER
mesago
 Messe Frankfurt Group
 Mesago Messe Frankfurt GmbH
 Rotebühlstraße 83–85
 70178 Stuttgart, Germany
 Phone +49 711 61946-0
 Fax +49 711 61946-91
mesago.com

EDITED BY
 ZIKOMM – Thomas Masuch
thomas.masuch@zikomm.de

DESIGN
feedbackmedia.de

PRINTING
 Druckhaus Stil + Find, Leutenbach-Nellmersbach

PUBLICATION FREQUENCY
 Published four times per year

Responsible for content under German Press Law:
 Bernhard Rues

© Copyright Mesago Messe Frankfurt GmbH
 All rights reserved.

ADVERTISING
 zikomm publishing UG
advertising@zikomm.de
 Phone +49 2332 95383-35

CIRCULATION
 23,500 copies

READER SERVICE
formnext-magazin@mesago.com
 Phone +49 711 61946-810



INDUSTRIAL
OPEN CHOICE OF MATERIAL
MECHANICAL STRENGTH
**ARBURG PLASTIC
FREEFORMING**
3D PRINTING TECHNOLOGY
SMALL-VOLUME BATCHES



WIR SIND DA.

More flexibility for your additive manufacturing! Our two freeformers offer everything you need for the industrial production of high-quality individual parts and small batches: different build chamber dimensions, two or three discharge units, and a variety of qualified original plastics. Also suitable for resilient and simultaneously complex hard/soft combinations. Anything's possible with our open system!
www.arburg.com

ARBURG