Vol. 5 No. 4 WINTER 2019

THE MAGAZINE FOR THE METAL ADDITIVE MANUFACTURING INDUSTRY

METAL AM

in this issue

MTC3 CONFERENCE REPORT

CARPENTER ADDITIVE

THE EVOLVING POWDER MARKETPLACE

Published by Inovar Communications Ltd

www.metal-am.com

Publisher & Editorial Offices
Inovar Communications Ltd
11 Park Plaza
Battlefield Enterprise Park
Shrewsbury SY1 3AF
United Kingdom

Tel: +44 (0)1743 211991
Fax: +44 (0)1743 469909
www.metal-am.com

Managing Director, Features Editor
Nick Williams
nick@inovar-communications.com

Publishing Director, News Editor
Paul Whittaker
paul@inovar-communications.com

Deputy Editor
Emily-Jo Hopson
emily-jo@inovar-communications.com

Assistant Editor
Kim Hayes
kim@inovar-communications.com

Production Manager
Hugo Ribeiro
hugo@inovar-communications.com

Advertising
Jon Craxford, Advertising Sales Director
Tel: +44 (0)207 1939 749
Fax: +44 (0)1743 469909
jon@inovar-communications.com

Subscriptions
Metal Additive Manufacturing is published on a quarterly basis as either a free digital publication or via a paid print subscription. The annual print subscription charge for four issues is £95.00 including shipping. Rates in € and US$ are available on application.

Accuracy of contents
Whilst every effort has been made to ensure the accuracy of the information in this publication, the publisher accepts no responsibility for errors or omissions or for any consequences arising there from. Inovar Communications Ltd cannot be held responsible for views or claims expressed by contributors or advertisers, which are not necessarily those of the publisher.

Advertisements
Although all advertising material is expected to conform to ethical standards, inclusion in this publication does not constitute a guarantee or endorsement of the quality or value of such product or of the claims made by its manufacturer.

Printed by
Cambrian Printers, Aberystwyth, UK

ISSN 2057-3014 (print edition)
ISSN 2055-7183 (digital edition)
Vol. 5 No. 4 Winter 2019

This magazine is also available for free download from www.metal-am.com

INOVAR COMMUNICATIONS

METAL ADDITIVE MANUFACTURING

Formnext 2019: Now to the challenge of turning record visitor numbers into real industry growth

The annual Formnext exhibition, AM's flagship international event, just keeps on growing. Now in its fifth year, the event, which takes place each November in Frankfurt, Germany, saw a 28% increase in visitor numbers for 2019, attracting more than 34,000 people from around the world. Four huge halls, more exhibitors, more sparkling warehouse-sized exhibition stands, all catering to the ever growing visitor numbers; the showcase event for AM certainly knows how to put on a show.

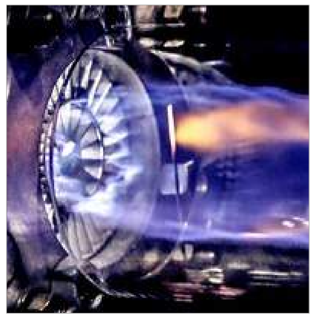
The question now being asked by many in the industry is: at what point does this increase in scale and footfall translate to a faster growth in orders for higher-volume applications? This is an issue that has been simmering under the surface for some time. The investments keep pouring in, be it into huge marketing efforts such as those on show at Formnext, or into new facilities, new AM divisions, new start-ups and R&D. But even at the top of some of the most AM-focused companies, whilst the conviction that AM will 'change the manufacturing world' remains rock solid, there is likely to be some frustration at the speed that change – in the form of new applications – is arriving.

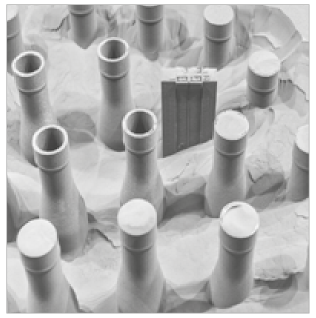
Perhaps it is simply a question of patience or, as our report in this issue on the third Munich Technology Conference suggests, it could be indicative of a need for greater industry collaboration. Nevertheless, optimism for the future of AM remains and, sooner or later, the flow of new, high-volume AM applications will arrive. Until that moment, however, the pressure of expectation continues to build.

Nick Williams
Managing Director

Cover image
Carpenter Additive collaborated with BMT Aerospace to create this aerospace slat track pinion gear using Carpenter Technology's premium Custom 465® stainless steel

METAL
ADDITIVE
MANUFACTURING





Contents

Regular features

industry news

Kennametal launches Additive Manufacturing business unit

Kennametal Inc., Pittsburgh, Pennsylvania, USA, has formed a new business unit, Kennametal Additive Manufacturing, to supply high-performance metal powders and finished AM parts for wear, erosion, corrosion and high-temperature applications.

"Kennametal Additive Manufacturing combines our recognised expertise in wear materials, such as tungsten carbide and Kennametal Stellite™, with the advantages of 3D printing – design flexibility, shorter development cycles and reduced lead times," stated Ron Port, Vice President, Kennametal Inc., and President, Infrastructure Business Segment.

Kennametal has been leveraging AM materials and processes within its existing businesses for some time to manufacture prototype components and cutting tools. Port explained, "We are focused on high-growth potential additive solutions, and this new business unit is advancing both what we make and how we make it, so we can produce better parts, faster and more efficiently, for our customers."

A metal additively manufactured carbide drill head (Courtesy Kennametal Inc.)

Sherri McCleary, Director of Kennametal's Additive Manufacturing Business, leads the new business segment, bringing thirty years of materials science and business development expertise to the role. The unit has already shipped its first production parts to customers in the oil & gas and power industries, including parts manufactured using powders specifically designed and optimised for AM, such as Kennametal KAC89 tungsten carbide and Stellite™ 6 AM, a wear resistant cobalt-chrome alloy.

In May 2019, Kennametal was announced as a beta customer for ExOne's new X125PRO Binder Jetting system. According to ExOne, the high-resolution production machine is capable of additively manufacturing metal, ceramic, and other advanced material parts directly, as well as using standard industry powders utilised in Metal Injection Moulding (MIM) and other Powder Metallurgy (PM) processes.

With its gas atomisation facilities, Kennametal is capable of producing atomised cobalt, nickel and iron powders optimised for specific AM processes. At its research and development facility for pilot production and prototyping in Latrobe, Pennsylvania, the business uses both Laser Powder Bed Fusion (L-PBF) and Binder Jetting and has post-processing capabilities including sintering, Hot Isostatic Pressing (HIP) and machining.

www.kennametal.com

GE Additive unveils new Concept Laser M2 Series 5

GE Additive unveiled the Concept Laser M2 Series 5 at Formnext 2019, Frankfurt, Germany. The latest iteration of the popular M2 machine is said to meet the high expectations for part quality and consistency from customers, especially in the highly-regulated aerospace and medical industries, as they move to serial additive production. The Concept Laser M2 Series 5 will be manufactured at the GE Additive Lichtenfels facility, and is available to order now, with delivery expected in Q1 2020.

"As our customers evolve and start to ramp up high-volume production, we will also continue to evolve our machine portfolio to meet their needs for repeatability, usability and quality," stated Chris Schuppe, General Manager – Engineering, GE Additive.

"Over the past year, teams from GE Additive have worked closely with colleagues at GE Aviation – which operates a fleet of M2s – to get direct feedback. Co-located teams collaborated on the critical characteristics needed for the next iteration of the M2 and to make a good part, but also on input on the mechanical operations, performance and productivity of the machine, and on improvements in reliability and quality," added Schuppe.

This collaborative work incorporated an extensive machine design, system and component review, and an extended testing period. The resulting machine is said to be configured to meet the exacting requirements of highly-regulated aerospace and medical industries.

The M2 Series 5 includes a dual laser system with up to 100% coverage per laser. It allows for a larger build volume thanks to increased surface area (245 x 245 mm) and 350 mm z-axis. The system incorporates a glovebox system for non-contact handling of reactive materials, better filter change and inerted sieving and powder exchange.

www.ge.com/additive

The new M2 Series 5 includes a dual laser system (Courtesy GE Additive)

Meltio combines wire and metal powder in single AM machine

The Meltio M450 was on show at Formnext

Meltio, based in Linares, Spain, and Las Vegas, USA, introduced its new Additive Manufacturing technology at Formnext 2019. Said to be the world's first metal AM system capable of building fully dense parts from wire and powder in the same machine, the company's new Meltio M450 system uses multi-laser technology and eliminates the need for nozzle changes when switching between wire and powder.

The company states that its AM technology can process any commercially available metal wire or powder, either individually or simultaneously. It allows for multiple materials and brings the ability to mix alloys in situ.

The M450 offers a build envelope of 250 x 200 x 450 mm and incorporates a sealed atmosphere that eliminates oxidation, enabling the processing of reactive metals. It features a powerful on-board computer with touchscreen display and a feature rich GUI with advanced custom designed software to allow easy model slicing and access to process parameters. The machine can also be controlled via a tablet or computer through a local wireless network or via an Ethernet connection.

The system can be also be used as an all in one AM solution for repairing parts, laser cladding, laser welding, laser texturing and polishing.

The same AM technology is also available in the company's Meltio Engines, which are said to enable CNC machines to be converted into hybrid manufacturing systems. It can also be integrated into robotics manufacturing systems.

Meltio also offers mid and large build size FDM 3D printers and 3D Inspection Systems using structured light.

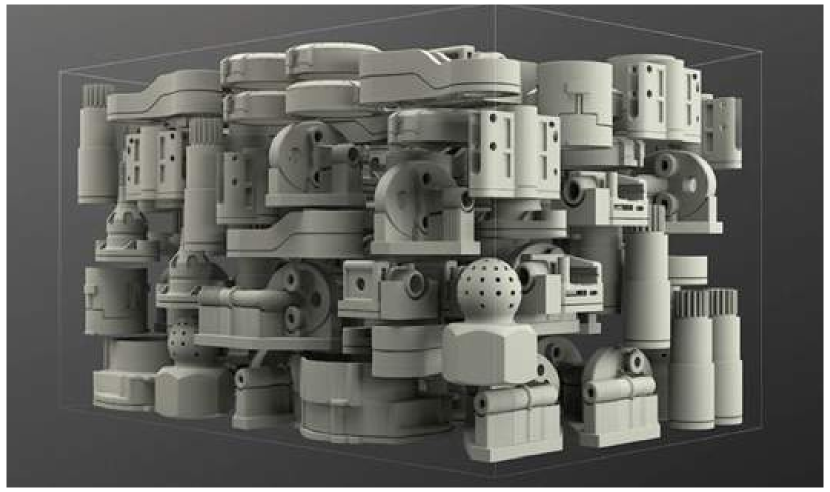
https://meltio4d.com

Desktop Metal launches new metal Binder Jetting system for machine shops

Desktop Metal announced its new Shop System™, a metal Binder Jetting system designed for machine shops and metal job shops, at Formnext 2019, Frankfurt, Germany. Beginning at $150,000, the high speed, single-pass system is said to introduce high-quality metal binder jetting to a new market of machine shops and metal fabrication job shops, a global industry estimated to be worth nearly $180 billion.

The Shop System is said to offer an end-to-end solution, including the AM machine, powder station and furnace, which integrates with existing shop operations. It can be used to additively manufacture end-use metal parts that span a variety of industries, including manufacturing, tooling, automotive, consumer, electronics and marine, with the quality, surface finish and tolerances needed to co-exist with machining.

Parts produced on the Shop System are built fully supported in a powder bed and feature hand-removable sintering setters. This, it was stated, could avoid hours of labour machining or wire EDM to remove support structures, reducing the total number of manufacturing steps needed, increasing shop productivity and capacity without requiring additional head count or machinist hours.



Desktop Metal's Shop System is suited to mixed-volume part production (above), as well as batch and mid-volume production (Courtesy Desktop Metal)

The Shop System can manufacture a batch of complex parts every six to twelve hours, enabling from tens up to hundreds of near-net shape metal parts to be produced each day, says Desktop Metal.

"Shop owners have been enamoured by the versatility, speed and cost reduction that Binder Jetting technology can provide, but, until now, it hasn't been accessible to them," stated Jonah Myerberg, co-founder and CTO of Desktop Metal, who led the technical development of the system.

"The Shop System offers users the same fully-dense metal parts at an affordable price that works in harmony with machining on the shop floor. What's more, the system enables owners to both save and make money by eliminating tooling costs, lowering lead times, and bringing in new business because of an improved part-cost equation," added Myerberg

The Shop System has a spot size of 16 microns per drop, 1600 native single pass DPI and distributes up to 670 million drops per second. The system's 70,000 nozzles per line have built in five times redundancy, to help to avoid jet-outs, resulting in enhanced quality and reliability.

Available in variable configurations, the Shop System is designed to scale to each shop's throughput, including mixed-volume production of various geometries without the need for multiple setups.

www.desktopmetal.com

Construction begins on new Höganäs atomising plant for AM powders

Sweden's Höganäs AB has begun constructing its new atomising plant for the production of high-purity metal powders for the Additive Manufacturing industry. The powders produced will be sold globally under the trademark Amperprint®.

The plant is based at the Laufenburg production unit in Germany and completion is scheduled for the third quarter of 2020. The Freiburg Regional Council is said to have approved its construction and operation of the plant under the conditions of the German Federal Emission Control Act (BImSchG) in September.

Currently, Höganäs has a yearly metal powder production capacity of 500,000 tons. The company operates eighteen production centres worldwide and has a workforce of 2,500 employees.

"The investment in the million-euro plant will help us to significantly increase our market share for metal powders in the promising segment of 3D printing," stated Peter Thienel, Höganäs' Site Manager. "In addition, we want to further increase the attractiveness of Höganäs as an employer in Germany and are confident that we can continue to offer our co-workers long-term professional development."

www.hoganas.com

GE Additive expands Arcam EBM range with new Spectra L

GE Additive introduced the Arcam EBM Spectra™ L at Formnext 2019, Frankfurt, Germany. With the largest build volume in the company's range of EBM systems, the new machine is set to target increased demand for higher productivity, especially from sectors such as aerospace.

The latest addition to the Arcam EBM Spectra family will be manufactured at the GE Additive Arcam EBM facility in Gothenburg, Sweden, with delivery expected at the end of Q1 2020. Suited to large titanium applications, that cannot be achieved with laser-based AM, the system supports grade 5 Ti6Al4V and grade 23 Ti6Al4V alloys. Support for pure copper is planned for later in 2020.

The Spectra L has a build volume of Ø 350 x 430 mm and features a 4.5 kW beam power, increasing build speed by 20% compared to the Arcam EBM Q20plus. Improvements to powder layering and heat model control result in the Spectra L completing a full height build some 4.5 hours faster than the Arcam EBM Q20plus. The gains in build volume and build speed reduce cost-per-part by 10%, thanks to the system offering almost double the build volume of the Arcam EBM Spectra H, and being 13% larger than the Arcam EBM Q20plus.

The Spectra L builds on the extensive end-to-end industrialisation features debuted on the Spectra H by enhancing and improving power handling, beam diagnostics and calibration, as well as automation. The system is compatible with the Arcam EBM PRS 30, a new automated powder retrieval system suited to serial additive production environments, providing safe, efficient powder handling for operators.

"The Spectra L is perfectly suited to those customers on the brink of, or those who have already begun to industrialise additive into their business," stated Karl Lindblom, General Manager, GE Additive Arcam EBM.

"When we were developing the system, feedback in particular from our aerospace industry customers centred on reliability, repeatability and automation, but increasingly – as they begin to scale their fleets of additive machines – also the need for process and machine health analytics and an integrated system architecture," he added.

www.ge.com/additive

The new Spectra L has largest build envelope in the Arcam EBM family and is particularly suited to aerospace applications (Courtesy GE Additive)

Aperam and Tekna establish new metal powder company ImphyTek Powders

Aperam S.A., Luxembourg, and Tekna, a subsidiary of Arendals Fossekompani ASA with its headquarters in Sherbrooke, Canada, have approved the framework of a global joint venture which will combine their expertise to create nickel and speciality alloy spherical powders through a newly-established company, ImphyTek Powders™ SAS.

Aperam is a global provider of stainless, electrical and speciality steel, and is organised across three primary segments: Stainless & Electrical Steel, Services & Solutions and Alloys & Specialties. The company has 2.5 million tonnes of flat stainless and electrical steel capacity in Brazil and Europe. In 2018, it reported sales of €4,677 million and steel shipments of 1.97 million tonnes.

Tekna develops and produces high-purity metal powders for applications such as AM and microelectronics, as well as optimised induction plasma systems for industrial research and production. The company has manufacturing centres in Canada and France, as well as sales and distribution offices in China, India and South Korea.

The formation of the new joint venture results from an earlier Memorandum of Understanding (MoU) agreed by the companies in 2018, in which Tekna and Aperam partnered to develop high-quality spherical powders for metal AM and Metal Injection Moulding (MIM).

ImphyTek Powders SAS will be based in France and market Aperam and Tekna's jointly-developed metal powders to the AM and MIM industries.

www.aperam.com
www.tekna.com

YOUR AM TOOLBOX

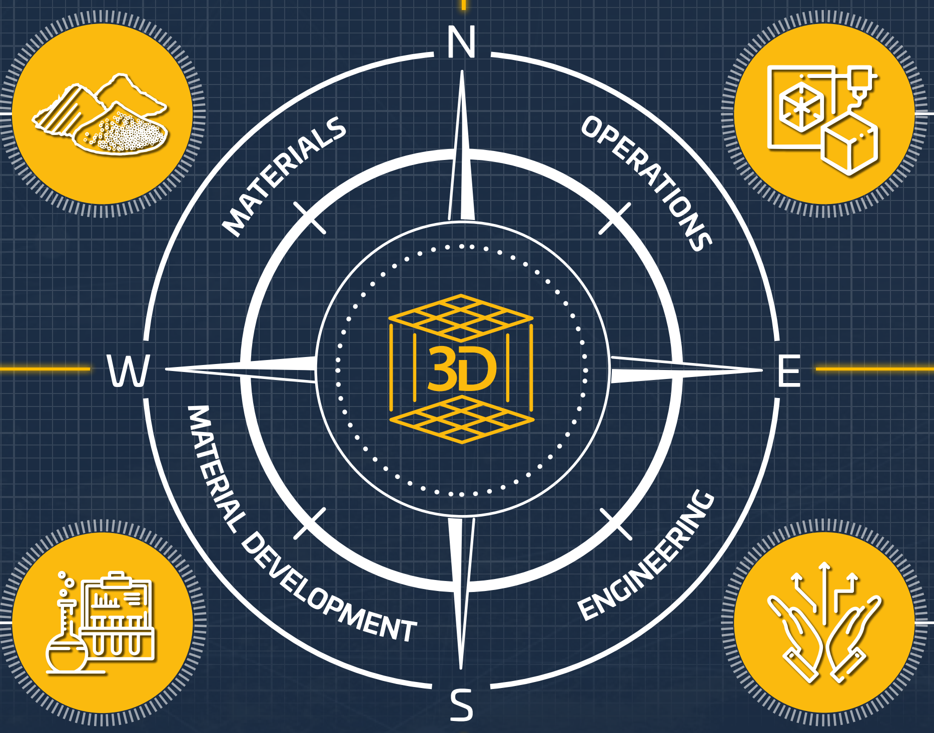
GKN ADDITIVE MATERIALS

GKN ADDITIVE COMPONENTS

- Low alloy water atomized steels, stainless steels and dual phase - structural steels
- Titanium-, Copper, Aluminium- and Nickel alloys, NiTi – Shape Memory alloys
- Magnetic alloys – Fe-Si

- High performance powder bed processes from 1 - 50.000 pcs
- Fully connected global print network
- MyAMQuality!

PRODUCT & PROCESS



ENGINEERING SERVICES

- Inhouse testing capabilities for mechanical and physical properties
- Printing studies for Laser AM and Binder AM; Powder morphology
- ASTM standardized methods to certify chemical composition

- Design for AM
- Application know-how
- Simulation and validation

DESIGN CONCEPT

MATERIALS → PART

AS 9100 · ISO TS16949 · IATF 16949

GKN ADDITIVE

GLOBAL PRINT NETWORK

R&D and manufacturing locations accross Europe, North America and Asia form our Global Print Network. It is part of GKN Additive's completely digitized value chain from powder to part.

R&D

PRODUCTION

DATA FLOW

Entering GKN's Global Print Network in Q1/2020

EMBEDDED IN IND 4.0

SECURE DATA TRANSFER AND PRINTING

FASTER DELIVERY TO CUSTOMERS

GKN Additive is your supplier for advanced metal AM components and materials for prototypes, medium series and the aftermarket. Our goal its to push 3D printing to its limits to make it simpler, faster and more accessible for you.

www.gknpm.com/additive

MIM and CIM in the spotlight at Formnext 2019

A major showcase of more than a hundred components manufactured by Metal and Ceramic Injection Moulding (MIM and CIM) was held at Formnext 2019, Frankfurt, Germany, November 19–22. Organised by *PIM International* magazine in partnership with Mesago Messe Frankfurt GmbH, the 60m² showcase put PIM technologies in the spotlight at a time when there is high interest in the potential of 'MIM-like' sinter-based AM technologies such as metal Binder Jetting and Fused Filament Fabrication.

The showcase featured parts from Europe, North America and Asia and included award-winning parts from the European Powder Metallurgy Association (EPMA), the Metal Powder Industries Federation (MPIF)'s Metal Injection Molding Association (MIMA), along with numerous application examples from Germany's MIM Expert Group (MIM Expertenkreis) and CIM Expert Group (Expertenkreis Keramikspritzguss). Dr Georg Schlieper, a regular contributor to *PIM International* magazine, was on-hand to speak to visitors about PIM technology and give background information to many of the applications on display.

Whilst the showcase fulfilled its purpose of increasing awareness of the use and potential of PIM, the extent to which a large number of AM-savvy visitors had no awareness of PIM, or worse, a fundamental underappreciation of the capabilities and properties of PIM parts, was surprising. It is inevitable, however, that awareness will improve as a result of MIM producers leading the drive to commercialise sinter-based AM processes as they seek to broaden the range of economically viable applications.

Beyond the PIM showcase, a number of MIM part producing companies were present in the exhibition halls, including Indo-MIM, GKN Sinter Metals, Alliance-MIM, MIMplus Technologies GmbH & Co. KG and MiMtechnik GmbH. Leading MIM-related materials and equipment suppliers were also strongly represented.

www.pim-international.com

The new PIM showcase introduced metal and ceramic injection moulding to a new audience

GKN Additive prepares distribution of AM powders for European market

To meet the needs of the European market, GKN Additive has announced it is to locally produce and warehouse AM metal powders through its GKN Additive Materials business segment. The company reports that it has identified a high demand for AM powders in Europe, finding that potential customers often cannot allow for a four to six-week lead time and are typically looking for one-week powder requests.

The company is now warehousing standard AM powders, such as 316L, 17-4PH and 20MnCr5, at its facility in Hueckeswagen, Germany. In addition to gas and water atomised powders, custom materials developed specifically for customers will be stored to allow the company to ship powders as needed.

GKN Additive and GKN Hoeganaes, the group's high-volume powder producing division, merged their expertise to form GKN Additive Materials in early 2019. GKN Hoeganaes produces over 300,000 t of engineered metal powders per year from facilities in Gallatin, USA, Bazhou, China, and Buzau, Romania for the Powder Metallurgy industry.

The first trial production runs of water atomised AM powders at its Buzau facility have now been completed. Alloys produced during these trials include ANCOR AM 4600 and ANCOR AM DP600, both low-alloy steels used in automotive and structural applications.

These materials are currently under evaluation by research groups in Europe such as SUPREME, IDAM and several customers in North America. Material is also available for development activities for Laser Powder Bed Fusion (L-PBF) and Directed Energy Deposition (DED) applications.

GKN Additive Materials stated its goal is to supply its AM materials to customers in Europe in a timely manner, while focusing on water atomised low alloy steels powders to help customers grow the market for AM parts.

www.gknpm.com

Marie Langer appointed EOS CEO

EOS GmbH, headquartered in Krailling, Germany, has reported that it is restructuring its company management with immediate effect, and that Marie Langer, the daughter of Dr Hans J Langer, founder of EOS GmbH and CEO of the EOS Group, has been appointed as its new CEO. The company explains that her key focus will be on strategy, marketing and communications as well as corporate culture, organisational and people development.

Marie Langer stated, "Thirty years of personal commitment at all levels and our shared culture have made us into the highly successful company we are today. We have successfully harnessed the pioneering spirit of the early years and combined it with the expertise of a global market leader."

She added, "From both a technological and an organisational perspective, EOS is optimally positioned for a successful future. My vision is that EOS stays at the cutting-edge of industrial 3D printing technology and that the company makes a sustainable contribution towards solving the huge challenges facing us today. We want our technology to do more than driving economic growth. We want it to provide positive environmental and social benefits."

Dr Tobias Abeln, CTO, and Bertrand Humel van der Leethe, COO, are leaving the company by mutual agreement. Dr Hans J Langer commented, "I would like to thank Tobias Abeln who has worked with passion and enthusiasm for the last eight years, during which he successfully built a strong and highly capable technical organisation that has been a cornerstone of our success. I would also like to thank Bertrand Humel van der Lee, for his key contribution to Sales, Service and Marketing across all regions during his time at EOS."

www.eos.info

Marie Langer has been appointed EOS GmbH's new CEO (Courtesy EOS)

Markforged to double production capacity with new facility

Markforged, Watertown, Massachusetts, USA, has opened a new manufacturing facility in Billerica, Massachusetts. The facility is expected to enable the company to more than double its Additive Manufacturing machine production capacity, supporting increased demand for its metal AM and carbon fibre AM systems.

This is the third major footprint expansion for the company in 2019. Earlier this year, it announced the opening of its European headquarters in Dublin, Ireland, as well as an artificial intelligence innovation centre in Cambridge, Massachusetts.

According to Markforged, demand for its materials and systems has 'exploded' in recent years, with its material production increasing by 81% in twelve months. The new facility is expected to support the fabrication of all Markforged materials, which are used by companies in aerospace, automotive and manufacturing.

"With the significant growth of Markforged printers in the field, the consumption of our materials continues to increase at a rapid pace. Our new facility in Billerica gives us the ability to meet the demands of today and operations for years to come," stated Matt Gannon, the company's Vice President of Operations. "Billerica was the perfect choice for our expansion. The region is a hotbed for manufacturing and technology companies and is strategically located with access to key partners and expertise to support the team."

www.markforged.com

Markforged's new production facility in Billerica, Massachusetts, will more than double capacity for production of its metal and carbon fibre Additive Manufacturing machines (Courtesy Markforged)

ExOne announces X1 160PRO Binder Jetting system for high-volume production

The X1 160PRO is the tenth and largest metal binder jet Additive Manufacturing system from ExOne (Courtesy The ExOne Company)

The ExOne Company has announced its newest machine and largest metal Additive Manufacturing system to date, the X1 160PRO. Designed for high-throughput and large-part production, the new X1 160PRO will reportedly offer build dimensions of 800 x 500 x 400 mm and build speeds of up to 10,000 cm^3/hour.

"Our technology roadmap has been leading us to this machine for more than two decades," stated John Hartner, ExOne CEO. "At the same time, the X1 160PRO was also designed in response to growing demand from automotive, defence and aerospace customers. We're incredibly proud of what this model means for the future of metal 3D printing and sustainable production of large metal parts without design limitations."

Due to ship in late 2020, the open material system will be capable of building in six qualified metals, including the popular stainless steels 316L, 304L and 17-4PH, as well as in ceramics. The X1 160PRO will also feature Industry 4.0 cloud connectivity and process-linking capabilities enabled by Siemens MindSphere.

The new system also incorporates ExOne's patented Triple Advanced Compaction Technology (ACT) system, said to be critical to delivering consistent part density and repeatability across the entire build area in the binder jet process. Triple ACT is reported to tackle the challenges associated with dispensing, spreading and uniformly compacting ultra-fine metal powders, with an average particle size, or D50, of 9 µm.

The X1 160PRO joins ExOne's growing family of metal AM systems, which includes the Innovent+, an entry-level system used globally for research, design and small part production, and the X1 25PRO, a mid-size production system which began shipping November 2019.

www.exone.com

Stefan Widing to be new Sandvik CEO

Sandvik's Board of Directors has announced Stefan Widing as the company's new President and CEO, effective February 1, 2020. The move follows the announcement that current President and CEO, Björn Rosengren, is to leave the company.

Stefan Widing is Sandvik CEO as of February 1, 2020 (Courtesy Sandvik)

Widing has served as Executive Vice President of Assa Abloy and President of HID Global Corporation, a technology division within Assa Abloy, since 2015. He holds an MSc in Applied Physics and Electrical Engineering and a bachelor's degree in Business Administration. Formerly, he served as General Manager for Assa Abloy's Shared Technologies and before that held various positions in Assa Abloy and SAAB Aerospace.

"We are very pleased that Stefan Widing will take on the position as President and CEO of Sandvik. Stefan is a highly appreciated leader with a solid industrial track record of developing organisations and businesses, both organically and through acquisitions," stated Johan Molin, Chairman of the Sandvik Board of Directors.

"In addition, his competence in advanced technologies and experience from leading digital transformations will be another valuable asset to Sandvik," he continued. "Stefan definitely has the capabilities needed to continue the decentralised way of working and to ensure Sandvik's future development."

"I really look forward to joining Sandvik," Widing added. "I'm convinced that such a technologically advanced industrial group, recognised for its very competent employees, has a lot of future potential not the least by further developing within the digital area and exploring new technologies, thereby leveraging efficiency, productivity and sustainability even more for its customers."

www.home.sandvik

Trumpf unveils new TruPrint 2000 AM machine for medical devices

Trumpf unveiled its latest metal Additive Manufacturing system at Formnext 2019, Frankfurt, Germany. Aimed at the medical device market, the TruPrint 2000 has been designed so that inert gas flows through it back to front, a development said to enhance the quality of built parts. The processing of metal powder in an inert gas environment also prevents contaminants from infiltrating the powder circuit, a key advantage for sensitive medical devices and similar applications. The new design also lets the operator remove excess powder from the component while in the system, rather than at a separate station.

Two 300 W lasers are reported to work in tandem to illuminate the machine's entire build chamber and boost the system's productivity. Taking the same approach as used for the TruPrint 1000, Trumpf's development engineers reportedly reduced the TruPrint 2000 laser's focal diameter to 55 micrometres to build components with smoother surfaces, enhanced quality and intricate grid structures.

"The machine's new design brings the benefits of lean manufacturing to users. It requires fewer add-ons, so the entry-level investment is lower for companies that want to get into AM," commented Florian Krist, Product Manager at Trumpf Additive Manufacturing.

The machine also incorporates automated powder bed and melt pool quality monitoring. In the event of an error, the system notifies the operator, who can then take remedial action. Another benefit is an end-to-end documentation trail that corroborates the quality of the printing process, a key prerequisite for the Additive Manufacturing of medical devices.

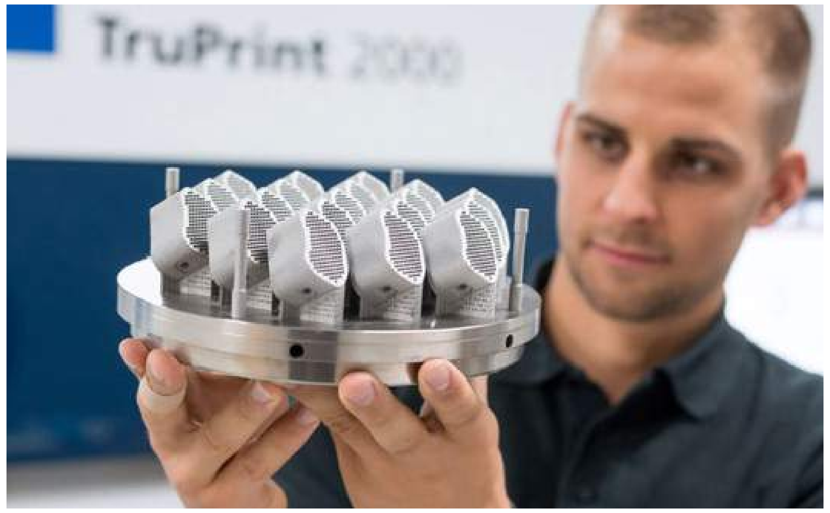
"With the TruPrint 2000, we are showing that Trumpf puts the needs of AM-focused industries first – that is, the aerospace, automotive, mechanical engineering, tool and mould making, and the medical and dental engineering industries. The TruPrint 2000 enables manufacturers to take advantages of Additive Manufacturing's benefits – particularly medical and dental engineering companies," stated Klaus Parey, Managing Director Trumpf Additive Manufacturing.

Trumpf has already used the new machine to build a number of metal interbody cages, which are implanted to add stability to the spine. These can be inserted as a placeholder between two vertebrae to restore the vertebral segment's natural height.

The laser's small focal diameter is said to be ideal for fabricating the implants' intricate structures, designed to aid osseointegration (bone in-growth). It is capable of producing nineteen implants in just twenty-four hours and is also suitable for dental applications, as well as non-medical applications such as tool and mould-making.

www.trumpf.com

The TruPrint 2000 enables the operator to remove excess metal powder without having to take it from the machine (Courtesy Trumpf)



Spinal implants, such as these interbody cages, can be produced on the TruPrint 2000 (Courtesy Trumpf)

Sandvik opens its plant for AM titanium powders in Sandviken

Sandvik AB, headquartered in Stockholm, Sweden, has officially opened its new plant for the production of titanium powders for Additive Manufacturing in Sandviken, Sweden. The official ribbon cutting was performed by Lars Bergström, President of Sandvik Machining Solutions, and the Governor of Gävleborg, Per Bill, before an audience of plant employees as well as customers and end-users of the titanium powder.

In addition to the opening ceremony, the full-day event programme included talks from leading companies from sectors such as aerospace and medical, as well as many AM system producers. There were also discussions on new developments in metal powder and Additive Manufacturing, focusing on titanium powders and nickel-based superalloys.

Peder Arvidsson, Process Owner Round Tools, and Matts Westin, Global Product Application Manager Milling, both from Sandvik Coromant, shared their experiences from the development of the lightweight cutting tool CoroMill® 390 and demonstrated how AM and titanium as a material both contributed to radical improvements in its performance.

Michele Antolotti, President, and Martina Riccio, Material and Special Process Manager, both from AM service provider BEAMIT, also shared case studies involving the AM of titanium for applications in the motorsports and racing sectors.

"Sandvik's launch of titanium powders for Additive Manufacturing supports a growing trend towards the 3D printing of titanium parts," stated Mikael Schuisky, Head of R&D and Operations in Sandvik's Additive Manufacturing division. "The additive process results in far less material waste than traditional subtractive techniques, while also encouraging new levels of design freedom. This is opening up the use of titanium in other industries, such as automotive and tooling."

Titanium atomisation at Sandvik's new facility (Courtesy Sandvik)

Keith Murray, Head of Global Sales at the Additive Manufacturing division, commented, "With the addition of titanium powder, the Sandvik materials offering to Additive Manufacturing is complete. In addition, we can also tailor the powder to any printing process, thanks to our extensive in-house capabilities in Additive Manufacturing."

www.additive.sandvik

First Additive Manufacturing machine from Alpha Laser

Alpha Laser GmbH, Munich, Germany, a manufacturer of mobile laser welding and cladding machines, has launched its first metal Additive Manufacturing system, the AL3D-Metal. The new Laser Powder Bed Fusion (L-PBF) system is said to offer a complete and safe solution for small-scale metal AM.

The AL3D-Metal was launched at Formnext 2019 (Courtesy Alpha Laser GmbH)

Incorporating a number of safety features for powder management, this innovation is said to enable the easier adoption of AM within small enterprises and laboratory settings. The company's patented cartridge system reportedly ensures operator safety regarding powder management, with components being built directly inside the cartridge.

After the build is complete, the parts are placed into a depowdering station, the AL3D-Cabin, inside the closed cartridge without any operator needing to come into contact with the powder. Having a footprint of 60 x 60 cm, this machine is thought to be one of the smallest metal printers available on the market. The accompanying AL3D-OS software is also said to allow easy programming and handling of the entire process.

www.al3d.alphalaser.de

Farsoon announces first installation of its new dual-laser metal AM system at US aerospace customer

Following the launch of Farsoon's FS301M metal Additive Manufacturing system in October, the company has announced the first installation of a dual-laser version of the machine at an un-named aerospace customer in the USA.

Farsoon's new system is suited to larger-sized applications (Courtesy Farsoon)

Being an early adopter of the machine, it was stated that the customer has been working with Farsoon through the development cycle to create a system that meets the demanding requirements of the aviation industry. Farsoon added that the initial qualification and testing data from the joint process development on the FS301M for Ti6Al4V Titanium, shows industry-leading performance for additive and near-wrought properties.

"The material data we're seeing on the 301 is at the top tier in the industry," the aviation customer stated after reviewing the testing result, "With surface roughness below 5um Ra, static performance at or above wrought and fatigue performance within the order of magnitude of wrought with as-built surface, the 301 finally allows for economical production without compromising part quality."

The dual-laser scanning strategy and calibration algorithms are said to improve build efficiency by precisely controlling both lasers' operation, achieving intelligent distribution of each laser while building a single large part or multiple smaller parts. With a build volume of 305 × 305 × 400 mm, both lasers have full coverage of the build area and can be set to use only one laser per part.

Farsoon celebrates its tenth year

Farsoon celebrated its 10th anniversary at its AM Innovation & Industrialisation Forum, held in Changsha, China, on October 24, 2019. The event brought together over 200 customers, partners and academic experts.

Hope Hou, General Manager of Farsoon, and Dr Xu Xiaoshu, Founder and Chairman of Farsoon, provided an overview of the company's innovations over the past ten years. A tour of Farsoon's new showroom, application centre, material testing lab and AM machine and polymer material production facilities followed further presentations by AM industry and academic leaders.

www.farsoon.com

Unitedcoatings Group to become Lincotek Additive as part of rebranding strategy

Unitedcoatings Group, headquartered in Rubbiano, Italy, has launched Lincotek Additive to provide a complete AM service as part of a wider initiative by the group, which is designed to consolidate a range of respected brands under the Lincotek name by January 15, 2020.

Turbocoating will reportedly become Lincotek Surface Solutions, while Eurocoating, Surface Dynamics, the former CoorsTek Medical (recently renamed Lincotek Medical), NanoSurfaces, Anteco and Eurocoating Wuxi will become Lincotek Medical and Artec Lincotek Equipment.

According to the group, Lincotek Additive will enable an improved focus on its Additive Manufacturing activities and customers will benefit from more expertise in research, design, engineering, production and assembly. Unitedcoatings Group explains that as a contract manufacturer with the complete service offer, Lincotek can help customers to scale up production and act as the supply chain partner that allows customers to reach economical and performance targets as much as the requested product characteristics.

The group stated that the ownership and management team of the Unitedcoatings business will ensure continuity as the transition to Lincotek takes place, providing reassurance and stability for all existing customers and partners.

Winfried Schaller, CEO of Unitedcoatings Group, commented, "The group's success under its different brands has been impressive and now it's time to present ourselves under one coherent umbrella while leveraging the goodwill and technology depth of our current businesses. The group has become a real global player – a much larger and unique company, strongly rooted in our core values and service concept."

Schaller added, "The rebranding process is part of our internationalisation strategy, which – in line with our growth plans – prepares the group for future challenges and guarantees continuity to our partners and the wider market in the long run."

www.unitedcoatingsgroup.com

Record breaking 300 mph Bugatti Chiron with AM exhaust components

APWORKS GmbH has revealed that the recent record-breaking Bugatti Chiron was equipped with additively manufactured titanium exhaust finishers. The car is the first hyper sports car to break the 300 mph barrier (483 km/h), a world record that was set at the beginning of August in Germany.

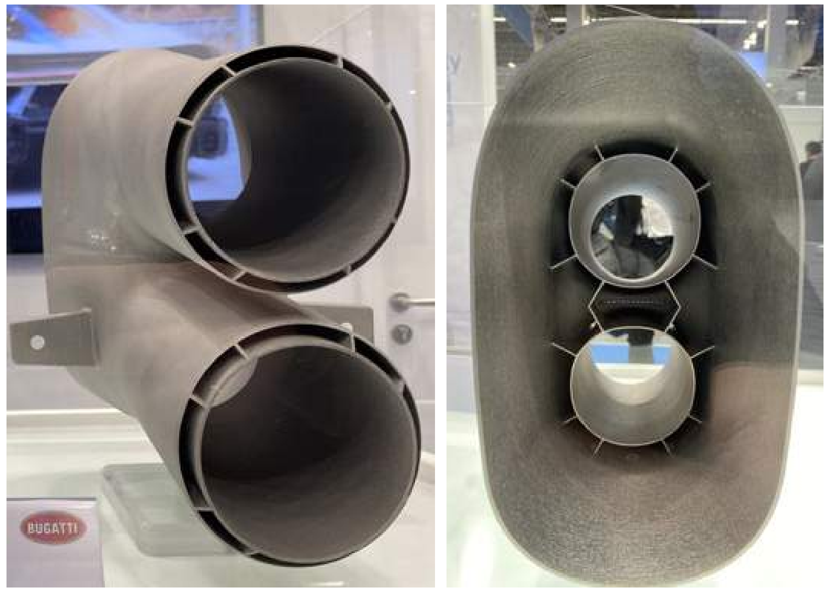
The pair of exhaust finishers are part of the modified longer tail section and are designed to push the exhaust emissions further from the rear end of the car to reduce turbulence and improve steering behaviour at high speeds. The design freedom offered by Additive Manufacturing enabled optimised exhaust aerodynamics resulting in increased downforce and enhanced high speed handling of the car.

Titanium is said to be best suited to this application as it combines high strength, heat resistance and low weight. In addition to the aerodynamic benefits, the low mass of the parts also contributes to the exceptional acceleration of the car.

Le Mans winner and Bugatti test driver Andy Wallace reached the top speed of exactly 490.484 km/h (304.773 mph) on August 2, 2019 on the test track at Ehra-Lessien in Lower Saxony.

"Congratulations to Bugatti on the world record. We from APWORKS are proud to be part of this amazing project, having produced the innovative exhaust finishers. The pair of finishers impress by the combination of lightweight, high performance material and optimised emission flow. A functional styling that exceeds limits and enables incredible performance." says Joachim Zettler Managing Director of APWORKS.

https://apworks.de



The exhaust finishers were on show at the APWORKS booth at Formnext

BASF acquires AM service provider Sculpteo

BASF New Business GmbH, Ludwigshafen, Germany, has agreed to acquire online Additive Manufacturing service provider Sculpteo, based in Paris, France, and San Francisco, California, USA, pending regulatory approval. The acquisition is expected to enable BASF 3D Printing Solutions GmbH, a wholly-owned subsidiary of BASF New Business GmbH, to market and establish new industrial AM materials more quickly.

Sculpteo operates an online platform with integrated production for the manufacturing of prototypes, individual objects and serial production components by a range of different Additive Manufacturing technologies, including metal Binder Jetting and Laser Powder Bed Fusion (L-PBF) alongside a range of polymer-based processes. BASF reported that it will develop this platform into a global network, offering an additional channel to market BASF 3D Printing Solutions' services and expand its customer bases.

Dr Dietmar Bender, Managing Director BASF 3D Printing Solutions, explained, "Through the acquisition of Sculpteo, we can provide customers and partners with even faster access to our innovative 3D printing solutions. In addition, our customers will benefit from an extended range of services. Together with Sculpteo, we are pursuing our goal of establishing Additive Manufacturing as a proven technology for industrial mass production."

"We are excited to join the BASF team and thus benefit from BASF's outstanding R&D to provide our customers with innovative solutions," added Clément Moreau, CEO and Co-Founder of Sculpteo. Moreau will remain Sculpteo's CEO following the acquisition.

It was also reported that the Sculpteo Design Studio and BASF's technical experts will collaborate to support customers with their AM projects from early planning phase through to the final part. This will enable BASF to offer its customers end-to-end industrial AM solutions.

www.forward-am.com
www.sculpteo.com

Liberty Powder Metals begins construction of new atomiser facility

Liberty House Group, parent company of Liberty Powder Metals, Sheffield, UK, has begun construction of a powder metals development facility in Teesside, UK, which it hopes will enable the group to expand its reach in specialist metals and materials for Additive Manufacturing.

The new powder metals facility will be based at the Materials Processing Institute in South Bank, Middlesbrough, UK, and an initial £10 million is also being invested to establish the Liberty Powder Metals business in this location. This investment will include a state-of-the-art vacuum induction inert gas atomiser (VIGA), which Liberty Powder Metals secured funding for from the Tees Valley Combined Authority Cabinet, UK, in October 2018. There are also plans to install a range of sieving, blending, packaging and analytical equipment at the facility.

The atomiser is expected to enable the group to enhance its position in the supply chain for precision steel components used in rapidly-changing and advanced sectors such as aerospace, automotive, energy and specialist industrial equipment. Dr Simon Pike, General Manager of Liberty Powder Metals, stated, "We are grateful to our partners for the work they have done to reach this stage. Finance from Tees Valley Combined Authority has been critical in making the project a reality and I look forward to continuing all our partnerships to make Teesside a global-leading centre of expertise for powder metal production."

"We are glad to see construction now starting," commented Chris McDonald, Chief Executive Officer for the Materials Processing Institute. "Advanced materials development is a core area of research at the institute and this investment by Liberty Powder Metals is an example of the benefits of partnerships and collaborations between industry and the Institute."

Tom Sellers, Commercial and Business Development Manager for Liberty Powder Metals, reported, "We are excited about the progress to date and I am looking forward to bringing our products to market and developing our customer base along with the strength of the Liberty brand.

Atomising Systems Ltd. (ASL) and Consarc Engineering designed the equipment for the powder metals facility, while K-Home International is managing the installation at the Materials Processing Institute. Commissioning was expected to take place from December 2019, with the aim of producing powders for sale from March 2020.

www.libertyhousegroup.com
www.mpiuk.com
www.atomising.co.uk
www.consarceng.com

Addilan demonstrates stability of its Wire Arc AM process

Addilan, Durango, Spain, recently released research results said to demonstrate the stability of its Wire Arc Additive Manufacturing (WAAM) process for metals including titanium, steel alloys, nickel superalloys, invar and aluminium. Addilan's WAAM machine is capable of producing medium-to-large complex parts at deposition rates of up to 6 kg per hour, reducing raw material consumption and lead time.

Addilan's WAAM machine is said to offer deposition rates up to 6 kg per hour (Courtesy Addilan)

Laboratory results from Tecnalia, a privately-funded applied research and technology organisation, appear to show that the stability of Addilan's WAAM process makes it possible to rapidly produce parts with good mechanical properties for aerospace, oil & gas, naval and railway applications.

"Our research focused on analysing material characteristics unique to wire arc welding in order to better understand how to stabilise the process and ensure the quality and repeatability of key process parameters," explained Alfredo Suárez, Head of WAAM at Tecnalia Research and Innovation.

Research results compared WAAM to block, foundry and forging measuring in terms of:

- Oxygen level (for Ti)
- Fatigue life
- Fracture toughness
- Tensile strength
- Elongation at break
- Microstructure composition
- Charpy impact testing

"For companies interested in end-to-end digital manufacturing, flexibility in manufacturing, production automation and industry 4.0, WAAM is one of the best value propositions for final and replacement part production," stated Amagoia Paskual, Addilan CEO. "We can now customise Additive Manufacturing solutions and build components using different materials, on the same machine, while ensuring the stability and integrity of each part."

www.addilan.com

Formnext 2019 reports 28% visitor growth

Formnext 2019, which took place in Frankfurt, Germany, from November 19–22, 2019, reported a 28% increase in visitor numbers throughout the four-day event compared to the previous year's figures. According to event organiser Mesago Messe Frankfurt GmbH, this year's Formnext was attended by 34,532 visitors and featured 852 exhibitors.

"Even in its fifth year, Formnext continues its impressive success story," stated Sascha F Wenzler, Vice President of Formnext at Mesago Messe Frankfurt GmbH. "AM has definitely arrived in the industry. Together with our enormously dynamic industry, we will continue to accompany, support and advance this development as a trade fair organiser."

For many, Formnext is an important platform, with companies often agreeing business transactions directly on the exhibition floor. This year there was said to have been a significant increase in interest from venture capital companies and industrial companies. Through its Start-up Challenge and the Start-up Area, the event offered new as well as established companies an avenue to present themselves to an international audience.

With the USA acting as the event's first 'partner country', the US Commercial Service and numerous other organisations offered a varied supporting programme. The trans-atlantic AM Standards Forum, taking place for the second time since its 2018 debut, advanced the development of internationally uniform norms and standards for AM, and more than fifty US-based companies exhibited at the event, with the number of US visitors growing by 25%.

Formnext 2019 was attended by 34,532 visitors (Courtesy Formnext)

Ken Walsh, Commercial Consul of the US Commercial Service, commented, "Formnext is very important for the industry and for US companies. This year the participation of US exhibitors grew by almost 40% compared to 2018, so that we could really show the variety of innovative products and services of American companies."

Formnext 2020 will be held from November 10–13, Frankfurt, Germany.

www.formnext.com

Oerlikon and Hirtenberger collaborate on AM part production

Oerlikon AM, the Additive Manufacturing unit of global technology group Oerlikon, and Hirtenberger Engineered Services announced at Formnext 2019 a strategic alliance to further industrialise series production and prototype parts using the Hirtisation Process.

Oerlikon AM and Hirtenberger began working together early this year to evaluate the Hirtisation Process, a post-processing technology for AM that allows three-dimensional surface treatment, including the removal of support structures and automatisation of the post-processing steps.

The two companies are intensifying their collaboration and have created a joint working group to explore how the process can be integrated into the AM value chain. The new process results in smoother surface textures. It also allows for the production of complex parts that require interior support structures during production, but which need those structures removed after completion, without impacting the integrity of the part.

The industries that can benefit most from this collaboration are those with complex parts, such as turbomachinery, oil and gas, automotive and general industry. Oerlikon AM will apply the technology in those industries first to help customers reduce part costs and achieve predicable and repeatable results.

"For Oerlikon AM, the Hirtisation Process addresses one of AM's major challenges, which is to provide our customers with parts with more complex geometries – some of which are not possible nor economical with existing AM and post-processing technologies," stated Dr Christian Haecker, Head of Oerlikon AM Industrialisation. "The process fits perfectly in our desire to offer customers services and products along the entire value chain. We also see a benefit in increasing repeatability of defined AM surface quality."

"We provide a crucial step in the process chain of 3D printing of metal parts," added Dr Wolfgang Hansal, Managing Director, Hirtenberger Engineered Surfaces. "We see ourselves as an industrial enabler of automated surface finishing. We maintain the full freedom of the printed parts design, while allowing cost efficient post-processing. Closing the interfaces along the production chain from post-processing back to construction, design and printing is key for the establishment of reliable additive manufacturing, from prototyping to large quantity serial production. For these reasons, Oerlikon AM is an important partner."

www.oerlikon.com

www.hirtenberger.com

World's largest multi-material AM system released

The Kraken, reported to be the world's largest and most accurate multi-material Additive Manufacturing machine and the result of a three-year EU-funded project, was officially released at the project's final conference at the Aitiip Technology Centre, Zaragoza, Spain, this September. The hybrid system integrates both additive and subtractive manufacturing technologies, with a maximum working area of 20 x 8 x 6 m.

Coordinated by Aitiip, the research project behind the Kraken was supported by the Horizon 2020 EU programme and saw fifteen partners collaborate on its development. During the conference, which welcomed 120 attendees, the project's partners presented early results and expressed their aim to revolutionise the manufacture of large parts with the production quality and efficiency the Kraken reportedly offers.

The Kraken uses Wire Arc Additive Manufacturing (WAAM) to process metallic materials and incorporates a bi-material resin extrusion system. An arc spray metallisation process also enables metal Additive Manufacturing on top of an existing polymer part. The system's subtractive capabilities allow for cutting, sanding and polishing operations.

The Kraken AM system allows multi-material builds (Courtesy Kraken)

All of the Kraken's operations are controlled by a laser tracker, which monitors the position of the working head 1,000 times per second, correcting its position automatically. The system also incorporates two types of cameras and artificial vision systems to control deposition flows and for the subsequent verification of the piece via three-dimensional scanning.

"Due to the integrated Leica Absolute Tracker, parts manufactured by the Kraken machine can be digitised in 3D and checked against the CAD design to verify the quality of manufacturing over the full volume of the machine, even fully automated if needed," stated Markus Steiner, Product Manager – Software and Connectivity – Portable Products, Hexagon Manufacturing Intelligence.

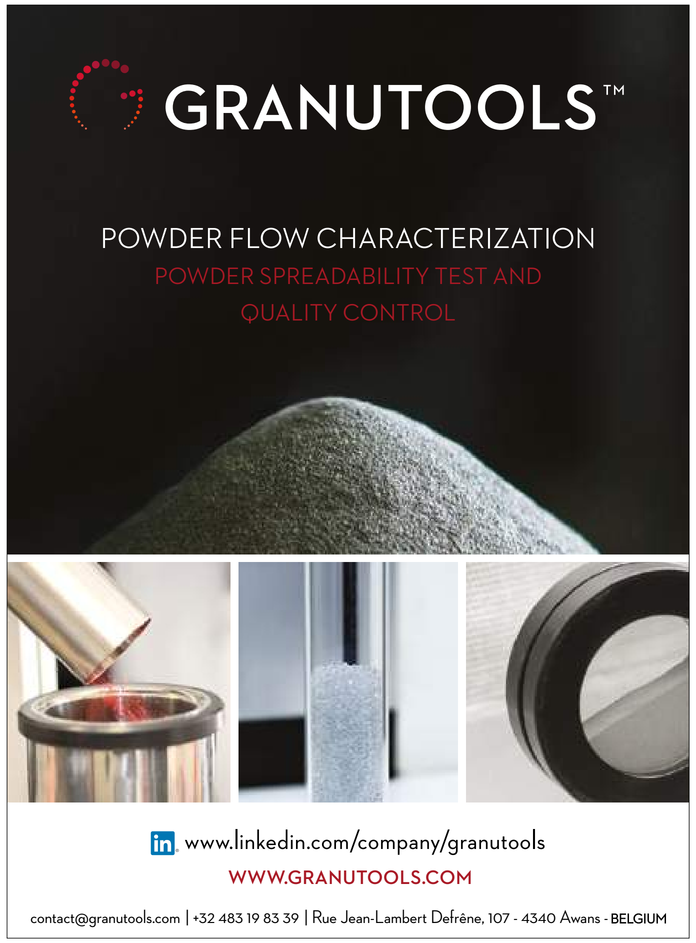
The possibility of building high-quality, large metal and resin parts by means of Additive Manufacturing has raised the interest of much of the industry. Hybrid lining panels for road tunnels have been manufactured for Acciona, one of the consortium partners. Thanks to the combination of resin and metal, electrical connections can also be produced much more easily. To demonstrate the Kraken's applications in the automotive sector, a mock-up of one of Pininfarina's latest car models has been produced to validate its design. The built piece had a size of 2.2 x 1 x 0.6 m and a weight of 250 kg.

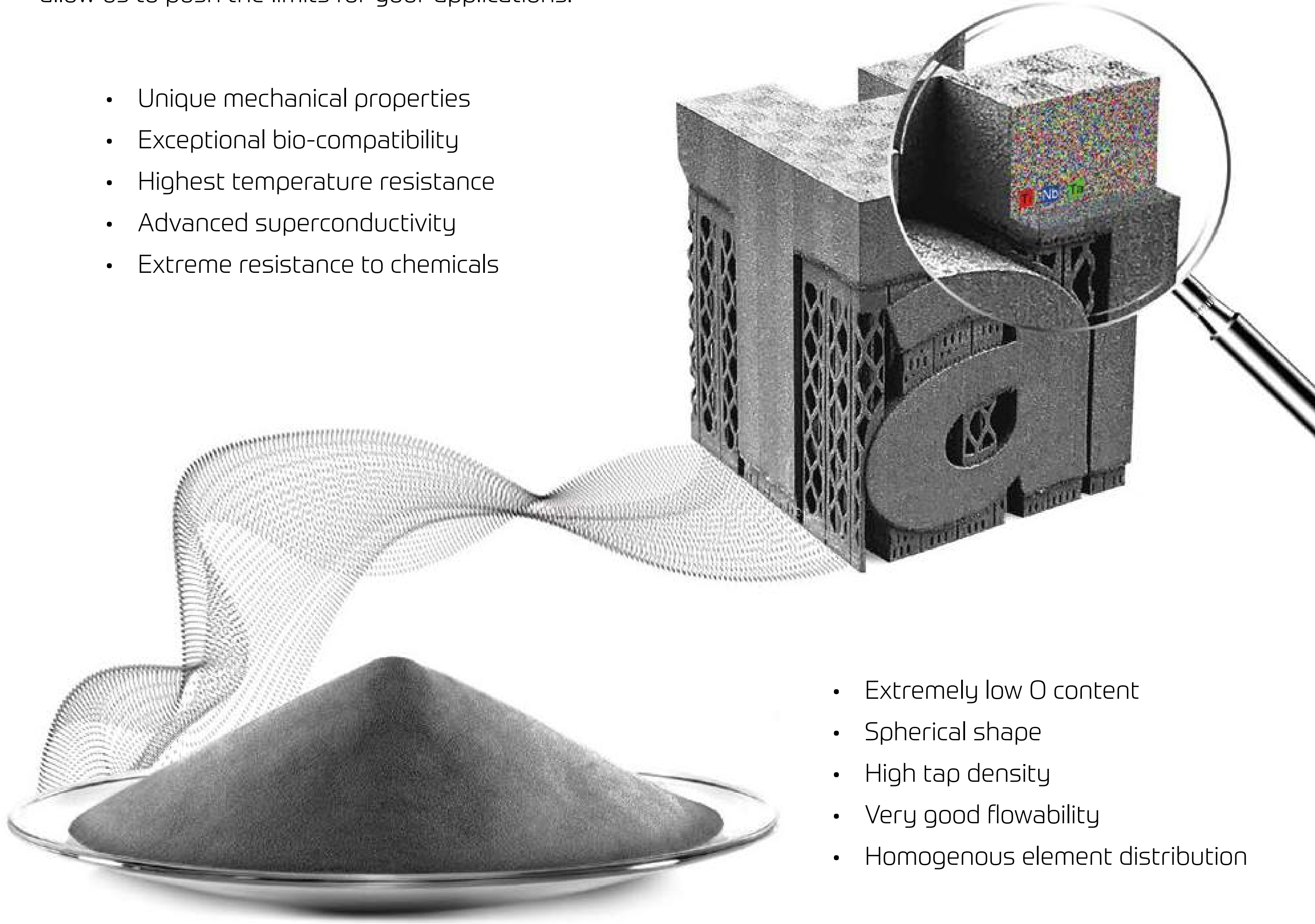
The sectors that can benefit from this system are thought to be broad, since it offers low-cost, high-quality, fast and efficient alternatives for the die and mould sector. José Antonio Dieste, Aitiip researcher and project coordinator, stated, "The machine is ready for the market, it has been tested in a real manufacturing environment and project demonstrators have been validated by the companies in real conditions. We can now deliver or install Kraken cells according to client demands."

"Guaranteeing accuracy in large workspaces of 100 m^2 is a challenge that Kraken has solved by integrating real time laser tracking technologies within the closed loop control of the robotic system," explained Francesco Crivelli, CSEM SA, who is responsible for designing the control algorithms and implementing the software. "Thanks to this method, tool precision can be assured down to 0.1 mm."

Further information about the Kraken system and the collaborative project is available via the project website.

www.krakenproject.eu
www.aitiip.com
www.cecimo.eu





H.C. Starck Tantalum and Niobium launches AMtrinsic metal powder range

H.C. Starck Tantalum and Niobium GmbH, Goslar, Germany, has launched its new range of atomised tantalum and niobium powders and alloys designed specifically for metal AM processes. Under the brand name AMtrinsic®, the new powders are suitable for a wide range of demanding applications.

The powder systems under the new brand AMtrinsic include elemental Ta/Nb powders and range from binary over complex multinary to high-entropy alloys also in customer specific compositions. Besides Ta and Nb, alloying elements include but are not limited to Ti, Zr, Hf, Mo, W, V, Sn, and Al.

Tantalum and niobium, as well as alloys containing these elements, offer a unique set of properties including high melting point, high corrosion resistance, excellent chemical resistance and high thermal and electrical conductivity. This makes them ideal for high-tech applications in fields such as chemical processing, superconductors, energy and high-temperature environments.

"With this new brand we express our approach to provide powders that allow to combine the unique intrinsic material properties of tantalum and niobium and their alloys with the geometric design freedom offered by additive manufacturing technologies," stated Dr Melanie Stenzel, H.C. Starck Tantalum and Niobium's Head of Marketing and new Business Development.

In addition, parts additively manufactured from Ta/Nb containing alloys may offer an alternative for the optimisation of mechanical and biological performance parameters in medical implants. Multinary alloy compositions or high-entropy alloys containing Ta/Nb are said to be especially of interest for the design of completely new intrinsic material properties that can provide superior solutions in challenging applications, especially when combined with the freedom of geometric design available using AM.

Dr Kazuyuki Marukawa, Vice Chairman H.C. Starck Tantalum and Niobium, added, "We are very much looking forward to taking this exciting path in further strengthening our position in the field of Additive Manufacturing metal powders and continuous powder developments with our customers and research partners."

www.hcstarck-tantalum-niobium.com

Submitting news..

Submitting news to *Metal AM* is free of charge.

For more information contact Paul Whittaker: paul@inovar-communications.com

| contents | news | events | advertisers | website | e-newsletter | Industry News

Admatec launches Admaflex 300 system for production of large-scale parts

Admatec Europe BV, Goirle, the Netherlands, has launched the Admaflex 300, which it claims is the world's first flexible and open system for high-volume metal and ceramic additively manufactured parts.

The Admaflex 300 is a modular system and, as well as being designed to enable the user to expand the system, it is possible to develop new materials, set up a customised printing process and have full control over it. Future developments, such as multi-material Additive Manufacturing, can be accommodated, as the machine is capable of handling a broad range of feedstocks.

The new machine has a build volume to 200 x 200 x 300 mm and offers integrated in-process quality monitoring for full traceability of the Additive Manufacturing process. Software and hardware components monitor temperature, humidity and foil usage. It also has a dual-camera system for real-time video capture, and time-lapse recording. This, for example, allows the user to partially halt the building of a defective product to allow the successful finalisation of the remaining parts.

"Our customers' feedback led to the development of an increased build platform size, enabling the investment casting industry, among others, to expand their ceramic 3D printing capabilities," stated Jaco Saurwalt, COO at Admatec.

The Admaflex 300 is equipped with a patented automated feedstock system that enables continuous high throughput and high volume production. The company supplies solutions for AM, debinding and sintering, and provides training to help customers achieve the best results during each step of the process.

https://admateceurope.com

The new Admaflex 300 AM system (Courtesy Admatec Europe BV)

DMG MORI launches new 5-axis hybrid system for complex components

DMG MORI's new LASERTEC 125 3D hybrid system (Courtesy DMG MORI)

DMG MORI has released its LASERTEC 125 3D hybrid, a new, 5-axis machining system with integrated laser deposition welding capability for the Additive Manufacturing of complex components. The new system is intended for the manufacture, maintenance and repair of components up to 1,250 mm in diameter, 745 mm high and weighing up to 2,000 kg.

The LASERTEC 125 3D follows on from the company's LASERTEC 65 3D hybrid which it launched in 2013. Since then, the range has expanded to include systems that combine Additive Manufacturing, via a powder nozzle or powder bed, with its established machining centres.

According to DMG MORI, the LASERTEC 125 3D hybrid, which is based on the company's rigid monoBLOCK platform, offers high dynamics, rapid build rates and repeatability. Automatic changeover between laser deposition welding and simultaneous 5-axis milling is said to reduce processing times by up to 80%. Such savings are also helped by eliminating the need for heat treatment due to the machine's ability to deposit material with a hardness of up to 63 HRC.

The company explains that a selling point of laser deposition welding is the possibility it offers to change between two materials quickly under CNC. Hard welding to reduce wear can be carried out in one area, while at the same time corrosion-resistant welding for environmental protection may be carried out in another. The cooling characteristics of a part can be significantly increased. As an illustration, a die casting mould can be produced by starting with a bronze core that dissipates heat effectively and welding onto it an outer skin of tool steel.

Multi-material applications and graded materials can be produced with the company's hybrid machines (Courtesy DMG MORI)

DMG MORI states that in the past five years, laser deposition welding has emerged as a key technology for repair and recoating. The damaged area is first prepared by milling before the repair is carried out by laser deposition welding. The part is then finished in a final milling process, all in a single set-up. Due to precise process control, the weld material deposited is reported to be of very high quality and the service life of repaired inserts for a die casting mould, for example, is three times longer than if it had been repaired by manual welding.

As with its sister models, the LASERTEC 125 3D hybrid can be integrated into a CAD/CAM process chain. Software for powder nozzle technology, developed especially for DMG Mori by Siemens NX, enables end-to-end programming of repairs with users able to change seamlessly between machining and laser deposition welding during programming. The process steps are sent to the machine in one program and executed alternately in automatic operation.

https://en.dmgmori.com

Cooksongold and 3D Lab target precious metal powder production

Cooksongold, headquartered in Birmingham, UK, and part of the Heimerle + Meule Group, has reported that it will be collaborating with 3D Lab sp. z.o.o., Warsaw, Poland, for the manufacturing of precious metal powders. The companies will utilise a specially adapted atomiser from 3D Lab, the AtoNoble, to revolutionise powder and parameter development. The machine uses a patented process to melt non-reactive precious metals into powder form.

According to 3D Lab, the AtoNoble is the first of its kind to be specially adapted for precious metal powders including gold, silver and platinum. The company explains that the AtoNoble has been designed to be compact, measuring approximately 199 x 81 x 114 cm, requiring less investment into infrastructure. It's also able to use smaller quantities of raw material. The companies believe that this will be vital in production and development in industries such as jewellery, healthcare and electronics that require precious metals.

Martin Bach, Managing Director of Cooksongold stated, "We are excited to announce this partnership with 3D Lab sp. z.o.o. We are confident that this revolutionary technology will have a major impact within the whole precious metal Additive Manufacturing market. Powder quality and costs are key drivers in this field and this technology will offer considerable advantages."

Jakub Rozpendowski, Business Executive of 3D Lab commented, "We're pleased to start our collaboration with Cooksongold in the production of precious metal powders. Their expert knowledge combined with our novel ultrasonic atomisation technology has a great potential to make AtoNoble an important solution for new metal material development by reducing the time to market for new, innovative products."

The AtoNoble powder atomiser for precious metal powders (Courtesy 3D Lab sp. z.o.o.)

www.cooksongold.com
www.3d-lab.pl

Simufact introduces new dedicated simulation solution for Direct Energy Deposition

Simufact, a global operating software company providing process simulation solutions and services to manufacturing industries, announced at this year's Formnext a dedicated simulation solution to help manufacturers improve quality for Direct Energy Deposition (DED) metal Additive Manufacturing processes.

Offered as a module inside its Simufact Welding 2020 software, it enables the user to quickly set up robust DED simulation models by simply importing existing tool paths direct from G-Code instead of defining weld paths manually. The software evaluates the stresses, strains, distortions, thermal history and hot spots during the manufacturing to clearly identify distortions that are out of tolerance and recommend compensations. Based on this, the user can adapt the G-code to optimise the DED printing process and improve quality.

"We are seeing significant demand for our new simulation solution because it helps to optimise such cost-efficient deposition production processes. DED offers a lot of innovation potential for hybrid manufacturing that combines conventional manufacturing technologies with Additive Manufacturing," explained Dr Hendrik Schafstall, CEO and Managing Director at Simufact Engineering.

www.simufact.com

EPMA and Fraunhofer IGCV issue call for partners for project on AM-EHS

The European Powder Metallurgy Association (EPMA) and the Fraunhofer Research Institute for Casting, Composite and Processing Technology (IGCV) have issued a call for partners for a proposed Club Project on Environmental Health and Safety Issues in Additive Manufacturing (AM-EHS).

The project aims to aggregate information on EHS procedures and regulations to drive recommendations for EHS in AM. For this purpose, standards from the fields of welding and powder-based technologies such as Metal Injection Moulding (MIM) will also be examined.

In this way, the question of whether regulations and standards applicable to Laser Powder Bed Fusion (L-PBF) in companies need to be extended, supplemented or changed will be investigated. With the results of the project, the partners of the consortium will have an overview of various challenges along the process chain, such as some of the challenges for industry and research in the L-PBF process chain.

The aims of the project include:

- Production of a project report including recommendations on safety procedures and safety equipment that will also be supplied to ISO TC 261, Technical Committee of ISO in Additive Manufacturing as an outline to be used in standardisation activities through EPMA, the official liaison between TC119 and TC261
- Production of an aggregated list of relevant safety standards

The duration of the project is expected to be eight to twelve months. Further information is available via the association's website.

www.epma.com
www.igcv.fraunhofer.de

GE Additive Arcam EBM launches development material support for pure copper and highly alloyed tool steel

GE Additive Arcam EBM has announced that during 2020 it will launch development material (D-material) support for pure copper and highly-alloyed tool steel. Available to all customers as a general release, a D-material is said to describe the maturity of process parameters for a specific material or family of materials. D-materials meet mechanical requirements for test bars on a limited build envelope to relevant industrial standards.

Obtaining the same properties for complex geometries requires additional development, the company stated, resulting in an industrialised material (I-material) – with process parameters optimised for production on specific customer applications with mechanical and chemical properties. It was added that the GE Additive AddWorks team would be available to provide guidance and support on the right process parameters for their applications, and with mechanical and chemical requirements for both materials. It was also added that some customers will manage customisation in-house themselves.

Pure copper parts produced by GE Additive Arcam EBM (Courtesy GE Additive)

"This general release of D-material support for pure copper and tool steel is an exciting development and opens up EBM to a wider range of industries and applications. We have opted to take an open, collaborative approach and will review feedback from customer using the D-material and gauge their long-term interest, before considering how we approach industrialising the materials," stated Karl Lindblom, General Manager, Arcam EBM.

GE stated that EBM is the only commercially available technology for Additive Manufacturing of crack prone alloys. Higher levels of carbon in the steel mix increase the material's propensity to crack during production with large temperature gradients.

Copper's ability to absorb energy varies with the wavelength of the energy source. Pure copper absorbs 80% of the energy from an electron beam, compared to only 2% of the energy from a red laser beam. This provides EBM with an advantage in terms of the ability to melt and ultimately productivity gains.

The ability to produce unique, complex geometries in pure copper without compromising the high electrical, or thermal conductivity is ideally suited to a range of sectors, including the automotive industry, or customers looking at applications for electrical connectors, induction coils and heat exchangers.

www.ge.com/additive

Velo3D delivers seventh of twelve metal AM systems to aerospace customer

Velo3D, Campbell, California, USA, has delivered the seventh Sapphire® metal AM machine to its largest production customer, which has ordered a total of twelve systems within the past year. All of the previously installed systems are said to be in full production and producing mission critical parts for aerospace applications. The remaining balance of the systems will reportedly ship before the end of Q1 2020.

Velo3D's Laser Powder Bed Fusion (L-PBF) makes it possible to build low-angle geometries without support structures. Where existing PBF AM machines will typically require extensive supports for angles below 45°, the Velo3D solution comprised of Flow™ software, Sapphire machine and Assure™ quality management software, can repeatedly produce high-quality metal parts with angles below 10°. It can also build large inner diameters up to 40 mm without the need of supports, as compared to 10 mm with existing metal AM systems.

"Our mission is to enable OEMs in aerospace and other key verticals to gain trust in 3D metal printing as a dependable manufacturing technology," commented Benny Buller, Founder and CEO of Velo3D. "Our end-to-end solution enables end-users to adopt Additive Manufacturing without extensive redesign, increasing the viability of 3D metal printing of existing parts."

Velo3D recently celebrated its one-year anniversary of commercialisation, announcing over $24 million in sales at the end of Q3 2019.

www.velo3d.com

Sandvik and BEAMIT showcase new metal powders and components

Sandvik and BEAMIT showcased their combined metal powder and Additive Manufacturing capabilities at Formnext 2019, Frankfurt, Germany. Following Sandvik's acquisition of a significant stake in BEAMIT earlier this year, the joint Sandvik-BEAMIT booth included several examples of parts made from a wide range of materials produced via different additive processes. Sandvik's range of Osprey metal powders, which now includes nickel-based superalloys and titanium powders, was also on show.

Sandvik states that its new, high-grade powders can be used to produce light but extremely durable components with internal geometries that maximise their performance characteristics, making them suitable for use in demanding industries such as aerospace, automotive and energy.

With these additions to the material programme, the company reports that it now offers one of the widest alloy programmes on the Additve Manufacturing market.

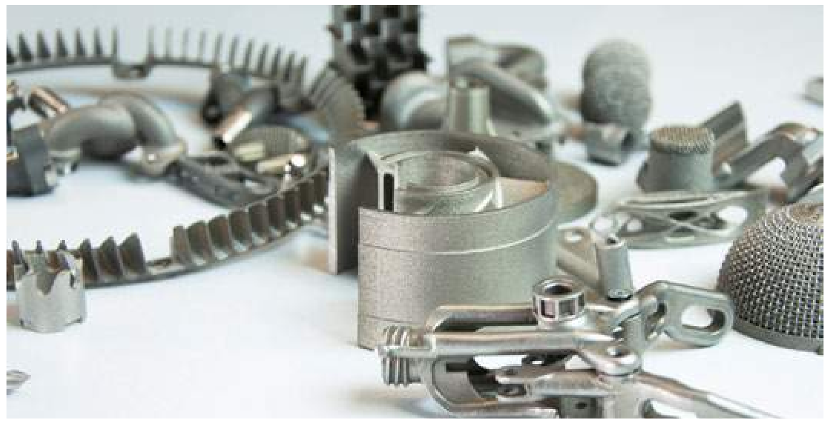
"By co-exhibiting at Formnext, our customers will have the opportunity to experience and discuss the complementary and combined power of Sandvik and BEAMIT," stated Kristian Egeberg, President of Sandvik Additive Manufacturing. "The Additive Manufacturing sector is developing fast and there is a need for AM-specialist-partners with the advanced skills and resources required to help industrial customers develop and launch their AM programmes. Sandvik and BEAMIT have leading capabilities across the whole AM value-chain and can enable companies to accelerate this development."

On display were additively manufactured diamond composites and a smash-proof titanium guitar, both finalists in the 2019 Purmundus Challenge at Formnext. BEAMIT also displayed its award-winning Lunar motorbike, with several additively manufactured parts in structural applications including a carbon fibre sub-frame, reportedly the world's first carbon fibre and additively manufactured titanium rear swingarm, and aluminium front fork mounts.

Sandvik also showcased its additively manufactured CoroMill® 390 titanium milling cutter, which, thanks to the AM process, was able to reduce its weight by 80% and increase its productivity by up to 200%. The company has also produced additively manufactured parts in super duplex steel Osprey® 2507-AM, with hardness and corrosion resistance properties that make them suitable for harsh conditions encountered in the offshore and marine industries.

Mauro Antolotti, Chairman and founder of BEAMIT, commented, "In Sandvik, we have an excellent owner and strategic partner who can provide us with leading materials expertise, development of high-quality metal powder suited for all AM processes, as well as world-leading post-processing know-how. Our partnership will benefit both current and future AM-customers going forward."

www.beam-it.eu
www.additive.sandvik



Top left: Sandvik offers a wide range of AM powders. Top right: AM diamond composite. Lower left: Selection of parts manufactured at BEAMIT. Lower right: Lunar motorbike with several AM parts (Courtesy Sandvik)

Carpenter Technology's new Emerging Technology Center brings end-to-end AM under one roof

Carpenter Technology Corporation, Philadelphia, Pennsylvania, USA, has officially opened its new Emerging Technology Center (ETC), in Athens, Alabama, USA. The 500,000 ft^2 (46,451 m^2) centre is said to offer true end-to-end Additive Manufacturing capabilities, having the facilities to atomise a range of speciality alloys into metal powder, additively manufacture the powder into parts and finish those parts under one roof.

According to the company, the ETC's post-processing equipment includes a state-of-the art quick cooling Hot Isostatic Press (HIP), as well as vacuum heat treating facilities, to optimise the material properties of high-value speciality alloy components. Parts manufactured at the ETC will be able to be qualified for use in a range of applications, from aerospace and transportation to oil and gas and energy.

Carpenter Technology stated that the ETC's facilities have been designed to maintain full traceability and provide analytical insights throughout the manufacturing process via a digital thread, allowing the company to manage the entire manufacturing process under one roof with a streamlined workflow.

Carpenter has invested $40 million in the ETC to date and expects to invest a total of $52 million in the centre. The ETC is sited adjacent to Carpenter's Athens manufacturing facility, which began operations in 2014 and produces speciality alloy products for the aerospace and energy markets.

"Our Emerging Technology Center is a critical component of Carpenter Technology's future growth and development, and is aligned with our business strategy of evolving to an end-to-end solutions provider and influential leader in the AM area," stated Tony Thene, Carpenter Technology Chief Executive Officer.

"We will also use it as a base to launch future investments as we expand our soft magnetics technology platform, scale up additional powder operations and demonstrate a number of next-generation materials we have under development today," he concluded.

www.carpentertechnology.com

SPEE3D builds world's fastest live print metal part at Formnext

During a live demonstration at Formnext 2019, SPEE3D printed a 1.012 kg copper hammer head in just ten minutes and two seconds, using the company's patented metal Additive Manufacturing technology.

"What we demonstrated here is really just the beginning. We believe ours is the fastest print demonstrated live at a show like this and we challenge other players in the industry to print a 1 kg part faster, whether it be metal, plastic or ceramic. We want to see development in the industry, and we look forward to pushing our technology even faster." stated Byron Kennedy, SPEE3D's co-founder and CEO.

SPEE3D's system uses a process it calls 'supersonic 3D deposition' to deposit metal powders by using a rocket nozzle to accelerate air up to three times the speed of sound, delivering manufacturing-grade, high-density metal parts.

Injected powders are deposited onto a substrate that is attached to a six-axis robotic arm. In this process the sheer kinetic energy of the particles causes the powders to bind together to form a high-density part with normal metallurgical properties. This allows metal parts to be produced 100 to 1000 times faster than with existing AM methods.

The live event was part of a larger demonstration by SPEE3D of their new SPEE3Dcell production system. SPEE3Dcell combines a SPEE3D AM machine with a heat treatment furnace and a computer numerical control (CNC) three-axis milling machine. In just six minutes, the cell was used to produce a spark-less copper hammer, with finishing and assembly on the trade show floor, demonstrating how the SPEE3Dcell can enable significantly faster, lower-cost and more scalable production than traditional casting or other AM techniques.

www.spee3d.com

SPEE3D built this 1kg hammer head in just over ten minutes, live at Formnext

GKN Additive to mass-produce energy-efficient industrial burners for Kueppers Solutions

GKN Additive and Kueppers Solutions, a specialist for industrial combustion technology, announced at Formnext 2019 a strategic partnership that will see the mass-production of high energy-efficient mixing units for industrial burners and tap into a new market to create a reduction of nitrogen oxide emissions in the industry.

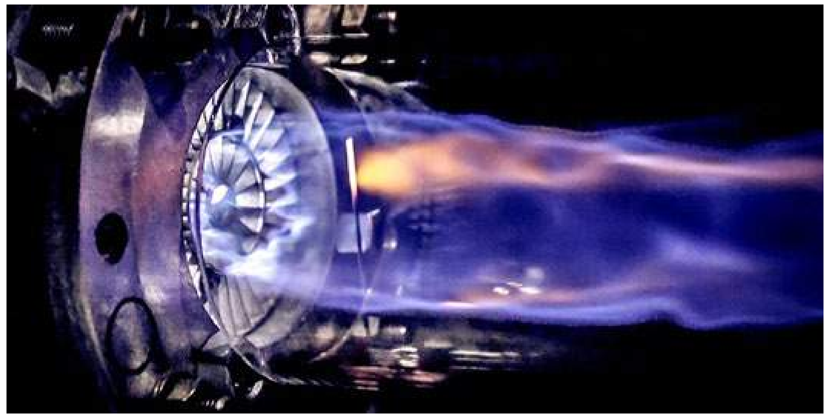
To make the burning process more efficient, Kueppers Solutions has developed a mixing unit for natural gas burners that optimises the combustion process with a significant reduction in nitrogen oxide emissions. Due to its design, the application is only feasible because of metal AM.

"Together with the RWTH Aachen University, we have screened the entire market in order to find a suitable partner for the industrialisation of our product," stated Jens te Kaat, CEO of Kueppers Solutions. "GKN Additive's experience in series production and their application know-how across a broad range of industries is unique. Typically, we are used to explaining our project in detail to potential partners and still tend to encounter obstacles. With GKN it was the other way around: their team was the fastest to understand the potential."

The current focus is now on the ramp-up of the mixing unit's series production and the joint development of a unique material, engineered for the application. GKN then intends to manufacture the next generation of the mixing unit using the HP Metal Jet, a metal Binder Jetting system.

"Climate change challenges all of us to think of new ways to substantially reduce emissions," commented Guido Degen, President Additive Manufacturing at GKN Powder Metallurgy. "Kueppers' mixing unit has made a significant contribution to preserving resources and, with our experience across the whole AM value stream, we will drive the industrialisation of this highly innovative product. Our common goal is to open up the market by upgrading thousands of outdated industrial burner systems with 3D printed mixing units."

www.gknpm.com/additive
www.kueppers-solutions.de



Kueppers Solutions has developed a mixing unit for natural gas burners that optimises the combustion process with a significant reduction in nitrogen oxide emissions (Courtesy Kueppers Solutions)

Producing the mixing unit is only feasible by metal AM (Courtesy Kueppers Solutions)

Gefertec to open its first US manufacturing facility in Virginia

Gefertec, LLC, the US division of metal Additive Manufacturing company Gefertec GmbH, Berlin, Germany, is to open its first US facility in Danville, Virginia, USA. The new manufacturing facility will initially be based at Danville's Institute for Advanced Learning and Research (IALR), before moving to a permanent space in Virginia's Danville/Pittsylvania County area in future.

The establishment of the new facility will involve an investment of $1.9 million and is receiving support from the Tobacco Region Revitalization Commission with a $45,000 Tobacco Region Opportunity Fund (TROF) grant, while the Danville Pittsylvania Regional Industrial Facility Authority (RIFA) will cover the cost of two years of temporary space at IALR.

"Gefertec is excited to announce the opening of our Danville – Pittsylvania County location as our first US location for our 3DMP Additive Manufacturing business," stated Andrea Clark, President of Gefertec, LLC.

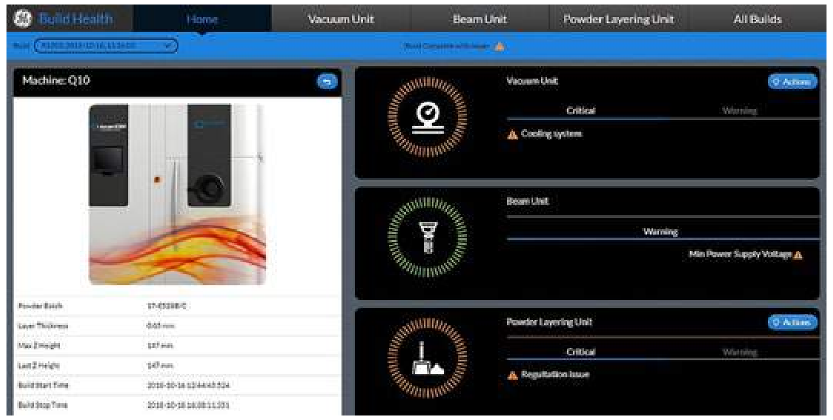
Tobias Roehrich, CEO of Gefertec GmbH, added, "This is in alignment with our long-term commitment to Danville and the Institute for Advanced Learning and Research and we are excited to expand our business to the US."

www.gefertec.de

GE Additive releases Arcam EBM Build Performance Analyser

GE Additive has announced the launch of its Arcam EBM Build Performance Analyser, a new suite of machine health data analytics. The software system is set for release in December 2019 for Arcam EBM Q10 and Q10plus customers, then from Q1 2020 for Arcam EBM Q20 and Arcam EBM Q20plus customers and then for Arcam EBM Spectra customers through Q2 and Q3 2020.

Developed by Arcam's software team in Sweden, with a team from GE Global Research Center in India, data are collected during the printing process from in-situ machine sensors, then analysed using intelligent algorithms to provide users with a holistic view of process and machine health. The software can run on both the machine itself or on a user's laptop.



GE Additive has announced the launch of Arcam EBM Build Performance Analyser (Courtesy GE Additive)

In addition to more visual user interface, featuring health indicators such as expected versus actual values, where needed operators are able to receive thirty-two root cause analyses with recommendations for any corrective actions, as well all warnings for non-critical events.

The team examined more than 350 log files to identify statistical clustering and applied machine learning, based on a combination or parameters to retrieve machine behaviour. The Arcam Build Performance Analyser identifies key parameter trend plotting and enhanced report generation and provides customers with meaningful, predictive data and information to inform decision making and future design and development.

"Being able to access and then make decisions based on real-time data analysis is another way we put our users in control of their systems. Whether they operate a single machine or entire fleets of our systems, the ability able to receive, interpret and use data smartly can save both time and cost," stated Karl Lindblom, general manager, Arcam EBM.

www.ge.com/additive

Siemens Gas and Power announces partnership with ASME to develop AM training services

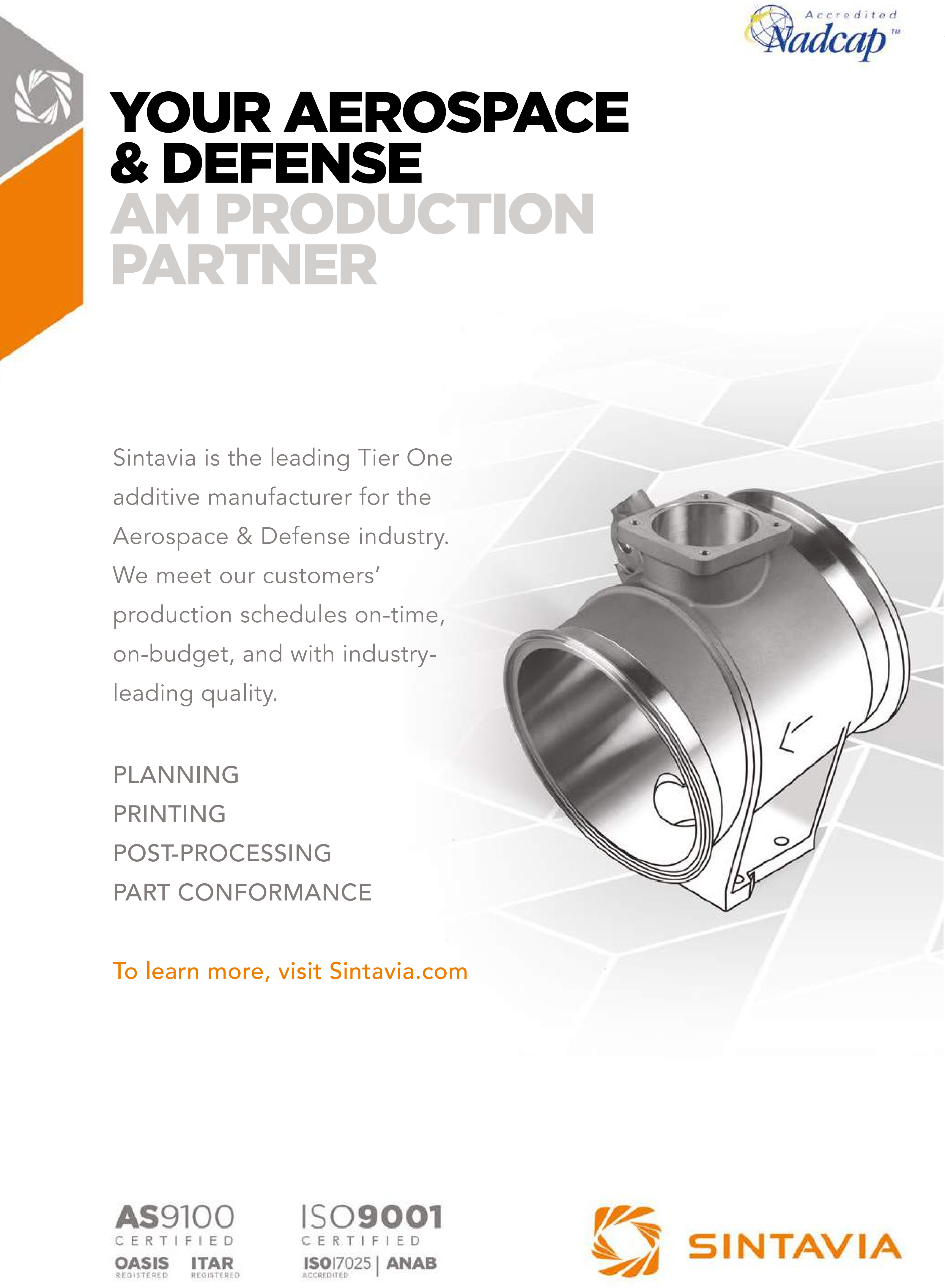
Siemens Gas and Power and the American Society of Mechanical Engineers (ASME) have announced their collaboration on the development of training services in Additive Manufacturing during Formnext 2019. The services will be offered through Materials Solutions, a Siemens business, as an extension of its additive services portfolio.

The agreement is said to lay the groundwork for the creation of unique AM training solutions to better support Siemens' customers on their additive journey. The course curriculum will cover the end-to-end Additive Manufacturing value chain and offer customers real-world applications experience from developing business cases, design for AM, material considerations, through to printing and post-printing process know-how.

"The agreement between Siemens and ASME is another milestone to support further adoption of Additive Manufacturing as an industrialised technology," stated Markus Seibold, Vice President of Additive Manufacturing at Siemens Power Generation Operations. "Cross-industry collaborations to advance AM adoption will promote innovation in design, material development and real, functional applications across the industry. Thanks to the collaboration with ASME, we can provide the experience of our experts to our customers and industries all over the world."

"ASME is dedicated to fostering innovation in the engineering community," commented Tom Costabile, ASME Executive Director/CEO. "Every day, additive technologies continue to change the manufacturing landscape. The combination of ASME's agile course development methodology and Siemens' wealth of real-world expertise in Additive Manufacturing enables us to share that knowledge through dynamic, practical learning experiences that will be readily accessible by customers and engineers everywhere."

www.siemens.com
www.asme.org



Sandvik and Renishaw to qualify new materials for Additive Manufacturing

Renishaw has reported it is collaborating with Sandvik Additive Manufacturing to qualify new Additive Manufacturing materials specifically for production applications. The work encompasses a broad range of metal powders, including new alloy compositions that are optimised for the Laser Powder Bed Fusion (L-PBF) process and which provide superior material properties.

Sandvik has worked with Renishaw AM systems since 2018 at its Additive Manufacturing Centre in Sandviken, Sweden. During this time, the two companies have developed process parameters for a range of Sandvik metal powders, including stainless and maraging steels, and the latest Osprey® nickel-based superalloys. Sandvik recently inaugurated a state-of-the-art titanium atomiser and powder processing facility and will now turn its focus to qualifying these alloys for industrial and medical use.

"With our 157-year materials knowledge, our comprehensive range of in-house steels, duplex and super-duplex stainless steels, as well as nickel-based alloys and our new titanium powders, Sandvik now offers the widest range of AM materials to the market under the Osprey brand," stated Mikael Schuisky, VP R&D and Operations at Sandvik Additive Manufacturing. "Renishaw's open machines have enabled us to rapidly optimise process parameters for our alloys for use in many different applications."

This parameter development work has reportedly highlighted opportunities to make small but important changes to the composition of Sandvik alloys, whilst remaining within the relevant ASTM specifications, and to optimise the mechanical properties of L-PBF components. Examples of this include a maraging steel with enhanced strength and hardness and a crack-free Osprey HX nickel superalloy.

"Much of the innovation in AM in the next few years will come from the pairing of enhanced machine performance with improved alloys," explained Stephen Crownshaw, AM Business Manager at Renishaw. "Better alloys mean better material properties, enabling AM components that are even more efficient and cost-effective. The consistency of Renishaw's latest AM systems, combined with Sandvik's material expertise, provides tremendous opportunities to advance AM processes and to make a stronger business case for AM."

As well as qualifying materials for sale to other manufacturers, Sandvik Additive Manufacturing has developed a range of AM production applications, including AM variants of its cutting tools. One example is Sandvik Coromant's lightweight CoroMill 390 milling cutter in titanium, which is 80% lighter than a conventional tool and enables metal-cutting productivity gains of up to 200%. This innovative new product has now gone into series production on the RenAM 500Q and was launched on the market in April this year.

www.additive.sandvik | www.renishaw.com

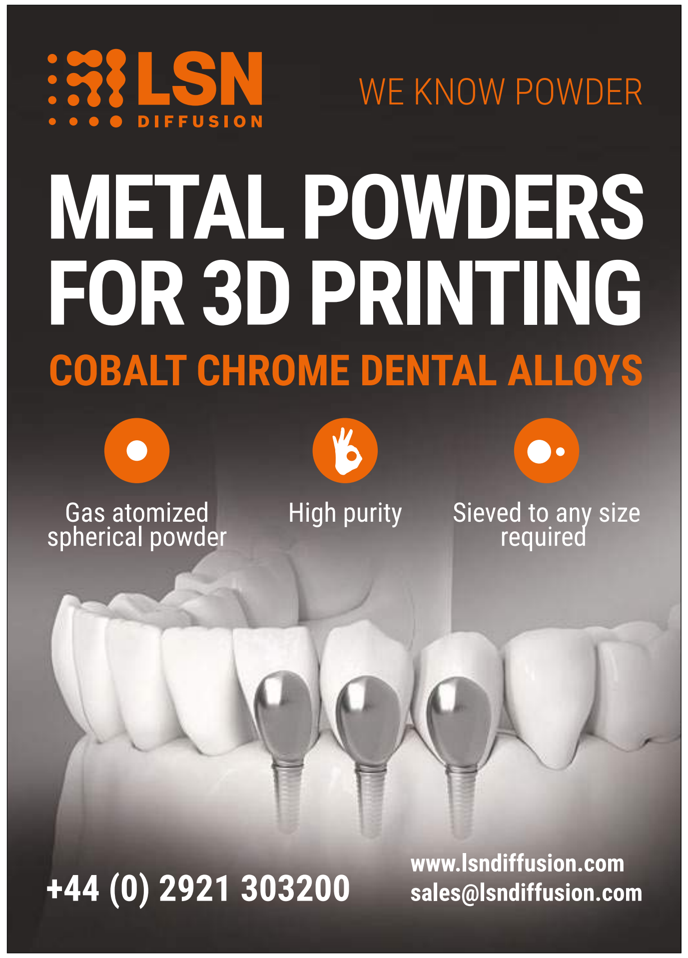
Indo-MIM accelerates move to offer metal Binder Jetting AM

Indo-MIM, a leading global manufacturer of components by Metal Injection Moulding (MIM), headquartered in Bangalore, India, reports that from January 2020 it will be accepting prototype sample orders for metal AM parts. Orders are expected to be produced on the company's Desktop Metal Production System at its facility in San Antonio, Texas, USA.

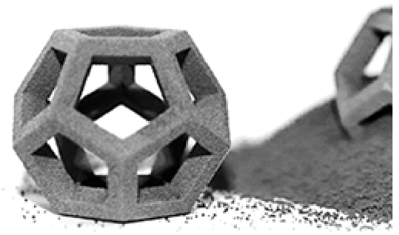
Indo-MIM is initially offering customers two material choices, 17-4 PH and 316L stainless steels, with more material options to be added by summer 2020. Suitable part weight is said to be between 5-250 g and prototype samples are available within ten days. Series production volumes are reported to be in the range of 10-50,000 parts per year, with the company saying it will offer increased volumes of up to 500,000 parts per year by 2021.

Indo-MIM has MIM production facilities in both India and the USA, as well as further sales offices in Europe and Asia.

www.indo-mim.com



ExOne and GTP use Binder Jetting for tungsten parts



ExOne and GTP hope to advance the AM of tungsten parts (Courtesy The ExOne Company)

The ExOne Company, North Huntingdon, Pennsylvania, USA, has entered into a collaboration with Global Tungsten & Powders Corp. (GTP), headquartered in Towanda, Pennsylvania, USA, a supplier of tungsten and molybdenum powders, semi-finished parts and SOFC components, to advance tungsten-based binder jet Additive Manufacturing.

The collaboration will focus on the development of two metal matrix composites, Cemented carbide (WC-Co) and Copper-tungsten (CuW). Cemented carbide is a material with high hardness and toughness, widely used for the production of cutting tools and wear-resistant parts. Copper-tungsten is used in applications where high heat resistance, high electrical and thermal conductivity, and low thermal expansion are required.

Under the collaboration, GTP will launch an Additive Manufacturing and sintering service for cemented carbide parts which can be used by customers that wish to explore the feasibility of new designs. GTP currently uses the ExOne® Innovent®, a Binder Jetting system for the AM of metal, ceramic and composite powders in a compact build area.

"Binder Jetting is the 3D printing method of choice for serial production of hard metal parts," stated Deborah West, Vice-President Business Unit Refractory & Specialty Powders, GTP. "Traditionally, tungsten carbide powder is pressed into the desired shape and then sintered to give it strength and density. Instead of costly and timely mould construction, the parts now can be printed directly in the desired shape, still using sintering technology to achieve the final strength."

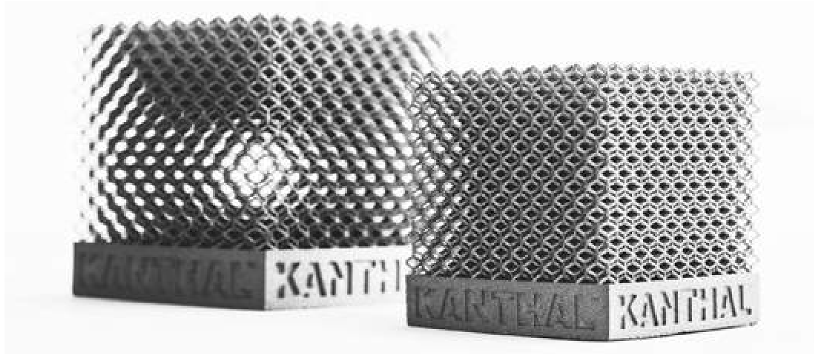
"As a market leader in the development and production of high-quality tungsten powders, GTP always stays on top of the latest technology," West continued. "We are excited to work with ExOne in the development of cutting-edge technology for the Additive Manufacturing industry."

Tim Pierce, ExOne's Vice President of Metal Commercial Products, commented, "Metal 3D printing using our exclusive approach to Binder Jetting has exciting and significant consequences for a variety of manufacturers, including those who make parts with cemented carbide and other tungsten composites. Our latest development collaboration with GTP will help advance the materials necessary to deliver on the vision of producing these parts faster, with less waste and more geometric design freedom."

www.exone.com

www.globaltungsten.com

Kanthal launches AM service for heating applications



Kanthal has launched its Kanthal Additive Manufacturing service which aims to use its new Kanthal AM100 alloy to provide AM services for heating applications (Courtesy Kanthal)

Kanthal, part of Sweden's Sandvik Group, has launched a new Additive Manufacturing service for the customisation of heating elements and components. Kanthal Additive Manufacturing will offer AM production along with the company's new iron-chromium-aluminium (FeCrAl) alloy, Kanthal® AM100.

Kanthal states it has been focusing on AM to gain a full understanding of how to best use its unique materials and expertise in electrical heating solutions to create value for the customer. With superior properties, the new Kanthal AM100 alloy is said to offer new possibilities in high-temperature applications.

Nicklas Nilsson, Kanthal President, stated that he sees a wide number of possibilities as well as great customer value with the new customisation service. "There are basically no limits to what you can design," he stated. "The possibilities are endless, and once you grasp that, it truly opens up for revolutionary innovation."

One area of potential noted is the transformation from gas to electric heating, a move that Kanthal believes will feature AM as an integral part. "It has so many benefits, from both a design and a business viewpoint, as well as of course from a sustainability perspective," Nilsson added. "This technology is the future."

www.kanthal.com

LÖMI launches debinding systems dedicated to sinter-based AM

LÖMI GmbH, Grossostheim, Germany, has announced a new series of solvent debinding systems to meet increasing demand from the Additive Manufacturing industry. The systems in the EDA-AM range offer three-in-one functionality by integrating debinding, the drying of parts and solvent recovery. This is said to save time and cost, as no additional handling of the parts is required between the debinding and drying process steps, while the integrated solvent recovery ensures a continuous supply of fresh debinding medium.

"The solvent debinding process offers a number of advantages, including a greater freedom of feedstock choice for AM part producers, as a wide range of feedstock can be processed," explained Christian Ferreira Marques, Managing Partner at LÖMI. "This enables part producers to test new feedstock and to optimise their processes, without having to invest in a another debinding system and without becoming dependent on a single feedstock producer."

Ferreira continued, "In addition, various organic solvents can be employed, such as ethanol, isopropanol and acetone. Solvent debinding systems offer very compact dimensions and are very economical in their operation due to their low energy consumption and very long lifetime, as the solvent debinding process causes very little wear and tear. The solvent is continuously reprocessed with a rate of up to 99% and returned to the process in a closed system. This makes our systems very safe and environmentally beneficial."

LÖMI's EDA-AM debinding series is specifically for the Additive Manufacturing industry (Courtesy LÖMI)

LÖMI's smallest AM solvent debinding system, EDA-30AM, is a tabletop unit with 16 litres batch loading volume for research, prototyping and small batch production. It is water-cooled and offers basic automation. The two larger systems EDA-30AM and EDA-50AM both feature integrated tanks for the clean and used debinding solvent. The EDA-30AM is a semi-automatic air-cooled system with 16 litre batch loading volume, while the water-cooled EDA-50AM offers 26 litre batch loading volume and full automation.

www.loemi.com

SLM Solutions and Honeywell to qualify new AM parameters for increased build thickness

SLM Solutions Group AG, headquartered in Lübeck, Germany, has partnered with Honeywell International Inc., Charlotte, North Carolina, USA, to help qualify new metal Additive Manufacturing parameters that enable manufacturing at increased thicknesses to reduce production times and costs.

As part of the partnership, Honeywell's Aerospace division will begin qualification efforts for aluminium builds using increased layer thicknesses of 60 and 90 µm on the SLM®500 Additive Manufacturing machine. SLM Solutions will provide its standard aluminium parameter sets for Honeywell to complete material qualification using its systems to achieve optimal material properties.

"SLM Solutions' latest technology will help Honeywell improve productivity while also meeting our material requirements for qualification," stated Dr Sören Wiener, Senior Director of Technology and Advanced Operations for Honeywell's Aerospace business. "We intend to qualify these parameter sets through repeatability testing in our production environment, including build and post-processing to generate an efficient process with a set of material property data."

Meddah Hadjar, CEO of SLM Solutions Group AG, added, "As the productivity leaders in Powder Bed Fusion, SLM Solutions has been continuously working to reduce build times by combining high-powered lasers with advanced parameter sets. Our open-architecture machines allow for customisation and we've shown over 60% reduction in build time with 170% real build rate increases compared to standard 30 µm parameters on our twin-laser machines."

"We're excited to work together with Honeywell Aerospace to further advance the industry through the qualification of even more advanced parameter sets for quad-laser systems used in qualified serial production," he concluded.

www.honeywell.com
www.slm-solutions.com

Optomec develops pure copper DED Additive Manufacturing process

Optomec, headquartered in Albuquerque, New Mexico, USA, has announced the development of a pure copper Additive Manufacturing process using its LENS Directed Energy Deposition (DED) systems.

According to the company, establishing a DED process for pure copper is especially important for designers of heat exchangers used in a variety of industrial applications in fields such as aerospace and chemical processing. This copper process is also applicable to alloys of copper such as bronze, brass and cupronickel.

"Pure copper is a big challenge for DED systems because of its high reflectance," stated Tom Cobbs, Product Manager for Optomec LENS systems. "The infrared wavelengths on most standard, laser-based AM systems are not readily absorbed by copper, making it difficult to establish a meltpool as the laser energy is reflected back into the source, causing all kinds of havoc."

"Our laser-based solution is virtually immune to any back reflection, so the laser can operate at full power on reflective surfaces without any difficulty," Cobbs continued. "Optomec engineers have developed process parameters to account for thermal conductivity differences as well as big changes in absorption, and have demonstrated efficient DED builds with pure copper."

A pure copper fin feature added to a copper tube using Directed Energy Deposition (Courtesy Optomec)

"We see this as a major milestone for LENS and DED Additive Manufacturing – because working with copper is essential for many of our customers. Copper is so critical because it enables the addition of high thermally-conductive features like cooling fins, the addition of soft metal sealing surfaces and high electrically-conductive surfaces for power transmission."

www.optomec.com

MSC's new generative AM design solution reduces process time by 80%

MSC Software Corporation (MSC), recently acquired by Hexagon, has announced the launch of its MSC Apex Generative Design, a new design optimisation solution that is said to improve quality through automation of design processes with embedded manufacturing knowledge. MSC Apex Generative Design aims to improve productivity by up to 80% compared to classic topology optimisation. The software produces a part design that is ready within a few hours – a fraction of time usually required.

"New design freedoms in Additive Manufacturing request new-generation software solutions, which take full advantage of the new DfAM [design for Additive Manufacturing] possibilities," stated Dr Thomas Reiher, Director of Generative Design. "We make the generative design process smarter by producing design candidates that both satisfy the engineering criteria and look as the designer intended when 3D printed."

Conventional topology optimisation workflows require manual work and multiple tools to achieve production-ready results, which can lead to information loss as data are converted. MSC Apex integrates all relevant steps within one Computer Aided Engineering (CAE) environment to improve productivity with a single user experience from design to additive manufacturing preparation.

The design process is workflow-oriented, providing easy and fast model setup from existing geometries or mesh in common CAD, STL, or MSC Nastran BDF formats. Designers can find optimised design candidates and perform design validation within the same CAE environment, simplifying the work process and reducing design iterations dramatically. The result is a fully integrated, automated optimisation process in which compatibility for previous and subsequent operations plays a vital role. This unique capability implies the conversion from the CAE mesh to CAD with no manual reconstruction of geometry, considerably simplifying the work process for designers.

The MSC solution combines print-ready geometries with robust metal (Simufact) and polymer (Digimat) build process simulation from Hexagon's Additive Manufacturing portfolio. Designers only generate part designs that can be successfully manufactured using their chosen material and print process to eliminate costly prototyping.

Hugues Jeancolas, VP Product Management, commented, "Additive Manufacturing promises innovation and manufacturing productivity advances. But to truly transform, the new technologies require automated design workflows with embedded process knowledge. We are integrating our structural analysis, design optimisation, and manufacturing simulation solutions to optimise and validate designs for additive processes before a single part is printed."

www.mscsoftware.com

Hiperbaric develops HIP equipment aimed at the AM industry

Hiperbaric, Burgos, Spain, has launched a new Hot Isostatic Pressing (HIP) system designed for use in the metal Additive Manufacturing industry. The move was announced at the company's twentieth anniversary event, which coincided with the inauguration of its recently expanded facilities.

Hiperbaric was launched in 1999 with the development of its first High Pressure Processing (HPP) equipment, a technology which employs high isostatic pressures (up to 6000 bar) to extend the shelf life of food and guarantee food safety. Its new business line will focus specifically on the production of HIP systems for the post-processing of metal parts.

At the anniversary event, attended by over 500 people, Andrés Hernando, Hiperbaric CEO, stated, "This new technology has been developed thanks to an investment of over €4 million and a tremendous engineering effort over more than three years."

HIPing has multiple applications, among which are the elimination of defects in parts produced by AM, the sintering of Powder Metallurgy parts and the densification of castings. The new equipment developed by Hiperbaric has a maximum operating pressure of 2,050 bar and an oven with molybdenum resistors that allows it to reach 1,400°C. Its hot zone has a diameter of 380 mm and a length greater than 1,000 mm, enough to house the build volumes of most AM systems on the market.

The HIP pressure vessel incorporates proven wire winding technology that is said to provide a vastly improved fatigue life and maximum safety, thanks to its 'leak before burst' failure mode. In addition, thanks to this design, Hiperbaric states that it has been possible to implement a rapid cooling system that significantly shortens the cooling stage, guaranteeing the metallurgical properties of the parts and improving the productivity of the equipment.

"Hiperbaric's dedication has allowed the company to become the world benchmark on HPP for the food industry. Today, its target is to become the leader of high pressure technology, regardless the industry of application," added Hernando.

www.hiperbaric.com

The new HIP has a maximum operating pressure of 2,050 bars and an oven that reachs 1,400°C (Courtesy Hiperbaric)

Additive Assurance launches beta QA solution and global partner network

Additive Assurance, a spin-out of Monash University, Melbourne, Australia, has launched its beta quality assurance solution and officially announced a global partner network.

The Additive Assurance product, reported to be suitable for any Laser Powder Bed Fusion (L-PBF) AM system, consists of an externally mounted sensor package connected to software driven by machine learning algorithms. It provides quality assurance information in real-time. The company states that the product is currently in testing with Foundation Partners from the energy, defence and aerospace sectors.

"The underlying technology came out of a research project between Monash University and the Defence Science and Technology Group in Australia," stated Marten Jurg, co-founder and CEO of Additive Assurance. "After thorough testing with Foundation Partners we are excited to officially launch our Global Partner Network and we welcome discussions with metal AM users working through qualification programmes."

The Additive Assurance team explained that they have been working closely with a network of industrial users frustrated with a lack of detailed build quality information for L-PBF systems in the AM industry. The team started exploring in-process monitoring approaches and developed a solution that not only solved their problem, but addressed industry-wide challenges around qualification.

Once a build is complete, a full set of quality assurance reports are generated, including detailed 2D and 3D defect maps and all critical process information, allowing full compliance and traceability in the supply chain. All data are stored on a managed cloud solution that allows machines across multiple locations to be tracked simultaneously. An option for an on-premise server is also available.

Additive Assurance is now seeking expressions of interest from interested parties in the defence, aerospace and energy sectors to join their partner network prior to the full product release in 2020.

www.additiveassurance.com

Scanlab showcases all-in-one scan system for multi-head L-PBF machines

Scanlab GmbH, a laser technology manufacturer headquartered in Puchheim, Germany, introduced its new scan head for metal Additive Manufacturing, the fiberSYS, at Formnext 2019. The new scan system is said to offer an all-in-one solution enabling its users to quickly and easily create high-efficiency laser systems and scalable machine designs. It is configured for control via an RTC board and for deflection of multi-KW single-mode fibre lasers.

The fiberSYS is Scanlab's new AM scan head (Courtesy Scanlab GmbH)

The sealed dust-proof scan head also features a fibre adapter for direct connection of the laser, as well as a process monitoring interface. According to Scanlab, the head incorporates ultra-low-drift galvos with digital encoders, regulated using new generation servo electronics. In combination with its optimally designed mirrors, the system is reported to deliver exceptional imaging quality and high dynamic performance and its pre-focus configuration with integrated z axis enables scan head usage without an F-Theta objective, reducing thermal drift.

"The 3D printing sector has been utilising multi-head machines for many years," the company explained. "Productivity for large-area workpieces in particular can be significantly enhanced by combining multiple scan systems with high-overlap image fields. The new system was developed with this key relationship in mind."

The new scan solution is expected to be available to order from the second quarter 2020. Scanlab stated that it will issue design recommendations for optimal usage of multiple scan heads, but that this is also an open, modular system platform which can be adapted flexibly to customer requirements.

www.scanlab.de

Titomic Kinetic Fusion exceeds minimum ASTM International standards

Titomic Limited, Melbourne, Australia, has reported the results of its $2.6 million co-funded IMCRC, CSIRO and RMIT research project, designed to develop certification standards for Titomic Kinetic Fusion (TKF).

The research findings reportedly show that Titomic's TKF process to additively manufacture titanium parts using CP Titanium Grade Two powder achieved ultimate tensile strength (UTS) of 634 Mpa, being 83.8% higher than 345 Mpa set by ASTM International, and an increased elongation of up to 27.7%, being 38.5% higher than 20%. This demonstrates that TKF has the fatigue resistance and strength required for applications in aerospace and other critical industries, and exceeds the minimum ASTM International standard requirements.

According to Titomic, the primary objectives of the two-year research programme are to develop new industry standards for fatigue, crack growth and fracture toughness of complex-shaped titanium structures produced using the TKF manufacturing process as further validation for AM parts for aerospace.

Jeff Lang, Titomic Managing Director, stated, "These test results not only provide validation to industry of titanium parts produced using our TKF process, but more importantly the research conducted across multiple titanium powder supply chains secured by Titomic outlines why we placed so much emphasis on securing feedstock powders with industry-leading companies to capture the entire value chain surrounding our technology whilst meeting ASTM International standards."

www.titomic.com

Isostatic Toll Services expands capabilities with new HIP system

Isostatic Toll Services (ITS) headquartered in Olive Branch, Mississippi, USA, reports that it has expanded its Hot Isostatic Pressing (HIP) capabilities up to 30,000 psi with the addition of a new HIP system to its range.

According to the company, the new system can fulfil the higher pressure requirements necessary for aerospace and orthopaedic parts and AM designs. The new system follows the installation of a 20,000 psi HIP system in 2018.

The company recently passed its NADCAP AC7102/6 audit re-certification for Hot Isostatic Pressing and is certified to ISO 9001 (Aerospace), ISO AS9100C (Aerospace) and ISO 13485 (Medical). It is also reported to have passed exhaustive onsite quality audits by MTU Aero Engines and Rolls Royce.

www.isostatictollservices.com

Simufact Additive 2020 expands scope of manufacturing simulation

Simufact announced at Formnext 2019 that its Simufact Additive 2020, a software solution for the optimisation of metal-based Additive Manufacturing processes, now provides cost estimation of the build process and improves interoperability with Materialise build preparation software and Renishaw machines to streamline manufacturing processes.

Simufact Additive now includes cost estimation (Courtesy Simufact)

Based on new technologies, the software is reported to provide higher performance and robustness.

In addition to designing and optimising the build process virtually, users can now estimate print job costs for single components or assemblies. Not limited to the build process, the capability also includes subsequent processes such as cutting, machining, drilling and grinding. This helps the user identify the best build variant by taking into account printing costs.

Following Simufact's efforts to simplify data exchange in the AM process chain, Simufact Additive 2020 now interfaces to Materialise using the 3MF industry-standard AM data exchange format. 3MF enables simple and reliable data transfer with third-party software and considerably reduces time for the model set up.

Simufact Additive 2020 includes an integrated Renishaw QuantAM API for build job preparation and export, which provides the user an error-free-data transmission from Simufact Additive directly to Renishaw printers. This functionality also improves productivity because the entire work process from design to built part is possible within the software. More interfaces are under development to allowing easy connection to other AM machines.

The new software release applies new Adaptive Voxel Meshing technology to improve the simulation speed by automatically adjusting the voxel sizes in the part. This provides more immediate results to users and makes the simulation even more reliable and robust.

Dr Hendrik Schafstall, CEO and Managing Director, Simufact commented, "Simufact Additive 2020 broadens our scope from pure-play process build optimisation software to provide cost optimisation. This new release also underlines our commitment to openness and interoperability with third-party products. We believe manufacturers should start wherever they want in the process to improve quality and efficiency and make additive manufacturing smarter."

www.simufact.com

Optomec integrates AutoCLAD Vision System into LENS DED machines

Additive Manufacturing machine maker Optomec announced at Formnext 2019 that it has integrated the Huffman AutoCLAD vision system with its LENS Directed Energy Deposition (DED) machines. AutoCLAD is a vision and software system that generates a custom toolpath for each part prior to processing.

Proprietary to Huffman, the system has reportedly been used extensively in production by major manufacturers and servicers of aircraft engines and industrial gas turbines to restore worn or damaged components. Adding this capability to the LENS brand of solutions is expected to enable customers to use automated DED for the repair of reactive metals like titanium in a controlled, argon atmosphere.

It also brings the AutoCLAD technology to hybrid Additive Manufacturing; the combination of AM and machining capabilities in a single system. AutoCLAD images the part and then automatically adapts and modifies the toolpath and DED parameters for each individual part based on variations in orientation, dimension and shape.

It not only adjusts the toolpath for variation, but it also adapts laser power to reduce the heat input into thinner areas, which drastically reduces the heat-affected zone (HAZ) of the finished part. Finally, by fine-tuning the toolpath for the individual part, a smaller overbuild is achieved which significantly reduces the final machining time after the Additive Manufacturing process.

"This latest enhancement combines three important technologies developed by Optomec into a single system," stated Mike Dean, Marketing Director at Optomec. "Combining the capabilities of AutoCLAD with Optomec's industry-leading controlled atmosphere technology and hybrid manufacturing solutions enables the processing of reactive metals without oxidation and allows Additive Manufacturing and machining in a single system."

"No other company has this combination, in fact, no one has software like AutoCLAD," he continued. "We see this as a big win for customers who want to use DED for the repair of titanium components as well as anyone doing repetitive part repair in industries such as oil and gas, mining, and tool and die."

www.optomec.com

Siemens cloud-based AM network connects demand with supply

Siemens has announced the official launch of the Siemens Additive Manufacturing Network, said to offer an advanced cloud-based solution to foster collaboration and process orchestration between engineers, procurement and suppliers of AM parts. The company stated that providing an end-to-end digital process, that connects the demand for parts with a supplier network, will help enable globally distributed manufacturing.

The Siemens AM Network is designed for enterprises, suppliers and partners that are looking to accelerate the adoption of AM. It is said to digitalise the order-to-delivery process by aligning the engineering and commercial processes for functional prototypes and serial production parts.

Early adopters are said to already be realising the benefits of the AM Network. Decathlon, the largest sporting goods retailer in the world with over 1500 stores in forty-nine countries, uses the network to manage its AM ordering process. The company controls production progress as part of their strategy to scale their use of AM globally and ramp up production, while maintaining high standards of quality.

"Siemens' Additive Manufacturing experts and industry veterans have developed the AM network based on a clear understanding of the complexities and needs of the industry, fostered by a sincere passion to promote the adoption of AM in the industrial domain," stated Zvi Feuer, Senior Vice President Manufacturing Engineering at Siemens Digital Industries Software. "As buyers, sellers and partners continue to plug into the ecosystem, they will find a streamlined, modular solution that can grow with each company's individual needs."

Earlier this year Siemens and HP continued to build on their long standing strategic alliance with the introduction of a joint AM solution targeting the automotive industry and other key industrial markets. The partnership is expanding with the integration of HP's advanced AM technology with the Siemens AM Network, and with the addition of HP's Digital Manufacturing Network partners to the Siemens AM Network. The HP Digital Manufacturing Network is a global community of digital manufacturing service providers with the capabilities to help design, produce and deliver high quality plastic and metal final parts at scale leveraging HP's Multi Jet Fusion and Metal Jet Additive Manufacturing solutions.

https://new.siemens.com

nTopology updates its computational-modelling software

Engineering software company nTopology Inc., headquartered in New York City, USA, has launched the latest version of its computational-modelling software, nTop Platform 2.0. The latest update is said to include support for pre-packaged, application-specific nTop Toolkits, letting engineers quickly learn and use its most powerful capabilities.

Bradley Rothenberg, CEO of nTopology, commented, "We are excited to release 2.0 of nTop Platform, nTop Toolkits enable the best engineering workflows to spread wide throughout industries, making the most advanced modelling technology accessible to any design engineer."

The nTop Platform was said to have been developed to solve engineering problems where geometry is a bottleneck. It can handle complexity and iteration with speed and ease and the prepackaged Toolkits and authoring capabilities can both be used to automate engineering workflows.

nTopology reports that it is also partnering with industry leaders in Additive Manufacturing hardware to deliver new capabilities to their users. Fabian Krauss, Global Business Development Manager at EOS explained, "The flexibility and high performance of nTopology software and its ability to package-up customer workflows helps us and our customers to create advanced Digital Foam."

Krauss added, "We use it in projects to create 3D-printed products with architected materials properties tailored exactly to customer needs. It unlocks the true potential of generative design in Additive Manufacturing for Digital Foam and for many other applications."

www.ntopology.com

A selection of metal AM passive heat sink examples designed with nTop Platform 2.0 (Courtesy nTopology)

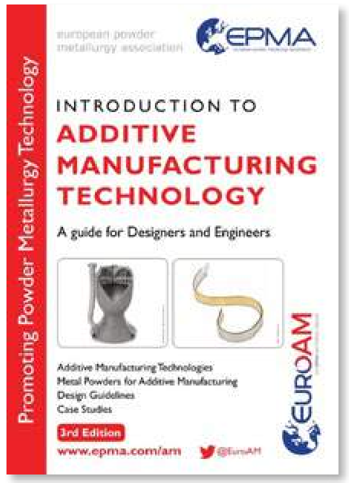
EPMA launches third edition of its *Introduction to Additive Manufacturing Technology*

The European Powder Metallurgy Association (EPMA), through the collaboration of its EuroAM Sectoral Group, has launched the third edition of its *Introduction to Additive Manufacturing Technology* booklet.

According to the EPMA, the new edition builds on the previous versions by further expanding the depth and range of case studies from several industries, as well as providing an update of the technology and new non-destructive testing processes.

The revised, sixty-eight-page edition now features over sixty case studies. It also includes detailed Information relating to the metal powders used in the AM process, from chemical composition to powder morphology. The booklet provides a comprehensive explanation of how to design components specifically for the AM process.

"This is still a great introductory booklet for potential users of the Additive Manufacturing process, as it provides a neutral view of the main AM processes and how to get the most out of this new manufacturing process" explained Andrew Almond, EPMA's Marketing Manager. "It is with great thanks to Adeline Riou and Claus Aumund-Kopp, who are the main drivers of these editions, that the newly revised edition has been able to be produced, as well as the support of the EuroAM Sectoral Group, to highlight the components that can be manufactured through the AM processes."



The EPMA has launched the third edition of its Introduction to Additive Manufacturing Technology booklet (Courtesy EPMA)

Copies of the third edition can be ordered from the EPMA or download from the association's website.

www.epma.com

EOS, PTC and Link3D to collaborate on quality assurance for AM using AR

PTC Inc., Boston, Massachusetts, USA, EOS GmbH, Krailling, Germany, and Link3D, Boulder, Colorado, USA, have announced their collaboration to develop augmented reality (AR) and manufacturing execution systems (MES) to enable production quality Additive Manufacturing at scale.

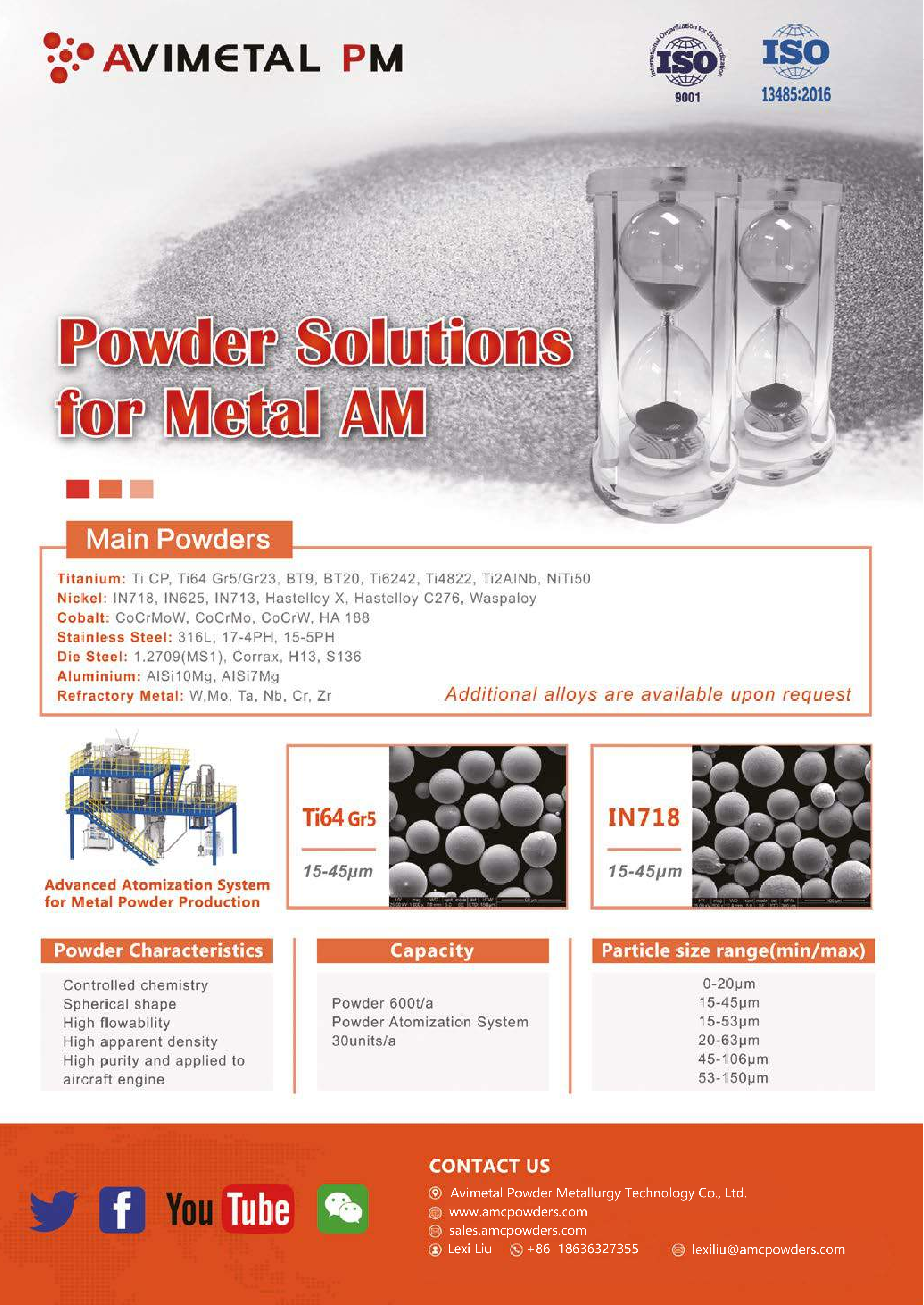
In regulated industries such as aerospace, medical and automotive, the highest quality standards must be established and maintained. The Six Sigma DMAIC process, as a basis for a stable production environment, can identify potential risks and introduce mitigation actions. Often, such risk mitigations require the use of manual checklists or working procedures that operators must be trained in and follow strictly. In many cases, the documents containing these checklists are paper-based and must later be digitised and archived. As a result, there is a risk of human error or even manipulation.

Organisations can digitally stream-line the process from ordering, costing and scheduling build cycles, but ensuring repeatable production quality by standardising human processes, especially when preparing Additive Manufacturing machines to produce orders, remains the missing link, explains Link3D. The new partners are reported to be configuring a way to close this gap by linking machine preparation and downstream manu-facturing processes with customised fixed workflows.

"Scalable and agile industrial use of EOS additive production systems requires skilled and knowledgeable operators for the critical steps in preparation and post processing," stated Christoph Braeuchle, VP of Production Innovation Management at PTC. "Procedural workforce guidance based on our Vuforia AR technology helps train and guide the workforce and complements Link3D Additive MES. With a connection between Link3D and our ThingWorx industrial IoT platform, this combined solution will empower our joint customers to further scale their use of additive production capabilities."

"By joining forces, we can help users implement programs to enable production quality at scale for EOS industrial 3D printers with PTC Vuforia powered by Link3D Additive MES," added Vishal Singh, CTO of Link3D. "The future of workforce training will be largely governed by AR / VR. MES is going to play a critical role in validating training compliance and production to meet part-related customer specifica-tions."

https://solution.link3d.co | www.ptc.com | www.eos.info



6K showcases High Entropy Alloy metal powders for AM

6K, a developer of microwave plasma technology for the production of advanced materials used in Additive Manufacturing, lithium ion batteries and other industrial markets, has announced that it can successfully design and produce High Entropy Alloy (HEA) spherical powders.

By partnering with Castheon, a US-based AM research and advanced manufacturing solutions provider, the two companies have additively manufactured what is stated to be the world's first metal alloy HEA part on a Laser Powder Bed Fusion (L-PBF) machine. Onyx HEA1000, and over fifteen other metal alloys, ceramic powders and parts, were on show at Formnext 2019.

"This HEA1000 demonstrator is an example of the power of 6K UniMelt plasma production technology," commented Dr Aaron Bent, 6K CEO. "We are fulfilling our desire to allow Additive Manufacturing designers to 'Build Boldly' by providing access to designer alloys not previously possible with today's melt alloy or atomisation processes. Our technology finally provides a scalable and cost-effective way to access non-eutectic parts in volume, and we are just seeing the tip of the iceberg."

HEA1000 is an experimental HEA spherical powder for use in commercial consolidation processes such as Additive Manufacturing, HIP or powder forging. HEAs are said to open limitless possibilities for having a 'perfect blend' of elements to tailor properties, such as high strength coupled with superior elongation, higher strength-to-weight ratios, or stable properties over a wider range of temperatures.

To date, introducing HEAs into production volume applications has been virtually impossible due to alloy manufacturing limitations and the scale available from melt processes. The availability of Onyx HEA reportedly expands the options for higher performance parts in aeroengines, airframes, industrial and medical applications, among others. At Formnext, 6K chose a challenging Fe-based alloy, with near identical ratios of Cr, Cu, Co and Ni. This composition family has been studied significantly, but has never been made in spherical powder form or additively manufactured.

"We have 3D printed many exotic alloys for aerospace propulsion parts, which are considered non-printable," stated Dr Youping Gao, CEO of Castheon. "Yet, this is the first time we have printed a custom HEA alloy that has elements with extreme melting temperatures. No one today but 6K has provided Cr and Cu in the same alloy with almost equal concentrations for additive manufacturing and it's simply not possible with melt eutectic alloying."

Through its metals reclamation technology, 6K can specifically target the powder size distribution to the required AM process. The company will be commissioning a new state-of-the-art AM powder manufacturing plant in Pittsburgh, USA, in early 2020 and is currently partnering with customers to pre-qualify and sample Onyx In718 in anticipation of commercial availability in Q2 2020, followed by Ti-AlV64 in Q3 2020.

www.6Kinc.com

www.castheon.com

Launcher schedules first full-scale test of its E-2 rocket engine

Launcher Inc., headquartered in Brooklyn, New York, USA, has scheduled the first full-scale test of its E-2 rocket engine for mid-2020 after securing a $1.5 million award from the U.S. Air Force and taking delivery of the engine's copper additively manufactured combustion chamber.

The combustion chamber and injector are critical parts of the E-2 engine. The copper alloy chamber was produced by AMCM GmbH, Starnberg, Germany, an EOS company, on AMCM's M4K machine. It is said to be the largest liquid rocket engine combustion chamber additively manufactured in a single part, measuring 86 cm tall with an exit nozzle diameter of 41 cm.

According to Launcher, the E-2 is the highest performance engine for small satellite launch vehicles currently in development. Generating 10 tonne-force of thrust per engine (22,000 lbf), four E-2 liquid rocket engines will power the first stage of Launcher's Rocket-1. A fifth vacuum-optimised E-2 engine will power the second stage.

The first full-scale test fire is scheduled for Q2 2020. The company states that it has already achieved its target combustion performance of 98%+ combustion efficiency using sub-scale versions of the E-2 engine additively manufactured with the same machine and materials.

The E-2 rocket engine features an AM combustion chamber (Courtesy Launcher)

www.launcherspace.com

www.amcm.com

Fraunhofer ILT project investigates L-PBF of tungsten carbide-cobalt

The Fraunhofer Institute for Laser Technology (ILT), Aachen, Germany, has launched a research project in collaboration with scientists from the Institute for Materials Applications in Mechanical Engineering (IWM) and the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University to investigate how Laser Powder Bed Fusion (L-PBF) can be used to process tungsten carbide-cobalt (WC-Co).

The research project, titled 'Additive Manufacturing of Machining Tools out of WC-Co – AM of WC-Co', aims to enable the metal Additive Manufacturing of cutting tools with longer tool lifespans, achievable by the incorporation of complex cooling geometries into the tool's design, at strengths comparable to cutting tools produced using conventional processes.

Fraunhofer ILT explained that, traditionally, cutting tools made of WC-Co could only be manufactured using complex sintering processes. Since these materials are so strong, and traditional sinter-based technologies only offer restricted geometric freedom, cutting tools have only been able to be shaped to a limited extent. This has made introducing complex cooling structures into the tools costly or simply impossible. AM offers a high degree of design freedom and near-net shape production and enables complex cooling structures to be generated within the cutting tool. L-PBF is particularly suitable for this purpose. In turbine construction, significantly higher operating temperatures have already been achieved through the use of AM parts.

A major challenge in the L-PBF process is temperature distribution in the workpiece, due to the fact that the metal powder is melted in the laser spot and then quickly cools down. Conventional systems have a heated base plate to slow down the cooling process, but this is not sufficient for refractory materials and large components. Uneven temperature distribution can cause tension or even cracks to occur in the component.

The team at Fraunhofer ILT has been working on this issue for some years and, in cooperation with the company Adphos Innovative Technologies GmbH, reports that it has developed a system in which a near-infrared (NIR) emitter heats the component from above. With an output of up to 12 kW, the emitter can achieve temperatures of up to 800°C in the component. In the 'AM of WC-Co' project, this technology is to be used to process tungsten carbide-cobalt.

The research project is funded by the Otto von Guericke e.V. working group of industrial research associations.

www.ilt.fraunhofer.de
www.rwth-aachen.de

Preheating the machining plane with the NIR is said to significantly reduce stresses in the L-PBF additively manufactured component (Courtesy Fraunhofer ILT)

Siemens and Materials Solutions open new innovation centre in Florida

Siemens AG, headquartered in Munich, Germany, and Materials Solutions Ltd – a Siemens Business (MSL), based in Worcester, UK, have opened a new advanced innovation centre in Orlando, Florida, USA. The 1,500 m^2 (17,000 ft^2) centre is equipped with advanced manufacturing and inspection technologies, said to enable faster solutions for industry and encourage innovation for new, advanced components and digital solutions.

Siemens explained that the centre will focus on rapid problem solving to support the company's energy businesses, while Materials Solutions will offer its Additive Manufacturing services to both the centre and external customers.

Vinod Philip, CEO of Siemens Service Power Generation; Steve Conner, CEO of Siemens Energy, Inc.; Markus Seibold, VP of Additive Manufacturing at Siemens Power Generation Operations; and Mark Kamphaus, Head of Technology & Innovation for Siemens Service Power Generation attended the opening of the new innovation centre. Also in attendance were a number of employees and key customers in the energy sector, as well as guests from other high-performance industries such as aerospace.

"This centre is unique, bringing together a multitude of our innovative processes under one roof," stated Tim Holt, COO of Siemens Gas and Power. "The combination of these competencies, with the twelve years of experience in metal additive that Materials Solutions brings, provides us with a distinctive capability to support the development of holistic additive solutions/services to our customers in our energy business, as well as in high-performance industries such as aerospace, automotive and others."

www.materialssolutions.co.uk
www.siemens.com

Guyson's new system for powder removal from medical implants

Industrial finishing equipment manufacturer Guyson International Ltd, headquartered in Skipton, North Yorkshire, UK, has launched a new 'Powder Flush' system designed specifically to flush residual powder from medical implant trabecular structures, once additively manufactured.

Additively manufactured orthopaedic implants are typically made by Electron Beam or Laser Powder Bed Fusion (EB- or L-PBF) processes from titanium powders. After manufacture, the bulk of the residual powder is removed from the build block with brushes and vacuums, sometimes followed with an air-wash or blast process to remove any semi-adhered powder particles, but because of the nature of the porous trabecular structures, small powder residues often remain trapped inside the component and must be removed.

The Guyson Powder Flush is based on the company's Orbit 600 rotary basket spray wash unit, built in full stainless steel 304 construction, fitted with a 100 l insulated tank and hot spray flushing facilitated through a high flow rate and pressure pump fitted with viton seals. The machine offers directed jets for powerful component flushing followed by compressed air-wash.

A PLC/HMI control panel to the left of the machine provides data monitoring and timed pre-heat function ensuring accurate and repeatable process operation. LED interior lighting and a double glazed viewing window, in the lid, facilitates visual checks on parts in process.

In operation, the implants are individually or batch loaded on non-contaminating fixtures presenting the work piece to the directed flushing jets in close proximity to the trabecular surface, thus ensuring thorough powder removal. Timed electronic door interlocks prevent the door opening during operation and until hot steam has dissipated at the end of the process.

Guyson's Powder Flush system for removal of residual Additive Manufacturing powders from trabecular implant structures (Courtesy Guyson International Ltd)

The machine is also equipped with process alarm signals with audible and visual cues via an Andon beacon to show the end of part processing, as well as fluid-level sensing and advanced filtration, fitted to the rear of the unit.

www.guyson.co.uk

Digital Metal forms agreement with Elnik Systems/DSH Technologies

Digital Metal, part of the Höganäs Group and a producer of metal binder jet Additive Manufacturing machines, has formed a collaborative agreement with debinding and sintering experts Elnik Systems/DSH Technologies, LLC. The process optimisation services of Elnik Systems/DSH Technologies are expected to benefit existing and future customers of Digital Metal in terms of optimised recipe/profile development parameters to ensure successful results.

Combining Höganäs' 100+ years of knowledge in metal powder fabrication and the expertise of Elnik/DSH Technologies in debind and sinter technology, Digital Metal stated that with this agreement, it is taking the next step to deliver real-world solutions to its existing and future customer base.

Stefan Joens, Vice President, DSH Technologies, LLC, stated, "We are excited to team up with the Digital Metal team to help advance the newest and most exciting metal manufacturing technology in decades!"

Christian Lönne, General Manager, Digital Metal, added, "Learning and exploring together with the curious and highly-experienced people at Elnik Systems/DSH Technologies LLC means that we together can provide even higher consistency and stability, as well exploring new fields for our fast-growing customer base."

www.digitalmetal.tech
www.elnik.com

PSI to supply new atomiser to IRT-M2P

Phoenix Scientific Industries Ltd (PSI), UK, is to supply a HERMIGA atomiser system to the French Institute of Technology IRT-M2P, Metz, France.

The HERMIGA 120/250 V3I atomisation system will be used in a research programme to produce aluminium alloy powders in batches of around 100 kg for use in metal AM.

PSI is a leading designer and supplier of advanced materials technology and systems. The company's solutions are deployed globally in a wide range of sectors and applications, spanning commercial multi-tonnage continuous powder production through to advanced metals research centres.

www.psiltd.co.uk

Metal additively manufactured Stealth Key wins first prize in the Purmundus Challenge competition

The winners of the Purmundus Challenge were announced at Formnext 2019, with Dr Alejandro Ojeda from Urban Alps AG taking first prize with the Stealth Key entry.

Organised by cirp GmbH, the Purmundus Challenge is sponsored by Germany's VDMA and this year included thirty-eight finalists in the competition. Three metal additively manufactured entries won the following awards:

First Prize: Stealth key

The Stealth Key, developed by Dr Alejandro Ojeda at Urban Alps AG offers a high level of security with superior copy protection, thanks to the use of metal Additive Manufacturing. The keys are made of a super-alloy and hide their code under narrow edges, ensuring that the key cannot be photographed, scanned or duplicated. Keys are custom made and individually coded.

The winning Stealth Key from Urban Alps offers superior levels of protection (Courtesy Urban Alps)


Designs such as the rocket chamber (left) and mountain bike frame (right) demonstrate how AM can combine multiple components, saving material and reducing weight (Courtesy Purmundus Challenge)

The Stealth Keys look and function like traditional mechanical keys and can be retrofitted to existing doors and locks to prevent physical security breaches.

www.urbanalps.com

Third Prize: Monolithic Rocket Chamber

Dr Paul Schüler and Andreas Krüger of CellCore GmbH, in collaboration with SLM Solutions Group AG, developed a monolithic and multi-functional rocket engine concept to demonstrate the potential and benefits of metal L-PBF Additive Manufacturing. The rocket engine demonstrator, produced in IN718 on an SLM 280 machine, combines a fuel inlet, injection head, thrust chamber and innovative structural cooling concept in one integrated design.

The core element of the demonstration piece is the functionally optimised lattice structure integrated into the chamber wall, which, in addition to providing the necessary stability, also offers opportunities for cooling by actively circulating liquid hydrogen. This structural cooling offers a significant improvement over conventional approaches.

www.cellcore3d.com

Public Choice Award: Mountain bike frame

Byron Blakey-Milner of NMU Eco-Car, based out of Nelson Mandela University, South Africa, designed and additively manufactured a Ti-6Al-4V mountain bike frame on an Aeroswift large-scale Additive Manufacturing machine. Given the very high cost of top of the range mountain bikes and components, the company believes that this design could compete economically with high-end carbon fibre designs.

Using topology optimisation, the designer was able to increase the frame's competitiveness with regard to weight and stiffness, without being limited to the single/split draw mould constraints of carbon bike frames.

www.mandela.ac.za

UK's MTC launches aerospace Additive Manufacturing hub in Coventry

The Manufacturing Technology Centre (MTC), Ansty Park, Coventry, UK, has launched an Additive Manufacturing innovation hub at its Aerospace Research Centre. The new hub aims to lead research, development and collaboration on metal Additive Manufacturing, developing and testing ideas for taking the technology forward.

The new hub's establishment is part of the £15 million MTC-led Digital Reconfigurable Additive Manufacturing facilities for Aerospace (DRAMA) project, which encourages suppliers to the UK aerospace industry to adopt AM. Supported by £11 million from the UK Department for Business, Energy and Industrial Strategy (BEIS)'s Industrial Strategy Challenge Fund, DRAMA has so far engaged with more than fifty aerospace supply chain companies and is inviting applications for new projects.

The hub will incorporate a manufacturing facility with a workshop and design, research and testing facilities for Additive Manufacturing users and researchers. An online reference resource will also be made available out of the centre.

The MTC stated that the hub will also offer training at all levels, advice on AM suitability, business case and implementation, research (both bespoke and collaborative), and business and technical support both online and in person. Dr Katy Milne, Chief Engineer for the DRAMA project at the MTC, stated, "The new hub will provide space and facilities for Additive Manufacturing designs and processes to be discussed by like-minded experts and users and taken forward."

"Additive manufacture has the potential to revolutionise design approaches and supply chains. There are more than 4,000 companies involved in the aerospace industry, and there are current examples where aerospace primes have reduced the part count by an order of magnitude, this could be really disruptive for the existing supply chain."

"For companies who move into this space, there are major opportunities," she continued. "Additive Manufacturing offers the biggest opportunity since the introduction of composites. What we have learned from the DRAMA project is that collaboration is vital and everything we learn for aerospace can be transferred to other sectors."

Further funding for the DRAMA project is delivered by Innovate UK, supported by the Aerospace Technology Institute. Other partners involved in DRAMA are Renishaw, the Midlands Aerospace Alliance, ATS Applied Tech Systems, Autodesk, Granta Design, the National Physical Laboratory and the University of Birmingham.

www.the-mtc.org

ncam.the-mtc.org/drama/overview

TÜV SÜD and ASTM International announce partnership for AM development

ASTM International and TÜV SÜD, Germany's testing and certification organisation, signed a Memorandum of Understanding (MoU) to develop programmes aimed at speeding the adoption of and trust in Additive Manufacturing technologies at Formnext 2019. The strategic partnership is said to support knowledge sharing and the growing use of AM technologies across many industry sectors.

The MOU will include joint development of new educational, advisory, qualification and certification services in several areas including:

- Land transportation and mobility
- Air transportation
- Industrial plants
- Consumer products
- Health care

"To unleash the full potential of AM, we need a smart global ecosystem of research, standardisation, education, testing and certification," stated Dr Mohsen Seifi, Director of global Additive Manufacturing programmes at ASTM International. "We are pleased to sign this MOU, which aligns two globally-recognised organisations' complementary strengths and will help create a robust technical foundation for AM innovation across many industries."

"TÜV SÜD is excited to be bringing its world-renowned expertise in regulatory and non-regulatory testing and certification to this important partnership," commented Holger Lindner, CEO of TÜV SÜD's Product Service Division. "We look forward to supporting the growth and adoption of AM technologies by implementing market-relevant standards with robust certification programs while also preparing to meet the future needs of the AM industry."

Gregor Reischle, Head of Additive Manufacturing at TÜV SÜD reported, "I am very much looking forward to bringing our extensive customer experience in the field of AM into the standardization processes and to enriching the partnership."

"This new technology is changing production globally and turning traditional business models upside down," explained Ken Walsh, Principal Commercial Officer of the U.S. Commercial Service at the U.S. Consulate in Düsseldorf. "It is therefore important that world-renowned AM organisations based both here and in the U.S., develop these new technologies in close cooperation." The U.S. Commercial Service provided a space for the event, but the U.S. Government is not part of the MoU.

This partnership involves the ASTM International Additive Manufacturing Center of Excellence and its efforts to develop joint programs in certification, education and workforce development.

www.tuvsud.com
www.astm.org

EPMA issues Call for Papers for Euro PM2020

The European Powder Metallurgy Association (EPMA) has issued a Call for Papers for its Euro PM2020 Congress & Exhibition, which will take place in Lisbon, Portugal, October 4–7, 2020. Abstract submissions are now invited for presentation in the technical programme.

Each oral session on the technical programme will contain four presentations, with twenty-minute slots for each paper, including discussion time. Poster presentations will be placed in allocated topic zones and will be displayed for the duration of the four-day event.

EuroPM will feature an exhibition of powder based technologies (Courtesy EPMA)

Abstracts for Euro PM2020 are invited on the following topics:

- Additive Manufacturing
- Environment & sustainability
- Functional materials: Functional materials, PM magnetic materials, porous materials
- Hardmetals, hard materials and cermets: Hardmetals, hard materials, and cermets and diamond tooling
- Hot Isostatic Pressing: HIP and alternative density processes
- Materials and processes for specific applications: Applications, materials and processes
- Powder Injection Moulding
- Press & sinter PM

Authors are invited to submit their abstracts using the EPMA's online submission form before the deadline of January 22, 2020.

www.europm2020.com

The third Munich Technology Conference: The challenge of AM adoption and the inside track on aviation

Now in its third year, the Munich Technology Conference series has achieved a remarkable status in its short history. It is recognised not only for bringing together the most powerful and influential minds in the international AM community, but for engaging them in open and broad-ranging discussions on the future of the industry. It is also an event that unashamedly 'wears its heart on its sleeve', having grown from the optimism of MTC1 to MTC2's call for vital collaboration, and a 'reality check' in the face of economic uncertainty at MTC3. *Metal AM* magazine's Emily-Jo Hopson reports.

The third Munich Technology Conference (MTC3), organised by Oerlikon and its partners GE Additive, Siemens, Linde, McKinsey, TÜV SÜD and the Technical University of Munich (TUM), took place in Munich, Germany, from October 8–10, 2019. Since its inaugural outing in 2017, which welcomed around 600 attendees, the Munich Technology Conference series has become one of the most anticipated events in the Additive Manufacturing calendar, with 2019's event reporting visitor numbers in excess of 1,500 from thirty-two countries. With the title 'Additive Manufacturing: Accelerating the Industrialization – A Reality Check', the MTC3 conference programme once again featured a number of prominent speakers from industry, academia and politics for frank and in-depth discussions on the current state of the Additive Manufacturing industry, barriers to full industrialisation, and the strategies which companies can take to help drive it towards this goal.

Welcoming attendees to MTC3, Prof Michael Süss, Chairman of the Board at Oerlikon, stated, "Three years ago, when we started MTC, there was a little less headwind and a little more tailwind. Since 2017, we have seen outstanding achievements which are really widening the scope of Additive Manufacturing. However, innovation is 'a shy deer', and when you have an economic crisis ahead – when the top economic powers of the USA and China are imposing taxes on one another, and German cars are seen as a threat to the national security of the USA, then something is not right. Innovation needs an environment where people are proudly and strongly moving forward; where they are ready to invest money in things which may materialise in three, five or ten years down the road. When people see negative indications, they will slow down."

Fig. 1 MTC3 took place in Munich, Germany, October 8–10, 2019

Fig. 2 Prof Michael Süss welcomes attendees on day two of the third Munich Technology Conference

This notion of cooling market expectations was echoed throughout, but the overall impression given by both the panellists and the audience – polled live at regular intervals via the innovative event app – remained optimistic. AM, like all industries, may face a challenging period in the near future in light of the economic uncertainty which is the result of a looming trade war, but enthusiasm and investment in the industry remains relatively strong.

While the market predictions of 2017, which often forecast 50 or 100% growth in the coming four or five years, have been replaced by somewhat more realistic projections of 10, 15 or 30%, these predictions are still highly positive in the context of a global manufacturing industry which is preparing for a challenging future. As Prof Süss stated, the race to industrialise AM is still ongoing, but, "it is less a sprint now, more a marathon. The companies which were in additive twenty years ago have stayed in additive, kept pace with additive, continued investing in additive, and are not slowing down," indicating the staying power and sustained development of a technology which has, in some quarters of conventional manufacturing, previously been regarded as a 'trend'. However, there is work to be done if AM is to shed this reputation and prove itself competitive outside of its relatively small pool of users and niche applications.

"We have very good success in small series," stated Prof Süss. "Companies like Bugatti and BMW are already using additive parts in production, not just to say they are, but for good reason – but we are not yet industrialised. The takeaway from a conference like this must be what we have done and what we can do to make our goals visible, achievable, and in the end: do it. Not just talking, but executing. The examples we have with the markets we are approaching are not enough; we have had some success, but we can do so much more."

So, what can the industry do better in order to drive Additive Manufacturing to the next stage of true industrialisation? According to Prof Süss, there are several areas which should be targeted as the industry takes its next steps. "We can team up and make better partnerships, we can team up and show people within the customer base what the benefit of AM is, and we can show society the benefit of AM," he explained. He also noted that, productivity-wise, Additive Manufacturing remains a long way from where it needs to be. While many Additive Manufacturing systems offer considerable capabilities and power to their users, these strengths are to some extent being wasted by the technology's currently limited capacity and the progress which is yet to be made on optimising for production, not just in terms of volume but in terms of application development and materials.

To miss the opportunity and to waste the competitive advantages offered by both AM technology itself and the 'tailwind' of keen interest and investment which surrounds it would be, Prof Süss believes, a criminal act. "But if you want to become part of this ecosystem, then you have to stay speedy, innovative and creative," he stated. The series of panels and presentations given at MTC3 by forty-nine speakers from industry and academia aimed to help attendees understand how to do just that.

Collaboration as key to industrialisation

Many challenges need to be overcome along and beyond the value chain for Additive Manufacturing to truly industrialise, and to overcome these challenges, industry, politics and science must work closely together. In one expert panel, leading figures from across the AM value chain came together to discuss one of the major themes of MTC3: the importance of collaboration in the development of AM toward broad applications in industry.

Dr Roland Fischer, CEO, Oerlikon Group; Dr Jan Michael Mrosik, COO, Siemens Digital Industries; Dr Christoph Schmitz, Senior Partner at McKinsey; Holger Lindner, CEO Product Service at TÜV SÜD; Francisco Betti, Head of Advanced Manufacturing Industry at the World Economic Forum; and Todd Skare, CTO, Linde, discussed the current status of collaboration in the industry, the challenges of forming effective partnerships, and where and why closer partnerships are needed to drive the industry forward (Fig. 3).

According to Betti, the four main types of collaboration required for the effective industrialisation of AM are:

- Collaboration between companies
- Collaboration *within* companies
- Collaboration on the academic level between universities, or between companies and universities
- Collaboration between the industry and governments.

Bavaria: A global centre of competence for AM

As a region, Bavaria has established a reputation as a global hot spot for AM. In addition to the Technical University of Munich (TUM), the region is home to a number of market leaders in AM, such as GE Additive, Linde AG, Oerlikon AM, Concept Laser, DMG Mori, EOS Group and more. Bavarian manufacturers of laser-based Additive Manufacturing machines are reported to have a worldwide market share of approximately 50%.

The area is also rich in software expertise, being home to Siemens and SAP. Certification providers such as TÜV SÜD and IABG offer a comprehensive service portfolio in AM, inspecting and certifying AM processes. In addition, a number of world-class companies in application sectors which can drive the industrialisation of AM, including automotive (BMW, Audi, Brose, etc), aerospace and aeronautics (Airbus, GE Aviation, Aircraft Philipp, MTU, etc), and energy (Siemens, MAN, Turbo SE, etc).

At the start of MTC3, the TUM, Oerlikon, GE Additive and Linde announced they would form the new Bavarian Additive Manufacturing Cluster, which aims to establish the region as the foremost economic area for digital manufacturing technologies. The initial partners will provide collaborative efforts expected to help integrate AM into industrial manufacturing processes. One of the first initiatives provided by the AM cluster will enable Oerlikon and TUM to create the The Additive Manufacturing Institute. The new research institute will focus on interdisciplinary research in raw material powders, optimised AM production and end-to-end process integration, including automation and AM digitalisation. The cluster will be open to additional participants in the future.

Each of the organisations represented within the panel is actively involved in collaborative efforts at various levels of the AM process chain. Oerlikon's partnerships in AM have been widely publicised, most recently as a founding partner in the Bavarian AM Cluster (see inset box above), and previously in the form of collaborations with companies such as MT Aerospace to accelerate the use of AM in the aerospace and defence market; RUAG Space for the identification of applications in space components; IABG to accelerate the qualification of AM components; Hirtenberger Engineered Surfaces to improve post-processing; United Launch Alliance for the production of metal AM components for the Vulcan

TUM's Additive Manufacturing Strategy

As one of Europe's leading technical universities, TUM has strong links with engineering companies and institutions worldwide. The TUM Department of Mechanical Engineering was established more than 150 years ago and has contributed significantly to the global engineering landscape, being the birthplace of the early refrigerator developed by Carl von Linde, and the diesel motor developed by Rudolf Diesel, to name just two historic inventions. Now, the university forms a major global research and development centre for Additive Manufacturing, using new study and training programmes to educate new AM specialists.

In December 2018, TUM adopted a future-oriented strategy which put Industry 4.0, and specifically Additive Manufacturing, at the centre of its research efforts with the formation of the Industry on Campus alliance 'Additive Manufacturing Campus Bavaria'. The university stated that by consolidating the expertise already present within its departments, it can take the lead in AM by bringing current developments to relevant industries through coherent research strategies. As such, TUM believes it can take a decisive role in driving the industrial adoption of AM as a key technology of the future, and improve the economic viability of industrial manufacturing. With its strategic TUM.Additive agenda, the university is focused on the development of effective research, teaching and infrastructure development in the following core areas of AM:

- Materials, interfaces and thermodynamics
- Design and functional geometries
- Production techniques
- Sensor technologies
- Numerical mechanics and simulation for process optimisation
- Cyber-physical systems, machine intelligence and IT security
- Verification, quality assurance and materials testing
- Business models for AM

Centaur rocket; and Siemens for the provision of digital enterprise solutions. Siemens has notably partnered with Solukon Maschinenbau GmbH on the co-development of an automated depowdering system, which is now in its beta testing phase, and is working with BeAM on the acceleration of Directed Energy Deposition (DED) technologies, to name just two examples. Linde, also a founding member of the Bavarian AM Cluster, has in the past year announced collaborations with Liebherr-Aerospace to optimise AM aluminium aircraft components, and with Gefertec to investigate the influence of process gas and oxygen on AM builds. The nature of McKinsey, as a management consulting firm, the World Economic Forum as a global public-private cooperation organiser, and TÜV SÜD as a certification provider, means that their activities depend on the industry's willingness to work collaboratively.

When polled via the event app's survey feature, 54% of the audience attending the panel responded that they saw the current level of stakeholder collaboration in Additive Manufacturing as satisfactory. However, the majority of panellists disagreed, stating that the current level of collaboration is not deep enough and does not cover enough of the value chain to achieve its goals.

Dr Mrosik noted that while the industry has seen some highly visible collaborations in recent years, current collaborative efforts are simply on too small a scale. "We're in a situation with AM where, from laboratories and small-sized applications, we need to move into scale. Different things are required for this; it's required that more material manufacturers, machine builders, machine users and designers have to collaborate together to create close process chains and homogeneous processes in order to scale up and achieve higher efficiency," he stated. "That's where all parties need to work much more closely than has happened in the past; there's where the dissatisfaction is."

While several initiatives have endeavoured to make this a reality by bringing together large numbers of companies in recent years, with a number of AM networks established, Dr Mrosik voiced the need for this process to be accelerated if the industry is to see results within an acceptable timeframe. But what is holding the industry back from achieving the kind of depth and breadth of collaboration required? According to Lindner, the primary factor which is missing is trust in the Additive Manufacturing process from companies which could potentially benefit from adopting it as a manufacturing technology through partnerships.

"The processes, the materials, the machines and the management are good enough now to produce parts that are at least as good as traditionally manufactured products," he stated – but due to the comparative newness of the technology, many companies are wary of committing to major partnerships to produce parts which may open them up to failure. "At TÜV SÜD, we hope that based on trust, the ecosystem 'helpers' who can collaborate to drive the industrialisation of AM can have the courage to single out good applications – because unless we can find these commercially viable applications, where the products are in use, and demonstrate that not only is AM technology ready, but also AM applications, we will not be able to accelerate."

| contents | news | events | advertisers | website | e-newsletter | MTC3: Perspectives on industrialisation

Fig. 3 Members of the collaboration panel speak during Day 2 of MTC3. From left to right: Dr Melinda Crane (Moderator), Todd Skare (CTO, Linde), Prof Geoff McFarland (Director of Group Technology, Renishaw plc) and Francisco Betti (Head of Advanced Manufacturing Industry, World Economic Forum)

Skare agreed with the panel that while collaboration is ongoing, the applications which are being tackled remain somewhat 'incremental', meaning that they are aimed at the development of small-sized applications in which the risk of failure is minimised. "I don't know if that's because companies are reticent to open up and let in bigger applications, or because we don't have those bigger ideas," he stated.

In order to chase those larger applications and thus bring AM to larger-scale industrialisation, "collaboration across the whole value chain needs to target, as an industry, faster, cheaper production, whatever that may involve," he explained. "If we want Additive Manufacturing to really take off and be a new industrial revolution, we need to change companies' evaluation of moving into additive from what is now a long spreadsheet of figures on which optimised Additive Manufacturing costs about the same as conventional manufacturing – for some applications – to a spreadsheet which shows a 20% improvement in cost so that people are driven to dive into it rather than wondering if they should sit on the sidelines and 'wait and see'. Even within Linde, our 'spreadsheet' tells us to wait a little longer. We need cooperation to find that step-change which can move things forward."

Schmitz took a more positive view, praising the development of large-scale collaborative AM networks over the past three years across the value chain; but, he agreed, the current speed of industrialisation is not satisfactory, and the partnerships which have been established to date must be leveraged effectively in order to accelerate. "The current level of collaboration between members from across the value chain offers a great opportunity to move from today's polarising 'tech-forward' approach, where we develop technologies, to a more 'application-backward' approach," he explained, "and from a networked collaboration system to much more targeted and focused

> *"The current level of collaboration ... offers a great opportunity to move from today's polarising 'tech-forward' approach, where we develop technologies, to a more 'application-backward' approach."*

Fig. 4 Members of the 'Driving Industries: Aviation' panel speak on Day 2 of MTC3. From left to right: Dr Melinda Crane (Moderator), Dr Remedios Carmona (AM Roadmap Owner, Airbus), Paula J Hay (Executive Director, Additive Design and Manufacturing, Collins Aerospace), Dr Anne Thenaisie (Managing Director Safran AM, Safran Tec), J D McFarlan III (Vice President Functional Enginering, Lockheed Martin Aeronautics), and Dr Melissa E Orme (Vice President, Boeing AM)

collaborations through which projects are undertaken to deliver and industrialise AM applications… and not get locked in and grounded at our current small-scale applications."

With so many major organisations so keenly aware of the importance of cooperation for success, why does the status of collaboration still – in the panel's view – lag behind what is needed to get the AM industry to where it needs to be? Dr Schmitz stated that a major obstacle was the absence of the necessary business models to enable the types of collaboration needed. A dominant dimension to this issue is the cost of funding new business models at the company level, and the difficulty of making the business case for this investment when the returns are yet to be proven. "I personally believe the biggest lever would be to go look for solutions-focused applications and products and then work backwards, and ask what it would take to improve the cost and make a global, full-value chain business case, not only a unit cost case," he stated. "This dedicated work is very important; we must find a much more targeted approach, which will enable our cooperations to become much more effective and solve issues where business models are concerned."

"Additive Manufacturing machines need to be integrated into manufacturing lines and ecosystems, and for this we need common standards… once standards are established, collaborations unfold and markets grow…"

Expanding beyond business models, Dr Mrosik introduced the vital importance of a global system of standards for AM from Siemens' perspective. "The market needs a common denominator in order to collaborate," he explained. "Additive Manufacturing machines need to be integrated into manufacturing lines and ecosystems, and for this we need common standards. We've seen [at Siemens] that once standards are established, collaborations unfold and markets grow, because acceptance grows in the market."

| contents | news | events | advertisers | website | e-newsletter |
MTC3: Perspectives on industrialisation

Asked how trust issues regarding the sharing of intellectual property impact companies' approach to collaboration, Lindner agreed that there are hurdles to overcome when inviting companies to cooperate with entities which would typically be seen as competitors. However, he stated, "those contentious issues regarding whether it is my data or your data, how much I pay you for using your data, and in exchange how much do I give you back," are purely internal discussions between players, and do not take into account the human-based engineering which is at the heart of innovation, or the interests of the end customer. "Sometimes, this is used as an excuse to hide behind the complexity of legal issues and competitive emotions; this is about attitude, and should not be seen as a roadblock to collaboration."

Bringing the panel to a close, Dr Fischer issued a call to action for senior management in the AM industry to 'step up' to drive collaborative efforts. "It starts with us," he stated, "and it's not only dedicating staff to working groups but also having direct and close contact with other companies in industry. Without regular contact we can't trigger the right momentum. That's what I take home, what I keep in mind and what I am getting prepared to do."

Industries driving AM: Aviation

One of the most fundamental routes to increasing the industrialisation of AM is to consider which markets can best drive demand for AM in its various stages of maturity, and encourage decision makers within those industries to buy in and engage with the technology. Additive Manufacturing is currently being tested in a wide range of industries, but there remain broad discrepancies in terms of the scale at which industries are willing to engage with the technology. On the path from prototyping and experimentation to mainstream industrial production, some markets have made significantly more progress than others.

Fig. 5 Door latch shafts for the A350 XWB passenger aircraft produced using Laser Powder Bed Fusion at Airbus Helicopters Donauwörth (Courtesy Airbus)

In this year's Driving Industries panel, the focus was on aviation, an industry already reaping the advantages of AM in many real-world applications. On the panel were Dr Remedios Carmona, Additive Manufacturing Roadmap Owner at Airbus; Dr Melissa E Orme, Vice President Boeing Additive Manufacturing; Dr Anne Thenaisie, Managing Director Safran Additive Manufacturing; Paula J Hay, Executive Director, Additive Design and Manufacturing at Collins Aerospace; and J D McFarlan III, Vice President Functional Engineering, Lockheed Martin Aeronautics (Fig. 4). Each of these high-level panellists presented case studies in which they offered their market assessments for AM, looking at what role the technology already plays in aviation with a range of success stories, and what can be learnt from these successes to accelerate its serial use.

Airbus

Airbus began using AM approximately ten years ago, primarily for models and tooling. Now, the company uses a number of Additive Manufacturing technologies in both metal and polymer, including Fused Deposition Modelling (FDM) and powder bed fusion of polyamides for non-loaded system and cabin parts, and Electron and Laser Powder Bed Fusion (EB- and L-PBF) using primarily titanium, aluminium and Inconel alloys. Titanium alloys are used for loaded parts, long lead time items and very high added value parts, aluminium for lightweight components in satellites, and Inconel for high-temperature and long lead time applications.

At MTC2, Airbus reported that it was interested in AM, but still at an early stage in its adoption of the technology. The main barriers at the time were the company's very high part requirements, the lack of mature AM machines and the marginal

Fig. 6 Metal additively manufactured space housing produced by Collins Aerospace (Courtesy Collins Aerospace)

Fig. 7 Metal additively manufactured heat exchanger produced by Collins Aerospace (Courtesy Collins Aerospace)

nature of the business case for AM. "We need to juggle with those three to make business out of additive," Dr Carmona explained at MTC3. "As of today, we can say that AM machines have improved in reliability, though there is still a lot to do. We have found that powder bed metals have only niche applications, so we will only be using this technology for very specific components. However, we are already in the first stages of serious, industrial production of non-critical parts by powder bed AM." For this use to expand and target a wider range of Airbus components, Dr Carmona echoed the sentiment seen across many of MTC3's panels and presentations, stating that performance and competitiveness both need to be improved and that design for AM is key.

Some successful examples of AM parts produced by the company were given. The first was a Venturi duct, a water waste system installed on the A350 as part of a design-to-cost initiative carried out by Airbus. Produced by Airbus-owned STELIA Aerospace in Germany, the Ti6Al4V part was produced using AM to save on recurrent costs. The main lesson which Airbus took away from the development and serialisation of this part for AM, Dr Carmona said, was that industrialising complex parts, or relatively complex parts, such as this makes sense for AM, and provides benefits even if it is a one-to-one part replacement and not an entirely new component.

The next example concerned a Nacelle Anti-ice O-Ring. This device takes hot air from a jet engine and passes it into the Nacelle inlet, preventing icing. Due to its complexity, Airbus faced a number of issues when producing this part using casting, stated Dr Carmona, resulting in a high number of scrapped parts during production. "We resorted to additive mainly as a back-up, but now it's the baseline, standard solution," she stated. The part is currently qualified for and flying on the A330NEO, and the company is now carrying out a similar qualification process for the A350 and A320NEO. "Additive has proven to be more competitive and more reliable in terms of production than the cast part," Dr Carmona added. "Our main lesson here has been that when compared with casting, AM can be highly competitive."

The final application presented was a door latch shaft designed specifically for Additive Manufacturing in Ti6Al4V and installed on the A350 (Fig. 5). Manufactured in Germany by Airbus Helicopters Donauwörth, the new AM component consolidates ten parts into just one, resulting in production cost savings over 20% and a weight reduction of more than 40%. This part, too, has completed qualification. "Here, the main learning is that the integration of components through Design for AM is the key, and it will continue to be the key for us at Airbus," Dr Carmona commented.

Collins Aerospace

Hay was enthusiastic about the adoption of AM at Collins Aerospace. Opening her presentation, she stated that thanks to the wide range of parts it produces, from large-scale landing parts to tiny lights and sensors, "Collins Aerospace has huge opportunities to apply additive – to the point where we probably have more parts and ideas than we have people that can even begin to think about them all." The first example given of a successful AM application at Collins Aerospace was a space housing (Fig. 6), currently in production, followed by a thermal management device, also in production, and an AM heat exchanger (Fig. 7), which is completing development prior to entering production.

Commenting on the biggest lesson she had taken away from the development of these three applications, Hay stated that, "While the technology was certainly challenging in each of these parts, I'm not sure it was the biggest challenge we had. We have amazing engineers, and if we give them a tough problem, they will figure out how to solve it. But if they don't have an organisation which is going to support and help them to do that, and apply this new technology, it's really hard."

So, what can the AM industry do to encourage organisations to provide this support? "If you don't have leadership buy-in, it's never going to happen," Hay explained. "You need to talk to them, get them involved, and change their mindset to 'how is additive going to solve my customer problem or my business problem?'" The key here is to educate leadership about the benefits and business models of AM and dispel some of the negative myths surrounding it, while being honest about the challenges posed by its adoption and the lead time required to bring new AM applications to fruition. "There are so many people in the chain who could say no," explained Hay, "and you have to get them involved to make them say yes."

Fig. 8 A number of workshops took place at MTC3, covering everything from alloy development to the impact of gasses on AM processes

The next major challenge Hay noted was the often spoken of skills gap in the AM industry. Primarily due to the newness for the technology and lack of AM-specific qualifications available, the pool from which companies can hire staff with the relevant proficiencies in AM processes, design, software, materials and more is comparatively small. Even where staff with these proficiencies can be found, experience has taught Hay that the path to integrate them into a company's wider talent base may not be easy.

"We have a very experienced engineering population in the aerospace industry who've lived through many painful stories," she explained, "but they aren't used to additive, they don't think additive and they're not trained in additive." When new, additive-focused engineers join the company, their excitement is not often met with enthusiasm, or willingness to experiment with what is seen as an untested technology.

On the importance of collaboration as one of the most important drivers for the industrialisation of AM, Hay's belief is simple – no company can do it all alone. For example, she said, "every one of us is probably spending money right now to characterise all the major materials on every major machine from every different powder manufacturer. That's a lot of money – and a lot of repeated money." However, if organisations can identify and pursue partnerships which offer a win-win for both parties, masses of repeated, cost-ineffective research might be eliminated. Where issues of trust and intellectual property arise, Hay believes that companies need to be realistic and honest about what 'counts' as IP and what doesn't. "Just because you've invested in something doesn't make it critical IP that's going to be a competitive discriminator for you. Find people that you can work with, start small, try things, and go from there."

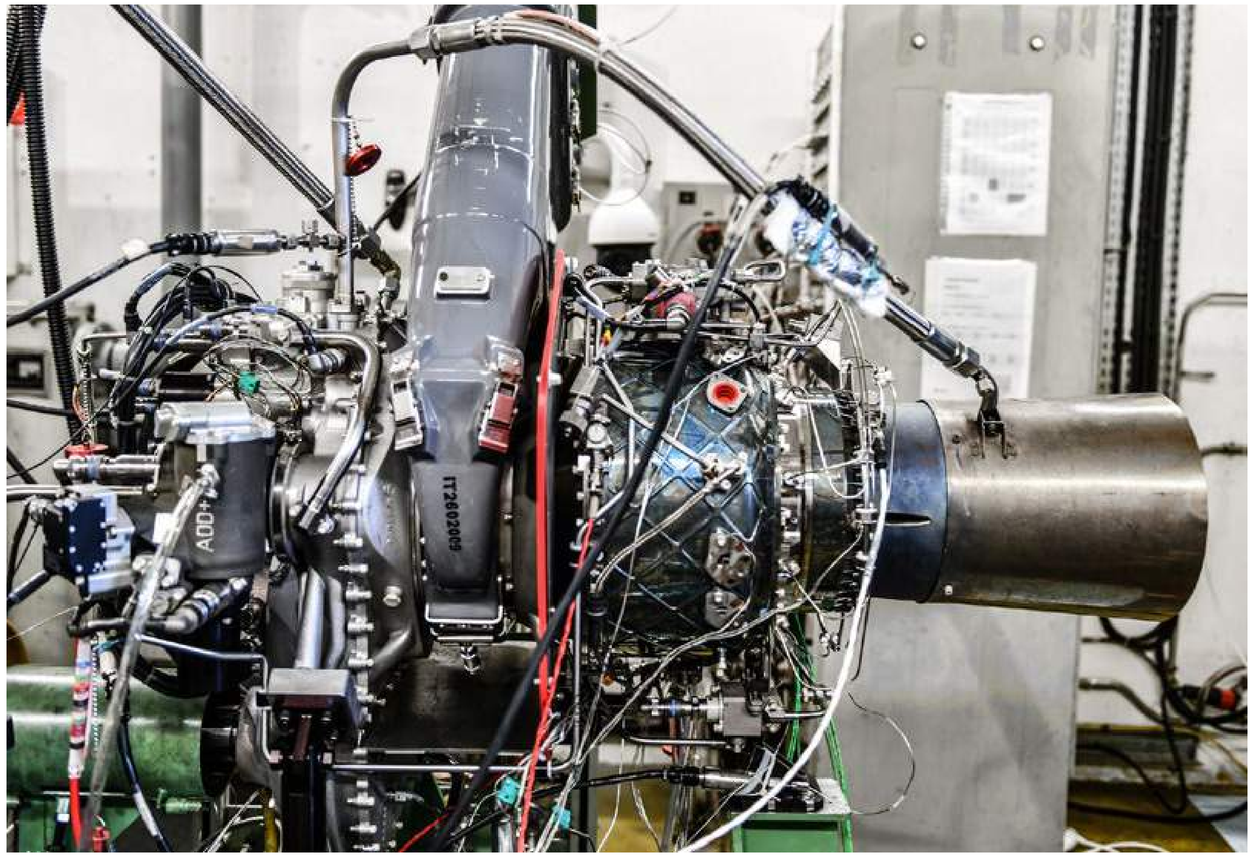


Fig. 9 Safran Group's Add+ demonstrator engine, which features almost 30% AM components (Courtesy Safran Group)

Safran Additive Manufacturing

Created five years ago, Safran Additive Manufacturing sits within Safran Tech, the research wing of Safran, whose innovations and capabilities are shared across the group's varied companies. The business's efforts to take advantage of the full benefits of AM have been highly publicised, and include a number of projects focused on driving the acceptance and industrialisation of AM in aviation, and the implementation of AM parts in real world applications. At the Paris Air Show in June this year, Safran Group unveiled the Add+ engine, a concept demonstrator featuring almost 30% AM components (Fig. 9).

When Safran acquired its first AM system in 2008, stated Dr Thenaisie, the company's goal was simply to use AM to replace cast parts with long lead times. In addition to this, it is now working on AM as a repair solution and for the production of spare parts on demand, but the main aim across all its AM projects is still to achieve sensible mass reduction on complicated parts. The company began with a single EOS machine, on which it prototyped parts such as static vanes, primarily in nickel-based alloys. With the production of prototype parts on this first system having proved successful, further machines were added, along with peripheral equipment. "Adding in-house equipment allowed us to get good specification on powders," Dr Thenaisie explained. "We were also able to specify procedures for repeatability, maintaining consistency across machines."

While at the start of its AM journey, Safran's AM production was limited to one or two key materials and primarily to Inconel 718, Dr Thenaisie noted that a major shift as the technology moves further toward production readiness has been the need to add many more alloys to suit the demands of customers. "Our customers have applications which

> *"The industry still has to gain the experience and confidence to use AM more widely, but we are in the 'trust zone' now – we have passed the 'hype zone', and we are convinced that Additive Manufacturing is a solution we can use."*

Fig. 10 Safran Tech's Dr Anne Thenaisie, right, speaks on the Driving Industries: Aviation panel at MTC3

require new materials," she stated. "If a customer says to us, 'yes, Inconel 718 is fine, but I would like titanium,' or 'I need high-temperature material', then we have to make sure the design office has the materials it needs, but we must also reduce the quantity of new materials that we use. Every time we test a new material for fatigue, for tensile strength, carry out temperature testing, etc, we are actually doing several millions of euros of work."

The key to reducing these costs, Dr Thenaisie explained, is to encourage standardisation within the company, as well as forward-thinking materials development. "We have to find ways for our design office to work with data that already exists and ensure they are not creating a new material where an existing alloy might suffice. And if we need to design a new material, we must make sure that it covers the future needs of our customers, or we will have to design new materials every year."

A positive takeaway from Safran's experience in AM has been that while the AM process poses unique challenges, and the qualification of AM parts can be lengthy due to the increased level of scrutiny placed on parts produced by new production technologies, Safran has proven that Laser Powder Bed Fusion Additive Manufacturing can have better repeatability than casting. "There remain some issues for the advancement of AM to production," she concluded. "Beyond issues of standardisation and qualification, there are the issues to solve regarding part quality and reliable part inspection. The manufacturing cost is also high; standardisation can help to decrease it. The industry still has to gain the experience and confidence to use AM more widely, but we are in the 'trust zone' now – we have passed the 'hype zone', and we are convinced that Additive Manufacturing is a solution we can use."

Lockheed Martin

Lockheed Martin began rapid prototyping with stereolithography UV cross-linked resin AM in 1988 and adopted metal Additive Manufacturing in 2002, when it used DED to produce what it believes were the first additively manufactured titanium parts ever flown on a fighter jet, installed on its F-16. In 2011, the Juno spacecraft launched carrying what the company further believes were the first additively manufactured parts ever to fly in space; L-PBF-produced titanium brackets used to hold a wave guide.

McFarlan outlined two more recent applications which evidence how the adoption of Additive Manufacturing has benefitted Lockheed Martin. The company recently began using L-PBF to produce spare titanium fittings for a climate control console in the F-22 fighter jet, replacing the corrosion-prone aluminium fittings it had previously used. The use of AM

MTC becomes AMTC: A new super-conference to alternate between Munich and Aachen

For 2020, the fourth Munich Technology Conference will depart from its roots in Munich and, under the new title of AMTC4, will take place at the Eurogress Event Center in Aachen, Germany, from October 20–22, 2020, in cooperation with RWTH Aachen. Thereafter, the event will alternate between the two cities. RWTH Aachen is the largest technical university in Germany, home to 45,000 students enrolled in 144 programmes of study. It is also home to the Aachen Center for 3D Printing. The university works with local small and medium-sized enterprises, as well as leading AM companies, to develop metal AM processes.

titanium reduced lead times – each replacement fitting now takes just four hours to build – and solved the issue of corrosion. However, certification of the fittings for use took six months, with the end result being that only two out of three proposed parts were approved for Additive Manufacturing. "While the production of these AM parts is very quick and reduces our lead time significantly, it is very hard to get them into service," McFarlan stated.

The second application example was Lockheed Martin's use of Sciaky's large-scale Electron Beam Additive Manufacturing (EBAM) technology to produce satellite propellant tanks which would conventionally be made by die forging, resulting in a significant lead time reduction from eighteen to six months. The 116 cm (46 in) diameter vessels are produced in Ti6Al4V, and are now fully qualified and ready to fly on the GPS III satellite upon its launch.

Boeing Additive Manufacturing

Boeing has been involved in Additive Manufacturing for two decades, primarily in the areas of polymer AM and tooling applications. The company has twenty AM sites worldwide, and currently has over 70,000 AM parts flying in aircraft and spacecraft. While the majority of these are polymer, many metal parts are also in service, with the company's first flying metal AM part having been produced in 2001. Most recently, in August this year, the company launched its metal additively manufactured AMOS 17 aft command horn antenna on the SpaceX Dragon, a cargo spacecraft.

Speaking on the formation of Boeing Additive Manufacturing in 2017, Dr Orme stated, "Our aim is to position Boeing as the leader in Additive Manufacturing. Boeing AM is an enabler for the Boeing enterprise – meaning all the units of Boeing, including commercial aircraft, defence and space, global services, etc – to insert additive into their programmes to create and own the intelligence of AM, taking advantage of the high-value aspects of AM, while developing a workflow practice that enables repeatable quality and the creation of transferable data across the AM supply chain."

One advantage Boeing has in its efforts to industrialise AM, Orme stated, is its core culture of intracompany collaboration. The new Boeing Additive Manufacturing Intelligence Centre, currently under development, will work closely with the group's global network of fabrication and innovation centres on the development of intellectual property and the digital aspects of the AM value chain, as well as drawing data from the group's research and technology activities. "We are trying to drive commonality through industry standards," she explained. "Boeing is a company which has been entrenched in its own standards for a long time, but we are working to change this. We are also trying to improve efficiencies overall and by doing this, we hope to become the global industrial champions in AM."

Boeing is currently working closely with Oerlikon to develop standard materials and processes for metal Additive Manufacturing. The companies' five-year agreement, announced in February 2018, is initially focused on the creation of standardised titanium L-PBF processes, ensuring parts produced by this method meet the requirements of the USA's Federal Aviation Administration and Department of Defence.

Conclusion

In a whitepaper published following the close of MTC3, Prof Süss expressed his belief that Additive Manufacturing is "on the home stretch" in the race to industrialise. The panel discussions and presentations given in Munich this October seem to reflect this, with frank commentary on the challenges still faced by the industry being paired with positive case studies of successful applications, and a general sense that Additive Manufacturing, for all its challenges, is very much on the right track.

One theme to reoccur more than any other throughout the two days' discussions and presentations was collaboration, which must be regarded as a necessity if the industry is to tackle the challenges that remain. That is reflected in this report, not only in the collaboration panel, but throughout. The form collaborations can take may vary, ranging from partnerships between companies on the AM value chain to enhance production workflows, to intra-company partnerships between departments, to academic partnerships with universities and research institutes, to collaborative efforts between commercial and government organisations to drive standards development. Regardless of the kind of partnership, it is clear from the discussions at MTC3, and the development of the industry over the past twelve months, that the most productive and efficient way in which companies can tackle the challenges of AM industrialisation is by working together.

In light of a seemingly constant flow of technological and applications developments, it can be easy to overlook the comparative youth of AM as a technology compared to its competitors. Consider that casting was developed in Ancient Egypt, and continues to be optimised and evolved to this day, and the twenty-to-thirty years AM has been in development seems very little time. Even modern CNC machining technology took forty-to-fifty years to reach its current state of widespread industrial adoption. Commentary around the industrialisation of AM can appear frustrated by its 'slow' progress, but the fact is that AM is making comparatively rapid headway.

MTC3 promised, and delivered, a 'reality check' on the progress of AM's industrialisation. But while the phrase carries negative connotations, in this case, the results of the reality check are good. AM's progress toward industrialisation has, in the past few years, been extremely positive; market predictions remain strong against a backdrop of a slowing global economy; the steps required to reach true industrialisation are well understood and being taken; and AM is industrialising at a faster rate than many of its predecessors.

Author

Emily-Jo Hopson
Deputy Editor and Features Writer
Metal AM magazine
emily-jo@inovar-communications.com

From atomisation to analysis: How Carpenter Additive is delivering improved material reliability, economics and quality

Metal Additive Manufacturing is a complex technology in which users struggle with materials reliability and quality on a daily basis. Here, William Herbert, Director Technology and R&D - Carpenter Additive, a division of Carpenter Technology, looks at how the company combines a 130-year heritage as a leader in speciality alloys with modern, digital solutions for powder management and material traceability, and supports the AM supply chain end-to-end by developing advanced materials, improving process economics and quality, and reducing risk in production applications.

The dreaded message came through early on a Friday morning from the operations supervisor: "Build failure occurred at approximately layer number 3000, almost 90% of the way through the run." The engineering team had been monitoring the Laser Powder Bed Fusion (L-PBF) machine as it quietly hummed all week, checking its critical process variables like the vital signs of a patient. The sizeable, valve-like component slowly taking shape in the build chamber bore all the hallmarks of a good additive part – intricate fluid flow features, hard-to-reach internals and long lead times for its cast predecessor. The team had spent days preparing the file, optimising the layout, analysing and screening the high-purity stainless-steel powder to be used, identifying potential pitfalls and attempting to avoid them through careful setup. Once the build began, the team had looked through the small window into the machine's build chamber once every half hour to check whether the laser was still sweeping and sparks still flying. The build was in the final stages of its eight-day sequence when the powder recoater blade scratched on a deformed part feature – a shard of metal jutting out of the powder bed.

A set of instructions was calmly issued back to the operators: "Stop the process. Allow the platform to cool, remove the plate and powder. Clean down the machine and turn it around to start all over again." But first, the team was called to a meeting to identify the root cause and avoid a recurrence on the next attempt. This first failure had cost a week of valuable labour and machine time and a tight delivery schedule was frustratingly affected.

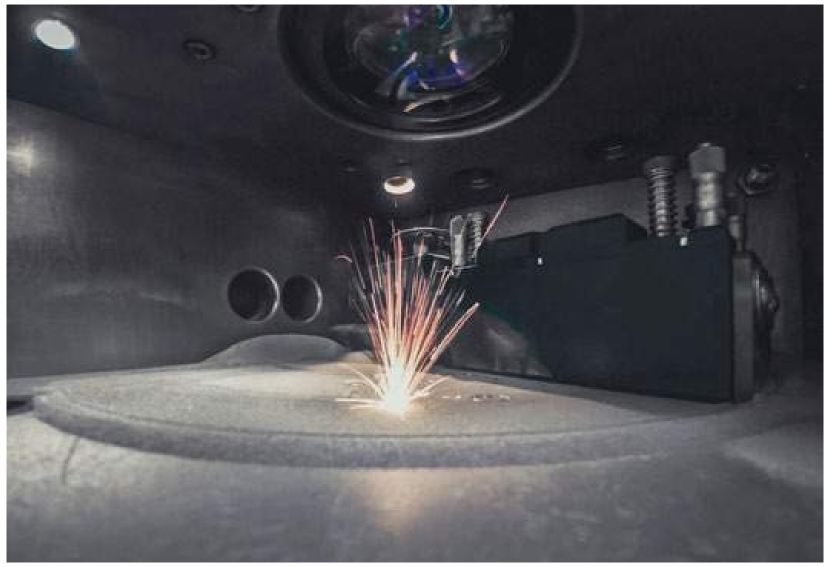


Fig. 1 A late build failure remains an all too common 'nightmare scenario' in L-PBF, leading to material, machine time and labour costs as well as delays

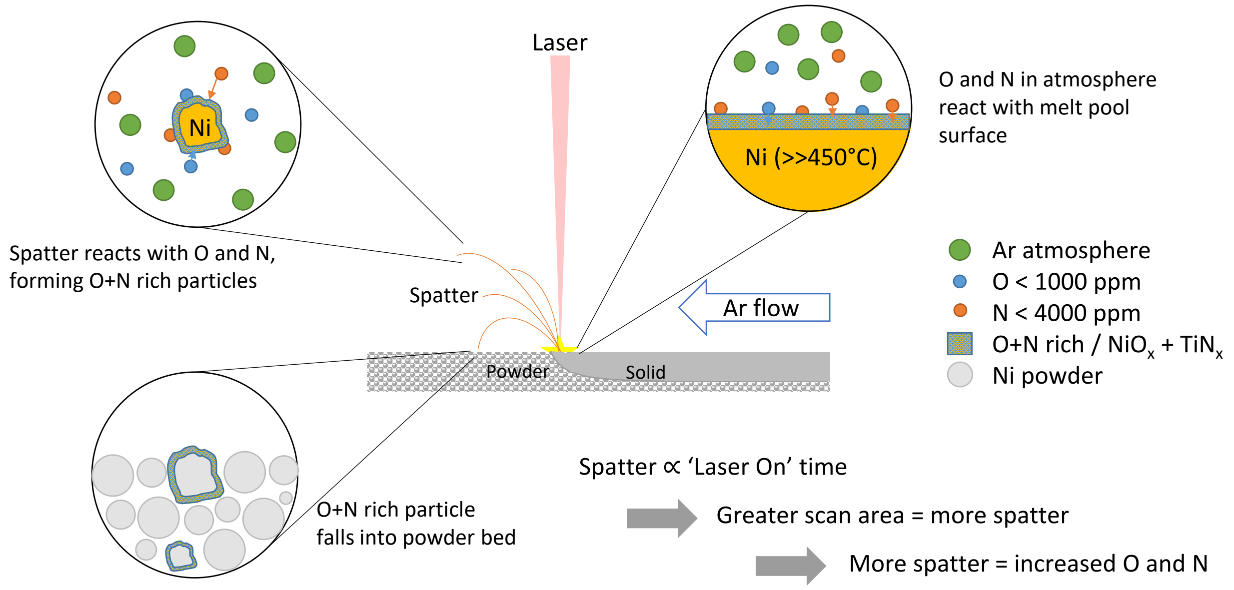


Fig. 2 Illustration of the 'spatter' process in Laser Powder Bed Fusion of a generic nickel alloy such as CT PowderRange 718. Small, molten particles are ejected by the local thermal forces from the melt pool and solidify in the machine chamber, leading to oxygen and nitrogen pickup. These O+N rich particles can lead to powder contamination that is very difficult to track. Carpenter Additive's PowderLife system is designed to assist users in retaining traceability and quality control throughout powder reuse cycles

Anyone who has worked with state-of-the art metal Additive Manufacturing systems will recognise this illustrative example and understand that the time was not completely wasted. Experienced industry colleagues are familiar with the quotidian learnings and continuous improvement of this industry; AM machines are a mass of complex pipework and electronics, with many potential points of failure. No single part build is identical, with each requiring the collective expertise of a group of experienced mechanical engineers and metallurgists, a range of software tools and knowledge accumulated from prior efforts to set up for success. Endless minor setbacks are followed by educated tweaks and corrections, gradually raising the bar for quality with each build, and informing the direction of new projects in a progressively upward trend. Preparing an additively manufactured part for production is an exercise in patience and rigour that can take months, if not years, of continuous improvement.

Materials challenges

Did anyone expect this to be an easy process? Decades after the inception of metal AM, we are still dealing with a fairly futuristic process, which, in large part, has yet to be standardised. L-PBF remains the most widely-used process; powerful fibre lasers, sometimes several at once, are directed through micrometre-perfect optics, laying down miles of seamless weld track in loose metallic powder, itself a highly insulating and occasionally volatile material. Parts produced by L-PBF are made up of thousands of tiny volume elements of material, cooled rapidly from the molten state into low-temperature, thermodynamically metastable solid phases in approximately 1/10,000th of a second.

We cannot always force these materials to behave as we would like. The densification of the powder bed into a bulk solid causes distortions that are hard to predict, hence the need to anchor the slowly materialising component solidly to an inches-thick build plate.

During cooling, the material tries to shrink, warp and pull in every direction, sometimes leading to observable macrocracking. On the microscopic scale, the as-built material invariably contains porosity from entrapped gas, keyhole welding or lack of fusion. Most alloys also undergo phenomena such as hot cracking, since molten alloys do not freeze all at once in a unified block, but instead form a 'forest' of extending, solidifying branches called dendrites – with remaining liquid being pushed into the micrometre-sized spaces in between. Where these gaps are not filled, or are pulled open by strain in the material, cracks on the scale of just micrometres can form. These microscopic defects often constrain the types of alloy that can be additively manufactured effectively, and limit the mechanical performance of those that can.

Finally, observing the powder bed during the process, we see the familiar sparks flying – these are in fact minuscule droplets of liquid metal ejected from the laser's path

Fig. 3 Carpenter Additive operates seven industrial atomisation facilities globally, producing high-quality, gas atomised powders for the AM industry across a wide range of materials

and burning in the low-level remnants of oxygen in the chamber. A steady flow of inert gas through the chamber is used in an attempt to carry these particles away, but many fall back into the bed of high-quality powder material as contaminating inclusions, which AM engineers nickname 'spatter' or 'soot' (Fig. 2). When the time comes to recycle unused powder for a fresh build, operators still do not know what influence soot has on the material quality, or how to keep track of it when powder is continuously reused.

The common thread throughout these issues is materials science. Although metal AM is perceived by the wider public as a digital technology, it is still inherently a metallurgical processing approach and thus complementary to other production techniques in which we precisely engineer and control the material's microstructure – such as casting, forging and welding. Alternative metal AM technologies such as Binder Jetting and wire- or powder-based Directed Energy Deposition (DED) are not necessarily simpler, each having their own metallurgical and practical idiosyncrasies and challenges. Reliability and materials quality are the essential pain points of metal AM today and every user of this technology still goes through experiences like those described above.

The launch of Carpenter Additive

If it were easy to operate industrial metal AM systems – just 'push a button and wait' – Carpenter Technology would not be working in this field. A global leader in speciality alloys for over 130 years, the company's approach is to help its customers solve the most challenging materials and process problems.

Throughout the AM industry's development over the last two decades, Carpenter Technology has supplied feedstock material and expert advice to those entering the space. So, extending its AM activity further was a natural step; the company aspires to be an irreplaceable partner in the supply chains where it operates, including the aerospace, medical, transportation, energy, consumer and other industrial sectors. In practice, this means collaborating with customers' engineering teams on their product platforms, advising on materials selection, working on next-generation alloys with specialised formulations and process techniques and developing new materials with specific 'form, fit and function' for challenging service requirements. Crucially for the emerging field of AM, Carpenter Technology is experienced in supporting lengthy and intensive qualification initiatives, sometimes beginning years in advance of the planned product launch.

Fig. 4 Top image, SEM of Carpenter 316L AM powder. Lower image, containers of standardised materials in the PowderRange™ portfolio, specifically optimised for different types of AM processes and covering 80% of today's application and machine types

Already one of the world's largest manufacturers of inert gas atomised powders and a supplier of AS9100-accredited additively manufactured components, in May 2019 Carpenter Technology consolidated its relevant divisions and launched a business unit fully focussed on supporting the metal AM industry with end-to-end expertise under the brand Carpenter Additive. In this article we look at three interconnected areas in which Carpenter Additive is bringing value to its customers: materials and processing technologies, PowderLife™ quality management solutions, and end-to-end manufacturing support.

Speciality materials and processes: The foundation for high-performance applications

Carpenter Technology supplies industry with hundreds of thousands of tons of highly-specified, vacuum-melted alloys in different product forms such as billet, bar, strip, wire, and powder. Our deep familiarity with metallurgical quality assurance and testing, which is required to service our mission-critical supply chains, is a cornerstone of Carpenter Additive's strategy in AM. Understanding the complex relations in structure-process-properties that dictate an alloy's performance, Carpenter Technology is well placed to provide expert advice and manufacturing solutions for AM technology.

Unlike subtractive techniques such as CNC machining and, instead, more analogous to casting, during metal AM processing a material's microstructure is engineered simultaneously with the geometry of the component. Material defects and therefore damage tolerance limits are directly linked to the way the component is manufactured and post-processed. Carpenter Technology is a partner and advisor with experience in high-end processing technologies that can bring a holistic understanding of materials, process and application requirements.

For its current metal AM customers, Carpenter Additive provides a portfolio of standardised powder alloy feedstock in its PowderRange™ portfolio. These materials, which are specifically optimised for different types of AM machine, provide an off-the-shelf solution for more than 80% of application cases today. However, for many new applications and designs, the standardised materials in PowderRange do not allow the user to take full advantage of what AM can offer. Carpenter Additive's customers frequently ask for advice on how to enhance the performance of these existing alloys, or, when needed, to develop next-generation materials and processes tailored specifically to their requirements.

A walk through Carpenter Technology's Research and Development Center in Reading, Pennsylvania, USA, illustrates how effectively and quickly we can incubate early product ideas and, subsequently, prove them out with end-to-end materials design or product enhancement – all under one roof. The team always starts with the end-user's problem, typically as a collaborative exercise with the customer: what are the product requirements? Have they considered all the viable alternative manufacturing routes and can AM provide enough of an advantage to

Fig. 5 Carpenter Additive's Widnes facility, UK, includes state of the art gas atomisation technology, powder storage and R&D facilities

make embarking on an AM design project worthwhile? What are the shortfalls with their current materials and processes and where are there necessary trade-offs in economics versus performance? Once these questions are understood, a wealth of materials design capabilities can be brought to bear on the problem.

Case study: Alloy development for a medical device

A global medical device company approached Carpenter Additive for help with a biocompatible, hypoallergenic (or ultra-low allergenic) stainless steel for medical instrumentation applications. Additive Manufacturing was of interest for its design flexibility, but there could be no compromise on material quality for devices that would be used in medical devices and surgical applications. Existing materials on the marketplace did not meet the company's stringent requirements for allergenic resistance, strength, and toughness.

Carpenter Additive started with the common stainless steel 316L and determined the alloy's relatively high nickel content did not satisfy regulatory requirements and customer preferences for hypoallergenic medical materials. However, some existing hypoallergenic alloys gain their strong mechanical properties from cold working, which is not feasible using AM processing. They sought the advice of the R&D computational materials group which, using state-of-the-art neural network simulation tools to screen through tens of thousands of chemistry permutations, narrowed down on the most promising alloy contents for this application space. This included variants of Carpenter Technology's premium BioDur® 108 stainless steel, an essentially nickel-free stainless steel with very high biocompatibility and high levels of strength, toughness, corrosion and fatigue resistance.

The team ranked the simulated results and, within a day, was able to manufacture the most promising alloy variants as small button samples on the scale of just a few grams using a plasma arc melting system. Then, mimicking conditions within the L-PBF process, the team made laser welds across the buttons and analysed the results carefully under a microscope, allowing them to select the exact alloys for full trials.

To pilot the full process, the team had to convert the selected alloys into powder feedstock for AM. Within the Reading R&D site also sits a powder atomiser that holds a charge up to 130 kg, and is therefore an ideal tool for small-scale AM trials. Other than its lesser size, the atomiser is identical to its bigger siblings at Carpenter Additive's industrial plants, which fabricate thousands of tons of AM powder annually and distribute

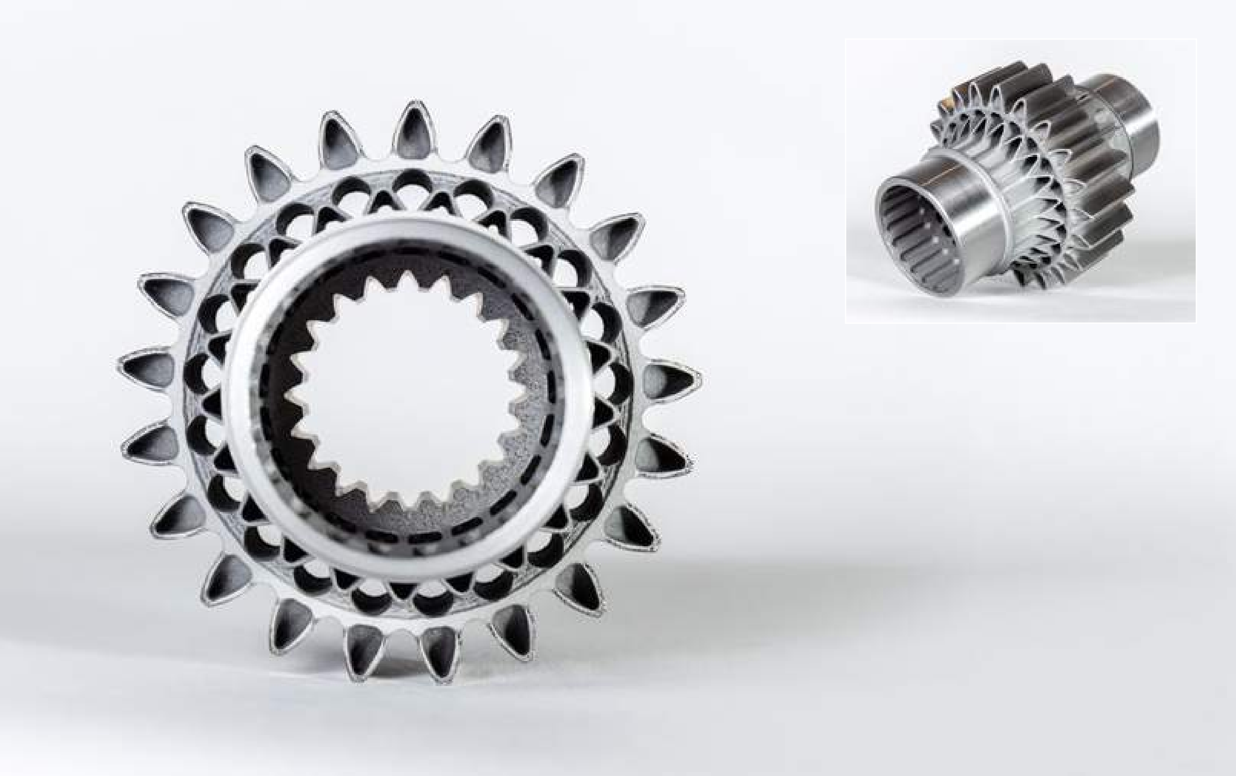


Fig. 6 Carpenter Additive collaborated with BMT Aerospace to create aerospace slat track pinion gears using Carpenter Technology's premium Custom 465® stainless steel for AM. Custom 465 has approximately 25% higher tensile strength and higher wear resistance compared to today's conventional AM stainless steel, 17-4PH. The gears are currently undergoing ground-based flight cycle testing to prove their longevity in wear and corrosion resistance for major aircraft manufacturers

them to customers all over the world.

Adjacent to the R&D atomiser is Carpenter's Additive Manufacturing Technology Center (AMTC). Built in 2017 and supported by over a hundred staff metallurgists and engineers, the AMTC brings together three different AM modalities within Carpenter Technology's R&D ecosystem: L-PBF, Binder Jetting and Directed Energy Deposition. The AMTC's mission is experimental work, early stage materials demonstration and application development. We think of this as our Technology Readiness Level (TRL) 0-3 location, where we can support customers with their fundamental questions and challenges.

The Carpenter team used the new powder feedstock to manufacture a series of AM mechanical test coupons. Down the corridor in the furnace room, the test coupons were subjected to a series of post-processing experiments with the objective of stabilising the material into the desired alloy phases via ageing heat treatment and Hot Isostatic Pressing (HIP). The mechanical properties of the post-processed coupons were measured and summarised in a recommendation for the medical device customer.

"The capability to perform this work under one roof within less than two weeks, with the advantages of speed, agility and control it provides, puts Carpenter Additive in a unique position."

The capability to perform this work under one roof within less than two weeks, with the advantages of speed, agility and control it provides, puts Carpenter Additive in a unique position. The business can proceed from early-stage ideas and fundamental challenges to pilot- and full-scale applications in the same location, and with full management of the process steps. Leveraging the depth of knowledge and wider metallurgical engineering talent at Carpenter Technology, the team is available to assist its customers with a wide range of material, process and application challenges. Over the past two years, the materials team at Carpenter Additive has investigated over twenty alloy types and advised dozens of customers on materials selection, process optimisation and part-making applications for AM.

Case study: Aerospace pinion gears

Carpenter and BMT Aerospace International, Oostkamp, Belgium, collaborated in the development of the metal AM aerospace pinion, shown in Fig. 6, manufactured using Carpenter Technology's Custom 465®, a proprietary, martensitic age-hardenable alloy offering a superior combination of strength, toughness, corrosion resistance, and tolerance to common AM microstructural defects, as compared to other high strength steels such as 17-4, 15-5, and Maraging 300. BMT Aerospace and its subsidiary BMT Additive initiated the project by partnering with Carpenter Technology to produce a redesigned pinion that could leverage the design benefits of Additive Manufacturing, whilst using high quality materials that would attain the high-performance expectations of the application.

The cooperation between the two companies resulted in an optimised and simplified manufacturing process for the part and presented the opportunity to further expand Additive Manufacturing part production across multiple applications. The parts were manufactured by Carpenter Additive, with design, validation and post-processing carried out by BMT Aerospace.

The gears are currently undergoing ground-based flight cycle testing to prove their longevity in wear and corrosion resistance for major aircraft manufacturers. Carpenter's custom 465 material has approximately 25% higher tensile strength and higher wear resistance compared to AM 17-4PH stainless steel.

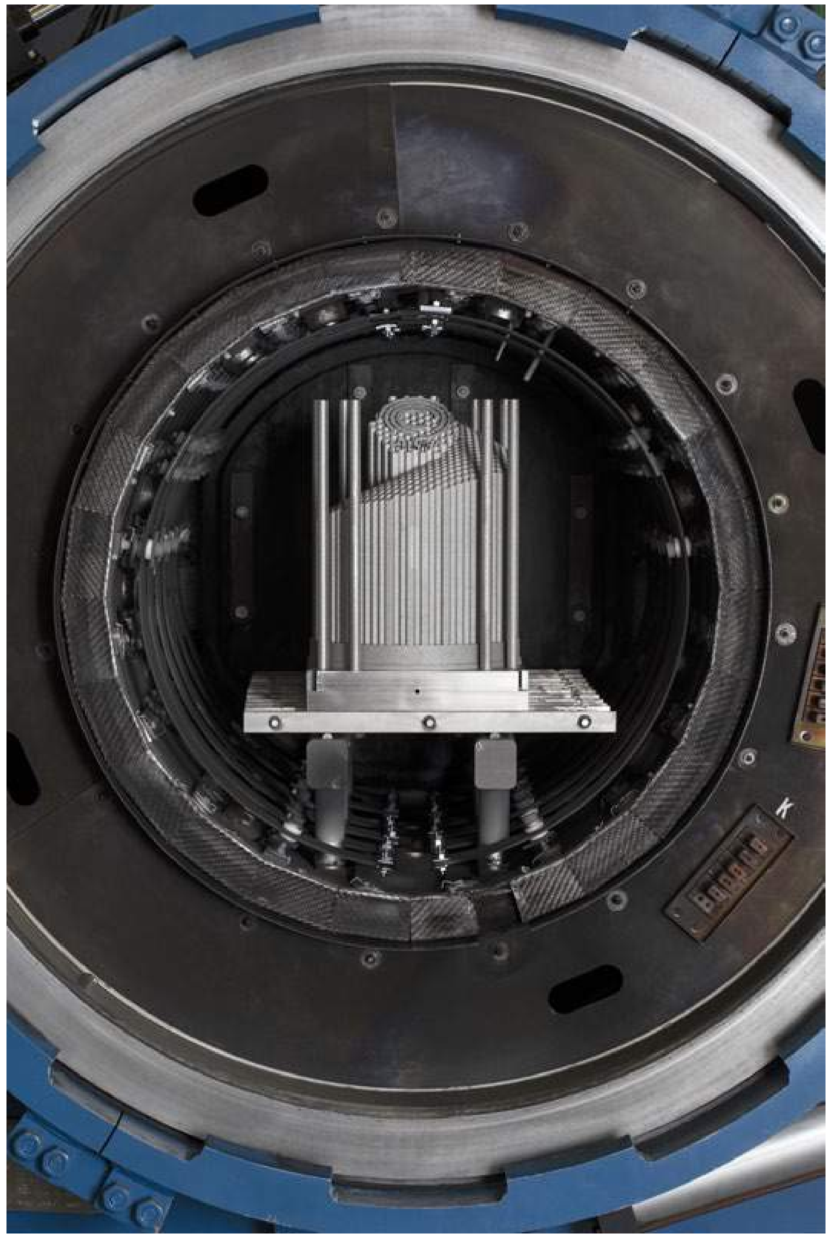


Fig. 7 A vacuum heat treatment furnace at Carpenter's Additive Manufacturing Technology Center (AMTC) in Reading, PA, USA

Improving manufacturing efficiency with PowderLife™ materials management

Research at Carpenter's AMTC sets the foundation and supports customers during the early stages of AM development. Much of the industry's collective effort is still focused on this foundational phase, seeking to identify relevant applications and prove them out at small-scale and low-rate initial production. However, once a material's performance within design guidelines is understood – and the business case for a new application is signed off – product managers face another series of questions and challenges as they look to scale up production.

These considerations boil down to a combination of economics, supply chain performance and risk. For Carpenter Additive's strategic customers, who have already achieved expansion of their AM programme or even reached full-rate production,

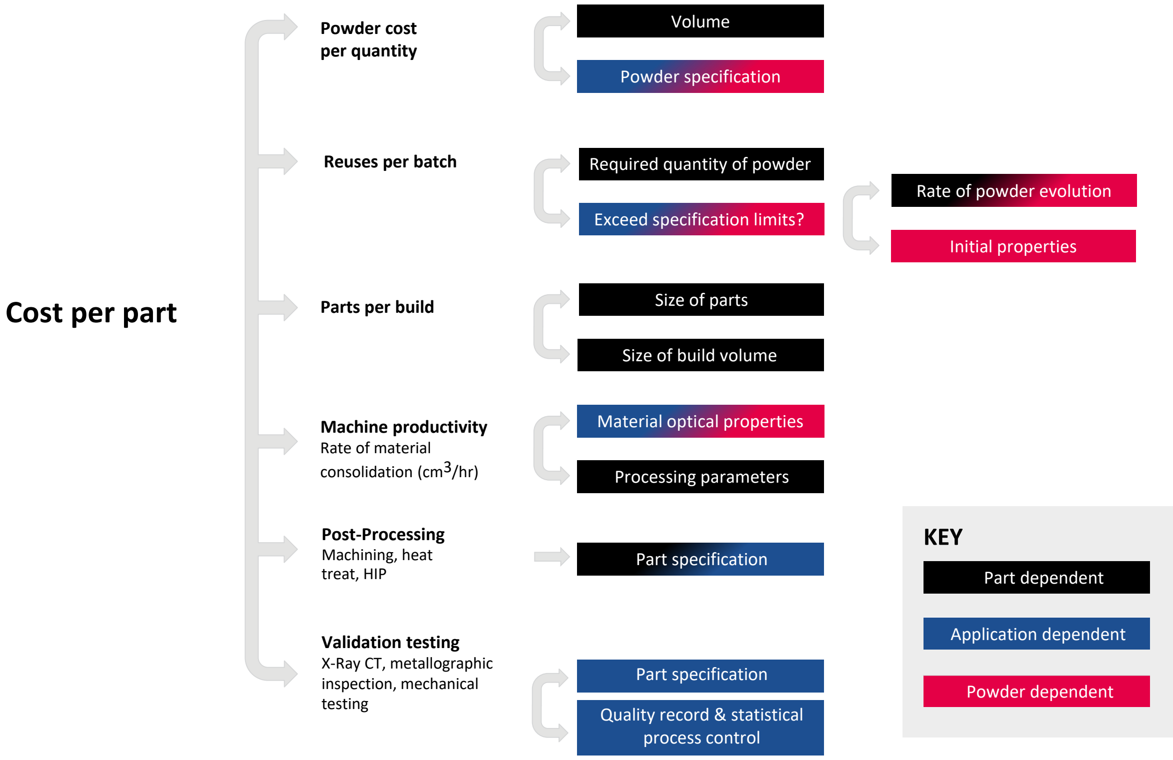


Fig. 8 AM parts have several important cost elements, which can depend on the part design, specific application, and powder requirements. Carpenter Additive's PowderLife system helps serial production customers identify the largest cost-down opportunities in the supply chain for economic improvements to their AM programme

Carpenter Additive sees priorities turning quickly towards operational considerations. These considerations include yield improvement, productivity and overall equipment effectiveness, material waste reduction, and environmental health and safety mitigation with large-scale powder usage.

Carpenter Additive's PowderLife suite of solutions has been developed specifically with these advanced AM users, who are looking to achieve a series of marginal gains from their AM production programme and drive sustainable improvements, in mind. The PowderLife solutions portfolio includes materials advisory services, customised powder management equipment and digital traceability applications to track and analyse powder reuse in real time on the AM factory floor. Carpenter Additive has found that near-term reductions in per-part cost of up to 30% are possible when a structured and methodical approach to production efficiency is taken using the PowderLife system (Fig. 8).

"Carpenter Additive has found that near-term reductions in per-part cost of up to 30% are possible when a structured and methodical approach to production efficiency is taken using the PowderLife system."

Machine productivity

Typically the largest individual cost line item, machine productivity is related to how efficiently the build volume is filled, the processing parameters and the amount of time it takes to recover the part and set up the machine for the next operation. For current AM technologies and applications, productivity improvements can be found by pushing machines towards the limit of the energy source, such as laser wattage. This is challenging to do whilst maintaining high material quality, because it depends on the alloy's optical properties, but is possible with some alloy classes. Other efficiencies can be achieved by reducing machine turnover time with efficient powder delivery and recovery solutions.

Material cost

Whilst material cost usually comprises less than 10% of the total per-part cost, it is a highly visible accounting line item because of the large amount of inventory needed to fill machines. Upfront costs can be brought down by examining the engineering specifications with the feedstock producer, such as chemistry and particle size distribution. As highlighted in Fig. 2, inventory degrades over time through multiple reuse cycles, leading to traceability and quality challenges. Extending the reuse of powder requires a careful understanding of the statistical process limits at which powder negatively impacts part quality. More importantly, and especially in highly-regulated end-use industries, clear traceability and digital documentation are essential to avoid the high cost of scrapped parts, as well as for managing recalls of components affected by feedstock quality escapes. Carpenter Additive works with customers across many types of material and application to manage powder reuse. Through the PowderLife programme, we advise on how to standardise processes and minimise costs, while reducing EHS risks associated with open powder exposure to operators.

Fig. 9 Carpenter Additive's newly built Emerging Technology Center in Athens, Alabama, includes both Electron Beam Melting machines and L-PBF systems

Secondary processing costs

Post-processing and validation testing are more difficult to control directly, but can comprise a significant fraction of per-part cost, often exceeding 50%. Today, AM producers compensate for the lack of measurable materials design tolerance by inserting witness coupons, or test pieces, alongside components to be built. These provide peace of mind that a destructive test can be carried out to determine build quality, but can add significant expenses over time. Carpenter Additive's PowderLife programme sets up a long-term solution for customers to reduce the burden of validation testing by maintaining a digital compendium or consistent record of process inputs and statistical materials property outcomes across large numbers of build cycles.

Bringing it all together: End-to-end manufacturing

The full range of Carpenter Additive's technology initiatives can be seen in operation at Carpenter's Additive Manufacturing production locations in Camarillo, California, USA, and at the newly built Emerging Technology Center (ETC) in Athens, Alabama, USA (Fig. 9). The Camarillo site operates under AS9100 Rev. D and NADCAP certification, meeting the industry's most stringent quality requirements. The Camarillo facility operates Electron Beam Melting (EBM) machines as well as L-PBF systems, used primarily to service the aerospace, defence and space sectors, although the company has recently seen a steady increase in the number of oil and gas, semiconductor and other industrial applications – signalling that AM is beginning to make a mark on a broader set of end-use markets.

Building on our strong foundation in materials and process technology, the mission of these end-to-end manufacturing locations is to scale up the use of Carpenter Technology's speciality alloys in AM and drive challenging applications into full production. Our business does not necessarily focus the bulk of our attention on quick turnaround, basic CAD-to-build AM services using today's mainstream alloys. Instead, new product developments are pushed from the R&D sites and Carpenter Additive puts them into practice through real-life part development. Low rate initial production can then be carried out and the knowledge gained later transferred to customer sites for full-rate production. Many customers also rely on Carpenter Additive to support their AM production needs on an ongoing basis.

The ETC demonstrates scaled-up process and application development, material traceability, component fabrication, post-processing and certification. Automated data collection at every step creates a digital library to reference specifications and results through the whole value chain. At the ETC, materials start life as raw elemental feedstock and are then weighed out and converted to powder using an industrial-scale powder atomiser at one end of the building. Powders are then transported in enclosed containers to alloy-segregated powder processing rooms and fed into L-PBF systems. Built parts, once heat treated or HIPed, are then machined and finished in the post-processing area, before undergoing part inspection and materials validation testing. The PowderLife system collects data and information across the entire lifecycle, creating a documented quality record as well as a future reference that can be used by Carpenter Additive for product enhancement and process optimisation opportunities.

"...the company has recently seen a steady increase in the number of oil & gas, semiconductor and other industrial applications – signalling that AM is beginning to make a mark on a broader set of end-use markets."

The future of speciality alloys in AM

Carpenter Additive brings a wealth of knowledge and expertise to its customers in metal AM, offering a range of services to help them succeed in bringing viable applications to production. Combining more than a hundred years of metallurgical leadership with modern software and data analytics to provide end-to-end materials traceability, Carpenter works with both customers who are relatively new to AM, and those who have already achieved full scale-up and are looking to drive continuous improvements in materials handling and efficiency. In each of these cases, Carpenter Additive helps the customer to tackle the considerable challenges of this technology while simultaneously driving the future of speciality alloys in AM.

Contact

William Herbert
Tel: +1 610 208 2174
wherbert@cartech.com
www.carpenteradditive.com

The evolving metal powder marketplace: Total solutions, vertical integrations and start-up innovations

This is a challenging and exciting time for producers of metal powders. Talk of the industrialisation of Additive Manufacturing is everywhere and key pieces of the AM jigsaw such as standards, quality systems and installed production capacity are falling into place. The nature of the companies which are looking to take advantage of the anticipated feast is, however, surprisingly diverse. In this article, Alex Kingsbury and Dayton Horvarth highlight how long-established metal powder giants are adapting to AM and how agile start-ups are carving out niches in the powder marketplace.

The industrialisation of metal Additive Manufacturing is the topic on everyone's minds right now; in order to sustain or enhance the current rate of growth, we need to see the continuous manufacturing of certified AM parts. Producing metal AM parts on a continuous basis not only ensures sustainable growth, it also has a market-stabilising effect. A stable market can be a more competitive market and, where demand is met with strong competition on the supply side, there is a market opportunity for the whole supply chain.

It is interesting to review the metal powder market with respect to industrialisation and competitiveness. Metal powders exist within established Powder Metallurgy (PM) supply chains; however, given the unique requirements of AM powders, an AM-specific marketplace for powders and their resultant supply chains has evolved. Metal AM powders are currently niche and expensive products relative to PM powders; this is driven by a number of factors – primarily, the market volume is still very small. Without sufficient scale, metal powder production processes are inefficient, demand is variable and market pricing remains somewhat fluid and inflated as a result.

Increasingly, there is an emphasis on speciality atomising equipment to produce dedicated AM powders in order to meet stringent customer requirements around morphology, purity and particle size distribution. In summary, dedicated AM powder production ensures that users receive high-quality product, but means that AM technology cannot leverage the benefits of being aligned to larger and more established supply chains.

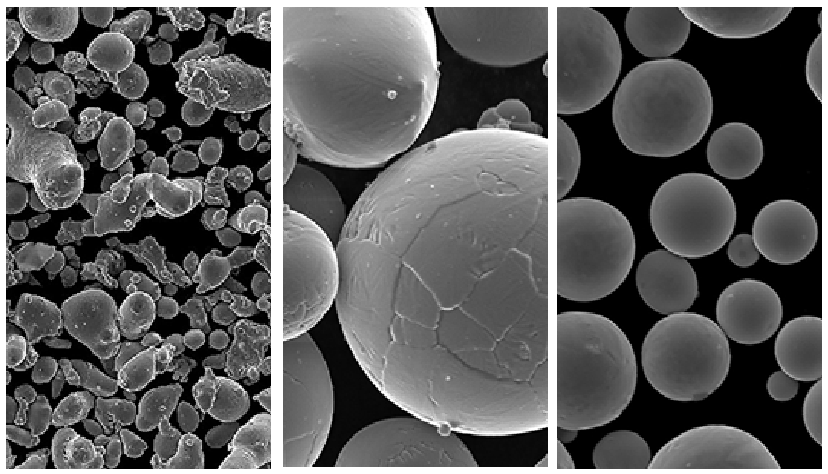


Fig. 1 The world of metal powders is diverse and there isn't necessarily a single 'right choice' of powder production process for all AM applications. These powders, from GKN Sinter Metals, are produced by water atomisation (left), conventional gas atomisation (centre) and Electrode Induction Gas Atomisation / EIGA (right). All can be succesfully used in AM when partnered with the appropriate application (Courtesy GKN Sinter Metals)

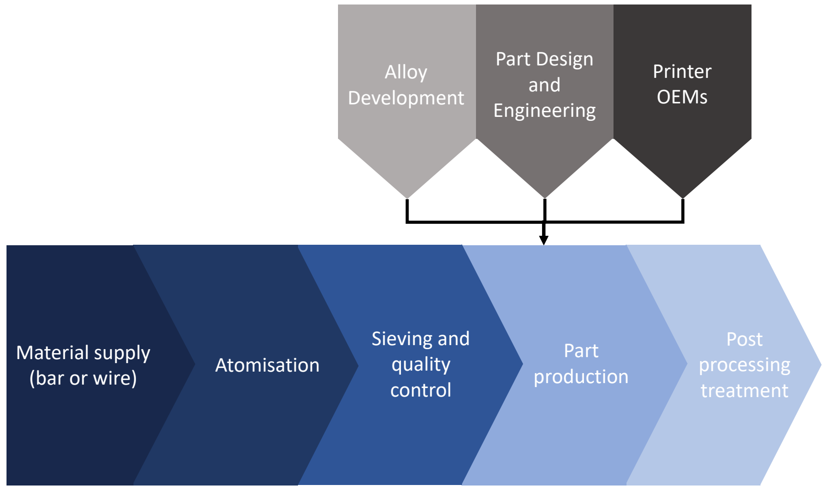


Fig. 2 The metal value chain for Additive Manufacturing

In this analysis, we take a closer look at metal powder manufacturers through the lens of investment and transactions. A select number of companies are discussed that highlight how both large players and smaller new entrants are employing different strategies to maintain competitiveness and better serve the AM market. In these relatively early phases of the metal AM market, there are still technical and market challenges that are constraining adoption. As this burgeoning industry progresses towards industrialisation, there are a number of emerging trends apparent that reveal how companies are addressing these challenges while remaining competitive and financially sustainable.

Market trends in metal powders for AM

The rapid rise in metal AM system sales has been met with a corresponding rise in the demand for AM-specific metal powders. Materials companies that were seeing moderate growth in their traditional markets are now targeting this high-growth and high-margin market. The shift has either taken the form of offering existing powder products suitable for AM to the AM market, investing in AM powder capacity, or both. Additionally, companies that were already catering to the AM market have made further significant investments in powder production capacity. With this spate of investment activity occurring, one could be forgiven for thinking that there is currently a significant unmet demand in metal powder for AM. Yet, surveying the number of certified applications currently in the public domain and accounting for many others that are not public knowledge, there seems to be a vast over-capacity for metal AM powders overall, particularly in titanium and nickel alloys.

The effect of this over-capacity is evidenced by decreasing AM powder prices observed over the past five years. Where supply outpaces demand, the market dictates that the price reduces. This reduction is positive for the industry as price reductions lead to lower part cost, and it puts significant pressure on powder manufacturers to remain competitive. As a result, larger companies are making strategic moves to increase market share, often involving the acquisition of AM-specific powder companies or broadening their existing AM portfolio capability. Overall, the trend is to increase vertical integration through internal investment or acquisition, with larger materials companies moving from being materials suppliers to total solution providers.

From powder supplier to total solution providers

Carpenter Technologies

Carpenter Technologies is an established materials provider to many industries that utilise AM and is an active example for strategic initiatives. Carpenter recently made three significant acquisitions of AM-specific companies; Puris LLC in 2017 and CalRAM and LPW Technology in 2018. A new division, Carpenter Additive, was established earlier this year to cater to this growing market.

As Ben Ferrar, Vice-President and General Manager of Carpenter Additive, explained, "The acquisition of LPW was the final piece of the puzzle in Additive Manufacturing capability. Our next step is to put all those assets and knowledge together; in doing so, we will achieve greater operational efficiencies." Indeed, the establishment of Carpenter Additive is a signal to the AM market that the company has sufficient in-depth experience in AM and is well-positioned to cater to demanding industries.

Ferrar's biggest concern is that non-quality driven suppliers are entering the market without an understanding of AM-specific requirements. The establishment of an Emerging Technology Centre in Athens, Alabama, USA, sees Carpenter deepening its understanding of end user requirements and furthering a vertical integration strategy by moving down the value chain.

Oerlikon

Another company making strategic acquisitions in metal AM is the Swiss-headquartered Oerlikon. Rather than being a strictly materials-focused company, Oerlikon has had a history of acquiring and developing technology applications. The acquisition of Sulzer Metco in 2014 established Oerlikon as a global provider of surface solutions.

With substantial R&D capability and experience with powdered metals and advanced materials, Oerlikon's move into AM was both logical and swift. Oerlikon's customer relationships from other PM markets and technology applications were successfully leveraged for this ease of access to the AM market. Additional acquisitions, such as citim GmbH, Scoperta Inc. and DiSanto Technology Inc., plus significant investments in powder production and an AM R&D and production facility in 2017 have cemented its position.

It is clear that the company has a very strategic focus on metal AM as a growth market, particularly as it divests itself of lower margin, lower growth assets. "Oerlikon sees Additive Manufacturing as the next industrial revolution. With our capabilities in powders and coatings, we saw that we could enter the AM field with an end-to-end service offering," commented Dr Sven Hicken, Head of Oerlikon's AM Business Unit. "We can take a customer's idea or vision and make that a reality. We can integrate the entire value chain for a customer, which simplifies their production significantly."

Sandvik

Swedish-based Sandvik AB began its corporate life more than 150 years ago in steel production. This materials technology business core has led to the development and evolution of new business divisions in cutting tools as well as technical solutions for the mining and construction industries. With more than forty years of accumulated experience in gas atomisation, Sandvik was an early supplier of metal powders to industries such as Metal Injection Moulding and was a key powder supplier from the earliest days of metal AM.

From 2014, Additive Manufacturing was used internally in Sandvik's Machining Solutions division, however the strength of combining both the materials and technology AM areas to better cater to external markets became obvious and, in early 2019, Sandvik integrated its metal powder business into its AM division; this now sits in the Materials Technology business unit. In an interesting twist, it was announced that the Materials Technology business unit would undergo an internal separation from the parent Sandvik Group and would prepare for a possible separate listing in Q2 2020. This was followed by the announcement that Sandvik would be acquiring a significant stake in AM service provider BEAMIT SpA.

With seeming perfect timing, just three months later Sandvik opened a new titanium powder production facility, expanding its AM powders offering to include all major alloy groups for AM. "The Additive Manufacturing sector is developing fast, and there is a need for AM-specialist-partners with the advanced skills and resources required to help industrial customers develop and launch their AM programs," says Kristian Egeberg, President of Sandvik Additive Manufacturing. "Sandvik and BEAMIT have leading capabilities across the whole AM value-chain and can enable companies to accelerate this development."

Fig. 3 A view of a Hermiga gas atomiser at the UK's PSI Ltd. Gas atomisation is currently the dominant technology for the production of metal powders for AM and a number of companies are able to supply production-ready atomisation systems that range from laboratory to industrial scale (Courtesy PSI Ltd)

Fig. 4 Plasma atomisation underway on an industrial scale at Canada's AP&C. GE acquired AP&C as part of its Arcam acquisition (Courtesy AP&C)

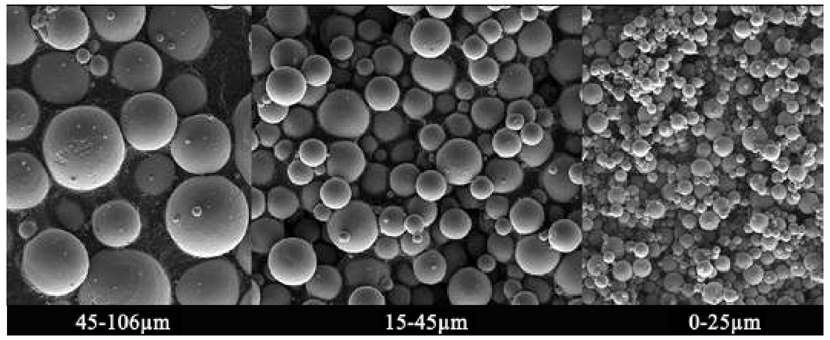


Fig. 5 Plasma atomised powders are noted for their high purity, high sphericity and minimal satellite content. As well as being used extensively in Additive Manufacturing, these powders are also finding application in Metal Injection Moulding, Hot Isostatic Pressing (HIP) and thermal spray coatings (Courtesy AP&C)

Vertical integration in every direction

Creating AM-specific divisions is an increasing trend and makes the most sense where acquisitions and investments can be streamlined under one banner. The formation of GE Additive was hardly surprising following GE's acquisition of Arcam AB and Concept Laser in 2016. The Arcam acquisition included AP&C, a manufacturer of AM-specific powders. Combining both machine sales and powder sales under one brand meant that GE Additive could stimulate market demand in machines by pricing the materials accordingly.

Another AM-specific division was formed in GKN Powder Metallurgy; GKN Additive just this year integrated its materials and components business under one brand. This unification again echoes the powder-to-product business line specific to AM that many others are adopting. However, unlike GE Additive, GKN combines materials and component manufacturing rather than materials and machines, exemplified by the company's recent acquisition of Forecast 3D.

In a separate example, one company covering all aspects of the value chain is Swedish-based Höganäs Group. Through its Digital Metal subsidiary, Höganäs is a machine OEM and service provider that leverages the company's core PM materials business expertise and powder supply further down the value chain. Continuing the trend for AM-specific metal powder atomisation, Höganäs has recently begun construction of a new atomisation plant for AM powders.

Powder production technologies

It is more than coincidence that AP&C as well as two other plasma-based powder manufacturers, Pyrogenesis and Tekna, are based in Canada. Plasma-based

technology is extremely energy intensive and Quebec is home to some of the lowest cost electricity in North America. Interestingly, both Pyrogenesis and Tekna have developed plasma-based powder production systems, initially focusing on the development of the hardware, but each has successively entered into powder production for AM. It is clear that to move further down the value chain while taking advantage of competitively-priced electricity boosts profitability.

Of all the AM powders, titanium is one of the most technically challenging materials to produce, but it also offers the most opportunity. Titanium powder production technologies only accept a bar or wire feedstock, which precludes the usual practice of remelting coarse and otherwise unsaleable size fractions. Therefore, there is room for technical innovation in titanium specifically; this explains why many suppliers of titanium powders claim to produce 'ultra-fine' or 'MIM cut' powders. These suppliers are aiming to align their available particle size distribution with AM demand to improve internal powder production economics.

Debate and research is now emerging around AM powder specification that suggests relaxing stringent requirements and instead focusing on optimal processability in a powder bed. This sentiment opens up an opportunity for alternative atomisation technologies. Edmar Allitsch, Managing Partner at AM Ventures Holding GmbH, states, "Current atomisation methods are not a good fit for AM technology. Ultimately there will be a new technology, this is one of the missing pieces we need to resolve." Many others share Allitsch's view and there are a number of new providers entering the market claiming to address the issue of yield for metal AM technologies. Some of these leverage existing technologies or are refining conventional technology further, while others are developing new production methods altogether.

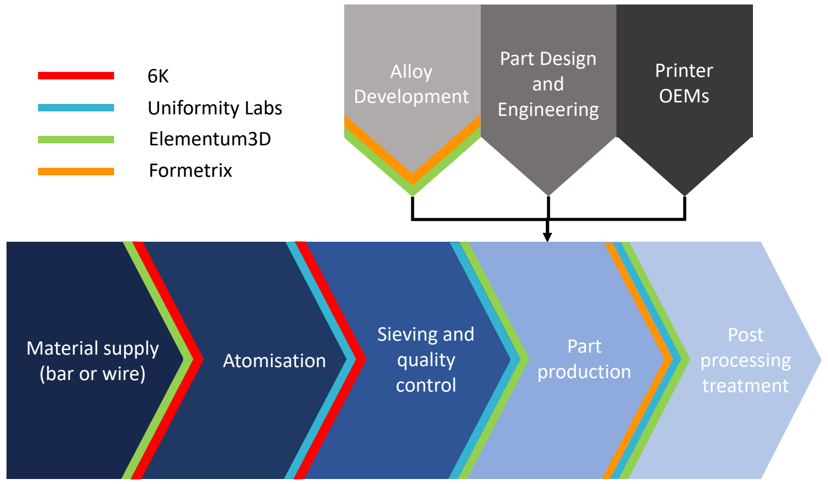


Fig. 6 The areas of the metal AM value chain that start-ups are looking to disrupt

Start-ups push the boundaries

Technology entrepreneurs may understandably be deterred from entering the metal powder market-place, given the increasingly crowded corporate landscape in materials, the technical requirements around powder specificity for AM and the lengthy qualification procedures for most additively manufactured parts. Additionally, start-up financing otherwise achieved through venture capital is averse to materials and hardware-dependent technologies due to long and capital-intensive development timelines.

Despite these factors, start-ups focused on metal powder production and alloy development are doing everything in their power to fundraise, innovate and redefine the industry status quo. It is these small groups that can efficiently drive technologies into today's niche market opportunities not worthwhile for larger companies to pursue. As a result, start-ups are better indicators than large companies for emerging technology trends and identifying tomorrow's mainstream market opportunities, when it comes to rapidly growing technology industries such as AM.

The industry's interest in materials, software and post-processing continues to increase, but metal powder start-ups still represent a portion of AM start-ups overall. High margins and comparatively low volumes may sound attractive in a recurring revenue business model, but the technical requirements and powder performance guarantees in the AM metal powder industry do not offer any encouragement to would-be founders. Each metal powder start-up interviewed has a unique value proposition and a sophisticated approach to value chain positioning (Fig. 6).

6K

6K, formerly known as Amastan Technologies, is a powder producer that has developed a microwave-based plasma process that produces the more common AM powders, such as Inconel and titanium alloys, as well as custom alloys. The company's UniMelt process does not fall under classic atomisation technologies and, as such, claims higher tap density and flowability powders without voids or satellite particles.

Aaron Bent, 6K's CEO, states that, "We can have the highest quality powder but at competitive cost with what plasma or gas atomisation suppliers offer." He also claims that the UniMelt technology sets itself apart with the ability to utilise input streams from machining by-products such

Fig. 7 6K's UniMelt® system can be deployed at the company's partner end-use locations or at sources of raw materials. The company states that a 6 m x 6 m self-contained footprint offers cost-effective deployment

as millings and turnings to produce AM powders. Bent further noted that, "We want to provide powders that give parts better integrity, while utilising feedstock derived from sustainable sources."

6K recently purchased a titanium recycling operation, in part for a consistent supply of material. In addition to the titanium alloy and Inconel product launches expected later in 2019, 6K's system can synthesise cathode and anode battery materials, which make up the company's second primary market vertical. With claims that border on powder production perfection amidst an abundance of machined scrap titanium availability, 6K believes that it can drastically improve metal powder economics in the near future.

> *"There are two fundamental problems for L-PBF and they don't include materials or material cost; the printers aren't fast enough and they require a PhD-level operator to run reliably."*

Uniformity Labs

Uniformity Labs is a California-based metal AM solutions provider that has a proprietary process for powder densification for use with new, recycled or reconditioned materials that enables its core value proposition: powders that dramatically improve metal AM parts and decrease build times. The company's algorithmically-determined powder distributions are not necessarily spherical, nor do they phase separate, while exhibiting extremely high bulk density and maintaining flowability requirements.

To address the market effectively, build parameters are developed in-house on various name-brand Laser Powder Bed Fusion (L-PBF) systems and in collaboration with various industrial and aerospace customers. The company's claims include triple the throughput on standard L-PBF systems with improved mechanical properties using their parameters and powders; initial results for sintered steel Binder Jetting parts suggest single digit shrinkage rates at 99%+ sintered density.

Adam Hopkins, CEO, views the company's near-term revenue as coming from part production and powder sales with a focus on Inconel, aluminium and steel alloys. When asked about metal AM powder economics, he remarked that, "There are two fundamental problems for L-PBF and they don't include materials or material cost; the printers aren't fast enough and they require a PhD-level operator to run reliably. You need to enable more applications on the thousands of slow L-PBF machines out there by speeding them up and facilitating printing of in-spec parts." Uniformity Labs hopes to enable a step change in machine economics as the market driver for its unique powder products and build parameters.

Elementum 3D

Whereas 6K aims to perfect spherical powders as a product and Uniformity Labs aims to improve the L-PBF process in conjunction with different powders, other start-ups are focusing on AM-processable alloy development to expand the limited options in AM. Elementum 3D is a metal alloy developer for L-PBF applications that works directly with machine manufacturers, powder manufacturers and end users to deliver better performing and unique alloy powders.

Developing new alloys on multiple name-brand L-PBF systems begins with sourcing atomised powders that are then modified physically and chemically by Elementum 3D. During AM builds, these modified powders undergo what the company calls a Reactive Additive Manufacturing (RAM) process that allows a finished ceramic-containing metal alloy to form. The company's powders notably increase printer throughput and offer matched or improved combinations of mechanical properties when compared with available AM alloys.

The leading products available are 2, 6 and 7-series aluminium alloy analogues containing 2% or less ceramic, with nickel superalloys and certain tool steels expected in the near future. When asked about specific alloy growth for metal powders in AM, Jacob Nuechterlein, CEO and Founder of Elementum 3D, sees a major opportunity for aluminium alloys in replacement parts, especially since the company's 6-series aluminium builds parts twice as fast as the more commonly available aluminium-silicon-magnesium AM alloys. Through materials development and custom build parameters, Elementum 3D's powder products help users match traditionally manufactured aluminium specifications with an added economic incentive. If this formula can be replicated in other materials, L-PBF's applicability expands in breadth of applications while increasing powder demand and reducing built part costs.

Formetrix

While Elementum 3D's initial focus is on high-strength aluminium, a Massachusetts-based start-up called Formetrix is focusing on AM tool steel development using multiple L-PBF printer brands. Harald Lemke, Chief Commercial Officer at Formetrix, described the company as downstream from the powder manufacturers, but leveraging contract manufacturing capacity in order to supply the company's higher performance tool steel powders.

He noted that L-PBF has not had any traditional tool steels that can be readily additively manufactured, leaving users with alloys such as M300 maraging steel. With tooling as the logical middle ground between prototyping and production applications, Formetrix has developed AM tool steel powders and formulated build parameters to deliver performance in applications such as automotive tooling.

The company's first material, L-40®, is being used for aluminium die cast and hot forming tooling as well as compression dies. Near-term value for the company will stem from delivering performance powders that match or exceed traditional tooling grades in applications that already benefit from L-PBF design freedom and turnaround times.

Start-up investment

Collectively, the four metal powder start-ups discussed here have raised more than $64 million in equity capital from institutional and private investors since 2015. There is no set formula for successfully raising start-up funding; however, summarising the value propositions for these four companies does illustrate certain similarities. Improved part performance is present in all four, while reduced build times and, by association, lower part costs are represented in three of them. All four companies

| contents | news | events | advertisers | website | e-newsletter | The evolving metal powder marketplace

leverage existing atomisation capacity or materials sources and focus on materials, process and/or application development. Each company's value proposition is intended to establish and increase demand for its metal powders in pursuit of stable and long-term recurring revenue.

"One thing is certain, all companies supplying to the metal AM market accept that success is a function of perseverance, commitment to quality and persistent innovation."

Even if the scaling economics do not compare with software technologies, recent strategic acquisitions by corporates such as Carpenter, GE and Oerlikon have not gone unnoticed by informed investors. Expect significantly more funding to follow these companies, as they grow and scale production capacity and product lines and continue to expand into new applications and industries.

New technologies, traditional materials

Many of the latest OEM entrants in the metal AM market are looking to ease the high level of materials specification faced by the industry, enabling lower cost material from existing supply chains to be utilised in their systems. Larry Lyons, Desktop Metal's VP of Product, agrees. "It's harder and slower to go down the cost curve when you are trying to establish a new technology with a small market. This limits adoption and industrialisation," he explained. "Tapping into the press and sinter and MIM supply chains was our approach for this reason."

For HP Inc., material choices are driven by risk-reduction as well as cost-reduction. Tim Weber, Global Head 3D Metals for HP, states, "So far we have been working with readily available MIM cuts. We encourage people to stick with something off the shelf; not only do you have the powder, you also have the sintering recipe."

While working within existing supply chains will reduce cost-per-part, the industrial offerings from both Desktop Metal and HP are not yet widely available. As a result, their implications for the materials supply chain are yet to be observed. With maturity, these new systems will necessarily dictate their own design rules and protocols; powder specification naturally flows from that process. So while leveraging existing supply chains is a sensible approach to reducing materials price and therefore part cost, increasing powder specificity may drive the prices of even standard PM materials up. It is too early to tell where the powder price equilibrium will settle for Binder Jetting technologies.

Where's it all going?

In the materials landscape, we are seeing many companies, both large and small, orient and organise around Additive Manufacturing technology. There is strong optimism and confidence in the growth potential of the metal AM market. Financing is flowing to support internal investments, acquisitions and early stage companies.

This support comes despite a comparatively small volume of production parts and against a backdrop of decreasing powder prices. As a result, the focus for all companies is on refining their competitive advantage. For larger companies, increased competitiveness is achieved through vertical integration and leveraging market power, whereas, for smaller companies, this means honing a value proposition that favours lower part cost without compromising quality.

With the machine OEM technology landscape moving quickly, materials producers, both large and small, must be agile in capturing new opportunities. New entrants in Binder Jetting technology are changing the powder requirements for metal AM parts, which is changing the conversations materials suppliers are having with customers.

One thing is certain, all companies supplying to the metal AM market accept that success is a function of perseverance, commitment to quality and persistent innovation. Investments are being made not based on hype, but on the conviction that the metal AM market has a long-term growth prospect and that now is the time to start positioning for that growth.

Futurist Roy Amara aptly summarises this sentiment when he says, "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run." While market volumes may be small now, continuing innovation in all aspects of the value chain and increased competition are driving down costs and setting the stage for new market opportunities across all industries.

Authors

Alex Kingsbury
alex.kingsbury@rmit.edu.au
www.rmit.edu.au

Dayton T Horvath
horvath@newcap.com
www.newcap.com
www.additiveexecutive.com

Alloys by Design: The future of materials for Additive Manufacturing

There is no shortage of Additive Manufacturing machines humming away in research laboratories, producing test pieces and exhibits for trade shows, but the hard truth is that relatively few are making components for serial production. In part, this is because the world is still waiting for materials which enable the technology to fulfil its true potential. In this article, Rebecca Gingell and colleagues from OxMet Technologies, Oxford, UK, explain how the company is approaching the design of novel alloys for AM, and reflect on its progress so far.

For five thousand years, whenever a new manufacturing method was invented, new alloys were never far behind. The techniques used to develop these alloys have evolved from the enthusiastic addition of arsenic to copper to make bronze, to the use of super-precise probes to assess atom distribution in modern alloys. Ultimately, however, the performance of components has been highest when they're made from alloys which have been tailored to the specific demands of the manufacturing process by which they are made. Additive Manufacturing is not likely to be any different.

While developers are having some success using legacy alloys in Powder Bed Fusion (PBF) and wire-based AM, the performance of AM components can be lower than cast or forged parts when produced from the same alloys, and many high-performing alloys are not amenable to the repeated melting entailed by most AM processes. A new generation of alloys is required; not just to overcome these challenges, but also to take advantage of the new alloy design opportunities afforded by AM technology.

OxMet, based in Oxfordshire, UK, is the developer and operator of a proprietary computational platform for the design and optimisation of new alloys. The company is currently commercialising a new series of nickel alloys, the ABD®-XAM series, which has been designed from a clean sheet for the specific demands of AM.

The range promises a combination of performance and AM processability unlikely to be matched simply by empirical modification of existing alloys. This article provides an overview of the ABD platform and how it can be applied to the development of alloys for AM, and reports on some of the results achieved to date.

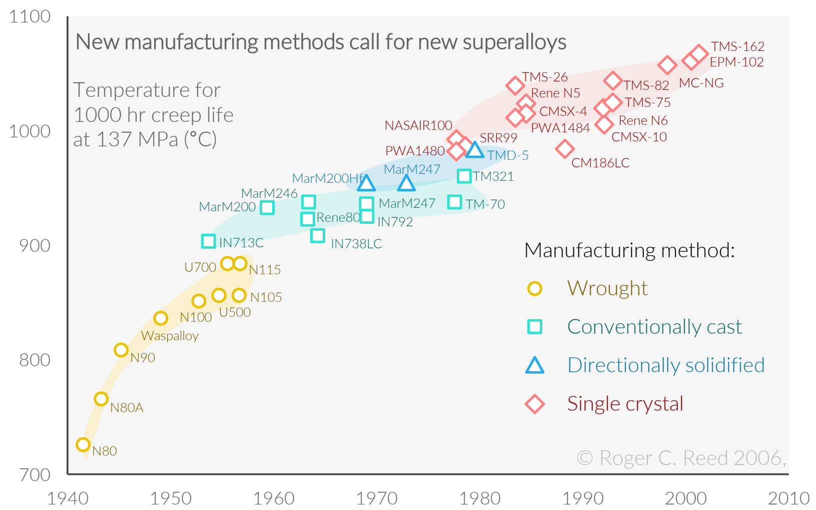


Fig. 1 As new methods of manufacturing superalloys emerge, new alloys are developed to take advantage of the new process

New alloys: A numbers game

Advanced manufacturers of alloys are generally able to control the proportions of elements in alloy compositions to an accuracy of 0.1%. Even small changes in the concentrations of different elements can lead non-linearly to large changes in behaviour and performance. Hence, the number of distinct alloys which could be made from a 10-element nickel superalloy, for example, could be as high as 10^{20}. Even for a comparatively simple alloy system, such as a ternary titanium alloy, there could be as many as 250,000 compositions exhibiting significant differences.

The size of these numbers, and the complex interaction between composition and process which determines alloy performance, has historically made alloy design difficult to approach analytically and computationally. The improvements of the past seventy years have therefore largely come about through increasingly well-informed empiricism: designers take a familiar alloy, modify the composition using insights from research and their own experience, and test samples to see if their efforts have been successful.

The relatively high cost of this approach has been a factor for conservatism, particularly in industries producing large or safety-critical parts – shortcomings which don't manifest themselves until a late stage of qualification in a large component can cost millions in waste.

In recent years, however, two key developments have occurred: physical models for predicting composition-dependent properties have improved, and computing horsepower has increased significantly. These changes have rendered the alloy design process more and more tractable by analytical approaches. The Oxford University research group led by Professor Roger Reed, from which OxMet Technologies emerged, has been one of the leaders in the growing field of computational alloy design.

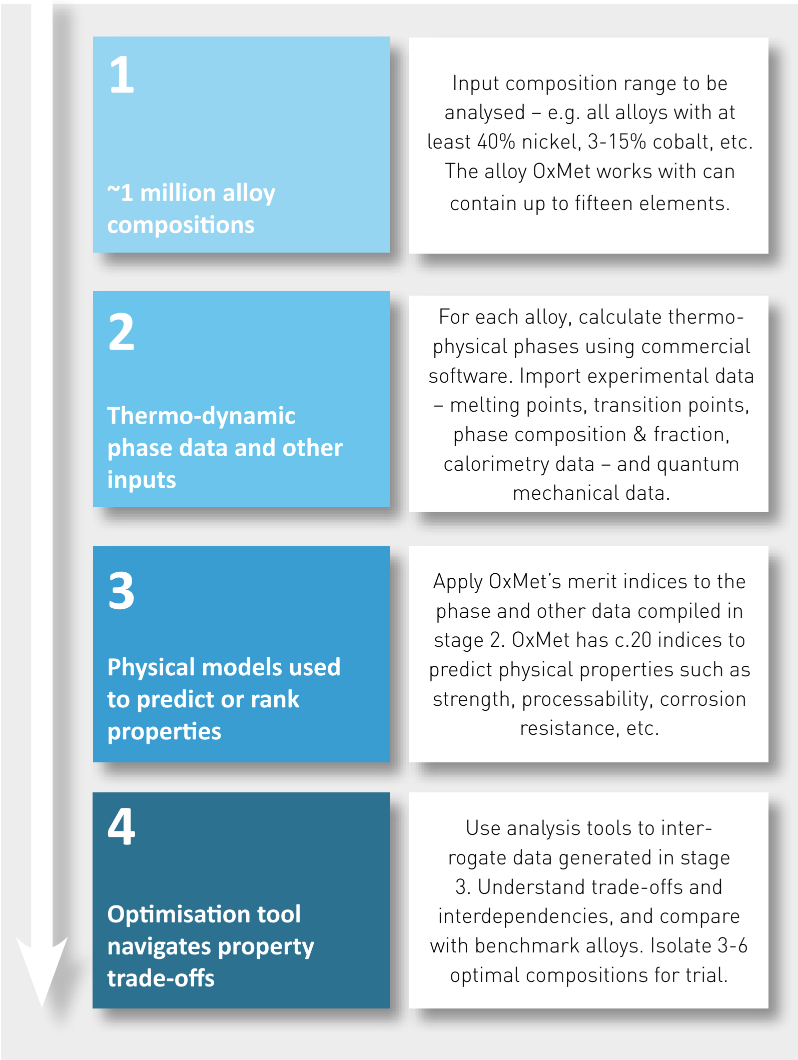


Fig. 2 Structure of OxMet's ABD platform (Courtesy OxMet)

OxMet's Alloys by Design platform

OxMet's ABD software platform is an optimisation tool for identifying new alloy compositions. It uses physical – and in some cases physical-empirical – models to analyse and rank millions of different alloys simultaneously on a range of economic and performance metrics. This enables the optimal alloy for the specific needs of a given application to be rapidly identified (Figs. 2-3).

The alloy design process begins with a consideration of the trade-offs in properties associated with the demands of a particular component, and a statement of which performance metrics are 'target metrics' – normally strength, creep resistance, or other metrics where one can never have too much performance. Then there are metrics which are 'threshold metrics': threshold metrics often include a ceiling elemental cost, and another common example is the lower limit for elongation common to alloy design projects for the automotive industry.

Secondly, on the basis of experience, Oxmet defines a wide alloy space – the palette of allowable major and minor elements for the target alloy, and upper and lower bounds for each element, with zero being the lower limit for elements for which inclusion is optional. OxMet then uses the ABD software platform to model the performance of all possible alloys within that space on the metrics deemed relevant in the scoping exercise, at user-determined intervals for the proportion of each element in the composition space (for reasons of computational economy, OxMet often scans a large space at a relatively coarse resolution, such as 0.25%, before zooming in on an attractive space for finer-grained evaluation at intervals of 0.1%).

The accuracy of the platform is evolving and varies between performance metrics, and some iteration is still occasionally required. But overall, it reduces the time taken to arrive at a new composition from many months, or sometimes years, to a few weeks. After the computational stage, OxMet will produce three or four compositions for testing, with the best of these often adopted as the final alloy.

The platform has further salient advantages, for example for highly multi-dimensional optimisation problems in which developers seek improvement on one or two performance criteria, but require that the alloy is adequate on a large number of others. As an example, developers of nickel alloys for turbine blades may seek improved high-load, high-temperature creep resistance, but also set thresholds for corrosion resistance, oxidation and fatigue.

The ABD platform allows 'global' optimisation from a clean sheet. Empirical approaches tend to favour local optimisation starting from a known alloy, whereas the ABD platform allows exploration of an almost limitless alloy space. This is particularly important when developing alloys for completely new manufacturing platforms.

Finally, and of great relevance for investors in materials development, the platform is very helpful in filing strong, broad, commercially valuable patents over compositions, because of the power it provides to discover and rationalise the boundaries of the 'compositional windows' within which promising alloys are likely to be found.

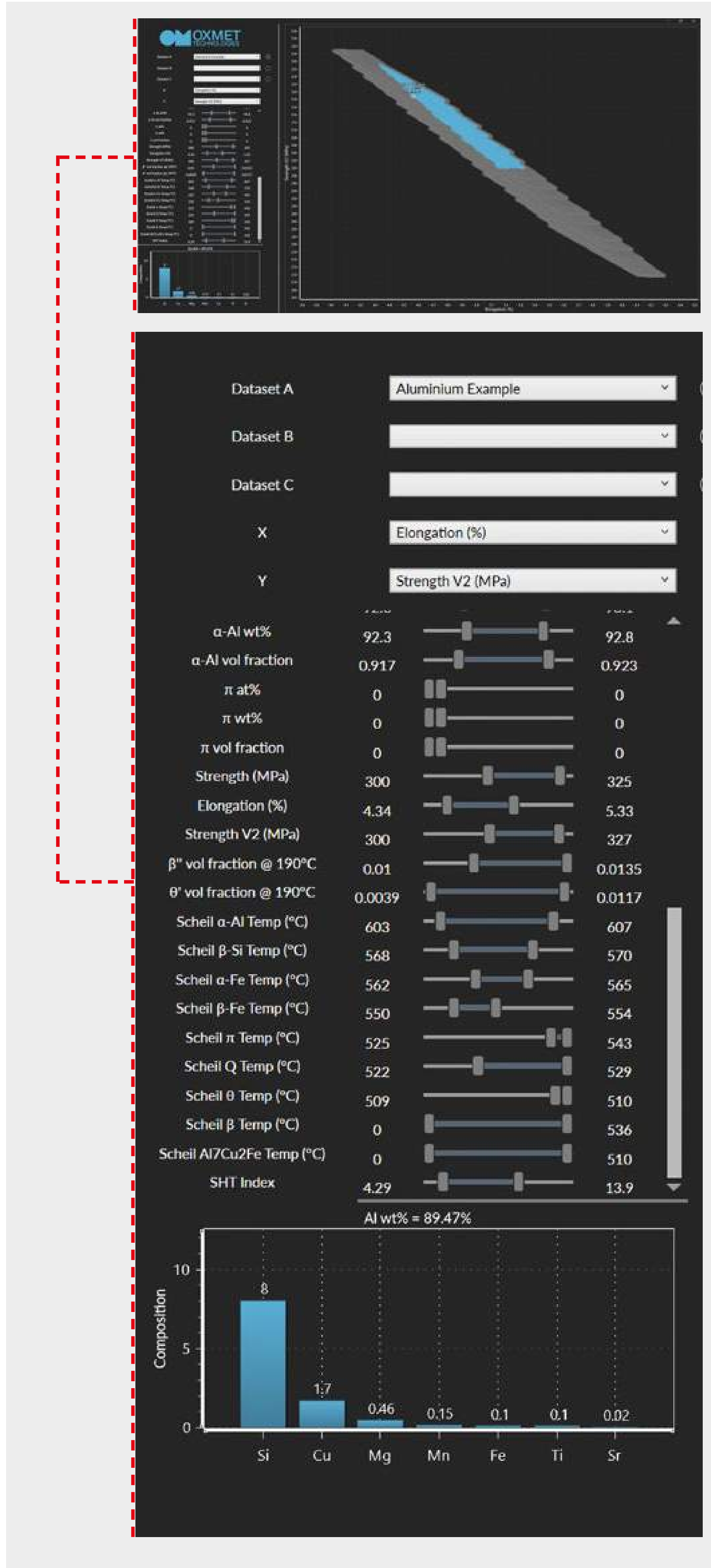


Fig. 3 OxMet's ABD software platform (Courtesy OxMet)

| contents | news | events | advertisers | website | e-newsletter |
OxMet Technologies : Alloys by Design

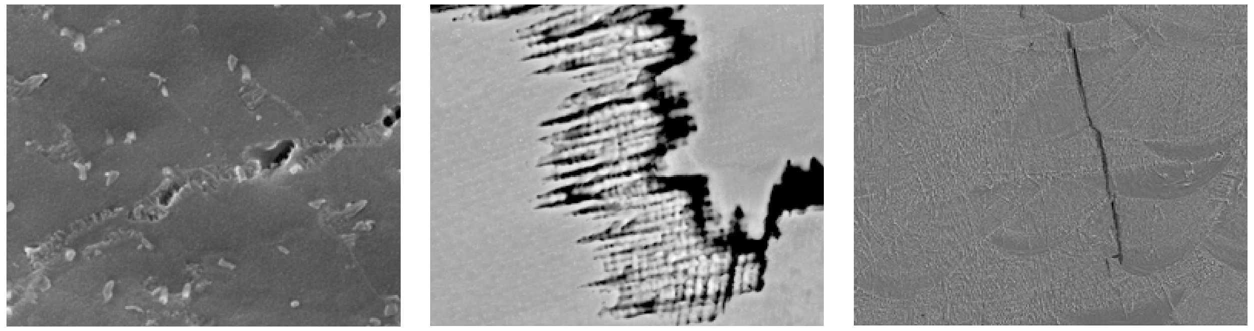


Fig. 4 Cracking mechanisms in AM nickel alloys: left and centre, liquidation / solidification cracking; right, strain age cracking (Courtesy OxMet)

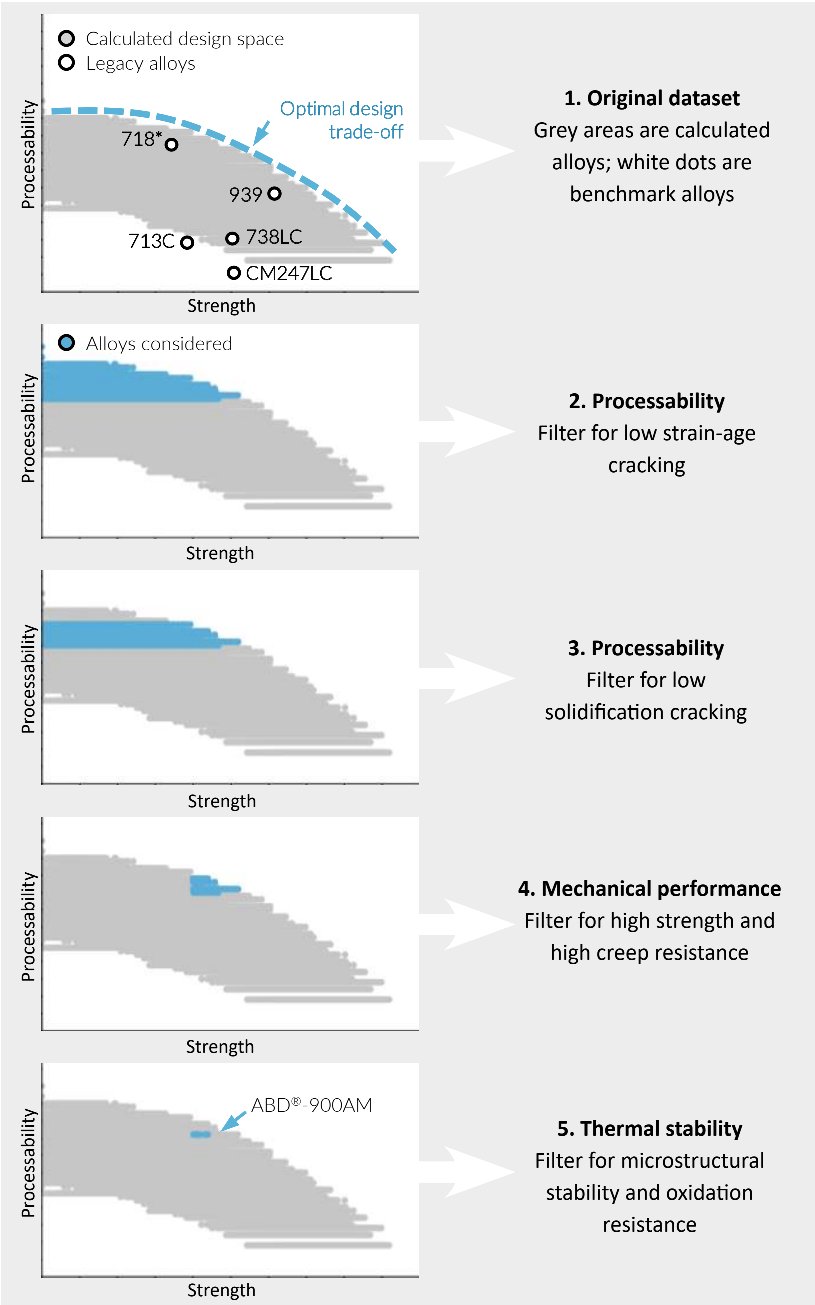


Fig. 5 OxMet uses its ABD® platform to predict the processability and strength of millions of alloy compositions, and then filter to identify the optimal trade off (Courtesy OxMet)

Using the ABD platform to design alloys specifically for AM

Alloys optimised for traditional manufacturing processes tend to underperform when used in AM. The precise limitations vary metal to metal; in titanium alloys, columnar growth and anisotropy are problems, while in aluminium alloys, solidification behaviour creates cracks, and in nickel alloys, unstable phases limit performance at high temperatures.

To apply the ABD platform, OxMet has to build physical models which predict an alloy's susceptibility to the relevant problems. These models can be incorporated in an optimisation exercise in which these susceptibilities can be avoided, while designing for strength, creep resistance, or other performance criteria.

Designing high-performance nickel alloys for AM

The particular challenge of high-performance nickel alloys is that the primary mechanism by which they have historically been made resistant to creep – the introduction of high levels of γ' phase – leads to cracking of various forms (see Fig. 4).

OxMet has built models for susceptibility to each of these mechanisms of crack formation, and has used these models and its model for strength in superalloys to explore an extremely wide alloy space (Fig. 5). This enabled OxMet to identify completely new compositions with a significantly lower propensity to crack during Additive

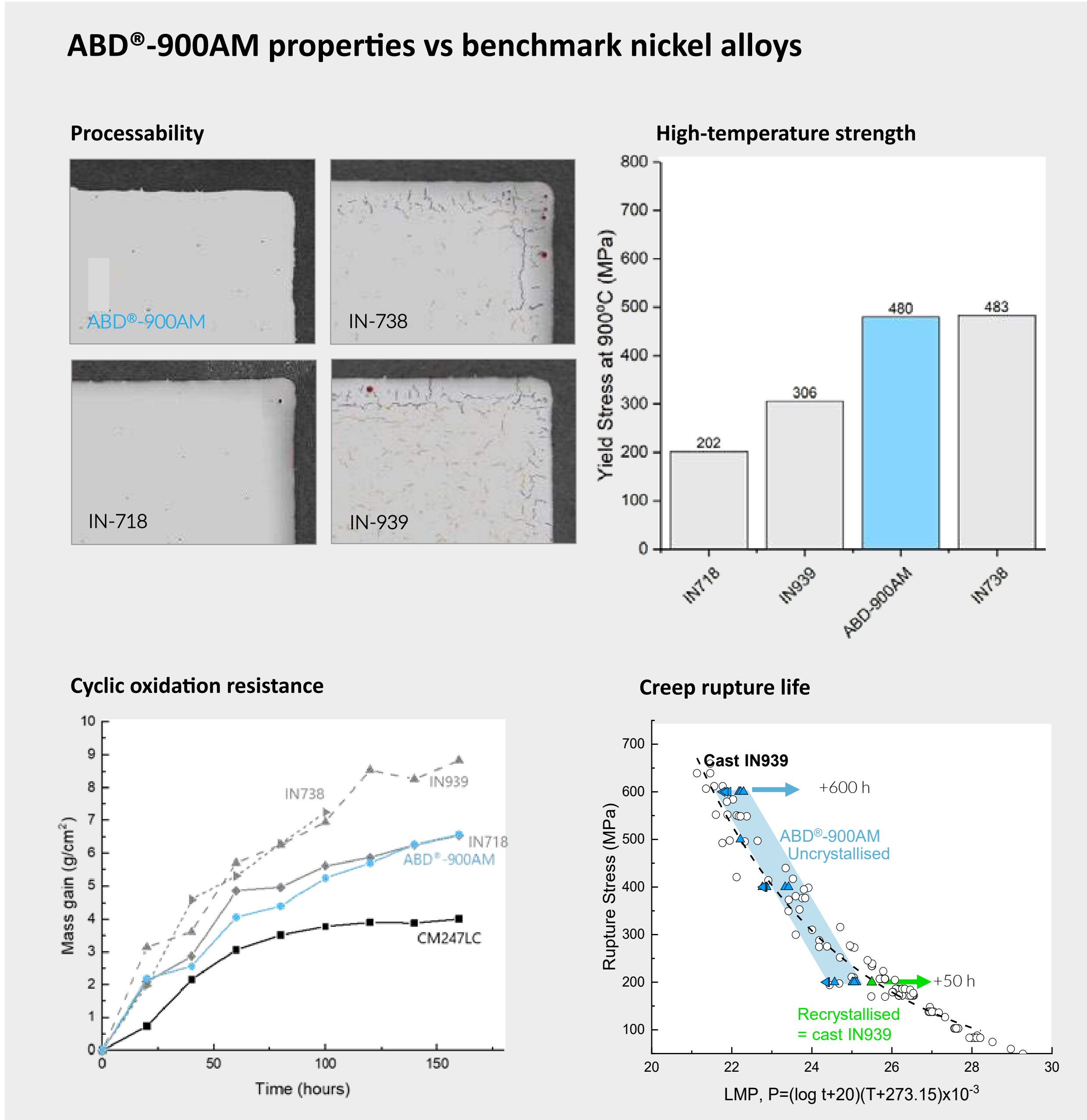


Fig. 6 The above charts and images indicate the ease with which ABD-900AM, in comparison to benchmark nickel alloys, can be processed by AM without compromising high temperature mechanical performance (Courtesy OxMet)

Manufacturing and post-processing than existing γ'-strengthened alloys, but which retain very high levels of strength and creep resistance at elevated temperatures.

Multi-optimisation strength models

A key tactic in achieving optimal results has been using all the levers available to improve mechanical performance, rather than rely only on those which have been used traditionally. For example, while increased fractions of γ' precipitate have been the traditional means of strengthening nickel alloys, the strength model used by the ABD platform shows there is another lever available: that of increasing the anti-phase boundary energy.

OxMet's ABD-850AM and ABD-900AM chromia-forming alloys – in as-built form at least – contain higher anti-phase boundary (APB) energies and lower γ' content than cast alloys designed to operate at similar temperatures. Following the build, the γ' content is raised through heat treatment if required.

Processability

The charts and images in Fig. 6 indicate the ease with which ABD-900AM can be processed by AM, by comparing crack length and densities between it and various commonly used high-performance nickel alloys. These include IN-718, which is known

Fig. 7 A turbomachinery part made with ABD-900AM. Produced by HiETA for Safran Power Units as part of the Materials and Components for Missiles Innovation and Technology Partnership (MCM ITP) programme (Courtesy Safran Power Units)

to be relatively easy to process by AM, and the more difficult-to-process IN939, IN738, and (not shown) M247. ABD-900AM shows similar levels of high-temperature strength and creep resistance as IN738.

Versatility

Interestingly, OxMet has tested processability by PBF with both the 30 µm normally used for the AM of high-performance nickel alloys, and 60 µm layers, and found that, with test pieces at least, fully dense parts can be made from ABD-900AM with 60 µm layers. This could have significance for the cost at which components can be made in serial production.

The ABD-XAM range was developed at Renishaw using a 400AM. However, it has successfully been used on multiple systems with similarly defect-free results, using IN718 process parameters.

Orthopaedic-specific alloys for bone implants

2007 saw the death of Monsieur Mangetout, the Frenchman who consumed a Cessna 150 in 1978. Whilst it is unlikely that this feat prolonged his life, he would certainly have met his iron quota in that year. Unfortunately, Monsieur Mangetout would also have consumed a large amount of vanadium, which happens to be poisonous.

Vanadium is an element in the most common titanium alloy for aerospace, the high-strength, high-stiffness Ti-6Al-4V (Ti64). Despite this toxicity, Ti64 is also the most common alloy for orthopaedic implants – not ideal for a component designed to last for decades. Ti64's mechanical properties are also sub-optimal. The high stiffness of parts produced in this material, so useful in the Cessna 150, causes stress shielding in bone (Fig. 8), leading to bone resorption and implant loosening. This 'macro' stiffness can be countered using mesh structures with high elasticity – but at a micro scale, osteoblasts still find it difficult to grow on the stiff, immobile struts. Finally, Ti64 is anisotropic, yielding varying properties depending on build direction.

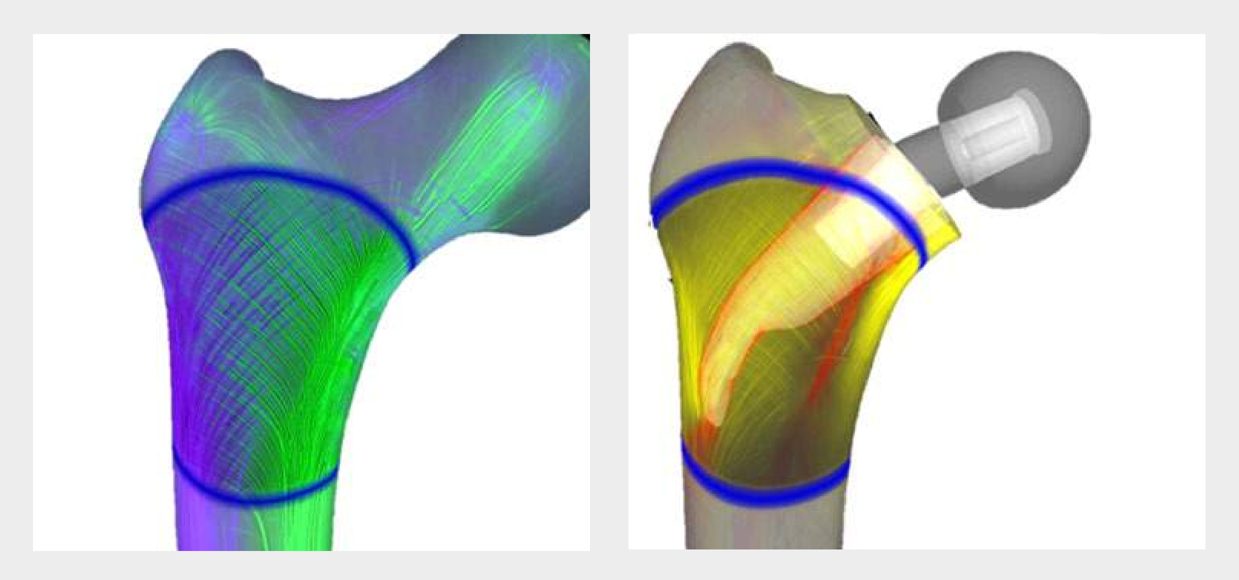


Fig. 8 Stress in a healthy bone (left) and unstressed bone with a Ti-64 implant (right) (Courtesy OxMet)

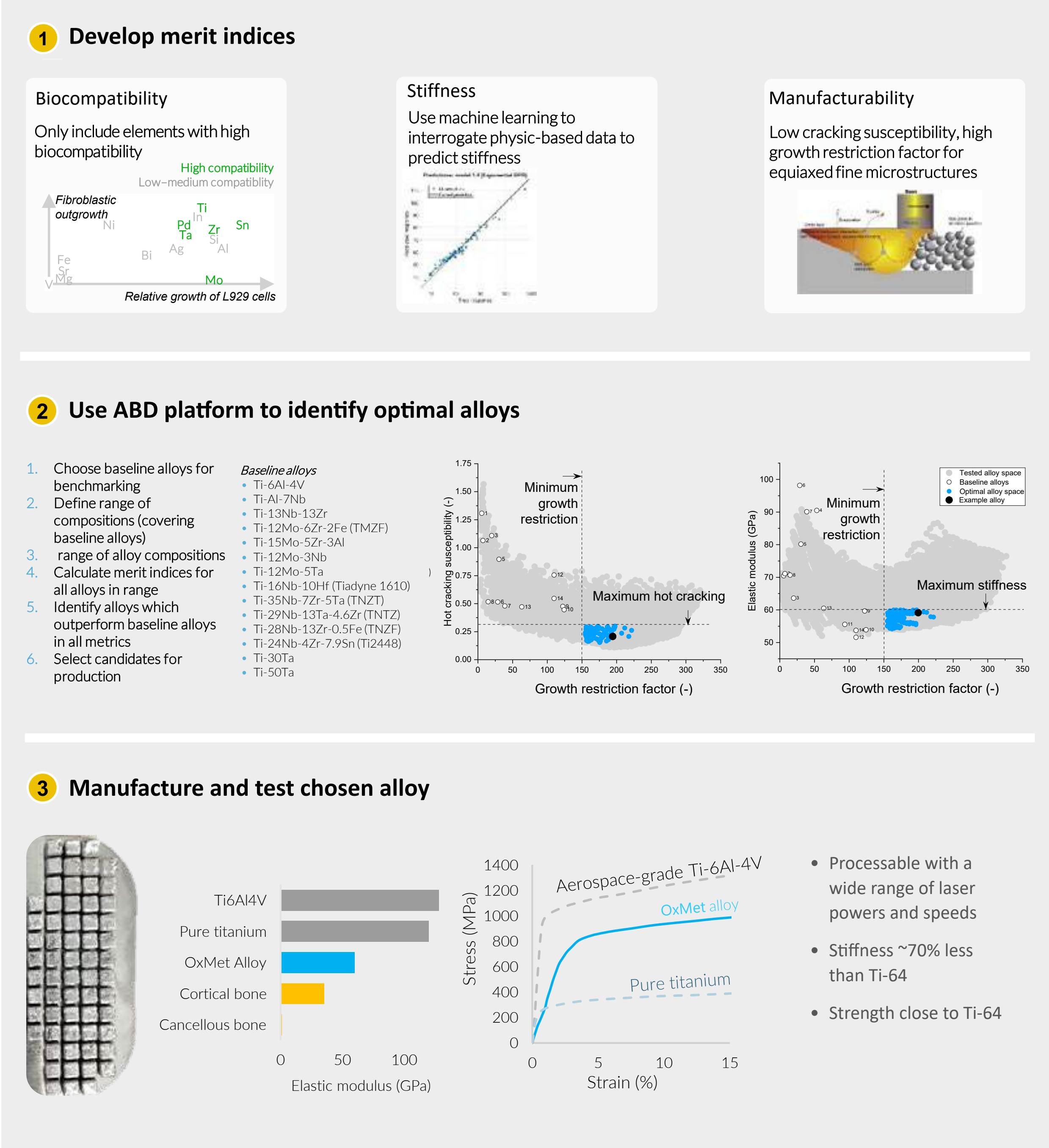


Fig. 9 Workflow for the development, testing and manufacturing of a new custom alloy for medical implants (Courtesy OxMet)

OxMet set out to design a titanium alloy with no cytotoxic elements, with a third of the stiffness of Ti64, and with enough strength to hold up a person. If the alloy could be isotropic with a wide processing window, so much the better. Fig. 9 shows the workflow for the development, testing and manufacturing of a new custom alloy for this type of application.

Introducing and commercialising new alloys

OxMet has two commercial models for its alloy development activities: licensing alloys it has developed itself and providing bespoke alloy development services to customers. It has recently licensed its ABD-XAM series of nickel alloys to Aubert & Duval, and the companies are working together to sample and promote powders under Aubert & Duval's Pearl®Micro brand.

As a would-be licensor of new alloys, OxMet needs to show a strong appreciation of the pathway new alloys need to take to market. Some parts of the alloy market are highly conservative, and have significant barriers even to trial new alloys.

The typical introduction pathway for new alloys

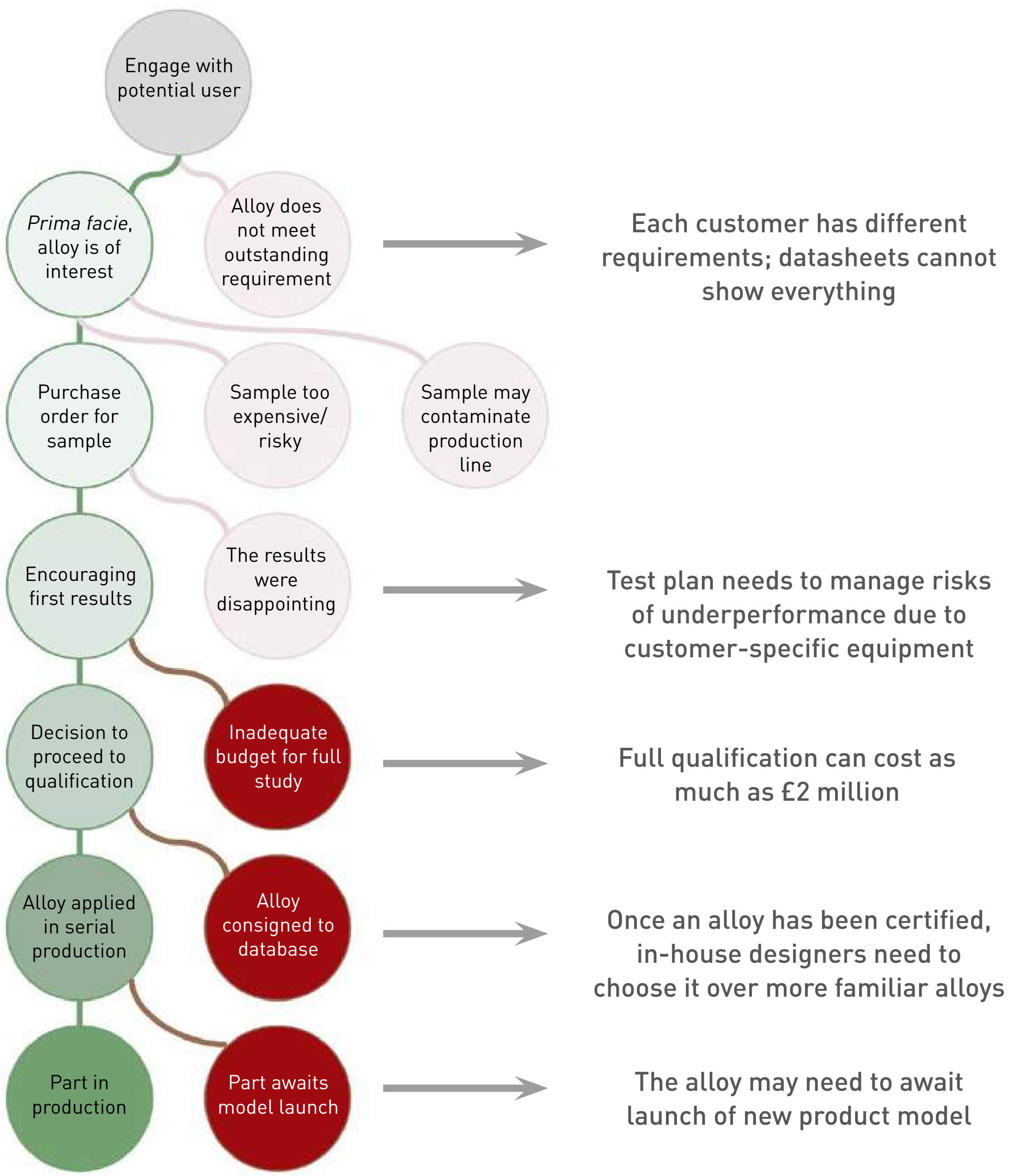


Fig. 10 The typical introduction pathway for new alloys (Courtesy OxMet)

Fortunately, the Additive Manufacturing industry is at an early stage of development when companies are more open to trying new alloys. The fact that the minimum volumes of alloy required to conduct a meaningful test are so much lower for AM than for many manufacturing processes also helps. Equally, the clear limitations of existing alloys are forcing a degree of adventurousness in alloy selection.

However, AM does bring some challenges of its own. AM production cells vary significantly, so that an alloy that can be built well on one machine may perform poorly on another. OxMet gets around this by designing compositions with wide processing windows. There is also large diversity in customer knowledge of AM and confidence with new materials.

Designers of AM components don't replicate traditionally-made parts; they take advantage of the design freedom afforded by the process. But many designers still specify the previously-used alloy, even though its properties after

AM can be radically different. While no company's new alloy introduction process is the same, the flowchart in Fig. 10 shows the typical introduction cycle for a new alloy, along with some of the pitfalls along the path at which an alloy can fall off a development schedule.

The future of materials for AM – bespoke alloys or all-purpose solutions?

A much-debated question in the OxMet kitchen is whether the future of Additive Manufacturing will be characterised by a few 'workhorse' alloys which will be put to multiple uses, or a plethora of different alloys, each matched to a small number of applications, or even a single application.

Those on the 'workhorse' side of the argument are led by Dr David Crudden, a veteran of extended aerospace alloy qualification campaigns and Head of Alloy Development at OxMet. This argument points to the high costs of qualifying new alloys in many of the industries where AM is of greatest interest, and the economies of scale which derive from material recycling, manufacture at scale, and a high level of competition between alloy producers.

Those who argue that the future is built in bespoke alloys, led by Dr André Németh, OxMet's Programme Director and a member of the founding team, argue that the principal virtues of AM are precise customisation and ever-denser functionality, and that there is no reason why AM alloys should be any different. They also note that raw materials account for a much lower proportion of total product cost than for traditionally manufactured parts, and that the atomisation by which the powder feedstock for most AM processes is created is in any case a relatively small-batch process.

Perhaps the conclusion is that different markets will find different answers; for some, qualification costs will continue to be a conclusive factor preventing alloy palette consolidation for some years to come, until opportunities for digital qualification start to bring down the costs of introducing new alloys. In other markets where barriers to new alloys are lower, such as in electronics, a wide range of alloys is indeed likely to develop, and intelligent master alloy and alloy customisation strategies will still allow high levels of recycled alloy use.

Contact

Rebecca Gingell
+44 1865 954 258
rebecca.gingell@oxmet-technologies.com
Unit 15, Oxford Industrial Park
OX5 1QU, UK

www.oxmet-technologies.com

Trumpf: Overcoming barriers to the adoption of Additive Manufacturing in the aerospace sector

Additive Manufacturing is arguably the ideal production method for numerous aerospace applications, particularly where lightweighting and part consolidation are concerns – yet no other industry takes such a cautious approach to embracing new manufacturing methods and imposes so many hurdles on the path to certification. In this article, Germany's Trumpf GmbH + Co. KG tracks the production journey of one part for Spain's Ramem S.A., as well as looking at further cases from the aerospace industry.

Safety is the highest priority in the aerospace industry. That's why it takes such a long time for new manufacturing methods to reach the shop floor, even though companies are constantly searching for new ways to cut high material costs and reduce component weight. The industry's cautious approach to fully embracing the promise of Additive Manufacturing therefore comes as little surprise – and only the most tenacious efforts to drive its adoption are likely to be successful.

Headquartered in Ditzingen, Germany, Trumpf enjoys a trusted reputation in the aerospace industry. As a leading producer of machine tools and lasers for industrial manufacturing, the company produces a number of Additive Manufacturing systems, including machines based on Laser Powder Bed Fusion (L-PBF) technology, which the company refers to as Laser Metal Fusion (LMF), ranging from the compact TruPrint 1000 to the larger scale TruPrint 5000. Also available is Laser Metal Deposition (LMD) technology, which can be applied with the machines TruLaser Cell 3000 and TruLaser Cell 7040. In providing both L-PBF and LMD technology from one source, Trumpf is able to offer its customers suitable technologies for a wide range of applications in the aerospace industry. In addition to its machines, the company provides a complete solution comprising digitalisation and servicing.

Fig. 1 Trumpf's TruPrint 1000 L-PBF machine

Aerospace case study: rakes

Spanish supplier Ramem S.A. specialises in the design and manufacture of mechanical and electromechanical devices. Headquartered in Madrid, it produces a wide variety of parts, including aerospace components with complex geometries and sophisticated technical requirements.

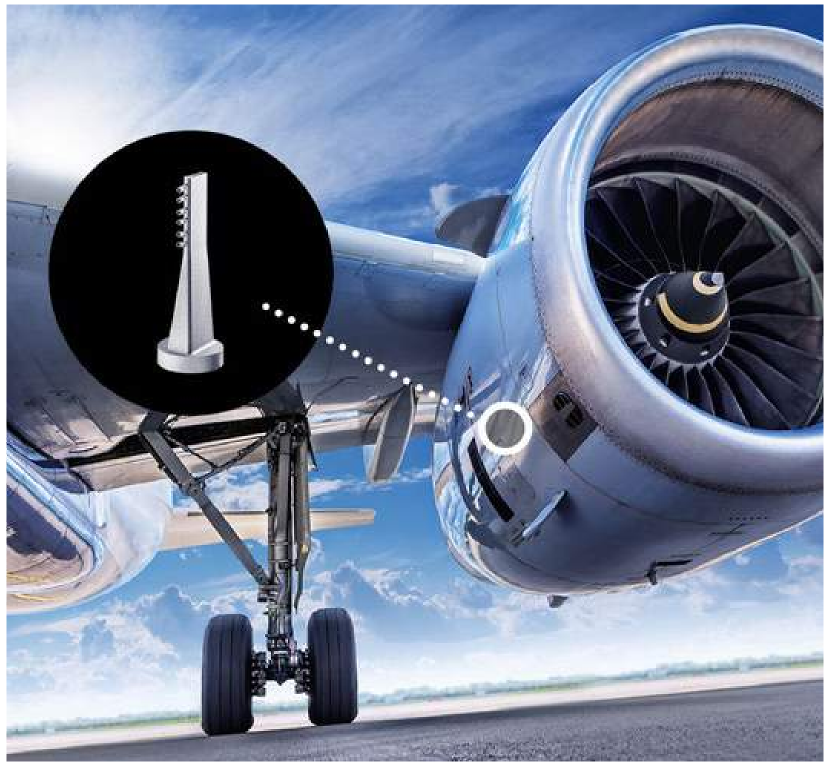


Fig. 2 Mounted directly in the path of the engine's air flow, rakes must be made to very high standards in order to withstand the extreme temperatures and tensile and compressive loads they are exposed to

As Silvia López-Vidal, the company's R&D Manager, explains, "We do a lot of high-mix, low-volume work in this field, which is why we have long been interested in Additive Manufacturing. When it comes to reducing weight, cutting down the number of subassemblies and slashing costs, AM offers far more potential than conventional methods."

Ramem is interested not only in the opportunities offered by AM, but also in the strategic benefits it brings. "AM will eventually make the leap into industrial-scale production in the aerospace sector, too. So we're making sure we're prepared for that moment by building up the necessary expertise in advance."

Ramem's engineers always have AM in the back of their minds, and constantly analyse the parts they produce to determine whether AM could add value to the manufacturing process. A rake is one example of a part that offers particular promise for transitioning to AM. Rakes are used in engine development to take the high-precision temperature and pressure readings which help engineers assess engine performance. Mounted directly in the path of the engine's air flow, these parts must be made to very high standards in order to withstand the extreme temperatures and tensile and compressive loads they are exposed to. A rake, therefore, is a highly complex part that must conform to precise dimensional requirements and feature a smooth, aerodynamic surface in order to deliver accurate measurements; a textbook example of a part which might be better produced by metal AM.

Rakes consist of four components that must be painstakingly milled, assembled manually and then welded individually. At their core are several internal tubes that serve as channels, with a wall thickness of < 0.3 mm. These channels are inserted into the rear of the elongated body of the rake and welded into place on the Kiel heads. The body of the rake is then sealed with a cover plate. "Those delicate channels must be inserted with maximum precision," explains López. "If just one of the welded Kiel heads is out of position, the whole rake has to be scrapped. The Kiel heads have dimensional tolerances of +/- 0.05 mm and feature a narrow, continuous opening, at the end of which the flow sensors are integrated."

Ramem's engineers immediately saw that the delicate rakes were perfect candidates for Additive Manufacturing. The challenge, of course, was to design them in a way that would be compatible with AM. This task was tackled by Prodintec, an RTO that specialises in redesigning parts for Additive Manufacturing. Prodintec succeeded in reducing the number of components from four to one. Yet the results of the first trial builds were disappointing, says López-Vidal. "The rakes were deformed during production, and the printing process deposited powder and other solids in the narrow channels. What's more, the Additive Manufacturing process wasn't meeting requirements – neither for dimensional accuracy nor for a smooth, pore-free rake surface."

López-Vidal and her team were not discouraged by this setback. At Formnext 2017, they visited Trumpf's booth and explained the problems they were facing to Julia Moll, Project Manager Additive Manufacturing, and her team. "The Trumpf developers were confident they could solve our problems with their lasers and powder," recalls López-Vidal. Using the CAD drawing from Prodintec as a starting point, the Trumpf team set out to find a solution. "The biggest challenge in the printing process was the issue of part orientation," explains Moll. "We had to align the part in such a way that we could print it without support structures, because we wouldn't have been able to attach those to the highly fragile Kiel heads or anywhere inside the part. We also had to rule out any risk of thermal distortion. That wasn't easy because the rakes are on one hand very thin-walled but also massive in volume on the upper part."

A TruPrint 1000 was used to additively manufacture the parts. This machine offers a build volume

| contents | news | events | advertisers | website | e-newsletter | Trumpf: Driving aerospace adoption

of about 100 mm x 100 mm and has a 200 W laser for the AM of delicate structures. Using this machine, the results ticked all the right boxes from the first prototype, says Moll. "A 3D scan enabled us to demonstrate that it had the required level of geometric accuracy, and using micrographs we established a density of 99.95%."

But the experts were keen to get even more accurate information, so they sent the prototype for a CT scan at Yxlon, a developer and producer of X-ray and computed tomography inspection systems. The company verified the uninterrupted continuity of the channels and the size of the pores. The Trumpf experts also automatically ascertained and checked over forty measurements inside the part. The results were positive, showing clear channels and the required dimensional accuracy, including the stipulated pore size of less than 100 µm.

"Redesigning the part has cut throughput times and reduced the amount of material we use by around 80%," stated Moll. "All in all, the decision to 3D print the rakes has reduced our overall costs by around 74%. That's a whole order of magnitude in this industry."

López-Vidal is optimistic that this part's manufacturing journey signifies AM's ability to provide practical solutions in the aerospace industry. "The key is to stay up to speed with this new method and keep decision-makers up-to-date with the opportunities offered by Additive Manufacturing. Rakes are yet another example of just how much potential AM has to offer."

"But the aerospace industry is a challenging market, and it will take us a while to convince our customers to use Additive Manufacturing for structural components and other key assemblies," she continues. "Nevertheless, we and other big suppliers are steadily expanding our strategic expertise in AM methods – and that's a clear sign of how confident we are that this technology will ultimately succeed.

Fig. 3 Trumpf has been commissioned to produce an additively manufactured mounting structure for Germany's Heinrich Hertz communication satellite

Aerospace case study: satellite mounting structure

Despite the acknowledged barriers to adoption in the aero industry, some space companies are already using AM to build complex components and achieve significant weight savings. AM is being used, for example, in satellites. The requirements for the production of satellite components have increased enormously in recent years; on the one hand, parts need to be as light as possible, because every kilogram that a launch vehicle carries into space costs the client several hundred thousand euros. At the same time, however, satellites must be robust enough to withstand the tremendous forces experienced during launch.

Trumpf Additive Manufacturing systems make it possible to meet these requirements. As an example, the company has been commissioned by the space company Tesat-Spaceroom GmbH & Co. KG to produce an additively manufactured mounting structure for Germany's Heinrich Hertz communications satellite, which will be used to test the spaceworthiness of new communication technologies, a mission being carried out by DLR Space Administration on behalf of the Federal Ministry of Economics and Energy and with the participation of the Federal Ministry of Defense.

The mounting structure includes strap-on motors that are used to modulate microwave filters. In collaboration with the company AMendate, Trumpf's engineers succeeded in optimising the topology of the mounting structure for AM and reducing its weight by 55%. The mount, originally 164 g, now weighs just 75 g. "This is just one example of how we can use additive processes in satellite construction to reduce weight and increase payload capacity," explains Matthias Müller, Industry Manager Additive Manufacturing for Aerospace and Energy at Trumpf. The team built the redesigned

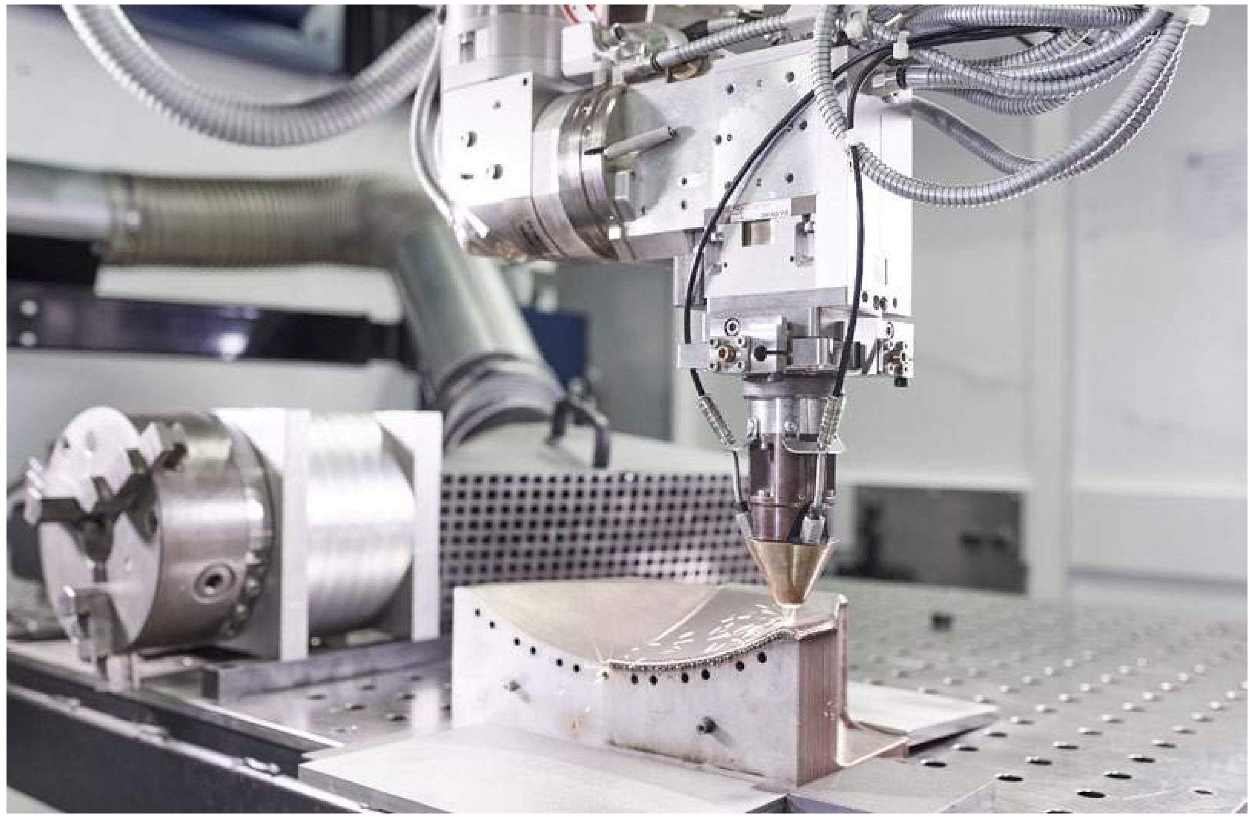


Fig. 4 LMD offers the perfect solution for aviation repairs

part on Trumpf's TruPrint 3000, a medium-format machine incorporating industrial part and powder management, a build area that is 300 mm in diameter and 400 mm high, and laser power of up to 500 W. The part's new geometry could not have been produced using conventional methods. As well as being lighter, the optimised mounting structure is more robust, and it is expected that during the launch of the satellite, it will withstand the same high forces as its predecessor and hold its shape better.

Aerospace repairs by Additive Manufacturing

AM can also be used for the repair of aerospace components. Laser Metal Deposition (LMD) technology, which Trumpf also develops, is suitable for this purpose. As a sample application, the Trumpf team repaired a high-pressure compressor blade – also known as a 3D aeroblade – using LMD. These components are used in aircraft engines and must be able to withstand extreme changes in temperature during flight. They are also in constant contact with dust and water, and typically show signs of wear on the edges and tips. Aviation engineers are required to periodically repair the blades to maintain engine efficiency.

LMD is the perfect repair solution for this job. On some sections of the blades, the material to be repaired is just 0.2 mm thick. Conventional methods quickly reach their limits in these kinds of applications, but using LMD technology, the laser can be positioned with an accuracy of approximately one hundredth of a millimeter before applying a precisely calculated dose of energy. At the same time, the system feeds in material of identical composition as the part itself.

Depending on the application, this process typically takes just a few minutes, and makes it easy to repair blades multiple times, significantly reducing cost per part in each engine overhaul. "Laser Metal Depisition delivers a low dose of energy – and that makes it perfect for aerospace applications," explains Oliver Müller-schön, Head of Industry Management Laser Production Technologies at Trumpf. "We can use it not only to repair and coat parts, but also to build up three-dimensional structures. That's simply not possible with conventional welding methods."

Helping customers achieve aerospace certification

In 2018, Trumpf assisted MBFZ toolcraft GmbH, Georgensgmünd, Germany, as it worked to become one of the first metal Additive Manufacturing companies to achieve Nadcap (National Aerospace and Defense Contractors Accreditation Program) certification for aerospace. Nadcap is an industry-driven programme whereby highly qualified individuals with experience in the

aerospace industry conduct the process audits of manufacturers, using criteria specific to an actual process, and can give successfully audited companies a competitive edge over their rivals.

Toolcraft manufactures precision components and automation solutions for a number of industries, including aviation and aerospace, using metal Additive Manufacturing alongside a number of other production technologies. The company regularly undergoes certification for aviation and aerospace; a requirement in order to be allowed to manufacture components for applications in these industries. The process of Nadcap accreditation involves comprehensive certification of the entire production environment; for L-PBF manufacturing, this meant documenting and ensuring transparency over the numerous process steps which take place before, during and after the L-PBF process.

Complete verification of the metal powder used was carried out, as well as the inspection of component quality through optical and tactile measurement and non-destructive surface testing. Special attention was also paid to the L-PBF process within the company's TruPrint 3000 machine. In addition to monitoring oxygen levels and air humidity in the process chamber, it was important that it be verifiable that the laser power and shape of the laser beam within the machine were coordinated in such a way that every part in a build was exposed in precisely the same way.

Trumpf proactively supported toolcraft prior to the audit with ideas, solutions and suggestions in order to furnish the quality assurance proof throughout the entire process – before, during and after the build. To do this, Trumpf employees examined the Nadcap question catalogue intensively, and developed testing procedures such as path precision analysis and laser power measurement. The actual TruPrint machine was also part of the audit,

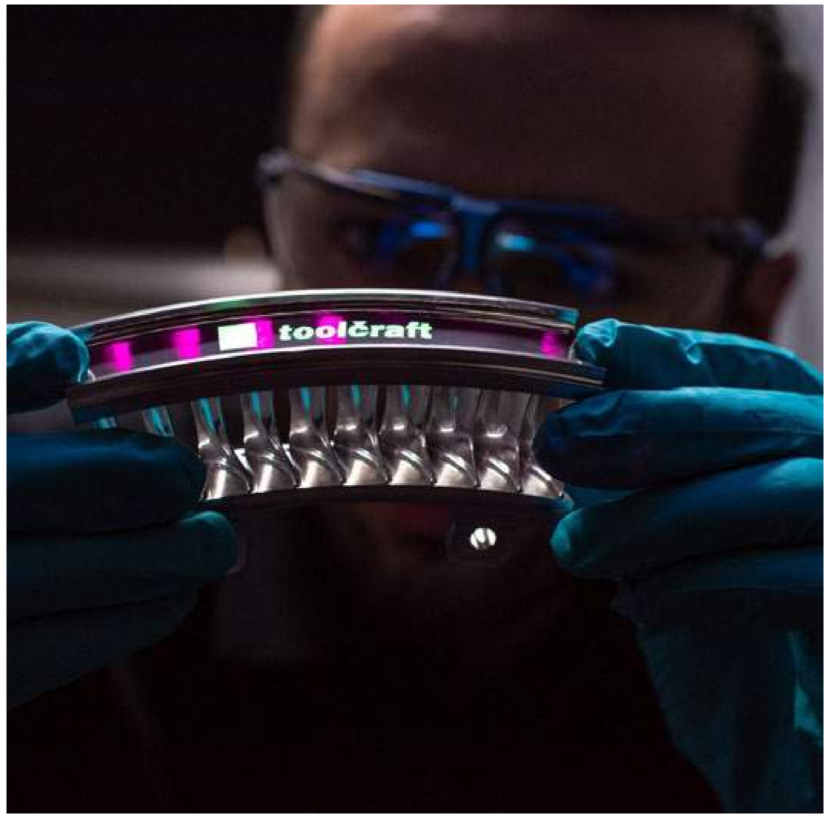


Fig. 5 MBFZ toolcraft GmbH approached Trumpf for assistance as it prepared for the first Nadcap audit of its metal AM operations

and here toolcraft states that it was able to rely on Trumpf as a laser and mechanical engineering specialist, guaranteeing quality and process stability for the beam source and all of its individual components.

> *"...toolcraft states that it was able to rely on Trumpf as a laser and mechanical engineering specialist, guaranteeing quality and process stability for the beam source and all of its individual components."*

Aiding toolcraft as it prepared for the Nadcap audit were its own on-site facilities, including a laboratory with extensive equipment to verify powder and component quality, meeting the powder management and quality control requirements of Nadcap. The company also has its own tensile and fatigue strength testing facilities, and manufactures a specific different material on each of its TruPrint machines, using an entirely separate room for powder and parts handling and unpacking. The maintenance and upkeep of the TruPrint 3000 by Trumpf's Technical Service department, and inbuilt intelligent monitoring solutions, also played a key part in the audit.

Thanks to Trumpf's assistance and its own comprehensive preparations, toolcraft passed the audit with zero errors. Christoph Hauck, Managing Director of toolcraft, stated following certification, "From the start of the process, Trumpf enthusiastically supported us in finding solutions for the Nadcap question catalogue. I believe that the zero errors found during the audit say everything there is to say about our successful partnership."

Conclusion

This article highlights the multifaceted ways in which Trumpf, and Additive Manufacturing technology as a whole, can support the aerospace industry. Although the hurdles posed by strict qualification procedures may prove challenging to overcome, Trumpf has demonstrated on multiple occasions that it can support customers in these areas, whether by aiding the development and production of parts fit for certification, as in the case of Ramem's metal AM rake, or by providing the expertise and technology to enable companies such as toolcraft to achieve aerospace certification for their AM workflows.

Contact

Ramona Hönl
Media Relations, Spokesperson Additive Manufacturing
Trumpf GmbH + Co. KG,
Johann-Maus-Strasse 2,
71254 Ditzingen
Germany

+49 7156 303-31251
Ramona.Hoenl@trumpf.com
www.trumpf.com

From silicone and rubber to steel and ceramic: the weird and wonderful world of wipers

In powder bed Additive Manufacturing processes, the recoater system is responsible for spreading a fine and even layer of powder for each layer of a build. This system typically uses wipers to create the necessary surface, with the variants of wipers used being almost as diverse as the number of AM machines on the market. Olaf Diegel and Terry Wohlers explain why it is not only machine operators, but also designers and engineers, who need to be aware of the weird and wonderful world of wipers.

The process of setting up a metal AM build job can be complex. Though it is rare for engineers and designers to be directly involved with the manufacturing of parts, in Additive Manufacturing they can greatly benefit from hands-on operation of machines; largely because it gives them a much better idea of the variables and complexities involved. If the designers of the parts to be built are not directly involved with the build job, it is critical that they at least have a good dialogue with the machine operators to ensure good results and met expectations.

On most metal AM systems, the building of parts occurs on a build plate. This plate can be either square or round, and is bolted onto the build chamber piston, which moves down by the thickness of a single layer after the completion of each melting operation. The powder is spread over the build plate in a thin layer by a recoater system consisting of soft silicone, rubber or carbon fibre brushes, a hard steel or ceramic wiper blade, or a hard roller. Different types of recoaters have advantages or disadvantages depending on the application.

Soft recoater blades

Because soft recoater blade material is flexible, this type of recoater is more forgiving when processed metal distorts and protrudes out of the top of the powder bed. In cases where a hard recoater physically crashes into protruding metal and halts a build job, a soft recoater may permit the job to complete, although with a potential imperfection at the point where the wiper has to flex to avoid a collision. Soft recoaters become damaged more easily, however, and typically need to be replaced after every job. Wipers that use a round silicone profile instead

Fig. 1 Example recoater blade with carbon fibre brushes

Fig. 2 Example of recoater with a silicone cord blade

of a rectangular one must be rotated after every job.

Soft recoaters are ideal for the Additive Manufacturing of a range of different parts at once, and for building particularly delicate parts. In a batch of different parts, even if one part happens to deform to the point where the wiper is deflected, the other parts will be unaffected, and the build will not need to be stopped.

Hard recoater blades

A hard recoater, whether a flat blade or roller, exerts more pressure on the powder than a soft recoater and allows for little part deformation. If a part deforms by more than a layer thickness of 20–80 µm (0.0008–0.003 in), the machine is likely to crash. This means that when the recoater hits the part that is protruding from the powder, the build stops. Alternatively, very fragile parts break off and are dragged across the powder bed.

Hard recoaters are ideal when identical parts are built on the same build platform, and the part has been tested to build without any major vertical deformations. If one part in the build deforms, the chances are that other parts in the build will also deform.

A hard recoater is not necessarily better or worse than a soft recoater. It is important to understand the nature of the parts being built and to choose the best recoater blade for the job.

General part positioning guidelines

How one positions the parts on the build plate can also have a major impact on the success and quality of the built parts, as well as on the lifespan of the recoater blade. As a recoater spreads a new layer of powder, the sections of the part that have been built should not move. If any distortion of a part occurs (however minute), it can exert mechanical force on the recoater. This force can be sufficient to bend or break the part, especially when features are delicate. If the part distorts but does not bend or break, it can be enough to crash the recoater, causing a build failure and/or damage to the recoater blade.

By correctly positioning parts on the build platform, one can minimise the amount of force the parts exert on the recoater. This can reduce or eliminate failed builds.

If a part is largely rectangular or contains long, flat walls, avoid positioning parts with long walls parallel to the recoater. This could cause the recoater to suddenly meet a large obstacle. Instead, rotate parts around the vertical Z axis to minimise the recoater force at any one point.

If you position a part parallel to the recoater and any distortion occurs

Fig. 3 Hard recoater with stainless steel blade

in the part, the recoater may not be able to pass over the distortion and will crash the build. Rotate the part around the Z axis by 5° to 45° so that the recoater does not suddenly meet a long, flat wall. This will greatly reduce the risk of a crash and can improve the quality of delicate features such as thin walls.

Try to avoid having the recoater make simultaneous contact with several parts at once. Staggering the parts on the build platform is often enough to minimise the risk of large, sudden resistance that can crash the recoater system.

Also avoid positioning parts directly behind one another. If a part distorts and makes contact with the recoater, the build might continue even though the recoater, or the part, is damaged. This is especially the case with silicone or carbon fibre brush blades. If the recoater is damaged, it will affect the quality of the part nested directly in line with the part that damaged the recoater blade.

The effect of this may be a deterioration in the spreading of powder directly behind the collision area. Whenever possible, nest parts on the build plate with space behind them along the recoating axis.

Position the tallest parts closest to the recoater. The reason for this is simple pragmatism. On some AM machines, you cannot place enough powder in the machine to build very tall parts. To build tall parts, the machine may need to be paused while powder is added.

However, some machines may also allow you to reduce the amount of powder deposited in each layer. In this case, one would use a normal amount of powder while the smallest parts are being built. Once these are finished, the amount of powder per layer is reduced to the point where enough powder is available to complete the entire build without needing to pause and refill the machine. Pausing and refilling the build chamber is undesirable due to the possibility of parts shrinking during the cooling time needed to do so.

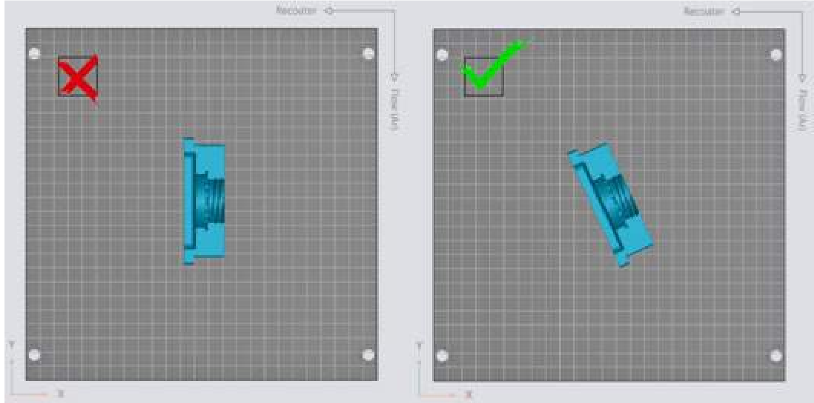


Fig. 4 Avoid parts parallel to the recoater blade

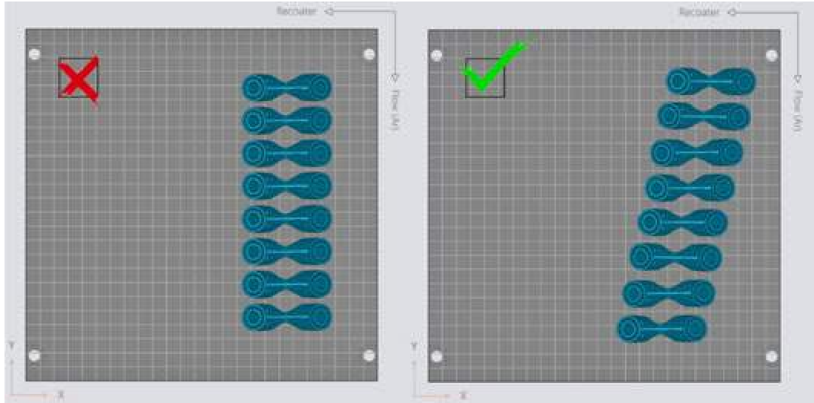


Fig. 5 Stagger multiple parts whenever possible

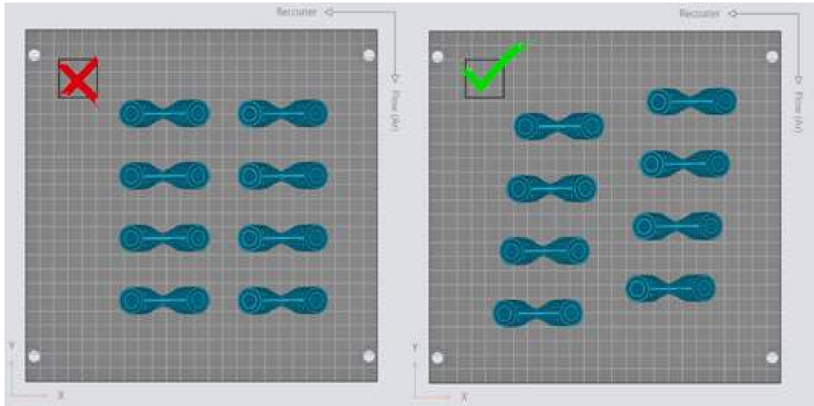


Fig. 6 Avoid parts lined up directly behind one another

An understanding of different recoater blade types, and their effects on build quality and reliability, is critical for effective metal AM. Any action that can be taken to minimise any stress on the recoater blade can help ensure parts have the best chance of being successfully additively manufactured.

Authors

Olaf Diegel and Terry Wohlers
Wohlers Associates, Inc.
Fort Collins
Colorado 80525
USA

www.wohlersassociates.com

Managing the industrialisation process: Notes from Euro PM's seminar on the future of Additive Manufacturing

During the Euro PM2019 Congress and Exhibition in Maastricht, the Netherlands, this October, a number of Special Interest Seminars were held focusing on various aspects of the Powder Metallurgy and Additive Manufacturing industries. In one seminar, Dr Uemit Aydin, GKN Additive, and Nicholas Turner, Materials Solutions, looked to the future of Additive Manufacturing and expressed their views on its industrialisation. David Whittaker attended the SIS on behalf of *Metal AM* magazine and reports on its conclusions.

One of the Special Interest Seminars (SIS) at the Euro PM2019 Congress and Exhibition, organised by the European Powder Metallurgy Association (EPMA) and held in Maastricht, the Netherlands, October 13-16, 2019, offered an outlook on the future of Additive Manufacturing. Specifically, two of the leading practitioners of AM processing, GKN Group and Materials Solutions, a Siemens business, gave their views on the keys to the successful industrialisation of metal Additive Manufacturing.

Industrialisation of AM: Effective metal Additive Manufacturing in practice

The first of the seminar's presentations was given by Dr Uemit Aydin, Global Business Development Director at GKN Additive. GKN can justifiably claim to be a world leader in powder metal solutions, with GKN Sinter Metals currently the number one global producer of precision powder metal parts (both by press/sinter Powder Metallurgy and Metal Injection Moulding), GKN Hoeganaes the second largest global producer of metal powders, and GKN Additive a global market leader in metal AM.

From the very broad range of AM technologies available, GKN Additive has chosen to focus on two technologies: Laser Powder Bed Fusion (L-PBF) and Binder Jetting (BJT), through its close co-operations with EOS GmbH and HP Inc., respectively. In relation to L-PBF, GKN sees the route to market growth as comprising three steps. Firstly, the company has defined the need to understand customer expectations of AM, and has developed the acronym TRUST

Fig. 1 The EPMA's Euro PM congress and exhibition series is firmly established as the leading European technical event on PM, MIM and metal AM

Fig. 2 Why traditional induction hardening coils deliver less value

to represent some of the key areas in which customers require expert guidance:

Technology
Which is the appropriate AM technology to select and are there any boundaries that need to be considered?

Reproducibility
AM processes are quite complex, so is the scatter of achievable quality an issue?

Materials
Understanding the available materials: how reliable are they and how do they perform in fatigue applications?

Supply chain
An important consideration when contemplating scaling up for higher volumes.

Transparency
This is vital in terms of reliability of delivery and part cost levels.

Secondly, for each given application, there is the need to consider, in collaboration with the customer, where value can be added in adopting AM as the manufacturing approach. Far from being limited to part cost comparisons, any consideration of AM adoption also needs to include added value in terms of product design (reductions in prototyping costs and lead times, elimination of tooling costs), production (impact on set-up costs and quality control procedures), logistics (aftermarket delivery considerations, coping with a high level of variety in parts, impact on stock levels) and other issues. The GKN/EOS strategy is to gain a full appreciation of parts that can add value, in order to identify product groups to focus on.

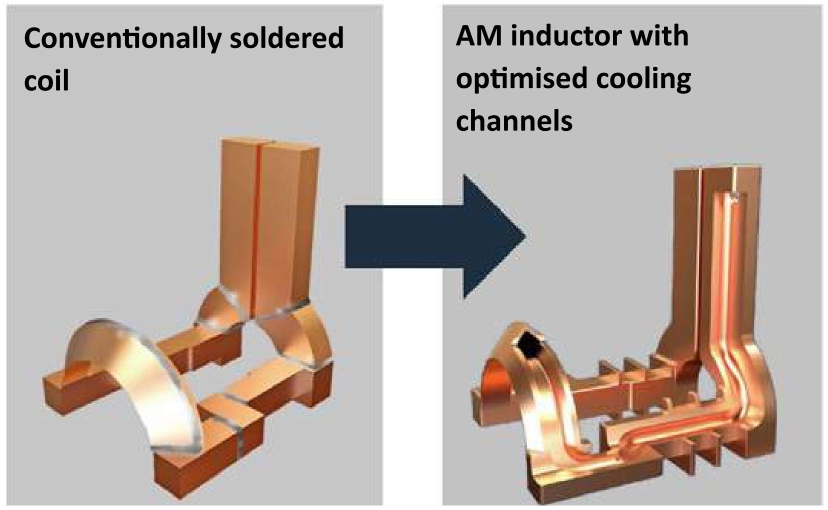


Fig. 3 AM product solutions for copper coils

The third step is then to find the most appropriate products for transitioning from conventional manufacturing methods to AM. Dr Aydin illustrated this step using three specific examples.

Induction hardening coils
The conventional route for the manufacture of induction hardening coils is a time-consuming process with high production costs. It involves the joining by soldering of many small pieces of copper (Fig. 2). Apart from the cost implications, each soldered joint generates a significant reduction in performance. AM can be effective in adding value to this application by building the coil as a single piece, incorporating customised cooling channels (Fig. 3).

The additively manufactured part delivers numerous advantages over the conventional product – a tripling of achievable product life, reduced energy consumption in manufacture because of the elimination of soldering, improved cooling in use because of the customised channels, optimisation of component shape, enhanced efficiency during the hardening process, reduced need for the holding of spare parts and reduced production downtime for set-up.

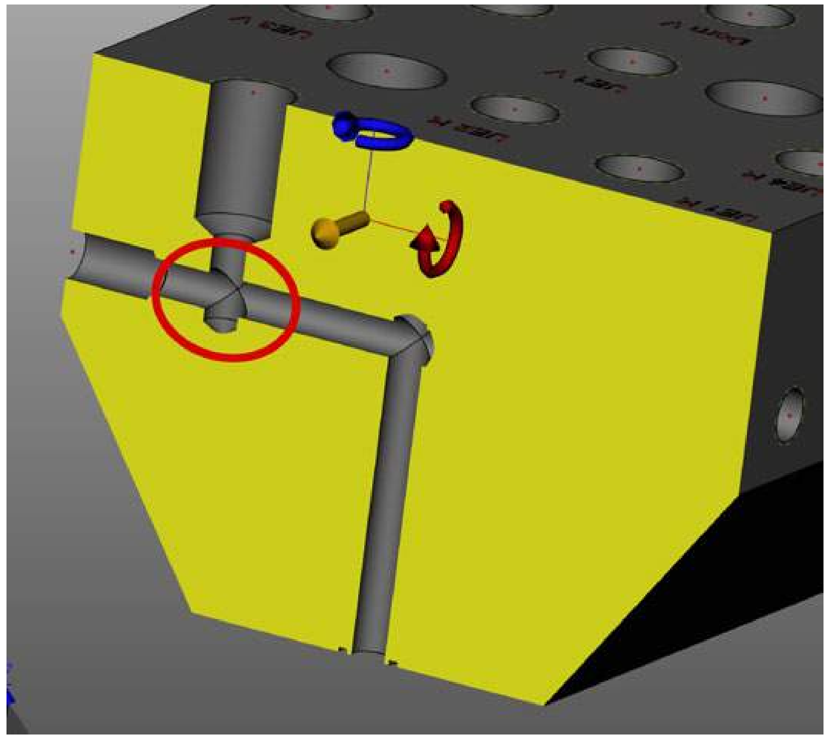


Fig. 4 Hydraulic/Adapter Blocks: conventional manufacturing issues

Hydraulic blocks
Conventionally, the manufacturing process for oil distribution blocks for hydraulic systems involves drilling vertical channels, drilling horizontally to connect vertical channels, threading the open horizontal channels, closing the horizontal holes with grub screws and final channel cleaning (Fig. 4). This route creates problems with burrs in the connection areas of the channels, reduced energy efficiency due to high friction and the occurrence of 'dead corners' (no oil flow) with a high risk of dirt collection. By adopting a 'Design for manufacture' approach, AM can tackle all of these problem areas, with the AM part (Fig. 5) delivering a product weight reduction

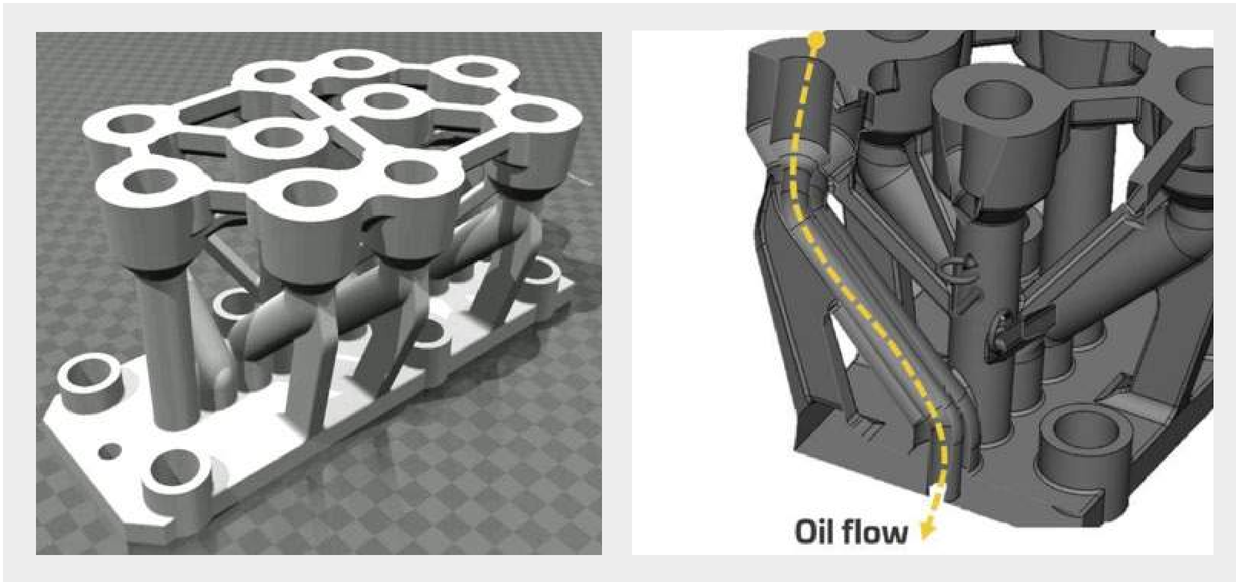


Fig. 5 Left, a redesigned AM hydraulic/adapter block; right, how the AM hydraulic block improves oil flow efficiency

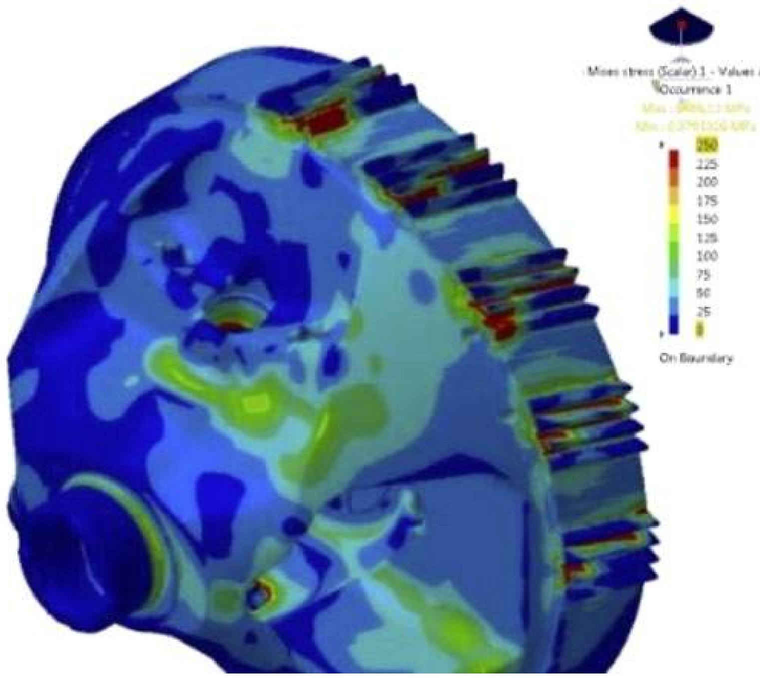


Fig. 6 Transmission housing + ring gear: topology optimisation including the application of FEM

of around 80% and improved oil flow efficiency. In addition, the achieved compact design saves space, and repeatability in the manufacturing process is enhanced.

Transmission differential housing and ring gear

The final product type discussed was a front transmission differential housing and ring gear for a hybrid automotive transmission. The motivation for this project was that the conventional design had a large reciprocating mass and offered significant opportunity for improvement with topology optimisation. A development project, in collaboration with Porsche Engineering, involved the selection and validation of case hardening steel 20MnCr5 in inert gas atomised powder form, compared with 16MnCr5 for the reference wrought steel gear; process validation involving the optimisation of build parameters to achieve 99.95% product density, optimisation of heat treatment parameters for stress relieving and case hardening and assessment of static and dynamic mechanical properties; topology optimisation, including the application of FEM (Fig. 6), and design modifications to improve the design's suitability for AM.

> *"Metal binder jet technology is deemed to be, in many ways, a perfect fit for the collaboration in that it combines HP's additive technology expertise with GKN's extensive expertise in sintering technologies."*

As a result of the project, the housing and ring gear was able to be manufactured as a single part (Fig. 7), providing a weight reduction compared with the conventional product of 13%, a stress reduction of ~ 40%, a reduction of 43% / 69% in gear tooth stiffness variations in the radial/tangential directions and 8% reduction in inertia.

Dr Aydin then looked to the future of AM, posing the question "What next?" In relation to L-PBF, collaborative developments with EOS were said too have yielded achievable development/production lead times of two weeks, full design freedom, the elimination of tooling requirements and build rates over ten times faster, enabling small series production up to around 2,000 parts.

GKN has concluded that it will benefit the company to 'rely on its own DNA' moving forward, drawing on its Design for PM expertise in terms of understanding the demands of the application and achieving the required performance, and supplementing this with a Design for AM philosophy, including the incorporation of functional porosity and high density where needed. Overall, the tenet must be to give the customer what he needs, rather than necessarily what he believed he wants.

A supplementary question was then posed regarding the future of AM – "Is Laser AM the future?" This question was provoked by the new focus on Binder Jetting, incorporating HP's proprietary Additive Manufacturing technology. Metal binder jet technology is deemed to be, in many ways, a perfect fit for the collaboration in that it combines HP's additive technology expertise with GKN's extensive expertise in sintering technologies. On the basis of the collaboration, this technology has been demonstrated to match L-PBF in terms of lead times, design freedom and freedom from tooling requirements, but with build rates of up to fifty times higher than L-PBF, thus potentially enabling medium series production up to 50,000 parts. Stephen Nigro, former president of HP 3D Printing, once predicted

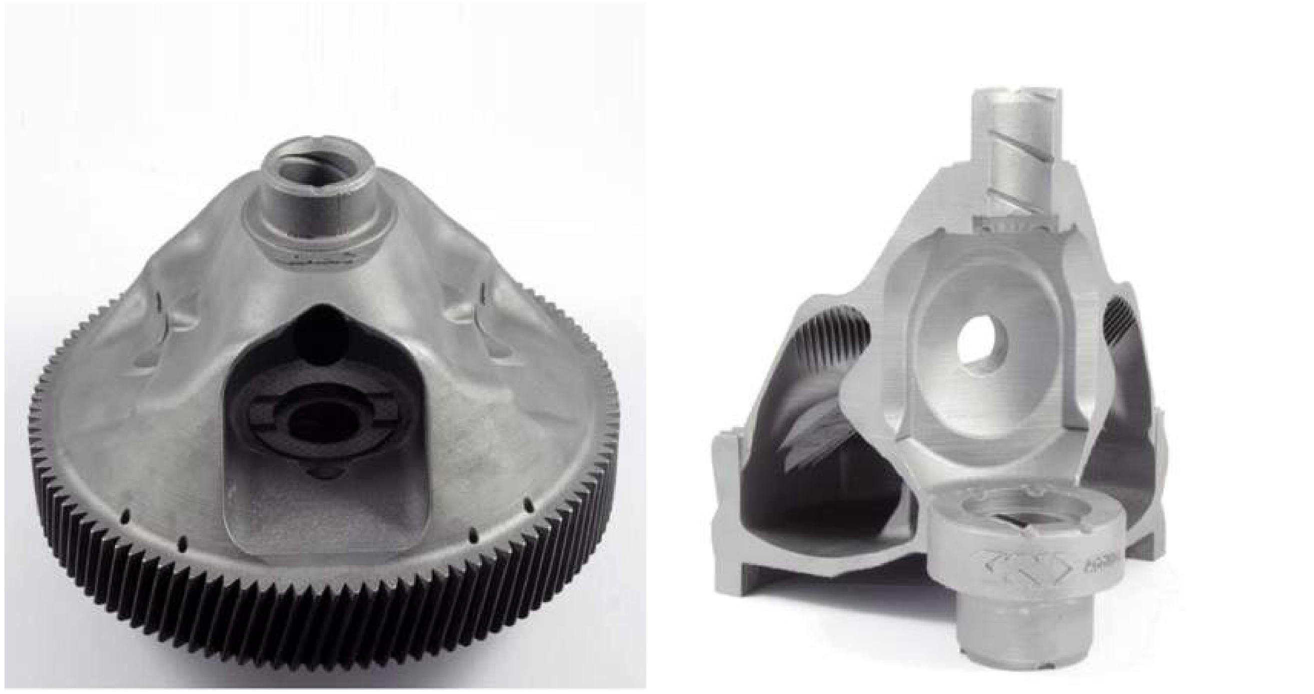


Fig. 7 Differential gear and housing redesigned for AM

that the collaboration between GKN and HP "promised to enable the production of millions of high-quality, low-cost 3D printed final parts."

GKN can therefore claim a unique process portfolio for the production of metal parts from one component to millions, with L-PBF AM producing parts at low volumes up to around 2,000 parts, BJT potentially producing parts in medium series up to around 50,000 parts, and conventional press/sinter PM and MIM producing parts in large series above 50,000. The company is pursuing AM opportunities with a global footprint, via a materials and manufacturing R&D centre in Cinnaminson, USA, a process R&D centre in Radevormwald, Germany, and digitalisation centres in Germany, Italy, USA and China.

> *"GKN can therefore claim a unique process portfolio for the production of metal parts from one component to millions, with L-PBF AM producing parts at low volumes up to around 2,000 parts"*

Industrialising L-PBF AM for serial production

Next, Nicholas Turner, Project Manager at Materials Solutions, provided the company's views on key enablers for the industrialisation of L-PBF AM for serial production. For this company, the major focus has been on the streamlining of its production facilities for maximum efficiency. Materials Solutions was established in 2006 and was first visited by *Metal Additive Manufacturing* magazine in the Spring of 2015 (see visit report at *Metal AM*, Vol. 1, No. 1, pp. 45-50).

At this time, the company had adopted a major focus on components in superalloys for aero-engines and land-based gas turbines for power generation applications, and had already established a reputation as a world leader in this field. Their capability for processing the 'difficult to weld' material, CM247LC, by L-PBF was, in particular, considered to be unique; hence Siemens' later interest in acquiring the business.

Later in 2016, Siemens took a majority shareholding in Materials Solutions, converting the business to fully-owned status in 2019. The burner insert in the company's SGT-1000 small gas turbine became the first fully-qualified AM application in a customer application and was followed, in 2017, by the award winning SGT-400 247LC blade component.

Fig. 8 Creating an effective factory layout for series L-PBF production at Materials Solutions

Siemens has adopted the strategy of industrialising L-PBF AM 'on a grand scale'. To pursue this objective, a €30 million investment has been made at Materials Solutions, involving a move to a new 4,500 m^2 production facility outside Worcester, UK, with a 1,500 m^2 mezzanine space. The target is to have up to fifty AM machines, a digitalised production facility and production and post-processing capabilities under the one roof.

"A circuit-style layout has been developed for uninterrupted end-to-end production flow, while safer, separated powder handling on the mezzanine level ensures that no forklifts are required on the factory floor."

In the move to full serial production, Turner identified three current challenges. Firstly, L-PBF machines are still evolving for industrialised production. Secondly, MTTF (Mean Times To Failure) cannot yet be consistently reported by OEMs on L-PBF machines. Thirdly, there is no established 'blueprint' for industrialised AM factories. To address these issues, the company offers a number of potential solutions; it is aiming at thoroughly-developed customer PPQ (Process Performance Qualification) processes, and is evolving processes for waste powder reduction and faster end-to-end (E2E) production. High-value processes are also being automated.

A key issue in generating these solutions has been defined as creating an effective factory layout to support industrialised L-PBF AM and post-processing (Fig. 8). At Materials Solutions, sixty-four modular machine bays have been created with full mechanical and electrical service availability. A flexible, open plan design has also been adopted to allow for re-configuration, and 10 m vertical shuttle storage has been installed to maximise the available floor space for 'value add machinery'. A circuit-style layout has been developed for uninterrupted end-to-end production flow, while safer, separated powder handling on the mezzanine level ensures that no forklifts are required on the factory floor.

Powder management has been optimised through automation and digitalisation (Fig. 9). This approach delivers a range of benefits: digitalisation embraces the human/machine interaction concepts of Industry 4.0, safety is enhanced with no powder exposure and no manual handling, a leaner process is delivered with reduced end-to-end cycle time, digital capturing of data on powder quality and longevity ensures traceability, and the automated process caters for serial production.

Efficient support removal, with minimal waste, has also been achieved. The inherent challenges in support removal relate to the observation that this can be a time-consuming, iterative and expensive process, which must be 'right first time' as an error risks writing off what could have been a multi-day build. Changes that might appear to offer only marginal gains can prove to be significant in large-scale production. Examples cited were the use of easily removed or 'knock out' supports and the automation of support removal with CNC machining to speed up post-processing and guarantee repeatability.

Managing unpredictable warping in heat treatment and maintaining standardised post-processing was considered as a further issue. Materials Solutions sub-contracts all heat treatment to third parties, with previous attempts to bring this in house posing significant challenges. In collaboration with its heat treatment sub-contractor, it has determined that heat treatment on the L-PBF base plate allows effective stress relief without warping. It has also been found that wire EDM delivers reliable and repeatable base plate removal, that precise shimming is required to support warped build plates, and that build plate warping of 2 mm+ is common in large builds. Reduction of the consequent build plate waste currently remains an unresolved challenge. Finally, the presenter emphasised that the issues highlighted in his contribution to the seminar were merely the 'tip of the iceberg' in achieving full control of L-PBF processing. The complexity of exercising such process control was illustrated by a complex fishbone diagram, previously published in Vol. 4 No 3 of *Metal AM* magazine (Autumn 2018), pages 170-171.

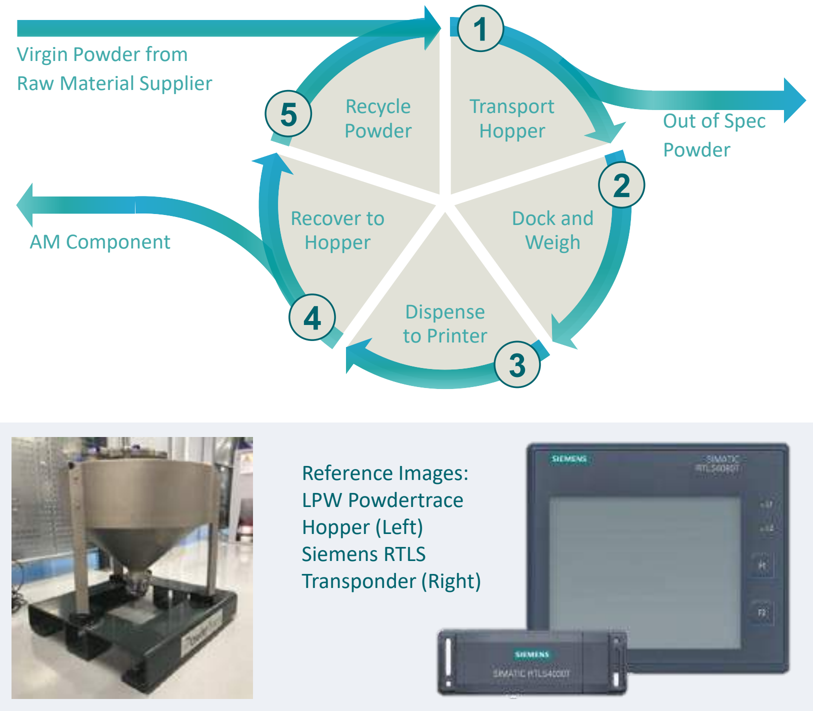


Fig. 9 Optimisation of powder handling via automation and digitalisation

Author

Dr David Whittaker
Tel: +44 1902 338498
whittakerd4@gmail.com

industry events

Pick up your free copy! *Metal AM* magazine is exhibiting at and/or being distributed at events highlighted with the *Metal AM* cover image

2020

TCT Japan
January 29–31, Tokyo, Japan
www.tctjapan.jp/photo_en.html

3D Medical Printing Conference & Expo
February 4–5, Maastricht, the Netherlands
www.3dmedicalconference.com

Additive Manufacturing Strategies 2020
February 11-12, Boston, MA, USA
www.additivemanufacturingstrategies.com

PM20
February 19-21, Mumbai, India
www.pmai.in/pm20

Additive Manufacturing for Aerospace & Space conference
February 25-27, Birmingham, UK
www.defenceiq.com/events-additivemanufacturing

Asiamold 2020
February 26-28, Guangzhou, China
http://asiamold-china.cn.messefrankfurt.com/guangzhou/en.html

3D Printing Asia
February 26-28, Guangzhou, China
https://3dprintingasiaexpo.cn.messefrankfurt.com/guangzhou/en.html

Manufacturing World Japan 2020
February 26-28, Chiba-ken, Japan
www.japan-mfg.jp/en-gb.html

MIM2020
March 2–4, Irvine, CA, USA
www.mim2020.org

Advanced Factories Expo & Congress
March 3-5, Barcelona, Spain
www.advancedfactories.com/en/

EPMA Hot Isostatic Pressing Seminar
March 10-11, Oslo, Norway
http://seminars.epma.com/hip-2020/home

METAV 2020
March 10-13, Düsseldorf, Germany
www.metav.com

4th AM Forum Berlin 2020
March 11–12, Berlin, Germany
www.additivemanufacturingforum.com

AMUG 2020 Conference
March 22–26, Chicago, IL, USA
www.amug.com

PM China 2020
March 24–26, Shanghai, China
www.pmexchina.com

Manufacturing World Nagoya 2020
April 15–17, Nagoya, Japan
www.japan-mfg-nagoya.jp/en-gb.html

Rapid + TCT 2020
April 20–23, Anaheim, CA, USA
www.rapid3devent.com

The 3D Printing / Additive Manufacturing Value Chain
April 21–22, Geleen, Netherlands
www.3dprintingevent.com

Space Tech Expo USA
May 18–20, Long Beach, CA, USA
www.spacetechexpo.com

3D PRINT Congress & Exhibition 2020
June 16-18, Chassieu, France
www.3dprint-exhibition.com/en/

WORLDPM2020
June 27–July 1, Montréal, Canada
www.worldpm2020.org

PM Life - Additive Manufacturing Module
August 24-28, Dresden, Germany
www.pmlifetraining.com/about/additive-manufacturing

Formnext + PM South China
September 9–11, Shenzhen Shi, China
www.formnext-pm.hk.messefrankfurt.com/shenzhen/en.html

Euro PM2020
October 4–7, Lisbon, Portugal
www.europm2020.com

advertisers' index

Advertise with us

The magazine for the metal Additive Manufacturing industry

Metal AM is the business-to-business magazine that focuses on commercial and technical developments in the metal AM industry.

As well as featuring the latest business and applications news, technical developments in the industry are also highlighted, making the magazine the essential resource for part manufacturers and end-users, along with equipment and material suppliers.

For more information contact Jon Craxford
Advertising Sales Director, Tel: +44 207 1939 749
Email: jon@inovar-communications.com