Customer Magazine

03|2018

BEYOND SURFACES

MANU-FACTURING

***3D printing the world:** Industry is embracing additive manufacturing*

***Surfaces in depth:** The future of coating technology*

***Team up to step up:** MTC² partners share their 3D printing visions*

oerlikon

«***Additive manufacturing is a revolution*** and is comparable with the advances brought about by the advent of semiconductor technology.»

Florian Mauerer (left), former Head of Business Unit Additive Manufacturing, and **Sven Hicken** (right), Head of Business Unit Additive Manufacturing.

ADDITION BELONGS TO THE FUTURE

Revolutionary technical innovation, a fundamentally new production method, a completely different value chain – these are three of the innumerable attributes with which additive manufacturing (AM) can best be summarized. We no longer ask the question: What can be manufactured? But instead: What does the application require? That is a truly radical departure.

Even our most modern manufacturing processes are still always “subtractive”, meaning that they involve cutting and removing material. One could say they produce waste. AM goes about things differently: rather than wasting material, it builds up, just as nature does. For that reason, AM is also referred to as “bionic manufacturing”.

AM places the material precisely where it is needed – and only there. That saves valuable resources. Equally important, it allows structures to be built up with nearly unlimited complexity and to be more functional and lighter, as well. That also saves resources – fuel in the operation of aircraft engines, for example. Blanka Szost, Head of Research & Development at the Oerlikon Technology & Innovation Center in Feldkirchen, takes us on a journey with her team starting on page 10 in this issue.

There is still a way to go in this field, however. The transition from research and development to industrialization must provide answers to important questions, such as: How can stability and traceability be safeguarded over the course of the entire process? What are the next steps in process standardization, and how can we use these to harness additional potentials for cost optimization? How can quality management be expanded commensurately?

To answer these questions requires an understanding of the entire “chain” and where it can be influenced – meaning essentially the engineering of the original material and the tuning of the physical (printing) process. What we need to move forward here is a pool of collected, reliable empirical values of the type that can be gained only through close collaboration between the end user and the manufacturer of the material and printer. The opportunities that could result from this are described starting on page 18 by Mohammad Ehteshami and Jason Oliver from GE Additive, with which Oerlikon cooperates very closely.

Prof. Dr. Michael Süß, Chairman of the Oerlikon Board of Directors, even poses the question of whether the future of European industry will “come out of a printer.” Read the article about this starting on page 26.

Amid all the excitement, we must still point out that AM does not yet always offer the ideal answer – for example, with reference to the cost-effectiveness of manufacturing or the service life of a component. “Classic” materials and processes have by no means outlived their usefulness. Quite the contrary, as Professor Thomas Lampke from the TU Chemnitz relates in the interview starting on page 6. And it is good to know that Oerlikon is able to deliver the right solutions in this area, as well.

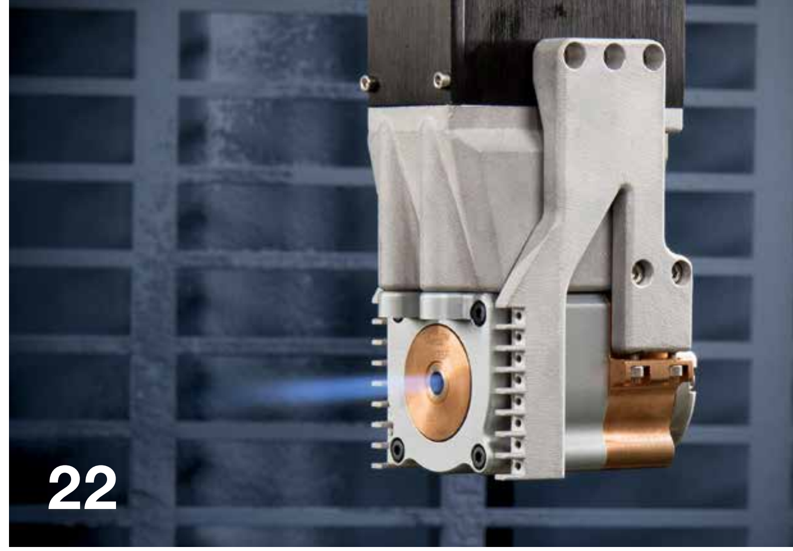
Florian Mauerer has established and developed the Business Unit Additive Manufacturing at Oerlikon over the past three and a half years. Without his passion and commitment, we would not have reached the place where we stand proudly today. Effective October 1, it has been my privilege to take the baton from him. I am now looking forward to continuing what he began, both with his outstanding team and with you, our valued readers. Let’s shape the future together!

I wish you a great deal of reading enjoyment with the new issue of “BEYOND SURFACES.”

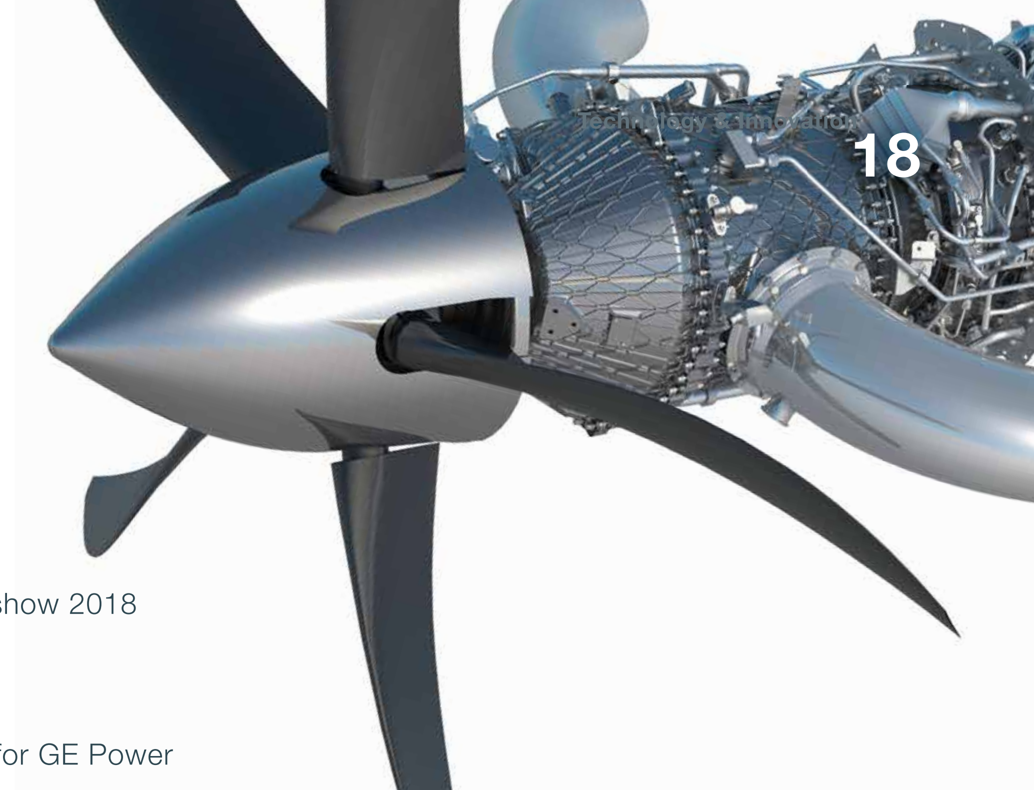
Cordially yours,

Sven Hicken
Head of Business Unit
Additive Manufacturing,
Oerlikon Group

Solutions



Technology & Innovation



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THE SURFACE OF THE FUTURE

Today's materials research reveals new possibilities through intelligent combinations

More functional and resilient. Smaller and lighter, too. These terms represent component properties that couldn't be more contradictory – yet they're part of the everyday routine for Thomas Lampke, Professor of Materials and Surface Engineering at TU Chemnitz. He told us about the answers that research and development hold in store for requirements like these.

Pursuing matters until they can be defined and understood. Spanning the range from the atom to the finished component. Fine tuning the triad of process, material structure and properties profile. These things sum up the fascination of materials research for Prof. Dr.-Ing. Thomas Lampke, Head of the Materials and Surface Engineering Group at the Chemnitz Technical University (Germany).

His path to Chemnitz was laid out shortly after the conclusion of his studies in mechanical engineering in Bremen. At the beginning of the 1990s, after the German reunification, he pursued further study and research here. Later, his post-doctoral opportunities included research activities as a visiting professor in Ontario, Canada, and Limoges, France, followed by subsequent teaching engagements in Chemnitz and at Paderborn University in Germany. During this time, the design of technical surfaces with functional properties, hybrid structures and the development of combined surface technologies got under his skin. He became intrigued by the way materials often drive innovations.

What is even more important to him, however, is the long-term perspective: research based on genuine curiosity without expected benefits as the primary objective. To safeguard current technological leads as well as prosperity, research must address society's needs, then meet them with reproducible results and valid findings from both fundamental research and application research. The "and" here is important to him: the one must not exclude the other.

Moreover, he says, research requires continuity without losing its currency. This is undoubtedly one reason why he maintains focus on what materials will promote sustainable, energy-efficient production and use of products. He is also of the opinion that this question is more sociopolitical than technical.

Prof. Lampke, what do you associate with the term sustainability in reference to materials engineering?

For me, sustainability means really thinking something through from its inception to its completion. The first thing I see is the availability of the material: Are the materials available in sufficiently large quantities? Are the deposits of these – often in crisis zones – geologically accessible, and is exploitation practicable from a political, economic and ecological perspective? What value creation is possible with these materials, especially as rare earths and noble metals are traded in a highly speculative manner on the markets? These aspects are powerful innovation drivers.

In addition to the question of energy efficiency?

Correct. Bionically optimized materials, lightweight construction – these are megatrends. From our perspective, this requires a "bivalent strategy": If we are energy efficient in production, then we want that to be just as much the case in the application. And this is where lightweight construction in terms of both materials and design can be a great help – with the right materials in the right places. This is also where the loop from availability, via the application of a component to recycling, is closed.

Is it true that modern materials must also deliver more and more performance?

One of the requirements for modern materials is indeed that with their use, the performance density of the component can be increased. With increasingly complex geometries and great cost pressure, the load profile also becomes more challenging. "Light" and "manufacturable" are only two necessary, but by no means

sufficient, requirements, even if they are the most important.

Materials need to perform better, but presumably also need to last longer?
Yes, increased service life is a big topic, which we are researching together with Oerlikon, incidentally. With systems that deliver more and more performance, for example high-performance jet engines in aerospace, an increasing number of components are subject to extraordinary thermal loading where an improvement in service life is essential. That has been accomplished today in a meaningful sense, although especially in cases like these, the requirements for performance density, longevity and robustness have grown disproportionately.

What options are available for increasing service life in this case?
One of the options we see for accomplishing this lies in a combination of surface technologies. Using various different known processes, we attempt to foster the creation of new layer morphologies and layer structures in a simple yet sophisticated manner. Initial results suggest service life increases in the two-digit percent range.

How do you solve this specifically for this application?
The investigation of aging processes has revealed that the oxygen absorption of the material must be controlled and limited. Oxidation processes alter the metallic material. The morphology changes; the material becomes brittle. Cracks can form quickly which then lead to total failure. In our concrete collaboration, we are dealing with the application of aluminum-based intermediate layers which, as an interdiffusion layer, form what is known as a TGO layer (Thermally Grown Oxide), thereby stabilizing the connection of the adhesive layer and the top layer. This suppresses the growth of undesired phases, and the barrier effect appears to be very positive.

The general area of "combined surface technologies" is a main emphasis of your research. Why?
Very frequently, the properties profile of a component – and this immediately includes the costs – can be achieved only through the use of less expensive materials, such as surface finishing and coating processes. I generally think that a process must be a means to an end and should not find its way into future process sequences based merely on the present-day know-how of a company. If progress can be achieved through the further refinement of a process, then that is one possibility. Beyond this, the interaction of different processes can be a means to an end both technologically and economically – provided that the process capability is a given.

What, exactly, does that mean?
Concretely it means that we try to combine processes. For example, by reinforcing a layer applied by means of thin film technology, PVD or CVD (Physical/Chemical Vapor Deposition) with a second layer applied using a different process. That could be thermal spraying or electroplating, for example. →

«Results can be obtained quickly, ***but that doesn't mean you have findings yet.»***

Prof. Thomas Lampke,
Professor of Materials and Surface Engineering, TU Chemnitz

«Material properties and system properties – such as corrosion and wear – are really ***two very different topics.»***

But a lot of work still needs to be done at the technique / process / material interfaces. The problem is that the respective process understanding, especially in relatively small, highly specialized companies, is present only in the discipline of one technology. And this is where we see the greatest opportunity for companies like Oerlikon: They have a command of various technologies and already use combinations of these, or are endeavoring to do so.

What are the drivers you see in particular for combining various processes?
I see one driver for combining surface technologies in the substitution of high-priced substrate or coating materials. Here it would be possible to attain very good results through applying a coating or through thermal, chemical or thermochemical treatments in combination.

Another is undoubtedly found in additive manufacturing. It will most certainly alter classic processes in a disruptive manner, but it will not be able to replace all manufacturing processes. That would be virtually impossible even for reasons of cost alone. Consequently, printed structures for high-load components will be subjected to subsequent heat treatment or surface treatment processes. The reason will be to create the component properties that are actually required. Structural properties and surface properties are actually two very different topics here.

A further application for surface engineering deals with lightweight structures. And I mean very light components, such as those based on high-performance polymers like polyether ether ketone (PEEK) or carbon-fiber reinforced carbons (CC), which we functionalize by means of thermal spraying. Based on a demonstrator, we were able to attain an outstanding result here in Chemnitz: We succeeded in functionalizing a carbon-fiber reinforced plastic (CRP), in this case based on a polyamide, using bronze, steel or INVAR multiple-layer coatings, which produced a 50 percent weight reduction as well as a reduction of thermal longitudinal expansion of up to 90 percent.

What new materials are you working with now?
There are many directions. One exciting topic is that of High Entropy Alloys (HEA), as they are known. They do not consist of one main element and a few additional alloying elements in a low concentration, but instead of a mixture in equal parts of usually four or five metallic elements. They were discovered already a number of years ago and possess exceptional strength as well as being temperature and wear resistant.

Of course, the question begs to be asked whether the properties known in the "full material" can also be transferred using surface technologies. We are conducting intensive research on this in Chemnitz. For example, in the application of entirely new materials based on high entropy alloys by means of thermal spraying.

What also seems very promising is the use of amorphous metal in surface engineering. "Metallic glass" types are usually iron-based, metal alloys which solidify amorphously and have truly unique physical properties: they are harder and more corrosion resistant than customary metals. We are now conducting research on controlling the existing advantages metallurgically and via the solidification in such a way as to maximize the mechanical and physical properties.

Have the "old" materials outlived their usefulness?
Definitely not. We are once again turning more attention to readily available and simple materials and their refinement. Even good old iron and steel have become very modern through new developmental trends. Steel, especially, is a much sought after and highly interesting material with respect to new increases in strength accompanied by sufficient ductility and toughness, availability, recyclability and the nearly inexhaustible possibilities for shaping it. For me, at least, there is no end for it in sight.

If you were to summarize the various facets of materials developments, what would be the most important from the perspective of the materials scientist?
Science is always driven by questioning and the desire to get to the bottom of things and truly understand them. Many effects and interrelationships are fundamentally known to materials science and their exploitation and transfer are frequently in focus when it comes to finding concrete solutions for challenges. That this is of great importance for surface engineering is made clear by the example of corrosion and wear. And this is not just a coincidence: Estimates reveal that the damage resulting from both corrosion and

wear causes a loss amounting to four percent each of the gross national income (GNI) – every year. For Germany, the GNI in 2017 amounted to about 3.3 trillion euros. Two times four percent makes 265 billion euros. I would consider that to be a significant amount. It is generally believed that if we were to succeed in transferring the knowledge which already exists to present applications, this loss figure could already be reduced by 20 percent.

Does that mean, then, that we actually already know how to improve materials with respect to corrosion and wear, but just don't do so?

One could say this is a problem of the cascade of knowledge: A great deal of effort is required before things that are known scientifically and are technically feasible are actually implemented and innovations are made. Of course, that might cost money initially. But the money is then saved on the other side. That means an equilibrium here would be counterproductive.

And that is one reason why linking good university teaching, fundamental research and the transfer of knowledge via "heads" into businesses is of decisive importance for Europe's business environment and to safeguard our prosperity. We offer a very attractive degree course dealing with this area in Chemnitz.

One thing is certain in any case: My team and I are excited about the future!

Many thanks for the interview.

Univ.-Prof. Dr.-Ing. habil. Thomas Lampke received his doctorate in 2001 at the TU Chemnitz. Since 2008 he has been the professor of Materials and Surface Engineering at the Mechanical Engineering faculty. He is a member of the TU Chemnitz Senate and has been the dean of the faculty for Mechanical Engineering since 2016. Prof. Lampke is also a review board member of the German Research Foundation (DFG), is active on various boards of scientific-technological associations and provides expert opinions for numerous prestigious international professional journals.

www.tu-chemnitz.de/mb/WOT

THE CONDUCTOR

For **Blanka Szost,** additive manufacturing (AM) represents an entirely new universe. She is exploring its unlimited possibilities as the **Head of Research & Development** together with her ten-member team in Oerlikon's Technology & Innovation Center near Munich.

By Gerhard Waldherr

August 3, 2018, Oerlikon's Technology & Innovation Center in Feldkirchen near Munich. At the spur of the moment, Blanka Szost was able to find a gap in her calendar for us. Three hours between team meetings, visits from customers and scientific studies – not to mention her daily attention to networking in the area of materials sciences and additive manufacturing. Professors, former fellow students, colleagues and experts from around the world make up a regular Who's Who in this young and exciting sector.

There's more to it than 3D printers and metal powders

Szost, born in 1984, is the Head of Research & Development in Feldkirchen, making her the counterpart to Shawn Kelly, who heads Oerlikon's R&D team in Charlotte. As does Kelly, Szost sees in AM "a completely new universe with virtually unlimited possibilities."

What does that mean concretely? "AM is the technology of the future," she says. "In addition to the obvious advantages, such as freedom in the design and development of new functions and materials, AM provides a sustainable and intelligent means of production that, in contrast to conventional manufacturing, doesn't create extensive waste products." Moreover, printers could be situated everywhere and supplied with powder. "At some point, we will probably even be able to print on the moon using moon dust to construct a base there."

Everything comes together in additive manufacturing, says Szost: Materials sciences, component design, production and post-processing. The fascinating thing is that "like nature, AM is capable of introducing stability and/or flexibility in parts at precisely the location where they need it." And what is R&D's role here? "Finding combinations of powder, process and materials that yield the maximum in terms of possibilities."

"At the moment, we are devoting extra attention to repeatability – the repetitive processes." And it is not just the 3D printers and metal powders that matter here, but also reliability, efficiency and quality. "AM makes the most sense with small and medium-sized production series with complex geometries that would otherwise require intensive use of machinery."

Szost has taken extra time for our visit. It starts with a tour through the Technology & Innovation Center. First to the 3D printers, then into mechanical, chemical and microscopy laboratory rooms as well as to the metal powders. Szost explains equipment and apparatuses, how AM works in a vacuum and how alloys from the printer are being investigated using Zeiss microscopes. She describes how she finds clues to unraveling the mysteries of additive manufacturing with her ten-member team of materials scientists.

And just how does the work of R&D take place? Trial and error? Szost smiles: "I would be more inclined to call it an educated guess because every single one of us contributes a great deal of knowledge."

Learning, understanding, explaining

Knowledge is what cooperation partners and customers, including the likes of Lufthansa Technik, Boeing, LENA Space or the printer manufacturers, are looking for. "What counts are the purpose the customer's product must fulfill, how many parts are needed and what working conditions prevail." This requires comprehensive understanding of the material in order to be able to provide succinct and constructive consultancy and innovative solutions. "To be honest: Not everything can be replaced by AM," because not everything makes sense. This needs to be communicated to the customer as directly and comprehensibly as possible. She adds, "'If you cannot explain it simply,' Albert Einstein once said, 'you have not understood it well enough.'"

Learning. Understanding. Explaining. That's the way it's always been. She tells us more just one floor higher in a conference room behind her office. Szost talks about her childhood in a small town in the south of Poland where she grew up with five siblings. When she wanted a radio at the age of ten, there was no money for it. She was told that she could have the broken-down television from up in the attic. With spare parts and the indefatigable energy of a hobbyist, the girl transformed the television set into a radio.

"I think time is the decisive factor in just about everything," says Szost. "When you are confronted with a complex mathematical equation for the first time, you don't understand anything. The second time, it's a bit better. The third time activates processes in your brain. And the fifth and sixth time, you begin to gain a command of the situation." →

«I always have to be learning. I always strive for ***perfection.*** And ***I'm not afraid of challenges.***»

During her doctoral work at Cambridge, she constructed the prototype of a machine. There was no other way to prove her thesis concerning a type of steel that binds hydrogen in its structure. The only comparable apparatus was located in South Korea. She worked for three months straight, 16 or 18 hours every day, until the machine was completed. “I always have to be learning,” says Szost. “I always strive for perfection.” Then she adds an important detail: “I’m not afraid of challenges.”

“I knew that AM was the next step for me”

Szost had studied the diverse facets of metallurgy, researched the atomization of powder and delved into the topics of components and surfaces. Oerlikon is leading in all three of these areas, and it is AM that connects them. As a result, she did not have to consider very long when the inquiry arrived. “I knew that AM was the next step for me and Oerlikon is the best possible place for that.” She is also convinced of the company’s DNA. “Perfection is very hard to achieve,” says Szost, “and everyone knows that. But when you strive for it, that can lead to excellence.” And that, she observes, is ultimately “one of the fundamental values at Oerlikon, which the staff endeavors to achieve.”

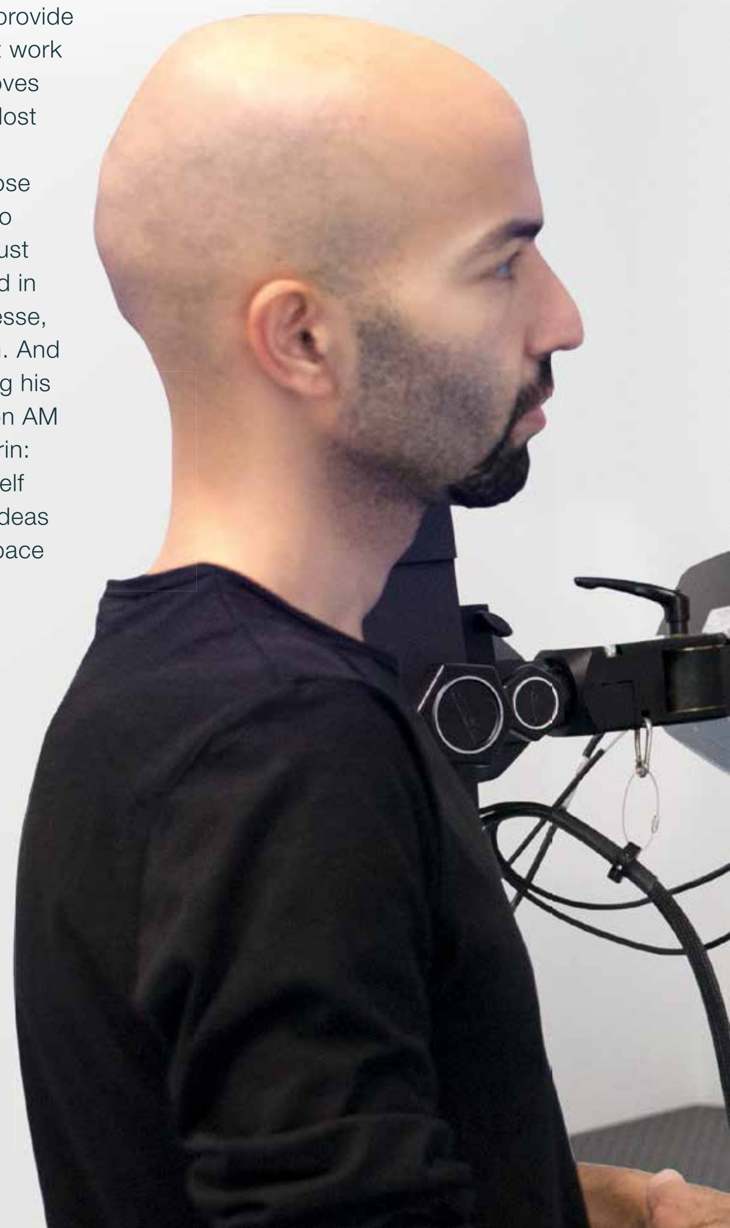
Of course, the head of R&D communicates that to her team as well. “We all believe in AM. It’s our mantra. It’s not a job in the classic sense, but rather a way of life.” Szost’s everyday routine does not follow a rigid or even foreseeable set of rules. At present, work in Feldkirchen is being conducted on 20 projects that are all in different stages of completion. Time and again, she discusses intermediate results and the current states with her team and describes customer requirements. Often colleagues simply stand in her office door, which is always open. They come around with a question, a suggestion or a new discovery.

“I have outstanding people here,” says Szost, “a highly talented team.” They are all young people from various countries with different professional and cultural backgrounds. The common denominator: “They all love the technology and are passionate about taking on challenges. They should share their expertise and exploit the potential of their professional, national and cultural diversity.”

Everything depends on the team

“The team is the foundation,” says Szost. “Communication and coordination are the key to its success. We need to empower people – that’s the only way for them to contribute their best. But we also need to provide structure to enable efficient work processes.” Anyone who loves technology is prone to get lost in the jungle of details from time to time, and thereby lose their orientation. “There’s no doubt that sometimes we just have electrons flying around in our heads,” says Olivier Messe, who is part of Szost’s team. And Marius Knieps, who is doing his doctoral work at Oerlikon on AM alloy design, adds with a grin: “I have already caught myself fantasizing about how my ideas will revolutionize the aerospace industry in 20 years.”

“Four highly qualified emails on a certain topic are of no use,” explains Szost, “if the people haven’t coordinated their efforts to work in a common direction.” An orchestra, she muses, in which everyone plays what they want will never produce a symphony. Consequently, the department head requires that everyone talk to each other, and that they listen and acknowledge the contributions of others so that trust and a team spirit are created. That applies to her, as well. “She guides us like a conductor,” says Messe. “She has a great deal of experience, is unbelievably qualified, warm-hearted and friendly, but can also be strict when necessary.” And that is the way it needs to be. The conductor needs her ensemble as much as they need her.



«We all believe in AM. ***It's our mantra.*** It's not a job in the classic sense, but rather a way of life.»

Dr. Blanka Szost
Head of Research & Development
Oerlikon AM

Dr. Blanka Szost was born in Muszyna in the Voivodeship of Lesser Poland. After being fascinated by a lecture delivered by a professor, she studied materials sciences in Krakow and finished in June 2008. She subsequently applied for and was awarded the prestigious Vulcanus Scholarship in Japan, where she worked with the JFE Steel Corporation until August 2009. When the manager there saw Szost reading a book by the famous materials scientist Sir Harshad Bhadeshia, he encouraged her to apply for a research project at the University of Cambridge. From October 2009 to September 2012, she was engaged in doctoral studies at Cambridge under Bhadeshia dealing with the topic of "Hydrogen Trapping and Mechanisms." From December 2012 until November 2015, Szost worked for the European Space Agency in Noordwijk, The Netherlands. Afterward, she moved to Johnson Matthey in Reading, Great Britain. Since 2017, she has headed the R&D Competence Center at Oerlikon in Feldkirchen near Munich. Blanka Szost has been the recipient of ten scholarships and awards and has published eight scientific works.

MANUFACTURING
INDUSTRY

Manufacturing technology is as diverse as the use cases for which its products are employed. The processes involved are subdivided into **six main groups according to DIN 8580.** Typically, a workpiece will go through several of these on its way from its raw state to becoming a finished product. The history of manufacturing technology is nearly as old as that of mankind and finds itself in a process of constant change. Currently, manufacturers are busy with the networking and digitalization of their factories, often summarized with the keywords **Industry 4.0 or Smart Factory.** This development is accompanied by a great deal of confidence, but also by uncertainties.

MANUFACTURING PROCESSES ACCORDING TO DIN 8580

PRIMARY SHAPING
A fixed shape is created out of a shapeless material (liquid, powder or ductile).

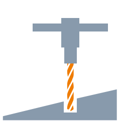
Examples: Casting, sintering (additive manufacturing), burning, baking

METAL FORMING
The shape of a workpiece is modified while the net amount of material remains the same.

Examples: Bending, forging, drawing, pressing, metal spinning, rolling

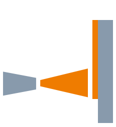
JOINING
Two or more workpieces are permanently connected at joints

Examples: Welding, soldering/brazing, gluing, screwing, riveting



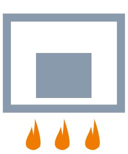
CUTTING
The shape of a workpiece is altered by removing material.

Examples: Separating, cutting, erosion



COATING
A permanently adhering layer is applied to a workpiece to improve its surface properties.

Examples: Painting, galvanizing, powder coating, hot-galvanizing



MATERIAL PROPERTIES
The properties of a material are influenced to improve the ease of processing or to optimize the actual application.

Examples: Annealing, hardening, heat-treating, tempering, austempering

Cobots,

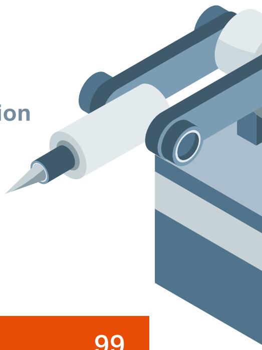
or collaborative robots, work together with humans in their immediate proximity and are not fenced off. In some use cases, they can help to **reduce the error rate from the two-digit range down to only 1%.**

Source: EEF

1,768 3D printer systems

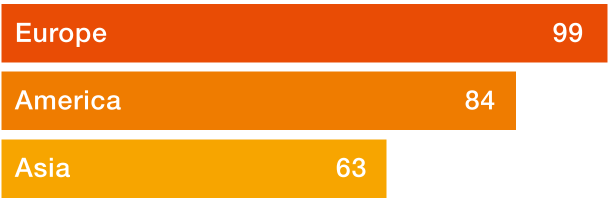
for metal were sold in 2017. This represents an increase from 2016, when the figure was 983, of about **80%.**

Quelle: Wohlers Report 2018

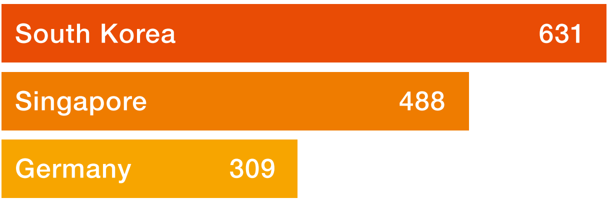


74 robot units

per 10,000 employees were in use on average in 2016.

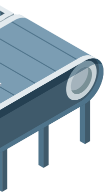


Per country comparison:

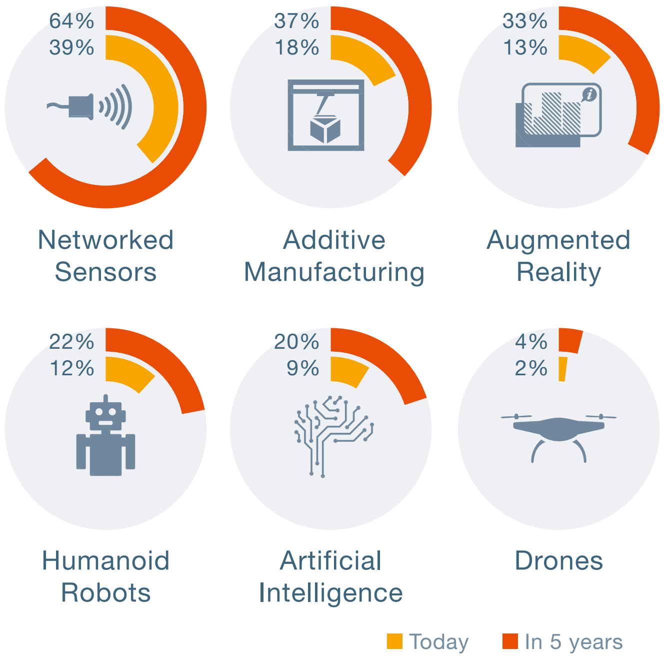


While in 2016 there were 1.82 million robots, in 2020, **3.05 million** units are expected to be in operation.

Source: International Federation of Robotics (IFR)

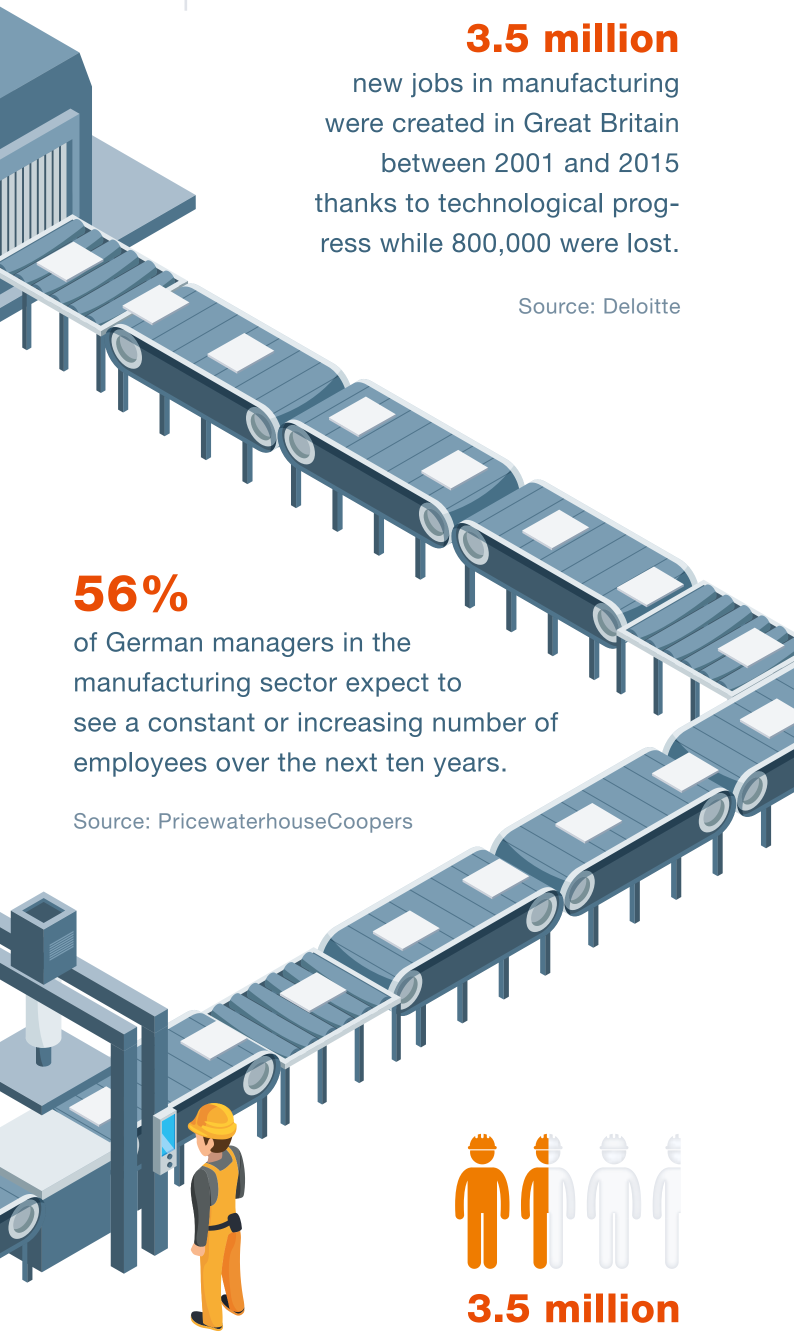


According to a poll of about 200 German managers, the use of many digital technologies will increase significantly in the next five years:



Source: PricewaterhouseCoopers

INDUSTRY 4.0
OPPORTUNITY OR RISK?



3.5 million
new jobs in manufacturing were created in Great Britain between 2001 and 2015 thanks to technological progress while 800,000 were lost.

Source: Deloitte

56%
of German managers in the manufacturing sector expect to see a constant or increasing number of employees over the next ten years.

Source: PricewaterhouseCoopers

3.5 million
workers will be needed in manufacturing in the next ten years according to estimates in the USA. At the same time, it is assumed that 2 million jobs will remain vacant due to inadequate qualifications.

Source: Deloitte

ADDITIVE ADVOCATES:

MOHAMMAD EHTESHAMI AND JASON OLIVER

By Randy B. Hecht

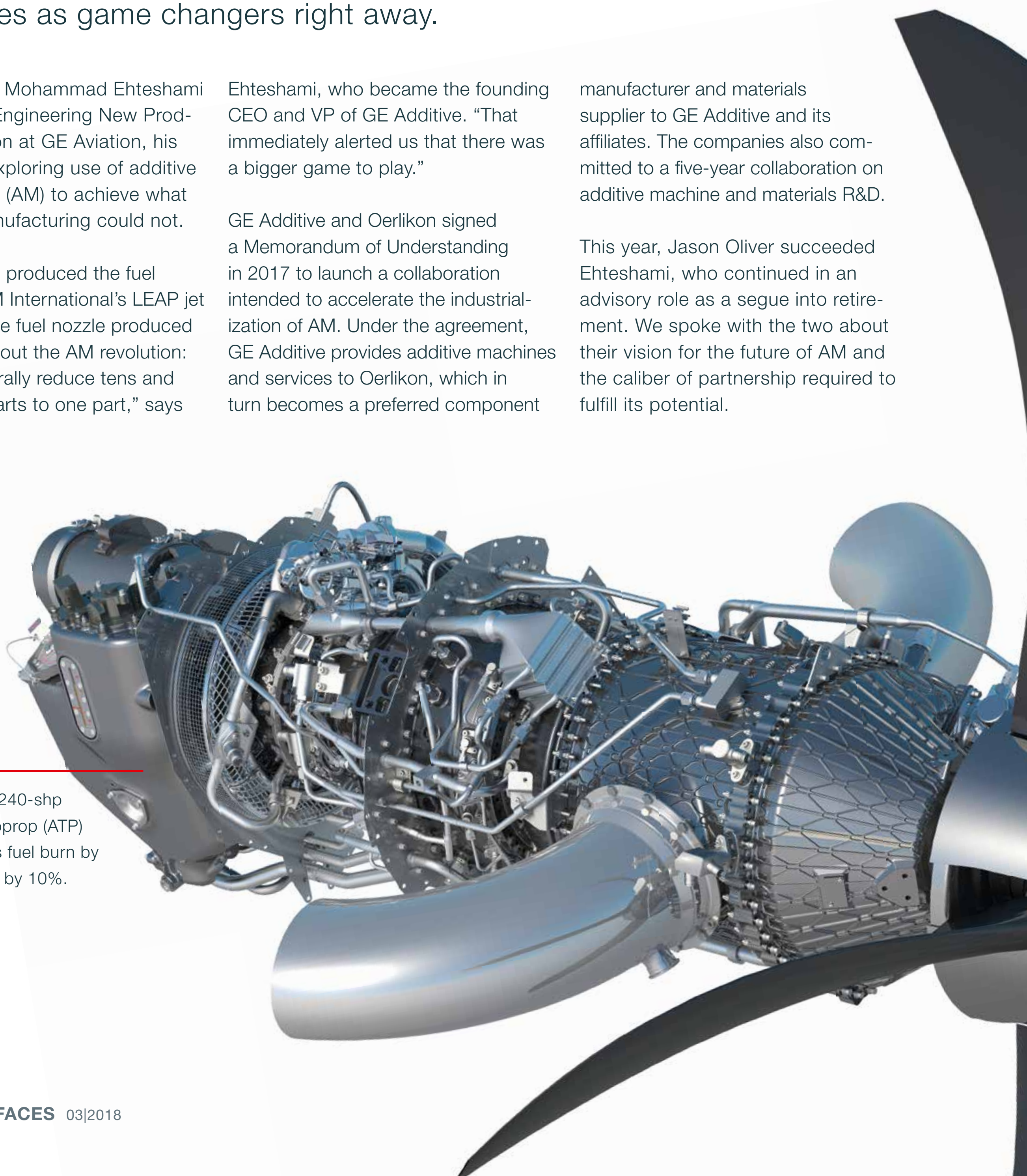
Some **R&D breakthroughs** reveal their impact slowly. Others announce themselves as game changers right away.

In 2011, when Mohammad Ehteshami was Head of Engineering New Product Introduction at GE Aviation, his team began exploring use of additive manufacturing (AM) to achieve what traditional manufacturing could not.

This early R&D produced the fuel nozzle for CFM International's LEAP jet engine. And the fuel nozzle produced a revelation about the AM revolution: "You could literally reduce tens and hundreds of parts to one part," says Ehteshami, who became the founding CEO and VP of GE Additive. "That immediately alerted us that there was a bigger game to play."

GE Additive and Oerlikon signed a Memorandum of Understanding in 2017 to launch a collaboration intended to accelerate the industrialization of AM. Under the agreement, GE Additive provides additive machines and services to Oerlikon, which in turn becomes a preferred component manufacturer and materials supplier to GE Additive and its affiliates. The companies also committed to a five-year collaboration on additive machine and materials R&D.

This year, Jason Oliver succeeded Ehteshami, who continued in an advisory role as a segue into retirement. We spoke with the two about their vision for the future of AM and the caliber of partnership required to fulfill its potential.



GE Aviation's 1,240-shp Advanced Turboprop (ATP) engine improves fuel burn by 20% and power by 10%.

How did your initial assessment of AM's potential compare with the capabilities you see in AM today?

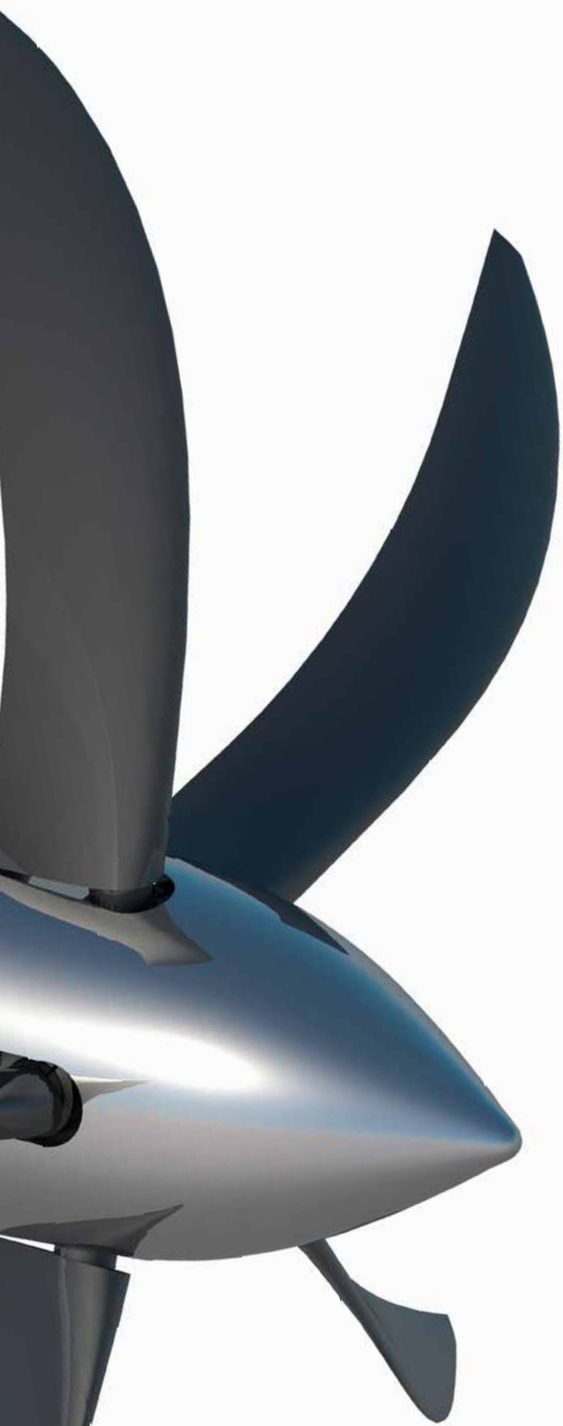
Mohammad Ehteshami (ME): The initial impression was, this is disruptive, and you really have two choices: to be disrupted, or to disrupt. What we've seen so far has actually exceeded my original impression. As an example: We have now a GE Aviation jet engine that is about 30% printed. We took 855 parts and reduced them to 12, and that engine is running now. It's called GE Catalyst. You need a couple of years for your tooling to create a cast part. Then you have to do significant machining and defect elimination to make that cast part ready for use. AM reduces almost all that by a factor of ten. You don't need the tooling. You just take the design and print the part.

Do we now fully comprehend AM's capabilities, or are we still discovering and developing its potential?

ME: We were developing additive for five or six years before we started to think of creating our own business plan to become a vertical inside GE. Now we have three different modalities of machines inside GE Additive: the laser, electron beam and binder jet machines. We have printed about 30,000 parts that are in the field in GE, and with each of these modalities, we're finding new capabilities almost every quarter.

What is your vision for the industrialization of AM?

Jason Oliver (JO): I think industrialization with use of AM is really going to take off in the next couple of years as →



«You really have two choices:
to be disrupted, or to disrupt.»

Mohammad Ehteshami,
former CEO and VP of GE Additive

Mohammad Ehteshami (l.) and Jason Oliver (r.)

major events happen – a major shift in the performance of a car, for example. That's when true industrialization will spread. A couple of events in the next year or two will drive industrialization by driving the interest level of all kinds of companies, and they will really start to dig in and educate themselves. That is the answer: It's about educating everyone about what the potential is.

What are your priorities in the industrialization process?

JO: For me, it goes back to the need to educate the world. We have a major program working with universities and schools where we donate AM machines, both on the polymer side and the metal side.

We're also looking at industries where we see big potential, and we're trying to help them understand how embracing it – designing with additive in mind – will change the fundamental performance of products. It's not just replacement of a manufacturing method. It's an actual disruption of products themselves, making them better, more efficient, cheaper, lighter. We're going to help industries that need those kinds of things to identify the potential and get them moving into additive.

ME: The process is the creation of an eco-system. You don't want to print an existing thing, because there's very little advantage there. You take advantage of it when you redesign for additive manufacturing. You get better performance, lower costs, lower number of parts, lighter and more durable parts. GE Additive engineers can help design, install the machine, provide powder, create the inspection and quality process and create an eco-system for our customers.

Does that set up blueprints that can carry over from aviation and aerospace into automotive or other industries?

ME: Yes and no. Yes in terms of production, industrialization and volume. No because aviation is a regulated industry. Once you create a design, it is controlled by the FAA or some other authority figure, just as medical is controlled by the FDA. You don't have the equivalent in other industries. In the auto industry, you can have parts created by anybody and everybody as long as they meet certain criteria. That's what I'm talking about when I say a regulated industry versus an unregulated industry.

Similarly, materials that cut across these industries in some cases are very similar or identical. In other cases, they are completely different. Titanium is used for implants in the medical industry and is also used in aerospace, but very little is used in the auto industry or in energy. On the other hand, aluminum can go across aviation, automotive and many other industries.

JO: As you move into some of these less regulated industries, cost becomes a major factor. AM and those of us who supply its components will have to get much more focused on how you get costs down to the barest levels. We need to get the speed of machines up. We need

«Anybody who assumes they’re going to do this themselves is going to lose. ***We have to be partnered*** with a range of companies and customers to be successful.»

Jason Oliver,
CEO and VP of GE Additive

to get costs of powder down. The whole eco-system has to flow and be automated. Our need to get into those industries is driving us to make those improvements.

Jason, which elements of Mohammad’s vision will have the most long-term impact on GE’s AM work?
JO: First and foremost is his vision to always push technology. He’s one of the primary reasons why GE Aviation has deployed AM so successfully. It’s the focus on continuing to drive technology that’s now a part of the culture that he’s established. That’s a phenomenal place to be in when you’re a large startup, as we are, in a very early industry like AM.

Number two is his just get it done philosophy. Mohammad’s vision was not just to create a company that pushed the levels of where additive is. It was more about creating a company that had an impact on the world. I’m a huge believer in what AM is going to do to change the world.

How do you hope to emulate his leadership?
JO: He’s very motivational, and I try to emulate that. He gets people to want to do things and want to move forward and go aggressively. And the other piece is having fun. It’s hard to find Mohammad on a bad day. It’s something I want to continue to emulate.

Mohammad, which elements of Jason’s vision make you most enthusiastic about watching future AM developments and advances at GE?
ME: Number one, the fact that he comes from doing a lot of work on startups. He has played the whole spectrum, and he has this incredible amount of energy. The second part of it is, he understands the front end of the business a lot more intrinsically than I would, and that’s a huge play for GE Additive. We have a lot of engineers who understand the technical part of it. But we didn’t have a businessman who understood the printing and what a startup should look like. Jason brings that capability to our team.

You have commented about the transformative power of AM. Are collaborations key to achieving that transformation?
ME: Collaboration, competition and accommodation will transform any new technology – but AM in particular, because it is so disruptive and because it touches all elements of both manufacturing design and the business model. Oerlikon and GE Additive can truly bring this to fruition.

JO: The technology impacts so many parts of the business, from design to manufacturing to digitization of everything in the business. Anybody who assumes they’re going to do this themselves is going to lose. We have to be partnered with a range of companies and customers to be successful.

What characteristics do you look for in those partners?
JO: Number one, a vision. It’s great to talk to guys like the Oerlikon team who are all in on AM. That’s number one, because GE is all in on AM as well. Number two is the quality of the leadership, the levels of trust, and generally, that those leaders are driving their teams in a similar direction to where we want to go. It could be markets. It could be the technology and the use of the technology. And number three is whether there’s a common understanding around business models: what the partnership looks like.

How far do you envision this partnership will be able to go, and what do you envision being able to achieve through this partnership?
JO: The goal is to help both companies continue to lead in AM. We will keep developing the partnership because we are convinced that Oerlikon and GE will equally benefit from the success we have in the space.

Innovation, collaboration and new additive manufacturing create

UNIQUE SPRAY GUNS

By Erik Sherman

According to an old saying, what is difficult can be achieved at once.
The impossible takes a little longer.

Coating solutions supplier Oerlikon Metco faced that challenge in high velocity oxygen fuel (HVOF) coatings, which protect mechanical parts under demanding conditions. Important applications were impossible with existing spray equipment. Interdepartmental cooperation, innovation, and additive manufacturing enabled new technology to go where no HVOF spray gun had gone before.

Jet-propelled coatings
In mining or oil and gas, dirt and grit invade small spaces and act like abrasives, grinding parts down. Turbine blades face temperatures that get hot enough to melt steel. Pistons, pumps, shafts, cams, valve seats, and many other devices face the friction of use and contaminants.

HVOF coatings – from as thin as a fine human hair to as thick as ten millimeters – protect these mechanical parts and others. Whether tungsten carbide, a chrome alloy, cobalt, stainless steel, copper, or a materials science development, HVOF coatings help machinery resist water, corrosion, oxidation, or heat. Some coatings even restore damaged existing surfaces.

The 30-year-old HVOF process is supersonic, as oxygen and fuel ignite and then mix with metallic powder. The molten powder spray jet moves faster than the speed of sound to cover the target metal surface. The result is a dense coating that bonds tightly.

“When you mix the powder with the fuel and oxygen, melt it and then project the combination, it’s like spray painting with a rocket nozzle,” said José Colmenares-Angulo, project leader at Oerlikon Metco.

There are other benefits. Coatings create stresses on the target surface as they cool. An HVOF spray gun can tailor the stresses, unlike other technologies. The technology can also apply coatings that replace hard-chrome that otherwise requires an electroplating process that creates toxic byproducts.

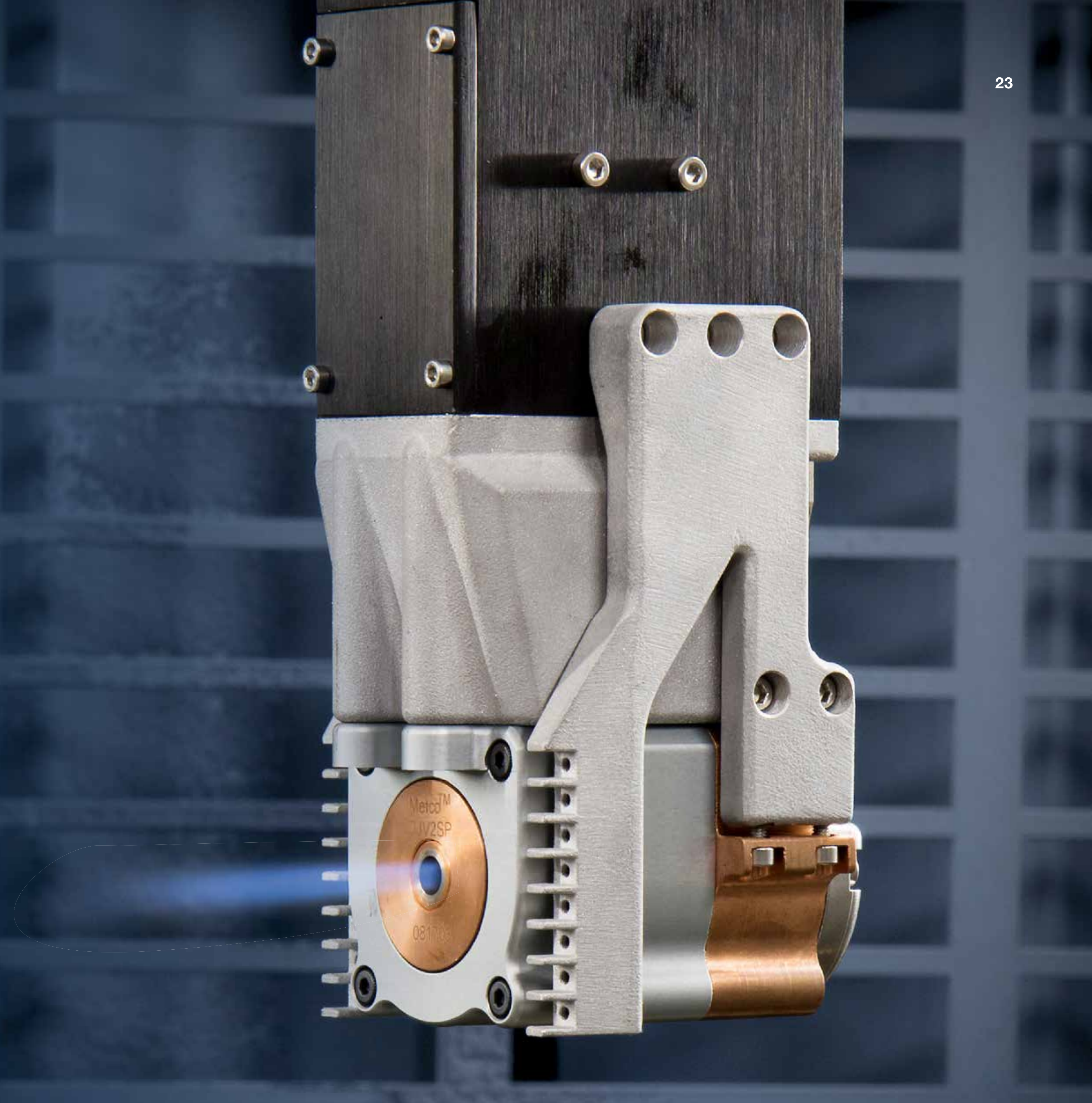
Too small to spray
HVOF has traditionally used large spray equipment – fine for the face of a turbine blade, a piston, hydraulic rod, or other exterior surfaces.

But for interior surfaces like the inside of a cylinder, HVOF spray guns present a challenge. “Normally, an HVOF gun sprays at least 12 inches from the surface,” Colmenares-Angulo said. “You can’t do that in a cylinder.” But customers want the technology’s advantages in those applications.

Oerlikon Metco had a 9-inch gun that sprayed at an angle to reach interior spaces: an improvement, but still too large. So, the company decided to create the Diamond Jet™ Vortex spray gun, which could deploy HVOF technology in more confined spaces. “The main aim was to work in smaller spaces,” Colmenares-Angulo said. Customers wanted equipment that was simple, so it was easy to use and reliable to avoid production delays.

In typical spray gun designs, oxygen and fuel combine in a combustion chamber to heat and accelerate the powder before the spray nozzle expels the molten material onto the target.

The new Vortex gun had to spray less than two inches from the target surface, giving less time to mix the combustion gases. Powder had

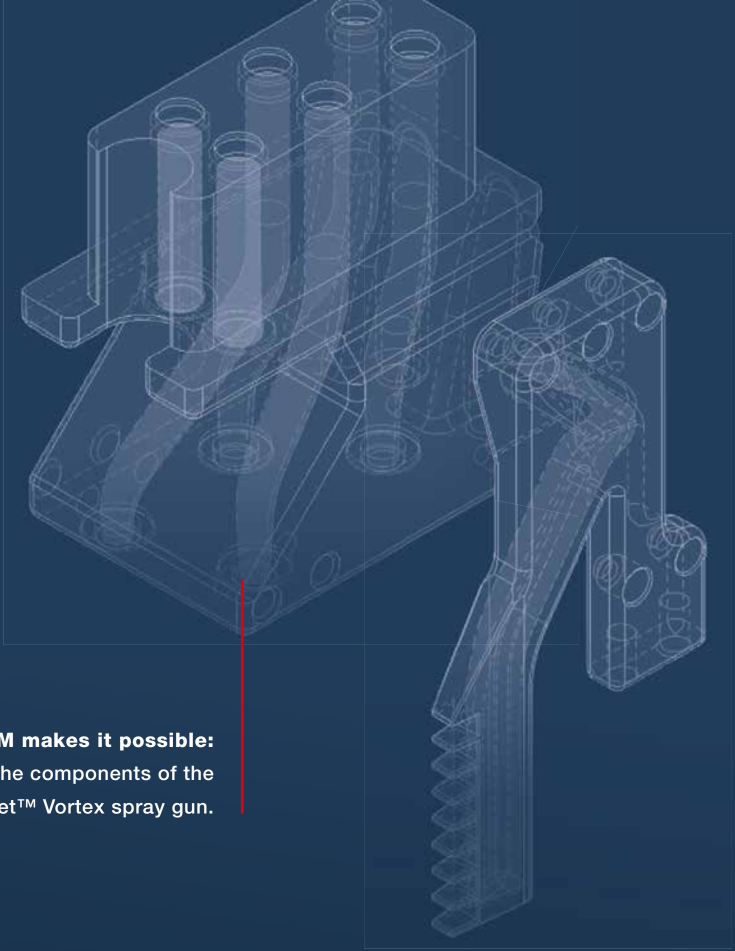


«You have cooling channels that turn 90 degrees and other things that ***couldn’t be done without additive manufacturing.***»

José Colmenares-Angulo,
Project Leader, Oerlikon Metco

«We're going to have the know-how to ***develop what customers need*** in the future.»

José Colmenares-Angulo,
Project Leader, Oerlikon Metco



AM makes it possible: The components of the Diamond Jet™ Vortex spray gun.

at most a third of the time to melt than in older spray guns. "We had to change the fluid dynamics of the combustion," Colmenares-Angulo said. "That required a lot of technology that the older guns didn't use."

A product of collaboration

Success depended on collaboration among R&D departments for equipment, materials, and additive manufacturing across multiple locations in two countries.

Oerlikon Metco acquired a patent for a new way of combining the fuel, oxygen, and metal powder. The new gun swirls the oxygen in a vortex through a chamber to increase linear space available for the powder to melt while minimizing the length of the gun.

Traditional machining created the nozzle of copper: a critical material choice to dissipate heat quickly enough to prevent it from melting during use. But the entire spray gun needed a dual cooling system. That's where additive manufacturing (AM), commonly called 3D printing, entered.

Water channels surrounded the nozzle to pull heat away. Air channels helped control the temperature of the workpiece being sprayed, so the coating could cool quickly enough.

However, standard machining couldn't create necessary shapes. "You have cooling channels that turn 90 degrees and other things that couldn't be done," Colmenares-Angulo said. AM could precisely deposit bits of melted material to create the complex cooling channel shapes without further machining. The system could also be smaller and lighter, both extra benefits.

Challenges and valuable lessons

AM also reduced the cost of creating the multiple prototypes necessary during development. Even with sophisticated engineering software to model the complex fluid dynamics, it still took experimentation with models to develop the final design.

The device also had to work with existing industrial spray controllers that manage the process, so customers didn't need to replace them. The result: new applications for established technology and many insights. "We learned a lot about combustion and fluid dynamics," Colmenares-Angulo said. Oerlikon Metco also had the opportunity to see how this new type of spray gun might work with different gas mixtures, materials, and applications. "We're going to have the know-how to develop what customers need in the future."

STRONGER TOGETHER

Oerlikon expands its **portfolio and expertise**

ADDITIVE MANUFACTURING FOR AIRCRAFT

Cooperation with Lufthansa Technik

More flexibility and cost savings in the areas of procurement, manufacturing, warehousing and supply chain management: These are the objectives for the cooperation between Oerlikon and Lufthansa Technik. The companies are partnering on a study whose aim is to develop stable (and thus repeatable) processes for the application of additive manufacturing (AM) in the maintenance, repair and overhaul of aircraft. To that end, the companies will design sample component geometries for production on identical printers at three locations worldwide – in Charlotte, USA as well as in Barleben and Hamburg, Germany. In order to examine the reproducibility reliably, the printers will use the exact same process parameters and powder specifications. The companies will then provide the study results to the respective industrial bodies as a means of supporting the definition of standards for qualification and approval of aircraft components from the AM sector. “Together with Oerlikon, we will be able to establish the planned worldwide network of AM repair centers more quickly,” says Bernhard Krueger-Sprengel, Vice President of Engine Services at Lufthansa Technik.

DESIGN ADVANTAGES IN ASTRONAUTICS

Partnership with RUAG Space

RUAG Space, a leading supplier for the astronautics industry in Europe, and Oerlikon affirmed their collaboration at the Farnborough Airshow 2018. They are already working together on a bracket to be applied to the payload fairing of the European Ariane rockets. It will be produced by means of additive manufacturing, which allows for design optimizations. The solution is projected to reduce costs by one fourth and weight by one half and to double the stiffness. Effective immediately, the companies also seek to jointly develop processes and standards for the metal-based additive manufacturing of space flight components. An additional aim is to refine existing alloys for AM and to develop new metal materials.

Dan Johns, CTO Oerlikon AM; Florian Mauerer, former Head Oerlikon AM; Michael Pavloff, CTO RUAG Space and Franck Mouriaux, Chief Engineer Product Group Spacecraft, RUAG Space

GROWTH IN MEDICAL AM MARKET

Acquisition of DiSanto Technology, Inc. (DTI) from GE Additive

Oerlikon AM acquired DiSanto Technology, Inc. (DTI) from GE Additive: DTI specializes in manufacturing orthopedic implants for hips, knees, spines and extremities, which it supplies to orthopedic OEMs, including the top five in the US. Announced on June 1, this acquisition enables Oerlikon AM to establish a stronger presence in the medical market at a much faster pace, where regulatory requirements and specific medical capabilities are high barriers to entry.

Additively manufactured medical hip implant.

PRINTED IN EUROPE

Will the future of European industry come out of a printer?

Prof. Dr. Michael Süß has been Chairman of the Oerlikon Board of Directors since 2015. BEYOND SURFACES met with him in his home town of Munich. We spoke with him about the **potential and the perspectives for additive manufacturing (AM)** and how Oerlikon seeks to position itself in this new business segment. We became acquainted with a man who thinks simultaneously in terms of both business management and economics. And whose special strength is the ability to enthuse and draw people together for a common goal.

Mr. Süß, when did you first encounter a 3D printer?
That must have been in 2006 or 2007, when I was still with Siemens. A staff member involved in the maintenance business in the USA suggested acquiring a holding in a company that manufactures components in the additive sector. I took a look at it and was impressed immediately.

What were you thinking at that moment?
It was less a clear idea than a collection of possibilities that this new technology could offer. I was overwhelmed by the potentials, but even more so by the business models that I could envision behind them. I was fascinated and realized immediately: This is a technology that will make a lot of things possible and bring fundamental changes.

Why?
AM is far more than an improvement of existing processes. It fundamentally changes our understanding of industrial manufacturing. It's as though we turn a minus into a plus. We no longer machine material away, but build something up in layers. This creates products with completely different material properties and designs with entirely new shapes and inner workings, including cavities and curved channels. We can build complex honeycomb structures, imitating nature, which would be totally impossible with conventional milling and casting techniques. Moreover, prototyping is shortened decisively and printing can be carried out virtually anywhere. All of these factors open up new possibilities for businesses and customers alike.

Businesses in the automotive, aerospace and medical industries, to name only a few, have been producing by means of AM for quite a while. What positioning in the market does Oerlikon envision?
We want to be a supplier of services ranging from development right on to manufacturing. One of our strengths here is that we have outstanding materials competence that has been built up over the course of many years. We also have a broad range of industry know-how gained through cooperation with many customers, and we can use that to make further contributions. We are unique in the area of AM because we cover the entire process sequence. This enables us to meet the demands of not just a few business cases, but rather, many – much like a subcontractor that serves customers in a diverse spectrum of industry sectors. With AM, we can create new realities. The ability to create something new is attractive and has always been especially motivating for me.

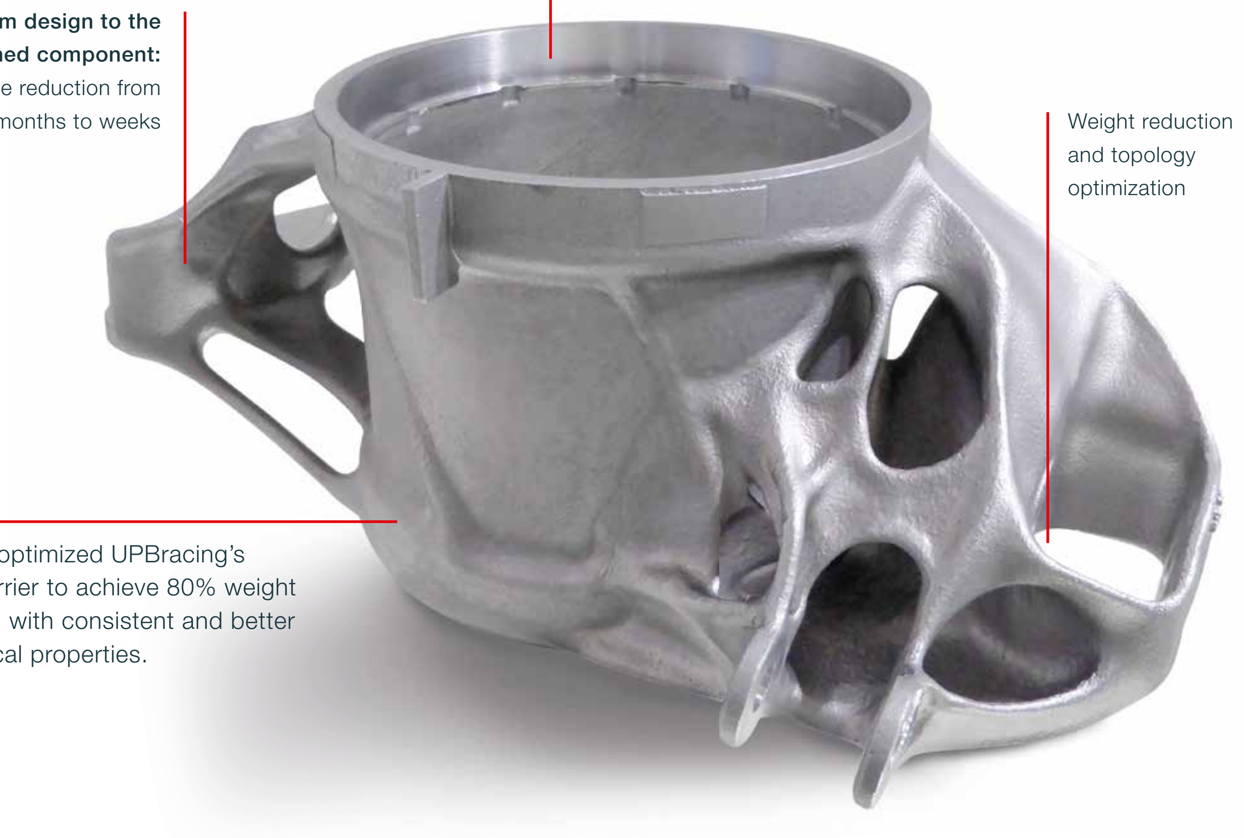
What realities will additive manufacturing create?
In my mind, it is definitely one of the technologies that will change the world. For me, AM is revolutionary at a level similar to that of the invention of the Internet. It's not possible to estimate exactly how fast this will take place and how radical it will be. But I consider AM to be one of the physical arms of the digital revolution in industry. It will alter the face of industrial production in the long term.

When?
It has already begun.

Although there is not yet any reliable process sequence? Although the technology and machinery generation is only just now taking form? Although many AM-capable materials are only in the developmental stage and there are many open legal questions?
Those are the usual teething troubles. It is entirely normal for new technologies to develop slowly at the beginning. The first wave of hype concerning AM has already come and gone. Many have taken initial steps, but the technology was not yet advanced enough for a fixed integration into the production process. Today, the printers are better, we know more about the materials, we have more appropriate software across the whole process range and the players on the market have taken their places. The time is now ripe for AM to take off. Consider similar developments, such as mobile telecommunications. My first cell phone in 1993 for example felt like a brick. Then came email, then text messaging. Today, nobody types in a message on their cell phone – they speak it. We will experience a similar evolution with AM. The business segment today is already noticeably more serious, down-to-earth and stable than it was ten or fifteen years ago. Large and small companies alike have understood that this is a technology no one can afford to ignore.

What is currently the greatest challenge?
The question: How can we improve productivity? And that's not a matter just of the printer, but of the entire production process.

How can Oerlikon as a medium-sized company achieve its ambitious objectives?
By considering well where we are going to invest our money and which allies we will choose. That is why we have engaged in a cooperative effort with General Electric, a company →



Oerlikon optimized UPBracing's wheel carrier to achieve 80% weight reduction with consistent and better mechanical properties.

that is many times larger than we are. In doing so, we have made an agreement to be mutually preferred partners for each other and to engage in joint research. We collaborate with three universities, including the TU Munich. Beyond this, we have a very close cooperation with the governmental sector, which plays a central role for the development of AM. In the end, the right balance of partnerships, cooperations and networking will prove to be decisive.

You have referred to AM as an opportunity for Europe to regain value creation from low-wage countries in Eastern Europe or Asia. Could you explain that, please?
It is especially the countries with higher engineering competence that AM affords the greatest opportunities. If they are able to further develop the technology and know-how, they will benefit from the next wave of industrialization. And then, wage costs will be moved into the background while increased productivity comes into the foreground; intelligence beats costs. This is because the low wages at the machine are then no longer the decisive factor for effectiveness in production. Our production lines will become more and more complex in the future. That means we need competence in the form of good people who can keep this highly productive process running. And technology and a workforce also require capital.

But both of these are not found in western industrialized countries alone.
Principally speaking, AM allows industries to be established in any country. But that can be done faster and more successfully in a core industrialized country where the necessary structures, ways of thinking and the workforce are already established; then, all you need to do is take all that to the next level. Who can access capital most easily? Highly developed societies. The poorer the society, the higher the interest rates and the more expensive the capital is. Where can I find top people? In countries with a high educational level.

Consequently, it is no coincidence that Oerlikon's AM Technology Center is located in Munich, as is the Munich Technology Conference, which is expressly dedicated to the topic of AM and brings commerce, science and government together.

We have every type of industry in this region: Audi and BMW, two automobile manufacturers; MAN, Krauss-Maffei in the defense sector; Infineon in the chip sector; Airbus and MTU in aerospace; specialists in health care and a good deal more. We have two large university clinics and 13 universities in total, including the TU, one of the most acclaimed of its type. Virtually every type of opportunity to test and employ the technology in a diverse array of industry sectors is present here. In addition, you have an outstanding infrastructure and an international airport. On top of all that, you have a state government that has always had a modern perspective and been open to the needs of industry. It is precisely this triad of commerce, science and government that convinced us to open our AM Innovation Center here and to conduct the Munich Technology Conference with the TU Munich as our partner.

How are you able to utilize these conditions concretely?
By actively approaching companies, by talking with them about how we can move things forward together through the use of additive manufacturing in industrial production, in robotics technology, etc., and even in design. We do this in as many economically potent clusters as possible in Europe, the USA, Russia or in Asia. We have established the prerequisites for driving this topic forward in Munich as well as at five additional locations. Many of the developments in the digital world reveal that the value of a system becomes greater the more players are involved. This is why we need to consciously focus on cooperation and networking so that as many as possible benefit from economic developments. But that's not something you can achieve overnight or with a mindset that's governed by quarterly results. It takes five, eight, or ten years of consistent pursuit.

That is the way economists talk, but not managers.
If you ask me, we desperately need more managers with a mindset that accommodates the broader economic picture. Not only do I as a person need to make a contribution from an economic perspective, so do entire companies. That is the only way to create the boundary conditions for successful business administration and maintain them long-term. This includes good educational opportunities, a reasonable measure of social peace, as well as incentive for advancement in society and a social safety net. And, of course, a good bit more. For my taste, this kind of thinking is far too underdeveloped among managers. The really clever ones are those who do the right thing and also earn a profit while doing so. That is a constellation in which I want Oerlikon to be involved. I will mobilize all of my knowledge and ability to make that happen.

«Our production lines will become more and more complex in the future. That means ***we need competence in the form of good people*** who can keep this highly productive process running.»

Prof. Dr. Michael Süß, born in 1963 in Munich, studied mechanical engineering at the Technical University of Munich (TUM). During his studies he started working in the foundry at BMW, where he also began his professional career in 1989 as a production engineer. Alongside his professional commitments, he received his doctorate (Dr. rer. pol.) in 1994 from the Institute for Industrial Engineering and Ergonomics at the University of Kassel, Germany. After positions with BMW, Porsche and Georg Fischer, he was the CEO at MTU Aero Engines AG and a key player in their stock market launch. In 2006, he moved to Siemens AG. In his position as CEO of the Energy sector, Süß actively participated in the debates concerning how the energy transition could be accomplished in Germany safely, sustainably and, especially, in a financially manageable manner. He attained a good reputation as a well-networked manager capable of strategic action and with a global mindset.

In 2015, Michael Süß was appointed to the chair of the Oerlikon Board of Directors where, since then, he has developed additive manufacturing as an independent business segment. In addition to his activities at Oerlikon, Süß is, among other things, a lecturer and honorary professor at the TUM. He is married, the father of four children and lives with his family on Lake Starnberg.

THE DREAM OF FLIGHT

OERLIKON AT FARNBOROUGH INTERNATIONAL AIRSHOW 2018

People have been dreaming of flying since the early 19th century, when Albrecht Ludwig Berblinger became the first person in the world to build a functional glider in Ulm, Germany. Owing to poor weather conditions, his initial journey did not end so well, with Berblinger falling into a river – much to the crowd's amusement. Around 100 years later, in 1903, the famous Wright brothers succeeded in building the first engine-powered aircraft and completed a sustained and controlled flight. This important invention ensured their names would go down in history.

Nowadays, the aerospace industry represents one of the fastest growing markets in the world. Each year, 3.8 billion people travel by airplane – equivalent to over half of the world's population. And this trend continues to grow. The Farnborough International Airshow (FIA 2018), the world's second biggest air show, celebrated this passion for flying with its special event from July 16 to 22, 2018. Altogether, around 150 of the newest aircraft models were on display. Over 80,000 visitors and over 1,500 exhibitors took part in the fair, located around 50 kilometers southwest of London.

Using its approach of "Making Aerospace Innovations Fly", Oerlikon presented its aerospace technologies to OEMs (Original Equipment Manufacturers) and suppliers alike. High-performance materials, surface technologies and additive manufacturing technologies play a key role in guaranteeing the functionality and performance of critical aircraft components. All major aircraft engine manufacturers today use Oerlikon technologies to boost performance, improve safety and efficiency, and reduce emissions.

MORE TURBINE EFFICIENCY

OERLIKON IN-HOUSE COATING CENTER FOR GE POWER

The gas and steam turbines of GE Power India Limited operate using fossil fuels and are very efficient. This generates more than 4.5 GW in India, which bridges the gap between power consumption and availability. But meeting the high demands posed by these supercritical and ultra-supercritical turbines requires the use of innovative solutions. GE Power, a long-time Oerlikon Balzers customer, is now gaining benefits from the in-house coating center that Oerlikon Metco Thermal Spray Services opened in Ahmedabad, India. The center makes materials and processes available that increase the turbines' efficiency and the service life significantly. This coating center in the fast-growing industrial region has moved Oerlikon one step closer to its customers.

BACK TO THE ORIGINAL SHARPNESS

Why the Starrag Group relies on Oerlikon Balzers to recondition tools

The **Starrag Group,** with headquarters in Rorschacherberg (Switzerland), is a global leader in the manufacture of precision tools for **metal, composite materials and ceramics machining.** The special tools employed are a decisive quality factor in the manufacturing process. With Oerlikon Balzers as a partner, Starrag is able to offer a global regrinding service for these tools. →

Machine tools from Starrag are always part of an overall solution: When combined with wide-ranging technological and other services, the company can guarantee a high level of process quality as well as productivity over the entire life cycle.

Challenging flow components

Starrag has made a name for itself especially in the machining of flow components – blades, rotors and impellers for the aerospace industry. The manufacturing technology for this must meet exacting standards: "Not only do the parts have increasingly complex geometries and demand ever closer tolerances, the materials are also becoming increasingly difficult to machine: Titanium, Inconel and other nickel alloys – i. e. everything that is difficult to machine," relates Michael Straub, Head of Tool Engineering at Starrag.

The special geometries of the parts are one thing. What is especially difficult is obtaining a finish with micron-range accuracy on the frequently razor-thin blades. This involves special requirements for cooling and workpiece clamping in the 5-axis machining center of the machine tool. Any component instability can easily lead to vibration during processing, and this must be brought under control by the machine and tool.

Tooling specialist

It comes as no surprise, then, that the Swiss firm has also developed into a specialist for the necessary milling cutters. Once again, the complex geometries and the materials that are exceptionally difficult to machine pose the greatest challenge: "Every tool is developed for the concrete use case with specific contours, angles and radiuses," explains Michael Straub.

The solid metal tools, which are developed and produced in Rorschacherberg, require not only good concentricity properties, but also very high surface finish quality. This is only one reason why Starrag has relied on the coating competence of Oerlikon Balzers for many years: "Oerlikon Balzers is often already involved in the development process when we match tools and coatings to one another."

Safeguarding process quality

The tools determine the process quality to a great extent. However, tools have only a limited service life, after which they become dull and lose their cutting performance and quality. Regrinding serves a clear objective: "Our premise is that the customer can depend on obtaining the same quality with a reconditioned tool as with a new tool. This is the only way

Complex geometries: Manufacturing flow components places high demands on the machine and the tool.

to safeguard for the long term the process which we were once able to sell him," says Michael Straub.

Tools from Starrag are employed throughout the world. "With Oerlikon Balzers as a partner and with their competence and far-reaching network of customer centers, we can deliver original quality to our customers even in remote countries."

This is a convincing advantage because tools are the cost driver in the industrial manufacturing sector. Oerlikon Balzers maintains reconditioning services in locations proximate to important industrial centers in America and Asia. This ensures short pass-through times and eliminates high transportation costs.

Regrinding AND edge preparation AND coating

For Straub, Oerlikon Balzers' overall package is decisive: Sharpening, edge preparation and coating come from a single source. "That is exceptional and ensures quality and cost effectiveness," he affirms. Typically, with other providers, tools pass through the hands of several providers during reconditioning.

One standard worldwide

To ensure a seamless transition, Starrag delivers the geometry data for the tools to the Oerlikon Balzers competence center for grinding in Stainz, Austria, directly after their customers accept the manufacturing process. The Stainz team prepares data that are then made available for the respective machines in the various reconditioning centers around the world. This takes place after the regrinding result has been tested together with Starrag. The result is a uniform standard ensured worldwide.

Consequently, the two partners share their know-how very early on: "For us, it is important to be able to offer our customers good after-sales service. This includes regrinding their tools," says Michael Straub. "With Oerlikon Balzers, we have a unique advantage: Reconditioned tools are just as good as new tools – and it's worldwide, fast and cost effective."

«With Oerlikon Balzers, we have a unique advantage: ***Reconditioned tools are just as good as new tools*** – and it's worldwide, fast and cost effective.»

Michael Straub,
Head Tool Engineering, Starrag Group

STRENGTH IN PARTNERSHIPS

Additive manufacturing (AM) is a cutting-edge technology that has already changed the manufacturing landscape. In 2017, Oerlikon kicked off the Munich Technology Conference (MTC) – a platform where scientists, manufacturers and politicians discuss the **ongoing integration of AM in production processes.** Under the slogan "industrialize AM" the 2nd MTC was hosted in October 2018 at the **Technical University of Munich with world-leading partners Linde, Bayern Innovativ, Siemens, TÜV SÜD and GE.** For BEYOND SURFACES they give an insight in their AM efforts.

GAS-ENABLED EXCELLENCE

Founded in 1879 by German engineer Carl von Linde, The Linde Group is one of the leading gases and engineering companies in the world today. Pierre Forêt, GDC Coordinator Additive Manufacturing, explains what role gases play in the additive manufacturing process.

What projects has Linde already realized with AM?

As a leading industrial gases company, our focus naturally lies on supporting the additive manufacturing industry in making the best use of the gas molecules that we provide. Atmospheric gases play an important role in both the core printing process and pre- and post-production processes such as metal powder production and storage. As is well understood, the AM process takes place within a closed chamber filled with high-purity inert gases such as argon and nitrogen. What is less well known are the impurities which can remain present in that atmosphere. Even extremely small variations in oxygen content can impair the mechanical properties or chemical composition of the end product, particularly for O_2 affine alloys like Ti-6Al-4V. A key project for Linde has been to overcome this challenge to give manufacturers more reproducible printing conditions. One solution, ADDvance® O_2 precision, has been one of our first technologies for the AM market. It can be installed on any printer and provides continuous analysis of the oxygen level with very high precision. It can also control this oxygen level to a desired value, which enables faster and higher quality printing for specific materials. It is already in use at several companies at the forefront of AM such as Liebherr Aerospace, France and BMW, Germany, as well as other industrial and academic partners.

In what area does Linde plan to work with AM in the future?

Our number one focus is to provide gas-based solutions to meet the challenges faced by our additive manufacturing customers. However, Linde is a technology leader and provides hundreds of different burners for the metals production and fabrication industries or for flame treatment processes. One great example is how the technology is starting to be used internally, with a new type of LINDOFLAMM® burner that our colleagues designed and printed recently. Normally the burners are produced using many single parts that need to be machined and welded together. The LINDOFLAMM burners are a special technology that use a fast heating acetylene flame to reheat metallic surfaces. The first AM burners have been printed and are in the testing phase. They appear to be easier and faster to produce than conventional burners.

Another great example comes from our Heat-treatment colleagues that have designed and printed a new CARBOTHAN® lance (a product used in furnaces to feed methanol and nitrogen under high temperature). The new lance has integrated sensors that measure key parameters to enable predictive maintenance.

Pierre Forêt
GDC Coordinator Additive Manufacturing, Linde Gas

THINK TANK FOR AM INNOVATIONS

Bayern Innovativ is the technology and innovation agency of the Free State of Bavaria in Germany. Its task is to discover topics of relevance for future innovations. In doing so, it engages in important networking activities. Dr. Matthias Konrad, Member of the Executive Board, explains why it is important to tackle innovation projects jointly and how Bayern Innovativ implements this concept of collaborative work.

What is Bayern Innovativ and what goals does it have?

Innovations require initiative and must be planned purposefully and moved forward actively. This requires ideas, courage, knowledge, competence, networks and a strong partner. Bayern Innovativ joins forces with Bavarian companies as a think tank and serves as an innovation facilitator for their innovation projects. More than 100 employees with very diverse educational backgrounds – including engineers, natural scientists, economists and communications experts – manage various different networks. Within those, they create focused intersections of potential cooperation partners from the economy and science and provide information concerning national and international sources of funding. Tailored services are intended to aid Bavarian companies in closing gaps in technologies, supply chains and marketing channels.

Why does Bayern Innovativ support projects in the area of additive manufacturing in general and the MTC in particular?

In recent years, Bavaria has become a leading location in the area of additive manufacturing. There is a well defined ecosystem that comprises both successful companies along the entire value-added chain as well as scientific institutes. Bayern Innovativ has dealt with additive manufacturing intensively for years now already. This technology is one of the main topics of the “New Materials” cluster, for example.

With the future-oriented 3D printing initiative, additive manufacturing has been selected as one of the core topics of the Bavarian state government’s “Bavaria Digital II Master Plan”. The new “Additive Manufacturing Hub Bavaria” created specifically in this context at Bayern Innovativ is intended to become established as a contact partner for all players in the field of 3D printing. It is designed to bring together diverse know-how sources from companies, universities, higher education institutes, networks and initiatives within the Bavarian additive manufacturing scene. The objective is to increase the visibility of the competencies involved here and to develop Bavaria’s position in technological leadership. In the context of the future-oriented 3D printing initiative, joint research projects for the industrialization of additive manufacturing are being funded by the Bavarian Ministry of Economic Affairs.

With this background, Bayern Innovativ welcomes platforms with a topical focus, such as the MTC. There, representatives from industry and scientific institutions alike are provided with current, first-hand information on future trends and developments. It offers the opportunity to discuss concrete issues in the context of workshops, for example. This means it thereby also supports the objectives of Bayern Innovativ and the “Additive Manufacturing Hub Bavaria” in an outstanding manner.

Additively manufactured component for the chemical engineering exhibited by ZMP, Fürth at Material Innovativ

Dr. Matthias Konrad
Member of the Executive Board,
Bayern Innovativ

ACCELERATING THE GLOBAL ADOPTION OF INDUSTRIAL AM

Siemens has more than ten years of experience in utilizing additive manufacturing and is operating more than 55 industrial AM machines. We spoke with Dr. Karsten Heuser, VP of Additive Manufacturing at Siemens' division Digital Factory about their experience with the technology and their future plans.

What projects has Siemens already realized with AM?

One example is the production of hot gas burner fronts in Finspång. Utilizing Siemens NX software for AM, the burner was redesigned from 13 single parts into one printed component, the production lead time improved from 26 to 3 weeks and 22% of its weight was reduced. The burners are being produced in a serial production with an annual capacity in the 4 digits. Simulating the production plant optimizes the product flow, production setup and production configuration. Simulating the build process before printing virtually detects print defects and deformation and compensates errors to enable first-time-right printing. Digital right management safely transfers data packages between IT and production equipment, driven by industrial control, drives and motors, like e. g. new generation EOS machines. Monitoring of the process allows failure prediction, avoids unplanned downtime and optimizes service processes.

Besides Powder Bed Fusion, Siemens is working in strategic partnerships with leading machine builders to provide industrial and robotics integrated Material Extrusion for lightweight composite materials, Directed Energy Deposition for hybrid metal parts for e. g. the tooling industry as well as Jetting for e. g. medical applications. A growing open Eco-system of partners is embraced by co-innovating industrial additive manufacturing further. Within an AM Experience Center located in Erlangen, Germany, the full industrial process chain is made accessible from the design to the printing of the part and services around the production. It can be elaborated in hands-on workshops with AM manufacturers as well as AM machine builders.

Why did you choose AM over traditional production methods?

It's not either or. Additive manufacturing augments industrial manufacturing technologies to reimagine products by reducing weight or expand performance by bionic designs or accelerate innovation cycles and to reinvent manufacturing by eliminating e. g. assembly processes or make low volume production affordable. Besides that, it enables to rethink business models, might it be for zero inventory, on demand printing, individualization or digital spare part business models.

In what area does Siemens plan to use AM in the future? Why?

Today, Siemens is already one of the largest users of additive manufacturing in the area of Mobility as well as Power Generation for hot gas parts. To enable the transformation for the manufacturing industry from prototyping to industrial additive manufacturing, Siemens offers a comprehensive portfolio of seamlessly integrated software, automation and technology-based value add services. The Siemens' AM Network accelerates the global adoption of industrial additive manufacturing by digitalization of the supply demand chains and enables fully distributed manufacturing. Industrial additive manufacturing will be utilized by the automotive, aerospace, medical, machinery or energy industries in the future.

Burner front for gas turbines: AM and conventional design

Dr. Karsten Heuser
VP of Additive Manufacturing, Siemens Digital Factory

INDUSTRIAL ADDITIVE MANUFACTURING READINESS

Founded in 1866 as a steam boiler inspection association, the TÜV SÜD Group has evolved into a global enterprise. More than 24,000 employees work at over 1,000 locations in about 50 countries to continually improve technology, systems and expertise. They contribute significantly to making technical innovations such as Industry 4.0, autonomous driving and renewable energy safe and reliable.

Gregor Reischle, Head of Additive Manufacturing, explains how TÜV SÜD is driving the future of additive manufacturing technology.

What projects has TÜV SÜD already realized with AM?

Because our focus is on industrialization of additive manufacturing solutions, the AM team at TÜV SÜD has designed services within all AM industry-relevant segments. The most mature services are our training programs, which address more than 10 different themes. In these training courses, we are focusing on enabling participants to rapidly gain personal expertise with qualifications such as QM & Production Manager for Industrial AM. Secondly, we are working with companies including Deutsche Bahn AG (DB), for which TÜV SÜD is inspecting suppliers of 3D-printed spare parts. We designed a specific assessment program for this customer, which leads to certification and official authorization as “Industrial Additive Manufacturer”. This certification enables companies like DB to qualify their suppliers using standardized criteria, but also allows potential suppliers offering 3DP services to differentiate their services from their competitors which are not ready for “industrial AM” services. We will certify 5 German service providers in this field in 2018. Thirdly, we are qualifying equipment manufacturers in accordance with existing standards and launching the first pilot projects in the field of material certification.

In what areas does TÜV SÜD plan to work with AM in the future?

The success of AM solutions at industry level will only come about by defining, implementing and complying with manufacturing standards. Today we are still lacking many of these steps, and the coming years need to be spent investing in filling the gaps so that we can soon establish part quality results that are 100% satisfactory and repeatable. The market will ramp up exponentially, and new manufacturing and commercial scenarios will require new solutions in quality approval for on-demand printed parts. TÜV SÜD plans to play the role of enabler for the pioneers within this field of additive manufacturing. We aim to make commercial 3D printing possible around the world by standardizing and professionalizing the entire additive manufacturing segment in the years ahead, and are working together with global players to contribute to standards and service opportunities – and thus to the evolution of 3D printing.

But won’t 3D printing endanger TÜV SÜD’s business in the field of product certification?

Not at all. A job market will develop that clearly reflects the growing use of 3D printers in the next few years. A human being inspects a company today; in the future, a system will inspect a process solution – and of course, this digital system will also need to be developed and inspected. The opportunity for personalized, more complex designs with greater and more sustainable added value for the product itself is a compelling argument. Production, especially in case of shorter supply chains, will benefit product owners, manufacturers and consumers. TÜV SÜD is ready for this coming era and is looking forward to supporting the market with the testing, inspection and certification services that are needed. We will soon become the number one enabler of industrial additive manufacturing solutions, which will contribute to the growth of the entire industry.

Gregor Reischle
Head of Additive Manufacturing, TÜV SÜD

We can reach critical mass only by

WORKING TOGETHER

Over 1,000 experts from industry, science and technology met at the 2nd Munich Technology Conference (MTC) to discuss the industrialization of additive manufacturing, with the creation of an AM ecosystem emerging as the most popular answer to this question.

«If we really want to scale AM up and industrialize it, we need new perspectives. All players of the value chain have different perspectives when they look at the challenges of the others. This exchange is exactly what we need. ***A team is always the better solution.***»

Dr. Christian Bruch, Member of the Executive Board, Linde Group

«The Technical University of Munich collaborates with the industry because ***critical mass can only be achieved by joining forces.»***

Prof. Dr. Wolfgang A. Herrmann, President, Technical University of Munich

Often described as brand-new technology, additive manufacturing (3D printing) was actually invented back in the early 1980s by the American Charles Hull. However, more fully harnessing the benefits of this technology now requires support from a much wider group. This is why the second Munich Technology Conference (MTC^2) on additive manufacturing was held on October 10 and 11, 2018, with the theme of #industrializeAM. Representatives from industry, science and research met at the Technical University of Munich to share their experiences and successes with this technology at the two-day conference.

Technology is changing our way of thinking

Additive manufacturing describes a revolutionary method of production that enables objects to be built up layer by layer. This technology has the potential to fundamentally change not only our lives, but also our way of thinking. Until now, it has been possible to develop ideas only after new technological capabilities or materials were invented. In the future, a need will be defined first, with the question of how to meet it following afterward. “How do I solve this problem?” – this is what it will really boil down to.

There is no doubt that this will also result in changes to the way we work. Experts agree that 3D printing will create many new occupations and fields of work. For existing professions, such as industrial designers, engineers and product managers, additive manufacturing will create new opportunities in development and production. These are all dependent on a fundamental rethink – from now on, functionality alone is key.

3D printing often plays a part in modern industrial manufacturing. In medicine especially, this new technology is already firmly established: the result is that the individual circumstances of each patient can be better taken into account. In order to be able to fully exploit the potential of AM in other industries as well, several adjustments will be needed, from R&D to the production processes through to application. →

«One area we are focusing on is the establishment of ***repeatable processes for AM.*** An additively manufactured part should have exactly the same quality no matter where you print it and which printer you are using.»

Dr. Roland Fischer, CEO, Oerlikon Group

«We haven't trained the engineers in our world ***to rethink.*** This is something we need to do. When GE Aviation developed a new advanced turboprop engine this was a complete rethink. ***We were able to reduce 855 parts to only 12 parts thanks to AM.»***

Jason Oliver, Vice President & CEO GE Additive

Two days, six central issues, nine workshops

On the first day of the conference, participants debated these challenges through presentations and panel discussions. The central issues included the creation of an AM ecosystem; how AM industrialization is progressing in a range of sectors, including aviation, the automotive industry and medicine; and how to take on existing challenges along the entire AM value chain. Industry experts and scientists also discussed the materials required for AM and how the portfolio of materials should develop. More than ten participants from the hardware industry offered new ideas about the latest developments in printing and how to fully exploit this potential.

On the second day of the conference, the seven MTC^2 partners held a range of workshops, all aiming to address the question of how to make additive manufacturing more widely usable and industrialized. Alongside Oerlikon, these partners included the Technical University of Munich (TUM), Bayern Innovativ, Linde, GE Additive, TÜV SÜD and Siemens.

«We are providing testing, certification and training for new AM processes and applications. And we use these ***to create new industry standards*** and, even more important, ***to create trust among the players of the AM value chain.»***

Prof. Dr. Axel Stepken, CEO TÜV SÜD

«Siemens is mastering the challenges connected to AM through a full digital tool chain. We use the digital twin of a product in order ***to design and simulate an additively manufactured part.»***

Dr. Jan M. Mrosik, CEO Digital Factory, Siemens

OERLIKON BALZERS OPENS
LARGEST PRODUCTION CENTER IN SLOVAKIA

Oerlikon Balzers chose Veľká Ida as the location of its largest, most important site for coating and heat-treating automotive components. The new 5,000 m^2 facility, an expansion of the existing service center, adds to the company's prominence in one of Slovakia's most important industrial centers, a hub for manufacturers of automotive components. Here, complex components – primarily ball pins – are heat treated with BALITHERM IONIT OX for automotive industry customers from around the world. This environmentally friendly alternative to conventional corrosion protection methods offers excellent corrosion resistance, very good tribological properties and enhanced surface hardness. As a result, the ball pins attain a longer service life. "Veľká Ida is today the largest of Oerlikon Balzers' production centers. It complies with the highest quality and environmental standards and provide. 300 specialists are employed here and provide customers with the latest heat treatment methods, which meet the high standards of both today and tomorrow," says Jochen Weyandt, Head of Oerlikon Business Unit Automotive Solutions.

DR. HELMUT RUDIGIER AT
WEF'S ANNUAL MEETING IN CHINA

How can collaboration accelerate innovation in the Fourth Industrial Revolution? On this topic, Oerlikon's CTO, Dr. Helmut Rudigier, shared his views as a panelist and participant at an interactive workshop at the World Economic Forum's Annual Meeting of the New Champions 2018, held in Tianjin, China, September 18–20. Dr. Rudigier demonstrated how Oerlikon is pushing forward the industrialization of additive manufacturing (AM) through establishing a cluster of partnerships with corporations (GE Additive, Boeing, Lufthansa Technik and Ruag), academia (TUM and Skoltech), and associations such as America Makes and the Shanghai AM Association. And, in creating platforms such as the Munich Technology Conference and the Bavarian AM Cluster, Oerlikon brings together leading minds, with the support of the local government, to accelerate the application of AM along the entire value chain. He stressed that a single company cannot do all of it on its own, and partnerships are critical in order to tap AM's full potential. He also highlighted that such collaborations can work only if there is openness, cooperation at eye level, fair treatment of intellectual property and equal access to markets.

HOMECOMING AFTER 66 YEARS OF SUCCESSFUL SERVICE
OERLIKON BALZERS EVAPORATION SYSTEM

In 1946, Professor Max Auwärter founded the "Gerätebauanstalt Balzers" with the objective of making vacuum thin-film technology, until then largely unknown, usable on an industrial scale. The location has remained the same, but the company is today called Oerlikon Balzers and is the leading supplier of surface coatings.

One of the first "evaporation systems" for coating components was the BA 500, made in 1952 and still intact today. It returned to its "birthplace" in Balzers at the end of July when the owner, the Technische Universität Braunschweig, agreed with a heavy heart to part company with the system. For many decades, it served there in the production of semiconductor technology samples.

"Many doctoral students and professors used this piece of equipment to carry out both fundamental and application research. It reliably 'processed' half of the elements in the periodic table and was one of the best systems at the Institute for electrophysics. Competitors were never able to reach the same level of reliability," were the words of farewell from retired but still active Technological Assistant, Gerhard Palm, in reference to the BA 500.

Additive manufacturing becomes real

ROCKET SCIENCE

By Erik Sherman

Don't call the founders of LENA Space rocket scientists, even though they technically are. Instead, call them rocket engineers.

The company develops space technology with the ultimate goal of end-to-end rocket propulsion systems for launch vehicles that could bring satellites or other payloads into orbit. Co-founders CEO Edward Fletcher and CTO Lee Giles consider themselves engineers with a focus on space.

Rather than moving directly from theory to a final product, the LENA team develops initial concepts based on the science. Then it moves into engineering. "It's often better to apply the theories to a certain point, run an experiment to test, then move on incrementally from there," said Fletcher. Such development, with new rounds building on what was learned in previous ones, lets LENA's team keep improving their results. And with help from multiple divisions of Oerlikon, the company has efficiently and economically moved forward.

Following a successful research and development grant application for funding with the UK Space Agency, the team started work on key propulsion hardware. The technology is also expected to have spin-off uses in energy, environment and transportation applications on Earth.

In 2017, the team first focused on developing what is known as a turbopump, which is like the fuel pump of a car. LENA is also considering two potential proof-of-concept terrestrial applications: improved pumping performance on existing firefighting trucks and lightweight high-performance pumps for flood control.

From supercars to rocket engines

Fletcher and Giles met as part of a land-speed record project developing a rocket-powered supersonic car. "We founded LENA Space after a discussion about developing rocket propulsion hardware outside the USA," Giles said.

The entire LENA staff comes from an engineering background in rapid – and unusual – forms of transportation. Fletcher worked on jetpacks in New Zealand and hybrid airships in the U. K. Giles worked in automotive research and development (R&D), including concepts to eventually be included in supercar projects from McLaren Automotive. Many of the other team members came out of the race car industry.

> «It's often better to apply the theories to a certain point, run an experiment to test, ***then move on incrementally*** from there.»
>
> **Edward Fletcher,**
> Co-founder and CEO, LENA Space

Post-Processing: Oerlikon Metco thermal barrier coating applied to the inner surface; Oerlikon Balzers PVD corrosion / wear resistant coating applied to the outer surface.

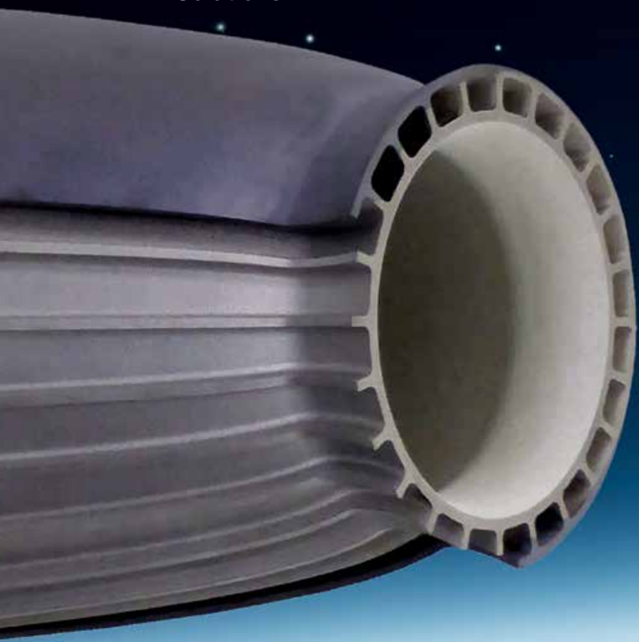
Additively manufactured rocket nozzle of a 60 kN rocket engine development for LENA Space: AM has unlocked new efficient designs of the nozzle, with one of the key benefits being the regenerative cooling channels.

The engineers at LENA face some interesting challenges in their current work. A turbopump pulls propellant from storage tanks and delivers the fuel to the rocket motor. But the conditions it faces are far more difficult. Designed to support a 13-tonne (28,660-pound) thrust engine, the turbopump has to move 60 kilograms (132 pounds) of propellant per second under a crushing pressure of 1,015 pounds per square inch, which is like being more than 700 meters (2,300 feet) under water.

The turbine portion has to spin nearly 20,000 revolutions-per-minute, or about three times a normal car engine. The turbopump must also bear up under extraordinary temperature differences of thousands of degrees between the liquid fuel and burning gases.

Finding the balance between performance and costs

The company's iterative design-test-improve approach offers distinct advantages for moving toward optimized products. But it creates its own challenges. Building multiple prototypes can get expensive, especially when the subject is the turbopump, commonly counted as half the development cost of an entire rocket engine. →



«Instead of a series of parts assembled with seals and bolts, ***we can produce the unit as a single piece.»***

Lee Giles,
Co-founder and CTO, LENA Space

LENA needed to control costs during the iterative design process while providing the strength, resilience, and endurance to meet performance requirements. Oerlikon was able to help in rapid prototype construction and materials selection through Oerlikon AM, the division for additive manufacturing, more popularly known as 3D printing. In addition, Oerlikon Metco provided high-end thermal barrier coatings (TBC) for the parts.

One of LENA's newest developments is regenerative rocket nozzles. Cold liquid propellant flows through a cooling jacket around the outside of the engine, in the process controlling temperature before the fuel burns and comes out through the inside of the nozzle at temperatures surpassing those of a blast furnace. Historically, the cooling channels that initially carry the propellant would be pipe, either brazed or welded to the exterior of the nozzle. The traditional approach adds weight and makes for a complicated and more expensive manufacturing process.

"With additive manufacturing, it is possible to create the complex geometry of the cooling channels far more easily," Fletcher said. "It's also possible to simplify the design and reduce costs. Instead of a series of parts assembled with seals and bolts, we can produce the unit as a single piece," Giles added. Fewer parts also mean lighter products, fewer potential points of failure for improved reliability, and improved performance.

Oerlikon provided the prototyping services using its in-house equipment. More important, the company's deep expertise in materials science helped it develop the mix of alloys that will provide the necessary strength and heat characteristics.

But those alloys still face tremendous heat. To bear up under temperatures that exceed what you'd find in blast furnaces, Oerlikon Metco and Oerlikon Balzers surface coatings gave critical added resistance and endurance.

Collaboration for disruptive innovation

Fletcher and Giles both knew Dan Johns, Chief Technology Officer at Oerlikon AM, through mutual work on the supersonic car project. "Dan introduced us to the capacities of additive manufacturing, including how and when to exploit AM techniques," Fletcher said. "We've been really impressed with the range of skills of Oerlikon."

In addition, Oerlikon's expertise helped speed development, and the ability to get materials and manufacturing simplified LENA's supply chain. "We were able to stick to our strengths at LENA and allow Oerlikon to stick to theirs," Giles said.

"Working with LENA Space gives us the opportunity to solve extremely hard technical challenges by bringing together Oerlikon AM, Oerlikon Metco, and Oerlikon Balzers," Johns said. "The three brands work together to accelerate innovation. We learn faster and inspire each other to think in new different ways. It is also a fantastic example of how our concept of 'Open Collaboration' really works to break down conventional thinking. I haven't heard anyone say, 'We've tried that before and it didn't work.' To welcome disruptive innovation is one challenge. Achieving it is another. This collaboration shows we can accomplish both."

As far as the future goes, it's not sky-high, but space-high.

2019 Trade show dates

In the upcoming months, Oerlikon will again be represented at the important surface solutions and additive manufacturing trade shows. We look forward to your visit!

Europe

Mar 14–15 **Additive Manufacturing Forum**
Berlin, Germany

Apr 3–4 **Plastics in Automotive Engineering**
PIAE 2019
Mannheim, Germany

May 8–9 **Plastteknik Nordic**
Polymer production, materials & industrial design
Malmö, Sweden

May 21–23 **automotive interiors EXPO 2019**
Stuttgart, Germany

May 21–23 **Engine Expo**
Stuttgart, Germany

June 17–23 **International Paris Air Show**
Paris, France

June 18–21 **EPHJ-EPMT-SMT**
Geneva, Switzerland

June 25–27 **Rapid.Tech**
International Trade Show & Conference for Additive Manufacturing
Erfurt, Germany

America

Mar 5–7 **HAI Heli Expo**
Atlanta, USA

Mar 31–Apr 4 **AMUG**
Additive Manufacturing Users Group
Chicago (IL), USA

Apr 8–11 **Space Symposium**
Colorado Springs (CO), USA

Apr 29 – May 2 **AeroDef Manufacturing**
Aerospace and defense manufacturing conference
Long Beach (CA), USA

May 21–23 **RAPID + TCT**
3D Printing & Additive Manufacturing Event
Detroit (MI), USA

June 11–13 **OMTEC**
Orthopaedic Manufacturing and Technology Exposition & Conference
Chicago (IL), USA

Asia

Jan 24–30 **IMTEX 2019**
Indian Metal-Cutting Machine Tool Exhibition
Bangalore, India

Feb 21–23 **TCT Asia**
3D manufacturing technology event
Shanghai, China

Mar 12–16 **INTERMOLD Korea 2019**
Die & Mold specialized exhibition
Ilsan (Seoul), Korea

Apr 15–20 **CIMT 2019**
China International Machine Tool Show
Beijing, China

May 22–24 **Automotive Engineering Exposition 2019**
Yokohama, Japan

June 22–24 **INTERMOLD Nagoya 2019**
Japan Metal Stamping Technology Exhibition
Nagoya, Japan

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