Vol. 10 No. 4 WINTER 2024

THE MAGAZINE FOR THE METAL ADDITIVE MANUFACTURING INDUSTRY

METAL AM

in this issue

ALUMINIUM ADDITIVE MANUFACTURING
COUNTRY FOCUS: TÜRKIYE
AM FOR HYDRAULIC APPLICATIONS

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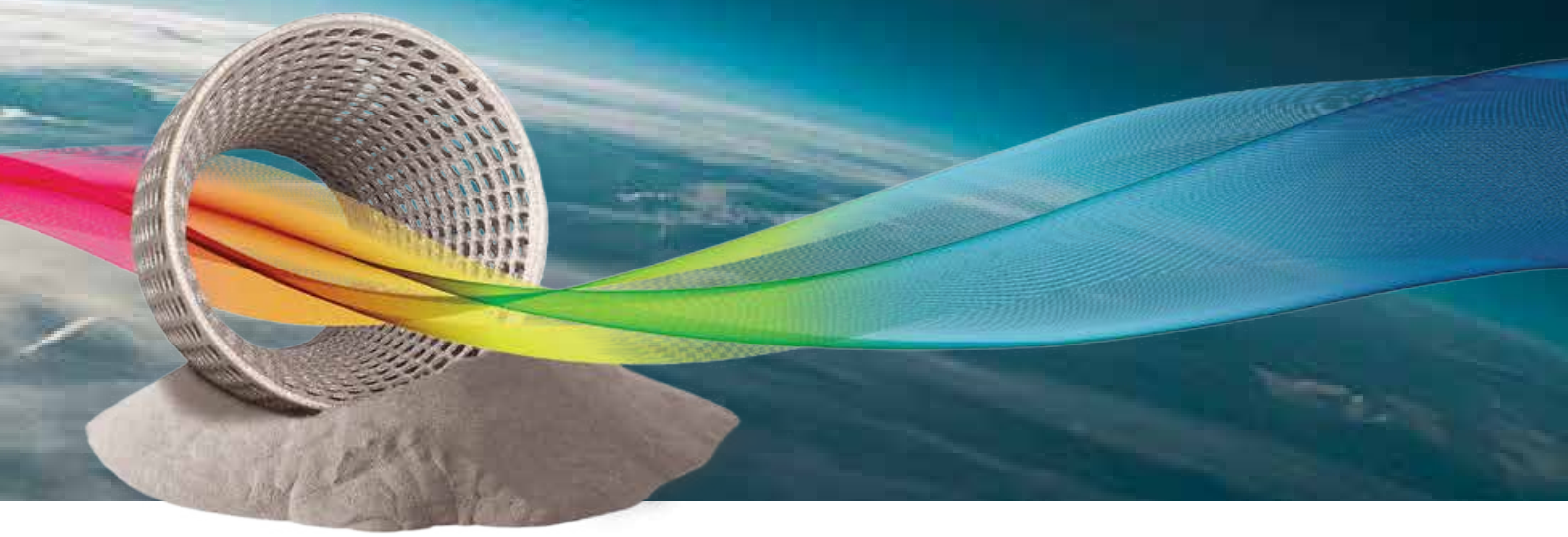

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This magazine is also available for free download from **www.metal-am.com**

INOVAR COMMUNICATIONS

METAL ADDITIVE MANUFACTURING MAGAZINE

A year of progress: Metal Additive Manufacturing magazine's expanding reach

As we reflect on the past year, it's easy to lose sight of just how much has been accomplished in an environment that moves at such a fast pace. For the team at *Metal AM*, this is undoubtedly the case.

At the heart of our efforts are our twice-weekly newsletters and quarterly magazine. For each magazine issue, we focus on delivering unique and impactful content that reaches beyond the 'Additive Manufacturing bubble' to highlight the technology's true potential. With PDF downloads and digital views averaging nearly 50,000 per issue, it's clear that our approach is resonating with a broad audience.

In addition to our core activities, 2024 marked the successful launch of our first two live webinars, both of which provided invaluable insights for participants and clear results for our sponsors. We also introduced a monthly LinkedIn newsletter, which has already attracted nearly 14,000 international subscribers. This, combined with our almost 37,000 followers, makes *Metal AM* magazine the largest AM media presence on LinkedIn – despite our metals-only focus.

As we look ahead to 2025, our mission remains focused on expanding our publication's reach to a broader audience of potential end users and continuing to deliver exclusive, valuable content for AM professionals – all while working with our valued advertising partners to support their ongoing growth.

Nick Williams
Managing Director

Cover image
The UGO hydraulic manifold, used on combine harvesters, produced using Laser Beam Powder Bed Fusion (PBF-LB) AM (Courtesy Aidro Srl)

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Aluminium has emerged as a pivotal material in Additive Manufacturing, revolutionising industries such as aerospace, automotive, and beyond. Overcoming early processing challenges, advances in AM machines and alloy designs are unlocking aluminium's potential. Today, its lightweight, high strength and thermal properties, combined with advances in powder production and sustainability efforts, are driving its rapid adoption.

As Dr Martin McMahon explains, with growing applications and ongoing materials development, aluminium is poised to play a transformative role in shaping the future of AM technologies. >>>

125 Shaping a national Additive Manufacturing ecosystem: The strategic growth of metal AM in Türkiye

Türkiye's Vision 2025 roadmap places Additive Manufacturing at the core of its aerospace innovation strategy, with a view to driving innovation in aircraft production and beyond. This article explores Türkiye's efforts to integrate AM technologies, driven by the country's leading aerospace producer, Turkish Aerospace Industries (TAI), and powered by the vital contributions of organisations such as EKTAM and ALUTEAM.

With academia-industry collaboration, international partnerships, and advances in materials and processes, Ümit Aytar reports on how Türkiye is shaping a robust AM ecosystem. >>>

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137 How metal Additive Manufacturing is transforming modern hydraulic systems

Hydraulic systems are important across many industries, providing high power density in compact, efficient packages. However, conventional subtractive manufacturing methods restrict design and performance. Additive Manufacturing offers a solution, enabling the production of complex geometries that enhance flow dynamics whilst minimising material use.

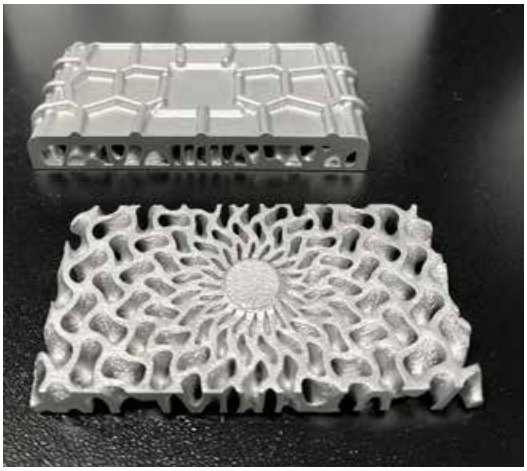
In this article, Valeria Tirelli, CEO of Aidro Srl, considers how AM is reshaping hydraulic component design and production, offering new possibilities for enhanced performance, sustainability, and application-specific customisation. >>>

145 High-performance product development in the era of computational design: a case study with nTop and NASA

The era of computational design is reshaping the engineering and product development landscape, enabling industries to tackle complex design challenges with unprecedented speed and efficiency.

This article explores how NASA, using software from nTop, leveraged cutting-edge tools and methodologies in a unique application development.

In combination with the capabilities of Additive Manufacturing, the project saw a scientific instrument component's original material, beryllium, replaced with an aluminium alloy, providing a significant part cost reduction whilst exceeding all necessary performance requirements. >>>



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155 The Additive Manufacturing of record-breaking pure copper heatsinks for high-performance computing applications

As high-performance computing (HPC) and Artificial Intelligence (AI) applications drive demand for more powerful processors, thermal management has become a critical challenge. This article explores the development of a generatively-designed and additively manufactured liquid nitrogen (LN2) heatsink, created by 3D Systems and Diabatix in collaboration with SkatterBencher and ElmorLabs, that achieves groundbreaking cooling performance. Thanks to Additive Manufacturing, the resulting pure copper heatsink promises to open up new markets for the technology in this rapidly growing market. >>>

165 The Additive Manufacturing of tool steels: how non-linear modelling enables precise hardness control

Vibenite® steels are the hardest additively manufactured tool steels available today. Parts made of Vibenite materials are produced by Electron Beam Powder Bed Fusion (PBF-EB) Additive Manufacturing, followed by heat treatments that include Hot Isostatic Pressing (HIP), hardening and tempering.

This combination enables the efficient production of wear-resistant parts that do not require cutting or welding and are impossible to produce via conventional processes.

In this article, the authors explain how they have combined AM processing with HIP and hardening treatments optimised using non-linear models to control hardness. >>>

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Our advertisers' index serves as a convenient guide to suppliers of AM machines, materials, part manufacturing services, software and associated production equipment.

In the digital edition of *Metal AM* magazine, available at www.metal-am.com, simply click on a company name to view its advert, or on the weblink to go directly to its website. >>>

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Industry news

To submit news please contact Paul Whittaker, Group News Editor: paul@inovar-communications.com

Latest Ferrari and Mclaren supercars feature structural AM components

Ferrari and McLaren have launched their latest supercars, with both featuring additively manufactured structural components.

Both the Ferrari F80 (left) and McLaren W1 (right) feature AM structural components (Courtesy Ferrari and McLaren)

Ferrari F80

The new Ferrari F80 marks the first time that the Italian sportscar maker has used metal Additive Manufacturing for structural components in a road car. The company announced that the F80's independent suspension, including a double wishbone layout, active inboard dampers and suspension arms, are created by Additive Manufacturing.

The F80's active suspension system was completely redesigned to manage vehicle dynamics in all conditions. This included the need for a flat ride on the track, where variations in ride height must be minimised, and the need to effectively soak up bumps in road surfaces during normal driving.

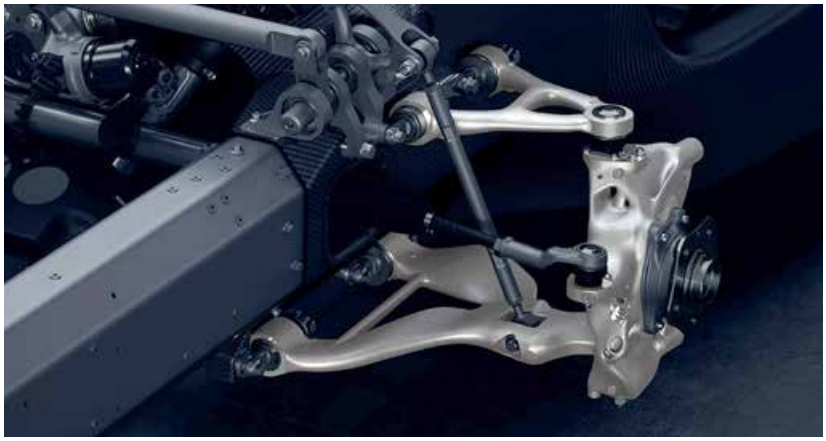
The new setup results in an optimised layout, more precise wheel control, reduced unsprung mass, elimination of the anti-roll bar, and the introduction of a dedicated camber angle correction function.

At low speeds, the system prioritises mechanical balance and centre of gravity control. As speed increases, the ride height control system works in tune with the active aero system to optimise aerodynamic balance. When under hard braking, such as when entering a bend, ride height control minimises variations to prevent instability caused by the weight transfer towards the front. While cornering the system contributes to increasing downforce to maintain the optimal balance. As the car exits the bend, the system contrasts the tendency for the balance to shift towards the rear, maintaining the best possible conditions for traction for all four wheels and stability.

The F80 is powered by a three-litre V6 internal combustion engine and hybrid electric motor system. Together, they produce a total of 1,200 hp, making it the most powerful road-going Ferrari ever created. It has a claimed 0-62 mph of just 2.15 seconds and can reach a top speed of 217 mph.

The F80 will be produced in a limited run of just 799 and costs

The F80 independent suspension is actuated by four electric motors, a double wishbone layout, active inboard dampers and suspension arms created by Additive Manufacturing (Courtesy Ferrari)



The McLaren W1 features additively manufactured titanium components (Courtesy McLaren Automotive)

around €3.6 million ($3.9 million). However, it is reported that all have now been allocated to new owners.

McLaren W1

The McLaren W1 is the latest supercar from McLaren Automotive, and successor to the legendary McLaren F1 and P1. The W1 features Formula 1-inspired front suspension, mounted directly into the carbon fibre monocoque, with externally visible front arms and key components, some of which have been additively manufactured for weight optimisation.

The company reported that titanium Additive Manufacturing has been used for the front uprights and wishbones. These form integral parts of the McLaren Race Active Chassis Control III system, which includes an active inboard heave suspension, rear active drop links, and adaptive damping.

The W1's advanced suspension system reportedly enables the supercar to maintain stability and provide excellent cornering performance, both on the road and the track.

This announcement followed the news in July this year that McLaren would use Divergent Additive Manufacturing technology to produce chassis components for its next-generation supercars. Divergent's DAPS technology helps the automaker integrate more complex and innovative designs into its vehicle architecture, particularly in its additively manufactured suspension components.

The DAPS system is said to enable McLaren to significantly reduce the weight of critical structures while achieving better manufacturing efficiencies and supporting a more sustainable supply chain.

McLaren announced that a total of 399 W1's, starting at around £2 million each, are set to be produced, all of which have now been reserved.

www.ferrari.com
www.mclaren.com

L3Harris delivers its first additively manufactured copper thrust chamber RL10 rocket engine to ULA

L3Harris Technologies, Melbourne, Florida, USA, has delivered the first RL10 engine that features an additively manufactured copper thrust chamber to United Launch Alliance (ULA).

The latest version, the RL10E-1, uses Additive Manufacturing to reduce the number of parts in the thrust chamber by 98%. The engine is set to fly on a ULA Vulcan rocket next year.

"The RL10 has been the nation's premier high-performance, upper-stage rocket engine for more than sixty years, propelling hundreds of military, civil and commercial satellites into Earth's orbit and sending spacecraft to explore every planet in our solar system," stated Kristin Houston, President, Space Propulsion and Power Systems, Aerojet Rocketdyne, L3Harris. "Incorporating 3D printing enables us to build an engine that maintains the performance and reliability our customers have come to expect, while significantly reducing cost and lead time to meet the demands of today's marketplace."

The RL10 is said to be a highly efficient, upper-stage engine capable of making multiple restarts in space to place spacecraft into precise orbits or propel them to interplanetary destinations. This delivery marks the first of 116 RL10E-1 engines L3Harris will deliver to ULA under its latest contract. Two RL10 engines with a combined thrust of approximately 48,000 pounds will power each Vulcan rocket's upper stage.

www.l3harris.com

The new L3Harris RL10E-1 rocket engine features an additively manufactured copper thrust chamber built with 98% fewer parts than traditional RL10 engines (Courtesy L3Harris Technologies)

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BLT secures Airbus A320 serial production contract

Xi'an Bright Laser Technologies Co, Ltd (BLT), based in Xi'an, China, has earned Airbus' recognition for excellence in metal Additive Manufacturing processes, especially for the serial production of large, complex aircraft components.

On November 12, 2024, during the 15th China International Aviation and Aerospace Exhibition, Airbus held a press conference at the Zhuhai Space Center, where senior executives from Airbus China shared updates on Airbus' latest developments in China and conducted a signing ceremony.

In this newly obtained production package, BLT will utilise its self-developed BLT-S400 metal Additive Manufacturing machine, along with its proprietary high-quality superalloy powders, to meet the serial production requirements for this new part number.

BLT states that over the years it has demonstrated exceptional batch delivery capabilities, consistently fulfilling its commitments to stable and efficient delivery in Airbus collaboration projects. This reliability has enabled the partnership to expand in both scale and depth, establishing a solid foundation for broader and more enhanced cooperation. The signing of this new part production package signifies a deepening phase in the Airbus-BLT collaboration.

BLT is producing this Airbus A320 O-Ring. The company uses its BLT-S400 metal AM machine and superalloy powder (Courtesy BLT)

www.xa-blt.com
www.airbus.com

AML3D raises AU$30M, plans to double US capacity and add European base

AML3D Limited, headquartered in Edinburgh, Australia, has successfully completed a two-tranche institutional placement, raising approximately AU$30 million (around US$19.5M) . This investment is expected to enable the company to take advantage of recent contract opportunities, including from the US Department of Defense and Boeing.

"This successful equity placement marks another significant milestone for AML3D with investor demand being extremely strong," stated Sean Ebert, AML3D's Managing Director. "We are now in an excellent position to continue to rapidly advance our US expansion from Ohio, to take advantage of the demand from the US Department of Defense, whilst exploring the European markets by leveraging the backdrop of AUKUS.

To meet the demands of its recent contracts, AML3D will invest AU$12 million to more than double the manufacturing capacity of its US Technology Centre in Stowe, Ohio. The enhanced Ohio facility will build and supply AML3D's Arcemy Additive Manufacturing machines and fulfil contract manufacturing, alloy testing and prototyping contracts under the leadership of Pete Goumas, President of US Operations.

The company will initially install up to four additional Arcemy machines for the production of manufactured parts into the existing US facility whilst looking to lease a second facility for the assembly of Arcemy machines for sale to customers and to support the rollout to the US Navy defence contracting supply chain.

United Kingdom / European expansion

AML3D also announced that it intends to invest approximately AU$5 million to explore opportunities within the UK and European markets. It will identify a location for installing an Arcemy machine for use as a production and demonstration machine. The company said it is experiencing similar demand signals as it experienced in its entry to the US market, and currently has a bid in for a system to a defence-related customer which it expects to secure.

Investment in R&D programmes

AML3D will also invest up to AU$3 million to continue developing its software and Wire Arc Additive Manufacturing (WAAM) technology. AML3D's R&D programme is also designed to expand the range of applications for its Additive Manufacturing technology to help support the US and global defence sectors.

Sean Ebert stated, "The decision in September by the US Department of Defense to award Blue Forge an additional US$951 million of funds is expected to help accelerate the adoption of AML3D's Arcemy technology. My understanding is a reasonable proportion of the new funds will be directed to scaling up and integrating Additive Manufacturing into the US Navy's Submarine Industrial Base. The completion of this AU$30 million capital raising provides AML3D with the funds to scale up our US operations to maximise this opportunity.

"The placement also allows us to accelerate development of our software and technology to maintain our market-leading position in Additive Manufacturing, to maintain our competitive advantage and drive growth and value creation for our new and existing shareholders."

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Dyndrite partnership brings LPBF Pro to Nikon SLM Solutions machines

Dyndrite Corporation, based in Seattle, Washington, USA, has announced a collaboration with Nikon SLM Solutions, whereby Dyndrite's LPBF Pro software will be integrated across Nikon SLM Solutions' metal Additive Manufacturing machine portfolio, including the NXG series and the SLM 125, 280, and 500 models. Through Dyndrite's LPBF Pro software, Nikon SLM Solutions' customers gain access to advanced toolpath strategies that maximise the capabilities of the open-architecture AM machine. This partnership introduces capabilities such as scalable slicing, low-angle support-free build, optimised multi-laser coordination, and on-the-fly laser manipulation, enhancing productivity, and part quality for industrial-scale Additive Manufacturing.

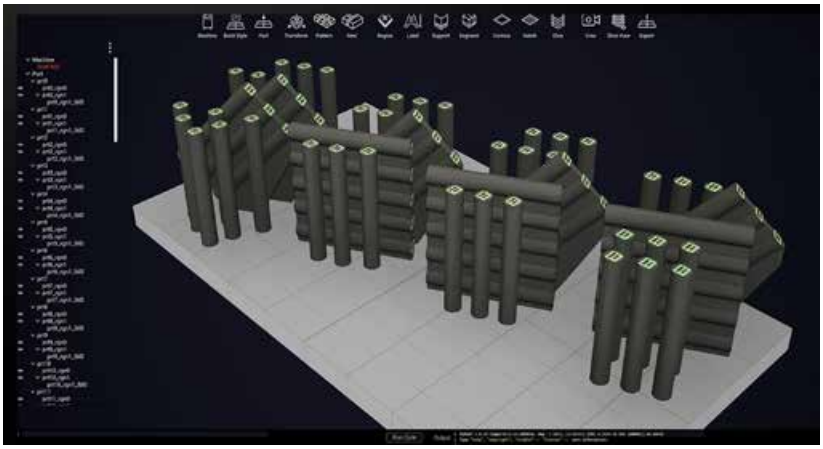
Using the toolpath generation with Nikon SLM's single and multi-optic laser systems, users can optimise scan paths to accelerate build rates, additively manufacture complex parts (e.g. those with intricate geometries, such as small features, thin walls, domes, and cantilevers), improve part quality and surface finish, and enable low-angle support-free builds.

Manufacturers will also be able to develop their own intellectual property (IP), toolpaths, and optimised multi-optic laser allocations for their unique needs.

Dyndrite's LPBF Pro features Python-based scripting language, allowing users to design critical manufacturing applications that can automate complex workflows, shorten time for qualification, codifies knowledge and scales production.

"This partnership between Nikon SLM Solutions and Dyndrite represents a milestone for industries where metal Additive Manufacturing is essential to achieving high-performance, differentiated parts," stated Simone Castellani, Chief Technology Officer, Nikon SLM Solutions. "Our combined commitment to open architecture provides customers with unparalleled access to capabilities that drive innovation, fast-track production, and maximise efficiency across the entire process. Ultimately, our customers benefit the most by reducing time-to-market and achieving lower end-part costs."

Dr Simon Merkt-Schippers, EVP of Product Management at Nikon SLM Solutions, added, "Dyndrite shares our customer-centric vision. Through open architecture and this partnership, we provide our customers access to the most powerful solutions available while supporting their specific needs, ultimately bringing low end-part costs and accelerated end-to-end production closer to reality."



Dyndrite's LPBF Pro software will be integrated across Nixon SLM Solutions' metal Additive Manufacturing machine portfolio (Courtesy Dyndrite)

www.nikon-slm-solutions.com
www.dyndrite.com

JUSTWAY offers range of advanced on-demand manufacturing services

JUSTWAY, a rapid prototyping and on-demand manufacturer based in Hangzhou, China, has updated its online marketplace offering manufacturing services designed to meet the diverse needs of clients across a range of sectors. The production service options now include CNC machining, metal and polymer Additive Manufacturing, sheet metal fabrication, injection moulding, and urethane casting.

"Our mission at JUSTWAY is to provide our clients with unparalleled service and support throughout the entire manufacturing process," stated the company. "We understand the importance of precision and reliability, and we are dedicated to delivering solutions that exceed expectations."

For Additive Manufacturing services, customers can receive instant quotes by uploading their 3D files through the website. The online catalogue features over 100 materials, supporting everything from single prototypes to high-volume production. Metal options include aluminium, stainless steel, titanium and tool steel.

"In a competitive global market, JUSTWAY stands out for its dedication to quality and customer satisfaction," the company added. "We are constantly investing in the latest technologies and training to ensure that we remain at the forefront of the manufacturing industry."

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HP announces upgrades and collaborations at Formnext 2024

HP has announced a number of additions to its Additive Manufacturing solutions portfolio and partnerships aimed at reducing cost, scaling production and accelerating the adoption of metal AM.

HP S100 platform upgrades
The company announced new configurations for its HP Metal Jet S100 platform, all intended to enhance quality, repeatability, speed, and reliability across a broader range of production needs. These updates are expected to enable research centres, OEMs, laboratories, and startups to explore metal Binder Jetting at reduced adoption costs.

In parallel, HP is collaborating with Volkmann and Sinterzone to develop respective configurations for the HP S100 platform.

Collaborations
HP has also been taking part in collaborations with ArcelorMittal and Eaton. With ArcelorMittal, HP has combined its own metal Additive Manufacturing experience with ArcelorMittal's sustainable steel in an effort to reduce production costs, expand material options, and drive broader adoption of additively manufactured steel in key industries like automotive.

Through its collaboration with Eaton, HP has been working to support testing and validation of advancements in it its Metal Jet Additive Manufacturing solution. Thus far, the companies have worked on nitrogen-enhanced sintering, which is said to improve the mechanical properties of 316L parts, and the S100 Powder Processing Solution, said to reduce cost and improve yield during Binder Jetting. Together, the companies will evaluate the technology's potential for high-performance applications, ensuring it meets the industry's demands.

Eric Johnson, Senior Manager of Additive Manufacturing at Eaton Research Labs, added, "Partnering with HP on this programme has been an exciting opportunity to advance the manufacturing readiness of this technology and develop a cost-effective process that meets the requirements for our most demanding applications."

HP Metal Jet Adoption Centre
In collaboration with AMES, located in Barcelona, Spain, HP is launching the HP Metal Jet Adoption Center. This state-of-the-art facility will combine HP's Additive Manufacturing technology with AMES' metallurgical expertise to facilitate a more efficient transition from prototyping to full-scale metal production. The centre will offer a range of services, application development, and process optimisation to support its European customers.

Leading Minds Consortium
The Leading Minds Consortium brings together industry leaders like 3D Systems, Ansys, EOS, HP, Materialise, Nikon, SLM, Renishaw, Stratasys, and Trumpf, with the goal of overcoming barriers such as cost, expertise, and system integration, making large-scale industrial AM more accessible.

www.hp.com

HP announced new configurations for its Metal Jet S100 Additive Manufacturing platform (Courtesy HP)

Protolabs to end metal Additive Manufacturing at German facility

Proto Labs Inc, headquartered in Maple Plain, Minnesota, USA, has announced plans to restructure its manufacturing facilities in Germany. These include closing its injection moulding facility in Eschenlohe and ending metal Additive Manufacturing at its Putzbrunn site.

According to a Form 8-K SEC filing, Protolabs will continue offering all its manufacturing services to customers across Europe, including injection moulding and metal Additive Manufacturing. These services will be fulfilled through internal manufacturing facilities and a network of manufacturing partners.

As a result of these decisions, the publicly-listed company expects to incur restructuring charges in the range of $4.5–6 million, consisting of around $2.5–3.5 million in severance and other employee-related costs, and $2–2.5 million in fixed asset and facility-related write-down expenses.

The report stated that it expects to incur approximately $4 million of the total restructuring charge in the fourth quarter of 2024, with the remaining charge to be incurred throughout the remainder of the restructuring process.

Protolabs expects to complete the restructuring plan within the next year.

www.protolabs.com

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Materialise reports sales increase of 14% in third quarter 2024

Materialise, headquartered in Leuven, Belgium, has announced its financial results for the third quarter ending September 30. Total revenue increased 14.2% to €68.65 million, while gross profit as a percentage of revenue was 57.2% versus 56% in Q3 2023.

Adjusted EBIT increased to €4.4 million for the third quarter of 2024 from €2.33 million for the 2023 period, while adjusted EBITDA increased to €9.9 million for the third quarter of 2024, up from €7.9 million for the 2023 period. Net profit for the third quarter of 2024 was €3.04 million or €0.05 per diluted share, compared to €4.01 million or €0.07 per diluted share, for the corresponding 2023 period.

"In the third quarter of 2024 Materialise once again delivered strong operational results," stated Brigitte de Vet-Veithen, CEO. "Our consolidated revenue of €68,652k rose more than 14% compared to the same period last year, with increased revenue in all three of our business segments. Materialise Medical posted an especially strong quarter with revenue increasing more than 24%. At the same time, we grew our consolidated Adjusted EBIT by 89% to €4,408k without compromising our continued investments to drive future growth."

de Vet-Veithen concluded, "The consistently strong operational performance of our business segments throughout the first nine months of this year strengthens our confidence that our full-year 2024 revenues will be within our previously communicated range of €265,000-275,000k. In spite of the integration of the recent FEops acquisition, we are also maintaining our Adjusted EBIT guidance of €11,000-14,000 kEUR for fiscal year 2024."

www.materialise.com

3D Systems sees Q3 2024 revenue dip

3D Systems, Rock Hill, South Carolina, USA, announced its preliminary results for Q3 2024, stating the company expects revenues of approximately $112.9 million, a $10.9 million decrease from Q3 2023.

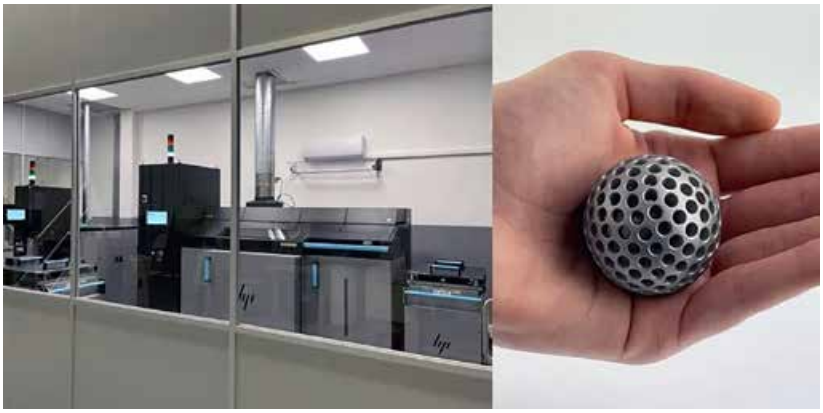
"As we review our third quarter performance, it's clear that we are continuing to navigate through a challenging operating environment particularly related to new hardware systems sales," stated Dr Jeffrey Graves, president and CEO of 3D Systems. "However, operations of our installed base, which is the largest in the world, remains very robust, driving strong materials utilisation. Revenue from consumable materials grew 10% compared to the third quarter of 2023, and 9% sequentially from second quarter levels. Top-line performance in our industrial markets reflects the timing shift of a few significant orders that subsequently closed early in the fourth quarter."

www.3dsystems.com

AMES opens HP Metal Jet Adoption Centre for EMEA at its Barcelona facility

Powder Metallurgy parts maker AMES, headquartered in Barcelona, Spain, has opened an HP Metal Jet Adoption Centre for the EMEA region at its Barcelona factory. The collaboration with HP was announced at this year's Formnext.

The state-of-the-art facility combines HP's expertise in metal Binder Jetting technology with AMES' detailed knowledge of Press and Sinter Powder Metallurgy component production. It is expected to be used to facilitate a more efficient transition from prototyping to full-scale metal part production.



AMES has opened an HP Metal Jet Adoption Center at its Barcelona facility (Courtesy AMES)

"We are thrilled to adopt the Metal Binder Jetting technology as an alternative method for the mass production of complex-shape components, expanding the limits of Powder Metallurgy to new applications out of the traditional Press & Sinter tech," the company stated on LinkedIn.

The centre aims to accelerate the penetration of metal Additive Manufacturing technology across all industries. It will offer a range of services, application development, and process optimisation to support European customers in quickly advancing production goals.

www.ames-sintering.com
www.hp.com

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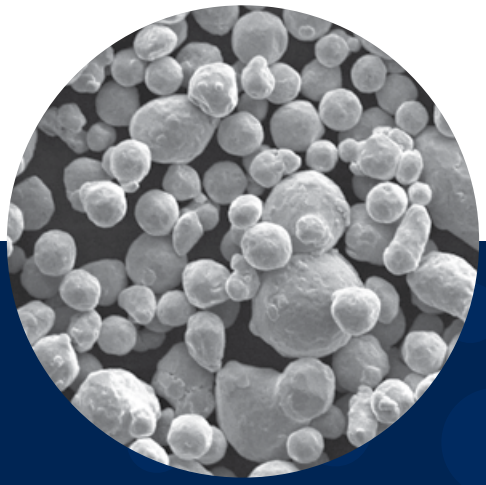

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ValCUN joins manufacturing demonstrator at Brainport Industry Campus to showcase AM

ValCUN, headquartered in Ghent, Belgium, reports it has joined the manufacturing demonstrator at Brainport Industry Campus (BIC), located in Eindhoven, the Netherlands. The company aims to showcase the value of Additive Manufacturing alongside conventional methods, such as milling, turning and casting, for industrial production.

ValCUN will demonstrate how its Molten Metal Deposition (MMD) technology creates added value with economic relevance to industrial products, ranging from customisation to serial production, and how it fits in the whole ecosystem.

Also onsite at the BIC is the AMcubator, an end-to-end Additive Manufacturing ecosystem that aims to develop scalable industrial applications. It provides the facilities for AM companies to house their experts in an application centre, as well as equipment in a pilot factory. Amongst the companies that joined AMcubator are AM-flow, Additive Center, Hexagon, KMWE and AMsystems.

"ValCUN, AMcubator and 3DOP share the same vision and it is a real pleasure that we can bundle forces to work towards the same goal," stated Jonas Galle, co-founder & CEO, ValCUN. "Looking forward to expand this concept together with the AMcubator partners amongst all 3DoP consortium members and beyond."

The opportunity is initiated within the framework of the project 'Optimisation of Production by 3DP' (3DOP), funded by the Interregional Innovation Investments (I3) Instrument, as part of the European Regional and Development Fund (ERDF). The project aims to transform the future of manufacturing through Additive Manufacturing Innovation and unlocking investments in this area at both the technology providers and industrial manufacturers.

Jan De Pauw, CTO ValCUN, adds "To make this concept even more concrete, the 3DOP consortium launched an Open Call to innovative companies to let them explore the possibilities of industrial Additive Manufacturing for their business. We hope that this minifactory concept at BIC acts as a trigger and enabler for this Open Call."

The 3DOP Open Call is a unique opportunity to develop an innovative idea by gaining access to the 3DOP partner facilities/services/solutions in a one-stop-shop and accessing high-quality services of the entire 3DOP ecosystem for free. It offers SMEs a chance to access consortium-developed facilities, capabilities, and services to validate and test innovative ideas.

www.valcun.be

ProductionToGo partners with Meltio to expand reach in DACH region

Meltio, headquartered in Linares, Spain, has announced that ProductionToGo, based in Karlsbad, Germany, is now an official sales partner for the German, Austrian, and Swiss (DACH) markets.

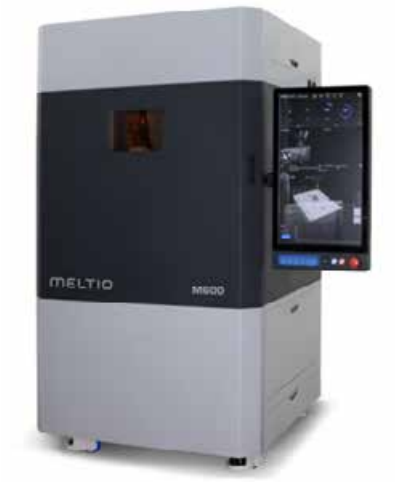
Under the agreement, ProductionToGo will play a key role in the distribution and support of Meltio's metal Additive Manufacturing solutions. The company will focus on building a supportive ecosystem for Meltio's technology in the DACH territory, partnering and driving business opportunities alongside technology centres, tooling machine companies, robotic integrators, academia, and industry.

"We at ProductionToGo are honoured and excited to be working with such a forward-thinking company as Meltio from now on. By integrating Meltio's products into our 3D printing portfolio, we can offer our partners and customers the newest cutting-edge capabilities in metal Additive Manufacturing and actively work together to influence the future of metal processing. We look forward to a long and active collaboration with Meltio," Ahmet Destan, Head of Metal at ProductionToGo, shared.

Meltio offers a metal Additive Manufacturing solution that enables industrial applications with a process built around welding wire, a safe, clean, and affordable metal feedstock.

Francisco González, Head of EMEA at Meltio added, "We are thrilled to be working with ProductionToGo 3D Solution and this collaboration between us serves as a great indicator of how Meltio's partner ecosystem and our unique wire-laser metal 3D printing technology for industries is evolving in the DACH region. Together, we will be able to cater to the ever-growing interest in Meltio's technology and its applications for different industries and reliable applications."

www.production-to-go.com
www.meltio3d.com



The Meltio M600 allows to printing of large parts or a batch of small parts in a row, simultaneously (Courtesy Meltio)

Renishaw launches dual-laser RenAM 500D Additive Manufacturing machine

At Formnext 2024, Renishaw, Wotton-under-Edge, Gloucestershire, UK, launched the dual-laser RenAM500D Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine. The latest in its RenAM 500 series, the new machine is said to lower the entry barriers to highly productive Additive Manufacturing by offering flexibility, cost efficiency and productivity.

The RenAM 500D features two 500 W lasers that can access the entire build platform. The RenAM 500D Ultra, fitted with Renishaw's TEMPUS technology, allows the laser to fire while the recoater is moving, reportedly saving up to nine seconds per build layer. The company noted that this time saving allows the machine to perform up to 3x faster than other single-laser machines without an expanding production footprint.

Renishaw has launched the dual-laser RenAM 500D metal Additive Manufacturing machine (Courtesy Renishaw)

"The new dual-laser system enhances the current RenAM 500 portfolio, providing exceptional productivity at a competitive cost," explained Louise Callanan, Director of Additive Manufacturing at Renishaw. "By making high-quality AM systems more productive than ever, we aim to lower the entry barrier to this advanced technology and encourage wider adoption across different industries."

The RenAM 500D models are fully compatible with Renishaw's AM software suite, including Renishaw Central and QuantAM. This integration enables current AM users to introduce the dual-laser machine to operations without any interruptions to current workflows. Machines in the series are also equipped with intelligent gas flow and configurable powder handling.

The RenAM 500D is available to order now.

www.renishaw.com

Wayland Additive expands presence in Nordic & Baltic regions through Teccluster partnership

Wayland Additive, headquartered in Huddersfield, UK, has announced a partnership agreement with Teccluster A/S, based in Egtved, Denmark, to market its Electron Beam Powder Bed Fusion (PBF-EB) Additive Manufacturing machines to the Nordic and Baltic regions.

"I have worked with 3D printers since 1989 and I have known Pete [Hansford] for many years," stated Lynnerup. "His experience in this industry is almost — ALMOST — as long as mine. What the Wayland team has achieved with the NeuBeam process is remarkable and solves many of the issues that companies using metal AM technologies face. It is particularly impressive that the Calibur3 system can deliver advanced applications in a much broader range of metal materials, including notoriously difficult materials such as Tungsten and Moly [Molybdenum] and associated alloys. Add to this the fact that parts produced by Calibur3 require only a fraction of the post-processing that other metal processes require, and the Calibur3 system is a compelling solution for manufacturers with complex metal applications. I am looking forward to sharing this solution across my network."

Peter Hansford, CRO at Wayland Additive, also commented on the partnership agreement, which was finalised at Formnext 2024, "This agreement with Teccluster further demonstrates the excitement about, and the very real demand for, the capabilities of our NeuBeam process. As Per says, we have known each other for a long time, and he is one of the most knowledgeable people I know in this industry. It is brilliant that Wayland and Teccluster will be working together to deliver the capabilities and the advantages of Calibur3 to a wider audience. I am delighted to be working with Per and expanding machine sales across the Nordic and Baltic regions."

www.waylandadditive.com
www.teccluster.com

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CP Ti, Ti6Al4V GR5(23), BT9, BT20, Ti17, Ti31, Ti6242, Ti4822, Ti2AlNb
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IDS Cologne, Germany Mar 25-29, 2025

rapid + tct Los Angeles, USA Apr 8-9, 2025

Global AM companies form Leading Minds Consortium

A number of global Additive Manufacturing companies have come together to form the Leading Minds Consortium, in an attempt to address barriers manufacturers may face when adopting and scaling industrial AM. Announced at this year's Formnext, the consortium includes Ansys, EOS, HP, Materialise, Nikon SLM Solutions, Renishaw, Stratasys and Trumpf, and is also open to new member companies. Their initial focus is on developing a common language framework for Additive Manufacturing.

According to a 2023 survey conducted by B2B International, companies recognise Additive Manufacturing as a key trend in manufacturing, but almost all companies (98%) experience challenges and barriers to adopting the technology. These include a lack of expertise, perceived high costs, and a sometimes complex integration with established processes. Overcoming these hurdles requires more than individual efforts; Leading Minds calls for industry-wide collaboration to make the technology more accessible to a broader range of manufacturers.

The primary objective of the Leading Minds consortium is to increase awareness of AM's capabilities across more industries and eliminate hurdles that manufacturers face. This collective effort is not just about enhancing Additive Manufacturing, but about taking practical, actionable steps to reshape the manufacturing landscape to be more innovative, sustainable, and capable of meeting the evolving needs of advanced manufacturing.

One of the consortium's first initiatives is to address the fragmentation and complexity of industry nomenclature to ensure that all players can operate with a clearer understanding of Additive Manufacturing's capabilities. At present, many companies and technologies operate using different terminology for similar concepts, making it difficult to collaborate effectively and limiting the full potential of Additive Manufacturing in industrial production. To resolve these miscommunications, the consortium intends to develop a common language framework that facilitates better communication, allowing manufacturers and technology providers to work together more effectively.

www.ansys.com
www.eos.info
www.hp.com
www.materialise.com
www.nikon-slm-solutions.com
www.renishaw.com
www.stratasys.com
www.trumpf.com

ADDiTEC expands sales network with UK-based Tri-Tech 3D

At Formnext 2024, ADDiTEC, Palm City, Florida, USA, announced a strategic collaboration with Tri-Tech 3D, Stoke-on-Trent, UK, to expand UK sales of ADDiTEC's product line. The range includes the AMDROiD — a turn-key laser-wire-based Directed Energy Deposition (DED) Additive Manufacturing robotic solution — and the Hybrid machines, multi-technology manufacturing platforms that combine Liquid Metal Jetting (LMJ) and laser-based DED capabilities with CNC machining.

"This represents a significant milestone in our commitment to deliver exceptional value to customers in the UK," stated Brian Matthews, CEO of ADDiTEC. "As a proud native of the UK, I am personally excited to work closely with Tri-Tech 3D to meet the growing demand for advanced manufacturing solutions across sectors like aerospace, automotive, and energy."

The companies stated that their collaboration hopes to support efficiency, innovation and sustainability in UK manufacturers through the addition of ADDiTEC's Additive Manufacturing capabilities. It was noted that sectors known for rigorous demands on material performance and production precision (e.g. aerospace, defence, automotive) may benefit from the flexible technology.

Tri-Tech 3D's Managing Director, Adrian Painter, added, "Working with ADDiTEC allows us to further our mission of providing cutting-edge solutions to our clients. Their advanced technology is a perfect fit for our existing product portfolio, and we're excited to introduce these new capabilities to our customer base across the UK."

Tri-Tech 3D is ADDiTEC's official UK sales partner (Courtesy ADDiTEC)

With a strong presence reported in the UK, Tri-Tech 3D can provide potential technology adopters with advice on initial specifications and work with ADDiTEC to grow its UK install base. Tri-Tech 3D is supported by sister company Cadspec, allowing it to offer an end-to-end solution for customers integrating CAD/CAM software with advanced manufacturing.

www.additec3d.com
www.tritech3d.co.uk

Lockheed Martin expands Additive Manufacturing capabilities with state-of-the-art Texas facility

Lockheed Martin has announced the addition of a state-of-the-art Additive Manufacturing facility at its Grand Prairie, Texas, USA, site. The expansion includes the addition of large-format, multi-laser Additive Manufacturing machines, as well as heat treatment and inspection equipment that enables rapid development and production of AM parts across the corporation. This includes the installation of two NXG 600E machines from Nikon SLM Solutions.

"We continue to invest in AM technology to provide value for our customers in a way that empowers our engineers to innovate and rapidly integrate new product designs and capabilities to the production floor," said Tom Carrubba, Vice President of production operations at Lockheed Martin Missiles and Fire Control. "This allows us to create affordable and modular designs that can simplify both high and low-volume production processes."

Transforming product design and development

The expansion leverages one of its existing machining hubs and is intended to support its customers' immediate and future product needs across Lockheed Martin.

"As part of our 1LMX digital transformation initiative, we are implementing AM in the early phases of our new product designs as a technical risk reduction tool," said Hector Sandoval, a Lockheed Martin fellow. "Other benefits of AM include improved product performance, as well as reduced development and lead time of our product portfolio."

The machines used in Lockheed Martin's facilities can produce intricate geometries and lightweight structures that reduce machining operations, lead times and material waste by manufacturing near-finished parts.

"Using this state-of-the-art, large platform AM technology at Lockheed Martin enables us to rapidly iterate and manufacture all of our products, resulting in savings and design freedom for all of our customers," stated Brian Kaplun, a Lockheed Martin fellow. "AM lives in the digital world and this allows us to support our customers in a far more nimble and responsive fashion than if we were using traditional design and manufacturing methods."

Lockheed Martin has recently installed two large format NXG 600E machines from Nikon SLM Solutions (Courtesy Lockheed Martin)

The digital nature of AM enables manufacturers to precisely control the production process, ensuring high levels of accuracy and consistency and resulting in significant benefits in repeatability and qualified processes for its customers. Additionally, AM designs can be iterated, optimised and produced more efficiently than traditional manufacturing methods, reducing time and cost while ensuring high-quality parts.

AM in practice

For example, in developing the multi-mission Mako hypersonic missile, engineers used AM to make guidance housing and tail fin parts, explained Lockheed Martin. They demonstrated that these critical assemblies met requirements at a fraction of the cost – 1/10th – and reduced production time, making it 10x faster and cheaper compared to conventional subtractive methods.

Lockheed Martin has also implemented AM technology on many new and legacy programmes, such as manufacturing F-35 simulator cockpits and components on GMLRS. By using a model-based engineering approach and leveraging AM expertise, the company redesigned a GMLRS antenna assembly test unit, reducing the number of parts. This enabled cost savings per unit and reduced its production schedule by months, driving solutions faster and more affordably.

There are significant AM opportunities in operations on its current production programmes. This may include greater cost and schedule savings. The ability to produce much larger structures with these AM systems is seen as a competitive advantage against near-peer threats and provides unique solutions for national security.

AM also enables technical and supply chain-risk reduction. By using AM as replacements for items such as brazements, heat exchangers, casting, etc., Lockheed Martin can consolidate parts and reduce the product design phase and manufacturing lead time.

www.lockheedmartin.com

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Meltio unveils the Meltio Engine Blue integration kit at Formnext

Meltio, headquartered in Linares, Spain, introduced its Meltio Engine Blue integration kit at this year's Formnext. The setup is intended to enhance and streamline the manufacture of metal parts with industrial robotic arms and vertical machining centres, bringing Meltio's wire-laser Directed Energy Deposition (DED) Additive Manufacturing technology to factories and workshops.

"The new Meltio Engine Blue represents a crucial breakthrough in Meltio's Directed Energy Deposition technology, designed specifically to respond to the current demands of the manufacturing industry around the world," stated Alejandro Nieto, Meltio Product Manager. "For our industrial customers, the Meltio Engine Blue represents a significant improvement in reliability and deposition rate, enabling increased production speed and quality.

"With a fibre-optic-free system and a 1.4 kW blue laser head, we have simplified integration into robotic arms and vertical machining centres, reducing maintenance times and eliminating common problems such as the need for continuous laser alignment. This approach will allow our customers to optimise their processes, reducing downtime and improving compatibility with a wide range of materials."

The Meltio Engine Blue directs the build head, where the blue lasers melt the metal. It can process a range of metals, including stainless steel, titanium, copper, aluminium and nickel, making it possible to additively manufacture metal parts with high reliability and optimised density.

By eliminating the need for constant laser alignment and featuring an upgraded wire feeding system, the Meltio Engine Blue is intended to allow for more continuous, uninterrupted operation. The more compact and lightweight design also includes upgraded safety features reaching the highest performance level (depending on integration), enabling a high level of protection in the industrial environment.

In addition, the use of blue lasers reduces energy consumption by a reported 30% and offers a deposition rate up to 3.5x higher than the previous version.

"The development of the new Meltio Engine Blue has been a painstaking process of more than two years, in which our engineering team has worked collaboratively with our partners and integrators to identify and overcome the challenges faced with the V3," stated Alejandro Nieto. "Among the most important industry demands were the need to reduce maintenance time, increase reliability, and improve deposition rate. The elimination of components such as fibre optics and collimators has simplified the system, while the blue laser head and dual power supply system allow continuous and flexible operation, adapting to different materials and applications."

www.meltio3d.com

The Meltio Engine Blue integration kit streamlines the manufacture of metal parts with industrial robotic arms and vertical machining centres (Courtesy Meltio)

AM-Flow unveils its latest automated in-line quality control system

AM-Flow, based in Amsterdam, the Netherlands, unveiled the next generation of its AM-Quality automated in-line quality control system for Additive Manufacturing at Formnext 2024 . The latest iteration is designed to support high-precision production environments, conducting scans with 50 µm accuracy. These scans are capable of identifying issues such as breakages, warping, and surface defects. AM-Quality enables early detection and correction of sub-quality builds directly during production.

AM-Quality's patented technology is intended to adapt to infinite geometries, enabling its integration into any production line. The system performs rapid OK/Not OK evaluations within a five-second takt-time, with the option to generate full metrology reports, and is capable of inspecting up to 720 products per hour.

Utilising eight high-speed CMMs, AM-Quality generates 3D scans at a higher quality than nominal digital-source files (such as STL, STEP, and CAD).

www.am-flow.com

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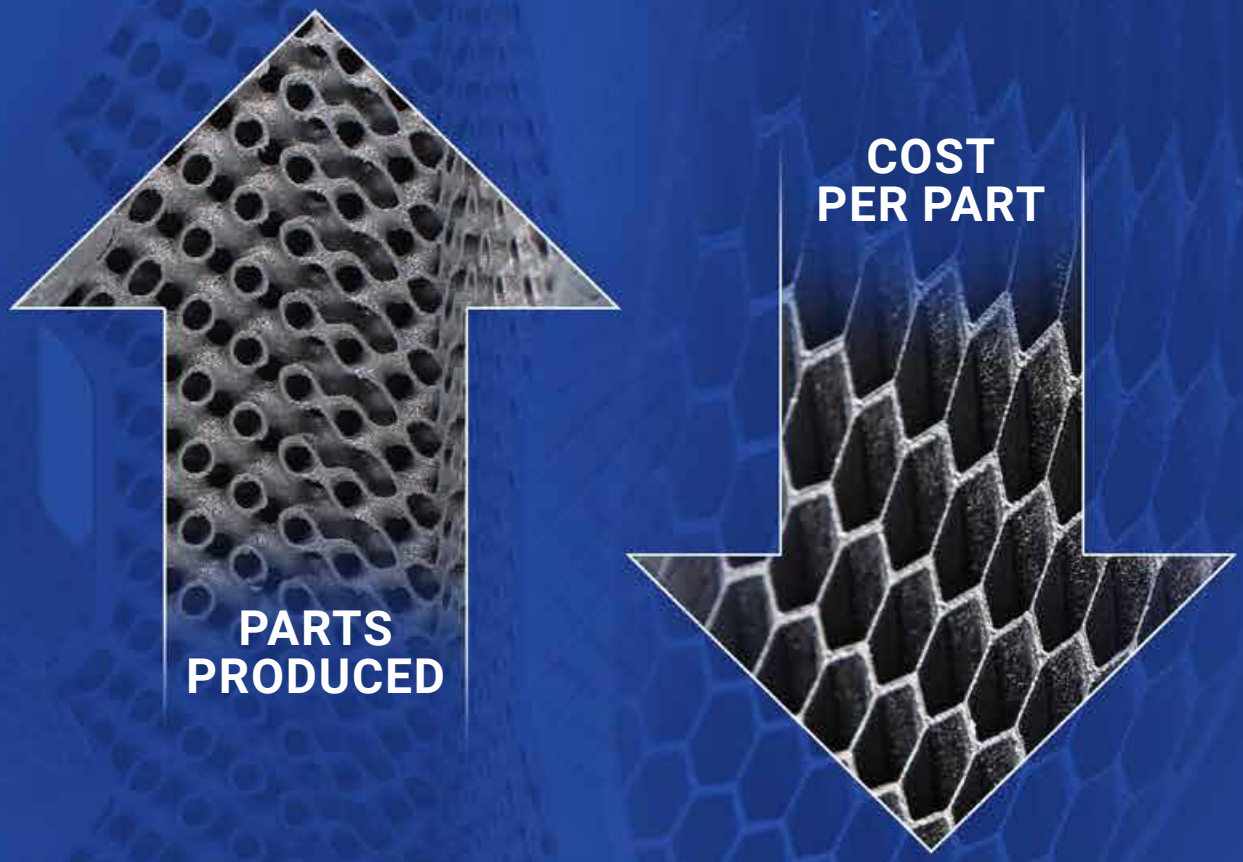

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Part design credit 3D Systems

Angelelli Automobili shows additively manufactured Ducati Panigale V4 motorcycle frame

Angelelli Automobili, based in Rome, Italy, showcased its additively manufactured Titan-Alu Panigale V4 motorbike frame, designed for the Ducati Panigale V4, at the EICMA Motorcycle Show in November at Fiera Milano, Milan, Italy. The frame, based on a 2020 design by Davide Angelelli, was optimised for AM using the company's proprietary Alien Mesh Design software and manufactured by WEAREAM based in Brescia, Italy.

"This groundbreaking advancement represents the peak of our Additive Manufacturing technology, first pioneered in 2018, and now fully ready to tackle every challenge in both the automotive and motorcycle motorsport sectors," Davide Angelelli stated in a LinkedIn post.

Each component of the Ducati Panigale V4 frame was engineered to be a single, seamless component, eliminating the need for moulds, resins, welds, or CNC machining. Angelelli Automobili credits these developments to its customisable algorithms which can be tailored for specific applications, enabling the customisation vital for luxury vehicles, limited-production series and one-of-a-kind builds.

"In 2018, we achieved a milestone by creating the world's first car chassis entirely via Additive Manufacturing," Angelelli added. "Now, we proudly continue this legacy, delivering a technology set to redefine motorsport performance and innovation."

www.virtualmind.it/angelelliautomobili

The additively manufactured Titan-Alu Ducati Panigale V4 motorbike frame (Courtesy Angelelli Automobili)

Nikon SLM Solutions sells its 1,000th machine to Bosch to drive innovation in automotive industry

Nikon SLM Solutions has announced the sale of its 1,000th machine — an NXG XII 600 Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine — to Robert Bosch GmbH.

Bosch is expected to use its NXG XII 600 to optimise the production of critical parts for powertrain technology, hydrogen and electric drive applications from its 3D Printing Manufacturing and Processing Centre in Nuremberg, Germany. Here, the company focuses on the use of Additive Manufacturing in both prototyping and serial production.

"We're honoured to celebrate our 1,000th system milestone with Bosch, a longstanding partner who truly understands the transformative power of Additive Manufacturing," stated Sam O'Leary, Nikon SLM Solutions' CEO. "The NXG XII 600 is designed for high-output production environments, and we look forward to seeing Bosch leverage this technology to push boundaries in automotive and beyond."

The NXG XII 600 features a twelve-laser configuration and is suitable for the production of large-scale, high-quality components, particularly those made from more challenging materials like aluminium alloys. The machine includes an exchangeable build cylinder to minimise downtime and a closed-loop powder handling system that prioritises operator safety and material efficiency.

www.nikon-slm-solutions.com
www.bosch.com

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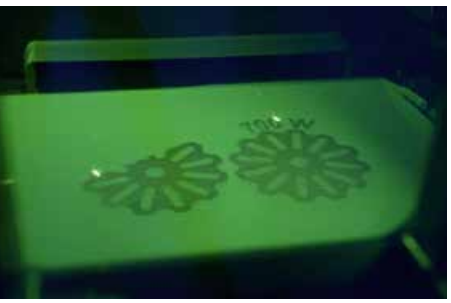


The TruPrint 3000 is our versatile medium-format machine. Benefit from increased productivity thanks to the cooled build plate, the De-focus function, and full 700 watt laser power – perfect for processing specialty alloys and reducing your part costs. The new powder handling station, designed for easy sieving and conveying of metal powder within just 1 m^2, ensures consistently high powder quality.

www.trumpf.com/s/TruPrint-3000

Farsoon introduces compact FS191M Laser Beam Powder Bed Fusion machine

At Formnext 2024, Farsoon Technologies, based in Changsha, China, has unveiled its FS191M Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine. This machine is intended to advance the solutions available for pilot projects and low-volume manufacturing.

"The FS191M builds on the success of our small volume FS121M system, first launched in 2016," said Wenyu Guo, Director of Farsoon's Metal Product Line. "Over the past six years, we've worked closely with industrial and research partners to optimise productivity, streamline workflows, and expand process capabilities — all while maintaining a low cost of ownership. This approach is enabling us to unlock new markets, including consumer products, tooling, and more."

The FS191M features a standard φ191x199 mm build cylinder and 500 W fibre laser, nearly 4x the build volume of the FS121M. Farsoon noted this as one of the largest build capacities in its category. For research and development purposes, the FS191M offers an optional φ78x80 mm build platform, which is intended to reduce material costs and enhance flexibility. The ability to switch between platform sizes allows users to transition from validation to low-volume production.

Designed with a compact footprint of 0.94 m^2, the FS191M can be conveniently deployed in office environments, providing versatility for a variety of setups.

The FS191M Additive Manufacturing machine includes a high-precision F-Theta lens for consistent and accurate laser performance; an integrated filtration system enabling smooth and efficient operations; in-chamber monitoring cameras for real-time process oversight; a recoater design for reliable and uniform powder distribution; and an advanced control card for process control. Additionally, its open parameter strategy allows users full customisation of material processing, making it suited for diverse industrial applications.

Farsoon notes that its FS191M includes add-on modules and capabilities, including:

- SRS (Support Reduction System)
- High-resolution melt pool monitoring
- 3D structured light monitoring system for high-precision Z-axis monitoring in order to reduce powder recoating defects
- Advanced optical solutions like laser beam shaping
- High-temp build plate up to 400°C

www.farsoon.com

SWISSto12 adds four Additive Industries MetalFabG2 Additive Manufacturing machines

SWISSto12, based in Renens, Switzerland, has expanded its production capacity with the purchase of four MetalFabG2 metal Additive Manufacturing machines from Additive Industries, headquartered in Eindhoven, the Netherlands.

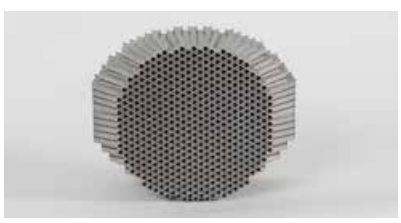
The MetalFabG2s, are equipped with four full-field lasers for maximum productivity. As each and every laser can access and melt material all over the 420 mm x 420 mm build plate, it enables users to achieve precise geometrical tolerances and the highest laser utilisation during every layer of a build process. The build size also enables SWISSto12 to push the limits of Radiofrequency (RF) satellite payload performance and create next-generation systems with mechanical and thermal features integrated in large monolithic products, maximising the value of a reduced part count and mass savings.

Out of the four machines procured by SWISSto12, three will be dual-core versions of the MetalFabG2 which incorporate advanced automation features for build setup, build changeover, build starts, laser calibration, integrated powder handling solutions and advanced scanning strategies. The combination of size, precision and productivity makes the MetalFabG2 a compelling production asset for demanding applications like RF components.

Mark Massey, CEO of Additive Industries, shared, "We are delighted to announce SWISSto12's investment in our MetalFabG2s. It is a testament to the trust they place in our technology to meet the exacting demands of their industry. Our metal 3D printers, equipped with four full-field lasers, provide unparalleled precision and automation, making them an ideal choice for SWISSto12's cutting-edge RF products."

Emile de Rijk, CEO of SWISSto12, added, "Our collaboration with Additive Industries marks a milestone in our pursuit of excellence in RF technology and production scale-up. The quality and capabilities of the MetalFabG2s align seamlessly with our commitment to innovation and quality. This investment enables us to service the growing requirements and production volumes for our aerospace customers."

www.additiveindustries.com
www.swissto12.com



SWISSto12 is a leading manufacturer of advanced satellite payloads and Radio-Frequency systems (Courtesy Swissto12)

WAAM3D launches large format Cold-Wire Gas Metal Arc RoboWAAM XP

WAAM3D, based in Milton Keynes, UK, launched its new large-format RoboWAAM XP at this year's Formnext. The Additive Manufacturing machine incorporates Cranfield University's patented Cold-Wire Gas Metal Arc (CWGMA) process that enables deposition rates of up to 15 kg per hour, without compromising on the quality and precision required for high-performance materials.

RoboWAAM XP expands the size, and mass capabilities of the company's integrated systems and works natively with alloys of iron, aluminium, nickel, and copper. It has been under development since 2018, and under industrial testing over the last two years with trusted partners in the energy, space, marine, and mining industries.

Featuring a maximum build envelope of 2 x 2 x 2 m, and a maximum payload of 2.1 tonnes, the RoboWAAM XP fully integrated system is intended for manufacturing industries that have a requirement for large-scale spare parts with a short lead time. Besides the patented CWGMA process, RoboWAAM XP ships with MIG, MAG, and CMT capabilities provided by Fronius and, due to its default 8 axes of motion, there is no compromise on the geometrical complexity that it achieves, irrespective of the size of the payload.

Cranfield University's CWGMA process not only provides a high level of control but also enhances process efficiency by achieving higher deposition rates at the same energy input. The result is a significant boost in productivity through faster process speeds, whilst delivering in terms of quality and precision.

WAAM3D has launched its new large-format RoboWAAM XP fully integrated system (Courtesy WAAM3D)

"The introduction of WAAM3D's latest, fully-integrated RoboWAAM XP system offers users higher productivity, whilst maintaining precision and control," stated Dr Jialuo Ding, CTO of WAAM3D. "It is a testament to the partnership between WAAM3D and Cranfield University and our teams' commitment to innovation and excellence in the field of Additive Manufacturing. The launch of RoboWAAM XP is a pivotal moment in the industry, as it offers a solution that meets the growing demand for higher productivity, while maintaining the stringent quality standards necessary for advanced applications."

Stewart Williams, one of the company's founders, Technical Director at WAAM3D and a Professor at Cranfield University, added, "The key innovation with CWGMA is the addition of a non-energised cold wire to a conventional GMA process. Through this novel arrangement, high efficiencies can be obtained by nearly doubling the amount of material deposited for the same energy input. The addition of a non-energised wire greatly stabilises the process, making it suitable for a very broad range of materials. With the unique level of control offered by CWGMA, there are also opportunities to adapt the microstructure to attain the desired properties."

www.waam3d.com

Expansion of HIP and vacuum heat treatment capabilities at ITS Bilbao

Isostatic Toll Services Bilbao SL (ITS Bilbao), Spain, has announced that it intends to commission its fourth MEGA Hot Isostatic Pressing (HIP) unit within the next three years and, by Q2 2025, to commission a fully molybdenum vacuum heat treatment furnace from TAV. Its first heat treatment unit, the 1200 x 1600 x 1200 mm furnace will feature a maximum vacuum of 10-5 mbar, making it suitable for titanium. This additional heat treatment capability will enable ITS Bilbao to offer a combined MEGA HIP and MEGA Heat Treatment service to its HIP customers.

ITS Bilbao ran the first cycle of its MEGA HIP unit in December 2019. While the COVID-19 pandemic followed shortly after, with its impact on the aerospace sector felt by the company, demand for toll HIP services surged again following the recovery. This increased demand prompted the company to decide, in Q1 2022, to double its existing capacity. A MEGA HIP unit, identical to the original, was commissioned in the following year.

Over the following twelve months, demand for the second unit exceeded its capacity, leading to the installation of a third MEGA HIP unit in 2024. Set to be commissioned in 2025, the unit is identical to the previous, with a Ø1088 x 2570 mm loadable zone corresponding to 2.4 m^3, and an increased maximum working pressure of up to 138 MPa (20,000 psi).

www.isostatictollservices.com

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ArcelorMittal and HP partner to advance steel Additive Manufacturing

ArcelorMittal and HP have announced a strategic collaboration to advance the use of steel in Additive Manufacturing. Together, the partners will work to bring new steel solutions to a sufficient Technology Readiness Level (TRL), then leverage the ArcelorMittal Research Center as an incubator for new applications developed in collaboration with customers.

The move is intended to save customers the initial investment needed to evaluate and qualify the technology, up until the process can be transferred to a contract manufacturer for final industrialisation and production.

"We are thrilled to collaborate with HP in advancing steel Additive Manufacturing," stated Aubin Defer, Chief Marketing Officer, ArcelorMittal Powders. "This collaboration leverages our combined expertise to develop innovative solutions to drive the industry forward. The promising results of our steel powders with HP's Binder Jetting technology are a testament to the potential of this partnership."

By combining HP's Metal Jet S100 Binder Jet Additive Manufacturing technology with ArcelorMittal's sustainable steel solutions, the collaboration aims to lower the cost of AM. This, it is hoped, will unlock a range of applications for Additive Manufacturing, particularly in the automotive sector. The partnership will also extend material options, developing steel products with unique properties that are unattainable through conventional manufacturing.

Alexandre Tartas, Global Leader of Metals Sales & Go To Market at HP, added, "We are excited to join forces with ArcelorMittal to push the boundaries of steel Additive Manufacturing. This collaboration will enable us to leverage our technical expertise and ArcelorMittal's leadership in sustainable steel solutions to create groundbreaking advancements in the industry. Combining the steel expertise of ArcelorMittal and HP Additive Manufacturing positioning in high volume production offers a unique value proposition for the manufacturing industry."

www.hp.com

corporate.arcelormittal.com

ArcelorMittal and HP will collaborate to advance the use of steel in Additive Manufacturing (Courtesy HP)

Siemens to acquire software provider Altair Engineering

Siemens has signed an agreement to acquire Altair Engineering Inc, an industrial simulation and analysis software provider based in Troy, Michigan, USA. The deal, valued at approximately $10 billion, will see Altair shareholders receive $113 per share. The price represents a 19% premium to Altair's closing price on October 21, 2024, the last trading day before media reported the possible transaction.

"Acquiring Altair marks a significant milestone for Siemens," stated said Roland Busch, president and CEO of Siemens AG. "This strategic investment aligns with our commitment to accelerate the digital and sustainability transformations of our customers by combining the real and digital worlds. The addition of Altair's capabilities in simulation, high performance computing, data science, and artificial intelligence together with Siemens Xcelerator will create the world's most complete AI-powered design and simulation portfolio. It is a logical next step: we have been building our leadership in industrial software for the last fifteen years, most recently, democratising the benefits of data and AI for entire industries."

By adding Altair's highly complementary simulation portfolio, with strength in mechanical and electromagnetic capabilities, Siemens aims to enhance its Digital Twin to deliver a full-suite, physics-based, simulation portfolio as part of Siemens Xcelerator. Altair's data science and AI-powered simulation capabilities allow users from engineers to hobbyists to access simulation expertise, decreasing time to market and accelerate design iterations.

"This acquisition represents the culmination of nearly forty years in which Altair has grown from a startup in Detroit to a world-class software and technology company. We have added thousands of customers globally in manufacturing, life sciences, energy and financial services, and built an amazing workforce, and innovative culture," said James Scapa, Altair's founder and CEO. "We believe this combination of two strongly complementary leaders in the engineering software space brings together Altair's broad portfolio in simulation, data science, and HPC with Siemens' strong position in mechanical and EDA design. Siemens' outstanding technology, strategic customer relationships, and honest, technical culture is an excellent fit for Altair to continue its journey driving innovation with computational intelligence."

www.siemens.com
www.altair.com

Quintus introduces new QIH 200 URC Hot Isostatic Press with post-processing ability

At Formnext 2024, Quintus Technologies, based in Vasterås, Sweden, introduced its large-format QIH 200 URC Hot Isostatic Press (HIP). The new press integrates Quintus' High Pressure Heat Treatment (HPHT), a proprietary process that combines stress-relief (SR), HIP, high-temperature solution annealing (SA), high-pressure gas quenching (HPGQ), and subsequent ageing or precipitation hardening (PH) into one integrated furnace cycle.

Production of wrought, cast, Powder Metallurgy, and additively manufactured components has traditionally involved several heat treatment steps post HIP, often outsourced to a third party. The QIH 200 URC's additional capabilities allow multiple functions to be performed at a single location.

"Our new press model QIH 200 URC produces faster throughput and higher workpiece quality," stated Peter Henning, Director Marketing and Sales, Quintus Technologies. "Having fewer pieces of equipment on the production line also enhances efficiency and dramatically reduces per-unit processing costs while generating significant savings in space, energy, and infrastructure. We expect this press to become a cornerstone of lean production lines for AM, casting, and PM HIP industries."

The hot zone of the model QIH 200 URC measures 880 mm in diameter and 2,150 mm in height. With an operating pressure up to 207 MPa (30,000 psi) and temperature up to 1,400°C, the press can reportedly achieve 100% of maximum theoretical density and improve the ductility and fatigue resistance of critical, high-performance materials. It is suited for components produced through a variety of Additive Manufacturing and Powder Metallurgy processes as well as casting.

The press also features Quintus's exclusive Uniform Rapid Cooling (URC) and control systems which offer full digital connectivity to enable the repeated performance of customised heating, densification, and cooling regimes.

Alongside its equipment, the company offers a Quintus Care, a customised service programme that works to ensure customers receive operational reliability, maximum performance, controlled annual cost and long-term partnership. Participants in the programme have access to Quintus' application centres, where they can receive assistance on technical challenges and process parameters from materials science experts.

"As the industry leader in advanced Hot Isostatic Pressing technology for over seventy years, we have noted exceptional interest in new manufacturing approaches that improve quality, lower operational cost, and significantly reduce both lead times and environmental impact," added Johan Hjärne, recently appointed CEO of Quintus Technologies. "Our new QIH 200 URC press is the result of our strong focus on materials science and materials processing research, and we are very pleased to support our customers' goals for innovation, productivity, and sustainability."

www.quintustechnologies.com

Quintus Technologies introduced its large-format QIH 200 URC Hot Isostatic Press at Formnext 2024 (Courtesy Quintus)

GKN Aerospace opens Additive Manufacturing facility in Sweden

At an event attended by Sweden's Minister of Infrastructure, Andreas Carlson, GKN Aerospace formally opened its Swedish Additive Manufacturing facility. The company has reportedly invested some £50 million in the new venture, and has plans to create around 150 new job opportunities for highly skilled operators, technicians, and engineers at the Trollhättan site.

With support from Swedish Energy Agency and Industriklivet, the plant is expected to become a central hub for innovation in aircraft engine components. New technology means that GKN Aerospace is expected to greatly reduce the use of raw materials, making the aircraft engine lighter and more efficient. "We are the first in the world to industrially produce aircraft engine components on this scale, so our facility is completely unique," stated Martin Wänblom, VP Operations for GKN Aerospace Sweden. "The fact that we can take this step shows what cutting-edge expertise exists in Sweden and especially here in western Sweden."

www.gknaerospace.com

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Continuum opens sustainable metal powder production facility in Houston

Continuum Powders hosted the grand opening of its global headquarters and manufacturing facility in Houston, Texas, USA, on December 5. Reported to be North America's largest sustainable metal powder production facility, the company planned to offer guests the chance to see the company's low-carbon production methods firsthand.

The completion of the Houston facility is said to reflect the company's commitment to environmental responsibility, with the entire building operating as a green manufacturing centre. The site is also pursuing green certification goals and is designed to maximise energy efficiency through renewable energy usage and recycling initiatives.

Continuum also stated that the opening of the new facility marks a significant step forward in delivering sustainable solutions that meet the demands of a rapidly evolving industrial landscape. With increased production capacity and multiple US locations, the company is now positioned to deliver products faster at reduced shipping costs, enhancing supply chain resilience for customers.

"Our new Houston facility not only expands our production capabilities but also allows us to scale our mission of decarbonising the manufacturing industry," said Rob Higby, CEO of Continuum Powders. "We are committed to providing high-quality, cost-competitive metal powders while minimising environmental impact. Our technology represents a distinct advantage in the market, offering sustainable solutions that align with the needs of forward-thinking industries."

The ribbon-cutting ceremony featured (left to right) Cory Steffek, Ara Partners, Betty Russo, Texas Economic Development & Tourism Office, Rob Higby, CEO of Continuum Powders, and Rizk Ghafari, COO of Continuum Powders. (Courtesy Continuum Powders)

The facility features Continuum's proprietary Greyhound M2P (melt-to-powder) plasma atomisation process, which enables the repurposing of alloyed metal waste-stream products into high-quality metal powder in a single step. By enabling a cradle-to-cradle process, the platform can reduce the need for transportation, product handling, primary melting, and extensive long bar processing operations, while also minimising the environmental impact by reducing the mining of elemental metal resources.

"Houston represents a leap forward in our operational efficiency and sustainability efforts," said Rizk Ghafari, COO of Continuum Powders. "By combining state-of-the-art technology with our commitment to decarbonisation, we are not only supporting our customers' needs but also setting a new benchmark for responsible manufacturing in the industry."

www.continuumpowders.com ■

ValCUN expands team and plans relocation to support business growth

ValCUN, headquartered in Ghent, Belgium, has announced plans to relocate to a larger facility in the Ghent area in early 2025. The move aims to accommodate projected growth and enable further development of the company's product range and capabilities.

As part of its expansion plans, ValCUN has strengthened its team by adding key personnel to its business development, research engineering, and office management teams. These strategic hires are expected to support the company in its growth phase.

"We are delighted to welcome new colleagues to the team," stated Jonas Galle CEO. "Each of them are filling up key skillsets that we were lacking for entering a new company stage and to ensure the continuation of our exponential growth. In addition, we are excited to announce that this team growth is accompanied with the moving to a new larger premises by beginning of next year. This gives the business the right platform for further growth."

ValCUN's Additive Manufacturing machines use a proprietary Molten Metal Deposition (MMD) technology. The process is a single-step method that uses metal wire as feedstock. The aluminium filament is fed into a heating chamber where it is melted. The chamber has a nozzle at the bottom through which liquid metal is extruded, fusing with the previous layer to build up the part.

Molten Metal Deposition technology is said to result in a cost reduction of 75% to 90% compared to other metal AM technologies, as it offers energy efficiency, waste reduction, and the elimination of toxic chemicals or powders. The method also produces parts which don't require debinding, sintering, powder removal or Hot Isostatic Pressing (HIP).

www.valcun.be ■■■

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Caracol launches large-format metal Additive Manufacturing machine

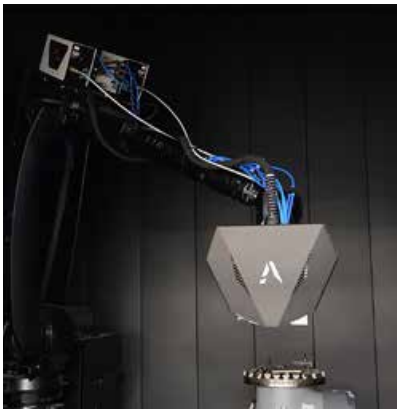
Caracol, based in Barlassina, Italy, debuted its large-format Vipra AM Wire Arc Additive Manufacturing (WAAM) machine at this year's Formnext. The company's new robotic platform aims to transform the production of large-format metal components.

"At Caracol, we believe that the future of manufacturing lies in combining a strong application focus with advanced innovative technologies that reshape the capabilities of industrial production lines," stated Francesco De Stefano, CEO of Caracol AM. "With Vipra AM, we've leveraged the extensive know-how developed over years working on advanced process control and software for Large Format AM with thermoplastics and composite materials, to develop a proprietary cutting-edge metal platform that combines state-of-the-art hardware and software with advanced robotic monitoring and automation. Thanks to this innovative technology, we want to enlarge the possibilities of industrial manufacturers to produce their most complex large-scale projects."

The company stated it has spent several years developing and scaling parts production with the Vipra AM, in an effort to develop a platform that could target specific applications. This led Caracol to two new Vipra configurations: the Vipra XQ and the Vipra XP.

"The launch of Vipra AM represents a significant breakthrough for the metal Additive Manufacturing industry," added Gianrocco Marinelli, Metal Additive Manufacturing Director at Caracol. "In today's competitive market, manufacturers face mounting challenges, from material waste and long lead times to the pressure of reducing costs while maintaining high performance. Vipra AM introduces cutting-edge capabilities and complements existing processes, enabling hybrid production models that combine legacy techniques with advanced metal deposition to help manufacturers optimise production lines, reducing waste, accelerating lead times, and driving overall efficiency without overhauling their entire operations."

Vipra XQ (Extreme Quality)
Using Plasma Arc Deposition, the XQ is suited for components requiring very high levels of strength, high-quality finishes and precision, such as large-scale, high-strength, high-integrity parts for sectors like aerospace (e.g. load-bearing brackets and structural components) and energy (e.g. valves, gauges and structural piping connectors). The machine can be used to process a range of metals, including stainless steels and titanium alloys.



The large-format Vipra XQ Wire Arc Additive Manufacturing machine (Courtesy Caracol)

Vipra XP (Extreme Productivity)
The XP is focused on maximising productivity and minimising operating costs in the production of complex large-scale metal projects. The machine is able to additively manufacture aluminium and nickel-based materials, making it suited to parts where lead times and lighter weights are the main focus, including the transportation industries (e.g. automotive components, aerospace pressure vessels, marine propellers) and lower-end architecture (e.g. sculptures and lightweight organic structures).

www.caracol-am.com

CNPC to manufacture APWorks' Scalmalloy powder for AM

CNPC Powder, headquartered in Vancouver, Canada, has formed a strategic alliance with APWorks GmbH, based in Taufkirchen, Germany, to manufacture and commercialise Scalmalloy, its high-performance aluminium-magnesium-scandium alloy developed for Additive Manufacturing.

"We are excited about this agreement with APWorks and an impressive milestone for the company to expand our portfolio and production line with the manufacturing of an important material such as Scalmalloy," stated Kathy Liu, General Manager of CNPC Powder. "We are also prepared for possible future joint development of new Scalmalloy formulations."

Developed for Additive Manufacturing, Scalmalloy has a proven track record in a wide range of applications in aerospace, robotics, marine and motorsport, and is an approved material under the FIA regulations. Combining high strength with excellent ductility and processability, it is said to be an ideal material for use in highly loaded and safety-critical parts.

Jon Meyer, CEO of APWorks, added, "We see this agreement as important for the industry. CNPC has demonstrated a high level of quality control and their powder is achieving excellent results. We look forward to working with CNPC to further improve the economics and availability of Scalmalloy powder, for the benefit of the industry as a whole."

www.cnpcpowder.com
www.apworks.de

United Grinding acquires GF Machining Solutions

United Grinding Group, based in Miamisburg, Ohio, USA, has signed an agreement with Georg Fischer AG, Schaffhausen, Switzerland, to acquire its division GF Machining Solutions (GFMS), based in Biel, Switzerland. The move is expected to strengthen United Grinding's market position and serve its global customers with more comprehensive solutions. The transaction is valued between $714–737 million (CHF 630-650 million) and is expected to close in Q1/Q2 2025, subject to regulatory approvals.

GF Machining Solutions offers a range of tooling for PM presses under its System 3R brand (Courtesy GF Machining Solutions)

GF Machining Solutions provides solutions for manufacturers of precision parts and tools and mould and die makers. Its portfolio includes machines for milling, eroding, laser texturing, laser micromachining and Additive Manufacturing. The group currently employs around 3,500 people at over forty global locations.

Through its System 3R brand, GFMS provides a range of tooling for the Powder Metallurgy industry. When producing punches and dies, the tooling reduces setup times and is said to improve accuracy and quality with fewer rejections. When used in the powder compaction press, setup times are also drastically reduced, with improved accuracy and quality of parts.

For metal Additive Manufacturing, GFMS partners with 3D Systems to offer a range of machines. These include the DMP Flex/Factory 350 and DMP Factory 500.

The DMP Flex 350 enables the efficient production of very dense, pure metal parts and includes improved gas flow technology for improved uniform part quality across the entire build area. The DMP Factory 500 is a workflow-optimised metal Additive Manufacturing machine that produces parts of up to 500 x 500 x 500 mm in size. Engineered using 3D Systems' metal additive technology along with GF Machining Solutions' technical and industrial knowledge, the DMP 500 incorporates precision System 3R clamping systems.

United Grinding is one of the world's leading manufacturers of grinding, eroding, laser, and measuring machines, as well as machine tools for Additive Manufacturing. The company employs around 2,000 people at over twenty locations.

United Grinding's majority shareholder is Patinex AG, a Swiss holding company. Through its Mägerle, Blohm, Jung, Studer, Schaudt, Mikrosa, Walter, EWAG, and IRPD brands and competence centres in America and Asia, the company offers a large product portfolio and a full range of services for the production of high-precision components.

www.grinding.com
www.gfms.com

Incus introduces redesigned and rebranded Hammer Evo35

Incus GmbH, based in Vienna, Austria, has announced the launch of its Hammer Evo35 lithography-based metal manufacturing (LMM) Additive Manufacturing machine, a redesign of its Hammer Lab35.

The Hammer Evo35 is designed to deliver higher production capabilities and industrial performance. It is intended for use in professional environments that prioritise floorspace and effective machinery.

The Hammer Evo35 has undergone an architectural overhaul, with a CNC-grade frame, mechanics and updated projector units. These projectors are expected to better support the LMM technology, enabling fine resolution, improved surface finishes and larger build fields.

The new machine also offers a climate control system said to be improved from the Hammer Lab35 in an effort to keep the Evo35 operational in all production environments. Evo35 also features new software architecture, streamlining communications with ERP systems.

"We are proud to introduce the Hammer Evo35, a reflection of our ongoing dedication to advancing metal Additive Manufacturing," said

Incus has launched an updated and rebranded iteration of its Hammer Lab35: the Evo35 (Courtesy Incus)

Incus CEO, Dr Gerald Mitteramskogler. "This redesign combines all the benefits of our core LMM technology with new features that increase efficiency, reduce costs, and improve safety while maintaining the superior quality our customers expect."

www.incus3d.com

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Low carbon environmental protection

www.cnpcpowder.com

Amazemet unveils Powder2Powder atomiser for recycling metal powders

Amazemet Sp Zoo, based in Warsaw, Poland, introduced its new Powder-2Powder (P2P) atomisation machine at Formnext 2024. The P2P system is reported to provide a versatile solution for recycling metal powders, and manufacturing custom pre-alloy powders directly from powder feedstock. The technology combines plasma processing and ultrasonic atomisation to transform irregular or oversized particles into highly spherical, satellite-free powders optimised for Additive Manufacturing. Unlike plasma spheroidisation, the P2P technology allows powder size to be independent of the initial feedstock, reportedly making it the only technology capable of direct atomisation of pulverised titanium feedstock.

"The Powder2Powder system goes beyond recycling," explains Łukasz Żrodowski, inventor and CEO of Amazemet. "It gives manufacturers the ability to customise powder compositions, improve powder sphericity, and optimise particle size distribution, solving critical issues in the AM industry."

Extensive trials using +200 µm oversize and irregular Ti alloy powders have reportedly shown exceptional results with the P2P system. Operating at a frequency of 40 kHz, the system consistently achieved a powder morphology with an aspect ratio (D50) exceeding 0.95. The particle size distribution (PSD) was precisely controlled, producing powders with D90 < 80 µm and yielding particles <63 µm and ⩾80%. Nearly 97% of the resulting powder was suitable for AM processes, including Laser Beam Powder Bed Fusion (PBF-LB), Directed Energy Deposition (DED), and Electron Beam Powder Bed Fusion (PBF-EB), highlighting the machine's potential to enhance sustainability in metal powder production.

Tomasz Choma, Application Engineer at Amazemet with the new Powder-2Powder atomiser (Courtesy Tomasz Choma)

Additionally, the P2P system can process blends of elemental powders, creating pre-alloyed materials tailored to exact chemical compositions. This capability makes it invaluable for both research and industrial applications. Tests conducted with Ti and 10% wt. Mo elemental powders showed that both refractory elements formed homogeneous alloy powders during processing. Set for release in Q1 2025, this patented technology addresses two critical challenges in the AM industry – upcycling of powder waste and custom powder production – delivering advanced functionality that surpasses traditional recycling methods.

powdertopowder.amazemet.com

Mesago Messe Frankfurt postpones Formnext Chicago 2025

Mesago Messe Frankfurt has announced that Formnext Chicago will not take place in 2025, with the show being postponed due to unfavourable scheduling and the challenging situation in the AM industry. The organiser said that the clash of dates with RAPID + TCT Detroit was making it more difficult for exhibitors and visitors to commit to one of two important events.

Whilst Mesago Messe Frankfurt stated that it worked to resolve the scheduling situation with all parties involved, the negotiations were unsuccessful.

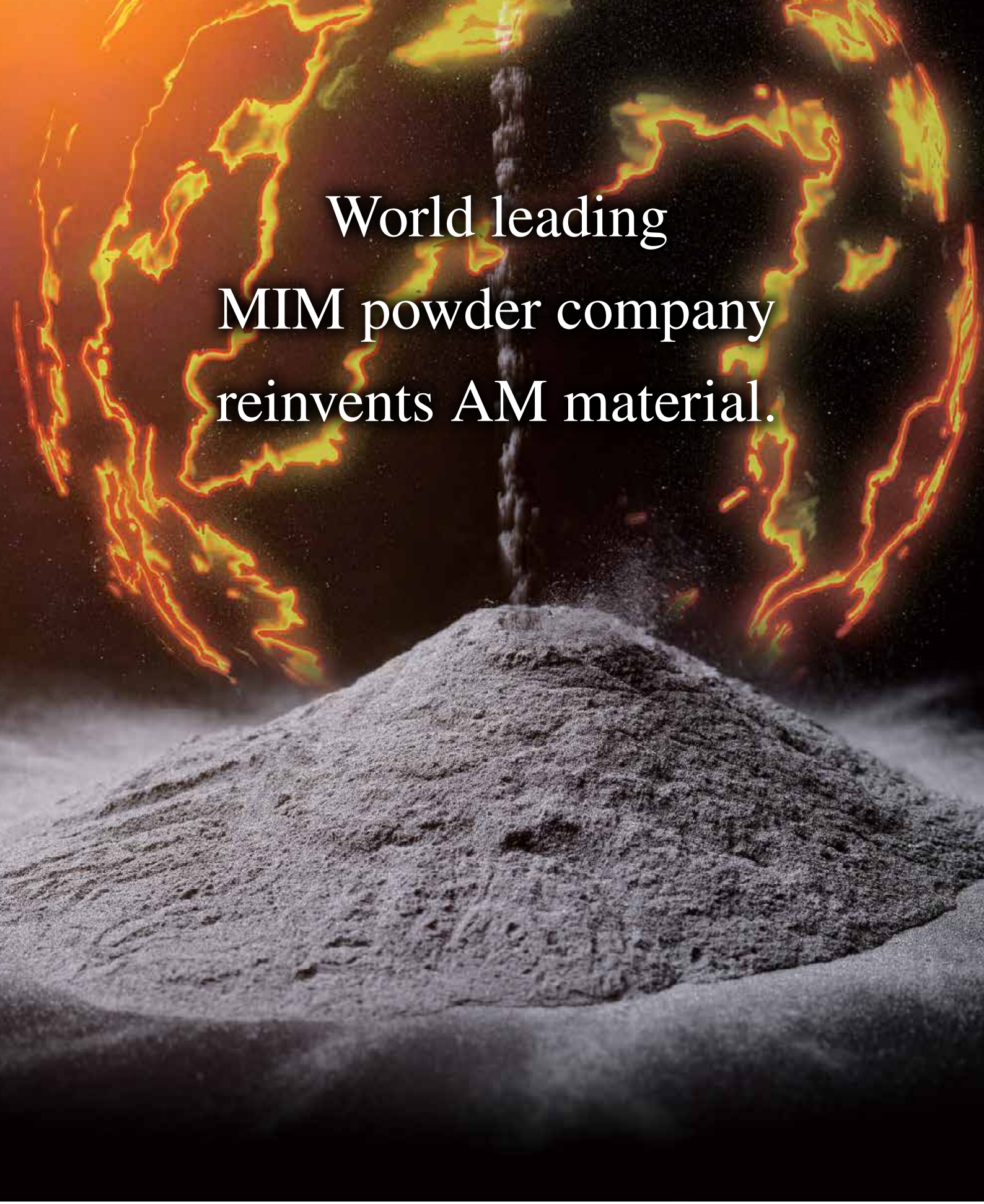
"After careful consideration and intensive discussions with our key partners, we have jointly decided to postpone the start of Formnext Chicago, which was originally scheduled for 8-10 April 2025," explained Sascha Wenzler, Vice President at Mesago Messe Frankfurt GmbH. "This decision was not taken lightly. We are convinced that it is in the best interests of the industry and the companies involved."

In partnership with AMT – The Association For Manufacturing Technology (organiser of IMTS), Gardner Business Media and Messe Frankfurt USA, Mesago Messe Frankfurt is working to develop a new strategic approach for the US market, ensuring future events are well-timed and aligned with the needs of the Additive Manufacturing industry.

"Our priority is to support the buyer and seller community in ways that truly benefit their businesses, and we believe this is the best course of action to achieve that goal," explained Douglas Woods, AMT President.

"We thank our partners and the entire community for their support and understanding and look forward to working together to shape the next steps for Formnext in the US," added Petra Haarburger, president at Mesago Messe Frankfurt.

www.formnext.com



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m4p material solutions secures €3 million funding to expand metal powder production

m4p material solutions GmbH, with operations in both Austria and Germany, has announced it has received a €3 million investment from Finindus NV and Berkau Beteiligungs GmbH. In addition to the financial backing, the investors will bring valuable connections in the metallurgical and Additive Manufacturing sectors, along with extensive experience in supporting the growth of emerging companies.

m4p specialises in advanced metal powders for industrial Additive Manufacturing. It offers a portfolio of over 160 products designed and manufactured specifically for Laser Beam Powder Bed Fusion (PBF-LB) applications and used by over 400 customers.

The company develops and produces standard alloys optimised for Additive Manufacturing as well as customised powders which are tailored to specific applications.

The additional funding will facilitate the expansion of m4p's geographical presence into North America and Asia, the introduction of new innovative alloys for Additive Manufacturing and the support of additional AM technologies besides PBF-LB. Furthermore, m4p will deploy its fully digitised business processes, improving the supply chain and quality experience for existing and new customers.

"m4p impressed us with their strong position in their home market, which we quickly understood is due to their unwavering commitment to customer satisfaction, paired with a profound understanding of both materials and processes," said Roel Callebaut, Senior Investment Manager at Finindus. "By seamlessly integrating flexibility with stringent contamination control of powders and minimising batch variability they empower their customers to focus on what they do best: building exceptional parts."

Andreas Berkau, of Berkau Beteiligungs, added, "As one of m4p's first customers, I have been able to follow the company's development closely over the years. I have been particularly impressed by the fact that m4p has managed to build up an excellent reputation among users, service providers and machine manufacturers in recent years. I look forward to supporting m4p in the coming years with both capital and technical expertise."

Philipp Tschertou, CEO of m4p, shared, "We are honoured to have Finindus and Andreas Berkau as new shareholders, as they bring their market knowledge and experience on top of the financial funding for further market penetration. We are looking forward to a successful and rewarding cooperation with our top class shareholder group for the benefit of our customers."

www.metals4printing.com

Beehive Industries secures $12.4 million contract for Additive Manufacturing low-cost jet engines

Beehive Industries, based in Englewood, Colorado, USA, has been awarded a $12.46 million contract to collaborate on the development and production of low-cost Small Expendable Turbine (SET) engines with the University of Dayton Research Institute (UDRI) and the Air Force Rapid Sustainment Office, Wright-Patterson Air Force Base, Dayton, Ohio, USA.

The contract is to develop a 200 lb thrust class engine using Additive Manufacturing, and covers the design, manufacture, testing, and qualification of the engine, including demonstration of manufacturing scalability, completion of flight testing, and an initial production run of 30 engines. The programme will be completed within 24 months and work will be performed in Beehive's Cincinnati, Denver, and Knoxville facilities.

Earlier this year, Beehive announced the successful test completion of its 500 lb thrust engine as part of its strategy to develop a family of engines ranging from 100-5,000 lbs of thrust for a variety of applications including drones, standoff systems, and Collaborative Combat Aircraft. This programme will enable Beehive to build on that success and apply its additively-enabled design and manufacturing processes directly in support of the need for capable, affordable, and readily available propulsion systems.

"Beehive is excited to have this opportunity to bring its capabilities to bear on the affordable mass challenge for the US military in collaboration with the University of Dayton Research Institute," said Gordie Follin, Chief Product Officer for the company. "Our state-of-the-art Additive Manufacturing approach opens up new possibilities to radically alter the traditional relationships between cost, performance, and scalability while delivering high performance engines purpose-built for their applications."

Brian Stitt, Division Head for Sustainment Technologies Transition at UDRI, said the Research Institute team is excited to partner with the US Air Force Rapid Sustainment Office and Beehive Industries to advance Additive Manufacturing in the aerospace and propulsion fields.

"This partnership will not only propel the Air Force but the additive industry as a whole, and we are proud to be a major part of it!," Stitt shared.

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Addimetal introduces K2-2 metal Binder Jetting machine

Addimetal, based in Toulouse, France, launched its K2-2 metal Binder Jetting Additive Manufacturing machine at Formnext 2024. Reported to be the first French-designed metal Binder Jetting machine, the K2-2 includes customisable build parameters and is equipped with the company's Orion software to enable workflow integration. After four years of development, and a successful year of beta testing, Addimetal is now offering the machine with a starting price of under €200,000.

"The K2-2 represents a game-changing advancement for industries like aerospace, automotive, luxury, and more. Our goal is to become one of the European leaders in metal Additive Manufacturing," stated Mohamad Koubar, CEO of Addimetal. "With the K2-2, we provide a solution that bridges the gap between lab-scale research and full-scale industrial production."

The K2-2 is capable of processing a variety of metallic powders and custom binders and features a build box measuring 200 x 200 x 200 mm. It is equipped with a wide build platform and is reportedly the largest print head on the market, covering over half the platform in one pass. The open system allows the use of non-proprietary binders, offering users greater material flexibility. It includes real-time environmental control with visual sensors to optimise the workspace for peak performance.

"Our machine's ability to use non-proprietary consumables offers unparalleled freedom to manufacturers, providing the flexibility they need to push the limits of innovation," said Franck Liguori, CCO of Addimetal. "We've designed the K2-2 to be versatile, cost-efficient, and easy to integrate into existing workflows, making it ideal for R&D teams and industrial applications alike."

The K2-2 includes customisable build parameters (Courtesy Addimetal)

Addimetal is actively exploring strategic funding opportunities to accelerate its development and drive forward innovation in its field.

www.addimetal.com

nLIGHT offers 2 kW dynamic beam shaping laser for PBF-LB AM

nLIGHT, Inc, based in Camas, Washington, USA, has announced the production launch of its Corona AFX-2000, a 2 kW laser with proprietary beam shaping technology which aims to boost productivity in Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing.

The AFX-2000 has reportedly undergone successful commercial validation with a leading customer supporting the aerospace, defence, and automotive end markets. Using aluminium alloys, this customer is now said to be achieving build speeds up to three times faster when compared to other large-format PBF-LB Additive Manufacturing machines.

Using dynamic laser beam shaping, the AFX-2000 is said to successfully deliver twice the amount of available power compared to current state-of-the-art lasers while maintaining a stable process. The increased power that AFX-2000 provides enables higher productivity and lower cost per part while maintaining the stability needed to produce high quality parts.

"The exclusive beam profiles of the AFX-2000 have brought [PBF-LB] print speeds to exciting new levels while maintaining precision, control and material quality for laser powder bed fusion," said Rob Martinsen, Chief Technology Officer of nLIGHT. "The dynamic beam shaping technology in these lasers allows for productivity-optimised switching between profiles ideal for fine-scale features and contour exposures, to extremely fast and highly reproduceable build rates using ring beam profiles, making it the most versatile and efficient laser available for metal AM."

"We anticipate the AFX-2000 to be widely adopted for highly reflective alloys such as aluminium and copper, materials that benefit greatly from stable, high-brightness laser processing," he continued. "The AFX-2000 will enable our customers to meaningfully reduce part costs for high-volume manufacturing."

Now in production, the AFX-2000 is offered in nLIGHT's modulus platform, an integrated multi-laser sub-system designed for ultra-high-productivity PBF-LB Additive Manufacturing machines. The modulus platform aims to simplify the integration, control, and serviceability of multi-laser machines, while enabling new levels of machine utilisation and reproducibility of production parts.

www.nlight.net

Conflux Technology secures $11 million funding to advance production system for heat exchangers

Conflux Technology, based in Geelong, Australia, has announced its $11 million Series B capital raise to further technology development and increase customer support worldwide. Breakthrough Victoria led the round, which was also participated in by AM Ventures and Acorn Capital.

"At Conflux Technology we pride ourselves on providing efficiency through heat transfer performance and weight-reduction at the heart of the world's devices," said Michael Fuller, founder and CEO of Conflux Technology. "With this additional funding and support, we will continue to advance our products and expand to support our customers across the globe."

The funding will be used to speed up the development of Conflux Production Systems (CPS) – an advanced end-to-end manufacturing solution for producing AM heat exchangers – as well as scale hiring and support customer demand across the US, Europe and Asia. CPS is a comprehensive production system that replaces traditional heat exchanger manufacturing plants, automating the production of complex AM structures to ultimately address supply chain risk, increase efficiency, and streamline operations.

"Investing in Conflux and their revolutionary new heat exchanger technology signifies our commitment to sustainable innovation and efficiency," said CEO, Grant Dooley of Breakthrough Victoria. "Conflux and this investment is a great testament of the innovations coming out of Australia, and we're proud to be playing a part in the creation of sustainable jobs in our region and supporting a local company that has solidified its position on the world stage."

Conflux Technology has built a strong reputation while serving a wide range of industries, including motorsports, high-powered industrial machines, hydrogen, e-mobility, defence and more. The latest funding has made growth and expansion possible, and Conflux is partnering with Odys Aviation to drive the development of the next generation of regional VTOL aircraft.

With the combination of Odys' expertise in hybrid-electric propulsion and Conflux's manufacturing solutions, the companies aim to create a heat recuperator turbo-generator solution that integrates seamlessly into an existing aerospace turbine and can reduce fuel consumption by over 40%. The solution targets reduced weight and increased efficiency of the turbo generator system. The system is planned for integration in Odys Aviation's 21 ft wingspan 'Laila' aircraft, a plane designed in multiple configurations for cargo, and once deployed, should enable the aircraft to achieve a range of 450 miles with payloads up to 130 pounds.

"Conflux's Additive Manufacturing and metal 3D printing technology erase traditional design barriers, allowing us to bring geometrically complex and performance-optimised recuperator designs to life — ultimately resulting in longer-range and higher-payload aircraft. We're excited to be working with Conflux's team to redefine the capabilities of VTOL UAS systems," James Dorris, co-founder and CEO of Odys, stated.

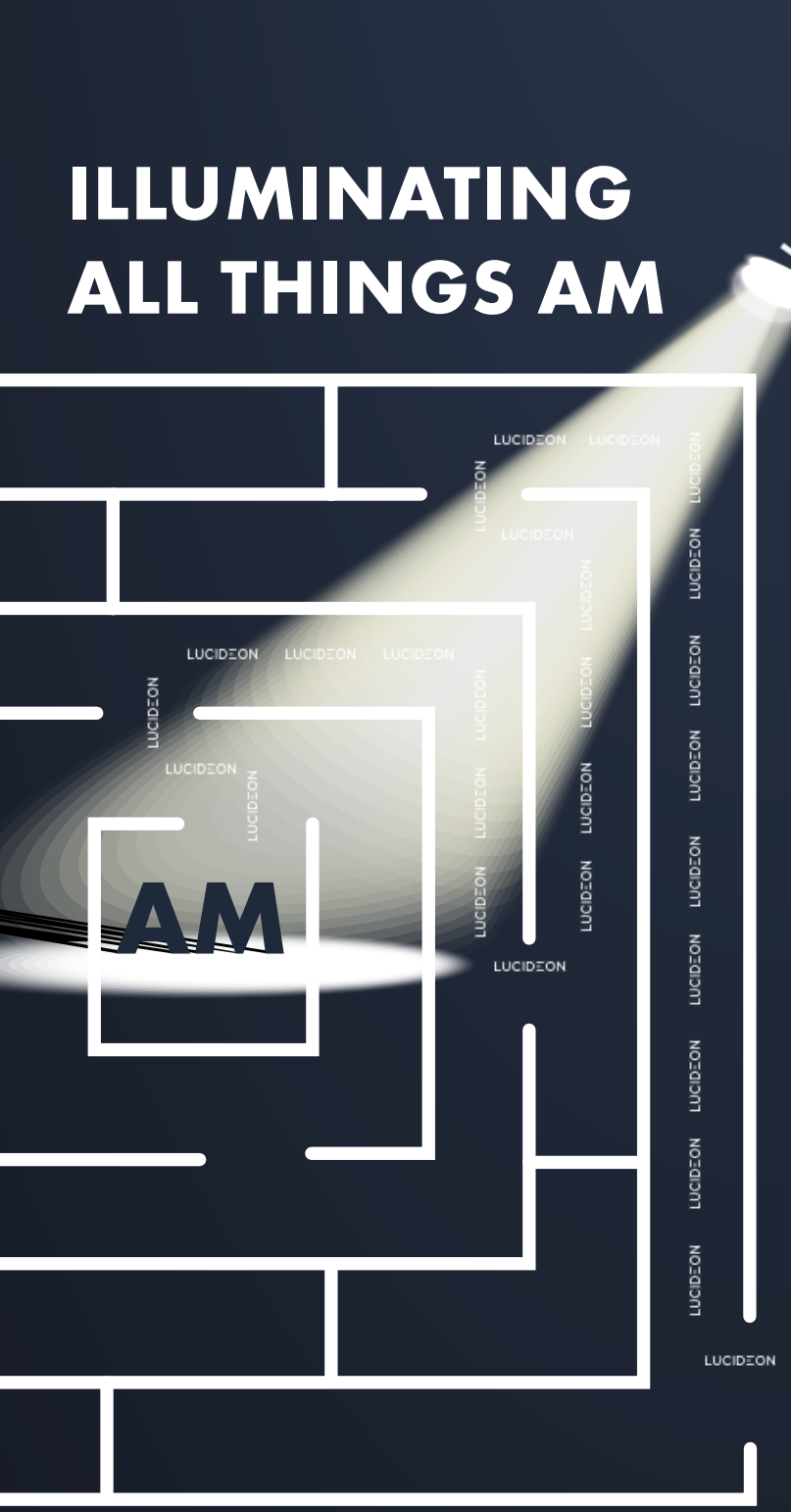
"Next-gen aviation is a key industry for us, and we're continuing to demonstrate our commitment to helping innovators in this space. We're proud to be supporting customers like Odys Aviation by providing them with the tools they need to drive advancements in sustainable aviation and power their aircrafts efficiently," added Fuller.

Conflux Technology is currently addressing $6 billion of the heat exchanger market globally and is excited to expand further through new partnerships and other developments that will be announced in the coming months. The company's goal is to productise both their heat exchanger designs and the process of manufacturing them so their customers can produce their Conflux heat exchangers locally for quick and efficient production and continued growth will help them achieve that.

www.confluxtechnology.com

Conflux Technology has announced its $11 million Series B capital raise to further technology development and increase customer support worldwide (Courtesy Conflux Technology)

ILLUMINATING ALL THINGS AM



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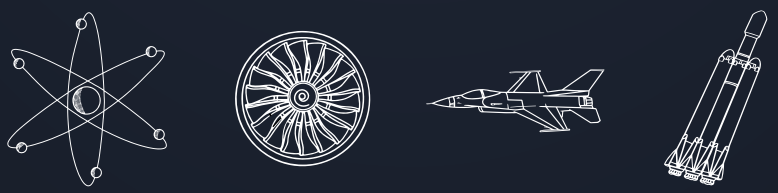

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Freeform secures NVentures and AE Ventures investments for metal Additive Manufacturing with AI

Freeform, a metal Additive Manufacturing company founded by engineers from SpaceX and based in Los Angeles, California, USA, has announced a major investment from NVIDIA's NVentures and AE Ventures. This investment is said to signal the start of a new era in advanced manufacturing, where artificial intelligence and hardware-accelerated computing converge to redefine metal production for industries ranging from aerospace to automotive.

As part of this investment, Freeform will join NVIDIA Inception, a programme that supports startups, and will leverage NVIDIA's accelerated computing platform to advance its existing AI-driven platform, which provides real-time predictive control over the complex physics of the metal Additive Manufacturing process.

"At Freeform, we are pioneering a transformation in manufacturing, where machine learning and supercomputing converge to make the impossible possible," said Erik Palitsch, CEO and co-founder of Freeform. "Building on NVIDIA's technology allows us to push the boundaries of what metal 3D printing can achieve, giving us the power to produce high-quality, digitally verified parts at speeds that were unimaginable a few years ago."

A new manufacturing facility built with AI

By utilising NVIDIA's accelerated computing platform, Freeform is building what is reportedly the world's first AI-native, autonomous metal Additive Manufacturing factory. This system integrates advanced sensing, process control, and machine learning to adjust the manufacturing process in real-time, guaranteeing precision and scalability at an unprecedented level.

"Freeform is leading the way toward autonomous manufacturing using accelerated computing," added Mohamed "Sid" Siddeek, corporate Vice President at NVIDIA and head of NVentures. "Their use of real-time AI-driven process controls and cutting-edge metrology systems sets a new standard for metal Additive Manufacturing."

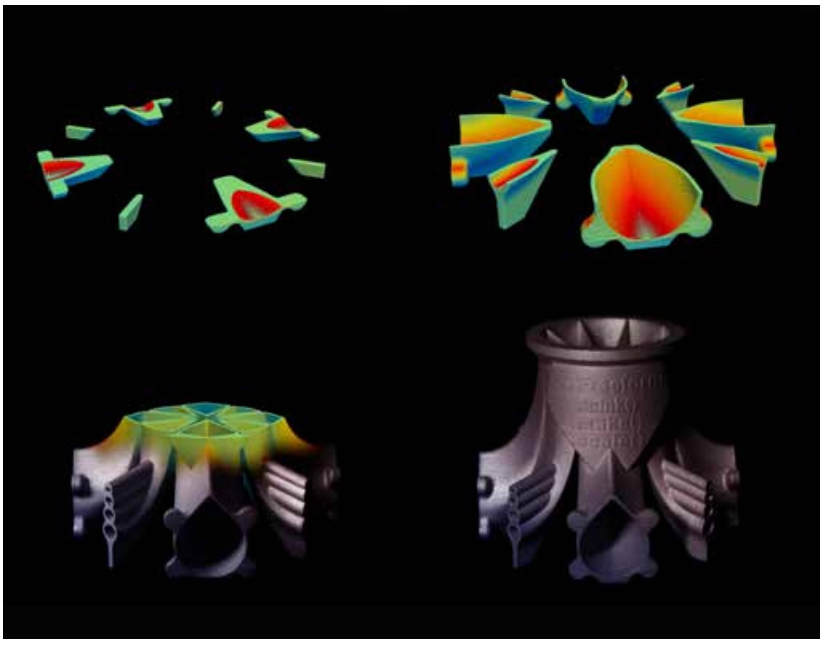
The company's deep-tech platform aims to solve the lack of intelligent process control in traditional metal Additive Manufacturing. Freeform's AI-powered platform learns continuously from each build, allowing it to predict and control outcomes in real time, ensuring every part is delivered with precision, speed, and digital verification.

Unleashing metal Additive Manufacturing at scale

The company will use the new funding to expand its portfolio of manufacturable materials, as well as to ramp up production capabilities for industries where quality, speed, and cost are paramount: defence, aerospace, energy, semiconductors, and automotive. The company's autonomous manufacturing technology is already being embraced by companies such as Boeing, which is planning on tapping into Freeform's capabilities to certify and scale metal parts for commercial aviation and defence in the future.

"To meet the demands of the 21st century, companies need technology that can move as fast as their ideas," said Eugene Kim of AE Ventures. "Freeform is light years ahead in metal Additive Manufacturing, offering a scalable, flexible solution that ensures quality at every stage — from prototype to full-scale production. This is the breakthrough the aerospace industry has been waiting for. AE Ventures partnered with the highest levels of Boeing's technical staff to review Freeform's printing capability, and we have walked away extremely confident in their ability to revolutionise metal Additive Manufacturing."

www.freeform.co



Freeform has announced a major investment from NVIDIA's NVentures and AE Ventures (Courtesy Freeform)

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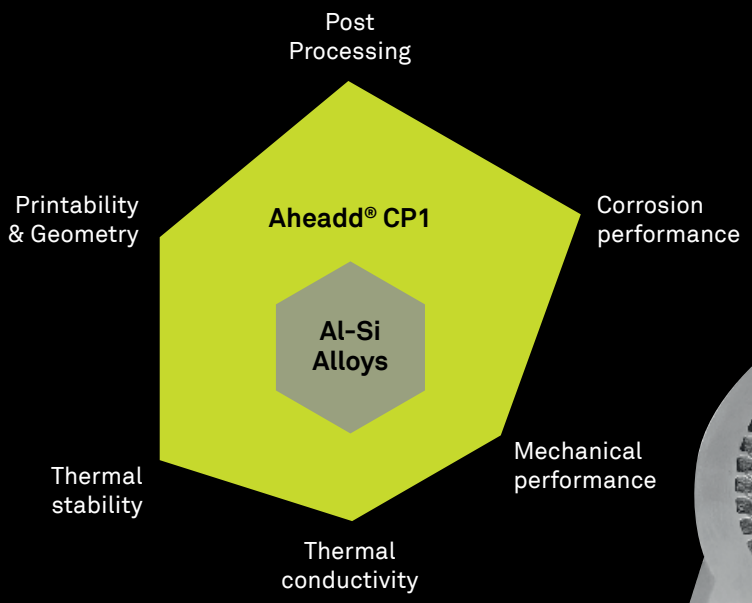

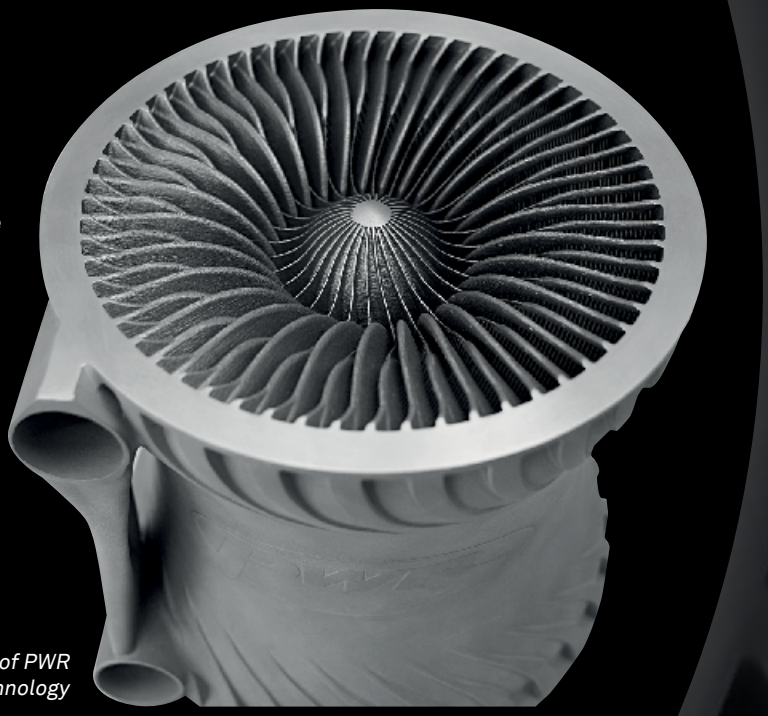

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Ursa Major secures $5M contract to develop copper AM for hypersonic flight

Ursa Major Technologies Inc, located in Berthoud, Colorado, USA, has secured a follow-on contract award with America Makes, Youngstown, Ohio, to qualify its copper Additive Manufacturing process for hypersonic flight. The contract represents a $5 million investment, with $4 million from America Makes and Ursa Major providing the remaining $1 million.

"Ursa Major continues to be at the forefront of implementing Additive Manufacturing in aerospace and defence programmes," said John Wilczynski, Executive Director of America Makes. "We are excited to partner with Ursa Major in demonstrating the impact Additive Manufacturing can have in solving supply chain and manufacturing challenges within our defence industrial base."

Ursa Major and America Makes began their partnership in 2021 with the establishment of the Ursa Major Advanced Manufacturing Lab in Youngstown. In the first two phases of the contract with America Makes, Ursa Major engineers developed an Additive Manufacturing process capability for NASA's high conductivity and high strength copper-chrome-niobium alloy GrCop-42 and produced prototype thrust chambers for the vacuum variant of the Hadley liquid rocket engine. Continuing through mid-2024, the collaboration's focus shifted from prototype manufacturing to the production and qualification of engine hardware.

Over the next twenty-one months, Ursa Major aims to use this $4 million to transition its copper Additive Manufacturing capability into flight-qualified hardware for its America Makes customers: the National Center for Defense Manufacturing and Machining (NCDMM) and the Air Force Research Laboratory based out of Wright-Patterson Air Force Base in Dayton, Ohio. Ursa Major will install a Velo3D Sapphire XC Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine to qualify its copper Additive Manufacturing process on a full-scale production platform. Once qualified, the company will manufacture thrust chambers to support both Hadley and Draper flight engines.

"America Makes has been a trusted partner for the past three years, allowing Ursa Major to create high-quality and scalable systems in our Advanced Manufacturing Lab in Youngstown, Ohio," shared Nick Doucette, Chief Operations Officer for Ursa Major. "This next step will establish Ursa Major as a scalable and trusted manufacturing partner in the defence and aerospace sector while maturing production readiness for our Draper and Hadley rocket engines."

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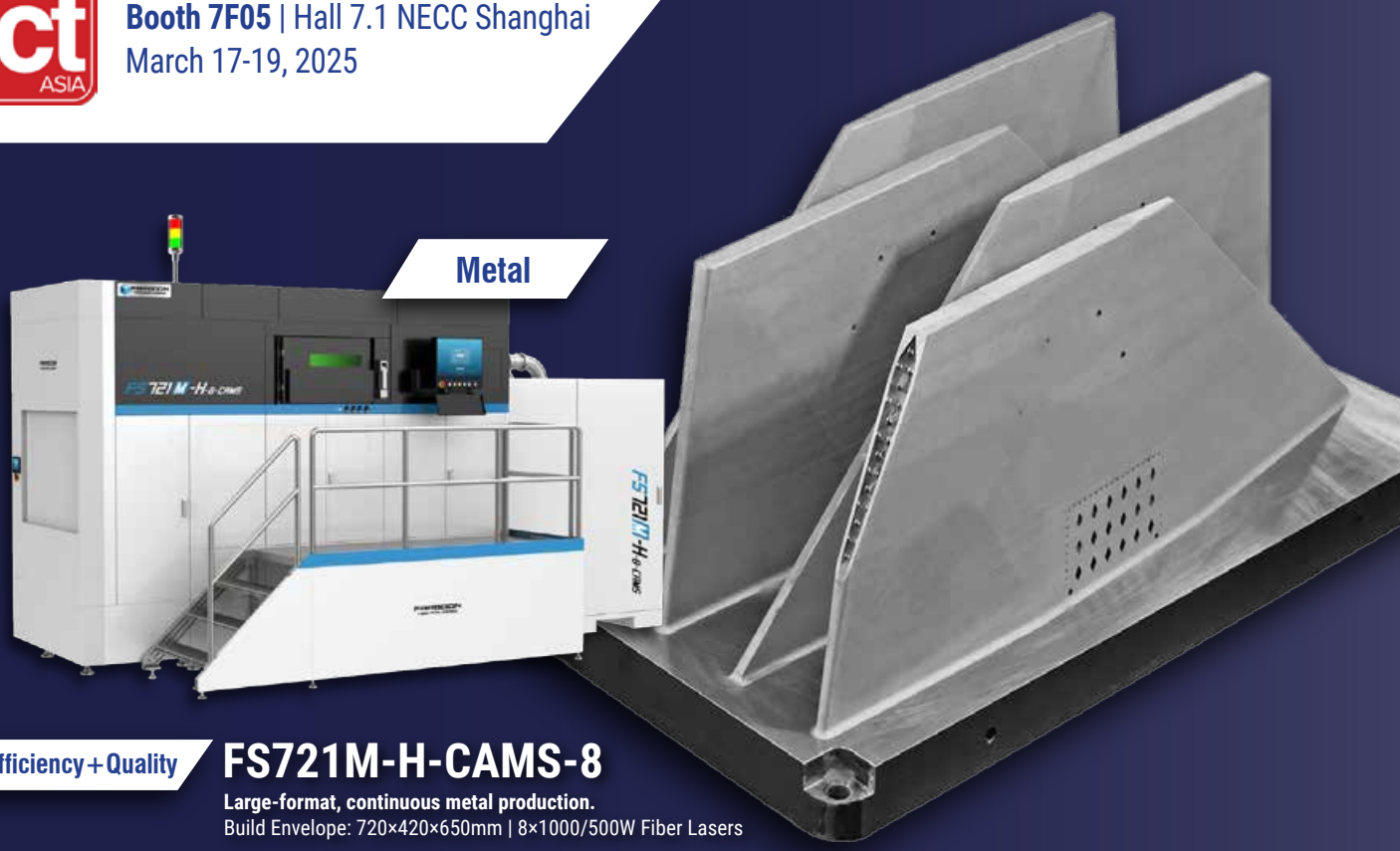

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Flexible beam-shaping process to optimise PBF-LB Additive Manufacturing

The Fraunhofer Institute for Laser Technology (ILT) and the Chair of Technology of Optical Systems (TOS) at RWTH Aachen University have announced a collaboration aiming to create a state-of-the-art test machine enabling them to flexibly investigate complex laser beam profiles in power classes up to 2 kW, a capability that allows customised solutions for industrial partners. This platform is designed to integrate Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing processes more efficiently and robustly into industrial production as demand grows.

PBF-LB machines often use 300-400 W lasers, but the Gaussian laser beam used can have significant disadvantages, explains ILT. The high concentration of power in the beam centre leads to local overheating and undesirable material evaporation as well as process instability, both of which can impair component quality due to spatter and pores. These issues can significantly limit the scalability of the process.

"One way to speed up the process is to use several lasers and optical systems in parallel," stated Marvin Kippels, PhD student in the Laser Powder Bed Fusion Department at Fraunhofer ILT. "However, the costs scale at least proportionally to the number of systems installed."

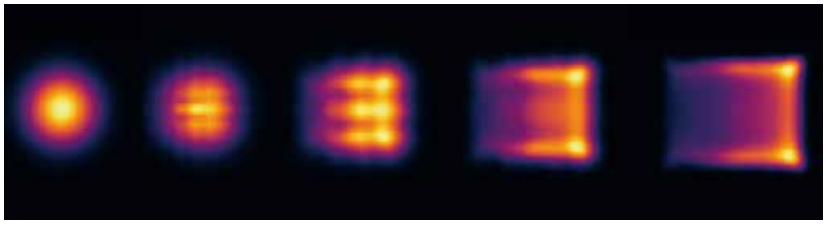
In addition, these machines cannot always be utilised homogeneously in real applications, which means that productivity cannot be increased proportionally to the power. A promising approach is to improve the productivity of the single-beam process, which can also be transferred to multi-beam PBF-LB machines.

The role of beam shaping

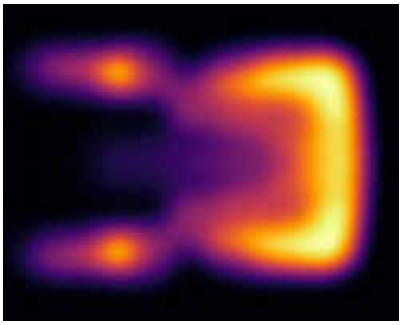
Previous studies have shown that even simple beam shapes with rectangular, ring-shaped or a combination of two Gaussian distributions produce promising results for both component quality and process speed. Fraunhofer ILT is now conducting comprehensive investigations into the potential of more complex beam shapes, something mostly unexplored.

"The interaction of laser beam and material in the process is so complex due to its dynamics that simulations can only provide indications of the actual melt pool behaviour," explains Kippels, who is currently setting up a new type of machine that uses LCoS-SLMs (Liquid Crystal on Silicon – Spatial Light Modulator), which will enable researchers to investigate almost any beam profile in the PBF-LB process.

With a laser power of up to 2 kW, Fraunhofer's machine is a platform for testing new beam shapes at very high power levels in the PBF-LB process. This allows suitable machine technology to be identified for an individual PBF-LB task. "We can optimise the [PBF-LB] process in a targeted manner," explains Kippels. He refers specifically to less material evaporation, less spatter formation, reduced melt pool dynamics, smoothened melt track surface, and increased process efficiency by adapting the melt track geometry.



Redistribution of the laser beam intensity during propagation after reflection at a phase mask of an LCoS-SLM. The initial distribution is on the left and the target distribution on the right (Courtesy Fraunhofer ILT)



LCoS-SLMs can be used to generate almost any beam profile by selectively bending the phase front of the laser beam (Courtesy Fraunhofer ILT)

Flexible beam profiles for specific requirements

Currently, machine technology is often promoted as able to produce specific beam shapes such as ring or top hat profiles. However, the choice of these beam shapes is not based on an in-depth understanding of the underlying process mechanisms, which is reflected in the sometimes contradictory literature on the subject. Only by understanding the processes can research specifically define which adjustments achieve a designated target, such as a certain melt track geometry.

This means that a beam shape must be developed and optimised for the application, which can then ideally be implemented in the company without needing Liquid Crystal on TLCoS-SLM technology. Using Fraunhofer ILT's research platform, industrial customers and project partners can leverage this flexibility in researching the laser-beam tool.

"We are still at the very beginning, but we can already see the enormous potential that beam shaping can offer for the [PBF-LB] process," says Marvin Kippels. "There is no one perfect beam shape; every application has its own requirements. Thanks to our flexible beam shaping, we can find the ideal distribution for each process, the best process parameters for the task in question." To achieve this goal, several departments at the Aachen Institute support the work of Kippels and his team.

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BLT-S400

Build Dimension

400mm×300mm×400mm (W×D×H)

Typical Parts

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* The actual models available may vary according to the product listings in each specific region.

Metal LPBF System

BLT-S600

Build Dimension

650mm×650mm×850mm (W×D×H)

Typical Parts

Steering Knuckle

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AddUp announces the MASSIF large-scale Additive Manufacturing project

AddUp, headquartered in Cébazat, France, has announced the MASSIF (Metal Additive System, Sustainable, Industrial, Eco-Friendly) project, which aims to drive industrial and technological developments in large-format metal Laser Beam Powder Bed Fusion (PBF-LB), ultimately up to 1.5 x 1.5 x 2 m in size.

The MASSIF project aims to boost productivity, reduce costs, and meet evolving sustainability goals, offering new capabilities for industrial applications. The first PBF machine developed around these concepts features a build volume of 750 x 750 mm x 1 m. The new machine is to be built on the foundation of AddUp's FormUp 350, currently used by global customers to deliver critical components such as medical implants, satellite and aerospace parts.

AddUp states that this new machine will upscale the benefits inherent to Additive Manufacturing, such as design flexibility, faster production times and higher levels of sustainability. In particular, the company notes the following attributes of its MASSIF machine:

- Increased productivity of up to 300%, reducing part costs by between 50-70%
- 12x larger build area than current AddUp machines
- Less than 10% powder waste
- AddUp's proprietary technology and in-process monitoring
- Use of green energy

"It was the association of the best experts, each in their field, that allowed us to launch the MASSIF project. This technological leadership in large-scale metal 3D printing will enable us to meet the challenges of energy transition and productivity for aeronautics, defence and space players, always in a co-design approach by AddUp with its clients," explained AddUp CEO, Julien Marcilly.

Under the leadership of AddUp, a consortium will bring together the unique expertise of each partner:

- **AddUp,** the consortium leader, is designing the machine and building a prototype that integrates the technological building blocks of the process and production quality monitoring solutions
- **Cailabs** will develop laser beam shaping solutions to increase build speed and, thus, machine productivity
- **ISP Systems** will develop a dynamic beam shaping solution to improve laser beam focusing quality
- **Dassault Systèmes**, which — with the 3DEXPERIENCE platform — will enable data to be used to create virtual models that simulate products, processes and factory operations, and develop a data enhancement solution aimed at the efficient manufacture of certified critical parts
- **Vistory** will develop a solution that enables the confidentiality and integrity of manufacturing data, protecting the creator's industrial property and ensuring the traceability of operations
- **CETIM** is contributing to the technological development of the prototype by carrying out tests on its own facilities and then integrating the final machine in its new Printing Bourges centre, thus validating the manufacturing parameters for different materials and produce the first demonstration parts for various target markets

The MASSIF project is already underway with prototyping and initial production. The first machine is anticipated to be installed at CETIM, where it will undergo further validation.

The machine has already been selected as the winner of the France2030 'Robots and Intelligent Machines of Excellence' programme. The initiative aims to structure and support the emergence of technological and industrial leadership in fast-growing emerging markets. By 2030, the programme anticipates a highly automated and intelligent industrial ecosystem that contributes to economic growth and sustainability.

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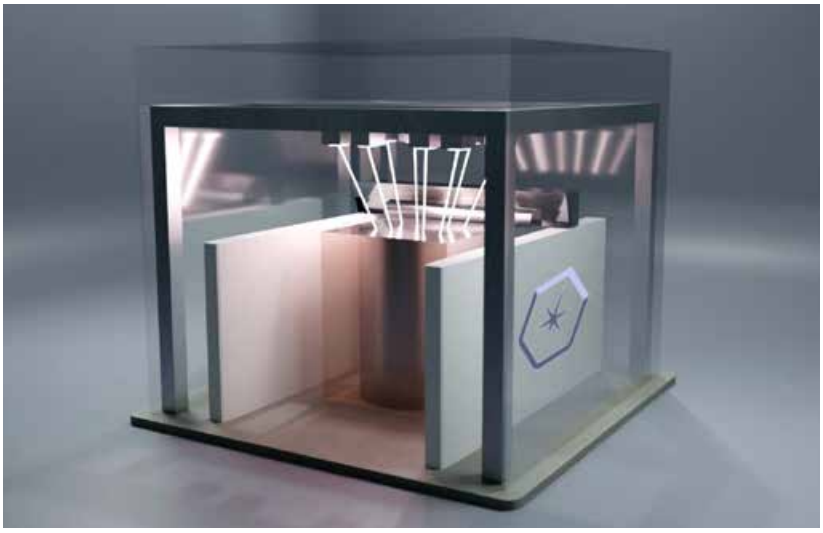

AddUp's MASSIF project aims to drive large-format PBF-LB (Courtesy AddUp)

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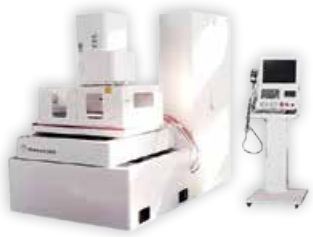
EDMMax 433W



400x320x280 mm (x,y,z axis) - 4 axis
Max. workpiece Wt: 600kg . 1320 lbs

EDMMax 434W

400x320x410 mm (x,y,z axis) - 4 axis
Max. workpiece Wt: 600kg . 1320 lbs

EDMMax 656W

630x500x625 mm (x,y,z axis) - 4 axis
Max. workpiece Wt: 1000kg . 2200 lbs

Uses pure water - no additives!

EDMMax 434WW

400x320x410 mm (x,y,z axis) - 4 axis
Max. workpiece Wt: 600kg . 1320 lbs

EDMMax 818W

1000x800x800 mm (x,y,z axis) - 4 axis
Max. workpiece Wt: 2700kg . 6000 lbs

FC 45HW

Made in Taiwan

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Max. workpiece Wt: 90kg . 176 lbs

Horizontal submerged cutting

EDMMax 1100HW

1100x1400x1250 mm (x,y,z axis)
Max. workpiece Wt: 3000kg . 6600 lbs

EDMMax 1800W

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Horizontal submerged cutting

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AMEXCI offers full metal Additive Manufacturing serial production at new Örebro facility

Metal Additive Manufacturing company AMEXCI has announced it has moved into a newly built 4,700 m^2 facility in Örebro, Sweden. This move increases the company's operational capacity and allows it to add full serial production capabilities, supporting customers from early development stages to high-volume production.

The expansion reflects the growth AMEXCI has achieved over the past seven years, during which time the company has refined its processes to serve a wide range of industries. This full-spectrum offering is said to make AMEXCI uniquely equipped to support its customers at every stage of the process, ensuring flexibility and scalability.

"Our purpose-designed facility with cutting-edge technology is a true game-changer for AMEXCI and essential to our growth, as this empowers our dedicated team to fully unleash their expertise and operate at their highest potential," stated Edvin Resebo, CEO at AMEXCI. "Over the years, we have built a deeply knowledgeable and dedicated team who are at the heart of everything we do. Their commitment and excellence allow us to provide tailored, high-quality solutions at every stage of the Additive Manufacturing process."

AMEXCI has stated that its holistic approach to Additive Manufacturing is rooted in a business model which combines academy, research and production.

AMEXCI's new production facility in Örebro, Sweden (top) and Installation of machines at AMEXCI's new production hall (bottom) (Courtesy AMEXCI)

By training engineers and continually engaging in research, the company intends to stay ahead of industry trends, driving both development and practical application for its customers.

www.amexci.com

Eplus3D unveils EP-M4750 large-format metal AM machine at its Global Partners Summit

Eplus3D, based in Hangzhou, China, hosted its 3rd Global Partners Summit, October 10–11, 2024. This two-day event brought together key customers, resellers and partners from around the world to explore innovations, discuss industry trends and witness new product launches. The summit also marked a significant milestone, with the company celebrating its 10th anniversary.

During the event, Eplus3D launched the EP-M4750, its latest large-format Laser Beam Powder Bed Fusion (PBF-LB) metal Additive Manufacturing machine. The EP-M4750 features a build volume of 450 x 750 x 530 mm and quad-laser system, enabling efficient large-scale manufacturing.

Compatible with titanium, aluminium, nickel, maraging steel, stainless steel and cobalt chrome, the EP-M4750 is an ideal solution for the direct manufacturing of large, high-precision, high-performance parts, making it suitable for a wide range of industries.

The summit continued with keynotes, interactive sessions, and technical presentations designed to showcase the latest advancements in AM and foster collaboration within the global AM community. Participants had the opportunity to network, share insights, and explore how AM technology is transforming industries such as automotive, aerospace, healthcare, energy, tooling and consumer goods.

Eplus3D recently hosted its 3rd Global Partners Summit 2024 in Hangzhou, China (Courtesy Eplus3D)

Eplus3D was keen to thank its partners FAM, Temisth, Wietech 3D, Constellium, PWR, HAGI, EML, Materialise, M4P and Italian RP for sharing their know-how on Additive Manufacturing technology and providing a highly appreciated add-on to its Global Partners Summit.

www.eplus3d.com

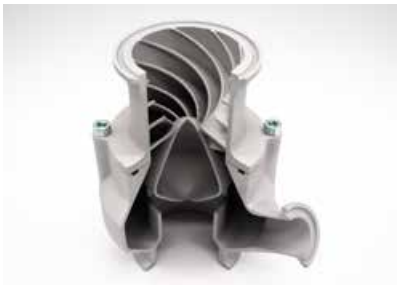
One Click Metal partners with TriMech to expand metal Additive Manufacturing solutions across Eastern US

One Click Metal, based in Tamm, Germany, has announced a new sales partnership with TriMech, Glen Allen, Virginia, USA. This collaboration will significantly expand One Click Metal's reach across the Eastern United States, offering metal Additive Manufacturing solutions to a broader range of customers.

With over fifty locations and 750 employees across the United States, Canada, the United Kingdom, Ireland, and Nordic Europe, TriMech is an established leader in delivering advanced manufacturing solutions.

Specialising in areas such as design, engineering, manufacturing, and process optimisation, Tri-Mech works with top-tier partners, including Dassault Systèmes, Stratasys, Formlabs, Artec, and Zeiss. This is believed to make them an ideal partner for selling and supporting One Click Metal's metal Additive Manufacturing systems.

"This partnership with TriMech is a great milestone for us in the North American market," said Gerrit Brüggemann, CEO of One Click Metal. "TriMech's extensive industry expertise and strong network are believed to make it the perfect partner to help One Click Metal bring its affordable, user-friendly metal Additive Manufacturing solutions to industries including aerospace, healthcare, electronics, and power generation. Whether prototyping or taking on full-scale production, TriMech clients are sure to embrace the accessible metal AM solutions."



One Click Metal has announced a new partnership with TriMech to expand One Click Metal's reach across the Eastern United States (Courtesy One Click Metal)

www.oneclickmetal.com
www.mfg.trimech.com

ODeCon launches the adAM-BASE for high-speed hybrid Additive Manufacturing

ODeCon, headquartered in Kaiserslautern, Germany, has expanded its adAM series of hybrid metal Additive Manufacturing machines with the introduction of the adAM-BASE. The new machine is a compact, entry-level model said to meet the needs of medium-sized enterprises. It is designed to unlock the potential of AM for a wide range of companies, including those in mechanical engineering, tool and mould making, dental technology, automotive, and aerospace sectors.

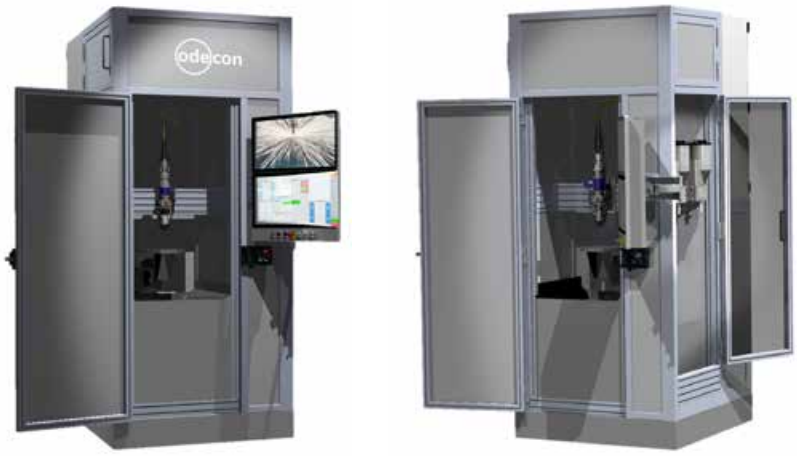
The adAM-BASE complements the company's existing adAM-PRO (designed for large-scale production) and adAM-RD (aimed at research and development). It uses the same wire or powder feedstock in a laser-based Directed Energy Deposition (DED) AM process, combined with CNC machining. With an entry price of under €300,000, the adAM-BASE provides a relatively affordable option for those looking to venture into high-speed Additive Manufacturing.

Like all models in the adAM series, the adAM-BASE features a fast five-axis CNC system that enables the processing of objects with nearly any structure. The hybrid machine can additively manufacture parts, post-process them, and coat them. It is also possible to do this with components produced externally.

A feature of the new machine is the ability to switch between different metal materials or alloy components during the build or coating process, adding significant value for applications with varying material requirements. Optionally, additional work heads can be installed, such as a laser cutting head, which further reduces lead times by enabling post-processing directly within the system.

The company has reported strong interest in the German market and international inquiries, notably from Sweden and Finland.

www.odecon.de



ODeCon has expanded its adAM series with the new adAM-BASE (Courtesy ODeCon)

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Norm 3D named EOS distributor and service partner for Additive Manufacturing in Türkiye

Norm 3D, a group company of Norm Holding, based in Çiğli, Türkiye, has entered a strategic partnership with German machine maker EOS, where Norm 3D will act as the official EOS distributor and Norm Holding the dedicated service partner in Türkiye. Norm 3D will be responsible for sales, technical support, consulting and technical services, taking over from former partner 3DDT.

This collaboration builds on EOS' global positioning, leveraging Norm 3D's extensive knowledge and established reputation in the Turkish market. Norm Holding will support Norm 3D as a service provider for application benchmarking with EOS machines, such as the EOS M 260 1 kW for metal Additive Manufacturing.

The EOS M 400 Series of metal Additive Manufacturing machines have a 400 x 400 x 400 mm build volume, and the choice of one 1,000 W or four 400 W lasers (Courtesy EOS)

Supporting Turkish industries with Additive Manufacturing

The partnership looks to enable industries like as aerospace, defence, medical, automotive, and consumer goods to access advanced manufacturing technologies and support services from a known local provider.

"We are thrilled to partner with EOS and bring their world-class 3D printing technologies to Türkiye," said Dr Cenk Kılıçaslan, AM Director of Norm Holding. "This collaboration aligns perfectly with our mission to advance the manufacturing capabilities of Turkish industries, enabling them to overcome production challenges and drive innovation in key sectors. We are committed to delivering exceptional service and support to our customers, ensuring they can fully harness the benefits of EOS's technology."

This partnership will provide the Turkish market with EOS' comprehensive portfolio of industrial polymer and metal Additive Manufacturing systems, software and consulting – provided through Additive Minds Consulting by using Norm Holding's PhD-level engineers, as well as technical services, including installation, maintenance, and repair, ensuring customers have access to the full lifecycle support needed for sustained success.

EOS and Norm 3D offer production capacity for local customers, making sure EOS Additive Manufacturing quality is available for customers that prefer to buy parts than manufacture them in-house. This enables fast part sourcing for rapid prototyping as well as for serial production, for local businesses.

"Customer centricity is one of our core tenets, and through our partnership with Norm 3D, we are confident that Turkish customers will receive the highest level of service and support," Markus Glasser, Senior Vice President EMEA of EOS, shared. "The Turkish market presents unique opportunities for industrial 3D printing, and with Norm 3D's local expertise, we are excited to empower manufacturers in the region to adopt our technologies and advance the next generation of manufacturing."

Norm 3D and EOS have stated that their collaboration reflects a shared commitment to advancing Additive Manufacturing and delivering innovative solutions to the Turkish market. It also hopes to reinforce Norm 3D's portfolio, which already includes Additive Manufacturing machines, raw materials, spare parts, and maintenance services. This will allow the company to offer a more comprehensive range of advanced manufacturing solutions to meet the diverse needs of Turkish manufacturers.

www.normadditive.com
www.eos.info

Continuum qualifies its reclaimed metal powders for Renishaw's RenAM 500

Continuum Powders, based in Los Gatos, California, USA, has qualified its metal powders for use with the RenAM 500 series of Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machines from Renishaw, based in Wotton-under-Edge, Gloucestershire, UK.

"The quality of Continuum Powders' materials and their commitment to what they call the circular metal economy align perfectly with Renishaw's vision for a more sustainable manufacturing future," stated John Laureto, AM Business Manager at Renishaw. "The availability of reclaimed metal powders that meet our exacting standards helps manufacturers reduce waste while maintaining peak performance."

Continuum Powders' CEO Rob Higby added, "We are thrilled to have our reclaimed powders qualified for the RenAM 500 series. This collaboration highlights our shared commitment to delivering high-quality, sustainable solutions to the market, and we look forward to further developing reclaimed powders that help customers achieve both their performance and environmental goals."

Other Additive Manufacturing machine makers who have collaborated with Continuum Powders to qualify its reclaimed metal powders include Desktop Metal and Velo3D.

www.continuumpowders.com
www.renishaw.com

E-Plus-3D

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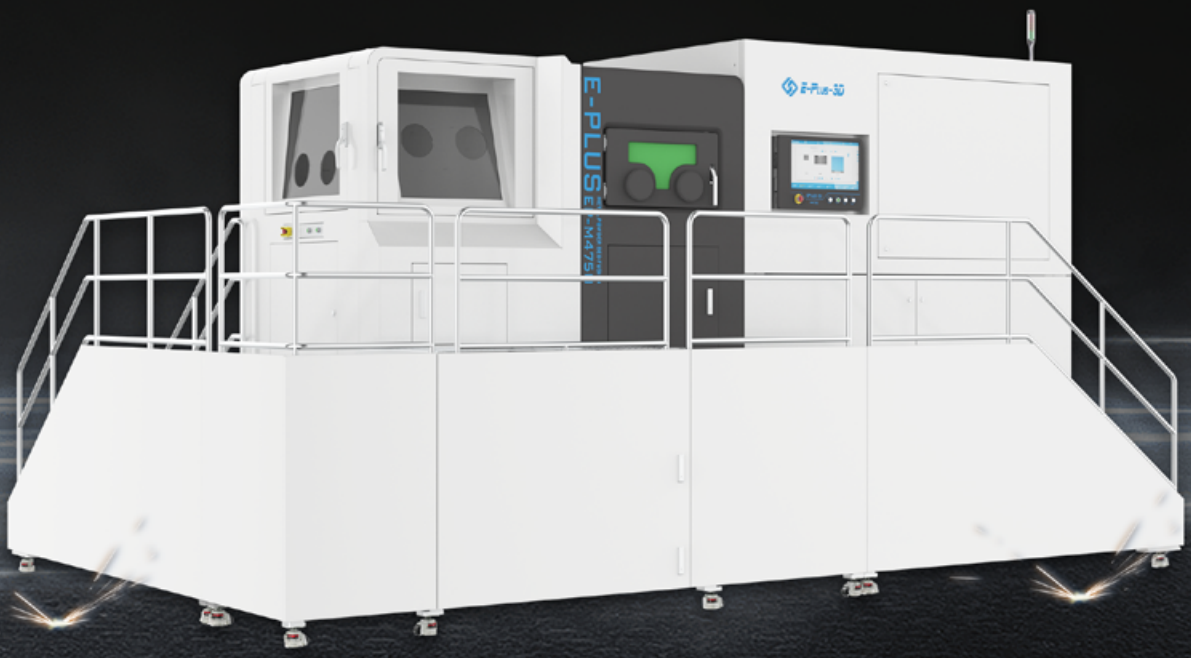

EP-M4750 *Metal PBF Machine*

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- Material: wide material application
- Application: aerospace, aviation, automotive and machinery industry

www.eplus3d.com
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Fortius Metals funding round totals $5 million to bring next-gen wire to market

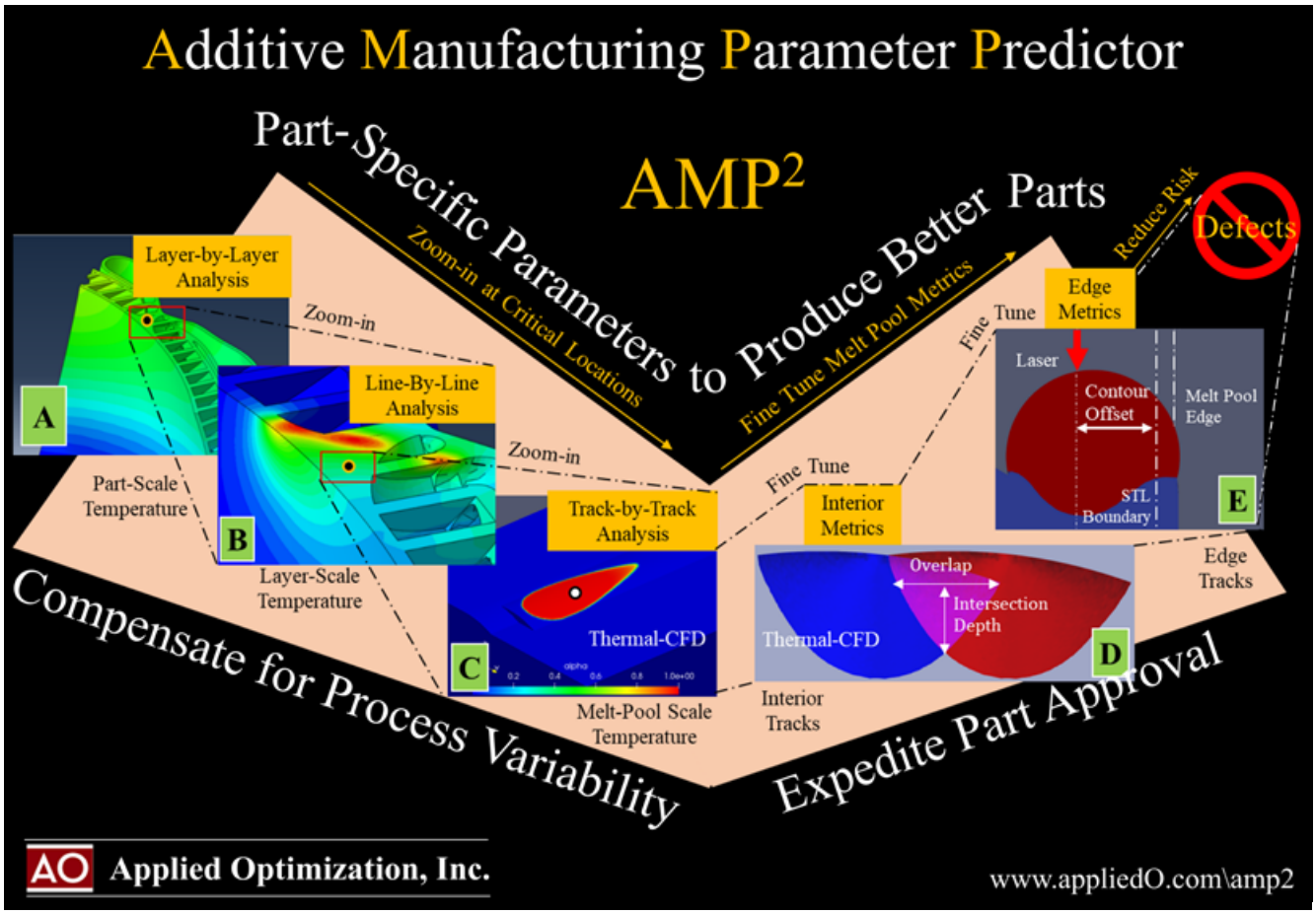
Fortius Metals, headquartered in Lafayette, Colorado, USA, has announced the successful closure of an additional $2 million in their Seed+ funding, bringing the total raised in the financing round to $5 million. The round includes the addition of new strategic investor Finindus, who joined after receiving clearance from the Committee on Foreign Investment in the United States (CFIUS). Previous investors include 412 Venture Fund, AM Ventures, and M7 Holdings.

Fortius Metals specialises in next-generation wire alloys for large-format Direct Energy Deposition Additive Manufacturing and robotic welding. The company's patented technology produces high-performance metal alloys that meet the rigorous requirements of aerospace and defence customers. Fortius customers and partners include the US Army, Navy, Air Force, and NASA, as well as several defence primes and commercial space companies.

"Fortius Metals has received broad interest from customers and this investment helps bring new products to market, such as our proprietary 6061-RAM2 and 7075-RAM2 aluminium welding wires that solves traditional "hot cracking" problems," said Jeff Lints, Fortius CEO. "We are helping our customers print designs using our robotic welding process expertise that were previously impossible. In 2025, the company looks forward to launching new wire alloys with advanced properties like IN625-RAM, 316LRAM, and 5183-RAM. We are proud to be a Colorado company along with many of our space and defence customers."

The proprietary alloys developed by Fortius Metals reportedly offer up to twice the strength of current commercial solutions used in welding and Additive Manufacturing. This provides customers with significant advantages in terms of design performance, product quality, and weight reduction. The company also offers robotic welding process expertise and proprietary predictive toolpaths that deliver dimensional accuracy, helping customers bring innovative designs to life with unmatched precision. The additional capital will help to accelerate these developments and enable Fortius to meet the timelines of customers who are eager to adopt this technology.

www.fortiusmetals.com



Wayland Additive Calibur3 metal Additive Manufacturing machine acquired by Fraunhofer IPK

Wayland Additive, located in Huddersfield, UK, has announced that Fraunhofer IPK (Fraunhofer Institute for Production Systems and Design Technology) has purchased a Calibur3 Electron Beam Powder Bed Fusion (PBF-EB) metal Additive Manufacturing machine.

In recent years, Fraunhofer IPK has conducted numerous research into laser-based AM applications with difficult-to-weld alloys. However, it is now starting to reach the physical limits of this technology. The Fraunhofer IPK team believes that the investment in the PBF-EB production technology from Wayland will increase the range of materials that can be processed with AM, particularly specifying titanium aluminides and CM247, among others. The other advantage of the patented NeuBeam technology identified by Fraunhofer IPK is the elimination of a complete sinter cake post-build, which dramatically reduces the post-processing time and costs required to produce complex geometric applications, even those with delicate internal structures.

According to Tobias Neuwald, Head of the Manufacturing Technologies Department at Fraunhofer IPK, "We are thrilled to be working with the most innovative manufacturers of cutting-edge technologies. This enables us to process new materials, open up new applications and bring the incredible possibilities of the Additive Manufacturing value chain to a wider range of users. Wayland Additive's Calibur3 metal AM system and their patented NeuBeam technology is exactly what we need to meet today's challenges in electron beam melting."

Mike Ford, Sales Manager at Wayland Additive, commented, "We are delighted that the Fraunhofer IPK team are so invested in Calibur3 and NeuBeam technology. It is exciting for us to continue to work in partnership with Tobias and his team to push the boundaries of metal AM and to drive new applications and new materials forward."

Will Richardson, CEO at Wayland added, "This announcement of yet another sale of a Calibur3 system is testament to the continuing growth of the metal AM sector, and the demand for production systems for advanced materials. We are looking forward to working with Fraunhofer IPK moving forward and accelerating even more production applications."

www.waylandadditive.com

One Click Metal and Magù partner to bring black titanium Additive Manufacturing to jewellery industry

One Click Metal, based in Tamm, Germany, has announced a new partnership with Magù, an Italian company specialising in titanium processing and precision casting. The move marks One Click Metal's official entry into the jewellery market.

Through this partnership, One Click Metal is introducing black titanium, a sought-after material in jewellery production, for use in its metal Additive Manufacturing systems. Black titanium offers a unique aesthetic while maintaining the strength and lightweight properties that titanium is known for – making it ideal for high-end jewellery designs.

The collaboration also extends to powder development, focusing on creating and refining materials specifically for the jewellery industry. By working closely with Magù, One Click Metal aims to expand the range of options available to jewellery designers, enabling them to craft intricate and durable pieces with ease.

"Our collaboration with Magù allows us to explore the full potential of advanced materials like black titanium, which combines exceptional strength and aesthetics. This partnership not only expands our material portfolio but also enables jewellery makers to push creative boundaries while maintaining the highest quality standards," Michael Volk, Product Manager Material, One Click Metal.

www.magusrl.it
www.oneclickmetal.com

Black titanium offers a unique aesthetic while maintaining the strength and lightweight properties that titanium is known for (Courtesy Magù)

Hexagon enables precision metal components with its Advanced Compensation process

Hexagon AB's Manufacturing Intelligence division has unveiled its Advanced Compensation technology, combining process simulation and 3D scan compensation to eliminate trial-and-error in precision metal part production. The new hybrid process allows engineers to pre-deform parts for global distortions and then fine-tune problem features using optical/CT scan data, with no metrology expertise required.

The Advanced Compensation approach uses geometry compensation to ensure large or complex metal parts 'distort' into their intended shape during the build process. By combining process simulation and 3D scan compensation, Hexagon states that even the most challenging parts, with tight quality tolerances, can be additively manufactured successfully with just one prototype build. The hybrid process combines process simulation with metrology-based compensation, fast-tracked high-quality builds, reportedly achieving surface profiles that are 98-100% within tolerance.

"If you're making a large complex geometry, simulation will save you time and money – even for a one-off part," stated Mathieu Perennou, Director of Additive Strategy at Hexagon. "But when simulation alone isn't enough, we've made it much easier to take an optical 3D scan then compensate those remaining problem features so you can print 'second time right.' This data-driven approach takes the guesswork out of printing small batch parts, and it can be scaled up to refine a process for larger volumes using digital twin approaches that consider not just the geometry, but also the machine parameters or material behaviour where part performance is critical."

Advanced Scan Compensation will be made available to all Simufact Additive customers in the Q1 2025 release.

www.hexagon.com

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AddUp tops US Air Force fatigue study for Inconel 718 components

AddUp, headquartered in Cébazat, France, has announced that it has achieved the top ranking among the participants of a High Cycle Fatigue study. The 'Development of Manufacturing, Heat Treatment, and Surface Finishing Guidelines to Yield Ready-to-Use IN-718 Additive Manufacturing Components' contract was initiated through the United States Air Force (USAF) and the Small Business Innovation Research (SBIR) programme and was led by REM Surface Engineering (REM).

Aimed to harness the potential of Laser Beam Powder Bed Fusion (PBF-LB) and surface finishing technologies to produce IN-718 components for legacy armament systems, the study researched the impact of various heat treatment and build parameter combinations in association with REM's surface finishing technology. The goal was to learn what effect each combination would have on a component's mechanical properties such as tensile strength and fatigue life. This blind study had participation from four major metal AM OEMs/service bureaux and included a variety of critical testing conditions to determine fatigue performance in additively manufactured components. These conditions included Hot Isostatic Pressing (HIP) versus non-HIP treatments, contour versus non-contour melting strategies, and angled building at multiple angles including 0, 45 and 90°.

AddUp stated that its results outperformed competitors, especially when parts produced on the FormUp 350 were combined with REM's surface finishing technology, the Extreme ISF Process, reportedly enhancing material properties for corrosion and fatigue resistance. AddUp's fine powder and roller recoater system on the FormUp 350 enables extremely high-quality surface finishes, an attribute which plays an important role in fatigue strength. REM's novel surface finishing solution was shown to have further strengthened these properties, reducing material degradation and maximising performance and reliability.

Fatigue resistance is essential in IN-718 applications, particularly in demanding aerospace and defence environments where structural integrity and reliability are crucial. The results from this study emphasise how fine-tuned AM parameters combined with advanced finishing technologies can reduce component downtime and cost, ensuring mission-critical operations proceed with enhanced performance.

"The fatigue study shows that the combination of AddUp's PBF-LB technology with REM's surface finishing process generated the highest fatigue resistance, providing valuable data for potential aerospace and defence component applications," stated Dr Augustin Diaz, Advanced Manufacturing and Innovation Manager at REM Surface Engineering.

www.addupsolutions.com

Solukon launches large-scale SFM-AT1500-S depowdering machine

Solukon, based in Augsburg, Germany, has announced its SFM-AT1500-S, a new depowdering machine suited for parts weighing up to 2,100 kg. The company reported that it has already received two orders for the machine, which was on show for the first time at Formnext 2024.

The largest depowdering machine from Solukon, the SFM-AT1500-S can accommodate parts with dimensions of up to 600 x 600 x 1,500 mm or 820 x 820 x 1,300 mm. Despite its ability to handle large components, the machine has been made as compact as possible. With special drive technology, Solukon has succeeded in making the system very narrow. The structure is also arranged so that no platforms or stairs are necessary to load the parts. This makes the system unique in terms of its footprint and particularly safe and convenient when loading and handling large components.

"The combination of compactness and maximum functionality is an absolutely unique feature of our new SFM-AT1500-S," says CEO/CTO Andreas Hartmann from Solukon.

The chamber of the new SFM-AT1500-S is made of 100% stainless steel and the rotary table has four separately controlled compressed air lines for different configurations of vibrator, knocker and blower connections. Solukon developed a decoupling concept whereby the part can vibrate in any position, but the rest of the chamber is still. A newly developed drive technology is used to move the parts.

The SFM-AT1500-S is compatible with SPR-Pathfinder software, which

Solukon's SFM-AT1500-S depowdering machine (Courtesy Solukon)

automatically calculates the ideal motion sequence based on the CAD file of the part. The software's Digital Factory Tool allows the depowdering procedure to be fully transparent during the entire cleaning process.

"Digital features are also essential in the large-scale part segment. Smart software is the only way to depowder complex structures without human programming effort. Plus, continuous tracking is the only way to achieve real transparency," Hartmann explained.

www.solukon.de

Hexagon and Nikon SLM Solutions achieve 75% weight reduction in Airbus A330 Fuel Air Separator

Hexagon AB's Manufacturing Intelligence division and Nikon SLM Solutions have collaborated to redesign a large, fabricated aircraft fuel system component using the design freedom of Additive Manufacturing. Using Hexagon's simulation-led Design for Additive Manufacturing (DfAM) toolchain and Nikon SLM Solutions' advanced multi-laser metal Additive Manufacturing technology achieved significant lightweighting, part consolidation and precise geometric tolerances.

Airbus Operations used the technology from its partners to redesign a Fuel Air Separator – a component that feeds the Airbus A330's Auxiliary Power Unit (APU). The combination of Hexagon's software and Nikon SLM Solutions' Additive Manufacturing technology has enabled the production of the simplified, more efficient AM A330 Fuel Air Separator prototype. The re-design achieved a 75% weight reduction from 35 kg to less than 8.8 kg, setting a new precedent for the use of Additive Manufacturing and simulation-driven design in the aerospace industry.

The fuel-air separator is a large, complex component that removes air from the APU fuel feed system, ensuring the APU can power essential aircraft systems when the main engines are off. The conventional part is fabricated from more than thirty individual components that require manual welding and assembly. This process is labour-intensive, which results in long lead times, and limits the potential for design improvements.

Airbus Operations and Nikon SLM Solutions initiated the research case study to optimise the production and performance of the air separator, creating an innovative process that used Nikon SLM's latest NXG XII 600 system – a large-format, multi-laser Additive Manufacturing machine – to simplify manufacturing, reduce lead times and streamline installation.

Hexagon AB's Manufacturing Intelligence division and Nikon SLM Solutions have collaborated to redesign a large, fabricated aircraft fuel system component using the design freedom of Additive Manufacturing (Courtesy Airbus)

Simulation-driven redesign unlocks design freedom

The team called upon Hexagon to redesign the part using a DfAM workflow to maximise the potential of the advanced Additive Manufacturing machine. Using Hexagon's MSC Apex Generative Design software, they consolidated over 30 individual components into a single lightweight part that met all necessary structural and performance standards. Hexagon's Simufact simulation tools were then used to optimise the manufacturing process and predict part deformation, ensuring that precise geometric tolerances were maintained. Global tolerances were controlled to +/- 5 mm, with critical functional surfaces refined to +/- 5 mm to ensure seamless compatibility with the aircraft's fuel system.

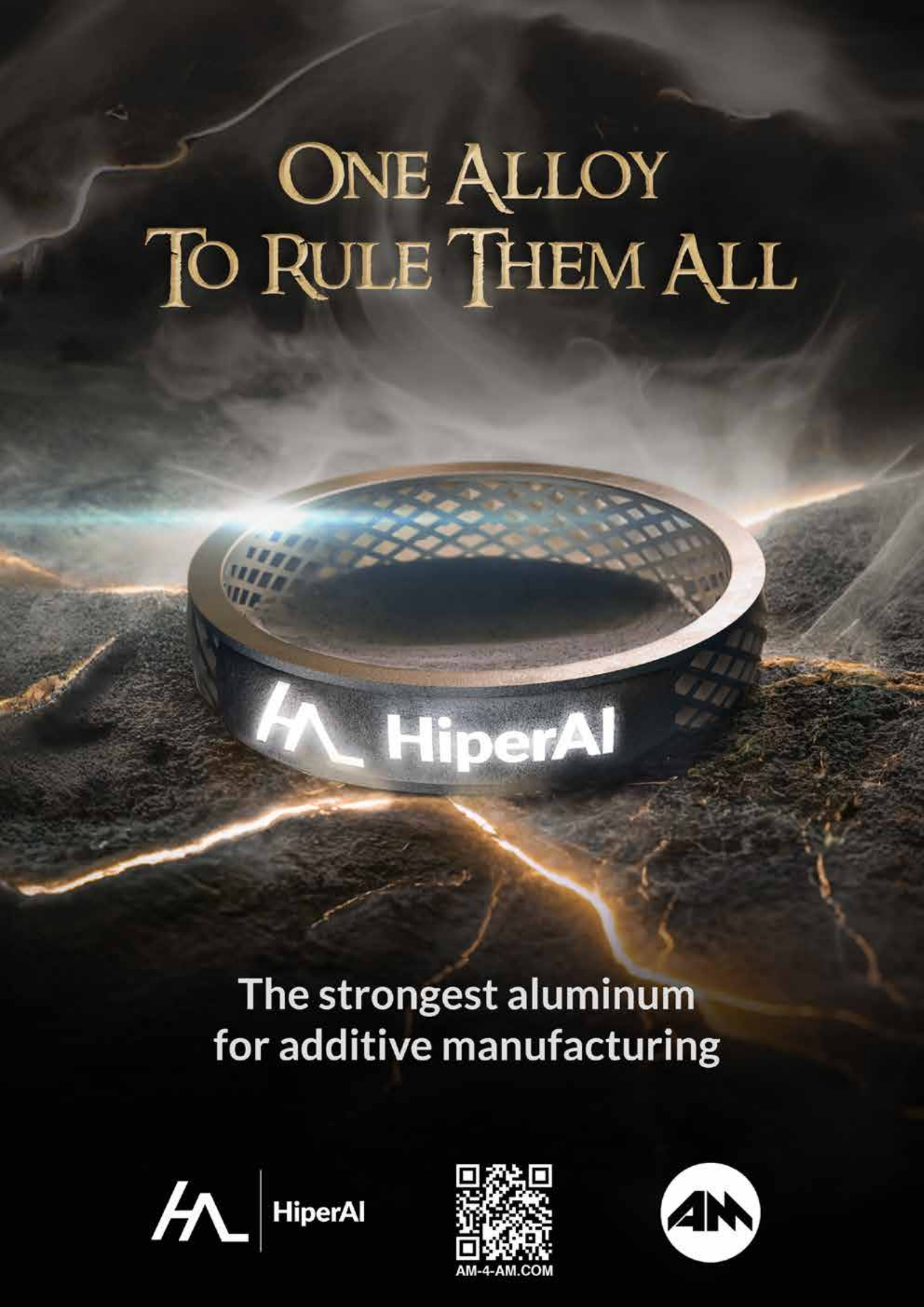
Simulation-driven design allowed for part optimisation while adhering to the stringent aerospace regulatory requirements. The Additive Manufacturing technology employed significantly reduced lead time by combining multiple manual processes and reducing production time. The large part was produced in just 68 hours, using optimised build data from Hexagon's AMSTUDIO build preparation software to fully utilise the NXG XII 600 PBF-LB AM machine and maintain precise geometric accuracy.

Advanced manufacturing drives sustainability innovation

Lower fuel consumption is due to reduced part weight, decreased manufacturing lead time, and enhanced efficiency gained through the manufacturing process.

This project demonstrates the power of combining Additive Manufacturing with simulation-driven design, and Airbus is well-positioned to expand these technologies in future aircraft designs.

www.nikon-slm-solutions.com
www.hexagon.com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Optomec and Siemens bring automated Additive Manufacturing to laser cladding in production environments

Optomec, based in Albuquerque, New Mexico, USA, and Siemens have announced a new solution for laser cladding high-value metal repairs in production environments using Additive Manufacturing. Unlike conventional systems that are labour-intensive and skill-dependent, the joint solution integrates the Optomec CS 558 machine and Siemens SINUMERIK ONE to deliver a system that automates and simplifies maintenance, repair, and overhaul (MRO) operations for increased productivity and cost savings.

According to Grand View Research, the global laser cladding market in 2023 was estimated at $561.3 million and is projected to grow at a CAGR of 9.3% from 2024 to 2030. Additive Manufacturing technology, such as Directed Energy Deposition (DED) used by the CS 558, expands laser cladding fabrication capabilities to repair complex components with mixed materials on various substrates to enhance performance, longevity and reliability.

Combined with Optomec's vision software, Autoclad, which generates a custom toolpath for each part prior to processing, manufacturers and servicers of high-value metal parts can restore worn or damaged components and use automated DED to repair reactive metals like titanium in a controlled environment. SINUMERIK ONE adds high-performance CNC to deliver maximum speed and path precision when machining free-form surfaces and fluid operation in high-load scenarios. Along with its digital twin, the SINUMERIK ONE digital native control provides the basis for future-oriented production with machine tools.

"Optomec and Siemens are introducing a transformative solution for the MRO of high value metals in production environments that is a paradigm shift for the industry," said Robert Yusin, CEO of Optomec. "This is a next generation solution that maximises efficiency, minimises operational complexity and greatly reduces time to ROI for customers."

Steve Vosmik, Head of Additive Manufacturing, US at Siemens, added "Our collaboration with Optomec represents a significant leap forward in industrial automation and Additive Manufacturing. By integrating SINUMERIK ONE with Optomec's advanced CS 558 platform, we are delivering a solution that simplifies complex repair processes with unprecedented precision and efficiency. This not only addresses current industry demands but also sets a new benchmark for the future of high-value metal repair in sectors like aerospace and energy."

www.optomec.com

Made Smarter backs three UK Additive Manufacturing firms

Three UK-based Additive Manufacturing companies have secured backing from Made Smarter, a UK government-funded programme promoting digital transformation among SME manufacturers. FDM Digital Solutions in Burnley, Additive Manufacturing Solutions (AMS) in Burscough, and Fusion Implants in Liverpool are using a grant from the programme to invest in new technologies.

Made Smarter's funding panel, which comprises leading figures from across the worlds of business, government and academia, offers grants of up to £20,000 towards new technology and digital tools.

"The grant funding has enabled purchase of game-changing technology to increase our offering in the world of Additive Manufacturing. This has made us more productive through end-to-end digitalisation of our manufacturing processes," stated Katie Higham, AMS Chief Operations Officer. "The support we have received from Made Smarter has been crucial to enhance our in-house technological capabilities, while supporting our digital transformation and upskilling our staff."

Donna Edwards, Director of the Made Smarter Adoption Programme, added, "These technology projects will have a tremendous impact on individuals, businesses, the sector and society. They will boost efficiency, productivity and growth, creating new jobs and upskilling existing roles, all while shifting the dial on creating a more sustainable approach to manufacturing."

"I welcome these 23 companies into the Made Smarter family. Alongside the hundreds who have already reaped the rewards of the adoption programme, we have now invested over £25 million into the digital transformation of the sector," Edwards added.

AMS has received funding from Made Smarter. From left, Rob Higham, Director and CEO, and Katie Higham, Chief Operations Officer (Courtesy Made Smarter/AMS)

As well as grants, Made Smarter offers SME manufacturers access to funded support including digital transformation workshops to create a digital roadmap, impartial and expert technology advice, and leadership and skills training.

www.madesmarter.uk
www.fdmdigitalsolutions.co.uk
www.additive-manufacturing.co.uk
www.fusionimplants.com

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The product range includes a variety of alloys, such as Nickel, Cobalt, Iron, and Titanium.

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Shop your metal powders here!

CCAT and BFA to deliver Additive Manufacturing technical training to US Submarine Industrial Base

The Connecticut Center for Advanced Technology (CCAT) and BlueForge Alliance (BFA) are collaborating to deliver Additive Manufacturing technical training at CCAT's Talent & Training Accelerator in East Hartford, Connecticut, USA. The partnership will focus on providing manufacturers with hands-on training that enhances their ability to adopt cutting-edge AM technologies in direct support of the US Submarine Industrial Base and broader maritime ecosystem.

CCAT offers innovative programmes and services that help manufacturers increase productivity, efficiency, and competitiveness. This partnership with non-profit integrator BFA will ensure manufacturers in the region are equipped with the necessary skills and technologies to strengthen the resilience of the nation's maritime supply chain.

"Our collaboration with BlueForge Alliance marks a significant milestone in advancing the capabilities of Northeast manufacturers," said Ron Angelo, president & CEO of CCAT. "We're not just offering training — we're empowering businesses to adopt technologies that will bolster the US Submarine Industrial Base and strengthen the resilience of our supply chain. By investing in cutting-edge Additive Manufacturing and workforce development, we're helping to ensure the long-term success and competitiveness of the region's industrial base."

"The application of Additive Manufacturing across industry sectors is necessary for increased speed and flexibility of production as we strive towards increasing the resiliency and competitiveness of America's supply chain," Rob Gorham, co-founder and co-CEO of BlueForge Alliance, shared. "A strong battery of partners is critical in making this happen and BlueForge Alliance remains enthusiastic with CCAT's approach in addressing deployment challenges while at the same time building the next generation workforce."

The Connecticut Center for Advanced Technology and BlueForge Alliance are collaborating to deliver Additive Manufacturing technical training (Courtesy Connecticut Center for Advanced Technology)

www.ccat.us
www.blueforgealliance.us

AM 4 AM funding round to expand facilities and boost powder production

AM 4 AM, a producer of metal powders for Additive Manufacturing based in Foetz, Luxembourg, has announced the successful completion of a €1.3 million seed funding round. The round was led by Luxembourg Space Sector Development, EIT RawMaterials, and further supported by the Young Innovative Enterprise initiative from the Ministry of Economy of Luxembourg.

AM 4 AM announced that the €1.3 million investment will fund the expansion of its facilities, as well as enhance its production and product development capabilities. The company aims to install a complete powder development platform in its facility by the end of the year to meet the growing demand for high-performance materials.

"With this funding, AM 4 AM is entering a new phase in its development. The future infrastructures we will put in place will allow us to enhance production capacity, broaden our product portfolio, and accelerate our innovation efforts," stated Maxime Delmée, CEO and founder of AM 4 AM. "The 3D printing market is expanding rapidly, yet there remains a shortage of suitable metal materials. With HiperAL, our high-performance aluminium, we've demonstrated a groundbreaking ability to provide metals with the required properties, meeting the demands of this growing sector."

From its founding in 2019, AM 4 AM has pioneered an innovative technology for powder modification using cold plasma. This technology is said to enhance the properties of materials when additively manufactured, with the company's flagship product, HiperAL, reported to be one of the strongest aluminium alloys on the market.

"It's a real pleasure to see AM 4 AM continuing to grow and succeed from Luxembourg! After taking part in Fit 4 Start in 2022, the company continued its successful development from the Technoport in Foetz. Now, by leveraging the Young Innovative Enterprise scheme, AM 4 AM is set to expand and scale its operations internationally," said Sven Baltes, Manager of Start-up Relations at Luxinnovation.

The Luxembourg Space Sector Development Fund, under the oversight of the Luxembourg government and satellite connectivity solutions provider SES, is intended to support the fund's mission of bolstering Luxembourg's space ecosystem. AM 4 AM's powders, with their high strength, are well-suited to use in Additive Manufacturing intended for space.

Speaking about the investment, Bernd Schäfer, CEO and Managing Director of EIT RawMaterials, said, "Companies like AM 4 AM who work on advancing raw materials play a crucial role in the future of the European economy and its sustainability. EIT RawMaterials' focus on innovation and AM 4 AM's mission show perfect synergies, and I'm excited that we are part of this journey."

www.am-4-am.com

Titomic secures AU$30 million, appoints Jim Simpson as new CEO

Titomic Limited, headquartered in Brisbane, Australia, announced that Jim Simpson will succeed CEO and Managing Director Herbert Koeck, who has informed the board that he intends to retire at the end of 2024. In the interim, Simpson will assume the role of president of Titomic USA, Inc and Deputy CEO of Titomic Limited. In addition, Dag W R Stromme will assume the role of Executive Chairman to assist with and facilitate the transition of Titomic to new leadership, as well as its expansion to the United States.

Simpson has more than 40 years' experience in the satellite, aerospace, and defence sectors, having held leadership roles ranging from CEO of satellite companies Saturn Satellite Networks and ABS Corporation, to senior leadership positions at Virgin Orbit, Aerojet Rocketdyne, as well as Boeing. He possesses intimate know-how and in-depth experience within the US national security, international, commercial, and civil space arenas.

"We are thrilled to welcome Jim to Titomic. Jim is a deeply experienced and respected leader in the Satellite and Aerospace sector, having served as both CEO of early stage companies as well as senior executive of established OEMs. He has a proven track record of driving growth, innovation and team building," stated Stromme. "We look forward to working with Jim as he leads Titomic into its next phase of expanded product innovation and accelerating growth."

Titomic raises AU$30 million

The company also announced it has received binding commitments for an upsized two-tranche placement to raise approximately AU$30 million. The placement will result in the issuance of approximately 250 million new fully paid ordinary shares to eligible investors at a price of AU$0.12 per new share.

"This highly successful equity placement marks another significant milestone for Titomic. Investor demand substantially exceeded the initially targeted raise of A$25 million, and the Company elected to upsize the offering to A$30 million," added Stromme. "We are now in an excellent position to advance our cold spray technology by executing our US expansion to Huntsville, Alabama, expanding our global manufacturing footprint as well as further advancing our coating and repair solutions."

The funding and Jim Simpson's appointment come as Titomic establishes new operational headquarters and manufacturing facility in Huntsville, Alabama. This strategic move is said to be driven by the increasing interest from the US Government and defence OEMs in Titomic's advanced Cold Spray technology for manufacturing titanium parts for missiles, aerospace applications, and coating and repair solutions.

www.titomic.com

1000 Kelvin launches full AI-automated build preparation workflow AMAIZE 2.0

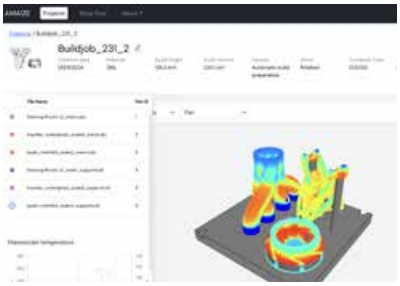
At Formnext 2024, 1000 Kelvin, headquartered in Berlin, Germany, announced that its AI co-pilot software, AMAIZE, has expanded beyond toolpath automation to include nearly the entire metal Laser Beam Powder Bed Fusion (PBF-LB) workflow. With AMAIZE 2.0, 1000 Kelvin aims to make the Additive Manufacturing process more reliable, efficient, and scalable for manufacturers across industries.

AMAIZE 2.0 now features a comprehensive suite of advanced automation tools designed to tackle some of the most persistent challenges in AM. These include:

- **Printability Checker:** Automatically validates and optimises designs for AM, reducing redesign cycles by 40%.
- **Cost Estimator:** Delivers accurate, upfront cost estimations, improving quotation accuracy by 30%.
- **Automated Support Structures:** Incorporates physics-based build preparation to save up to 20% in material costs and enable non-experts to easily implement successful build preparation workflows.
- **Exposure Strategy Optimisation:** Ensures first-time-right builds with AI-driven parameters, cutting failure rates by 50%.

These enhancements allow manufacturers to unlock higher Overall Equipment Effectiveness (OEE) and increase yield by leveraging AI-powered insights for every step of the manufacturing process.

"Our mission is to make Additive Manufacturing simpler, more accurate, and more predictable," said



AMAIZE, has expanded beyond toolpath automation to include nearly the entire metal PBF-LB workflow (Courtesy 1000 Kelvin)

Dr Omar Fergani, PhD, Co-founder and CEO of 1000 Kelvin. "With AMAIZE 2.0, our customers can achieve consistent, first-time-right results with greater confidence and speed. We're finally unlocking the true value of the 3D printing industry."

AMAIZE 2.0 is now available for early adopters, which already include companies such as Emerson, HENNgineered, FKM, A*Star, and Ultimetal, among others.

www.1000kelvin.com

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Contact us at sales@burloaktech.com.

NIST awards $15M to ASTM International to establish Standardisation Center of Excellence

The US Department of Commerce's National Institute of Standards and Technology (NIST) has awarded $15 million for the establishment of a Standardisation Center of Excellence (SCoE) to support the international standardisation of critical and emerging technologies. The new centre will be led by global standards organisation ASTM International, alongside several key partners including ANSI, A3 Association for Advancing Automation, ASME, IEEE, UL Standards and Engagement, CSA Group, Accuris, and Nexight Group.

"Broad US participation in the international standards process is vital to ensuring global market access for our products and services in the highly competitive and rapidly evolving technologies and that the resulting standards are based on sound science," said NIST Associate Director for Laboratory Programs Charles Romine. "This first-of-its-kind public-private partnership will help us advance international standardisation for the critical and emerging technologies that are changing our lives every day, such as artificial intelligence, quantum technology and biotechnology."

The SCoE will focus on four broad areas:

- Pre-standardisation engagement to encourage and ensure private sector-driven participation — especially by underrepresented groups such as small- and medium-sized enterprises (SMEs) — in international standardisation
- Workforce capacity building to create a pipeline of professionals, especially early- to mid-career professionals, who can engage in and lead international standards development efforts
- A collaborative pilot programme with NIST to accelerate the development of industry-driven standards where needed for selected CETs
- Creation of an information and data sharing hub to serve as a central resource for all stakeholders involved in standardisation, with information and tools that are tailored to meet the specific needs and priorities of particular critical and emerging technologies

The centre's efforts will align the US Government National Standards Strategy for Critical and Emerging Technology (USG NSSCET) and its Implementation Roadmap. The centre is also intended to support and complement the broader goals of the United States Standards Strategy as published by the American National Standards Institute (ANSI).

NIST will provide funding for the SCoE through a cooperative agreement over a five-year period and will actively engage with the centre and its stakeholders, providing technical expertise and leadership. It was added that future funding awards will be subject to the availability of funds.

www.nist.gov
www.astm.org

ONE3D adds Nikon SLM Solutions NXG 600E to support aerospace and defence customers

ONE3D sro, based in Mohelnice, Czechia, has acquired an NXG 600E Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine from Nikon SLM Solutions. The investment is expected to support the company's work with aerospace and defence clients, including its role as an industrial partner in Lockheed Martin's development project for the Czech Army's F-35 fighter aircraft programme.

This NXG 600E enables the production of parts up to 600 x 600 x 1,500 mm and uses twelve 1 kW lasers. ONE3D has stated that the acquisition aligns with its strategic growth plan, enabling production expansion at high quality.

David Kadlčík, co-founder and CSMO of ONE3D, remarked, "Using technology from Nikon SLM Solutions is a major step forward for our production. We will be able to create complex metal parts with larger dimensions, greater precision, and higher efficiency than ever before. This will allow us to better match designs to Additive Manufacturing capabilities, optimise material and energy consumption, and reduce the time from concept to final product. Working with such an experienced partner gives us the confidence that we are at the forefront of industry practices. I am confident that with this new machine, we will take our capabilities and competitiveness to a whole new level."

Sam O'Leary, CEO of Nikon SLM Solutions, commented, "We are thrilled to support ONE3D in their journey toward advanced, large-scale Additive Manufacturing. The NXG 600E is engineered to meet the toughest demands of high-performance industries, and with its capabilities, ONE3D is poised to set new benchmarks in precision, productivity, and innovation. We look forward to seeing how they leverage our technology to push boundaries and deliver transformative results for their aerospace and defence clients."

In its over a decade of experience, ONE3D's R&D department has collaborated with leading companies and research institutions. It has achieved ISO 9001, ISO 14001, and ISO 45001 certifications and is currently pursuing AS9100 certification.

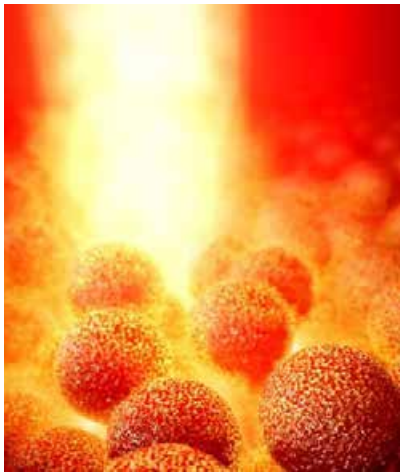
www.nikon-slm-solutions.com
www.one3d.cz

Novel wet etching technique boosts absorptivity of metal powders

A team from the United State's Lawrence Livermore National Laboratory (LLNL), Stanford University and the University of Pennsylvania, has developed a novel wet chemical etching process that modifies the surface of conventional metal powders used in Additive Manufacturing. By creating nanoscale grooves and textures, the researchers have increased the absorptivity of the powders by up to 70%, allowing for more effective energy transfer during the Laser Beam Powder Bed Fusion (PBF-LB) process, particularly for challenging materials such as copper and tungsten.

One of the persistent challenges in PBF-LB metal AM is the high reflectivity of certain metals, which can lead to inefficient energy absorption during the manufacturing process and can even damage some AM machines. This inefficiency often results in inadequate build quality and increased energy consumption, the researchers explain.

"Currently, with standard commercial laser-based machines, high-quality pure copper metal AM is generally considered infeasible," said co-lead author and LLNL materials scientist Philip DePond. "Our method combines the effects of traditional surface treatments [that increase absorptivity] but doesn't compromise the purity or material properties of copper that make it desirable — namely its high thermal and electrical conductivity. More fundamentally, we showed that laser-powder interactions extend to regions beyond the melt pool. This has been shown in simulations, especially those of high-fidelity done at LLNL, but not really detailed experimentally. We demonstrated that those interactions exist and can be beneficial to the process."



A rendering of laser energy striking powder (Courtesy Brendan Thompson/Lawrence Livermore National Laboratory)

The wet-etching technique is said to be relatively simple, but highly effective. The team immersed metal powders, such as copper and tungsten, in specially formulated solutions that selectively removes material from the surface. This process results in the formation of intricate nanoscale features that enhance the powder's ability to absorb laser light. To characterise the surface features of the etched powders, the researchers employed advanced imaging techniques including synchrotron X-ray nanotomography, which provided detailed 3D representations of the powder particles, allowing the team to analyse and accurately model the electromagnetic influence of the nanoscale modifications.

The team conducted extensive experiments to demonstrate and attribute the mechanism of increased absorptivity to the modified powders. Process optimisation studies and eventually bulk and complex sample Additive Manufacturing was performed using custom-built PBF-LB systems housed at LLNL's Advanced Manufacturing Laboratory and MIRILIS laser-material interaction laboratory.

Researchers said that the enhanced absorptivity of metal powders is a promising step forward for reducing energy consumption in manufacturing, particularly as the demand for more sustainable and efficient manufacturing processes continues to grow. One of the team's key findings was that they could manufacture high-purity copper and tungsten structures using lower energy input, less than 100 J/mm^3 for copper, which is around the range for high-density titanium and stainless steel alloys, and ~700 J/mm^3 for tungsten, around 1/3 less energy than is typically employed.

"In a broad sense, we are enabling the printing of copper without the risk of damaging the AM system itself," DePond explained. "The process parameter window becomes wider as well, which allows a wider variety of scanning conditions to be explored, which often are needed when printing complex geometries. Finally, a handful of machine manufacturers have even gone the great lengths of creating entirely new machines to process copper and other highly reflective materials. These turn out to be nearly double the cost of a traditional machine, so the barrier of entry to printing these materials is prohibitively high."

The potential applications of the findings could have an immediate impact on production. Researchers said the ability to manufacture with less energy not only reduces operational costs but also minimises the environmental impact of the manufacturing process and opens copper Additive Manufacturing up to a whole new contingent of producers.

The enhanced absorptivity and improved powder dynamics could also enable the production of high-quality AM parts with greater relative densities. In their experiments, the researchers achieved relative densities of up to 92% with half the energy input compared to other additively manufactured copper components, and over 99% with higher energies, indicating the potential for producing stronger and more durable metal parts.

Co-authors on the paper include LLNL's M Matthews; O Tertuliano and L Capaldi of the University of Pennsylvania; and A Lee, J Hong, D Doan, M Brongersma, X Wendy Gu, Wei Cai and A Lew of Stanford.

www.llnl.gov
www.stanford.edu
www.upenn.edu

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- 100% reduction in porosity possible
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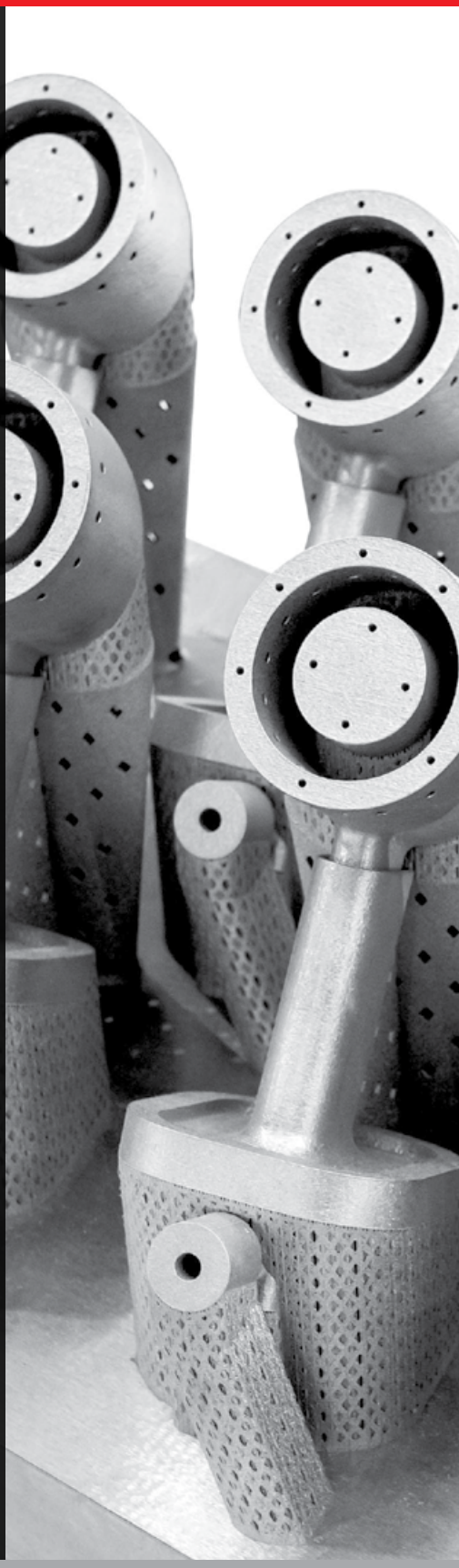
- Improved microstructure



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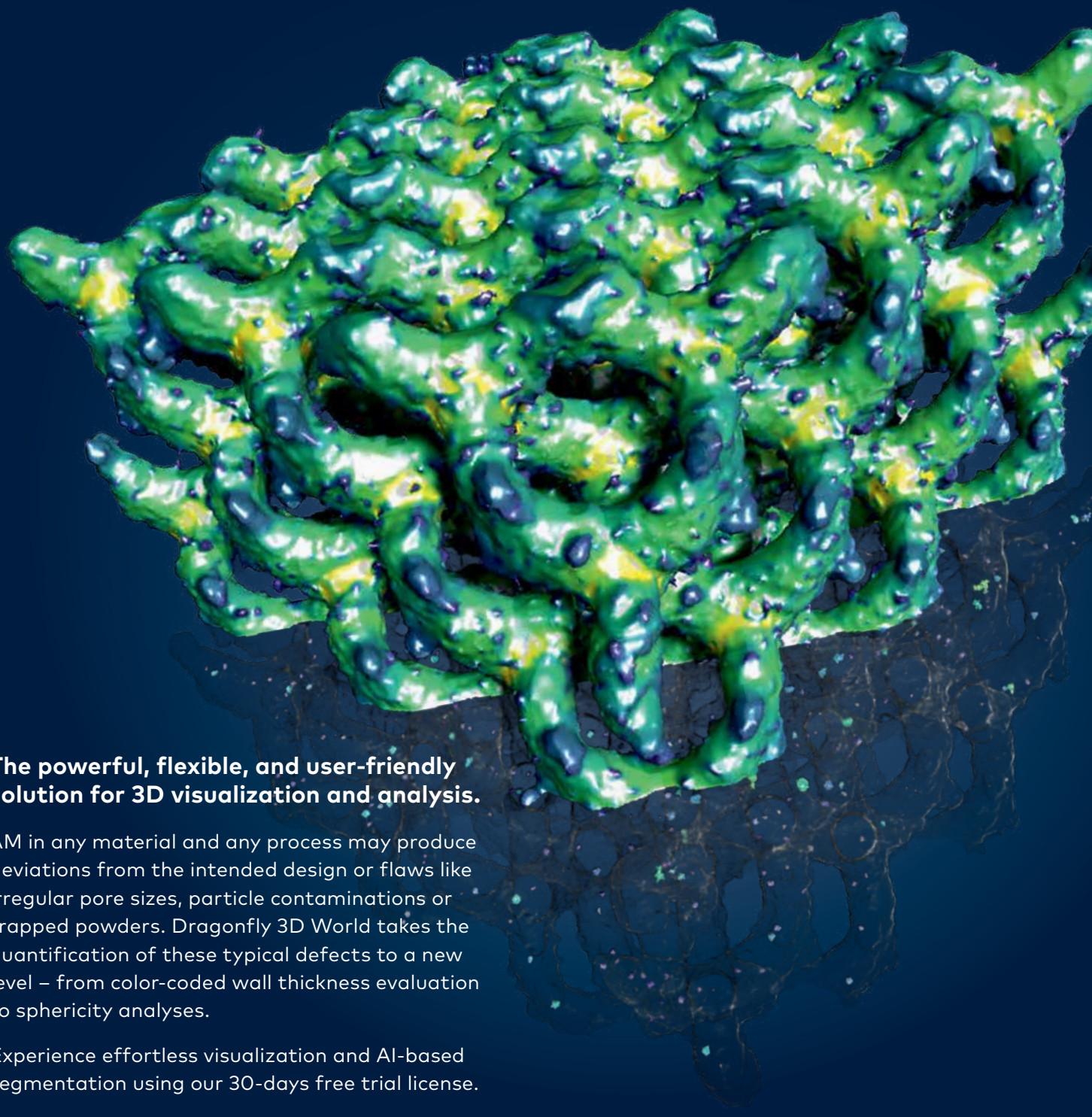

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AM in any material and any process may produce deviations from the intended design or flaws like irregular pore sizes, particle contaminations or trapped powders. Dragonfly 3D World takes the quantification of these typical defects to a new level – from color-coded wall thickness evaluation to sphericity analyses.

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ACMI opens Indonesian Additive Manufacturing Centre with multiple Farsoon metal AM machines

Farsoon Technologies, based in Changsha, China, has reported that Anugrah Cipta Mould Indonesia (ACMI) has established a new Additive Manufacturing centre for the production of footwear moulds. The new facility houses a number of Farsoon metal Additive Manufacturing machines, including the FS200M dual-laser and larger FS350M quad-laser.

Since its establishment in 1995, ACMI has grown into one of Indonesia's leading mould manufacturers, supplying some of the world's top footwear brands. The company manufactures a range of products, including outsoles, midsoles, and TPU soles.

"As early as 2015, we began using SLA 3D printing for casting. With the growing demand in the metal market, we invested in Farsoon's FS200M dual-laser system in 2021, making us the first manufacturer in Indonesia to operate a metal powder bed fusion machine for shoe moulds and other industrial applications," stated Min Seo Kang, ACMI's Lead Manager for metal Additive Manufacturing.

"As we continue focusing on shoe mould manufacturing and future expansion to other industries, the larger FS350M quad-laser system has become our go-to solution for accelerating series production. Farsoon's fast and professional technical support helped us master the operational processes and launch our own application projects with an impressively smooth learning curve."

After several years of metal AM, ACMI made the strategic decision to establish a dedicated AM Centre in Indonesia. The primary goal was to expand its service capabilities, while showcasing the numerous advantages and opportunities that metal powder bed fusion technology offers. These include faster lead times, superior quality, innovative design possibilities, and reduced costs compared to traditional manufacturing methods. The AM Centre will serve as a hub for innovation, helping to bring these benefits to the market.

"Shoe moulds, in my opinion, are among the most challenging applications due to their intricate design details and the strict requirements set by manufacturers," added Min Seo Kang. "With Farsoon's open parameter system, we can easily customise the processing and implement improvements in real time. Many leading shoe brands have expressed great satisfaction with the quality of moulds compared to traditional methods, and some have already started placing full-size production orders, including injection and compression moulds for EVA and TPU moulds."

"In addition to shoe moulds, we've collaborated with various industries, producing spare part models for automotive, marine, and cooling channel integrated automated robots — some of which are currently in development for production. With our FS350M machines currently running production with 316L (stainless steel) and AlSi10mg (aluminium) material, we are excited about expanding our manufacturing capabilities as we prepare for even larger orders at the upcoming AM Center," continued Min Seo Kang.

Working with ACMI and Farsoon has been Chanhon Additive Manufacturing Technology Co, Ltd (ChanHonTech), "We are thrilled to collaborate with ACMI in the footwear sector and witness how Farsoon's metal 3D printing technology has revolutionised Indonesia's footwear manufacturing in recent years," stated Binghua Lu, General Manager of ChanHonTech. "With over a decade of experience in the footwear industry, we are proud to provide fast, responsive local technical support to meet the demands of series production."

To contact ACMI, email Min Seo Kang: mskang@acmi.co.id

www.farsoon-gl.com

Farsoon founder Dr Xiaoshu Xu and Farsoon global technical team at ACMI AM Center (Courtesy Farsoon)

Freemelt to demonstrate serial production capabilities of orthopaedic implants using its eMELT PBF-EB

Sweden's Freemelt AB, based in Mölndal, has entered into a strategic agreement with a global orthopaedic implant original equipment manufacturer (OEM) to demonstrate the serial production capabilities of its Electron Beam Powder Bed Fusion (PBF-EB) Additive Manufacturing process.

This partnership is reported to mark a significant milestone for Freemelt, as the company's industrial machine, eMELT, has been selected by the OEM for a proof-of-concept project to demonstrate serial production capabilities. The eMELT machine will be installed at the OEM's production plant in Q2 2025, marking the beginning of the proof-of-concept phase.

"We are thrilled to have been selected by this esteemed OEM, a true leader in the adoption of Additive Manufacturing technology. This partnership is a testament to our team's hard work and dedication to delivering industry-leading productivity and cost efficiency in AM. We look forward to working closely with our new partner to accelerate serial production in Additive Manufacturing," stated Daniel Gidlund, CEO of Freemelt.

The demand for AM-produced implants is projected to grow significantly, from $1.7 billion in 2023 to $6.6 billion by 2032, driven by ageing populations and increasing joint replacement needs. Freemelt's eMELT machine is well-positioned to meet this growing demand, offering industry-leading productivity and cost efficiency, particularly for titanium, a material ideally suited for orthopaedic implants due to its biocompatibility, strength, and durability.

As part of the partnership, Freemelt will contribute its extensive expertise in PBF-EB technology and provide process and application engineering support to the project. This collaboration looks to enable the OEM to leverage Freemelt's expertise and technology to drive innovation and growth in the orthopaedic implants market.

Freemelt will demonstrate the serial production capabilities of its Electron Beam Powder Bed Fusion AM process (Courtesy Freemelt)

Including the previously announced order from another implant OEM, Freemelt now has two orthopaedic implant OEMs among its established customers.

www.freemelt.com

Equispheres' aluminium qualified for 3D Systems' DMP Flex 350 and DMP Factory 350 AM machines

Equispheres, Inc, based in Ottawa, Ontario, Canada, has entered into a supplier agreement with 3D Systems, Rock Hill, South Carolina, USA, which will enable the use of Equispheres' North-American-made aluminium powder with 3D Systems' DMP Flex 350 and DMP Factory 350 Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machines.

During testing, results were said to show that it is possible to achieve up to 50% productivity gains and an average density of 99.8% with a build rate of 49.7 cc/h at 60 µm layer thickness on the DMP Flex 350. The addition of Equispheres' Al is expected to allow customers to explore faster build speeds when producing automotive and aerospace parts (e.g. lighter brackets and supports, heat exchangers, and passive RF hardware).

"We are very excited about this supplier agreement with a partner that has such deep knowledge of 3D printing. Our materials print significantly faster than traditional aluminium powders, which dramatically lowers part production time and per-part costs," stated Evan Butler-Jones, Vice President — Product & Strategy for Equispheres. "When combined with 3D Systems' expertise in applications and its DMP Flex 350 and DMP Factory 350 printers, customers can expect to push past previous limitations related to speed and repeatability."

"We are pleased to enter this supplier agreement with a North American company such as Equispheres," said Marty Johnson, Vice President, product & technical fellow, 3D Systems. "As a leading Additive Manufacturing solutions provider, we value the opportunity to work with up-and-coming companies. Equispheres has developed an interesting material that enables 3D Systems' customers to produce high quality parts when used with our DMP Flex 350 and DMP Factory 350 printers. We look forward to seeing how this can help push the boundaries for production applications."

Aluminium is valued in Additive Manufacturing for its light weight and heat transfer capabilities. The consistent size and characteristics of Equispheres' powders aim to ensure consistent mechanical properties, making it well-suited to applications requiring high levels of precision and repeatability, including in sectors such as automotive production, aerospace, defence and energy.

www.equispheres.com
www.3dsystems.com

VMP
江苏威拉里

Jiangsu Vilory Advanced Materials Technology Co., Ltd.

Metal Powder Solution Solver

Company Profile

Jiangsu Vilory Advanced Materials Technology Co., Ltd. was established in 2015. It mainly engages in the research and production of metal 3D printing powders, and can also sell self-developed and technologically optimized powder making equipment. There are currently 20+production lines and 20+production lines under construction, with an annual output of 2500 tons of powder and 500 tons of titanium alloy powder.

VIGA

(Vacuum Induction-melting Gas Atomization)

Scope of application: It can prepare alloy powder materials such as iron-based, nickel based, cobalt based, aluminum based, copper based, etc. The materials are widely used in advanced manufacturing fields such as 3D printing, laser cladding, thermal spraying, powder metallurgy, and hot isostatic pressing.
Melting temperature: 1700℃.

Service Advantages

Strong Technical Strength, One-stop Service, Complete Quality System.

Equipment Advantages

Miniaturization, Digitization, Intelligence, Efficiency, And Convenient Operation.

Screening Integrated | Explosion-proof Certification | Power-off Protection | Cleaning Production line | Module Assembly | Dynamic Detection

Technical Rarameter

Name	Vacuum Induction-melting Gas Atomization(Technical Parameters)
Crucible Capacity	10~100kg
Pouring Method	Pouring of intermediate package
Maximum Melting Temperature	1700℃(long-term operation not exceeding1650℃)
Temperature Measurement Methods	Mechanical temperature measurement and dual color temperature measurement
Insulation Temperature	800-1400℃ (adjustable)
Total Power	100~700KW
Ultimate Vacuum Degree	6.67×10^{-1}Pa(cold state of empty furnace)
Pressure Rise Rate	≤ 5Pa/h
Inert Gas	Nitrogen or argon
Atomizing Gas Pressure	10-30Nm³/min
Atomized Gas Flow Rate	0~6MPa
Atomization Capacity	8~10kg/min
Production Frequency	3-4 hours per furnace
Common Powder Particle Size Ranges	15~45μm, 15~53μm, 53~150μm
Equipment Size	Customized according to furnace type
Note:Equipment parameters can be adjusted according to user needs	

T70X

T70X powder for laser selective melting product introduction

□ Application

Applied to aero-engine rotor parts, metal matrix composite matrix, high-pressure compressor blades, 650℃-750℃ high temperature short-term parts

□ Introduction

T70X alloy is a multi-component near-αhigh-temperature titanium alloy.

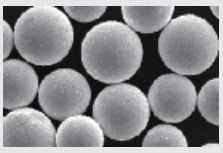
- Excellent mechanical properties
- Good high temperature performance
- Good thermal stability
- Good creep properties

□ Mechanical properties

Temperature	Direction	UTS/MPa	YS/MPa	ELA/%
Room temperature	XY	≥980	≥920	≥15
	Z	≥1000	≥920	≥15
700℃	XY	≥500	≥350	≥12
	Z	≥500	≥350	≥12
800℃	XY	≥260	≥140	≥40
	Z	≥260	≥140	≥30

□ Element

Element	Ti	Al	Sn	Zr	Mo	Si	Ta	Nb	W	C	Fe	O
wt.%	Bal.	5.4-6.3	3-5	2.5-6.4	≤0.96	0.25-0.5	0.3-3.4	0.2-0.5	0.2-0.6	≤0.07	≤0.03	≤0.17



CE application in progress please stay tuned...

International Service Website

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Address 2：No.101 Yangshan Road Economi and Technological Development Zone, Xuzhou City, Jiangsu Province, China
Email: yxzx@wllxcl.com Website：www.wllxcl.com Tel：0086-0516-68387188

Alloy development with InssTek's MX-Lab at global academic institutions

InssTek, headquartered in Daejeon, South Korea, has reportedly seen significant global success with its metal Additive Manufacturing machine, MX-Lab, which continues to attract leading universities and research institutions worldwide. A recent sale to the Institut Jean Lamour (IJL), Université de Lorraine, Nancy, France, further accelerates MX-Lab's successful global expansion. Additionally, installations are currently underway at other universities and research institutions.

The MX-Lab, independently developed by InssTek, is a dedicated Additive Manufacturing machine for material research using Directed Energy Deposition (DED) technology. The most notable feature of this AM machine is its 'Hexa Powder Feeder' system, which allows for the precise control of up to six different material ratios during experiments. This system ensures accurate powder feeding, even in micro-amounts, making it ideal for detailed and precise research applications.

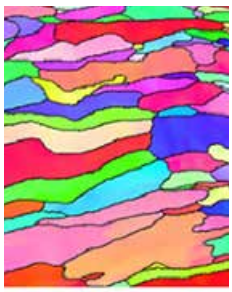
The MX-Lab is designed specifically for research purposes, offering a compact size that allows researchers to design and conduct experiments with high flexibility and ease. Its user-friendly interface and advanced capabilities enable scientists and engineers to explore a wide range of material compositions and properties efficiently.

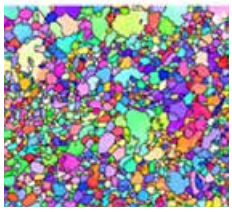
The MX-Lab has been adopted by universities and research institutions across 15 countries, leveraging its technology for research and development. Key customers include:

- Brown University (USA): Focusing on innovative research in materials science and engineering
- University of Michigan (USA): Studies on high-performance alloys and Additive Manufacturing process optimisation
- University of North Dakota: (USA): Utilising MX-Lab for the development of multi-material structures and machine learning applications in Additive Manufacturing
- VTT (Finland): Alloy optimisation
- COMTES FHT a.s. (Czech Republic): To make Functionally Gradient Material samples
- KAIST (South Korea): To find new compositions of High Entropy Alloys

An InssTek spokesperson stated, "The high interest and trust in MX-Lab's performance and potential from research institutions are driving our success in the global market. We aim to continue partnering with more institutions to contribute to innovative technology development."

www.insstek.com





The MX-Lab is a dedicated AM machine for material research DED technology (Courtesy InssTek)

Aurora Labs receives further order from Australian Department of Defence for experimental metal AM parts

Aurora Labs Limited (A3D), Tel Aviv, Israel, has announced the receipt of a second purchase order directly from the Australian Department of Defence. Under the order, the company will produce advanced experimental metal alloy components using its Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing.

"Securing this second order from Defence is a clear validation of our strategic focus on the Defence and aerospace markets," commented Rebekah Letheby, CEO of A3D. "It reflects our commitment to innovation and delivering precision-manufactured components that meet the stringent demands of these critical industries."

"We are building a strong relationship with defence, and this latest order which follows the initial purchase order for first phase printed products received in June 2024 confirms A3D's growing role in supporting Australia's sovereign defence capabilities," she continued. "Our team's deep knowledge in materials and metal printing processes ensures we are well positioned to continue expanding into these high-value sectors."

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ULT adds solutions for AM gas purification and extraction

Air treatment equipment manufacturer ULT, headquartered in Löbau, Germany, has announced the addition of the ACD 400.1 Ex extraction solution for the removal of atmospheres containing flammable components, and the AMF 60, a modular, compact gas removal machine.

ACD 400.1 Ex

The ACD 400.1 Ex was developed for the extraction and filtration of dry, flammable and non-flammable gases and vapours in concentrations up to 20% of the lower explosion limits. The system is a modular, two-stage storage filter device, consisting of an M5 dust pre-filter and two adsorption filter modules (activated carbon). To prevent ignition of flammable gases and vapours in the filter, the activated carbon filter elements and subsequent components — such as the explosion-proof fan compliant with ATEX Ex II 2G T3 and the ATEX-compliant motor — are earthed and designed to be free of ignition sources.

The ACD 400.1 Ex is noted for its extremely quiet operation, low energy consumption, and flexibility regarding changing workplaces or types of emissions. The filter cassettes are electrically conductive with a potential equalisation connection and offer a high safety standard for users when changing filters. A T3 blower is installed in the device, allowing gases of temperature classes T1-T3 to be extracted safely.

The extraction unit can be equipped with collection elements (extraction arms, hoses, pipes) in various sizes and types.

Due to the high degree of gas filtration, the cleaned gas can be fed back into the work area via the standard integrated recirculation mode. For applications involving carcinogenic, mutagenic or reproductively toxic gases, the devices can be equipped with an exhaust air nozzle for exhaust air operation.

AMF 60

The AMF 60 is a modular, compact and gas-tight extraction and filter system, suitable for all inert gases (e.g. nitrogen, argon, helium). In addition to simplified operation and safe maintenance and service, the AMF 60 enables low process costs and long filter service lives. The mobile, flexible system is equipped with a HEPA-H14 and reportedly offers a filtration performance of >99.995%, allowing the cleaned air to be returned to the work area. The storage filters allow contamination-free handling of highly flammable and health-endangering process pollutants.

The gas purification system can be integrated as a slave with I/O system or used as a stand-alone solution with CULT control. This specially developed new control includes standard components such as a timer for setting the running times or data log functions and modular extensions like sensor monitoring of all process parameters or customisable post-filters.

The AMF 60 requires a footprint of only 450 x 640 mm. Due to its UL conformity and voltage range between 90-250 VAC, the device can be utilised globally without any special adjustments.

www.ult-airtec.com

The ACD 400.1 Ex (left) and the AMF 60 (right) (Courtesy ULT)

One Click Metal expands Spanish presence with Dativic partnership

One Click Metal, based in Tamm, Germany, has announced a partnership with Additive Manufacturing solutions provider Dativic, Pontevedra, Spain. The move is expected to expand One Click Metal's presence in the Spanish market, particularly in universities, academic institutions and R&D centres.

Since its inception in 2013, Dativic has delivered Additive Manufacturing products and structured, efficient technology implementation to customers. Currently, the company has a product catalogue for AM under its Filament2Print brand. With this partnership, Dativic will promote and distribute One Click Metal's metal AM machines, focusing on educational institutions and R&D centres that seek prototyping and research solutions.

"Our collaboration with Dativic is a significant step in bringing our accessible and intuitive metal 3D printing technology to Spain," said Gerrit Brüggemann, CEO of One Click Metal. "Dativic's professionalism and deep industry experience make them an ideal partner to support academic and research institutions in leveraging the power of metal AM."

www.oneclickmetal.com

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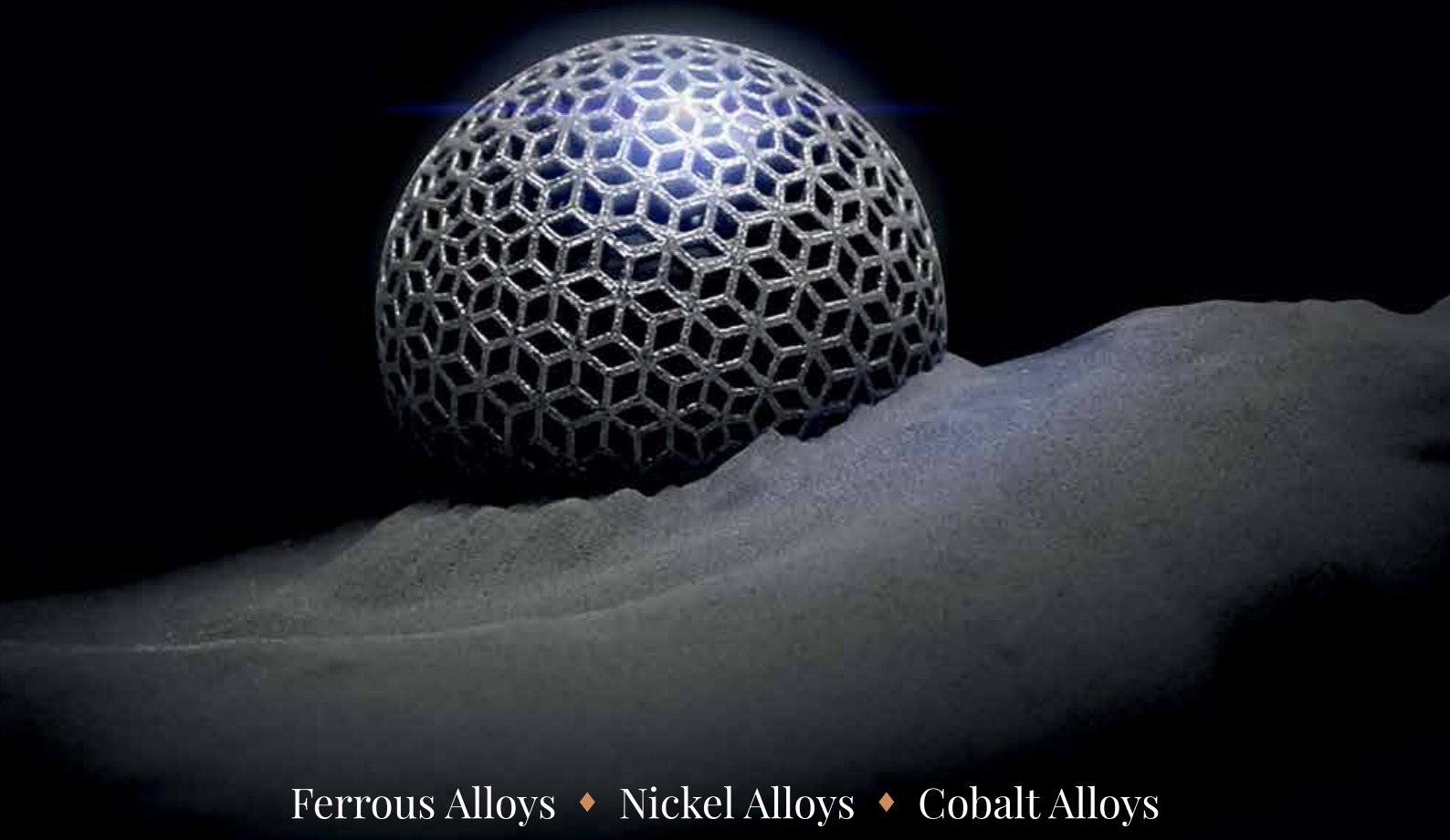

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Network established to develop process chain for sinter-based nickel Additive Manufacturing

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM), Dresden University of Applied Sciences (HTW), and the Fraunhofer Institute for Material and Beam Technology (IWS) are collaborating on the 'Simsalabim' project to design a continuous process chain for the sinter-based Additive Manufacturing of nickel-based alloys. Alongside the process chain, the project aims to establish new materials and processes in order to offer future industrial partners a broader range of solutions.

The end goal of the project is to reach TRL 5 whilst keeping resource efficiency in mind. The partners are aiming to save two to three development cycles and accelerate the calibration of new materials by a factor of five. In the long term, the project is also intended to serve as the nucleus for a regional network for sinter-based Additive Manufacturing processes. Based on the results of this project, other material classes (e.g. tool steels and cobalt-based alloys) are also to be investigated in the future.

The growth of sinter-based Additive Manufacturing

To date, metal Additive Manufacturing has primarily focused on laser-based processes. Although these are characterised by a high level of technological maturity, they can't meet certain challenges in the realms of materials, geometries and productivity. This gap is why the industry's interest in sinter-based additive processes is growing; the technology's advantages include the ability to process difficult-to-weld materials, high productivity, good surface quality and cost-effective production.

Sinter-based Additive Manufacturing processes metal powder without complete melting, reducing thermal gradients and the formation of residual stresses as well as susceptibility to cracking and the formation of harmful phases.

This offers a great potential for high-strength nickel-based superalloys in particular, as these alloys cannot be processed crack-free using laser-based processes. Characterised by high strength and corrosion resistance at high temperatures, these alloys are often the first choice for high-temperature applications in the energy, transport and hydrogen industries. The lower degree of maturity of sinter-based Additive Manufacturing processes compared to laser-based processes is causing reservations on the part of the industry with regard to the achievable properties, such as proximity to the final shape and material microstructure. There is, therefore, a need to digitally predict the sintering shrinkage of complex structures and the adjustment of material properties in particular.

Kick-off meeting for the project Simsalabim on October 25, 2024 (Courtesy IFAM)

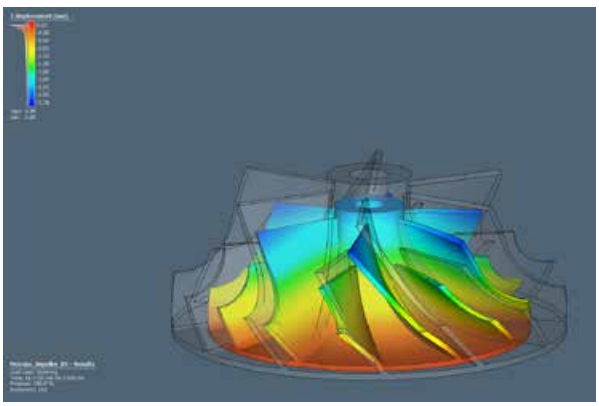
Invitation to exchange ideas within a network

Manufacturers and users of high-temperature materials are invited to an initial network meeting on November 27-28, 2024, in order to incorporate the specific requirements, needs and applications of the industry into the developments right from the start. The continuing network exchange will work to jointly advance the cost-effective production of components using sinter-based Additive Manufacturing.

With the Saxon scientific institutions Fraunhofer IFAM, Fraunhofer IWS and HTW Dresden — three research partners with distinctive expertise and in-depth experience in aviation, energy technology, Additive Manufacturing and Powder Metallurgy — are available on the development side.

www.ifam.fraunhofer.de
www.htw-dresden.de
www.iws.fraunhofer.de

Sintered part of an impeller, manufactured with GelCasting (Courtesy IFAM)



Simulation of sintering shrinkage and distortion with Hexagon Simufact Additive software (Courtesy IFAM)

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Cookson Industrial turns to Renishaw for cost-effective Additive Manufacturing of platinum rhodium

Renishaw, based in Wotton-under-Edge, Gloucestershire, UK, has reportedly helped Cookson Industrial, a division of Cooksongold, based in Birmingham, UK, to significantly reduce the cost of Additive Manufacturing platinum rhodium. Cookson Industrial can now produce platinum rhodium components on Renishaw's RenAM 500S Flex AM machine with exceptional material efficiency.

Cookson Industrial brings over 30 years of expertise in the design and production of precious metal alloys. The company set out to redefine platinum rhodium's use in Additive Manufacturing. However, with platinum rhodium prices averaging £80,000 per kilo, minimising material waste is crucial to making production commercially viable.

To meet this challenge, Cookson Industrial selected Renishaw's RenAM 500S Flex, a Laser Beam Powder Bed Fusion (PBF-LB) machine designed for research and development applications. Renishaw's AM engineering team worked closely with Cookson Industrial to adapt the system to the specific demands of platinum rhodium production. As standard, the RenAM 500S Flex is capable of achieving powder waste levels as low as 1.5%. However, to align with Cookson Industrial's requirements, customisations were needed to reduce it to less than 0.5%.

"Achieving near-zero wastage of platinum rhodium powder was a top priority," said Jason Morgan, Senior Applications Engineer at Renishaw. "We collaborated with Cookson's engineers to identify and eliminate potential 'powder traps' within the system, followed by rapid testing and redesigns to minimise waste while maintaining performance."

Renishaw's customisations included modifying internal system components to prevent powder accumulation, such as removing overflow bellows and optimising the rear overflow vent. Additional measures included chamber redesigns and the creation of specialised casings and covers, resulting in a 95% reduction in powder waste. Now, the RenAM 500S Flex allows Cookson Industrial to retrieve nearly all platinum rhodium powder, amounting to significant cost savings.

"Renishaw's technology and expertise were crucial to this R&D success, enabling us to make platinum rhodium parts on a commercial scale," commented Nikesh Patel, Head of Cookson Industrial. "The ability to minimise powder loss not only brings down our production costs but also makes large-scale production feasible, saving millions over the machine's lifetime."

Renishaw has enabled Cookson Industrial to significantly reduce the cost of Additive Manufacturing platinum rhodium (Courtesy Renishaw)

"This success paves the way for Cookson Industrial to explore new applications for platinum rhodium AM, including catalysts and aerospace engine nozzles," Renishaw's Morgan added, "Our collaboration with Cookson Industrial highlights Renishaw's commitment to supporting customers in every step of their AM journey, especially when working with novel materials."

www.cookson-industrial.com
www.renishaw.com

Nikon adds Additional Powder Feeder options for LM102A

Nikon Corporation, Tokyo, Japan, has announced the release of the Additional Powder Feeder (APF) unit for its Lasermeister 102A (LM102A) Directed Energy Deposition (DED) Additive Manufacturing machine. The APF is an optional powder feeder unit which enables feeding multiple kinds of metal powders into the LM102A.

These enhanced capabilities can contribute to the development of new value-added alloys and components that consist of multiple kinds of metals, explains Nikon.

In fields such as aerospace, defence, and energy, characteristics like high durability and corrosion resistance are essential in ensuring stable performance in harsh environments, including extremely high temperatures.

Existing superalloys alone may not sufficiently satisfy parts' requirements, whilst the development of novel superalloys may deliver critical next-level performance. Universities and corporate research institutes are already developing such solutions, and Nikon's APF is intended to support these programmes.

The Nikon LM102A with two Additional Powder Feeder units attached (Courtesy Nikon)

Two to four APF's can be incorporated to achieve specific user objectives, enabling four different kinds of metal powder to be fed to the AM machine.

www.nikon.com

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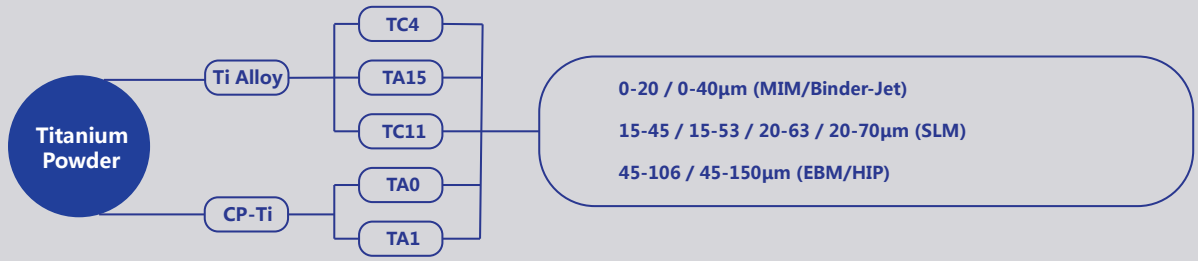
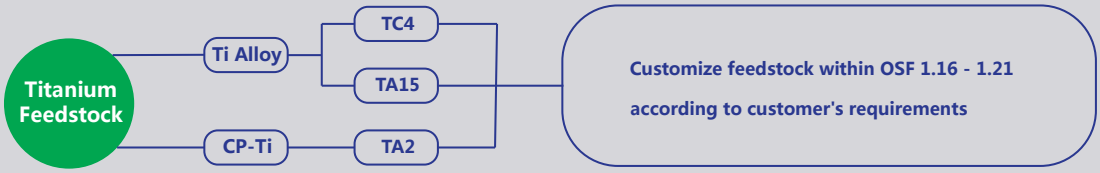
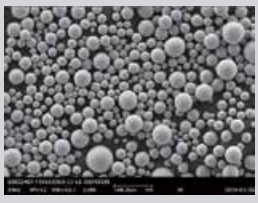
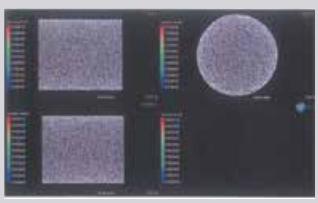


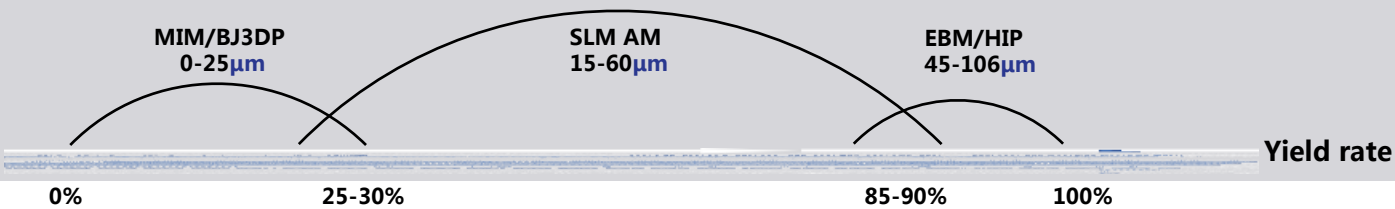
<In addition to the main grades of powders mentioned above, JSJW can also customize the production of multiple grades of titanium alloy powders>







Sample status	Test Temperature	Rm (N/mm^2)	Rp0.2 (N/mm^2)	A (%)	Z (%)	KU2 (J)
Longitudinal annealing	room temperature	1040	998	16.1	56.4	40.0
		1041	998	18.0	57	44.0
Transvers annealing	room temperature	1037	972	15.6	54.8	46.0
		1032	970	15.7	52.9	48.0



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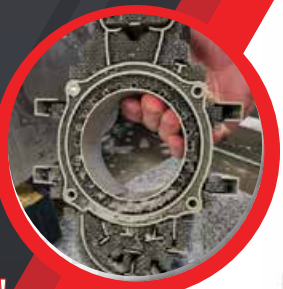

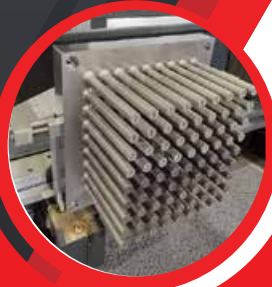

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2024 Excellence in Metallography Award won by AM powder research paper

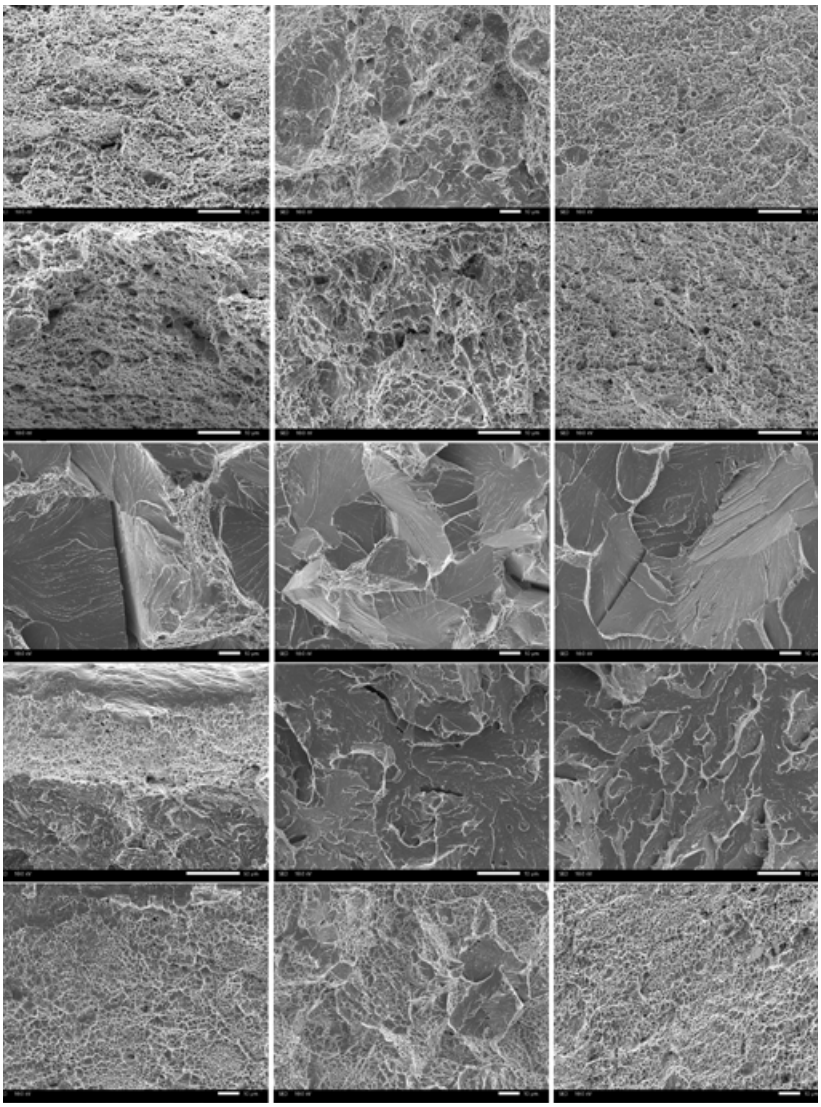
The Metal Powder Industries Federation (MPIF) has selected the paper "Impact Resistance of a Free Sintering Low Alloy Steel Produced by Powder Bed Fusion Using a Laser Beam," by Thomas F Murphy, FAPMI, Christopher T Schade, FAPMI, & Kerri M Horvay, Hoeganaes Corporation as the winner of the 2024 Excellence in Metallography Award.

The paper was selected from the highly qualified manuscripts presented at the PowderMet2024/AMPM2024 conference in Pittsburgh, USA, and critically evaluated for the prestigious award.

The full paper is available for download on the APMI website. It is also included in 'Advances in Additive Manufacturing with Powder Metallurgy-2024' and published in the autumn issue of the *International Journal of Powder Metallurgy*.

The authors will be officially recognised during PowderMet2025 in Phoenix, Arizona, June 15-18, 2025.

www.mpif.org



A selection of images of fracture surfaces from representative bars. All photos are oriented with the progression of fracture moving from the top of the frame to the bottom (Courtesy MPIF)

Freemelt, Saab, and Linköping University to strengthen defence applications with Additive Manufacturing

Freemelt AB, based in Mölndal, Sweden, has entered into a project aimed at developing and verifying the Additive Manufacturing of high-performance materials using its Electron Beam Powder Bed Fusion (PBF-EB) technology. In collaboration with Saab Dynamics and Linköping University, the team will focus on the Additive Manufacturing of oxygen-free copper with extremely high purity and controlled microstructure, a material with significant potential for advanced defence applications.

The project — funded by the Swedish Governmental Agency for Innovation Systems, or Vinnova — will validate Freemelt's technology through a demonstrator specifically designed for Saab Dynamics applications. The goal is to establish Additive Manufacturing for defence applications with high performance and sustainability, while also creating shorter, more secure supply chains for critical materials.

Freemelt brings its experience in PBF-EB to the project, enabling local production of advanced materials, while Linköping University will provide material science research. Saab Dynamics will focus on developing practical applications for the defence sector.

"This collaboration is an exciting step forward in making manufacturing more resilient and sustainable. Freemelt's advanced [PBF-EB] technology will play a key role in strengthening Sweden's defence industry to meet future challenges," says Daniel Gidlund, CEO of Freemelt.

www.freemelt.com

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LUMEX Avance-25

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(D)250mm x (W)250mm x (H)185m
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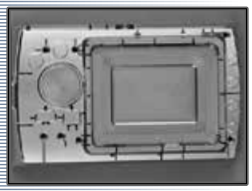
(* Option)



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The Matsuura Avance-60 the largest hybrid powder bed platform on the market.

LUMEX Avance-60

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More information at www.lumex-matsuura.com

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BLT explores the use of Additive Manufacturing in advanced robot component design

Xi'an Bright Laser Technologies Co, Ltd (BLT), based in Xi'an, China, has been exploring how Additive Manufacturing can be leveraged in the production of robotic parts. The company has outlined a number of robot components it has manufactured and explained the advantages of using metal Additive Manufacturing in the design and production process.

In recent years, the momentum of technological revolution and industrial transformation has been accelerating, explains BLT. Robotics, integrating information technology, control systems, and intelligent manufacturing, is increasingly pivotal in this transformation. Combining these disciplines not only brings mutual benefits, but can spur groundbreaking applications, advancing industries such as manufacturing, research, and education.

Complex structure forming

Additive Manufacturing enables the creation of robotic parts with sophisticated internal structures and unique shapes, such as topological and multi-scale lattice designs. For example, BLT's lattice cube exhibit incorporates eight different types of lattice cell structures within a single unit.

Lightweighting is crucial for enhancing a robot's performance and energy efficiency. Applying such designs to parts enables significant lightweighting, reducing the overall weight of components, improving robotic mobility, and decreasing energy consumption.

Rapid prototyping

Additive Manufacturing enables designers to swiftly produce multiple digital models, providing rapid functional validation and performance testing during the design phase. This capability accelerates prototype development, cutting both time and costs. For instance, BLT's trunk exhibit features parallel microchannels for heat dissipation on one side and biomimetic bone structures with multi-scale lattice characteristics on the other, resulting in optimal stiffness. These two designs are seamlessly combined into a single exhibit through Additive Manufacturing.

Integrated manufacturing

The single-step forming capability of Additive Manufacturing allows for the integration of multiple functional components during the design phase. One of BLT's exhibits, for example, integrates flow channels, actuators, and heat sinks into a unified structure that meets strength and functional requirements while reducing assembly costs and enhancing product stability and reliability.

Diverse material selection

Additive Manufacturing supports a wide range of materials, including plastics, metals, and ceramics, each offering specialised options to meet the demands of robotic components in various applications, such as high-temperature or corrosion-resistant environments.

Customisation and cost efficiency

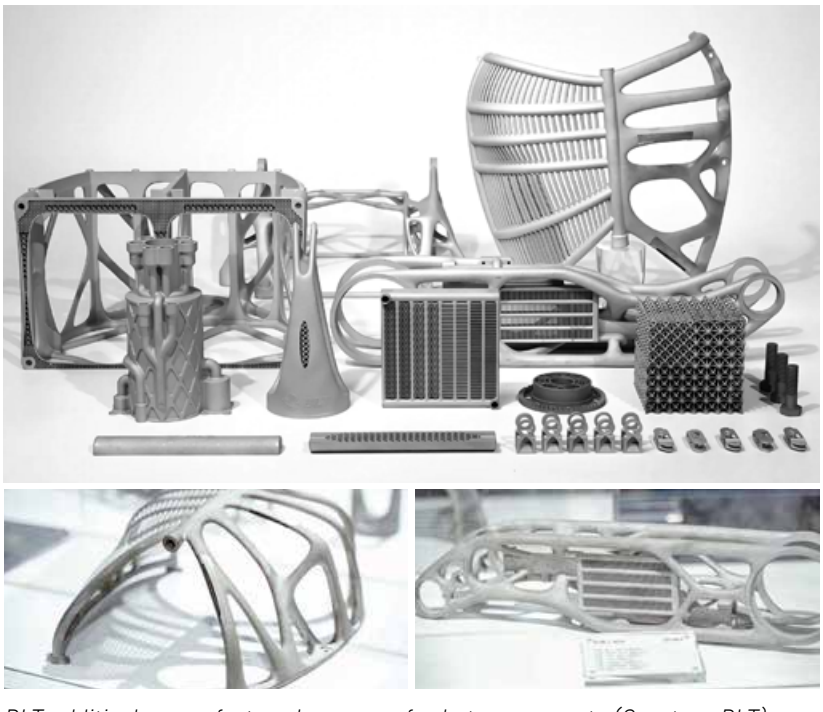
With Additive Manufacturing, customers can quickly turn design concepts into functional prototypes, enabling rapid identification and resolution of design issues in the early stages. This development cycle also reduces innovation costs. For small-batch or customised production, Additive Manufacturing eliminates the need for complex mould-making processes, streamlining production and lowering upfront development costs. This results in the rapid manufacturing of final components.

On-demand production and inventory optimisation

Additive Manufacturing enables local, on-demand production, shortening supply chains, and reducing logistics and inventory costs.

In summary, Additive Manufacturing introduces unparalleled flexibility and innovation to the manufacturing of robot components, making the production process more efficient, adaptable, and creative. Looking ahead, future robots can be expected to feature lighter structural designs with enhanced functionality and broader application potential.

www.xa-blt.com



BLT additively manufactured a range of robot components (Courtesy BLT)

WeAreAM expands AM capacity with new AddUp FormUp 350

WeAreAM, headquartered in Lombardy, Italy, has acquired a FormUp 350 metal Laser Beam Powder Bed Fusion (PBF-LB) Additive Manufacturing machine from AddUp, headquartered in Cébazat, France.

The addition of the FormUp350 is intended to bolster WeAreAM's goal to become a full-service provider of Additive Manufacturing, from powder atomisation through final part machining, finishing and testing. As the company expands its facility, it intends the FormUp 350 to play a key role in supporting industrial-scale, serial production for the medical and aerospace industries safely and efficiently.

"We are excited to integrate the FormUp 350 into our expanding facility," said Paolo Folgarait, CEO of WeAreAM. "AddUp's technology aligns with our goal of advancing Additive Manufacturing on an industrial scale for the Italian market. This partnership enables us to bring enhanced safety, reliability, and productivity to our customers, supporting them as they adopt AM for high-precision applications."

WeAreAM has added a FormUp 350 from AddUp to bolster its medical and aerospace production capabilities (Courtesy WeAreAM)

WeAreAM stated its selection of the FormUp was down to its safety features, specifically the Autonomous Powder Module (APM) which enables secure powder handling, an important factor when working with reactive materials like titanium. The company also cited the machine's precision, high surface finish, productivity, and reliability as factors.

Maurizio Romeo, CTO of WeAreAM, shared, "With over thirty-two years in the AM industry and twenty years focused on metal AM, I was highly impressed with the FormUp 350's safety aspects, particularly the APM. For us, ensuring the safety of our team and customers is paramount, and the FormUp 350 stands out in this regard. Its repeatability and precision make it a powerful addition to our AM portfolio."

The FormUp 350 is expected to be installed at WeAreAM's facility in Northern Italy in Q1 2025.

www.weaream.it
www.addupsolutions.com

Stifel to launch additive and advanced manufacturing-focused private equity fund for US businesses

Stifel Financial Corp, based in St Louis, Missouri, USA, has received final federal approval for its Stifel North Atlantic AM-Forward Fund, designed to provide capital to small- and mid-sized American manufacturers in the aerospace and defence industries, with a specific focus on increasing additive and advanced manufacturing capabilities in the domestic supply chain.

The fund was started to support the White House's AM Forward initiative, which was created in 2022 to improve the competitiveness of America's SME manufacturers and enhance domestic supply chain activity. As part of the final approval process, the fund has earned a Small Business Investment Company (SBIC) licence from the Small Business Administration in partnership with the US Department of Defense under the SBIC Critical Technology (SBICCT) initiative.

The fund aims to use a range of financing structures targeted to small businesses' specific needs. The initial funding includes significant capital commitments from industry-leading contractors, including Lockheed Martin, GE Aerospace, and ASTM International.

"Small- and medium-sized manufacturers are at the core of ASTM International, and we are excited that our global standards and solutions will serve as an innovative tool in connecting the diverse supply chains of our aerospace and defence industries," commented Andy Kireta, ASTM International President.

Capital from the fund will connect manufacturers with leading system integrators to meet the growing industry demand for low-volume, high-mix components. Additionally, the fund's investments will enable manufacturers to acquire new fixed assets, expand their working capital and achieve aerospace and defence certification and qualification.

www.stifel.com

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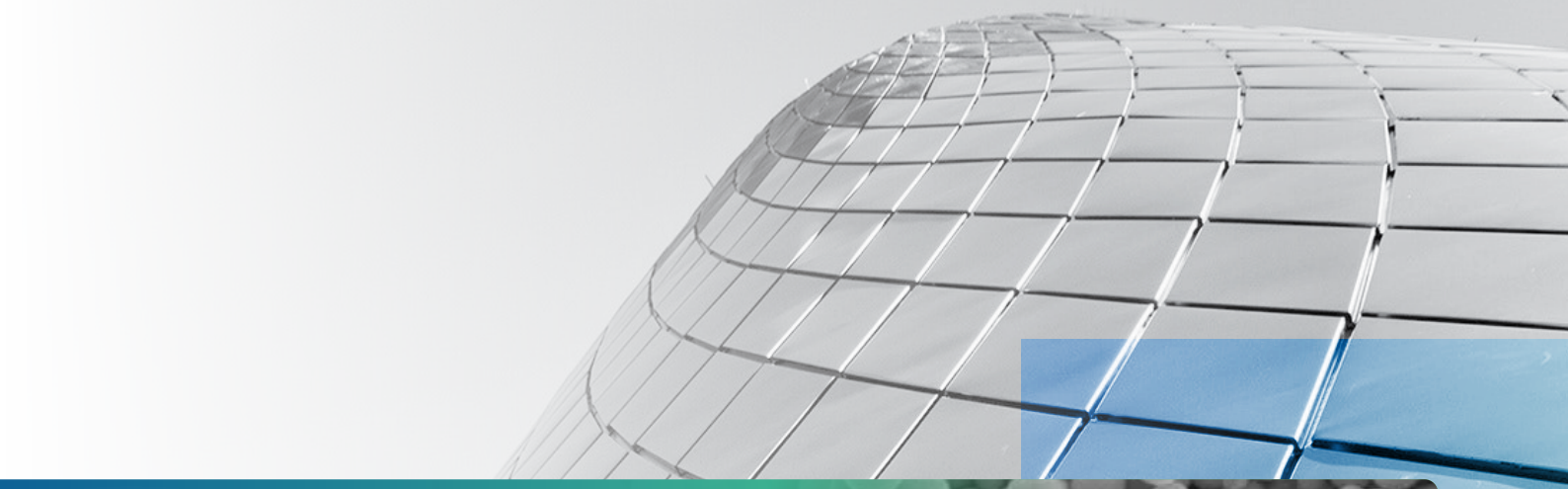

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Aluminium Additive Manufacturing: How a new generation of alloys will fuel industry growth

Aluminium has emerged as a pivotal material in Additive Manufacturing, revolutionising industries such as aerospace, automotive, and beyond. Overcoming early processing challenges, advances in AM machines and alloy designs are unlocking aluminium's potential. Today, its lightweight, high strength and thermal properties, combined with advances in powder production and sustainability efforts, are driving its rapid adoption. As Dr Martin McMahon explains, with growing applications and ongoing materials development, aluminium is poised to play a transformative role in shaping the future of AM technologies.

Aluminium alloys have been a target material since the introduction of metal AM technologies. However, in the nascent era of Additive Manufacturing, there was a significant issue to overcome: virtually all the metal AM machines used lasers. These were relatively low-powered CO_2 lasers, and those unfamiliar with the physics of laser-materials interactions should think of aluminium as being a mirror, in that it reflects a lot of light at the output wavelength of a CO_2 laser (10.6 µm). In fact, around 98% of light energy is reflected by aluminium at this wavelength.

To effectively work with aluminium required more available energy, and higher-energy CO_2 lasers were fairly big beasts back in the mid-1980s. This made it impractical to develop Laser Beam Powder Bed Fusion (PBF-LB) machines for metals such as aluminium. Further, this is before considering that the early attempts to process any metal relied on sintering polymer-coated metal powders, rather than the full melting of the metal.

Despite the apparent technological roadblocks, aluminium has remained a highly sought-after material in AM and has regularly been the most-searched-for material on the *Metal AM* website. In fact, in the month prior to this article going to press, queries relating to aluminium were amongst the highest of all searches on the website – and four times higher than the second most popular material. Looking back over the past couple of years, aluminium has always been in the top ten search terms.

Fig. 1 Bugatti's Tourbillon hypercar features AM aluminium components, including this PBF-LB suspension structure. The company is using Divergent Technologies' Divergent Adaptive Production System (DAPS) (Courtesy Bugatti Automobiles)

Fig. 2 This prototype aluminium alloy rear subframe of an electric vehicle, produced by Bright Laser Technology, features a hollow lattice filling structure with a wall thickness of 2 mm. The part is 20% lighter than a die-cast aluminium alloy alternative. The part measures 1,230 x 845 x 337 mm (Courtesy BLT)

"This led to aluminium alloys being sidelined in favour of titanium alloys and nickel-based superalloys. One thing we know for sure, though, is that aluminium became more and more popular as PBF-LB processes matured and machines began to feature 200-400 W lasers."

Does this mean that aluminium accounts for the leading applications in metal AM? Despite the interest, the answer to that is never going to be so straightforward. Most other industry reports and statistics would point to either stainless steel, titanium, or potentially nickel-based alloys being the most common. Why is this?

When rapid prototyping using metal started to become popular there was a switch to fibre lasers. However, there was still considerable difficulty in processing aluminium because the available power from these machines was still too low; typical maximum outputs were only 150-200 W. In reality, it is probable that a combination of relatively low power together with over-sized focused laser spot diameters was the cause for the poor early results of aluminium powders. This led to aluminium alloys being sidelined in favour of titanium alloys and nickel-based superalloys. One thing we know for sure, though, is that aluminium became more and more popular as PBF-LB processes matured and machines began to feature 200 W and 400 W lasers.

Early barriers to the adoption of aluminium

The main contributing factor to the slow adoption of aluminium was probably based on the availability of desired alloys. Early adopters of AM were in sectors that needed high-performance materials; for aluminium, this meant 2000 and 7000 series wrought alloys. Instead, the first aluminium alloy that was introduced directly by AM machine OEMs was AlSi10Mg. As someone who was intimately involved with developing this part of the AM sector, I have clear memories of the response of prospective AM parts users when I first introduced the AlSi10Mg alloy: unfamiliarity and confusion. The intended market simply did not recognise this alloy, and knew nothing about its performance or capabilities. Anyone in metal AM sales at that time will know that it was like trying to push water up a hill.

The early adopter of metal AM with the most interest in aluminium was the aerospace sector, where all of the Tier 1 suppliers and OEMs will insist on certainty around the Technical Readiness Levels (TRL) of any material to be used in an aircraft. Hence, introducing a new material like AlSi10Mg on top of a completely new method of production was never going to be easy. It was, however, far easier for sales teams to focus on other recognisable materials that were well-suited for aerospace and for which there were target applications, namely Inconels and titanium alloys. This situation did not change significantly until the introduction of F357 (AlSi7) and 6061.

Since the introduction of AlSi10Mg for AM, considerable groundwork has been carried out, in particular in the past five years. So, now that data do exist to underpin the use of such alloys in AM and international standards are being made available by ASTM and SAE International, these alloys will probably gain traction at a faster rate.

A second factor that may have been partly responsible for diverting

the early AM sector's interest away from aluminium was a little quirk that AM introduced to design theory and materials selection. To explain, let's look at why aluminium gained popularity as an engineering material in the first place.

In the context of aerospace, aluminium was attractive due to its ability to produce lighter structural components. However, the drawback to using these sorts of lighter, lower-strength alloys was the need to increase individual part sizes in order to achieve the desired stiffness or load-bearing capacity. At the time, however, there weren't any recognised grades of aluminium that engineers could work with, leading instead to a bit of a frenzy for titanium. While it is as strong as steel, titanium's biggest drawback when it was introduced was its price.

This all meant that – for most applications – there wasn't a sensible economic solution to lightweight AM parts. It was a very pervasive belief, too; I believed it until I had my first conversation with a founder of the company which would go on to change the world of hydraulics using AM. This company had almost immediately identified that the design freedom that AM brought about meant that lightweight designs could also be made from highly stiff, substantially cheaper materials like steel. For me, it was a light bulb moment. As the message spread that AM was enabling optimally designed steel parts, the appeal of aluminium faded a little.

The third and final possible reason for the slow adoption of aluminium was the fear of explosions – not necessarily catastrophic ones, but enough to cause injury, damage equipment, labs, or the immediate work environment. This fear was amplified by a degree of misinformation and a vocal, safety-conscious minority. As a result, explosion risk warnings were often plastered on any areas where aluminium powder might come into contact with air, leading many organisations to avoid working with the material altogether. Those that did eventually adopt it typically waited until either self-imposed safety regimes could be proven, or they were reassured by the high-level data and analysis that showed the risk of explosion may have been overstated by some.

Fig. 3 AlSi10Mg at scale: Eplus3D, based in Hangzhou, China, and LEAP 71, a developer of AI-based engineering technology headquartered in Dubai, United Arab Emirates, designed and additively manufactured this 200 kN rocket engine, standing more than 1.3 m tall. Believed to be the world's largest single-piece additively manufactured rocket thruster, it was produced in one uninterrupted build process that lasted 354 hours (Courtesy Eplus3D/ LEAP 71)

Let's be clear: health and safety is very important, and things can go disastrously wrong when rules are broken. Regardless, hearsay and fear of the unknown should never be a reason to stifle progress.

AlSi10Mg as a driver of early success

Fortunately, sufficient numbers of determined (or simply curious) people allowed AlSi10Mg to start to gain ground. Once people were able to identify this alloy as equivalent to the UK casting alloy LM9, or A360 in the USA, it became easier to talk about it as a suitable alloy for AM. Furthermore, with a little bit of detective work, it was identified as chemically similar to grades of aluminium already common in aerospace, resulting in a notable increase in the development of powders and laser parameters for these other alloys between 2012 and 2015. In many cases, it was realised that you could use the same laser process parameters for all these similar alloys, which included L169 (A357), AlSi7Mg (F357), and AlSi12Mg.

Although it has been proven many times over that these apparently subtle differences in the alloying contents can result in slightly different behaviours during melting, solidification, and cooling, it is in the

Fig. 4 Structural AlSi10Mg PBF-LB components developed and manufactured by BMW and used on the Rolls-Royce Ghost (Courtesy BMW)

subsequent post-processing after the build itself that has the most significant effect in determining final materials properties. Once the AM community understood that these alloys required more than just a simple stress-relieving step, and that blindly following previously used T6 types of heat treatment was not going to yield the desired outcome, this class of Al-Si alloys started to produce good results – and in some groundbreaking applications. We are all very familiar with the satellite TMTC brackets produced for Airbus Defence & Space, first featured on www.metal-am.com in March 2015.

Once AlSi10Mg had gained acceptance, and users understood that it was an age-hardenable alloy, the industry realised that it needed a baseline to measure everything against. This was especially important given that there was no realistic alternative in the form of other desired higher strength alloys, so the aerospace sector began to focus on fully characterising both AlSi10Mg and the F357 alloys.

Several years of intense data gathering have been conducted up to now – and from all over the world. It's also likely that the first standards for these alloys are either in publication or very close to completion.

"Once the AM community understood that these alloys required more than just a simple stress relieving step, and that blindly following previously used T6 types of heat treatment was not going to yield the desired outcome, this class of Al-Si alloys started to produce good results – and in some groundbreaking applications."

Specific challenges to the AM processing of aluminium

One small and rather restrictive group of alloys was never going to be enough, and there has always been the question of how to meet higher strength requirements. Take, for instance, the aerospace and motorsports communities, which were familiar with 2000 series and 7000 series wrought aluminium alloys and continuously demanded something similar, if not exactly the same.

2000 Series (predominantly Al-Cu alloys) and 7000 series (Al-Zn-Mg alloys) have been widely used where strength-to-weight ratios are critical, and both exhibit excellent machinability and relatively good corrosion resistance. However, they are known to be challenging to weld due to issues such as hot cracking, which is driven by significant thermal stresses during solidification as a result of their high alloying content.

In the context of AM, porosity is a significant issue in achieving fully dense parts. These alloying elements, as a consequence of the high reflectivity and thermal conductivity of aluminium, can lead to vaporisation and entrapment of gas pores. These are issues faced routinely in the PBF-LB and wire-arc Directed Energy Deposition (DED) processes (Fig. 5).

There are also several general challenges to be addressed when processing all aluminium alloys:

- The formation of very stable oxide layers that can interfere with the AM process, from

melting to bonding, particularly in PBF-LB and DED

- Close attention needs to be paid to thermal management to avoid overheating and resultant serious defects and warping
- When alloyed with light elements, the alloys may be unsuitable for some AM processes, such as Electron Beam Powder Bed Fusion (PBF-EB)
- Moisture, especially in PBF

All of the above challenges highlight the need for ongoing research and development to optimise alloy compositions and process parameters, specifically to improve the Additive Manufacturing process itself and the performance of aluminium alloys therein.

Early alloy innovation

Laser Beam Powder Bed Fusion dominated the early use of aluminium in AM, and, amidst the uphill struggle to convince the world that AlSi10Mg would be a good starting material, Scalmalloy emerged. Scalmalloy entered the AM sector as a completely new alloy. While everyone else was preoccupied with trying to achieve equivalence to 2000 and 7000 series alloys, the team at the then Airbus Group's Innovation Works derived its solution from 5000 series (Al-Mg alloys). By adding scandium and zirconium together, they were able to completely change the precipitation-strengthening characteristics of these alloys while maintaining the excellent corrosion resistance that 5000 series alloys are noted for.

However, this new alloy has taken a rather long time to gain popularity, stemming mostly from scepticism – maybe even envy. This was not aided by the fact that it seemed impossible to get hold of any immediately following its initial release around 2013. It took several years before it became available under licence to other companies and began being offered directly by powder producers

Fig. 5 AM aluminium parts are not limited to the PBF-LB process, as demonstrated by this large structure produced by wire-arc Directed Energy Deposition (DED), on display by WAAM3D at Formnext 2024 (Courtesy WAAM3D)

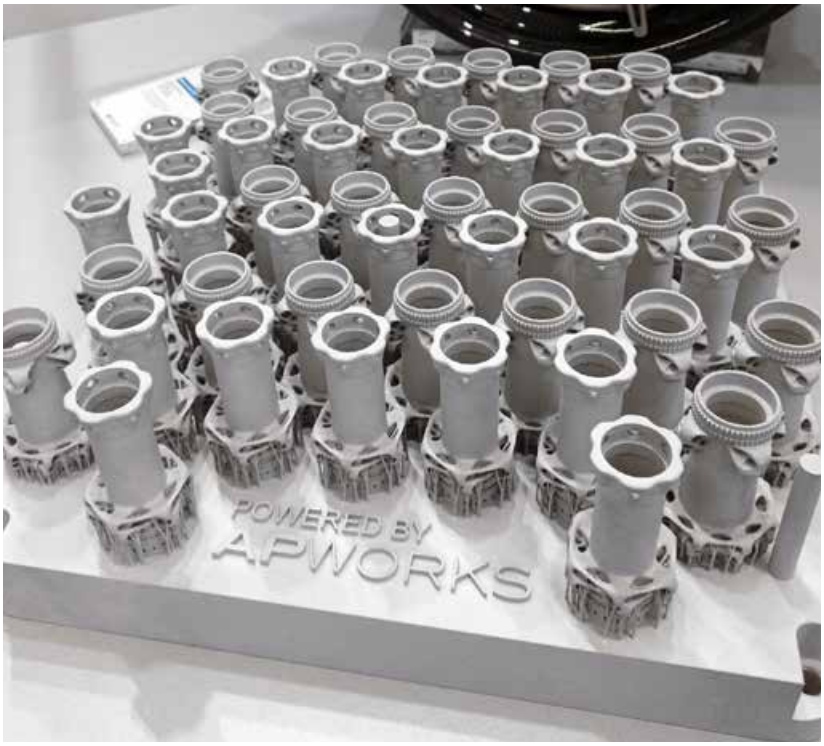

Fig. 6 A build plate of production bicycle axle parts made from Scalmalloy shown at Formnext 2024

Fig. 7 An example application for CustAlloy, a 'crash-proof' aluminium alloy developed specifically for Additive Manufacturing by Leibniz Institute for Materials Engineering (IWU) and Kymera International (Courtesy EDAG)

"The interest that Scalmalloy generated did, however, spark many more attempts to enhance existing wrought and cast alloy compositions with these and other transition and rare earth metals."

like Toyal. The most recent of these suppliers, CNPC, a rapidly growing provider from China, was announced at this year's Formnext.

The interest that Scalmalloy generated did, however, spark many more attempts to enhance existing wrought and cast alloy compositions with these and other transition and rare earth metals. Probably the most significant advantage of this alloy was that, for the first time, it was possible to achieve higher strengths in an aluminium alloy after only a single heat treatment.

The only other alloy that emerged at a similar period was the A20X casting alloy, but this was not intended for AM. A20X was derived from the familiar A201 alloy that contained copper and silver but was known to suffer from hot tearing during solidification. Aeromet International found a way to solve this problem with the formation of TiB_2 particles in the melt process during the production of the alloy feedstock. These tiny particles then go on to prevent large grain growth in a similar fashion to adding grain refiners to alloys (we'll come back to 'pixie dust' later on), albeit from a different starting point. Even though there was some interest in this alloy as early as 2012, it wasn't until 2016 that Aeromet decided to produce the A205 alloy as a powder.

As with the Al-Mg-Sc alloy, however, the whole of the AM sector did not initially have easy access to the A205 alloy powder, and so development was taken up by a select few. That said, being an existing qualified aerospace-grade material allowed easy entry to that sector. It didn't require any further additions or alterations to the composition so, as a result, it was used in the full AM production of flight-certified parts after only a short period of process development.

Unfortunately, little is 'on record' about where it has been used, by whom, and in what aircraft, and it wasn't until Aeromet

International chose to divest of its patented A20X alloy to Germany's Altana that the powder became more commercially available.

AM's aluminium expands

Aluminium alloys are prolific and used just about everywhere. However, it only takes very small quantities of other elements to change their properties. Some, similar to steels, contain large amounts of other single elements, as in the previously mentioned Al-Si alloys. Many more alloys contain a lot of small quantities of other elements.

Aluminium's versatility has given rise to an extraordinary range of alloys, and AM is only just starting to scratch the surface of what is available. The research carried out on the aforementioned materials has already highlighted the incredible complexity of the intermetallic phases that can form and precipitate in aluminium alloys. Some of these phases impart strength, toughness, corrosion resistance and even heat resistance to aluminium.

After the AlSi10 and AlSi7 grades, the next most popular alloys are those similar to the wrought alloy 6061. This alloy is also alloyed with both Si and Mg, but that is where the similarity ends as far as PBF-LB is concerned. Just like the 2000 and 7000 series alloys, it is known to suffer from hot cracking and porosity [4].

All is not lost for 6061, though, since suppliers such as Kymera (through its Ecka Granules business unit in Germany) have developed specific grades aimed at Binder Jetting (BJT) and other AM processes. The difference for 6061 and in all 6000 series alloys stems from the very low levels of Si. This has the effect of increasing the solidification temperature range between liquidus and solidus for the main alpha-aluminium phase, whereas the higher Si content casting alloys that sit much closer to the eutectic composition have a freezing range that is much smaller. It is this difference in the solidification ranges that is the probable cause for the hot cracking and/or tearing in the 6000 series alloys.

"Aluminium's versatility has given rise to an extraordinary range of alloys, and AM is only just starting to scratch the surface of what is available. The research carried out on the aforementioned materials has already highlighted the incredible complexity of the intermetallic phases that can form and precipitate in aluminium alloys."

Perhaps one of the extraordinary facts is that relatively little work has been carried out to investigate near 6000 series alloy compositions. Custalloy from Kymera [5] is also an Al-Si-Mg alloy, with a composition (3.5% Si and 2.5% Mg) that sits between the typical ranges for 6000 series and the higher cast grades, such as F357. However, these subtle changes allow Kymera to claim better mechanical performance than the more commonly used AlSi10Mg alloy (Fig. 7).

Others have tried to adjust the composition of 6061 directly, and our sister publication, *PM Review*, reported in November 2023 that Japan's Proterial had released a new variant called L61P. Since then, however, there have been no updates and nothing is known about use cases.

Besides these compositions, two other possible approaches could be investigated to try to improve crack-prone alloys. Firstly, changes to the composition with the addition of other elements to encourage faster nucleation of secondary phases or prevent significant grain boundary growth; this is essentially the route taken by Airbus with Scalmalloy. Secondly, the addition of other compounds, known as grain refiners, to accelerate the formation of metal crystals from the melt pool; several suppliers, as we are about to explore, have now introduced alloys based on the concept of pixie dust.

Whilst there has been an incredible amount of research carried out in university settings into other possible aluminium alloys based on existing wrought series alloys, very few have led to any commercialisation. For instance, the next most likely group of alloys that could be added to the AM family are the 5000 series Al-Mg alloys. These are known for their good corrosion resistance and moderate strength, making them popular in the automotive, construction, and marine industries. However, to-date there seems to be only one example of commercially available powder in the 5000 series, currently supplied by Elementum 3D.

A sprinkle of pixie dust

One can't simply wave a magic wand over 2000 and 7000 series alloys to make them weldable and remove the risk of cracking. But we can add 'a little something special' to solve these problems.

It's no secret in the world of metallurgy that grain refiners can be added to alloys to encourage fine-grained, equiaxed microstructures; they have been used in casting for decades, similar in fashion to that achieved with A20X alloys. However, when starting with metal powders,

Fig. 8 Example of bike parts made with Elementum 3D 6061-RAM2 in partnership with Trumpf and their customer, Intense Cycles (Courtesy Trumpf/ Elementum 3D)

there is another approach, and one which several companies already use: blending in compounds to existing alloy powder compositions. The biggest risk to this approach is in making too big a change to the original alloy composition and, in doing so, altering the material's properties.

First on the scene with a commercial offering was Elementum 3D with its Reactive Additive Manufacturing (RAM) technology. Realising that one size doesn't fit all, the company developed a recipe of compounds that react with each other in the melt pool and then form sub-micron-sized particles that act as grain refiners. It's a unique approach because, without the melting, these compounds would probably be undesirable contaminants.

The resulting fine-grained microstructures have also proven to be very strong with excellent fatigue performance. What's more, Elementum 3D developed several aluminium alloys almost in parallel and has found that the RAM can even be used with pure aluminium powder to give it better physical properties. To date, the company has applied this technology to 1000, 2024, 5083, 6061, and 7050 (Fig. 8).

In 2019, shortly behind Elementum 3D, HRL Laboratories followed a more conventional approach when releasing its 7A77 alloy. It is worth noting that HRL were the first to respond to a change in the numbering scheme used by The Aluminum Association (AA). When HRL decided to work with the 7075 alloy and subsequently add its own pixie dust (zirconium hydride nanoparticles [6]), it registered this new grade as 7A77.50.

Recognising that taking any existing alloy and producing it as a powder meant it could not properly be identified by either the cast or wrought alloy specifications, the AA decided to introduce a new scheme for powders. The new AA scheme includes annotations for the powder form and any subsequent solid alloy form produced from the powder. In this way, the AA has provided a

clear distinction between the more common wrought alloys, even though the powders may be derived from the same base alloy family. Others have since followed the new numbering scheme with 2A05.50 (the A20X alloy from Eckart) and 6A61.50 (6061-RAM2 from Elementum 3D).

The arrival of new, AM-specific alloys

So far, we've only looked at those alloys that have been altered in some way to make them more process-friendly, particularly for PBF-based Additive Manufacturing processes. However, there have also been some significant developments of completely new alloys targeted at metal AM. Companies such as Constellium, Fehrmann, NanoAl, and Toyal have all released alloys with completely new compositions; even machine OEM EOS has been added to the mix.

Fehrmann

Fehrmann's aluminium alloy, AlMgty, was introduced to address the critical need for high performance in a cost-effective alloy. Now a family of alloys, it was the first to be offered with a balance of strength, flexibility, and corrosion resistance against economic cost, attempting to be a game-changer in the AM landscape. Though not designed just for AM, the journey to develop AlMgty 80 began in 2017, with patents filed a year later and the eventual launch at Formnext in 2019. This led to quick adoption in the marine sector by Ziegelmayer, the yacht builder.

Of course, where weight reduction and performance are paramount, Al-Mg alloys do find favour. Applications in the automotive and aerospace sectors to produce sliding covers and vehicle chassis parts have demonstrated weight savings as well as lead to better fuel efficiency and sustainability.

However, unlike others examining this group of alloys, the Fehrmann approach was to simplify the alloy composition, avoiding expensive transition metals or rare earth elements, to target cost efficiency for those seeking lightweight and high-strength aluminium alloy solutions. Now, after several years of development, the AlMgty range has expanded to seven versions, including a Si-free version for successful colour anodising.

Lastly, whilst not one of the biggest suppliers of aluminium alloys, the company does come from a solid background in materials development. This has allowed it to investigate other alloys, which culminated in the release of a new Al-Zn alloy, AlZnty, believed to be the first of its kind dedicated to AM. Furthermore, Fehrmann is a key member of the German state-funded SIGNAL project, seeking to develop sinter-based aluminium alloys to be used in Binder Jetting applications.

Looking ahead, the company hopes to accelerate its alloy development through its own MatGPT software tool to optimise compositions in shorter times. If the outcomes of the SIGNAL project are positive, this indeed could be the significant step forward that metal AM needs, as the market demands for increased production rates could be conceivably met by Binder Jetting, much in the same way that we have seen for Metal Injection Moulding and high-volume production.

NanoAl

Another company that also initially focused on Al-Mg, NanoAl released its Addalloy 5T in 2020, and, although based on a 5000 series alloy, it was designed to be post-processed with a simpler heat treatment step following AM fabrication. There is not much known about the alloy, as NanoAl gives away very few details, but it is known to use Zr as the main constituent imparting greater compatibility for PBF-LB processes, and this could contain greater than 1 wt.% Zr [10]. Also in 2020, the company added Addalloy 7s, based on a 7000 series alloy, and Addalloy HX, that it describes as a low-alloyed aluminium.

A 2020 issue of *Metal AM* reported that NanoAl, a subsidiary of Braidy Industries serving as its research and development division, won a Gold Edison Award for 3-D Printing Enhancements for its proprietary Addalloy range. However, even following this highly prestigious award and the distribution agreement signed with Mitsubishi, it is rather difficult to come across any significant uses or success stories for these alloy powders in AM.

Equispheres

Some companies may have chosen to pursue new alloys while relying on traditional methods to produce

"So far, we've only looked at those alloys that have been altered in some way to make them more process-friendly, particularly for PBF-based Additive Manufacturing processes. However, there have also been some significant developments of completely new alloys targeted at metal AM."

Fig. 9 A large heat exchanger component produced by DMG Mori using Equispheres' aluminium powder and displayed at Formnext 2024

"...there has also been significant concern within the community about the safety of using aluminium powders. There was even a fear of explosions associated with aluminium, which deterred many from considering its use. Equispheres was the first to directly address these concerns with its proven, non-explosive AlSi10Mg solution, NExP-1."

their powders. However, it is well understood that aluminium alloys have historically been difficult to atomise and make into high-quality spherical powders. This is where a company like Equispheres stands out, as it has developed a unique atomising process to produce extremely uniform powders.

PBF-LB with aluminium is accepted as a more sensitive process, with this often attributed to the variable quality of aluminium powders. Early supplies consisted of powders that were at best described as 'rounded' rather than genuinely spherical. By the time AlSi10Mg was first introduced, AM users were already familiar with the quality of spherical powders, such as those used for CoCr and maraging steel.

Looking beyond the morphology of aluminium powders, there has also been significant concern within the community about the safety of using aluminium powders. There was even a fear of explosions associated with aluminium, which deterred many from considering its use. Equispheres was the first to directly address these concerns with its proven, non-explosive AlSi10Mg solution, NExP-1. This safety is achieved through uniformity in size and the complete absence of fines, a unique offering in the sector to this day.

The company reports that it now produces several versions of these alloys, specific to customer requirements. One patented solution is optimised for high-volume production applications. The uniquely uniform sphericity is said to allow for higher build speeds over a wider processing window in PBF-LB manufacturing. Another precision powder line has been engineered for applications that require greater control of feature resolution and surface finish, such as RF components.

Over the past few years, the company has been very successful at attracting investment, which most recently has enabled Equispheres to increase production capacity. In 2024, following the installation of

new atomising reactors, the company reported an order increase of 300%, with a commitment to supply the majority to existing customers.

Toyal

A company that is certainly no stranger to producing aluminium alloy powders is Toyal, already having a number of the so-called 'standard' alloys familiar to the AM market in its portfolio. However, perhaps less well-known is that the company has introduced a few other alloys for use in Additive Manufacturing under its Spheralloy brand. Along with the high Si content alloys, AlSi10 and AlSi12, other casting alloys Si9Cu3 (LM26), AC8A (LM13), and ADC12 (LM2) all list Cu and Fe as significant additions, presumably for enhanced precipitation hardening.

Toyal has also developed its own alloy, TCFE1Z, targeted at lightweight heat exchangers for the automotive sector and air conditioning units. Classed as a low-alloy aluminium, it has just 1.2% Fe and not much else. Its apparently unique feature as an AM material is higher corrosion resistance compared to AlSi10Mg and other commercially available alloys.

Constellium

Constellium's Aheadd alloys were also developed to address the growing demand for high-performance materials in Laser Beam Powder Bed Fusion (PBF-LB). The company involved industry partners during its extensive research and collaborated closely with a number of machine OEMs to develop alloys offering high strength, thermal stability, and good corrosion resistance. The launch in 2020 included two main variants: Aheadd CP1, which is purported to be optimised for high conductivity and productivity, and Aheadd HT1, said to be designed for high-temperature and high-strength applications.

Constellium has perhaps been a little less shy than some others about announcing which customers have used the Aheadd alloys. One notable example is the production of braille handrail signs for Deutsche Bahn, Germany's national railway company. These signs, made using CP1, are designed to assist visually-impaired passengers by providing tactile information in braille. And while AM is no stranger to F1, the use of aluminium is still uncommon, making it noteworthy that PWR has been using CP1 alloy for heat exchangers.

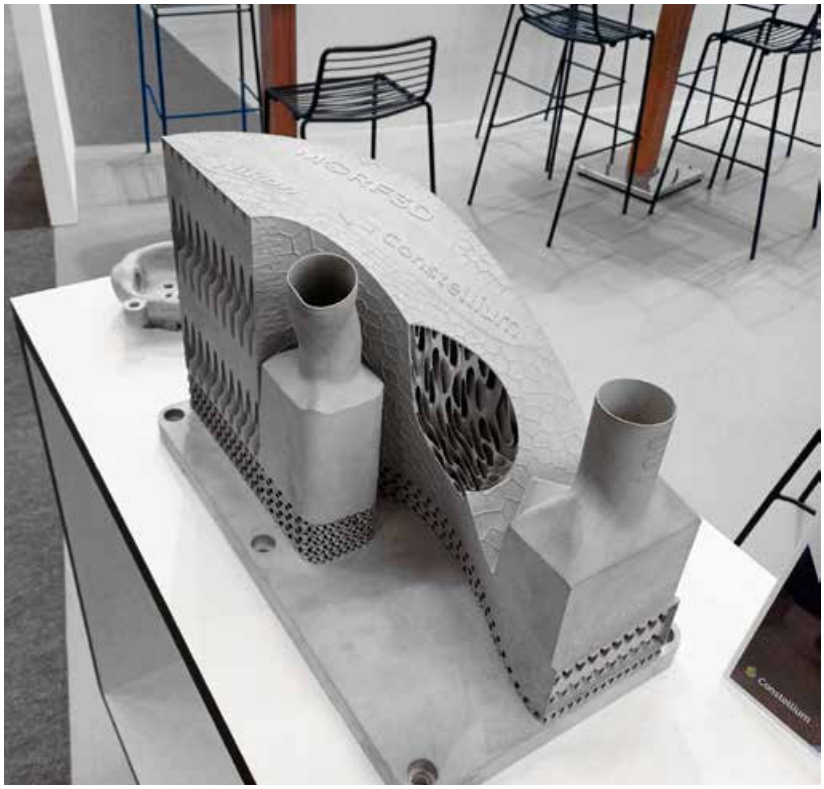

Fig. 10 An aluminium heat exchanger produced by Morf3D using CP1 powder from Constellium and shown at Formnext 2024

"Constellium's Aheadd alloys were also developed to address the growing demand for high-performance materials in Laser Beam Powder Bed Fusion (PBF-LB). The company involved industry partners during its extensive research and collaborated closely with a number of machine OEMs..."

EOS

In a rather unique position, as the only machine OEM with a team dedicated to the development of the powder supply chain incorporating the innovation of new materials, EOS has released two high-strength aluminium alloys. This has come as a response to demands from existing customers for higher strength, higher temperature capabilities, and the ability to be anodised or electrolytically polished.

As a nod to the growing concerns about the costs of AM parts (even if, in many cases, the idea that AM is more expensive than traditional manufacturing is incorrect), EOS

Fig. 11 This bracket made from Al5X1 under evaluation by an automotive OEM was on display on the EOS booth at Formnext 2024

acknowledged that any new alloys also had to come with a completely different cost structure, targeting more economical overall costs when compared to existing custom high-strength AM aluminium alloys already in the market.

EOS released the recognised aluminium alloy, Al2139 AM, for elevated temperature use. The company claims that this has unmatched strength in the range of 50-200°C. Additionally, EOS has recently developed a new alloy, Al5X1, which combines high ductility, moderate strength, and higher corrosion resistance with an ability to be colour-anodised. Speaking to its development team at Formnext, they were keen to point out a small bracket component under evaluation at a leading automotive company, shown here in a striking anodised red finish (Fig. 11).

It's also clear that applications such as this will keep the use of aluminium in AM on the increase, and, for once, it is perhaps a good thing that it is not solely dependent on the aerospace sector. One reason behind EOS's decision to develop its own alloys was to address the costs of purchasing and post-processing high-strength aluminium powders. For instance, the Al-Mg alloy, Al5X1, has the benefit of not requiring water quench prior to ageing and has significantly higher yield and tensile strength than AlSi10Mg. Additionally, neither this nor the Al2139 alloy contains expensive elemental additions.

It would be remiss not to mention the work EOS has done to highlight sustainability. Last year, it was reported that 2024 would see EOS demanding its AlSi10Mg suppliers to use at least 30% recycled alloy feedstocks, targeting a 25% reduction in CO_2 emissions. Most other powder producers rely on the provision of green energy, and, whilst it is generally accepted for other metals such as steel, the use of recycled aluminium has always been a source of concern. Even though EOS does not directly produce its own powders, it is certainly a step in the right direction to use recycled materials, and the response from existing customers has been reported to be positive. In fact, so much so, that EOS is now seeking to increase the percentage of recycled feedstock in its aluminium powders.

New processing technologies broaden the potential of aluminium AM

While PBF-LB has dominated for many years and Directed Energy Deposition, whether using lasers or arc welding technologies, has started to gain more ground, in some ways, both may have been a hindrance to the wider adoption of metal AM. This is down to the fact that most of the AM world has been focused on chasing the high-value opportunities associated with working with titanium, nickel superalloys, or other special steels and alloys. The lack of choice and difficulties of having to deal with the interaction between highly reflective materials and lasers combined with complex heat treatment cycles may also have deterred others from wanting to work with aluminium alloys.

Developing better alloys, those suited directly to fusion-based AM technologies [8], is one route to working with aluminium. The other is changing the technology. This is why we have seen the recent emergence of several alternatives to PBF-LB, some of which are inher-

ently more appropriate for aluminium or other metals with relatively low melting points.

Some of the best solutions are relatively simple. For new aluminium-based AM technologies, success has not always come from groundbreaking inventions but from innovation. Innovation enables the repurposing of existing technologies into AM applications. These include Binder Jetting and Cold Spray and – to a lesser extent – Directed Energy Deposition.

While aluminium was not an early focus of these technologies, this has shifted – something especially evident after visiting Formnext this year. It's worth noting two new DED technologies, as both companies chose to launch with aluminium wires rather than the more common materials.

Caracol, already known for its large-format robotic FDM machine for polymers, introduced a new DED machine this year. The Vipra machine incorporates two welding technologies, one of which uses Cold Metal Transfer, a form of MIG welding where the weld wire sequentially withdraws from the weld pool before ejecting a drop of metal. This cooler process is ideal for aluminium alloys, such as the 2319 alloy highlighted at the exhibition.

Another new player in the AM scene is MADDE from Korea. While its DED process is similar to others on the market, the company launched by demonstrating its capability to additively manufacture virtually any aluminium alloy available in wire form. Speaking with one of the founders, it was stated that the process had already been optimised to work with 5000 series alloys and that they plan to release parameters for 2000, 6000, and 7000 series aluminium alloys in 2025.

Leaving behind the more common technologies for a moment, new adaptations of existing technologies have been developed specifically to exploit aluminium's low melting point. These include Ultrasonic Welding (UAM), Friction Stir Welding (FSW), Liquid Metal Jetting (LMJ),

Fig. 12 A large wire-arc DED cylinder made from 5000 series alloy wire shown at the MADDE booth at Formnext 2024

"Another new player in the AM scene is MADDE from Korea. While its DED process is similar to others on the market, the company launched by demonstrating its capability to additively manufacture virtually any aluminium alloy available in wire form."

Fig. 13 Aluminium 6061 parts additively manufactured with Additec's ElemX machine on the USS San Diego (Courtesy ADDiTEC)

and a form of Fused Filament Fabrication (FFF), along with variants or combinations of these technologies, collectively referred to as Molten Metal Deposition.

Ultrasonic Additive Manufacturing

Ultrasonic AM has most notably been developed by Fabrisonic. The technology deposits strips of metal, similar to Laminated Object Manufacturing (LOM), and has already been successfully applied to aluminium alloys. However, Fabrisonic did not set out to solve AM just for aluminium; in fact, the main string in the technology's bow is that it allows for the deposition of different metals that are traditionally difficult to join. It is also commonly used in hybrid applications, where CNC machining is combined with depositions, as well as for embedding electronics and sensors into metal parts.

It appears that Fabrisonic is the sole vendor offering this specific type of technology. However, I am convinced I have come across at least one other form of UAM developed for aluminium wire or rods. Unfortunately, the quirks of internet search engines and my fading memory have kept me from locating more information. I will leave that as a challenge for readers to explore further.

Before we leave UAM, it is also worth noting that ultrasonics have been combined with a number of other metal AM technologies, such as DED and PBF-LB, in order to control microstructures forming out of the melt. Whilst research in this area has not primarily been for aluminium alloys, in aiming to solve some of the difficulties of trying to work with other metals that are prone to cracking, this could likely be applied to the non-weldable, high-strength aluminium alloys.

Additive Friction Stir Deposition (AFSD)

Adapted from the friction stir welding solid-state joining process, AFSD uses a non-consumable rotating tool to generate frictional heat and plastic deformation in a consumable alloy rod. It is effective for use with any of the common aluminium alloys, including those in the 2000, 5000, 6000 and 7000 series of alloys. The most important aspect of AFSD is that there is no melting, even though the temperature can be near the melting point. This means there is no risk of solidification cracking, even when relatively large volumes are being deposited. In fact, this last point is also one of AFSD's other advantages, as large parts can be produced in a relatively short time. Secondly, since there is no melting, AFSD also avoids the risks associated with void-free, fully dense parts and can result in refined microstructures, improving strength and fatigue resistance.

AFSD has been successfully applied to various aluminium alloys, including high-strength grades like 7075. However, unlike most AM applications which are focused on manufacturing new components, AFSD has often been studied for use in repair. This was the subject of several talks this year at the AMUG conference in Chicago, where Boeing presented several use cases. In Boeing's view, AFSD is particularly valuable for maintaining and repairing critical aerospace components where material performance and reliability are paramount.

In terms of equipment suppliers, MELD Manufacturing Corporation is one of the leading providers of AFSD technology within the AM sector. There have been many adaptations of existing FSW machines for use in AM, particularly within institutions such as the TWI in the UK and EWI in the USA. One would anticipate seeing several other suppliers in the coming years since AFSD is also particularly suited to large-scale AM and hybrid systems that are combined with CNC machining.

Liquid Metal Jetting (LMJ)

This process involves the controlled ejection of molten metal droplets to build up a part; to date, it has only been successful with aluminium

alloys. It works by passing aluminium wires through heating coils, melting the alloys into a crucible, and agitation of this crucible results in the controlled expulsion of a droplet of molten alloy. The drops deposit and solidify to form the object.

LMJ's journey began with Vader Systems, a startup founded by Scott and Zachary Vader, the inventors of MagnetoJet. This attracted quite a bit of industry interest right from the start since the concept, in essence, seemed rather simple and similar to inkjet printing. To underscore this fact, in 2019, Xerox – very well known in the inkjet space – acquired Vader Systems to enhance its own Additive Manufacturing capabilities.

Under Xerox, the technology was developed further and the company rebranded as ElemX. However, even though it had successfully signed agreements with the US Navy, the Rochester Institute of Technology and Siemens, the company failed to realise significant commercial success. The ElemX business was then acquired by Additec in the summer of 2023 (Fig. 13).

The journey for LMJ continues with the newest entrant, GROB, making a significant impact on this year's Formnext exhibition. Missing the opportunity to see the machine operating live at the show, it was still clear that GROB had elegantly integrated LMJ technology into its machine architecture.

Fig. 14 An aluminium lampshade demonstration part produced by Valcun using its Molten Metal Deposition (MMD) process (Courtesy Valcun)

Stack Forging

Alloy Enterprises has come up with a unique way to make parts in 6061 from rolled sheets. This new method is probably the most like LOM in that it uses laser-cut profiles that are stacked together to make 3D parts. Simply, the machine removes all the holes that make hollow volumes within solid parts of each layer, then coats the surface with an inhibitor that acts like a mould-release agent. Once all the cut sheets are precisely stacked, they are 'forged' together by diffusion bonding, resulting in a semi-solid block.

The 3D object can rest securely in the block since it is encapsulated in the non-bonded support material. Once the support material, previously treated with the inhibitor, is removed, the parts need a further heat treatment for the desired strength or other properties.

So far, the process has only been applied to 6061, but it would be easy to imagine other aluminium alloys being used in this new form of metal AM.

FFF for metals

Metal Fused Filament Fabrication (FFF) has been successfully applied to metals by mixing metal powder with polymer compounds, and commercial solutions have been available for several years. However, processing aluminium via sinter-based routes presents known challenges, meaning very few have attempted it. One company, however, has successfully overcome this difficulty, but with a twist on FFF: by directly depositing fused wire without the need for any polymer binder.

Valcun, the Belgian-based inventors of the Minerva technology, have achieved this innovation, which they call Molten Metal Deposition (MMD). Valcun has kept things relatively simple with a machine that can be plugged into any domestic electrical supply, much like the numerous FFF-style plastic printers operating in the Free Form Fabrication space.

Though it currently only offers 4008 and 4043 as standard weld wires, Valcun states that 6061,

Fig. 15 An aluminium Ar gas filter made for AMCM PBF-LB machines by Conflux Technology (Courtesy Conflux)

6082 and 7000 series alloys will also be available soon. However, other aluminium weld wires could probably be used in this technology (e.g. the A20X alloy from Eckhart in Germany, and the wires from Fortius Metals produced using Elementum3D alloys).

The MMD process has also been used to produce parts that require no further post-processing: not just aesthetically pleasing lampshades but real-world engineering components. At the recent Formnext exhibition, Valcun showcased a cooling fan used in data centres that was 10% more efficient than the previously manufactured part. Each of the fins was in the as-built condition, and it was suggested that the surface roughness had no negative impact on the aerodynamics, possibly because the layers are parallel to the flow of air in this application.

Aluminium's future

Looking ahead, we should expect to see much more growth in the use of aluminium for Additive Manufacturing applications. Over the past decade, it's been shown that it isn't so simple to turn profits from low-volume, high-value items produced from expensive alloys; this is one area where growth could certainly be driven by the adoption of aluminium.

At Formnext this year, the presence of AM service providers was somewhat limited, so it wasn't possible to test this hypothesis in great detail. However, at least one specialist in this area was present: Conflux Technology.

Conflux has become an expert in producing incredibly fine structures in aluminium alloys using PBF-LB for heat exchangers, so we asked for their opinion on the subject. Like much of the broader industrial sector, those working within the company would like to see aluminium alloys better-suited to the harsh applications that currently require higher-performing wrought alloys. For example, with parts now in production for the AMCM machines (Fig. 15), Conflux can build heat exchanger geometries that outperform their traditionally manufactured counterparts.

To maintain its advantage, however, the AM parts must match or exceed the mechanical, thermal, and corrosion-resistant properties of their traditionally made equivalents. As such, Conflux is encouraged by the market's movement toward new high-performance aluminium alloy powders for application development. Still, the company would like to see more focus on the impacts of the build process on final properties, particularly in addressing anisotropy and achieving ageing during the AM process, so as to avoid the need for secondary heat treatments.

Conclusion

We have shown that there are now many more alloys available, opening up the potential for a broader range of applications. This article hasn't even attempted to include all of the powder producers, of which there is an ever-growing population. Considering this, it becomes clear that now is the time for the industry to remember that aluminium alloys have historically been developed with specific properties that provide clear advantages for particular applications. As far as AM is concerned, this specificity is exactly what we need more of; nothing demonstrates this more clearly than the extensive range of wrought aluminium grades.

The AM sector and the supply chain it supports do not need to compete for applications that have always been better-suited to other alloys; aluminium's lightness already supports a strong business case, and Additive Manufacturing offers highly viable solutions for processing it. Instead, the sector should place its focus on developing Al alloys for use in places where they best serve and are specifically suited to the unique requirements of Additive Manufacturing.

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Shaping a national Additive Manufacturing ecosystem: The strategic growth of metal AM in Türkiye

Türkiye's Vision 2025 roadmap places Additive Manufacturing at the core of its aerospace innovation strategy, with a view to driving innovation in aircraft production and beyond. This article explores Türkiye's efforts to integrate AM technologies, driven by the country's leading aerospace producer, Turkish Aerospace Industries (TAI), and powered by the vital contributions of organisations such as EKTAM and ALUTEAM. With academia-industry collaboration, international partnerships, and advances in materials and processes, Ümit Aytar reports on how Türkiye is shaping a robust AM ecosystem.

As part of Türkiye's Vision 2025 roadmap, the integration of Additive Manufacturing technologies into aircraft and helicopter production is regarded as critical to the country's industrial and economic development. Numerous structural metal and polymer aircraft components are manufactured through Additive Manufacturing processes globally, and the technology's potential in aviation maintenance, repair, and overhaul activities presents a further promising avenue for enhancing efficiency and innovation in the sector.

Turkish Aerospace Industries (TAI) is at the forefront of this effort. The organisation is working to efficiently integrate Additive Manufacturing into its ongoing aircraft design and production processes, enabling it to leverage AM's design approaches for series production as well as its potential for rapid product development.

To achieve this, Turkish Aerospace Industries is working to develop qualification methods for Additive Manufacturing processes used for series parts production, as well as the qualification and certification of raw materials, processes, equipment, and parts. The first qualification of a metal powder and the associated process for a metal additively manufactured component was completed in March 2023. The company hopes to build on this during 2025, expanding its list of qualified materials.

Turkish Aerospace has been integrating additively manufactured products into its platforms for many

Fig. 1 Turkish Aerospace Industries' KAAN aircraft, a fifth+ generation multi-role fighter, made its maiden flight in February 2024 (Courtesy TAI)

Fig. 2 EKTAM plans to leverage its capabilities to undertake a variety of projects in the field of Additive Manufacturing (Courtesy EKTAM)

years. A significant portion of these components are polymers, while others are metals, representing a variety of manufacturing modalities. The company has a strong history in Additive Manufacturing, which has remained relatively understated but is now being emphasised and promoted more actively.

Turkish Aerospace works with a wide range of organisations in Türkiye, all of whom contribute to the collective goal of advancing the use of AM in the country's aerospace industry. This article highlights the activities of a number of key partners in Türkiye who are contributing to the wider adoption of metal Additive Manufacturing in the country.

EKTAM

Additive Manufacturing is reshaping modern industries, contributing significantly to sectors beyond aerospace, such as defence, healthcare, and automotive, thanks to advantages such as its design flexibility and the potential to utilise a broad range of advanced materials.

Gazi University's Additive Manufacturing Technologies Application and Research Centre (EKTAM) was established in 2017, and has become a driving force in the AM community and a cornerstone of Türkiye's AM sector, facilitating the country's ambition to be a global leader in advanced manufacturing.

"Transferring technology from universities to private sector companies is a crucial process. Globally, only a limited number of institutions specialise in facilitating this transfer. EKTAM is the most important of these in the field of Additive Manufacturing in Türkiye."

Located within a Technology Development Zone, EKTAM serves as a national centre of excellence, fostering collaboration between universities, research institutions, and industries. Today, EKTAM uses its resources to advance the boundaries of Additive Manufacturing both domestically and internationally.

''Materials and Process Engineering is a critically important discipline in aerospace. Ensuring that requirements, qualification processes, and all key responsibilities of this department are firmly established before production begins plays a pivotal role in the successful implementation of Additive Manufacturing technology," stated Prof Dr Metin U Salamci, Director at EKTAM.

"Transferring technology from universities to private sector companies is a crucial process. Globally, only a limited number of institutions specialise in facilitating this transfer. EKTAM is the most important of these in the field of Additive Manufacturing in Türkiye," added Salamci.

EKTAM focuses on the R&D of next-generation AM technologies, emphasising collaboration between academia and industry. The main objective of the centre's collaborative R&D is the development with its partners of value-added manufacturing processes for metal AM across a wide range of applications – particularly

in the aerospace, defence, and healthcare sectors.

Domestically, EKTAM collaborates with universities, including Middle East Technical University, Istanbul Technical University, Izmir Institute of Technology, Erzurum Technical University, Sabanci University and Sivas University of Science and Technology. Internationally, it collaborates with Southern Denmark University Denmark; AGH University of Krakow, Poland; Azerbaijan Technical University and Michigan State University in the USA, to integrate AM technologies into undergraduate education.

Alongside its mix of academic partnerships, the centre collaborates with Turkish companies such as ASELSAN, TAI and Ermaksan Additive, as well as international partners such as Poland's 3D LAB and South Korea's InssTek Co.

EKTAM's activities align with Türkiye's growing focus on technological development. By developing domestic AM technologies and optimising production methods, the centre contributes to reducing the country's reliance on overseas suppliers, especially in advanced materials and manufacturing technologies.

To support EKTAM's focus on Powder Metallurgy, metal Additive Manufacturing and Design for Additive Manufacturing, the centre has invested heavily in state-of-the-art manufacturing equipment, including ATO LAB+ Ultrasonic metal powder atomisation systems, KUKA industrial robot technology which has been integrated into a Direct Energy Deposition (DED) machine developed in-house, an Arcam A2X Electron Beam Powder Bed Fusion (PBF-EB) machine, Ermaksan ENA Vision 250 and Concept Laser M2 Laser Beam Powder Bed Fusion (PBF-LB) machines, Wire Electrical Discharge (EDM) technology, and Micro CT scanning.

ATO LAB+ ultrasonic metal powder atomisers installed at EKTAM use two different modules: an Induction Melting System (35 kHz) and a Wire Feeding System (20 kHz, 35 kHz), which produce different size powders at different frequencies. These ultrasonic metal powder atomisers are used to produce low volumes of high-quality metal powders for Additive Manufacturing application development. Both reactive and non-reactive metal powders can be processed, including aluminium, copper, stainless steel, titanium, and other alloys, making them highly versatile tools for a variety of research and development applications.

One vital aspect of EKTAM's mission is education. Through its masters and doctoral programmes, the centre trains students and professionals, many of whom go on to lead research projects. The close relationship between EKTAM and industry enables students to work on real-world projects and gain invaluable hands-on experience.

Twenty-nine permanent employees from academia and industry work at the facility, contributing to research and education activities. Within the scope of the COFUND project titled 'Advanced Materials and Advanced Manufacturing Technologies,' nineteen international PhD students have come to Türkiye to begin

Fig. 3 Nozzle and test specimens fabricated on a Concept Laser M2 PBF-LB machine (Courtesy EKTAM)

"EKTAM's activities align with Türkiye's growing focus on technological development. By developing domestic AM technologies and optimising production methods, the centre contributes to reducing the country's reliance on overseas suppliers, especially in advanced materials and manufacturing technologies."

Fig. 4 EKTAM's research team (Courtesy EKTAM)

their doctoral programmes at Gazi University, Middle East Technical University, Istanbul Technical University, and Izmir Institute of Technology. The PhD students involved in the project will research topics related to Advanced Materials and Advanced Manufacturing Technologies, contributing primarily to product-based research for the AM community. In addition, EKTAM has fostered international research partnerships, such as its dual-degree doctoral programme with Michigan State University. These collaborations enhance the centre's ability to train the next generation of experts in AM technologies while contributing to global knowledge exchange.

EKTAM's work builds strong relationships between academia and industry, making the centre a national leader in the area. In addition, active participation in global research collaborations – including EU-funded Horizon projects and international academic exchanges – also places EKTAM as an important player on the international stage.

"EKTAM's contributions extend beyond research to practical applications, with numerous scientific publications and industrial applications that bolster Türkiye's standing in the global AM community."

Through these collaborations, EKTAM ensures that its research keeps pace with the latest advancements in AM technologies worldwide. EKTAM's contributions extend beyond research to practical applications, with numerous scientific publications and industrial applications that bolster Türkiye's standing in the global AM community. Such work has led to technological advancements that benefit both Türkiye and the broader international ecosystem.

ALUTEAM

Aluminium alloys are becoming increasingly important in Additive Manufacturing thanks to their unique properties and versatility. Known for their lightweight nature, excellent corrosion resistance, and high strength-to-weight ratio, aluminium alloys have found widespread applications across industry, particularly in aerospace, automotive, and electronics. By combining these alloys with Additive Manufacturing, lightweight parts that are both strong and durable can be produced, making them ideal for high-performance applications where weight reduction is crucial.

Processing aluminium alloys by AM can achieve complex geometries that would be challenging or impossible to produce using conventional manufacturing methods. This allows for the creation of optimised, lightweight parts without compromising structural integrity – especially useful in sectors such as aerospace, where reducing mass translates to fuel efficiency.

Moreover, AM results in reduced material waste and shorter production cycles. The ability to selectively deposit material only where needed minimises excess use, leading to significant cost savings, especially when using high-value materials. In addition, advancements in AM technology have improved the properties of aluminium alloy parts, enhancing their mechanical properties and surface finish to meet rigorous industry standards.

The Aluminum Testing, Education, and Research Center (ALUTEAM) was established at Fatih Sultan Mehmet Vakıf University in 2011 and originated from a project initiated at Aluexpo in partnership with the university and the wider aluminium industry. With the support of the Entrepreneurial Aluminum Industrialists and Businessmen's Association (GALSİAD) and the Istanbul Development Agency (ISTKA), ALUTEAM officially began its operations in 2013. The centre expanded in 2015, starting a project partnership with the Istanbul Ferrous and Non-Ferrous Metals Exporters Association (İDDMİB) and, in 2018, with the Turkish Aluminum Industrialists Association (TALSAD).

ALUTEAM collaborates with a range of industries, primarily aluminium, aerospace, automotive, defence, healthcare, and education. By merging academia's research capacity with the industry's manufacturing expertise, ALUTEAM generates projects aimed at fostering productive and sustainable university-industry collaborations. It operates as a non-profit testing, education, and research centre.

ALUTEAM conducts the necessary testing across all industry sectors and alloy series, focusing on R&D and product development efforts tailored specifically for the aluminium industry. The centre's laboratories include Metallography, Microscopy and Materials Analysis Laboratory, Casting and Heat Treatment Laboratory, Advanced Characterisation Laboratory, Thermal-Energy Testing Laboratory, and Mechanical Testing Laboratory. With a robust laboratory infrastructure that has completed over 8,000 material tests, and with a team of experienced researchers, ALUTEAM provides collaborative opportunities for numerous academics and industry professionals. Additionally, its TURKAK 17025-accredited laboratories offer professional commercial services through a concurrently developed business model.

ALUTEAM also develops and delivers vocational/technical training and seminars based on the sector's needs, with national and international projects enriching these educational services. While professional training programmes are prioritised, content is also created for university students. Brands such as Cephe Akademi and ALUTalks were developed to support seminars and academia, with summer and autumn internship/training programmes contributing to the development of young professionals. Since its establishment, ALUTEAM has organised 106 vocational and technical training sessions and seminars, reaching more than 3,000 participants and developing nearly 2,000 hours of content. External professionals who come as guest speakers – as well as the centre's researchers and academics from the university – support the training programmes.

As an R&D centre, ALUTEAM places high value on academic output, including articles, conference papers, book chapters, and national and international project work. To date, ALUTEAM researchers have co-authored a hundred articles with researchers from various universities and institutions. The professional

Fig. 5 Investments in technologies such as XRD support pre-production and post-production process control requirements in Additive Manufacturing (Courtesy ALUTEAM)

"By merging academia's research capacity with the industry's manufacturing expertise, ALUTEAM generates projects aimed at fostering productive and sustainable university-industry collaborations."

Fig. 6 The manufacturing area at ALUTEAM utilises Additive Manufacturing technology, producing metal and polymer materials via Laser Beam Powder Bed Fusion (Courtesy ALUTEAM)

teams have successfully completed fifteen national and international projects and are currently managing five more. All educational, testing, and Additive Manufacturing efforts are integrated with ALUTEAM's research activities to support each other.

ALUTEAM also develops materials such as Inconel, stainless steel, and maraging steel in addition to aluminium, and the organisation has extensive research infrastructure and expertise to develop production parameters for specialised alloys.

"ALUTEAM also develops materials such as Inconel, stainless steel, and maraging steel in addition to aluminium, and the organisation has extensive research infrastructure and expertise to develop production parameters for specialised alloys."

In 2023-2024, ALUTEAM enhanced its Additive Manufacturing laboratory infrastructure with new investments, doubling its fleet with the addition of two Additive Manufacturing machines. With over 16,000 metal Additive Manufacturing parts produced and more than 30,000 PBF-LB production hours, the ALUTEAM offers experienced manufacturing capability. In addition, it has produced over 140,000 polymer AM parts, making it one of Türkiye's leading Additive Manufacturing centres.

Through its Additive Manufacturing business model, ALUTEAM supports R&D efforts and AM product development and commercialisation to companies in the defence, aerospace, automotive, and biomedical sectors, to name a few. The development and commercialisation of domestically produced Additive Manufacturing machines is also a key focus area for ALUTEAM.

Turkish Additive Manufacturing Association (TAMA)

Turkish Additive Manufacturing Association is a non-governmental entity established in 2018 and officially registered as an association in 2023. It promotes and disseminates Additive Manufacturing technologies in Türkiye. TAMA is managed by academics, researchers and professionals who are experts in Additive Manufacturing and related technologies. TAMA also aims to organise international conferences, events, online webinars, student activities and professional training.

Fig. 7 Turkish AM cluster successfully attracted numerous participants to the association's conference in Antalya, Türkiye, in April 2024 (Courtesy TAMA)

MetalWorm

MetalWorm specialises in robotic wire-arc DED. Its holistic approach to problem solving includes advanced toolpath strategies, real-time process monitoring, adaptive process control, materials science, and a process parameter library suitable for different materials and geometries. As part of this all-encompassing strategy, MetalWorm manufactures robotic Additive Manufacturing machines that are suitable for various levels of research as well as industrial production.

Fig. 8 The MetalWorm robotic wire-arc Directed Energy Deposition machine is designed to enhance efficiency and flexibility in metal manufacturing. With low buy-to-fly ratios, these machines minimise waste by precisely depositing material only where needed, enabling the efficient use of high-value metals (Courtesy MetalWorm)

Norm Additive & Norm 3D

Founded in 2021 under the umbrella of Norm Holding, Norm Additive continues to serve and enhance capabilities across various sectors beyond the parent company's automotive industry, including aerospace, white goods, machinery and automation, and medical. Located in Izmir, Norm Additive's 750 m^2 facility utilises PBF-LB technology.

The company's production and engineering equipment includes GE Additive M2 S5 and EOS M290-1 kW metal AM machines. Norm Additive offers a wide range of materials, including metal alloys such as AlSi10Mg, 316L stainless, EOS's CuCp copper and MS1 maraging steel, furthermore it has an ever-expanding

Fig. 9 Norm Additive's organisational structure highlights its comprehensive range of services and expertise in Additive Manufacturing (Courtesy Norm Additive)

> *"In addition to Norm Additive, Norm 3D was established in 2024 to meet the needs of customers in Türkiye who wish to acquire Additive Manufacturing technology. The company partners with EOS GmbH and is its sole official distributor in Türkiye."*

materials portfolio. Post-processing services such as heat treatment, surface polishing and cleaning, machining, sandblasting, and surface coating are provided in-house. Its extensive workshop and technical capabilities – including assembly, integration, and fastening component installation processes – enable the production of fully finished parts.

In addition to manufacturing services, various engineering studies are conducted on customers' existing products and parts to enable sustainable and lightweight product manufacturing. Norm Additive also offers reverse engineering services through its 3D scanning and CMM capability. With a newly established quality control department, opened this year, parts undergo quality inspections and are then delivered to customers with detailed reports.

In addition to Norm Additive, Norm 3D was established in 2024 to meet the needs of customers in Türkiye who wish to acquire Additive Manufacturing technology. The company partners with EOS GmbH and is its sole official distributor in Türkiye. Norm 3D is responsible for offering suitable machine options to customers looking to purchase AM machines, managing the sales process, and providing all maintenance and repair services after the sale. In addition, it supplies raw materials and spare parts to its clients. The company is headquartered in Izmir, with offices in Istanbul.

Alloy Additive

Conventional welding experience is highly valuable in Additive Manufacturing. This expertise is especially important in relation to DED based technologies. As a result of prioritisation efforts, it is essential for Türkiye to develop its own AM machine production capability, to establish its own production parameters, and utilise locally-sourced raw materials.

Since its foundation in 2020, Alloy Additive has been pushing the limits of what DED technology can achieve. The company's approach utilises a Tungsten Inert Gas (TIG) welding robot to achieve industry-leading deposition rates, enabling the rapid manufacturing of large parts using a wide range of materials, including titanium alloys, Invar, Inconel, and stainless steels.

Alloy Additive's core innovation lies in its proprietary software, which enables precise control over DED process parameters. This enables manufacturing with 95% less material waste compared to conventional methods. This efficiency not only saves costs but also reduces CO_2 emissions by 90%, making the approach equally attractive for its sustainability.

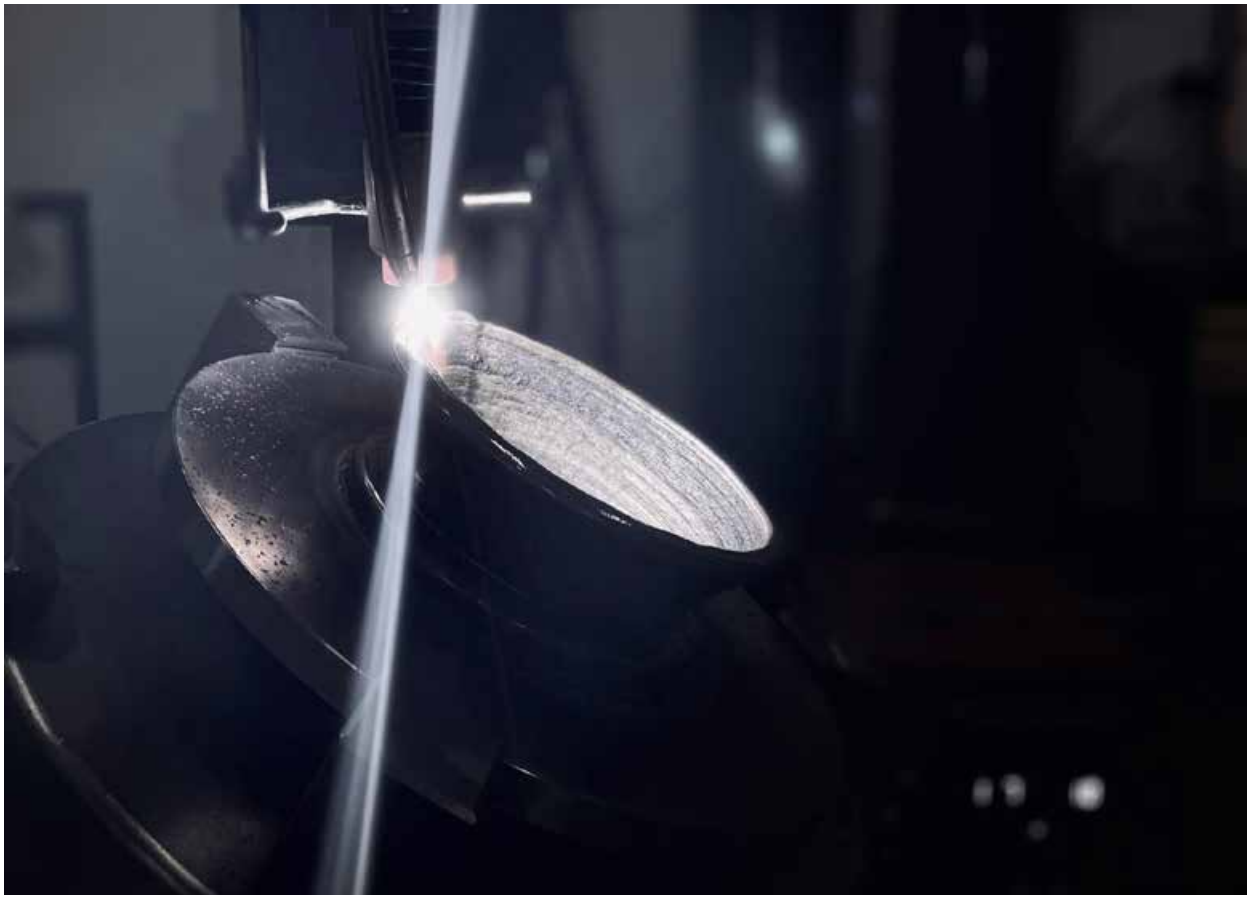

Fig. 10 Alloy Additive continues to push the limits of large-scale part production with wire-arc DED technology (Courtesy Alloy Additive)

Enjoying order-of-magnitude reductions in lead times, as well as features unattainable by conventional machining methods, Alloy Additive customers use the company's DED parts in a diverse range of applications, including rockets, racing yachts, trucks, trains, moulds, and petroleum refinery equipment. Alloy Additive has also experienced success repairing large parts in-situ, helping customers avoid the expense of machine downtime.

Having recently secured multiple programme awards and investments, as well as new international customers who require huge multi-meter scale parts, Alloy Additive is poised to continue transforming the landscape of advanced manufacturing through rapid, cost-effective, energy-efficient, and environmentally conscious large-scale metal manufacturing solutions.

ADDME

ADDME is a spin-off from Coşkunöz Holding that leverages the latter's seventy years of engineering expertise. ADDME provides end-to-end support to its clients, from redesigning conventional parts for Additive Manufacturing to production and qualification processes. As one of Türkiye's leading Additive Manufacturing brands, ADDME offers a wide range of industrial solutions, from prototyping to mass production, and it stands out in the industry with its advanced technologies. It specialises in high-performance materials such as titanium, nickel and aluminium alloys processed using Powder Bed Fusion technologies. By contributing to its clients' innovation processes, the company has become one of the most reliable business partners in the industry.

"As a result of prioritisation efforts, it is essential for Türkiye to develop its own AM machine production capability, to establish its own production parameters, and utilise locally-sourced raw materials."

Fig. 11 ADDME participating at the 2024 Additive Manufacturing Conference (AMC). The company develops high-precision metal parts production projects focused on quality and speed to meet customer requirements in sectors such as automotive, aerospace, defence, and medical (Courtesy ADDME)

ADDME provides engineering and design optimisation services with its expert AM team in Additive Manufacturing, supporting the entire process from design to the final product. Through its training programmes, it aims to boost the knowledge of professionals in the industry. ADDME also plays a key role in R&D projects that help transition conventional parts to Additive Manufacturing, enabling companies to enhance their competitiveness in this field.

Conclusion

Aligned with global developments, AM provides advantages in flexibility, cost-effectiveness, and speed within production processes, making it an increasingly vital technology. The metal Additive Manufacturing sector in Türkiye is rapidly advancing to meet the innovative production demands in the defence, aerospace, and space industries.

Collaboration between universities, research centres and industry organisations is essential for the broader adoption of metal Additive Manufacturing. By establishing standards and clarifying part of a validation process, Türkiye's competitive edge in this field will be further enhanced, helping the country build a robust metal Additive Manufacturing ecosystem that supports its national production goals and strengthens its global standing.

"The metal Additive Manufacturing sector in Türkiye is rapidly advancing to meet the innovative production demands in the defence, aerospace, and space industries."

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- Notification of Abstract Acceptance: January 31, 2025
- Selected Full Papers Submission to JAMTECH: February 16, 2025
- Revised Papers Submission: March 2, 2025
- Authors Notification of Final Acceptance: March 7, 2025
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How metal Additive Manufacturing is transforming modern hydraulic systems

Hydraulic systems are important across many industries, providing high power density in compact, efficient packages. However, conventional subtractive manufacturing methods restrict design and performance. Additive Manufacturing offers a solution, enabling the production of complex geometries that enhance flow dynamics whilst minimising material use. In this article, Valeria Tirelli, CEO of Aidro Srl, considers how AM is reshaping hydraulic component design and production, offering new possibilities for enhanced performance, sustainability, and application-specific customisation.

Hydraulic pumps, cylinders, and other actuators deliver greater power in smaller packages than engines, electric motors, and mechanical actuators. Hydraulic valves easily control direction, speed, torque, and force through controls that range from the fully manual to those managed by sophisticated electronics.

Historically, the production technologies that create these hydraulic components have not kept pace with their expanding range of applications. Enter metal Additive Manufacturing, a set of industrial processes offering new opportunities to capitalise on hydraulic technology's high power density by improving the design and production of fluid power parts such as manifolds, valve blocks, and valve components.

As Additive Manufacturing continues to make headway across industry as a whole, a growing number of hydraulics and fluid power system users are already benefitting from the use of weight- and size-optimised hydraulic components with complex features that would be difficult or impossible to produce via conventional manufacturing. This is especially the case since AM overcame challenges linked to the very high pressures under which hydraulic components are used.

Why AM is different

Additive Manufacturing offers a different approach to the established methods of designing and manufacturing hydraulic parts. Instead of

Fig. 1 As AM continues to make headway across industry, a growing number of hydraulic component users are adopting the technology (Courtesy Aidro Srl)

Fig. 2 Aidro's CEO, Valeria Tirelli, with an additively manufactured hydraulic component produced by Laser Beam Powder Bed Fusion (PBF-LB) (Courtesy Aidro Srl)

starting with a metal block, the Additive Manufacturing process allows engineers and technical designers to design hydraulic parts based on the specific needs of an application, rather than the constraints of past manufacturing processes.

Free from the limitations of conventional machining, parts can be designed for the most efficient combination of manufacturing and performance, including the optimisation of internal channels for higher flow and lower pressure drop. It is also possible to produce numerous different prototypes, within a matter of hours, to determine the best design before going on to mass production, whether that is via conventional or Additive Manufacturing methods. These components can be made from a variety of materials – including stainless steel, aluminium, and Inconel – the performance of which compares favourably to forged materials. Indeed, many AM-processed materials have better mechanical properties and densities than their cast equivalents.

Although hydraulic components can be produced either by conventional manufacturing or AM, conventional manufacturing necessarily has drawbacks. As a subtractive process, material is removed – generally via CNC machining – from a larger piece, usually a metal casting or bar, to leave the desired shape. Excess material is often left in place to save the expense of removing it, resulting in parts that weigh far more than necessary.

Machining is also limited in its ability to produce certain designs. Passageways in conventional manifolds often must be positioned to prevent cross-drilled channels from intersecting, and allow enough material between channels to provide adequate strength. Further, auxiliary holes drilled to connect internal passageways need to be plugged, creating the potential for a future leak.

"Free from the limitations of conventional machining, parts can be designed for the most efficient combination of manufacturing and performance, including the optimisation of internal channels for higher flow and lower pressure drop. It is also possible to produce numerous different prototypes, within a matter of hours..."

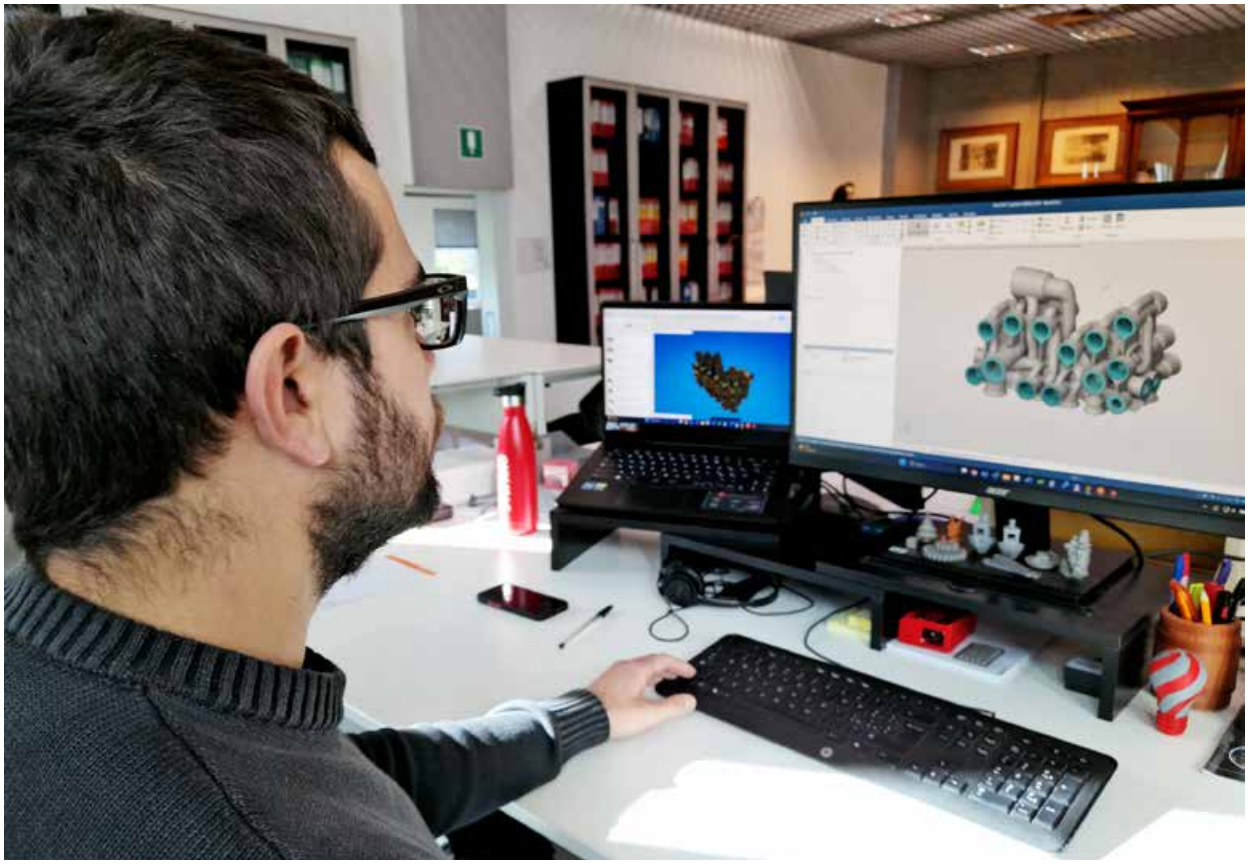

Fig. 3 It is in the design phase where significant value can be added to an additively manufactured component (Courtesy Aidro Srl)

Additive Manufacturing, on the other hand, 'builds' the desired part layer by layer. With this technology, flow channels can be placed exactly where they are needed – and be optimised for size and shape. Until now, flow channels, particularly in components such as valves, were usually circular because they were machined with rotating cutters. By building a component in layers, designers can specify configurations that would be difficult or impossible using subtractive manufacturing methods.

"Additive Manufacturing, on the other hand, 'builds' the desired part layer by layer. With this technology, flow channels can be placed exactly where they are needed – and be optimised for size and shape."

Manifold flow paths can now be made with cross-sections and in special shapes instead of a round hole, optimising flow capacity in a channel of the same (or smaller) width, sometimes in a smaller space. Because passageways connecting internal channels don't have to be machined from outside a manifold, the need for hole plugs is eliminated.

Although there is a wide variety of Additive Manufacturing processes, this article focuses on Laser Beam Powder Bed Fusion (PBF-LB), in which metal powder is melted, layer-by-layer, using a laser. Other processes used for hydraulic components include Binder Jetting (BJT), in which the powder particles are held together by a binder before being sintered.

In both cases, material is added only where necessary. This enables manufacturers to create new, lightweight designs with varying geometries and reduced part counts. Instead of assembling three or four components (e.g. valves and manifolds), a single part incorporating these components can be designed. This delivers weight reduction, eliminates assembly operations, reduces the risk of leakage from joining multiple parts, and cuts down machining hours.

Fig. 4 Image of the UGO hydraulic manifold, used on combine harvesters (Courtesy Aidro Srl)

Delivering sustainability in both production and usage

In many instances, Additive Manufacturing delivers significant sustainability benefits. AM processes require substantially less material than subtractive processes such as CNC machining, which must necessarily start with more material than the final component requires. Reductions in energy consumption when comparing forging or casting to Additive Manufacturing have also been demonstrated.

The creation of lightweight parts through the use of AM also benefits the sustainability goals of end-user industries. Vehicles or mobile machinery into which the lightweight parts are installed can benefit from improved fuel efficiency, as the use of lightweight components reduces overall vehicle weight and, thus, fuel use. This is especially useful in aeronautics and space applications, where every gram shaved from components means not only a lower environmental impact but significant cost savings.

"In many instances, Additive Manufacturing delivers significant sustainability benefits. AM processes require substantially less material than subtractive processes such as CNC machining, which must necessarily start with more material than the final component requires."

Case study: the UGO manifold

An interesting example from the agricultural machinery sector is the hydraulic manifold shown in Fig. 4. Designed by Aidro, the UGO is an excellent example of an additively manufactured manifold that showcases the advantages of the technology for fluid power systems.

The UGO manifold is the system through which combine harvesters

are controlled. It operates on hydraulic cylinders and motors, traditionally consisting of:

- Six directional control valves
- Four pressure-reducing valves
- One pressure release valve
- One bypass
- Two pilot-operated check valves

The additively manufactured manifold performs exactly the same functions as the original unit it replaces, but it is half the size and weight (Fig. 5). While the conventional manifold is made from multiple materials (aluminium for the base, cast iron and steel for the valves), the new design is made entirely from 316L stainless steel. This material combines excellent strength, high ductility, and good thermal properties, which, along with its high resistance to corrosion and pitting (including from chemical corrosion), makes it particularly suited to machines used in agricultural applications. 316L is also able to better withstand the atmospheric agents and chemical products used in this sector.

Pressure testing of additively manufactured 316L has also shown that mechanical properties – such as tensile strength, elongation, impact toughness, and hardness – are as good if not better than conventional materials.

Fig. 5 The additively manufactured manifold (top) performs exactly the same functions as the original unit it replaces (bottom), but it is half the size and weight (Courtesy Aidro Srl)

Comparing conventional manufacturing to the Additive Manufacturing of the assembled manifold			
Characteristics	**Original manifold**	**AM manifold**	**Notes**
Weight	23.3 kg	11.3 kg	Both weights include valves
Number of components	194	42	The reduced weight is mostly attributable to the removal of screws, gaskets, caps
Material	Aluminium for manifold and cast iron/steel for valves	316L stainless steel	
Working pressure	250 bar	250 bar	250 bar is what is required of the application, though AM manifolds can withstand higher pressures without issue; the pressure rate of the valves, however, tops out at 350 bar

Table 1 A comparison of the original and additively manufactured manifolds (Courtesy Aidro Srl)

Fig. 6 Detail view of the UGO manifold (Courtesy Aidro Srl)

Fig. 7 The UGO manifold being tested under operating conditions (Courtesy Aidro Srl)

As previously highlighted, one advantage of adopting Additive Manufacturing is the ability to combine multiple parts into one, reducing assembly time and simplifying the supply chain. In the case of the UGO manifold, the original consisted of 194 parts; including thirteen main blocks, twelve valve body blocks, one base manifold, and numerous small components such as spools, o-rings, screws, gaskets, and caps. The AM version of the manifold consists of only forty-two parts, including one central block.

Performance

The operating performance of the UGO manifold exceeds that of the original part because the curved shapes of the internal channels mean that there are no 90° angles at intersections (Fig. 6). Further, as mentioned above, passageways connecting two or more internal channels don't have to be machined from outside the manifold and subsequently plugged to prevent fluid from flowing out. Indeed, in the conventional manufacturing of hydraulics, manifold intersections are created by drilling a hole on one side and another on the other side of the block, a result of machine tools limitations. Free of these limitations, engineers can design components based on the principles of Computational Fluid Dynamics.

The ability to additively manufacture optimised curved channels enables better flow dynamics and reduces pressure drops. This, combined with removing the risk of leakage through the elimination of auxiliary caps and plugs, offers a two-fold advantage: performance is optimised and the risk of environmental damage is limited.

Moreover, the design freedoms enabled by Additive Manufacturing allow engineers to position flow channels precisely where they are needed in a variety of shapes and sizes. This means that flow channels can be spaced closer together than with conventional manifolds, which makes

finished products more compact and lighter. In this example, the AM UGO manifold is 50% smaller than the original component.

The smaller sizes of components enabled by AM are especially valuable when parts are intended for mobile applications with comparatively little space for hydraulic systems. The shape of the UGO manifold has been adapted to the available space, with connections customised to exactly where the external piping arrives. This means the manifold needs no modifications after production, as it is designed precisely for its unique application.

Conclusion

Additive Manufacturing represents a transformative shift in the design and production of hydraulic components. By freeing engineers from the constraints of traditional manufacturing, AM enables the creation of lighter, more efficient parts with optimised flow dynamics and enhanced performance.

The case of the UGO manifold demonstrates how AM can drastically reduce component size and weight, simplify assembly, and improve reliability by eliminating features prone to failure, such as auxiliary plugs. Beyond performance, the sustainability benefits of AM, including reduced material use and energy consumption, align with the growing emphasis on environmentally responsible production. As the technology continues to evolve, it is set to play an increasingly critical role in the fluid power sector, driving innovation while meeting the diverse demands of modern applications.

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"By freeing engineers from the constraints of traditional manufacturing, AM enables the creation of lighter, more efficient parts with optimised flow dynamics and enhanced performance."

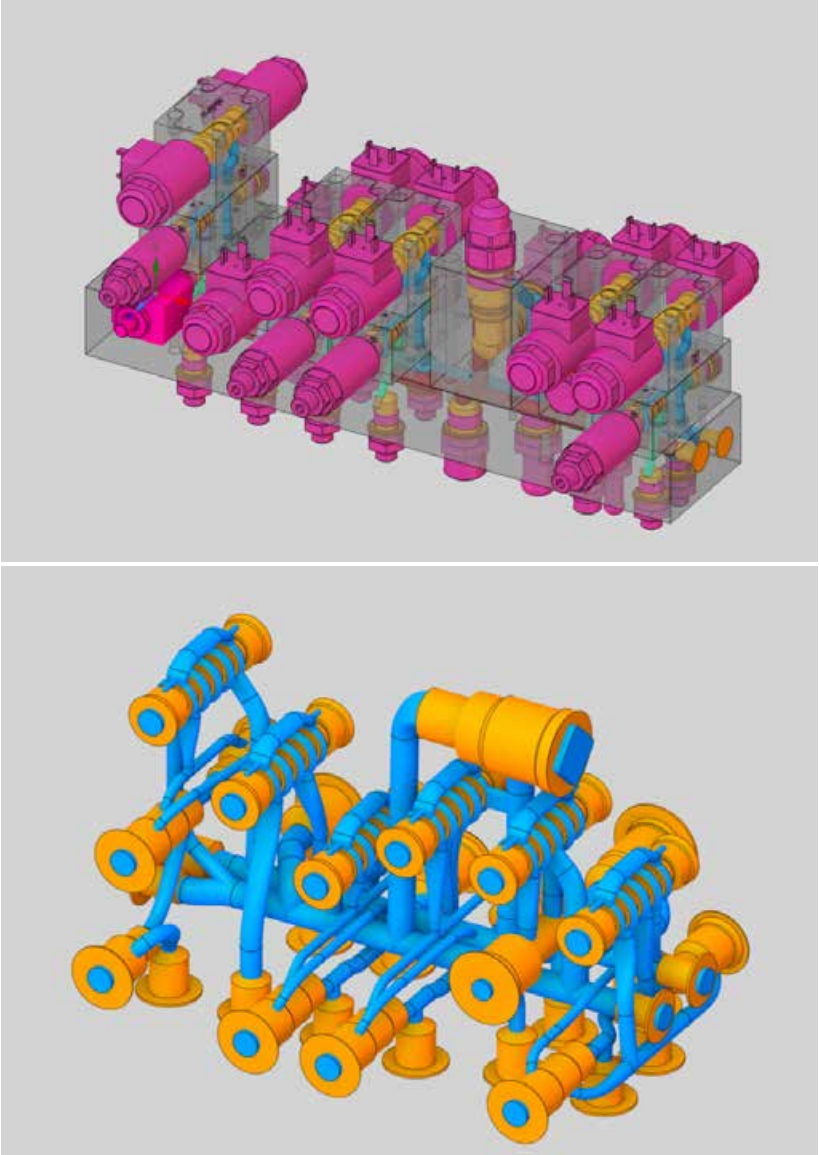

Fig. 8 The original manifold (top) consists of 194 parts, including thirteen main blocks, twelve valve body blocks, one base manifold, and numerous small components such as spools, o-rings, screws, gaskets, and caps. The AM manifold (above) consists of only forty-two parts, including one central block, and has vastly improved performance thanks to optimised channel design (Courtesy Aidro Srl)

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High-performance product development in the era of computational design: a case study with nTop and NASA

The era of computational design is reshaping the engineering and product development landscape, enabling industries to tackle complex design challenges with unprecedented speed and efficiency. This article explores how NASA, using software from nTop, leveraged cutting-edge tools and methodologies in a unique application development. In combination with the capabilities of Additive Manufacturing, the project saw a scientific instrument component's original material, beryllium, replaced with an aluminium alloy, providing a significant part cost reduction whilst exceeding all necessary performance requirements.

Driven by advances in computing power, Artificial Intelligence, Machine Learning, and digital manufacturing, the era of computational design has arrived – and it is poised to make an even bigger impact than any previous era of design, from paper to Computer Aided Design (CAD) to parametrics.

More to the point, computational design is quickly transforming how design-intensive industries solve complex problems in engineering and product development. These industries share similar goals: deliver high-performance products on faster timelines. Increased performance might mean faster aircraft, improved osseointegrative medical implants, cost-effective automotive vehicles, more sustainable consumer products, or the decarbonisation of the global industrial ecosystem. In all these cases, computational design is breaking down the barriers of conventional design tools.

The primary issue with conventional tools is the speed of iteration. Constrained by manual modelling of low-level design features, defining complex relationships between design features that are difficult to construct, and complex real-world physics, these tools simply move too slowly to support a highly iterative process required in high-performance product development.

Computational design solves this problem with algorithms that capture design intent and logic in order to generate solutions to complex engineering problems. When this happens, computational design effectively provides engineers with solutions to generate, visualise,

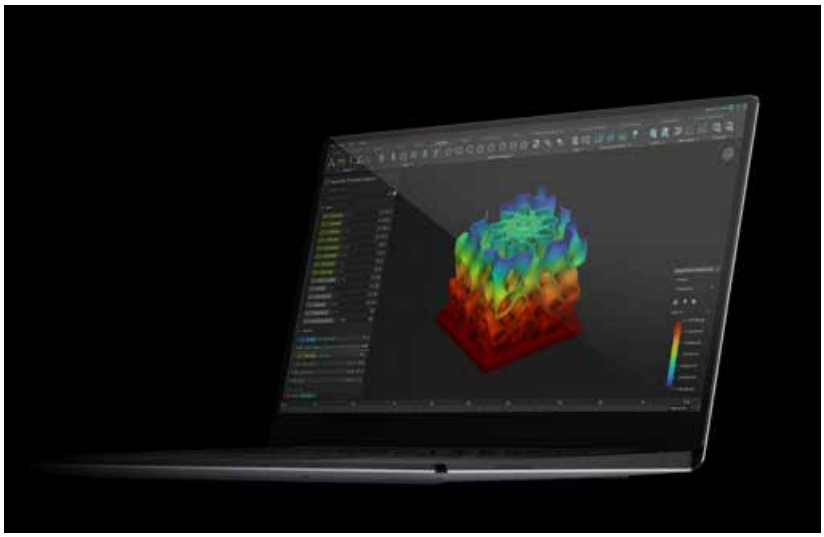

Fig. 1 Computational design is quickly transforming how design-intensive industries solve complex problems in engineering and product development (Courtesy nTop)

"...a computational design model doesn't just capture one version of a design. Since it evaluates intent and requirements algorithmically, the model effectively calculates an entire design space that represents the entirety of what is possible. This key difference enables a massive improvement in the speed of iteration."

explore and evaluate vast design spaces more rapidly. Ultimately this leads to better, more informed decisions and optimal solutions.

Importantly, a computational design model doesn't just capture one version of a design. Since it evaluates intent and requirements algorithmically, the model effectively calculates an entire design space that represents the complete scope of what is possible. This key difference enables a massive improvement in the speed of iteration. The building phase of a model might take a bit longer than drawing it manually, but once it is built, engineers can iterate in rapid-fire fashion.

Furthermore, significantly faster iteration empowers engineers to optimise products and incorporate manufacturability earlier into the process. This means engineers can find better solutions that balance production economics and quality and dramatically reduce time to market. The fact that design intent is 'baked in,' means that computational models can be version-controlled, reusable, and extensible to solve similar design problems.

What does that look like in actual practice? In a recent instance with Siemens Energy, the differences were stark: iterations were completed in seconds and minutes rather than hours and days. Using rapid iteration, the design team ran two hundred designs with just twenty-three errors – a success rate close to 90%. With traditional boundary representations (B-rep) CAD tools, the expected success rate is closer to 30%. In addition, design files that would have been 200 MB with traditional tools were just 3 MB.

All mainstream CAD systems use boundary representations (B-reps) as their geometric modelling technology. As the name implies, a B-rep describes a shape by modelling its boundary. The part's skin is wrapped in a collection of faces joined at the edges.

Computational design requires five key capabilities

To realise these benefits, computational design requires models that can respond intelligently to parameter changes – regardless of whether those changes are initiated by an engineer or a powerful computing platform. Specifically, these models must be:

1. Fast
Faster iteration demands features such as automation and real-time model updates that enable engineers to visually assess design changes more rapidly.

2. Flexible
Models require a high degree of freedom to change in order to capture a large design space. They need to support broad changes in shape, topology, material distribution and composition.

3. Reliable
Computational design relies on modifying inputs and recomputing the model, so computations must be reliable or the model will fail to update.

4. Closed loop
For a computational model to be useful for engineers, the physics must be fully integrated in order to facilitate closed-loop optimisation. Results from a structural analysis, for example, may indicate the stress value at each point in a design. These values form a scalar field that triggers automatic modifications that add material to strengthen areas of high stress and remove unnecessary material from low-stress areas.

5. Differentiable
A common design objective is to minimise a design property, such as manufacturing cost or weight. To find a minimum, the engineer (or computer) needs to know which direction is 'downhill.' This requires mathematical differentiation, because derivatives indicate how parametric changes will affect the design and which changes will improve it.

The power of implicit modelling

The primary difference between computational design and traditional CAD tools is seen in how they represent geometry. B-reps have significant flaws that make them unsuitable for computational design. In fact, their architecture has remained mostly unchanged for decades. As a result, they are not suited to parallel computing, especially GPUs.

In a typical B-rep system the GPU renders triangles from a geometry kernel running single-threaded on

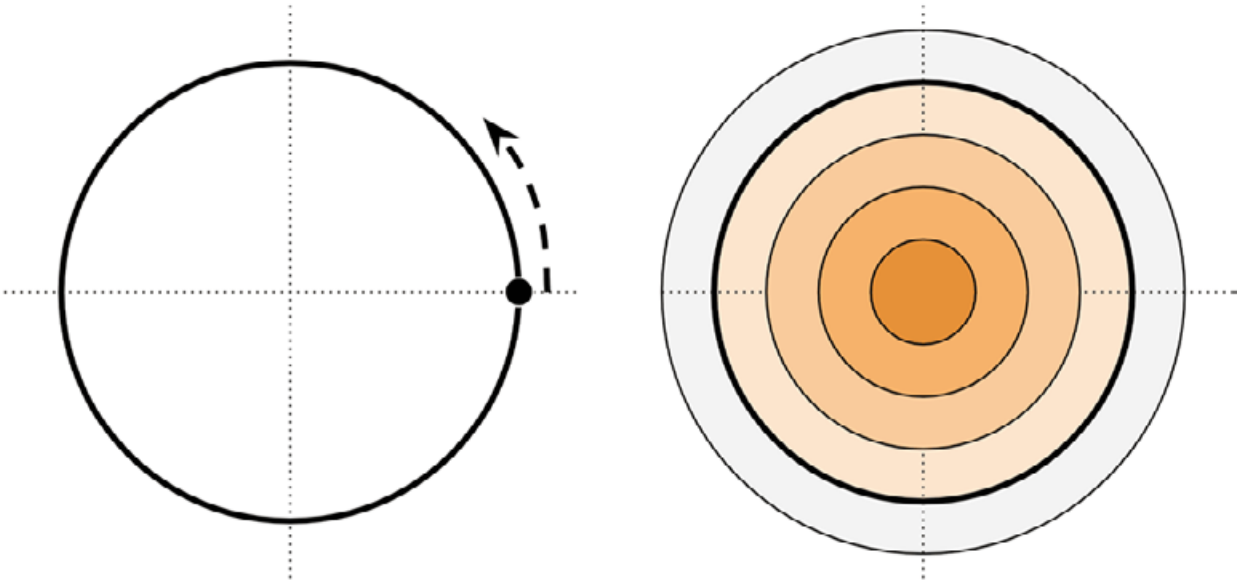

Fig. 2 A circle represented in a boundary representation (left) and a distance field (right) (Courtesy nTop)

one core of a CPU. B-reps are also unreliable and calculations fail for a variety of reasons, despite significant efforts to make them more resilient over the past four decades.

Computational design uses a completely different approach called implicit modelling. With implicit modelling, the shape of an object is described by a mathematical function that returns the distance to the closest point on its surface. The function is constructed so that it will be negative inside the object, positive outside the object, and zero on the surface. This is why it is called a Signed Distance Function (SDF).

This is critical because a key step in any modelling algorithm is deciding whether a given point P is inside or outside an object. If you have an SDF, this is easy: you simply check the sign of the function of P. This calculation is easy to parallelise because the results for different points are independent of each other. For this reason, implicit modelling calculations are incredibly fast on GPUs, delivering real-time interaction even for the most complex, intricate shapes.

How NASA uses computational design to replace beryllium with aluminium

The best way to understand the power and potential of computation design is through real-world examples of product development teams focused on high-performance products in competitive and demanding industries.

In this case, engineering research conducted at NASA Goddard Space Flight Center in Greenbelt, Maryland, was focused on the baseplate of a laser benchtop system. As the laser transmits heat to the baseplate – 200 W in the centre, running continuously – the surface deforms, compromising the accuracy of measurements taken with the laser. This design challenge is relevant to a wide range of laser, LiDAR and photonics systems used in aerospace.

Today, these baseplates are made from beryllium, a material that is extremely stiff and resistant to deformation under thermal loading. Unfortunately, beryllium is also very expensive and its dust is extremely

"Computational design uses a completely different approach called implicit modelling. With implicit modelling, the shape of an object is described by a mathematical function that returns the distance to the closest point on its surface."

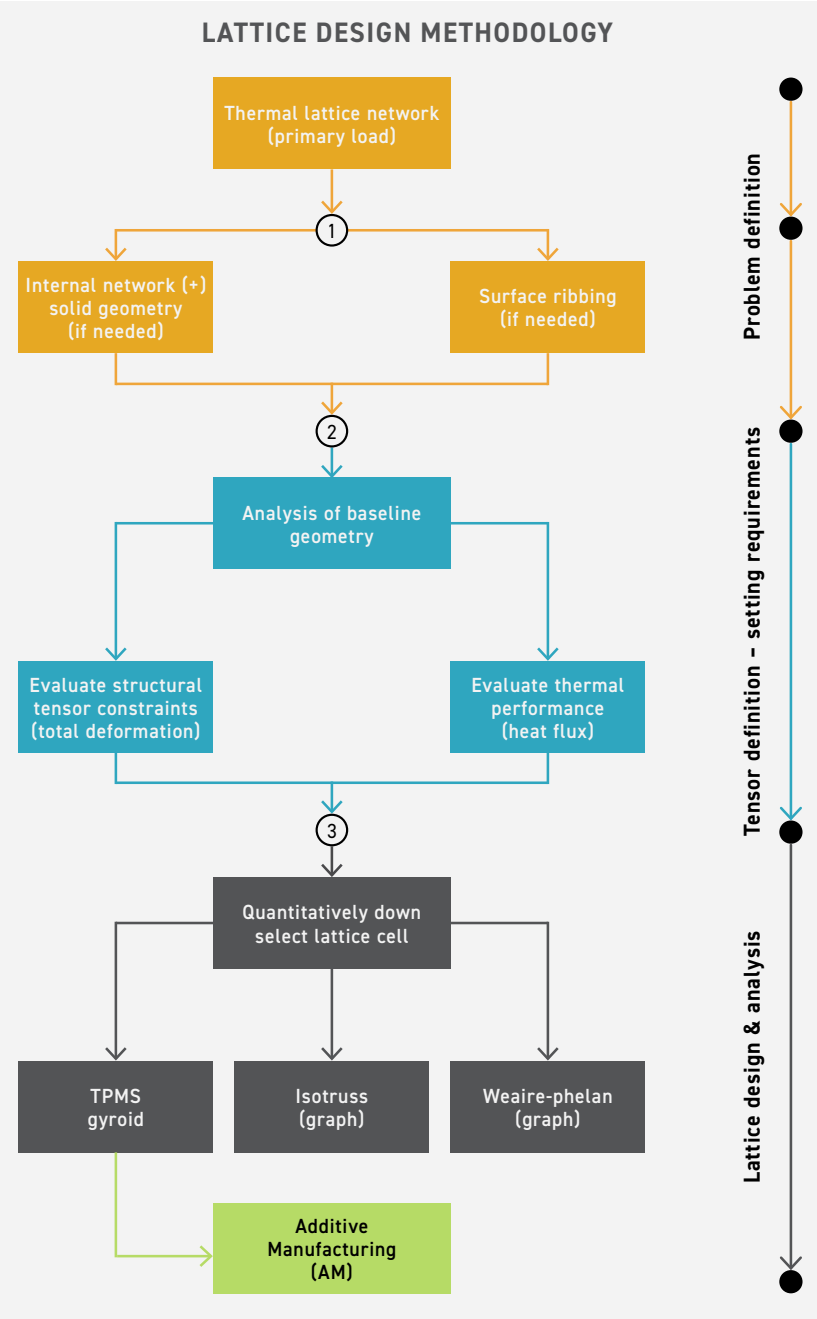

Fig. 3 Methodology used to select and apply lattice structure (Courtesy NASA)

"You're taking a cheaper and relatively weak material and asking how to make it outperform an extremely expensive advanced material that's 33% lighter. You have five constraints and it's a multi-physics problem. This is really difficult to solve."

toxic. There are also only a limited number of shops qualified to machine beryllium for aerospace applications, so lead times are very long.

The NASA team sought to replace beryllium with a safer, less expensive material without compromising performance. The chosen material was A6061-RAM2, a general-purpose AM aluminium alloy with an elastic modulus of less than half of beryllium. There is essentially no way to do this without computational design – an approach that can produce and optimise lattice networks engineered to enhance specific characteristics, such as strength and heat transfer.

In particular, the team wanted to determine a lattice network that could achieve similar deformation performance of forged beryllium with: an equivalent elastic strain (Von Mises strain) similar to beryllium, an equivalent stress (Von Mises stress) less than beryllium, and mass targets within ±10% of beryllium.

"You're taking a cheaper and relatively weak material and asking how to make it outperform an extremely expensive advanced material that's 33% lighter," stated Alex Souk, a Senior Mechanical Design Engineer at Goddard who helped lead the project. "You have five constraints and it's a multi-physics problem. This is really difficult to solve."

Developing a systematic approach to lattice design

Computational design held the key to the NASA team's approach. The team was particularly interested in constructing a systematised lattice design methodology that could be shared and reused in many other applications across NASA (Fig. 3).

The team started by establishing the vector field for optimisation. This involved simulating the thermal stress of the laser on both materials. As the team expected, the beryllium plate performed well with very little deformation ($1.56E^{-5}$), and the aluminium performed poorly with significantly more deformation ($4.43E^{-5}$) (Fig. 4).

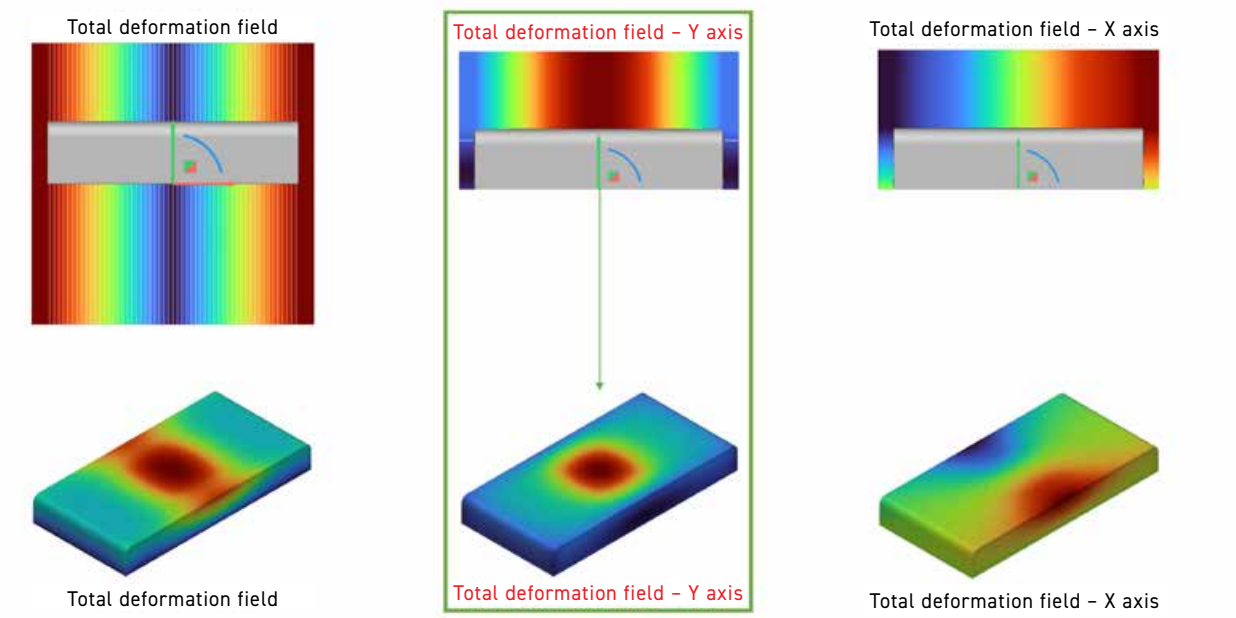

Fig. 4 Scalar field derived from thermal simulation used for optimisation (Courtesy NASA)

This field was imported into nTop software where a ramping function was applied. This capability lets engineers gradually change a value based on the scalar field. For example, areas of the part that experience high stress can be thickened while low stress areas remain as is.

"Due to the way nTop generates the geometry, you can specify that in areas where deformation exceeds a certain threshold, a certain thickness is needed," Souk explained. "Then we can ramp it back down by the time it gets to low deformation. nTop varies the scale of design parameters based on actual simulation data."

From this point, the team needed to figure out which lattice network to use, which is a perpetual problem in latticing. The team used a three-body diagram to understand the relevant physics models and then normalised the data to quantify the data of interest. Some lattices are stronger in certain directions, and other lattices are better for conduction. This quantifiable down-selection process led the team to consider three candidates based on the elastic modulus in the Y direction: a TPMS gyroid, an isotruss and a Weaire-Phelan structure.

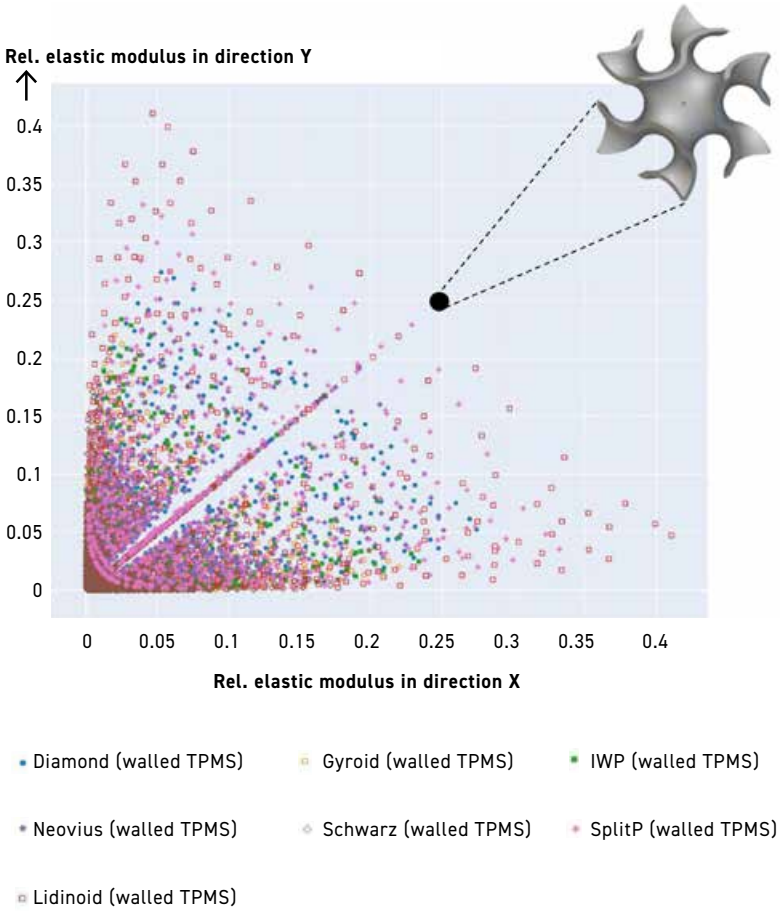

Fig. 5 Selection of the lattice based on elastic modulus in Y-direction (Courtesy NASA)

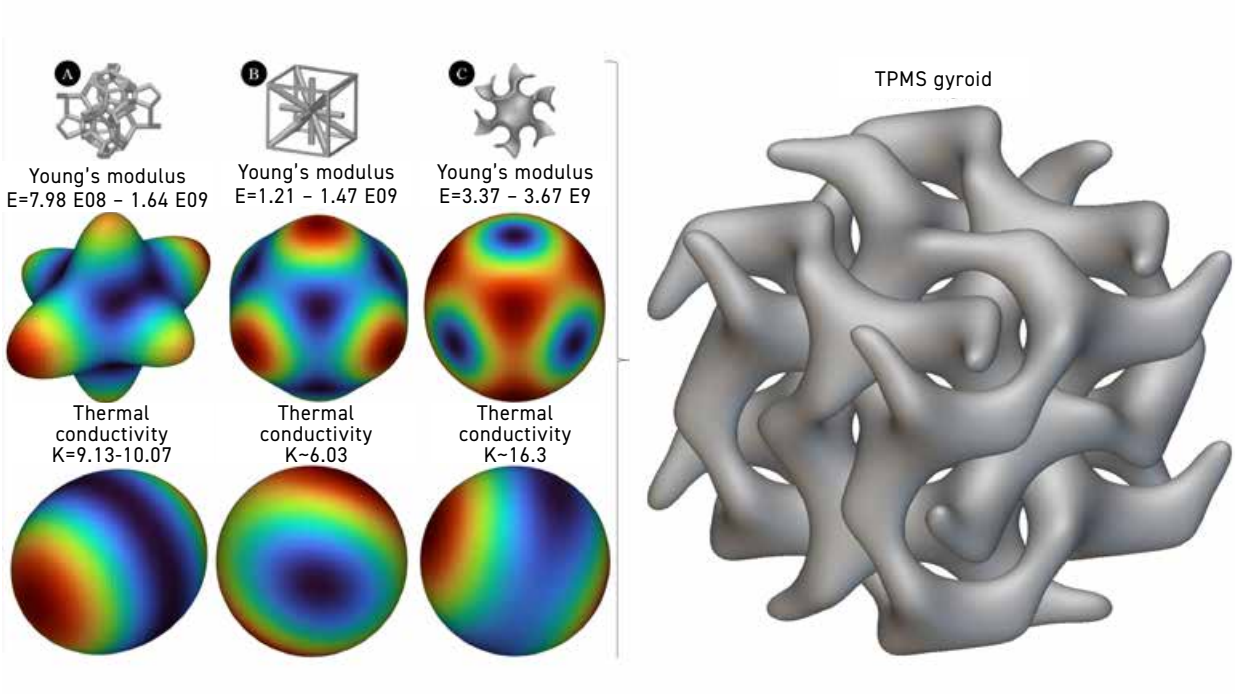

Fig. 6 Comparison of Young's Modulus and thermal conductivity of candidate lattices (Courtesy NASA)

In collaboration with Dr Ryan Watkins at NASA's Jet Propulsion Laboratory in Southern California, the team performed homogenisation to characterise equivalent material properties of different lattice unit cells. This revealed that the TPMS gyroid had the highest resistance to deformation (based on Young's Modulus) and the highest thermal conductivity (Fig. 6). In addition, it would be easier to manufacture than the others.

"The next step was determining the structure, which we believed would include Voronoi ribbing at the top layer to keep the skin strong, a gyroid-based lattice core that will do most of the heavy lifting, and then an aluminium wrap around the whole thing," Souk stated. "Then we got to work simulating all the different configurations to identify the optimal solution" (Fig. 7).

With nTop, the team was able to determine how the Voronoi ribbing impacted performance at a specific mass penalty. This helped them quickly iterate on a variety of configurations of ribbing structures and lattice networks. With these configurations established, the team performed a design of experiments (DOE) to find the most successful one.

"We ramped up certain values and looked at the results, looking at the convergence of data in physical properties and manufacturability," Souk stated. "We tried a lot of options with respect to thickness, dimension, Voronoi ribbing, and internal various internal lattice structure. You see what works and what doesn't and then adjust for a new iteration." Each iteration takes approximately five minutes to develop, but then it has to be simulated in a separate ANSYS software platform.

"Using nTop you can build workflows intelligently knowing what variables you intend to change," Souk added. "Then you can copy it, change those variables, and the model updates parametrically. We validated results in ANSYS, which is widely used in the industry."

"With nTop, the team was able to determine how the Voronoi ribbing impacted performance at a specific mass penalty. This helped them quickly iterate on a variety of configurations of ribbing structures and lattice networks. With these configurations established, the team performed a design of experiments (DOE) to find the most successful one."

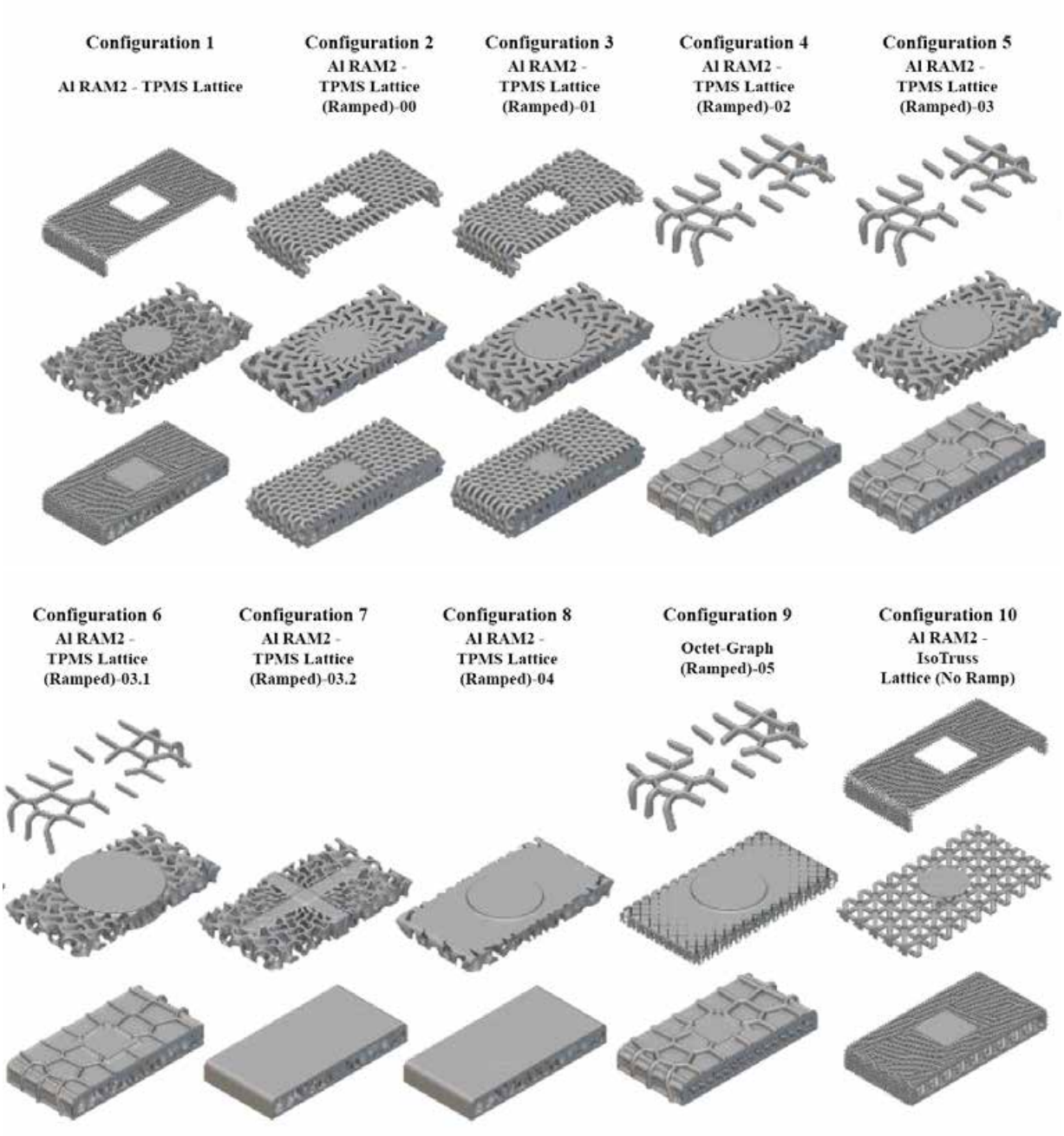

Fig. 7 Evaluation of varying lattice design configurations (Courtesy NASA)

Meeting stringent requirements for all five constraints

The results of the DOE were extremely successful. The winning AM aluminium model delivered a 10% mass penalty compared to beryllium but 22% less internal stress. Its deformation was 259% more than beryllium, but this percentage is less important than the actual difference in deformation due to the micron-level scale of the application.

"With this particular TPMS lattice, the difference between the two materials needs to be within 5 µm ± 10%," Souk stated. "We knew the aluminium would deform more than the beryllium. The question is, did we hit our requirement? In our case, the answer is yes."

Specifically, the deformation with the beryllium baseplate was 0.396 µm while the deformation with the AM aluminium baseplate was 1.419 µm. This means the total average deformation difference between the two materials was ~1 µm (±10%).

Importantly, the AM aluminium model delivered two other benefits in terms of its cost and fabrication time. "The configuration we chose has the gyroid lattice core with the Voronoi at

Results of DOE Study for each Lattice Network													
		Baseline		TPMS Gyroid Configurations								Beam config.	
	Mechanical Characteristics	Beryllium I-220H Grade 2	Aluminium 6061RAM2 (Solid)	Al RAM2- TPMS Lattice	AlRAM2 – TPMS Lattice (Ramped)-00	Al RAM2- TPMS Lattice (Ramped)-01	Al RAM2- TPMS Lattice (Ramped)-02	Al RAM2- TPMS Lattice (Ramped)-03	AlRAM2- TPMS Lattice (Ramped)-03.1	Al RAM2 – TPMS Lattice (Ramped)-03.2	Al RAM2- TPMS Lattice (Ramped)-04	Octet-Graph (Ramped)-OS	Al Ram 2 – IsoTruss Lattice (No Ramp)
1	Total Deformation (in)	1.56x 10^{-05}	4.43x 10^{-05}	9.83x 10^{-05}	6.1x 10^{-05}	6.57x 10^{-05}	6.14x 10^{-05}	5.59x 10^{-05}	6.02x 10^{-05}	5.43x 10^{-05}	4.64x 10^{-05}	5.65x 10^{-05}	1.28x 10^{-04}
2	Equivalent Elastic Strain (Von Misses Strain) (in/in)	3.97x 10^{-05}	9.99x 10^{-05}	1.1x 10^{-04}	9.89x 10^{-05}	9.43x 10^{-05}	1.19x 10^{-04}	1.25x 10^{-04}	1.0x 10^{-04}	1.19x 10^{-04}	1.07x 10^{-04}	1.13x 10^{-04}	1.43x 10^{-04}
3	Equivalent Stress (Von Misses) Stress (psi)	1745	1100	1206	1076	1026	1293	1359	1202	1294	1170	1219	1541
4	Mass (lbm)	0.26	0.39	0.26	0.42	0.46	0.33	0.29	0.30	0.29	0.35	0.36	0.28

% Difference Relative to Beryllium I-220H													
		Baseline		TPMS Gyroid Configurations								Graph config.	
	Mechanical Characteristics	Beryllium I-220H Grade 2	Aluminium 6061RAM2 (Solid)	Al RAM2- TPMS Lattice	AlRAM2 – TPMS Lattice (Ramped)-00	Al RAM2- TPMS Lattice (Ramped)-01	Al RAM2- TPMS Lattice (Ramped)-02	Al RAM2- TPMS Lattice (Ramped)-03	AlRAM2- TPMS Lattice (Ramped)-03.1	Al RAM2 – TPMS Lattice (Ramped)-03.2	Al RAM2- TPMS Lattice (Ramped)-04	Octet-Graph (Ramped)-OS	Al Ram 2 – IsoTruss Lattice (No Ramp)
1	Equivalent Elastic Strain (Von Misses Strain) (in/in)	0	151%	179%	149%	137%	199%	214%	177%	199%	169%	185%	259%
2	Equivalent Stress (Von Misses) Stress (psi)	0	-37%	-31%	-38%	-41%	-26%	-22%	-31%	-26%	-33%	-30%	-12%
3	Mass (lbm)	0	48%	-2%	59%	75%	26%	10%	14%	10%	33%	37%	7%
4	Total Deformation (in)	0%	185%	531%	292%	322%	294%	259%	287%	249%	198%	262%	723%

Table 1 Results of DOE study for each lattice network, and the % difference relative to beryllium (Courtesy nTop)

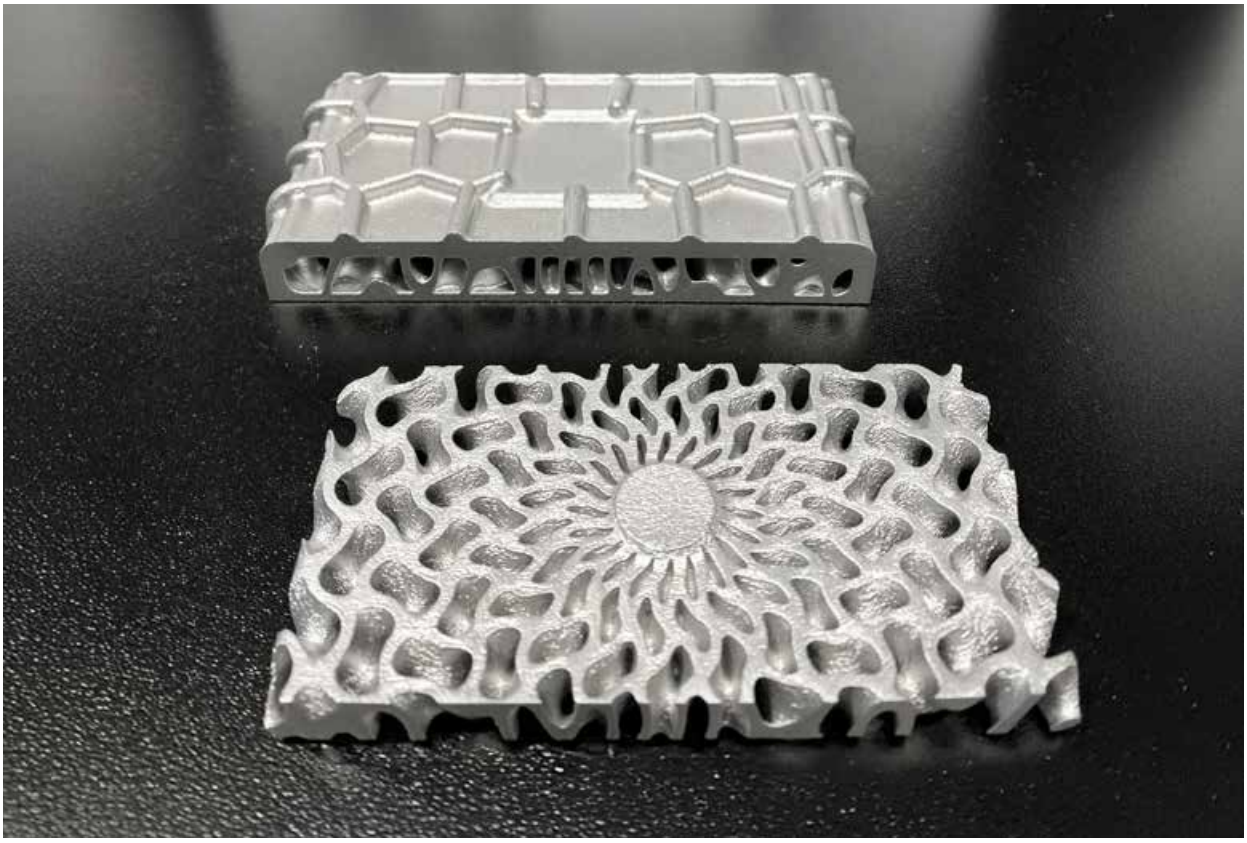

Fig. 8 Final additvely manufactured components showing internal lattice structure and complete part (Courtesy nTop)

the top, and they print really well," Souk stated. "We were able to define the features of the lattice without any issues, with clear separation in strut thickness between the two boundary layers. The final part was fabricated at NASA's Wallops Flight Facility in Virginia in nine days at a total cost of $1,200."

Compare those numbers to the beryllium part, which requires a thirty-six-week lead time and costs $20,000. "Ultimately, we were able to construct a lattice, optimise it, reduce our lead time by 36x and our cost by 20x," Souk stated. "The aluminium part outperformed beryllium in terms of internal stress with an acceptable mass penalty and within a micron of performance. That's a huge win for latticing.

"The fact that AM aluminium macroscopic mechanical meta-materials can compete with materials like beryllium could have significant follow-on effects at NASA.

"The applications for this have exploded. We have created a new unit cell that outperforms wrought aluminium for avionic packaging. There is another candidate in process for structural acoustics. Macroscopic mechanical metamaterials and nTop are also assisting in exciting research in the space of multi-material manufacturing under Russel Stein at NASA GSFC Code 543: Mechanical Systems Division," Souk explained.

"We've been using nTop for a little over a year and we're already submitting to a scientific journal, we have pre-patent applications, and a part that is currently being qualified for flight on a spacecraft," Souk concluded.

"The aluminium part outperformed beryllium in terms of internal stress with an acceptable mass penalty and within a micron of performance. That's a huge win for latticing."

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The Additive Manufacturing of record-breaking pure copper heatsinks for high-performance computing applications

As high-performance computing (HPC) and Artificial Intelligence (AI) applications drive demand for more powerful processors, thermal management has become a critical challenge. This article explores the development of a generatively-designed and additively manufactured liquid nitrogen (LN_2) heatsink, created by 3D Systems and Diabatix in collaboration with SkatterBencher and ElmorLabs, that achieves groundbreaking cooling performance. Thanks to Additive Manufacturing, the resulting pure copper heatsink promises to open up new markets for the technology in this rapidly growing market.

As the limits of computing power are continuously pushed in high-performance computing (HPC), effective cooling solutions have become increasingly crucial. The ability to keep processors cool during operation is one of the most critical factors for achieving peak performance and maximising equipment longevity. High-end graphics processing unit (GPU) clusters and Artificial Intelligence (AI) computing installations are often used in research environments and, at large scale, they are considered capital equipment, with maintenance and performance closely monitored.

Outside of large-scale installations, enthusiasts and professionals in the overclocking community constantly search for ways to extract every bit of performance from their hardware, pushing central processing units (CPUs) beyond their intended specifications. Overclocking increases clock speeds and power consumption, leading to significantly higher thermal loads that demand more advanced cooling solutions.

Additive Manufacturing and generative design have enabled the creation of the world's most powerful metal additively manufactured liquid nitrogen (LN_2) heatsink for extreme CPU cooling. This groundbreaking innovation was developed in response to a request from the renowned overclocking experts at SkatterBencher and ElmorLabs.

Through this innovation, a new benchmark has been set in thermal management, and it demonstrates capability at the intersection of

Fig. 1 Cross-section of liquid nitrogen (LN_2) heatsink for extreme CPU cooling (Courtesy 3D Systems/Diabatix)

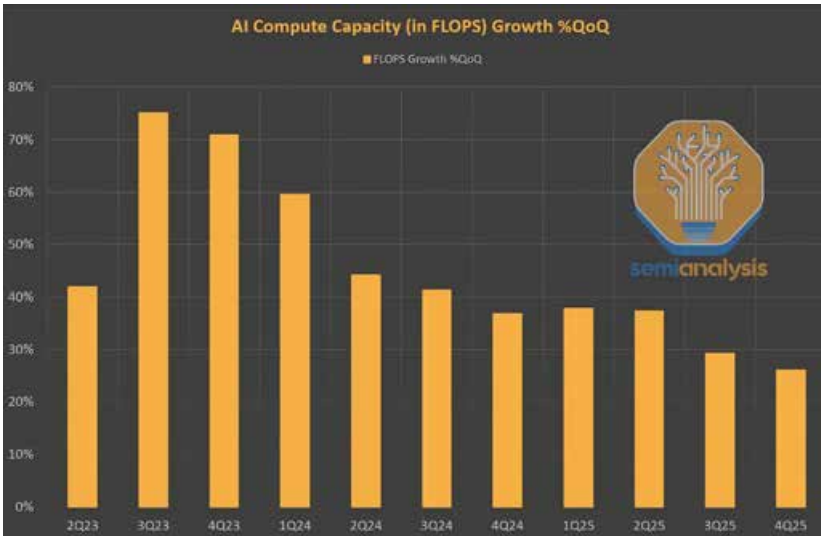

Fig. 2 The growth of AI computing capacity in FLOPS (Floating Point Operations Per Second, a measure of computing performance), as a percentage, quarter-on-quarter (Courtesy www.semianalysis.com)

"The high-performance CPU market is highly established, with transistor counts steadily increasing in line with Moore's Law, while the thermal footprint of a CPU is now growing slowly after years of rising thermal design power (TDP). In contrast, the GPU computer market is technically advanced but, by design, allows for greater space, density, and overall hardware footprint..."

generative design software, advanced manufacturing, and materials science. This solution – or variants of it – can be applied to large-scale HPC applications using standard cooling fluids.

Background on the use cases

Though the average consumer may never require one, most of us are familiar with the fact that high-performance workstation PCs and scientific computing data centres are commonplace in engineering disciplines for various purposes including 3D modelling, numerical simulation, and 3D rendering, among many other applications. In these applications, power and thermal requirements significantly differ from the average consumer ultraportable, low-power email and web browsing machines.

Furthermore, in industrial data processing applications, and data centre and hosting applications, the need for large-scale rack-based computing systems creates a complex system of networking, storage, redundancy, power supply, and of course thermal solutions to manage the heat coming from hundreds or thousands of high-performance computing modules in one place.

The power density of data centres has been steadily increasing over the past decade, and this trend is expected to accelerate further. In 2017, the average power density per server rack was approximately 5 kW, but projections suggest that within just a few years this density will reach 100 kW or more per rack.

This increase in power density is a response to the growing demands of HPC and AI. It's also forcing operators to reevaluate their cooling methods, as air cooling is no longer feasible in these power-dense environments. High-performance, specialised AI computing hardware is a fast-moving technical field with many of the usual chip makers entering the market to take part in a sector created by leaders such as Nvidia.

The high-performance CPU market is highly established, with transistor counts steadily increasing in line with Moore's Law, while the thermal footprint of a CPU is now growing slowly after years of rising thermal design power (TDP). In contrast, the GPU computer market is technically advanced but, by design, allows for greater space, density, and overall hardware footprint, enabling a more complex subsystem. This architectural flexibility supports growth and innovation that significantly outpaces Moore's Law.

New hardware domains – such as the tensor processing unit (TPU) and quantum processing unit (QPU) – are emerging and are expected to follow a similar technical development path to that of CPUs and GPUs, but at an accelerated pace. Furthermore, by 2025, annual spending on data centres to support AI applications is projected to reach $200 billion [1], marking a significant expansion over current global investment levels.

There is an associated issue with all this computing growth: where will all the power come from? With new, large-scale, power-hungry data centres rapidly emerging over

the next two to three years, there will be a significant strain on the power generation capabilities of regional infrastructure. The challenge of modernising the power grid, embracing green energy, and addressing the climate impact of all this is inseparable from the growth of computing technology.

The record-breaking CPU cooling application featured in this article is an important example of what can be achieved by generative 3D modelling and Additive Manufacturing for high-performance computing applications. However, for the majority of the consumer or engineering workstation market, this concept, combined with LN_2 cooling, remains largely unobtainable and cost-prohibitive. Nonetheless, the demonstration is a strong indicator of thermal management capabilities that, with further development, could become viable for high-power density applications, such as those mentioned above.

"By leveraging the unique, two-phase generative design capabilities of Diabatix's ColdStream platform, the engineering team has generated a heatsink that redefines the thermal performance of liquid nitrogen cooling."

From concept to design

Extreme CPU cooling using LN_2 is becoming the standard for computer overclocking enthusiasts as it allows for extremely low temperatures that are required to enable the desired extreme clock speeds. By leveraging the unique, two-phase generative design capabilities of Diabatix's ColdStream platform, the engineering team has generated a heatsink that redefines the thermal performance of liquid nitrogen cooling. Two-phase cooling has particular advantages over single-phase cooling, which allow it to reach much higher heat transfer rates, making it an ideal choice for extreme CPU cooling.

Single-phase cooling

Single-phase cooling relies on heat transfer through air or a liquid coolant, such as water or oil, which remains in its liquid state throughout the entire process. Heat is transferred from a hot surface to the coolant by convection, which then transports the heat away from the heat source. This type of cooling is relatively simple to implement and, consequently, is widely used in many systems. Yet, it is limited by many factors, such as the coolant's ability to absorb energy without heating up too much and the convective heat transfer coefficient values that can be reached at the solid-coolant interface.

Two-phase cooling

Two-phase cooling operates on a much more advanced principle by leveraging a phase change in the coolant. When a liquid coolant absorbs heat, it will change phase into a gas when it reaches the boiling temperature and heat continues to be added. The phase change allows the coolant to use the added heat as the latent energy required to evaporate the coolant. As a result, during the evaporating process, the coolant temperature remains constant and much more heat per unit of mass compared to single-phase cooling can be absorbed.

Due to the highly turbulent nature of the evaporation process, the convective heat transfer coefficients achieved at the solid-coolant interface can readily be an order of magnitude greater than those in single-phase cooling. This makes it highly attractive for high-power applications like data centres or power electronics. Once the liquid-gas mixture has carried the heat away, it is condensed back into a liquid, allowing the cycle to repeat. Because of the complexity of the phase change in both the evaporator and the condenser, this type of cooling is challenging to design using traditional design methodologies.

The Leidenfrost effect

In addition, a key factor in two-phase cooling that must be accounted for during the design process is the Leidenfrost Effect; a phenomenon where a liquid, upon coming into contact with a surface significantly hotter than its boiling point, creates a vapour layer that separates the liquid from the surface. This effect can completely nullify the effectiveness of two-phase heat transfer when it occurs, as the vapour layer acts as an insulating barrier and can effectively damage both the heat sink and the heat source. It is therefore crucial that two-phase heat sinks are designed in such a way as to prevent the Leidenfrost Effect during all operating modes.

The traditional design workflow for two-phase heat sink design is dominated by trial and error. A designer draws a cooling design, which can be tested against the specifications through either expert simulation software or prototype and practical testing. As with many other examples, when this design approach is applied to extreme CPU cooling, it results in a lengthy and costly process that demands multiple levels of expertise.

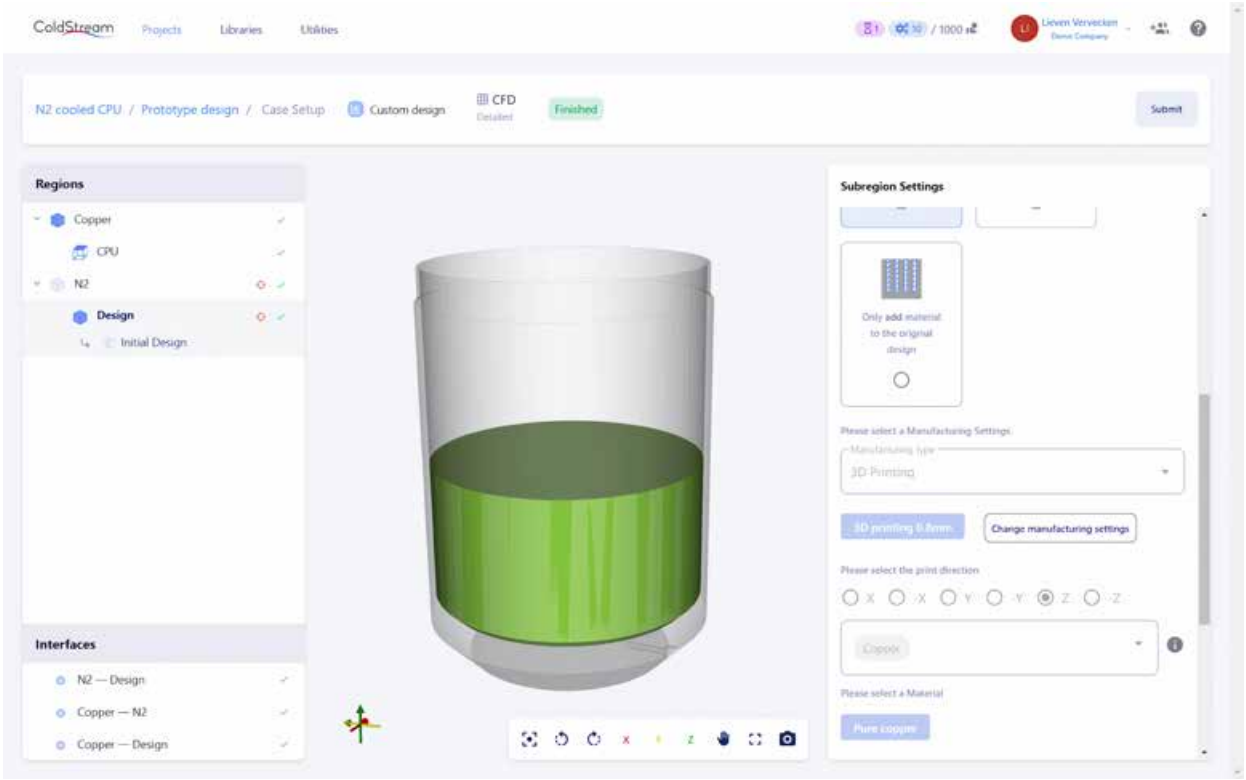

Fig. 3 ColdStream interface in case setup mode (Courtesy 3D Systems/Diabatix)

"By making use of physical modelling, massive computational resources, and state-of-the-art optimisation and artificial intelligence techniques, generative design can overcome the limitations of a traditional trial-and-error approach."

With the recent innovations by Diabatix in the field of two-phase coolant modelling, this trial-and-error process can be replaced by a highly effective generative design approach. This is an automated design process that requires minimal human input and interaction to achieve highly optimised designs that meet the functional requirements. By making use of physical modelling, massive computational resources, and state-of-the-art optimisation and artificial intelligence techniques, generative design can overcome the limitations of a traditional trial-and-error approach.

The simultaneous consideration of physics, design constraints, and manufacturing constraints is reduced to a few simple steps to formulate the input, with a generative design engine handling the rest. The starting point for generative design is not a best guess, but simply a description of the design target, an indication of the available design space, and a set of design limitations such as manufacturing constraints. When using generative design software, engineers are no longer designers in a committee, but they become managers of their own virtual design team.

The generative design input therefore reduces to the following five steps after which the process can start:

Create a CAD file
Create a CAD of the base geometry of the heat sink (in this case study the cylindrical container) and indicate the design space, i.e. the part of the volume that can be modified by the generative design engine.

Define material properties
Set the material properties to the desired copper alloy and LN_2 properties.

Set the operating and boundary conditions
Set the operating conditions and boundary conditions so that the design is optimised for the desired CPU power and operates at the saturation point.

Specify the manufacturing process
Specify the desired manufacturing method. For this case study, we apply the (PBF-LB) process using 3D Systems' DMP Flex 350.

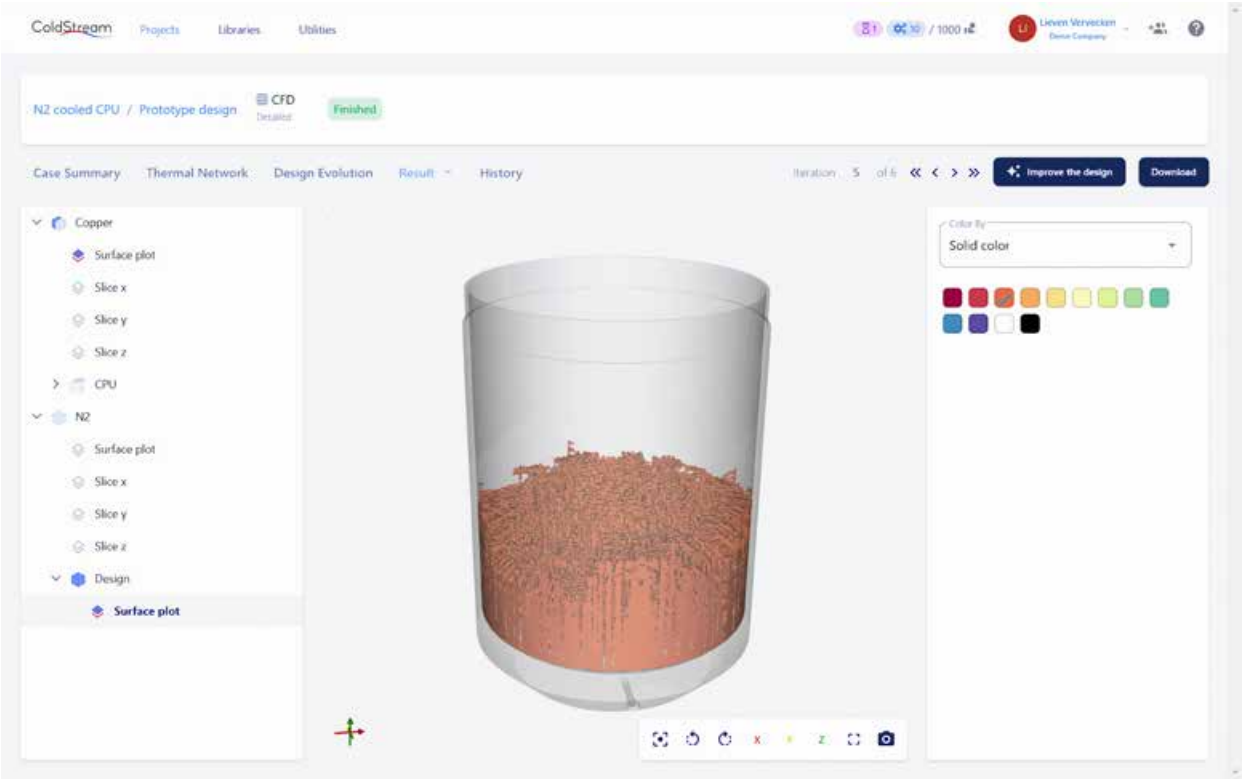

Fig. 4 ColdStream interface displaying the generated design for the LN_2 container (Courtesy 3D Systems/Diabatix)

Indicate the design targets

Indicate the design targets so that the process knows how to evaluate the performance of a design. This includes specifying the objective (in the case of CPU cooling, a minimisation of the temperature is typically a good choice) and constraints such as weight constraint.

Key to this entire process is having a highly accurate physical model that describes the heat transfer from the CPU to the liquid nitrogen. By leveraging advanced two-phase Navier-Stokes equations in a conjugate heat transfer modelling context, ColdStream can deliver the required level of physical accuracy and efficiently handle phase change phenomena within the fluid flow. Furthermore, by incorporating both liquid and vapour phases in its calculations, ColdStream models the complex dynamics of boiling processes, including heat transfer and flow instabilities, while also automatically preventing undesired effects such as the Leidenfrost Effect.

Since no step in the process requires human intervention, the generative design approach eliminates human bias when transitioning from concept to manufacturing-ready design. While traditional design methods rely heavily on the engineer's experience and intuition, which can inadvertently limit innovation, this limitation is removed with generative design. As a result, it has the potential to identify the optimal placement of material within the design space, which may not be immediately apparent or even counter-intuitive to human designers.

In practice, design engineers do not need to concern themselves with the complexity of physical modelling, as this is fully integrated into the process. Additionally, there are hardly any limits when it comes to model dimensions, operating conditions, or CPU powers. Instead, the simplicity of the process and the minimal input required ensure a high-quality user experience through an intuitive, easy-to-use interface (Fig. 4).

"...there are hardly any limits when it comes to model dimensions, operating conditions, or CPU powers. Instead, the simplicity of the process and the minimal input required ensure a high-quality user experience through an intuitive, easy-to-use interface."

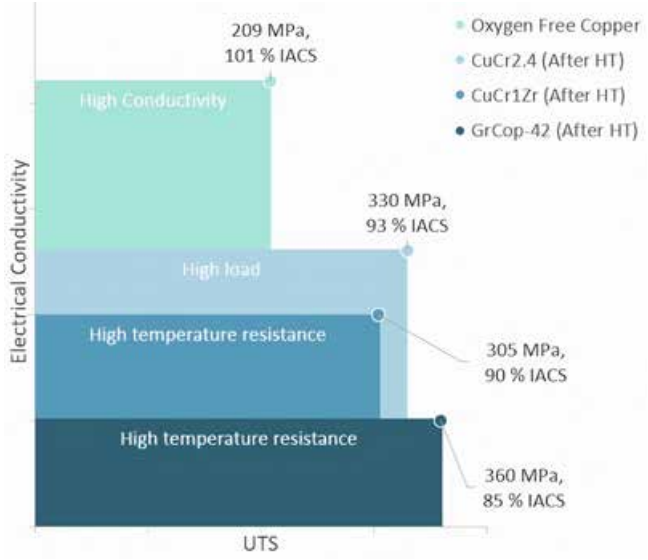

Fig. 5 Overview of relative conductivity versus ultimate tensile strength of various copper alloys. IACS (International Annealed Copper Standard) is an empirically derived standard value for the electrical conductivity of commercially available copper (Courtesy 3D Systems/Diabatix)

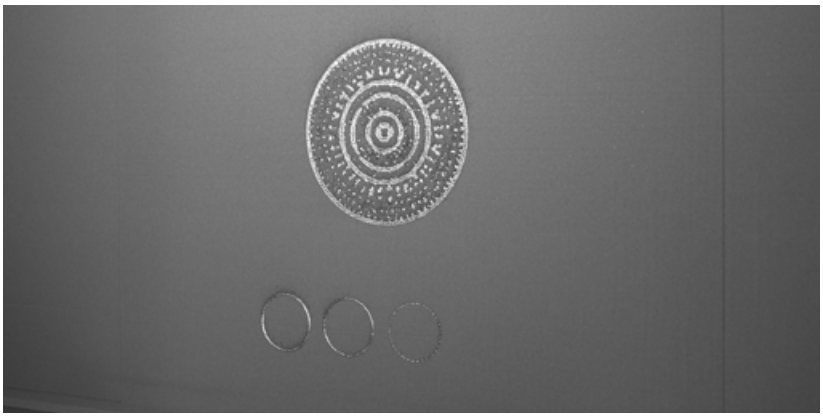

Fig. 6 Image of heatsink manufacturing in process on the DMP PBF-LB machine (Courtesy 3D Systems/Diabatix)

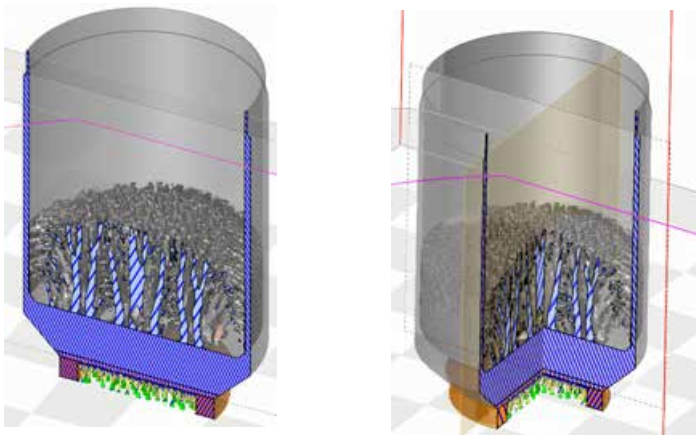

Fig. 7 Images of the cooler in 3DXpert (Courtesy 3D Systems/Diabatix)

Production

This new cooling solution was manufactured utilising certified oxygen-free copper powder for superior thermal conductivity of 390 W/mK. This approach allows for geometries that traditional manufacturing methods cannot achieve to produce components optimised for performance (Fig. 5).

Maintaining the purity of the copper powder during the build is of utmost importance as any oxygen in the copper matrix has a detrimental effect on its thermal conductivity. 3D Systems' vacuum chamber concept allows for a vacuum pre-cycle before the build job which actively removes air and moisture from the build chamber and the powder. After this cycle, the chamber is filled with high-purity argon gas.

This highly efficient and effective vacuum pre-cycle helps to achieve an extremely low oxygen environment. Furthermore, the vacuum chamber's leak-tight design ensures that no oxygen can enter the build chamber, resulting in exceptionally low argon consumption during the build. This vacuum chamber concept helps to eliminate the risk of oxygen contamination in the powder feedstock, leading to stable powder chemistry and a significant improvement in the reusability of the certified oxygen-free copper powder batch.

Not only does this manufacturing process enable the above benefits, but it also provides the capability to manufacture parts with measured thermal conductivity which exceeds the measured values of parts made with other machines and the same powder.

Initial physical testing

Following its development, the LN_2 heatsink underwent initial physical testing by ElmorLabs to validate its performance. The detailed initial evaluation confirms the predicted heatsink's exceptional cooling capabilities. In particular, the 3x faster cooldown behaviour compared to

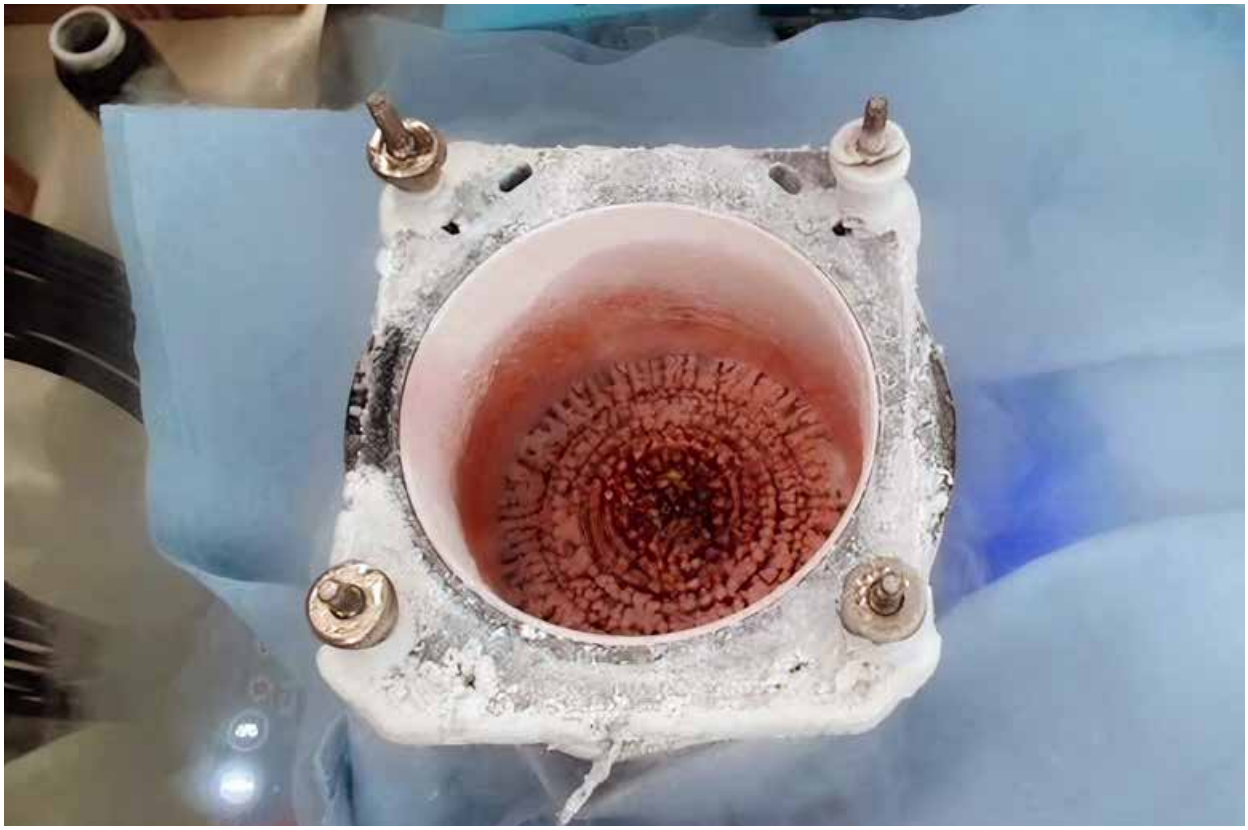

Fig. 8 Physical testing setup (Courtesy 3D Systems/Diabatix)

the Volcano LN_2 cooler, one of the top products in the market today, stood out during testing. Because the AI design and the Volcano have an identical mass of 1.7 kg and both use copper as the base material, this difference can only come from improved heat transfer at the surface and/or better heat transport inside the copper.

The tests demonstrated that the LN_2 container can easily handle a processor such as the Core i9-14900 KF with P-cores clocked up to 7.5 GHz, consuming 600 W of power. With a heatsink base temperature difference of 11°C compared to the Volcano LN_2 cooler, compared to a total heat up of only 9°C, the AI design proves to have the potential to carry more than twice as much power for the same base temperature. Therefore, the AI design passes the tests with flying colours with a huge margin left on reaching higher powers.

From the test data, the expected extraordinary thermal resistance of 0.011 kW was confirmed. That is only a 1.1°C temperature difference between the heatsink base and the liquid nitrogen per 100 W of CPU power, positioning it as one of the most powerful heatsinks in the world.

Further analysis revealed that this is only possible to achieve through an approximately +60% improvement of the heat transfer coefficient at the copper-LN_2 interface. It is clear that this leap in performance gain is only possible through, and is a direct result of, the power of thermal generative design.

Conclusion

The AI-designed LN_2 cooler demonstrated exceptional thermal performance, withstanding 600 W power at 7.5 GHz and achieving a thermal resistance of just 0.011 kW. Its optimised heat transfer coefficient at the copper-LN_2 interface allowed for a +60% efficiency gain over conventional designs. These results affirm that thermal generative design

Fig. 9 Demonstrating the results (Courtesy 3D Systems/Diabatix)

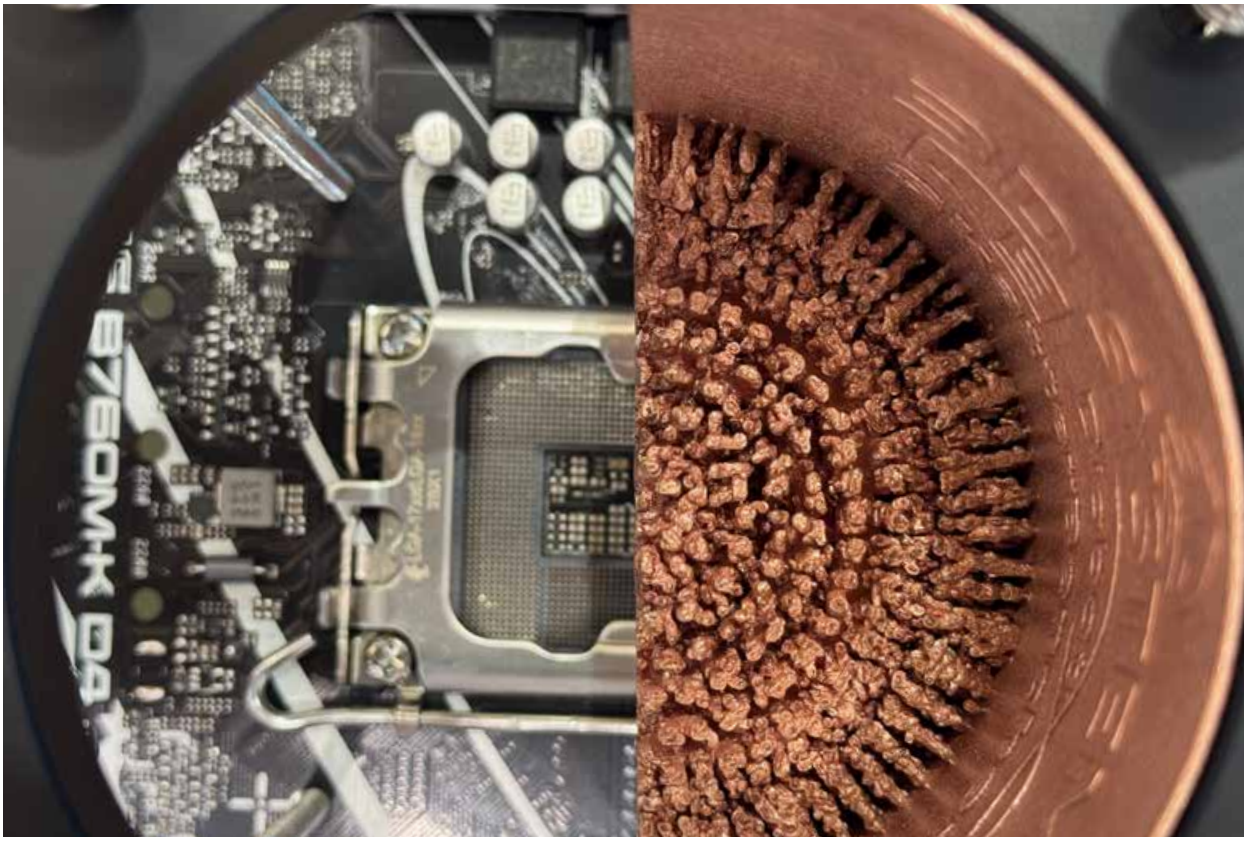

Fig. 10 Image of a cutaway AM heatsink in a demonstration application

can surpass traditional cooling limits, positioning this heatsink among the world's most powerful.

This pioneering project was initiated at the request of SkatterBencher and ElmorLabs, both leading authorities in the overclocking community. Their expertise and insights were instrumental in guiding the development process. Their ambition aligns very well with our commitment to pushing the boundaries of what is possible in thermal management. The current design is only the starting point of the collaboration. While preparing the supply chain for the commercialisation of the product, we are already preparing additional variants. At the top of the target list is to go beyond the 2,000 W mark in physical tests.

"The current design is only the starting point of the collaboration. While preparing the supply chain for the commercialisation of the product, we are already preparing additional variants. At the top of the target list is to go beyond the 2,000 W mark in physical tests."

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The Additive Manufacturing of tool steels: how non-linear modelling enables precise hardness control

Vibenite® steels are the hardest additively manufactured tool steels available today. Parts made of Vibenite materials are produced by Electron Beam Powder Bed Fusion (PBF-EB) Additive Manufacturing, followed by heat treatments that include Hot Isostatic Pressing (HIP), hardening and tempering. This combination enables the efficient production of wear-resistant parts that do not require cutting or welding and are impossible to produce via conventional processes. In this article, the authors explain how they have combined AM processing with HIP and hardening treatments optimised using non-linear models to control hardness.

There are numerous applications for very hard materials. These are used where parts undergo significant wear, and many such parts are produced by machining and welding. However, Additive Manufacturing has, in many cases, become a feasible alternative, particularly when part sizes are not overly large, and there is a need for shape complexity. The Vibenite® family of materials has made it possible to reduce wear on such parts by providing a much higher level of hardness whilst leveraging the shape freedoms associated with AM. Users, however, still have differing demands with regard to hardness, and, therefore, it was determined that there was a need to create a tool to select and control the hardness after heat treatment.

Vibenite materials, developed by VBN Components, Sweden, represent a significant advancement in the field of metallurgy, particularly in the production of high-performance steel alloys and hybrid carbides. Readers of this magazine will probably be familiar with Vibenite steels and the development of new materials for processing by PBF-EB [1]. Notably, Vibenite 290 is recognised as one of the hardest commercially available steels, achieving an impressive Rockwell hardness of 76 HRc (about 1250 HV).

The remarkable hardness of Vibenite materials is a result of a unique combination of alloying elements and advanced manufacturing processes, resulting in excellent microstructures as seen in Fig. 2, thus positioning Vibenite steels as a premier choice

Fig. 1 A shaper cutter blank in Vibenite 290, 76 HRc (upper left); hand-held knife blank in Vibenite 290, 73 HRc (upper right); food extruder in Vibenite 280, 63 HRc (lower left); complex shaped blasting nozzle in Vibenite 280, 70 HRc (lower right) (Courtesy VBN Components)

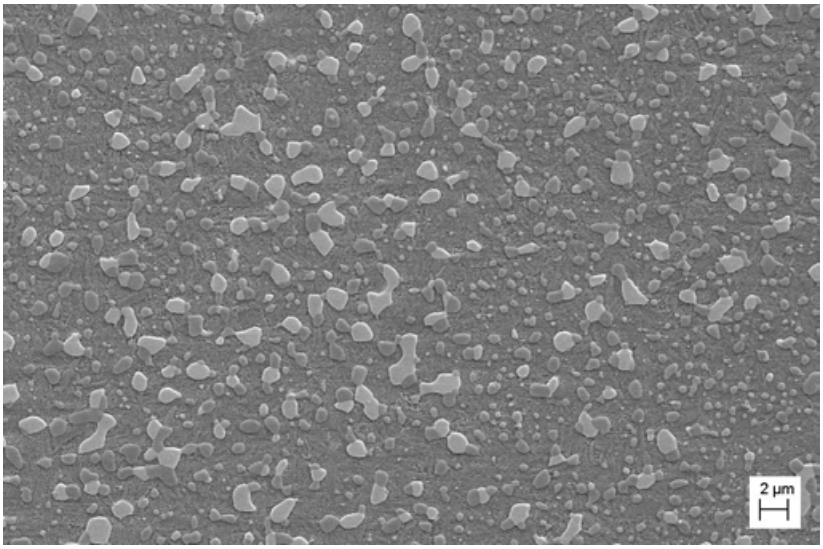

Fig. 2 The microstructure of additively manufactured Vibenite 280 consists of about 20 vol.% of carbides in a martensitic matrix which is ideal to achieve a very high hardness for the highest wear resistance (Courtesy VBN Components)

for applications requiring exceptional wear resistance and durability. In this article, Vibenite 280 (slightly less alloyed than Vibenite 290) has been used for the HIP + heat treatment modelling study.

Mechanical properties

The mechanical properties of Vibenite materials are characterised by:

High hardness
With a Rockwell hardness rating of 76 HRc, Vibenite 290 is among the hardest steels available today. Additive Manufacturing brings many advantages over the difficulties associated with traditional bar forging and rolling and expensive machining.

Excellent wear resistance
The formation of hard carbides within the steel matrix significantly enhances its resistance to abrasion and wear.

Good toughness
Despite their high hardness, Vibenite steels maintain a level of toughness that makes them suitable for demanding applications without being overly brittle. The reasons are the fine microstructure and extremely low oxygen content.

"The exceptional hardness and wear resistance make Vibenite steels ideal for manufacturing metal cutting tools and power skiving cutters that require a fine microstructure (enabling sharp edges) and longevity."

Applications

Vibenite materials are utilised across various industries due to their superior properties. Key applications include:

Components exposed to erosive wear
Dry or wet erosion parts include rough pump impellers and complex-shaped blasting equipment, particle separation parts, and nozzles such as fuel injectors.

Components exposed to abrasive wear
Sliding bearing parts and wire drawing nozzles, preferably with cooling channels.

Fatigue exposed components
For several machine equipment parts, such as fatigue-exposed valves or bearing rings, precise hardness control with extremely low oxygen content is crucial.

Cutting tools
The exceptional hardness and wear resistance make Vibenite steels ideal for manufacturing metal cutting tools and power skiving cutters that require a fine microstructure (enabling sharp edges) and longevity.

Knives
Used in environments where durability and edge retention are critical, such as food processing or packaging industries, but also hand knives.

Vibenite materials represent a significant leap forward in steel technology. With their exceptional hardness, excellent wear resistance, and good toughness, they have the potential to redefine standards in various industrial applications. As manufacturers continue to seek materials that can withstand extreme conditions while providing reliability and performance, they will likely play an increasingly vital role in meeting these challenges when processed by Additive Manufacturing.

The part manufacturing process

VBN Components uses what it calls the AM-HSS™ process to produce Vibenite parts. By carefully controlling the starting powder and the PBF-EB build process, a highly uniform distribution of alloying elements is achieved in each build, delivering the fine microstructures that contribute to overall performance. A tightly-controlled heat treatment process is then essential for achieving the desired hardness and microstructure. HIP, quenching and tempering processes optimise the balance between hardness, toughness and carbide formations.

What in the past used to be separate heat treatment processes have now been combined into a single piece of equipment, produced by Quintus (Fig. 3). A typical temperature profile during this processing stage is shown in Fig. 4. This paves the way towards much faster production with a lower environmental impact thanks to its reduced energy consumption.

Fig. 3 The HIP-URQ machine in which all heat treatment process steps can be done in one single cycle: preheating, Hot Isostatic Pressing, austenitising, quenching, and tempering (Courtesy VBN Components)

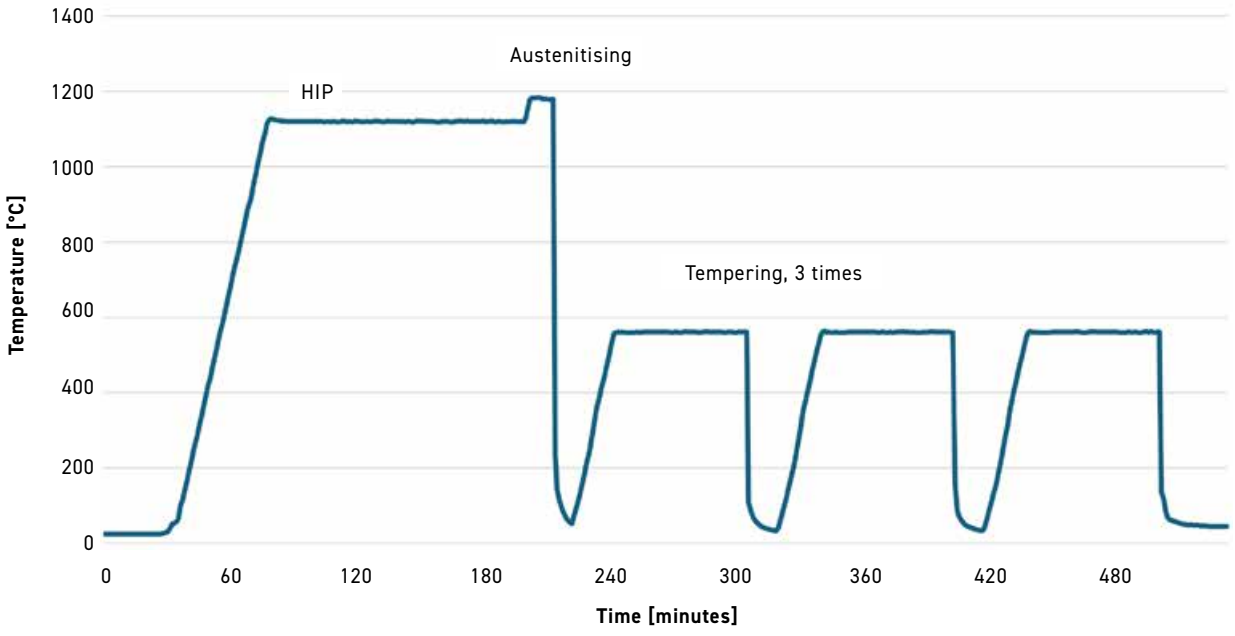

Fig. 4 Typical temperature profile over one cycle (Courtesy VBN Components)

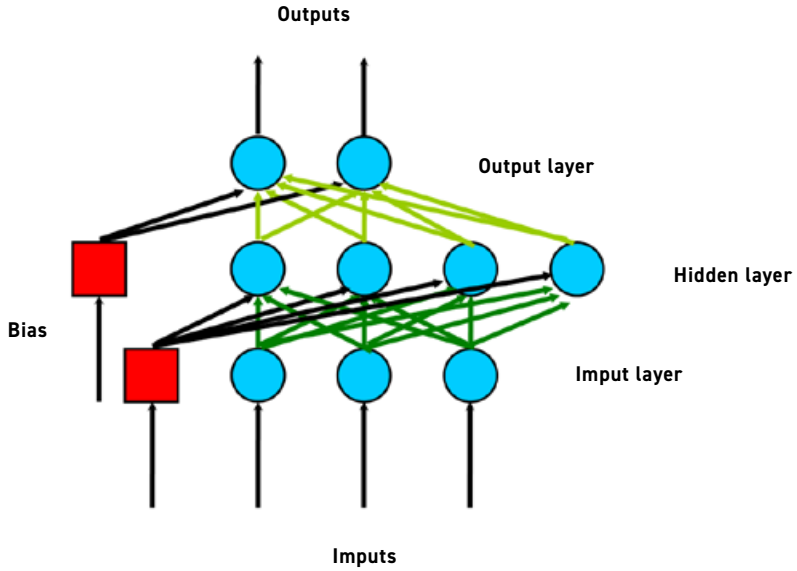

Fig. 5 A feed-forward neural network is often at the core of non-linear models (Courtesy VBN Components)

Non-linear modelling

There are hardly any processes in this world which are absolutely linear. It is, therefore, wise to address the non-linearities rather than ignore them. To treat the non-linearities, one can use new non-linear modelling solutions, such as artificial neural networks. Neural networks have the so-called universal approximation [2] capability, which makes them suitable for most of the function approximation tasks that we come across in process engineering and materials science.

Artificial neural networks consist of neurons in layers directionally connected to others in the adjacent layers (Fig. 5). There are many different types of neural networks, and some of them have practical uses in process industries [3]. The multilayer perceptron is a kind of a feed-forward neural network. Most neural network applications in industries [4-15] are based on them. The authors previously reported one application of neural networks in Powder Metallurgy [4].

The output of each neuron *i* in a feed-forward neural network is given by:

$$z_i = \sigma\left(\sum_{j=0}^{N} w_{ij} x_j\right)$$

where the activation function is usually the logistic sigmoid, given by

$$\sigma(a) = \frac{1}{1+e^{-a}}$$

The incoming signals to the neuron are x_j, and w_{ij} are the weights for each connection from the incoming signals to the i^{th} neuron from the j^{th} input. The w_{i0} terms are called biases. This results in a set of algebraic equations which relate the input variables to the output variables.

Non-linear models for Vibenite 280

There are always a large number of variables which influence the results of a process. Many of them have very small effects and do not generally contribute to the accuracy of the models unless a lot more detail is measured and becomes available in the data. Still, we have been able to utilise as many as seven variables in this case since dozens of careful, well-planned experiments have been carried out and recorded, along with hardness measurements.

In one of the non-linear models developed for Vibenite 280, these seven process variables were taken into account. They include total load in the equipment, wall thickness of the pieces, HIP temperature, HIP time, austenitising temperature, austenitising time and tempering temperature for a fixed tempering cycle (Fig. 6).

NLS 050 software was used to develop the models. Fig. 7 shows a plot of the measured hardness values against the values predicted by the non-linear model. The standard deviation of the prediction error is about 21 HV, which is comparable to the variation in the measurements from the same experiments. In other words, the repeatability of the experiments is about the same.

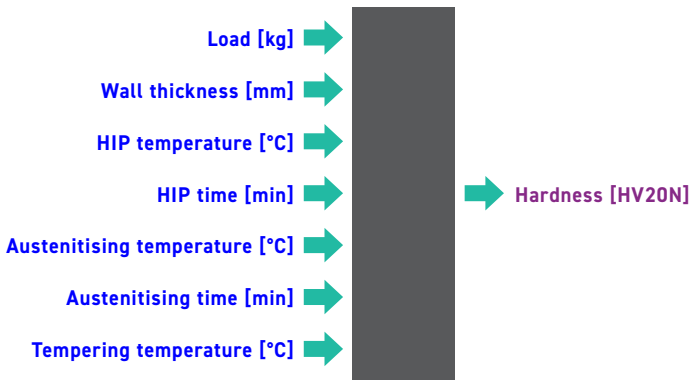

Fig. 6 A schematic diagram of the non-linear model for hardness of Vibenite 280 (Courtesy VBN Components)

Once the non-linear model was ready, it was implemented in software which would allow the users to calculate the hardness easily. Fig. 8 shows a screen from the LUMET system, a set of software components for easy use of non-linear models, which is in use by VBN Components. It shows a typical prediction calculation based on the non-linear model for hardness implemented in it.

It now becomes easy to see the effects of each of the independent variables. These effects, however, can vary with the values of other independent variables as well. Many such plots are made to see the interaction effects of pairs of variables. Sometimes, the effect of some variable may be positive at high values of some other variable but may become negative at low values of that second variable. These kinds of effects can be seen easily by plotting.

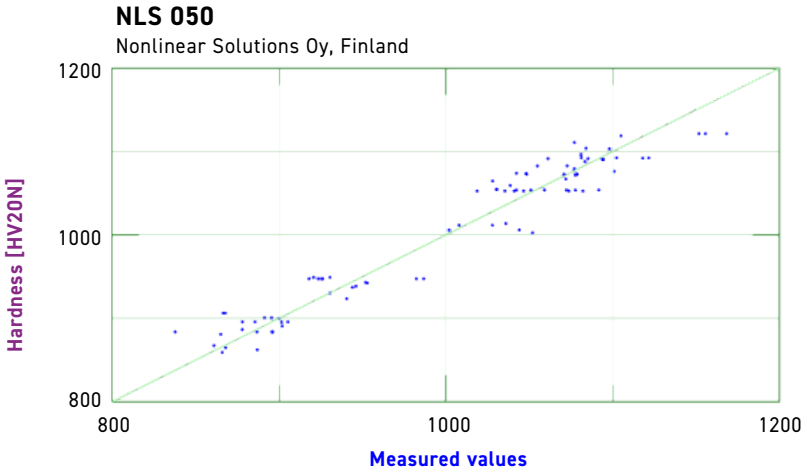

Fig. 7 A plot of measured values of hardness against the values predicted by the non-linear model (Courtesy VBN Components)

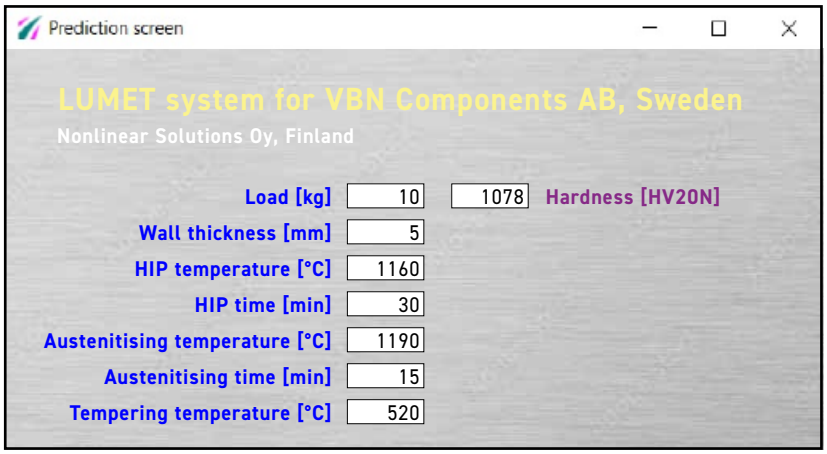

Fig. 8 The prediction screen of the LUMET system in use (Courtesy VBN Components)

Process development using non-linear models

One advantage of having process knowledge in the form of mathematical models is that it can also be utilised for optimisation. Maximising quality, production, and profitability are all optimisation problems. They usually come with two kinds of constraints: equalities and inequalities. All the process variables have to stay within operable limits, which are inequality constraints, and several results (such as product properties) of operating conditions, predicted by models, are equality or inequality constraints. In mathematical terms, these kind of optimisation problems are written as:

$$\text{maximise} \quad F(\boldsymbol{x}) \qquad \boldsymbol{x} \varepsilon \boldsymbol{R}^n$$

$$\text{subject to} \quad c_i(\boldsymbol{x}) = 0, \text{ for } i = 1 \text{ to } m$$
$$\text{and} \quad c_k(\boldsymbol{x}) \geqslant 0, \text{ for } k = 1 \text{ to } p$$

In process optimisation, the inequality constraints are usually the limits on process variables and possibly also product properties and are, therefore, simple inequalities in single variables. The problem can be rewritten more specifically as:

$$\text{maximise} \quad F(\boldsymbol{x}) \qquad \boldsymbol{x} \varepsilon \boldsymbol{R}^n$$

$$\text{subject to} \quad x_k \geqslant a_k, \text{ for } k = 1 \text{ to } n+n'$$
$$\text{and} \quad x_k \geqslant b_k, \text{ for } k = 1 \text{ to } n+n'$$

where n is the number of process variables. The $2n'$ constraints pertaining to product properties come from typically $n'+1$ product properties. It is, in principle, possible to maximise or minimise two or more variables at a time, but such multi-objective optimisation does not yield straightforward answers and is not used in practice. Many books, including [16], describe various solutions for this kind of optimisation problem in varying degrees of detail. Many of the solutions are based on gradient descent.

Making process optimisation accessible to metallurgists

It is good to have quantitative knowledge in the form of models, but it is important to be able to use that knowledge. As mentioned in the previous section, a variety of processes exist for optimisation, but metallurgists and materials scientists cannot be expected to be familiar with them. A software tool has therefore been developed which is easy

LUMET system
Nonlinear Solutions Oy, Finland

	minimum	maximum	answer
Load [kg]	15	15	15.0
Wall thickness [mm]	4	4	4.0
HIP temperature [°C]		1180	1180.0
HIP time [min]	30	90	30.0
Austenitising temperature [°C]	1050	1180	1180.0
Austenitising time [min]	10	20	10.0
Tempering temperature [°C]			480.0
Hardness [HV20N]	1080	1090	1083.35

Fig. 9 Determining process conditions for achieving a hardness of around 1085 HV (Courtesy VBN Components)

LUMET system
Nonlinear Solutions Oy, Finland

	minimum	maximum	answer
Load [kg]	15	15	15.0
Wall thickness [mm]	4	4	4.0
HIP temperature [°C]		1180	1180.0
HIP time [min]	30	90	30.0
Austenitising temperature [°C]	1050	1180	1180.0
Austenitising time [min]	10	20	10.0
Tempering temperature [°C]			560.0
Hardness [HV20N]	Maximum	found:	1171.087

Fig. 10 Determining process conditions for achieving the maximum hardness in the presence of the same constraints (Courtesy VBN Components)

"This software has, for some time, been part of the LUMET system. This brings this new technology to the 'fingertips' of metallurgists and materials scientists; they only need to know what they want to maximise or minimise and the limits on the variables."

for them to use without knowing the details of the methods used in it. This software has, for some time, been part of the LUMET system. This brings this new technology to the fingertips of metallurgists and materials scientists; they only need to know what they want to maximise or minimise and the limits on the variables.

Sometimes, one may only want to determine the process conditions that will result in the given product characteristics. This is essentially solving one equation in eight unknowns, which has, under normal circumstances, an infinite number of solutions. It is more practical and realistic to instead specify upper and lower acceptable limits on product properties, as shown in Fig. 9. The system finds one solution and presents it in the third column. The solution may not be realistic, in which case, one can specify more conditions and calculate again. It is, of course, possible to demand something impossible, in which case, the system tries to calculate the best compromise.

Fig. 9 shows a calculation of determining process conditions for achieving a hardness between 1080 HV and 1090 HV. If it is not necessarily a good solution, one can specify more constraints and calculate again. Alternatively, we can ask what the maximum hardness would be under the same constraints. Fig. 10 shows that the maximum hardness could be about 1171 HV if the process is operated with conditions in the third column. This can save large amounts of development effort and time.

Conclusions

Non-linear modelling using neural networks offers an effective approach to addressing complex challenges in process optimisation. By combining non-linear modelling with post-processing techniques such as HIP and heat treatment, it becomes possible to reduce process times while significantly improving material properties. This modelling approach

enables precise control over parameters to achieve specific outcomes, such as maximum hardness, without relying on extensive assumptions.

Additionally, non-linear models are capable of capturing the intricate interactions between composition, process, and dimensional variables – relationships that are often too complex for even highly experienced professionals to predict. When applied effectively, these models can optimise processes, enhance product quality, and reduce production costs with minimal effort, making them a valuable tool in advanced manufacturing.

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AM China 2025
March 10–12, Shanghai, China
www.amatex.cn

Fraunhofer Direct Digital Manufacturing Conference (DDMC 2025)
March 12–13, Berlin, Germany
www.ddmc-fraunhofer.de

AM Forum Berlin 2025
March 17–18, Berlin, Germany
www.am-forum.de

AMUG 2025
March 30–April 3, Chicago, IL, USA
www.amug.com

The 14th International Conference on Hot Isostatic Pressing (HIP 2025)
April 6–10, Aachen, Germany
www.hip2025.com

3rd European Military Additive Manufacturing Symposium
April 8–9, Bonn, Germany
veranstaltungen.dwt-sgw.de/?v=168

America Makes' Spring Technical Review & Exchange (TRX) with RAPID + TCT 2025
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www.americamakes.us/events/trx-spring/

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AMC Additive Manufacturing Conference
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www.amctr.org

rapid.tech3D Additive Manufacturing Con
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WAAmathon 2025 (Wire Arc Additive Manufacturing)
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6th International Symposium on Additive Manufacturing (ISAM 2025)
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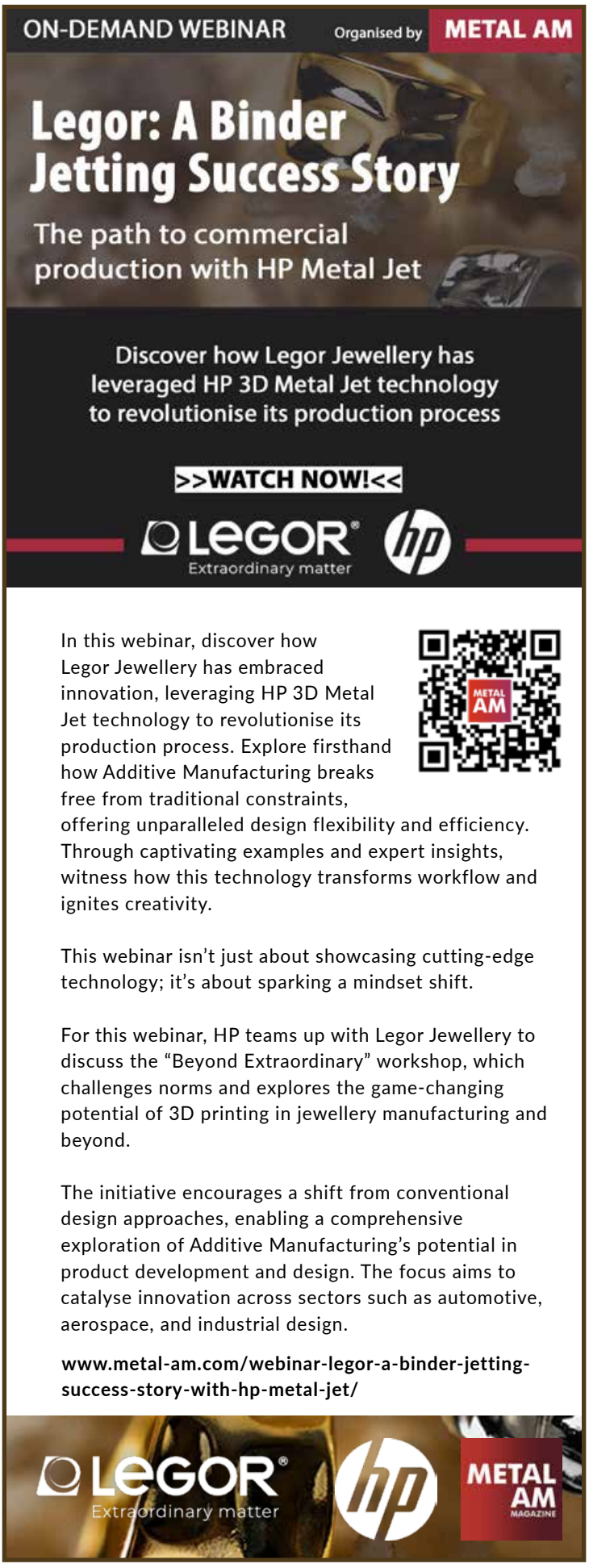

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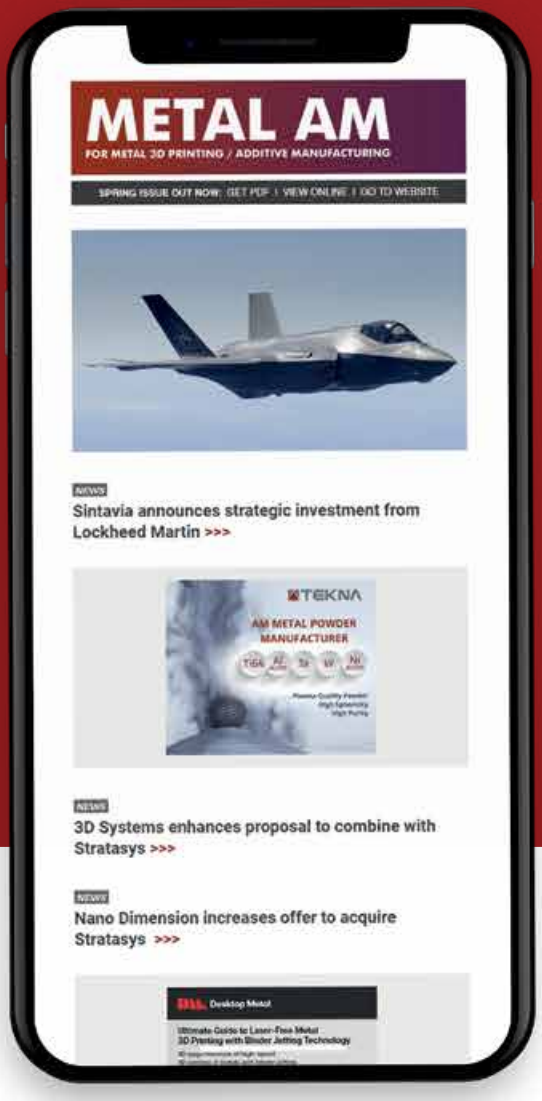

DDMC2025

Fraunhofer Direct Digital Manufacturing Conference

The Fraunhofer Direct Digital Manufacturing Conference DDMC 2025 is a bi-annual cutting-edge forum for discussion on Additive Manufacturing, which will take place from March 12 to 13, 2025 at the ParkInn by Radisson Berlin Alexanderplatz, located in the vibrant heart of Berlin, Germany.

Fascinating developments in additive manufacturing and 3D printing technology will be presented over two days at Fraunhofer DDMC 2025. Over 50 presentations by AM experts from industry and research will create an exciting program. In addition to AM technology development for metals, plastics and ceramics, the presentations will cover the topics of material innovations, process monitoring and artificial intelligence as well as sustainability. The traditional evening event in an attractive Berlin event location will take place on the evening of the first conference day and offers an excellent opportunity to make contacts, exchange experiences and develop new collaborations.

We are particularly pleased to once again welcome renowned experts in additive manufacturing from research and industry as keynote speakers to our conference - Prof. Bianca Colosimo (Politecnio di Milano, Italy), Prof. Wojciech Matusik (MIT, USA), Prof. Enrico Stoll (TU Berlin, Germany), Ben Hartkopp (Quantica GmbH, Germany) as well as Dr. Sebastian Piegert and Dr. Cynthia Wirth (Siemens Energy, Germany).

Please note that the conference is just three months away. Registration has just opened and we encourage you to take advantage of the early bird registration fees! We also encourage you to become a sponsor or exhibitor at DDMC 2025. Collect more info on our program, registration and sponsoring and exhibition opportunities on our website.

www.ddmc-fraunhofer.de

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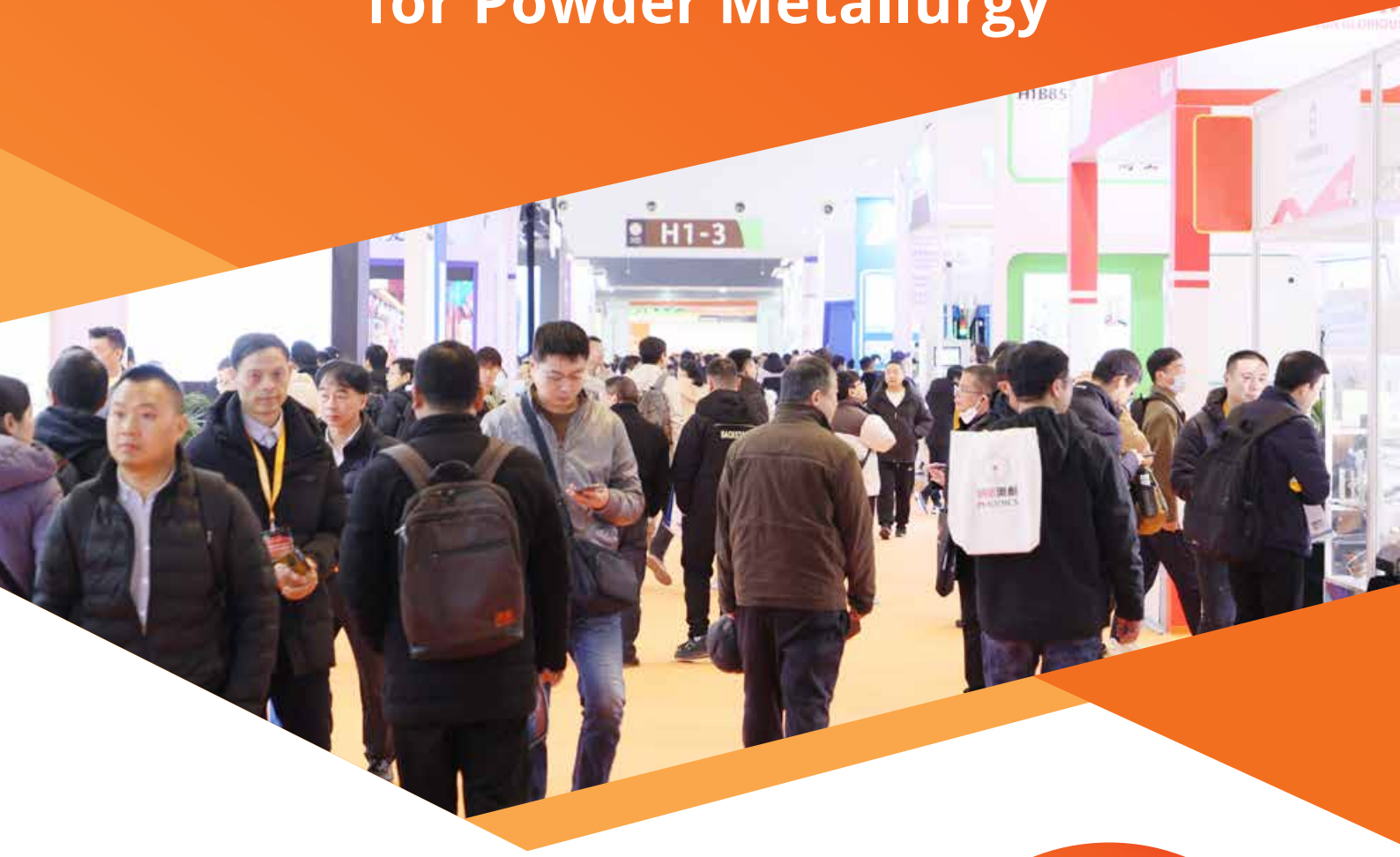

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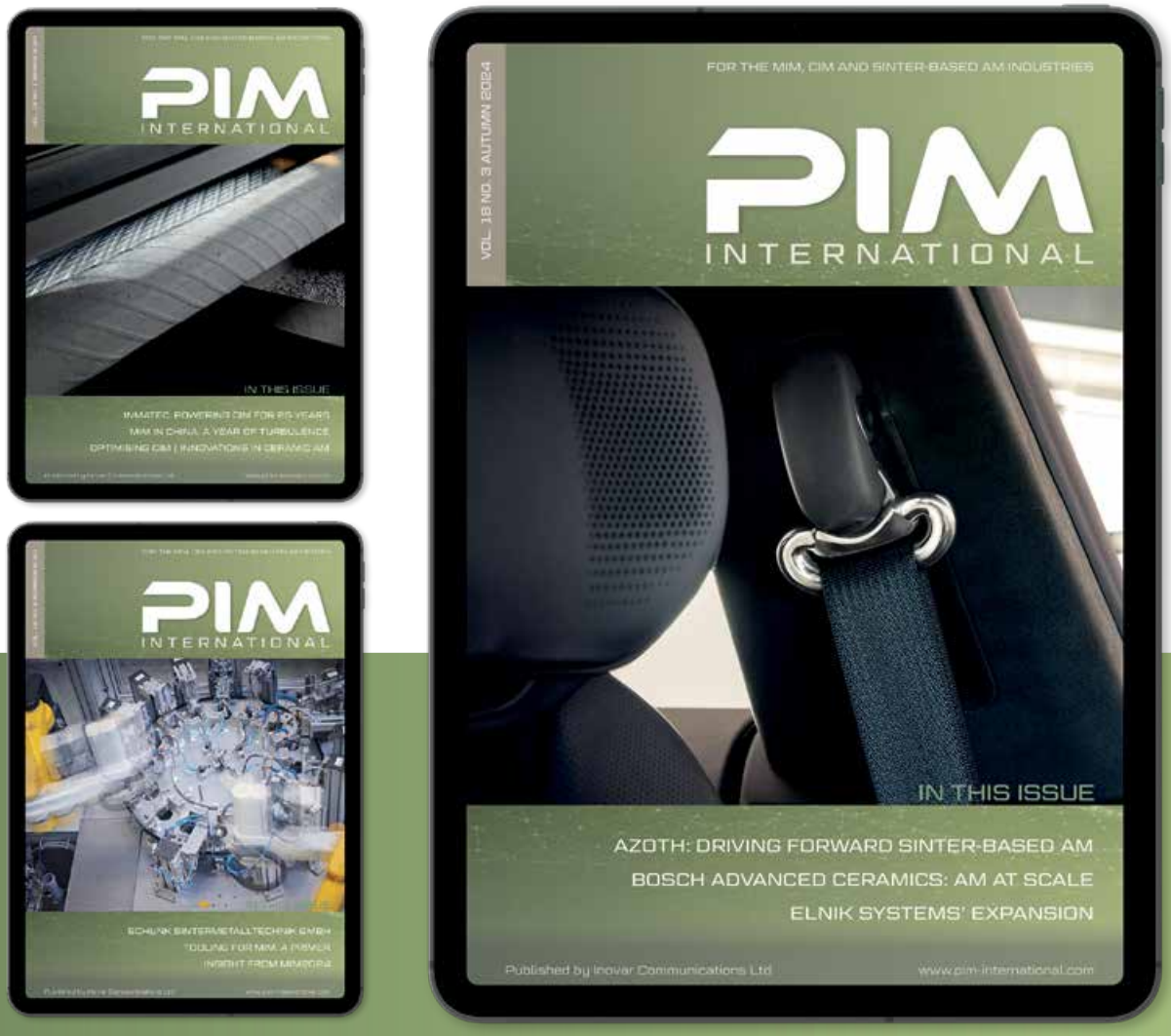

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