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METAL POWDER PRODUCTION

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The 1st Munich Technology Conference: AM is on course for broad industrial use

More than 600 international leaders in metal AM gathered in October for the 1st Munich Technology Conference. Organised and sponsored by Oerlikon, the aim of this unique event was to provide a dedicated platform for the discussion and sharing of best practices in AM production and applications, along with the business models needed to drive the industrialisation of AM. We invited Prof Dr-Ing Michael Zäh, Chair of Machine Tools and Production Technology at the Technical University of Munich, to consider the status of metal AM as revealed over the event's two days of presentations and discussions.

"A few decades from now, we will 3D print everything." Today, this is a frequently uttered platitude that at once reflects the hype and the misunderstandings that surround Additive Manufacturing technology. Undoubtedly, AM has huge potential as a replacement for conventional technologies in a large number of areas. However, we must not forget that AM is looking to compete with established technologies which can rely upon centuries of research, development and experience. As a consequence, in order to make a realistic judgment about future scenarios, we have to take a closer and more balanced look at the current status of the industry.

Oerlikon, the Swiss-based multi-technology corporate group with a long history in advanced engineering, recently provided a platform for a closer evaluation of the state of Additive Manufacturing during the 1st Munich Technology Conference. The event was held from October 11-12, 2017, at the Technical University of Munich (TUM), Germany. More than 600 AM industry professionals, from both business and academia, attended the event, as well as guests from politics and finance. Conference sessions were followed by panel discussions expertly moderated by prominent international journalist and political commentator, Dr Melinda Crane.

The conference followed the inauguration of Oerlikon's new Additive Manufacturing and Technology Centre in Feldkirchen near Munich on October 11. As highlighted previously in this issue of *Metal AM* magazine, the new technology centre aims to position Oerlikon as a

Fig. 1 The 1st Munich Technology Conference took place at the Technical University of Munich (TUM) and was dedicated to understanding the latest advances in metal Additive Manufacturing

Fig. 2 The conference attracted more than 600 international experts from the field of Additive Manufacturing

leading supplier and service provider for AM. According to the company, the centre's location will enable it to benefit from close contact with TUM and the associated Fraunhofer Institute IGCV in Augsburg, as well as with industrial leaders in the area such as BMW, Audi, Siemens, MTU Aero Engines, Airbus and General Electric, all of which are pursuing applications for Additive Manufacturing within their operations.

TUM itself was among the first academic institutions in Germany to explore additive technologies, beginning with the foundation of its Technology Transfer Centre in Augsburg in 1994, which has since been home to a successful team of scientists and specialists in AM.

The current status of metal AM

Based on the presentations at the 1st Munich Technology Conference and the lively panel discussions that followed, the current status of metal Additive Manufacturing can be characterised by the following statements:

The technology is readily available
There are today a large number of AM machine builders, all of whom appear to be successfully and continuously increasing their machine sales.

The technology has moved from prototyping to production
While in the late 1990s AM technology was predominantly known as Rapid Prototyping, with Rapid Tooling and Rapid Manufacturing also becoming common terms, it has gained ground since the 2000s and been adopted for value-added applications in many areas, even where rapidity is not really the driving factor.

There are still challenges to overcome
AM still suffers from many shortcomings, including issues relating to heat-induced distortion, poor part resolution due to the layer-based manufacturing process, potentially lower strength compared to some conventional processes, the risk of porosity and the potential for anisotropic material properties where they are not desired. FEM based simulation models also lack accuracy and validation.

Strengths and weaknesses of AM

Thanks to the impressive range of leading international figures from the world of AM in attendance, the panel discussions at the first Munich Technology Conference presented the opportunity to take a fresh look at the current status of metal Additive Manufacturing and to make a fair judgement concerning its current strengths and weaknesses.

Material efficiency
AM works without any tools or physical models and thus has an

Fig. 3 Lively panel discussions took place throughout the event, expertly moderated by Dr Melinda Crane

a-priori cost advantage over most conventional technologies. Material usage is extremely efficient: with the exception of the structures that are required to support any overhanging areas of the part during a build - and to help manage heat build-up during manufacture - there is no material wastage.

Is it correct, therefore, to say that AM is far more resource efficient than conventional technologies, as we only consume the material for building the part, thereby eliminating machining chips and other kinds of waste? Not necessarily, because manufacturing the raw material – in the majority of cases, as powder - requires an energy consuming process, and the AM process itself is energy-intensive. Materials used in metal AM will see melting temperatures at least three times during their life cycle: first in the raw material factory, second during powder production and third during the AM process. The powder required for powder bed fusion processes is also expensive when compared to material for casting or machining.

Of course, one cannot directly compare AM with conventional processes based solely on the efficiency of their materials usage. One of the key messages from the conference was that it will never make sense to simply take a part produced using a conventional manufacturing process and convert it to AM. AM thrives where there is an opportunity to add value through, for example, combining multiple components into one, designing features that have never before been possible to manufacture.

Health and safety considerations

We also must not forget about laser safety issues for laser-based AM processes and the hazards that go along with the handling of fine metal powders. The latter has risks in terms of the inhalation of carcino-genic materials, for example nickel and cobalt, as well as the significant risk of explosions when dealing with more reactive metals such as titanium and aluminium.

Parts manufactured in a powder bed require a labour-intensive removal from the working chamber and removal of adhering remainders of the powder. Managing these issues requires a considerable investment in safety measures, which poses an entry threshold for those thinking about entering AM.

Process simulation

Many AM technologies simply are not yet mature because of high heat-induced distortions. Models – predominantly based on FEM - used to predict these distortions so that countermeasures can be taken lack reliability and validation.

Design freedom

On the other hand, AM opens up completely new possibilities and features and an almost unlimited diversity and complexity of manufacturable geometries. We saw the first approaches to conformal

Fig. 4 Mohammad Ehteshami, Vice President and General Manager, GE Additive, stated at the conference, "Additive Manufacturing is still a young technology. But we've come a long way. And we are already printing things that people had predicted would only be printed in 2025. I hope that Additive Manufacturing mass production is not ten years from now, but two years from now."

cooling channels quite a while ago, honeycomb structures incorporating complex curved surfaces, movable joints manufactured in one build and topology optimised parts, to name but a few examples.

Consider the entire process chain

Is AM as simple as just one process yielding the finished part? Perhaps, in some cases. Many technologically advanced applications, however, require more accurate parts with more precise surfaces than AM alone can guarantee. Thus, finishing operations (such as milling, grinding, lapping, polishing, etc.) are necessary. So how 'rapid' is it in reality? It is rapid in the sense that we can go from CAD to process via just a few automated data manipulation steps - but the process chain can be laborious.

New markets for AM attract industry's giants

Industrial applications for AM are diverse and already numerous:

- Jet engine construction: lightweight design, complex internal features, reducing manufacturing complexity by combining multiple components into one
- Aircraft construction: bionic lightweight structures, fixation devices, interior panelling, cabin equipment such as seats and seat belt buckles in lightweight designs
- Automotive manufacturing: parts for prototypes and pilot lots, custom-designed components and low-series components for high-performance applications
- Medical technology: implants, dental prostheses, osteosynthesis-elements, hearing aids, illustrative models for surgery
- Industrial engineering: lightweight tools, conformal cooling in moulds and dies, gripper jaws
- Civil engineering: individualised components of buildings
- Furnishing: customised furniture designs
- In all industry sectors: any kind of filigree structures not economically manufacturable by other methods

It is a huge challenge to convey the new freedom in part design offered by AM to engineers in design departments; namely, the practically unlimited geometrical degrees of freedom, the ability to grade material properties within a part and even the capacity to manufacture joints within one build job. In embracing AM, we all have to rethink design from scratch.

The annual Wohlers Report indicates sound AM market growth of more than 25% per annum on average since the early 1990s. It has now reached sales of well over $5 billion per annum. Meanwhile, many enterprises are acknowledging the potential of AM and intensifying their activities in this field. The expansion of Oerlikon's activities in relation to metal AM is by no means unique, and the technical media appear to report new stories on the AM activities of enterprises on a weekly basis.

ThyssenKrupp AG, for example, the German steel and technology provider, recently opened a Tech-Center for Additive Manufacturing and considers the technology mature for industrialisation. The company mentions a number of workpieces realised on the basis of AM. Laser deposition using metal powders ranks high on ThyssenKrupp's agenda.

Half a year earlier, the entry of Voestalpine into Additive Manufacturing was also reported. Voestalpine is ThyssenKrupp's Austria-based competitor, and considers AM technology to be disruptive because of the multitude of new applications that it will make possible. Buzzwords of special interest are conformal cooling and shortened cycle times.

General Electric is currently undergoing a reorganisation of its research activities, which will have an impact on its Technology Centre in Garching, near Munich. While reallocating most of its research work to the business units, research on AM will remain a centralised activity in Garching. A new building, reserved just for AM, is nearing completion and is expected to employ more than one hundred staff in the long term. Not to be forgotten is GE's recent acquisition of machine builders Concept Laser and Arcam – extremely important acquisitions in the AM sector and a milestone in the development of the industry. So, GE has cutting-edge machine competence aboard.

Fig. 5 Dr Hans J. Langer, Executive Chairman, EOS Group, put into perspective the recent rapid growth in AM, stating, "It took EOS twenty years to sell the first 1,000 systems [1990-2010], another five years to sell the second 1,000 systems, and the last two and a half years to sell the third 1,000 systems. Today we have a worldwide installed base of around 3,000 systems. As of 2018, we'll be able to produce and install 1,000 systems per year."

Fig. 6 Prof Johannes Schleiffenbaum (right), from RWTH Aachen University, stated, "The beauty of Additive Manufacturing is that you can directly transform ideas into reality. This will enable engineers to be more creative and develop completely new things."

MTU Aero Engines has been working on AM for aviation for many years, in cooperation with Technical University of Munich at its Competence Centre for Construction Techniques. Some parts are already flying. In collaboration with TUM, a small jet-engine inspection opening was designed and optimised by taking advantage of AM's capabilities, in particular the geometric design freedom the technology offers.

BMW and Audi both have ample laboratory space for the technology and see application potential in tool and die making, for the building of prototypes and pilot lots, for filigree structures and for low volume

Fig. 7 Michael Schreyögg, Chief Program Officer, MTU Aero Engines AG, stated "AM achieves improvements through weight reductions of bionically designed parts. A bracket on an Airbus A350 that flight attendants use to steady themselves can now be additively manufactured with titanium – and weighs 500 g less. Extrapolating that over the 30 year life of an aircraft, this will result in a reduction of 300,000 tons of CO_2."

Fig. 8 Dr Karsten Heuser, Competence Center AM, Siemens AG, commented during his presentation, "Additive Manufacturing is a big investment for Siemens. But it's also a necessary investment."

applications. Both have recently intensified their cooperation with academia.

Last but not least, Deutsche Bahn, Germany's railway company, will reorganise its strategy for spare parts by making use of on-demand Additive Manufacturing to produce them as needed instead of storing them.

The impact on business models

With the advent of AM in industrial environments, it is very likely that a change in business models will take place – both in terms of the customer interface and changing internal procedures. Internal procedures will focus more on part design, on topology optimisation and on process simulation in order to benefit from AM's strengths. On the other hand, process planning will lose importance and become a standard procedure.

For suppliers in the field of conventional technologies, the question is whether there is a risk of becoming obsolete over time.

One successful business model we have seen is to offer the Additive Manufacturing of parts in the sense of a job shop. So AM is a technology which one would typically expect to be adopted by small- to medium-sized enterprises (SMEs), which have the flexibility and agility to enter AM. On the other hand, workplace safety and laser safety are more of an obstacle for SMEs compared to large industrial conglomerates, with the resources to allocate to new technologies.

Another challenge is to encourage designers to rethink design by taking the new possibilities offered by AM into consideration. German universities and colleges have only recently begun to educate the new generation of engineers, and coursework offered on AM is not yet substantial.

During Oerlikon's Munich conference, BMW's Dr Susanek presented a sober approach to a technology that has been subject to so much hype. According to Susanek, apart from building prototypes and pilot lots, not much application potential has been exploited yet within BMW. His application examples in production are few, and are more or less limited to custom-made design elements.

The medical industry has seen some of the greatest advances. Dental implants made by AM are state of the art, and the same holds true for knee and hip implants as well as many other devices, requiring a high degree of geometry optimisation and individualisation.

In recent years, magnesium has been discovered as a promising chemical basis for implants for bone repair. Magnesium and some of its alloys are biodegradable; meaning the human body dissolves them within months and without any harm to the patient. As a result, bone repair can be done using brackets made from magnesium and a second operation to remove the brackets becomes obsolete. A challenge to be mastered is the high reactivity of magnesium powder, and the working chamber of the AM machine has to be filled with shielding gas to avoid explosions.

Outlook

Additive Manufacturing is among the youngest of all production technologies. Will we print everything one day? I do not think so. This article is supposed to give a fair and realistic perspective on AM. There is a stable and above-average growth of the market, with good reason; AM will certainly capture its place on the palette of all manufacturing technologies and reach a broad industrial use. What can we contribute? Work hard, research relentlessly, educate our students well and, above all, remain optimistic and open minded.

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2nd Munich Technology Conference

It has been announced that the Second Munich Technology Conference (MTC2) will take place from October 10–11, 2018. For more information visit the event website:

www.oerlikon.com/am/#!mtc-event.php

Fig. 9 Dr Roland Fischer (left), CEO Oerlikon, with Dr Melinda Crane (centre) and Florian Mauerer (right), Head of Oerlikon's Additive Manufacturing Business Unit. Fischer stated at the close of the conference, "Looking at the industrialisation of AM, there is still a lot of work to be done. However, it is not a question of 'if' but 'when'. Once it happens, AM will bring massive changes in industry."

Fig. 10 A conference reception was held at the Residenz in central Munich, the former royal palace of the Wittelsbach monarchs of Bavaria. The Residenz is the largest city palace in Germany.

Oerlikon: Swiss industrial group positions itself as a leading developer of AM components and materials

Over a period of just twelve months, Switzerland's Oerlikon Corporation AG has made a major move into the world of Additive Manufacturing. Through a combination of acquisitions and new facility investments, the company has established itself as a leading international developer of both AM materials and components, offering its customers the complete process chain, from new alloy development to component post-processing and testing. *Metal AM* magazine's Nick Williams reviews the company's progress to-date.

The metal Additive Manufacturing industry is growing at a rapidly increasing rate. Interest among end-users is at an all-time high and an ever-broadening range of production applications is being reported on a regular basis. There are, however, a number of routes that a company can take to embrace AM technology. Just a few years ago, a company that had an application that it was looking to develop would probably have taken the obvious route of investing in a small production-scale AM machine and experimenting in product development, most probably with a team that had little experience of AM and a finite budget.

Many of the companies that took this route quickly discovered that the knowledge required to embrace all that Design for Additive Manufacturing offers – along with the technical complexity of the metal AM process and its associated processing steps – led to a long and expensive learning curve, punctuated by numerous build failures and increasing budgets.

This scenario developed into what is now a mainstay of the AM machine builder's portfolio – consultancy services that offer to guide potential end-users through all stages of the development of an AM application, from design through to the commissioning of a dedicated in-house AM facility.

A further route by which a company can embrace AM, however, is in many ways the most conventional: partner with a specialist AM service provider to develop an application and then outsource production or, on a larger scale, form a production joint venture. The outsourcing of production course commonplace in the world of

Fig. 1 An additively manufactured AlSi10Mg distributor housing produced by Oerlikon's AM facility in Barleben, Germany

Fig. 2 A large additively manufactured heat sink from AlSi10Mg

industrial manufacturing, for example for the manufacture of machined or cast components.

Working with an external partner for a product's development and manufacture is by no means new in metal Additive Manufacturing – service bureaux have existed in the world of metal and plastic prototyping for many years. However, as demand for AM components for critical, high-value applications has grown, the concept of the AM service bureau has radically transformed into a far more sophisticated and industry-focused business model that is designed specifically for the volume production of aerospace, medical, automotive and power generation components - as examples - to the necessary international standards. Such partners must of course also be able to handle all of the necessary materials development, post-processing and quality monitoring that is required in metal Additive Manufacturing. It is within this space that Swiss engineering leader Oerlikon has positioned itself.

Oerlikon's path to AM

Headquartered in Pfäffikon, Schwyz, Switzerland, Oerlikon is a major industrial technology group with more than 13,800 employees in thirty-seven countries and 2016 sales of CHF 2.331 billion ($2.37 billion). As such, it has the financial resources to support its ambition of becoming a leading player in AM. The group has over the last year steadily expanded its AM-related capabilities to the point where it can now support its customers through the entire AM process chain, from alloy development through to powder production, application development and component manufacturing, post-processing and quality inspection.

The company's new Additive Manufacturing business, led by Florian Mauerer, fits within its Surface Solutions segment, one of three divisions in the Oerlikon group, with the others being Manmade Fibers and Drive Systems.

As a leader in advanced surface solutions, Oerlikon has had an interest in metal powder technologies for many years and this was further enhanced by its acquisition of Sulzer's Metco division in 2014. This business, which specialises in the production of novel, high-performance metal powders such as superalloys for thermal spray applications, saw increasing demand for its products from the growing AM sector.

However, it was Oerlikon's announcement in December 2016 that it was to acquire international AM producer citim GmbH that gave the first clues as to the group's AM ambitions. citim's core expertise lies in metal Additive Manufacturing for small-series production and functional prototypes and the company operates production sites in Europe (Barleben, Germany) and in North America (Kennesaw, Georgia, USA). Its primary markets are high-tech industries such as aviation, automotive and energy and in 2015 it generated sales of CHF 12 million (US $11.8 million) with around 120 employees.

Dr Roland Fischer, Oerlikon's CEO, stated at the time of the transaction, "The competencies and team from citim will serve to consolidate our position in the Additive Manufacturing business, marking the acquisition as an important move for us to drive the industrialisation of Additive Manufacturing and to become an independent service provider for the production of additively manufactured components".

In May this year Oerlikon announced a further acquisition; that of Scoperta Inc., an advanced materials development company with a proprietary process technology that enables the rapid design and development of new materials using computational software.

With these acquisitions, Oerlikon rapidly gained expertise in all areas of the AM process chain and successfully positioned itself as a leading player in the AM industry, with its services supported by its global network of service and production centres.

The story of citim

citim is without doubt the 'jewel in the crown' of Oerlikon's Additive Manufacturing business unit. Founded in 1996 as a spin-off from Otto von Guericke University in Magdeburg, Germany, the company first focused on prototype tooling. In the following years the company's portfolio of production technologies steadily grew to include Selective Laser Sintering technologies in 2004 and Selective Laser Melting in 2009.

Today, citim operates twenty-seven AM machines across its sites in Germany and the US, with the latter site established in 2013. In 2016 the German operation moved into a new 7,000 m² state-of-the-art production facility on a 25,000 m² site. The knowledge and experience that its staff gained over more than twenty years of AM production of course not only brings expertise, but a high degree of credibility in an industry that is still seen by many as young and unproven.

In addition to metal AM technologies for prototype and series production, citim also offers precision sand casting, die casting with rapid tooling and HSC/CNC machining and milling - all with a focus on the rapid turnaround of low-volume production runs for small-series applications or prototyping.

citim also retains its founding expertise in plastic prototyping and low volume production using Selective Laser Sintering and injection moulding. For the latter, prototype tools can be rapidly manufactured from aluminium, with manually operated inserts where needed, to produce prototype components that can be regarded as 'series-identical'.

XJet's new AM production system installed in Barleben

In November, Oerlikon announced that XJet's new Carmel 1400 Additive Manufacturing system was being installed at the Barleben facility. This was the first international installation of XJet's inkjet-based technology for the additive production of ceramic parts. The NanoParticle Jetting™

Fig. 3 A view of citim's Additive Manufacturing operation in Barleben, Germany. In 2016 the operation moved into a new 7000 m² state-of-the-art facility

Fig. 4 An operator cleans a machine in preparation for a new build. citim operates twenty-seven AM machines across its sites in Germany and the US

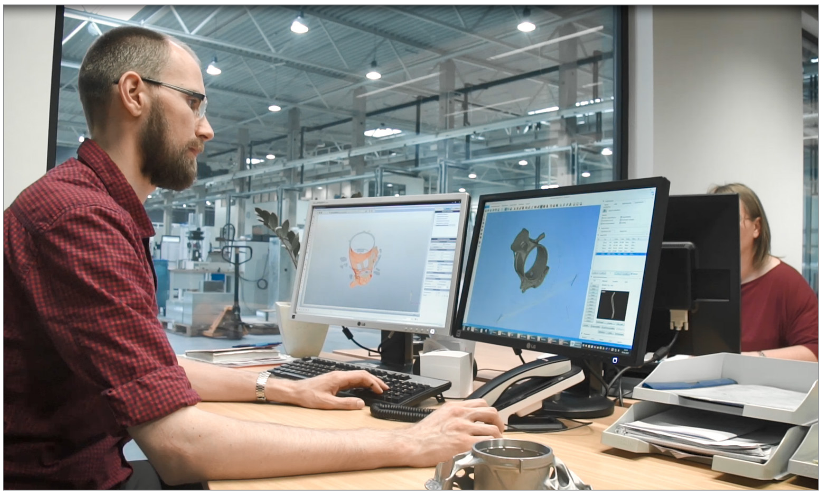

Fig. 5 Oerlikon partners with customers in the complete AM component cycle, from conception to production and post-processing

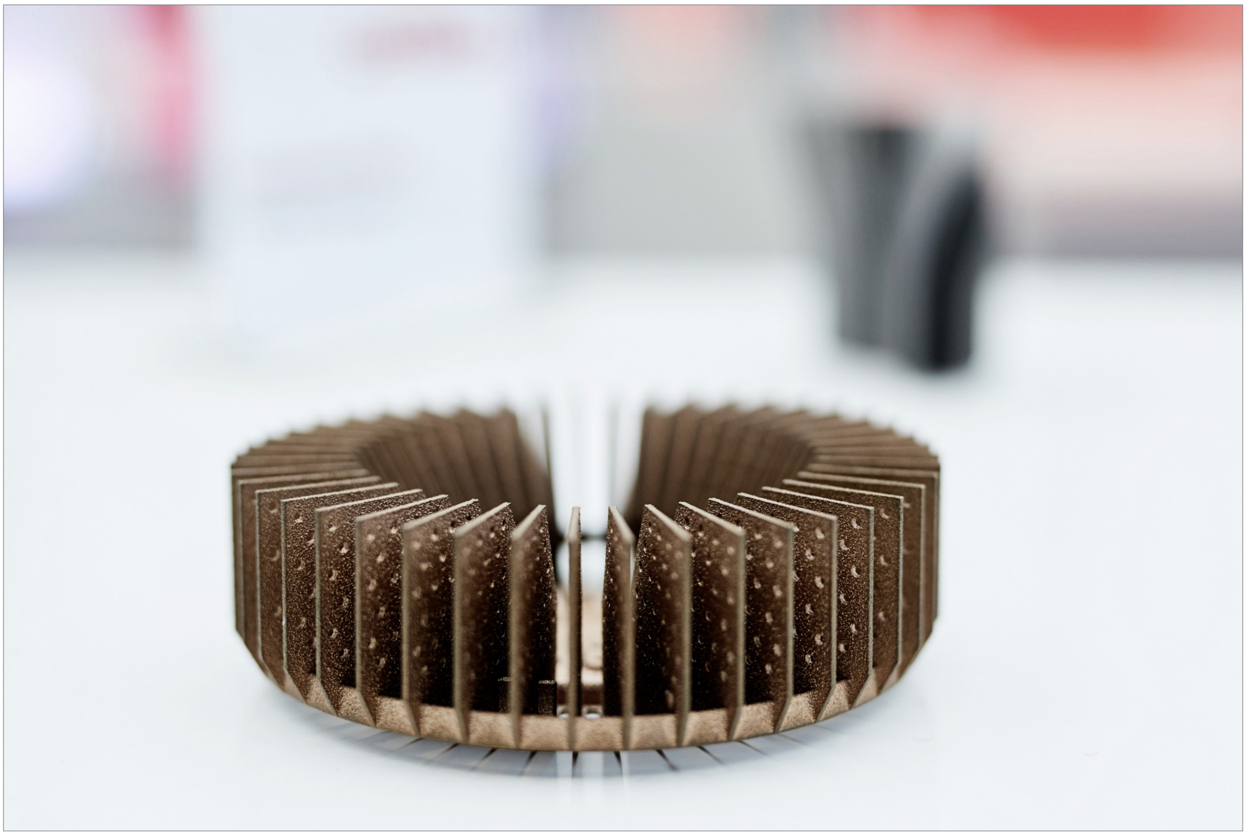

Fig. 6 An additively manufactured CuNi2SiCr cooling element

(NPJ) system featured in the machine uses separate nanoparticle 'inks' or fluids for the build and support material. This enables ceramic or metal parts to be produced with the ease and versatility which one associates with inkjet printing. The parts are then debound and sintered.

The system is configured to manufacture ceramic parts from zirconia, however at a later stage it can also be used to manufacture metal components that require the very fine resolution details that the Carmel system can offer.

"The cooperation with XJet is an exciting opportunity for us to expand our AM offering beyond metals and into ceramics," commented Andreas Berkau, Head of AM Service Europe. "With over twenty years in the industry, citim has established itself as a leading international supplier of AM parts that meets evolving industry needs and remains at the forefront of AM technology. This collaboration enables us to stay ahead of technology developments and maintain our technology leadership."

"With an investment of around $55 million in the facility, the company is anticipating the creation of over a hundred new jobs when fully operational in 2018."

Florian Mauerer added that this collaboration with XJet is a natural extension of Oerlikon's existing activities and, "further strengthens our technology offering and leadership position in the field of AM."

New US Additive Manufacturing facilities bring additional AM and powder production capacity

In July 2017, Oerlikon announced that it would further expand its Additive Manufacturing business in the US with a new state of the art R&D and production facility for AM components in Charlotte, North Carolina. With an investment of around $55 million in the facility, the company is anticipating the creation of over a hundred new jobs when fully operational in 2018.

"Charlotte is an important step in our plans to grow our Additive Manufacturing business and our investment in key technology areas. The investment underlines our intention to become a leading independent global partner in the industrialisation of Additive Manufacturing," stated Fischer.

Oerlikon also announced that it would be building a new $50 million state-of-the-art manufacturing facility in Plymouth Township, Michigan, USA, dedicated to producing advanced materials for Additive Manufacturing and surface coatings. This facility will develop and manufacture a range of metal powders for AM, including titanium alloys. The site features the latest generation of vacuum inert gas atomisation (VIGA) technology, combining vacuum induction melting with inert gas atomisation systems.

In addition, the facility houses a state-of-the-art research and development lab for further alloy developments of titanium and other alloys (e.g. nickel, copper, iron and cobalt) for joint R&D projects with customers and will have the capacity to produce custom powders in small batches.

AM-grade metal powders currently offered by Oerlikon include nickel-, cobalt- and titanium-based alloys as well as stainless steels and maraging steels.

Fig. 7 An automotive piston demonstration part that highlights the weight saving potential of AM

Innovative alloy development

Oerlikon's acquisition of Scoperta has put the company in a leading position to develop the next generation of material solutions for industrial applications, with powerful 'big data' analytical software used to design new alloys in a matter of months rather than years. The result is that new alloys can be commercialised much more effectively, thereby giving customers the materials needed for their applications far faster than through conventional empirical material development methods.

Such an alloy development solution is of particular interest for the metal AM industry, as there are cases where a brand-new AM-tailored alloy system may be a far better solution for specific applications, in terms of performance, cost and processability, than conventional cast alloy compositions. For example, new alloys can be developed to match the specific performance criteria of an existing alloy, but with a completely different composition.

Fischer stated, "The expertise and team from Scoperta adds great value and complements well with Oerlikon's existing strong materials heritage and competence. With industries seeking solutions to improve performance and sustainability, the need for advanced materials and products is continuously growing. This investment underscores our aim to stay at the forefront of the new era of innovating for advanced materials, which will be used in surface solutions and also in Additive Manufacturing."

"In our transition to become a powerhouse in surface solutions and advanced materials, such targeted and selective investments will reinforce our in-house capabilities and provide additional growth opportunities for Oerlikon."

The acquisition of Scoperta undoubtedly strengthens Oerlikon's position in the market for metallic and ceramic materials and extends the scope of services to customers in terms of developing individualised materials in significantly reduced development times and costs.

Munich as a centre of AM excellence

In October this year, Oerlikon formally opened a new Additive Manufacturing Technology & Innovation Centre in Munich. The centre will allow existing and potential customers to see and experience first-hand the design and production of metal components by AM along the process chain, from design and simulation to production and post-processing.

The centre will leverage its partnership with TU Munich, and its proximity to leading global industrial companies in the aerospace, automo-

Fig. 8 Guests at the opening of Oerlikon's new Additive Manufacturing Technology & Innovation Centre in Munich, Germany

Fig. 9 The official cutting of the ribbon. Left to right: Dr Bernhard Schwab (Director, Bavarian State Ministry of Economic Affairs and Media, Energy and Technology) with Oerlikon's Dr Roland Fischer, CEO, Prof Dr Michael Süss, Chairman of the Board, and Florian Mauerer, Head of the AM Business Unit

Fig. 10 An exterior view of Oerlikon's new Additive Manufacturing Technology & Innovation Centre in Munich

tive, power generation and medical devices sectors in the Munich region, to drive forward research and innovation in AM. The company states that it has made "a high single-digit-million Swiss Franc investment" in the centre, which will house over fifty AM engineers, technicians and application specialists.

Mauerer commented at the inauguration, "We are excited to open the AM Technology & Innovation Centre in Munich to drive the integrated development of new materials, production capabilities and processes, software, automation and post-processing solutions. Bringing all the different aspects of the AM value chain under one roof is central to our contribution to industrialising AM and to offering our customers comprehensive and fully integrated AM services. The Munich Centre uniquely connects the dots between our material science, component design, production and post-processing engineering capabilities."

Partnerships to support R&D

Earlier in the year, Oerlikon entered into AM-focused research partnerships with the Technical University of Munich (TUM), Germany, and Russia's Skolkovo Institute of Science and Technology, Moscow. These partnerships are designed to support the company's strategy to extend its leading position in surface solutions into Additive Manufacturing. In anticipation of the expected growth in demand for advanced component production by Additive Manufacturing, these collaborations will also address some of the most pressing research and development challenges in the field.

Roland Fischer stated, "Innovative technology is key to our growth strategy and gives Oerlikon a distinct advantage. These partnerships mark yet another important milestone in our efforts to take a leading position in Additive Manufacturing. Our goal is to deliver innovative products and services in surface coatings and advanced materials to meet customers' growing demand for advanced components that are lighter and with embedded functionalities. Additive Manufacturing offers cost-effective production solutions coupled with increased design freedom for even more highly complex geometries. With our leading expertise in advanced materials and surface technologies, we are ideally positioned to be a driver of this technology."

Markets and collaborative agreements with industry

Oerlikon's AM business is primarily focused on industrial and medical applications. Industry sectors covered include aerospace, automotive, power generation and tooling.

Within the aerospace sector in particular, applications for AM can generally be seen as falling into three types; complex engine parts, structural components and replacement parts. AM technology enables the production of aerospace parts at a lower weight, significantly reducing life-cycle costs, and for aircraft applications such as brackets, ducting and seat belt buckles, Oerlikon states that AM can be leveraged for weight and flow optimisation, sound reduction and near-net part substitution. AM is also being used in aero engine applications to integrate components, reducing part counts and mass for compressor vanes, diffusers, acoustic attenuation, heat exchangers and more.

It was therefore a natural fit when Oerlikon signed a Memorandum of Understanding at the 2017 Paris Air Show with GE Additive and its Concept Laser and Arcam businesses. The agreement included the provision of additive machines and services to Oerlikon, while Oerlikon became a preferred component manufacturer and materials supplier to GE Additive and its affiliated companies. GE and Oerlikon also agreed to collaborate on AM machine and materials research and development over the five-year period of the agreement.

Oerlikon and LENA Space collaborate on AM for space launch technology

Fig. 11 Florian Mauerer presents an AM propulsion system impeller developed in collaboration with LENA Space

In an example of the way in which Oerlikon's AM business is working with users of AM technology, the company recently began a collaboration with LENA Space, a rocket propulsion start-up based in the UK, to develop optimised AM components for propulsion systems. These systems are used in small launch vehicles to launch payloads in low Earth orbit.

This partnership combines LENA's experience and vision for fast-to-market, high-performance, low-cost launch propulsion technology with Oerlikon's end-to-end services in Additive Manufacturing to drive wider adoption of the technology in the space industry.

All parts, components and systems used in space need to meet highly stringent requirements in terms of weight, power and structural design and they need to function optimally in demanding space conditions. Additive Manufacturing, states Oerlikon, can help deliver new and cutting-edge technologies and solutions to satisfy such demands.

This collaboration serves to bring innovative approaches to addressing such manufacturing challenges for space. LENA Space designs and develops turbines, impellers, pumps, combustion chambers, regenerative cooling systems and more.

Dan Johns, Global Head of R&D - Additive Manufacturing at Oerlikon, explained, "We look forward to partnering with LENA Space to develop truly innovative products using our Additive Manufacturing capability. In particular, we will bring into the collaboration our differentiating capabilities in four areas: design for additive engineering, rapid alloy development (RAD), additive process knowledge to create high quality, repeatable components and our advanced coatings. Through our expertise, we aim to expand the operational envelope."

Natasha Allden, Chief Commercial Officer at LENA Space stated, "At LENA, we continually challenge and innovate technology and processes. Additive Manufacturing allows us to make step changes in producing complicated designs not possible with traditional machining, improving the performance whilst reducing the mass of our products. We look forward to our partnership with Oerlikon and shaping the future of space propulsion technology."

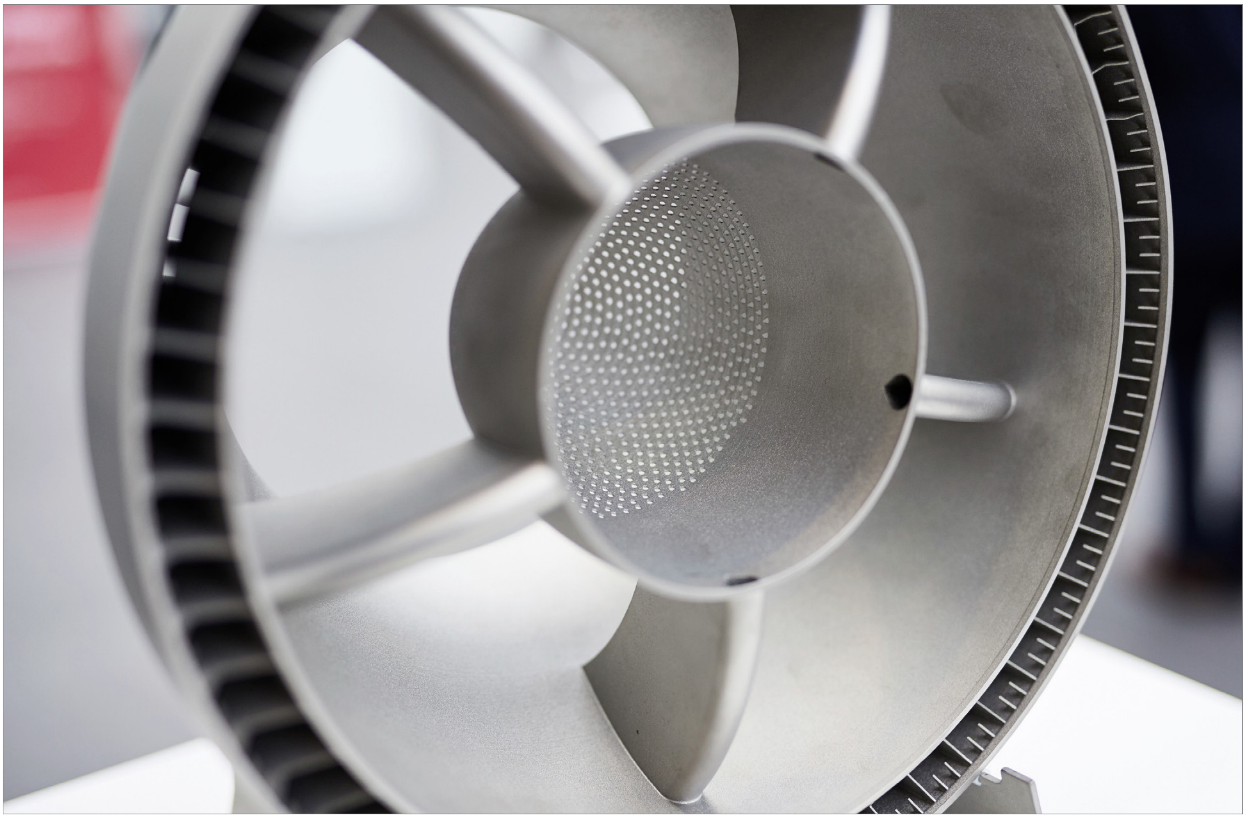

Fig. 12 This double nozzle, manufactured from Inconel 625, is a demonstration part for the aerospace sector

At the time of the agreement, Mohammad Ehteshami, Vice President and General Manager of GE Additive, commented, "GE Additive and Oerlikon both understand the transformative power of Additive Manufacturing. This is further proof that the adoption rate of additive is growing rapidly and we're proud to partner with Oerlikon." From Oerlikon's perspective, this arrangement will significantly strengthen its ability to meet the growing demand for additive components and materials for a variety of industry sectors.

Conclusion

Oerlikon believes that success will come from offering the complete AM process chain to its industrial and medical customers, becoming a single source for a full suite of integrated services for end-to-end component manufacturing, from materials, design and applications engineering to series production and post-processing. This, it states, will help customers reduce product development times and production costs, shorten their supply chains and increase the reliability, performance and sustainability profile of their AM activities.

In order to place themselves in a position to deliver on this, the company has moved quickly and decisively. In a period of just twelve months, it has become a leading player in the international AM industry through significant investments and acquisitions. There is no doubt that such developments will positively contribute to the continued growth of AM as the industry moves towards series production at a rapid pace.

The company has already demonstrated, through its organisation of the impressive 1st Munich Technology Conference (covered elsewhere in this issue), that it is open to working in collaboration with the wider community to collectively drive forward the growth of Additive Manufacturing.

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