Issue 2 | 2020-21/Q4

AM CHRONICLE

3D Printing Voice of the Region

Asia Pacific | India | Middle East | Africa

FEATURE ARTICLE

NAMIC SG NATIONAL ADDITIVE MANUFACTURING INNOVATION CLUSTER

SINGAPORE DRIVING AM IN ASIA PACIFIC

MIDDLE EAST FOCUS

EXPLORING THE ORTHOTICS AND PROSTHETICS 3D PRINTING ECOSYSTEM IN UAE

OIL & GAS

A DIGITAL FUTURE FOR SPARE PART MANAGEMENT

INDIA FOCUS

METTLE FOR METAL, A FEARLESS VOYAGE: SRIDHAR BALARAM

PUBLISHER

CNT Expositions and Services LLP
126 A, Dhuruwadi,
A. V. Nagwekar Marg,
Prabhadevi, Mumbai - 400025,
Maharashtra, India.
Tel : +91 22 2430 6319
E-mail : editor@catnewtech.com
www.amchronicle.com

FOUNDERS

Dilip Raghavan
Aditya Chandavarkar

EDIT & DESIGN

Amol Thakur

ADVERTISING

Ankush Matai
+91 22 2430 6319
marketing@catnewtech.com

SUBSCRIPTION

The AM Chronicle Journal is a quarterly publication in the digital format (and in print format upon request). No charges are levied for subscription. However, this is subject to change at our discretion, without prior notice.

EDITORIAL

Shaping your AM Business

The last 18 months have been challenging to say at best across the world with disruptions in supply chains and the usual way of conducting business. The Additive Manufacturing (AM) industry has shown great amount of resilience in this period and has been at the forefront in supporting the medical industry to reduce the demand and supply gap on essential components.

In our interactions with the AM supply chain stakeholders and the end user community in the region including Asia, India, Middle East and Africa we clearly see a wider acceptance for AM and its applications. Singapore with its pro-AM policies and conducive environment has quickly become the hub for 3D Printing in the region. The UAE is also building a dedicated policy framework with the launch of the 3D Printing Strategic Alliance to bring the relevant stakeholders together with a focus on construction, healthcare and consumer applications.

In a positive development, The Ministry of Electronics and Information Technology (MeitY) in India has tabled a National Strategy for Additive Manufacturing and the first National Centre for Additive Manufacturing is being established in Hyderabad, Telangana in partnership with the Telangana Government.

AM Chronicle in these past few years has also evolved from being a mouth piece for our AMTech Expo to now a dedicated digital content platform and the 3D Printing Voice of the Region in APAC, India, Middle East and Africa.

To do justice to the breadth and depth to the developments of the Additive Manufacturing industry and the end user segments we felt the need to create a quarterly technical magazine – AM Chronicle Journal to compliment our online knowledge platform – amchronicle.com. This quarterly publication will be a dedicated thematic publication which will deep dive into developments, technical insights and market information from industry experts.

These are exciting times for the AM eco-system in the region with an upward growth curve and widespread acceptance across various industries ! With our various community building initiatives including AM Chronicle, AMTech Expo and Additive Academy we look forward to empower the Additive Manufacturing Industry in the Region.

Aditya Chandavarkar
Co-Founder - AM Chronicle

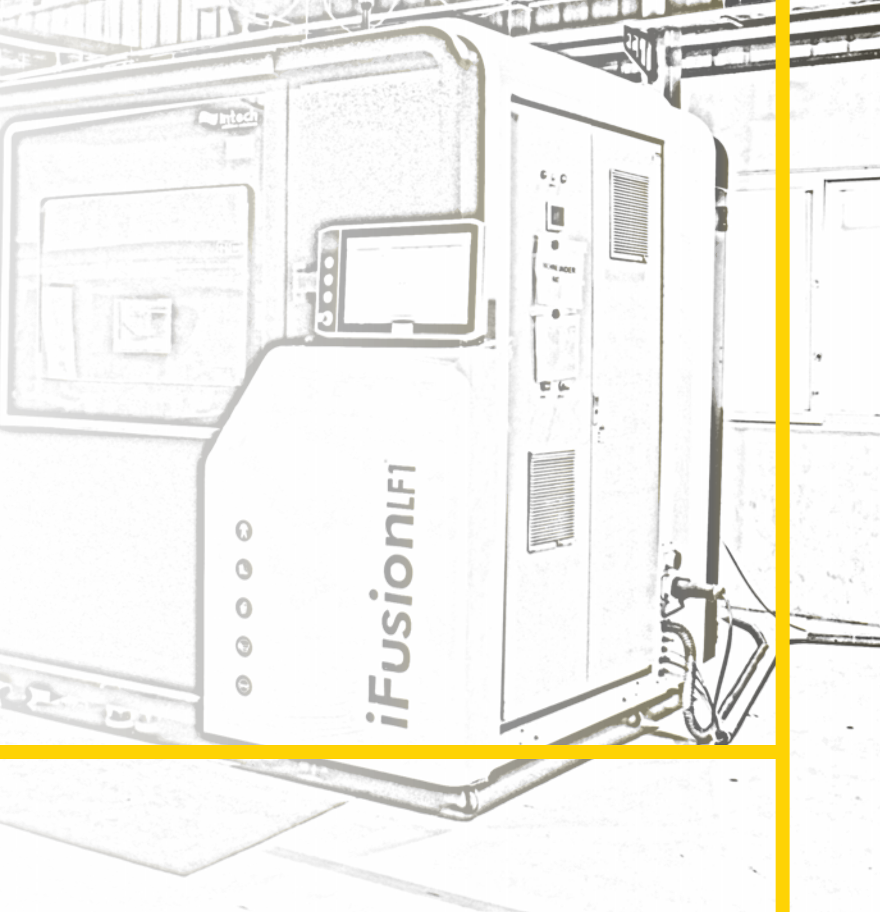
Intech additive solutions

INTECH ADDITIVE SOLUTIONS

FIRST INDIAN ORIGINAL EQUIPMENT MANUFACTURER

to develop and supply Metal 3D Printers based on Laser Powder Bed Fusion (LPBF) technology.

Intech Additive is a complete solutions provider in Metal Additive Manufacturing (AM) systems and AM Software.



PRODUCTS AND SERVICES

AMBuilder
A powerful Build Processing Software with intuitive work-flows and intelligent features

iFusion LF™
High-performance Large Format LPBF Metal 3D Printer

DESIGN FOR ADDITIVE MANUFACTURING (DfAM)
For a Complete AM Journey

AMOptoMet
A One-of-a-kind Parameter Optimization Software

iFusion SF1®CE
High-performance Small Format LPBF Metal 3D Printer

+91 63664 50455

marketing@intechadditive.com

www.intechadditive.com

CONTENTS

Singapore Driving Additive Manufacturing in Asia Pacific

Dr. Chaw Sing Ho

As a part of our AM Chronicle regional outreach, in this feature article we focus on Singapore, which is quickly establishing itself as Hub for Additive Manufacturing in the APAC region with a conducive policy environment and a serious technological push.

To dive deeper into the evolution of Additive Manufacturing in Singapore it is our pleasure to be speaking to Dr Chaw Sing Ho, Managing Director, National Additive Manufacturing Innovation Cluster or commonly known as NAMIC. NAMIC is a national platform initiative in Singapore led by NTUitive and supported by the National Research Foundation under the Prime Minister's Office, in partnership with Enterprise Singapore, Singapore Economic Development Board and A*STAR.

Dr Ho Chaw Sing is the co-founder and Managing Director of NAMIC (National Additive Manufacturing

Innovation Cluster), a Singapore government platform initiative to catalyse innovation and scale industrial adoption of digital additive manufacturing technologies. Since its inception in late 2015, NAMIC has raised several millions in public-private funding to support various AM initiatives across several industry sectors. Before joining the public sector, he spent several years with HP Singapore and Chartered Semiconductor, where he undertook various executive roles in technology and product development, as well as supply chain manufacturing operations. An advocate for technology for good and 3D Printing's role in sustainable development and manufacturing, Chaw Sing has participated in numerous forums, including at the World Bank Group, Development Research Centre China, and the World Economic Forum – Centre for the Fourth Industrial Revolution. He is passionate about nurturing deep tech start-ups.

You come from a diverse background of electronics, inkjet and academics, can you share insights on your AM journey ? (Keep interview questions in Red)

In my career, I have worked in various roles however it has only been at 3 organizations including the current one at NAMIC. I started my career as a Process integration engineer at Global Foundries in the semiconductor business and later joined HP overseeing business operations in the inkjet industry. The common element, which connected the dots between these two roles, was manufacturing. As far as Additive Manufacturing is concerned, this journey really started when I was in HP in 2011. We were at that time exploring different innovations for new business's and 3D Printing was one of them. The idea was at that time put into cold storage and was revived sometime in 2014-15. In 2015 I was approached by Dr Jui Lim who s now the CEO of SGInnovate to start this office. Back then I was in a comfortable job but wanted to do something more impactful at a societal level so I happy to setup the National Additive Manufacturing Innovation Cluster office from scratch.

I really resonate with the quote made by Steve Jobs at Standford University while taking some of my important life decisions:

"You can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future. You have to trust in something - your gut, destiny, life, karma, whatever." – Steve Jobs.

Can you share some insights about the journey of creation of NAMIC and how the AM ecosystem evolved in Singapore ? What challenges did you overcome to drive adoption of AM in Singapore ?

The idea of NAMIC came about due to the early foresight of the Singapore government to invest in Additive Manufacturing R&D in 2010 – 2015. As I mentioned earlier by former boss Dr Jui Lim, wanted to find way to harness all these early R&D Infrastructure investments in the AM Centre of Excellence's across the country and try to turn these research activities into tangible economic outcomes. We are a small island state so it made a lot of sense to have a neutral body to coordinate the activities and not duplicate activities. That was the primary mission for NAMIC. I w came in as the first employee in this organization to bring an outside perspective since I had no history or baggage from the public sector.

On the challenges front, getting different organizations to work together and in this case mostly the public funded universities and research institutes under a common framework was a major undertaking. Even though at the idea level everyone was on board but to actually make it happen is a totally different ball game. I think from Day 1 it was clear to me that people would be key so we setup a cluster leadership model with like-minded people from our 3 main universities – NUS, NTU and SUTD to work through the differences towards a common mission. The next part was building a team in my office to oversee the strategy and outreach activities. It was not easy recruiting, as we needed to find the right people with a public private partnership mindset. I was fortunate to bring on board some of my colleagues from my previous companies.

One of the other major obstacles was the lack of an enterprise AM ecosystem in Singapore when we started, there were less than 20 companies operating in. We had to develop a goal together with Singapore EDB and Enterprise Singapore to chart a path forward where we needed to identify across the value chain what type of business's we needed to start as well as bring in from other countries. Today we have been progressing very rapidly and from less than 20 companies we today have more than 170 companies in Singapore.

We have been focusing on startups and spin off companies from local universities. Whether they are developing the technology as a technology service provider or using the technology for product innovation. Startups are a very key focus for us and we have also been working with startups across the world to have their business presence in Singapore.

Which are the main industries adopting AM in Singapore and can you share some success stories ?

At NAMIC we have always looked at the 3D Printing ecosystem with a sectorial perspective, given the unique challenges, every sector faces. We were also aware that this is was a transformative technology, which could help business's pivot to move up the value chain. The initial focus was on strategic sectors, which are somewhat indigenous to Singapore including the Maritime, Offshore and Aviation MRO. As you know the aviation industry has suffered quite a bit during the pandemic so a lot of our Aviation related plans have been delayed. One sector where we have been able to make good progress is the Maritime, Marine and Offshore space. We have been able to successful create the entire value chain – including OEMs, Solution providers, Qualification and Certification companies. Importantly, we have also developed an ecosystem of end user shipping companies. This is something we have been able to achieve with a consortium approach and now have close to 40 companies across value chain, designing, developing and deploying the components

The biomedical industry is another area where we have made progress. We have created a group of like-minded clinicians in Hospitals to adopt such solutions. We have been able to develop AM applications in the dental space, which is the fastest growing biomedical application in AM, pre-surgical models, guides and event in implants. We are working with various Orthopedic, Pediatric and other domain specialists to help them improve patient outcomes. We have also focused on developing the regulatory space, we have developed 3D Printing guidelines together with the Health Science Authority similar to US FDA. This helps to provide the right regulatory endorsement and framework to enable 3D printing medical supplies to the Singapore health care industry.

Of course there are a lot of other opportunities, which can be developed further because if you look at the size of the market it is perhaps less than 0.1% of the total manufacturing output globally which is estimated at about $ 14 trillion accounting for the pandemic impact. We think that these numbers will go up but along the way there will be challenges of justifying the economics for adoption and how do you actually scale as the investment cost is not trivial

Considering the growth of AM in Singapore, What new initiatives is NAMIC focusing on currently and in the near future ?

We recently completed our planning cycle for the next 5 years. As you know, the Additive Manufacturing industry is very dynamic in nature, so we are making these plans with a mindset that we will make adjustments as needed depending on the market evolution. The three areas, which I would like to mention where we are focusing, are –

Biomedical or Healthcare

We are looking to stretch the applications of AM in healthcare towards bioprinting, tissue engineering and organoid 3D Printing. This approach is very much in line with the push for personalized medicine and work for better patient outcomes. Whether it is to develop better drugs that are personalized to an individual need or a much better fit in terms of a customized medical implant. We are also bullish towards areas like 3D Printed alternative proteins. There have been number of initiatives in the world, just to name a few, In Israel you have Redefine meat doing 3d printed meat or steaks. In Singapore we have Shok Meat looking at creating 3D Printed seafood alternatives.

Integration of Workflows

One of key areas where we feel there is a gap in the industry is to integrate process workflows from design stage, printing to post-processing. Today there are various solutions for CAD Design, Simulation or Generative Design however these are disparate to each other. It is important, as an industry for us to figure out how to create standardized workflows so that multiple softwares are not needed just to complete the design process On the printing or fabrication side there has been much improvement on the printing speed and cost effectiveness, however the post processing is still an issue where processes like support removal or de-powdering are all manual. If we need to push towards mainstream manufacturing we need to identify how to automate these processes.

Standards, Testing and Certification

We need to have a better way to predict the quality of AM parts. This is something we have identified after discussions with various stakeholders as one of our focus areas. Especially if you look at Aviation, this is one of the impediments for more wide scale adoption of AM. Right now doing qualification is very painful process as this is done by part and not by process. We would like to explore if we can use digital modeling or digital twin process to provide additional data sets to predict quality as opposed to monitoring only parts using some of the NDT evaluation techniques

How would you describe the association of NAMIC with the region and how can it be the engine of growth for the entire region.

This is something we ideate about quite often; being in Singapore the end user market is limited relative to the world. It was very clear to us even when we first started this office, that to make this technology more pervasive we have to support and promote the benefits and share some of these learning's in the neighboring countries as well. In a limited way we do focus on outreach and ecosystem building initiatives like our work with you at the Indian 3D Printing Network and AMTech in India, In China we work with associations very specific to 3D Printing. A lot more needs to be done to reach down to the grass root level beyond the associations. We see the same challenges in Singapore working with various industry sectors and the trade associations. A lot of the used cases are relatively unique however the business models revolve around cost reduction or productivity improvement. Eventually the end customers must be able to reap the benefits of this technology, so this is something we need create education awareness and platforms, whether its through the annual conferences we organize, or being connected with the grass root level in countries in ASEAN region to create similar like minded ecosystem wherein we can make more end users aware of the benefits of this technology.

“The demand generation is a key focus for us compared to the sales side ecosystem development that we have been doing in the last few years”.

ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

Mettle for Metal, A fearless voyage

Sridhar Balaram

With the line of products that they offer at Intech, Sridhar Balaram aims to put India on the Global Map of Metal 3D Printing.

Sridhar Balaram

My story of Intech Additive Solutions, I hope, will inspire a generation of dreamers. Starting out as a young novice, with dreams that seemed as distant as the horizon, my self-belief and vision were my only anchors. The key driver for me has always been my undying passion for my craft, steadfast belief in AM technology, combined with constant perseverance. As with everything else, the challenges felt gargantuan. But as experience has taught me, for anyone brave enough to look beyond the obstacles and focus single-mindedly on the goal, dreams do turn into reality.

I'm Sridhar Balaram, the Founder, CEO & MD of Intech Additive Solutions. My early interest in anything metal drew me towards working for Galvano in the 1990s. Little did I know that this mere spark of interest would transform into an inferno of passion for exotic applications and metals over time. Galvano, at that time, was a start-up steel casting foundry with a limited reach and presence primarily in the local industries. With the sole objective of providing world-class products and services to customers, Galvano began its rise to international prominence. Galvano established an in-house precision machine shop, Induction heat-treatment, and assembly shop as part of the forward integration process. It carved a niche for itself in the casting arena and won over numerous satisfied customers, many of whom were reputed global Excavator OEMs.

My rich experience at Galvano taught me that, more often than not, our success march will be punctuated with unforeseen setbacks and external factors that we have no control over. For example, the global financial meltdown of 2010, which affected most of the world, also significantly impacted my OEM customers and me. With revenues drying up, we were amidst some uncertain times.

The road ahead was extremely challenging with businesses being unpredictable and with speculative pipelines. The financial gloom was widespread, and its ripple effect was felt in the local casting industry. I was apprehensive, impatient, and willed myself to think outside the box. I realized that a real entrepreneur is one who readily transforms adversities into opportunities. A well thought out unique response to the situation was my only way out. As luck would have it, metal 3D printing caught my attention. It was still at its infancy stage in India, and to me, it showed the promises of endless possibilities for the future. I delved deeper into metal 3D printing and started exploring the opportunities it presented. Knowing that with greater risks come greater rewards, I decided to trust my gut and go for the plunge.

In 2012, I founded Intech DMLS. It happens to be "the first metal 3D printing service bureau" in the country. My first step was procuring two metal 3D printers from a German OEM. With the printers in hand, Intech started serving the local manufacturing industry. Our services were limited to the printing and machining of components. In the early days of inception, we used 3D CAD models provided by the customers and helped in giving them workable prototypes. We had a good run at providing these services over the next few years.

Though of the highest quality, I soon realized that our service offerings only enabled us to engage superficially with our customers. I felt the urge to find the opportunities to go beyond the meagre revenue streams, move up the value chain, and serve my customers at the highest level. It was vital for me to add more value to customer interactions along with their products.

With this in mind, we ventured into the Design for Additive Manufacturing (DfAM) while also teaching the metal 3D printing design rules to customers. Through our design consultancy services, we educated our customers on the immense benefits and possibilities that 3D printing offered. In addition, I invested in fresh engineering talent and cutting-edge software tools to make Intech the go-to source for metal 3D printing.

Our customers recognized the great value in our consultancy engagement. We guided them on the various aspects of metal 3D printing. We also assisted in prototyping for Functional Testing, Molds and Dies, and Low Volume Production Parts (Legacy Spares) for specific industry verticals such as Defense and Aerospace. With all our combined efforts, by 2016, Intech had gained a lot of traction in India's manufacturing sector and successfully created a name for itself in metal 3D printing. We also did have our fair share of roller coaster rides to conquer to get to this stage.

Being a yearning entrepreneur, I set my sights even higher and wanted to add value to the home-grown manufacturing landscape of our country. I found myself, once again, in the position to create a difference. My experience in the industry now allowed me to see the shortcomings and limitations of metal 3D printers manufactured by overseas OEMs. For example, I observed that all the global 3D printer OEMs heavily relied on third-party software. This formed a significant barrier for the timely and user-friendly software customizations required by the customers. Another inadequacy in established global 3D printers also garnered my attention: Not a single printer could print with new alloys, which was often a particular and urgent requirement of OEMs.

As a matter of habit, I took a leap of faith, trusted my instincts once again, and invested heavily in R&D, human resources, and the technology to manufacture a home-grown 3D metal printer and related software. In 2020, the investment and the belief paid off. We launched the iFusion Series Systems (machines based on Laser Powder Bed Fusion Technology), India's first indigenous high-end industrial 3D metal printer that guarantees the most value for money to customers. Though it would be perceived as audacious, this step required a lot of innovation and uniqueness to stand apart in the market. The team at Intech gave it their absolute all for this dream to manifest into reality. Going out with all guns blazing, we also developed the AMBuilder software (Build Processing Software). AMBuilder enabled the OEM customers to save time for the customizations required. Passionate about making a bold statement to the AM world at large, we went further and developed the AMOptoMet software. It has the rare distinction of being the world's first and unrivalled New Alloy Parameter Development Software. AMOptoMet is sure to make the AM world sit up and take notice as it takes only minutes to accomplish what would otherwise have taken overseas OEMs months to achieve. Developing AMOptoMet necessitated the team to innovate and use Artificial Intelligence algorithms and a massive amount of statistical data and logic. This catapulted the software into being the first-of-its-kind-in-the-world status!

With the line of products that we offer at Intech, I now dream of putting India on the Global Map of Metal 3D Printing. This is because I have planted a seed of innovation in the conducive soil of Atmanirbhar Bharat. Though Intech is still a fledgling in the AM world, I genuinely believe it is just taking flight. What gives me confidence that Intech will make its mark in the AM world is that the roots of our experience run deep, 30 fruitful years, to be precise.

Through the years, as Intech DMLS transformed to Intech Additive Solutions, one thing that has always been constant is the unwavering support from my exceptionally talented team. We still have miles to go for all I know, but what is certain is that we will not be taking our foot off the accelerator anytime soon. Their doggedly determined unidirectional efforts in creating world-class metal 3D printers and associated software are surely set to simplify and revolutionize the AM space. We are hungry to conquer the world – with my team by my side, supporting and nurturing my dream.

I'm highly optimistic that Intech will soon become a household name, not just in the Indian manufacturing sector, but will be a force to be reckoned with on the global stage.

ABOUT THE AUTHOR

Sridhar Balaram

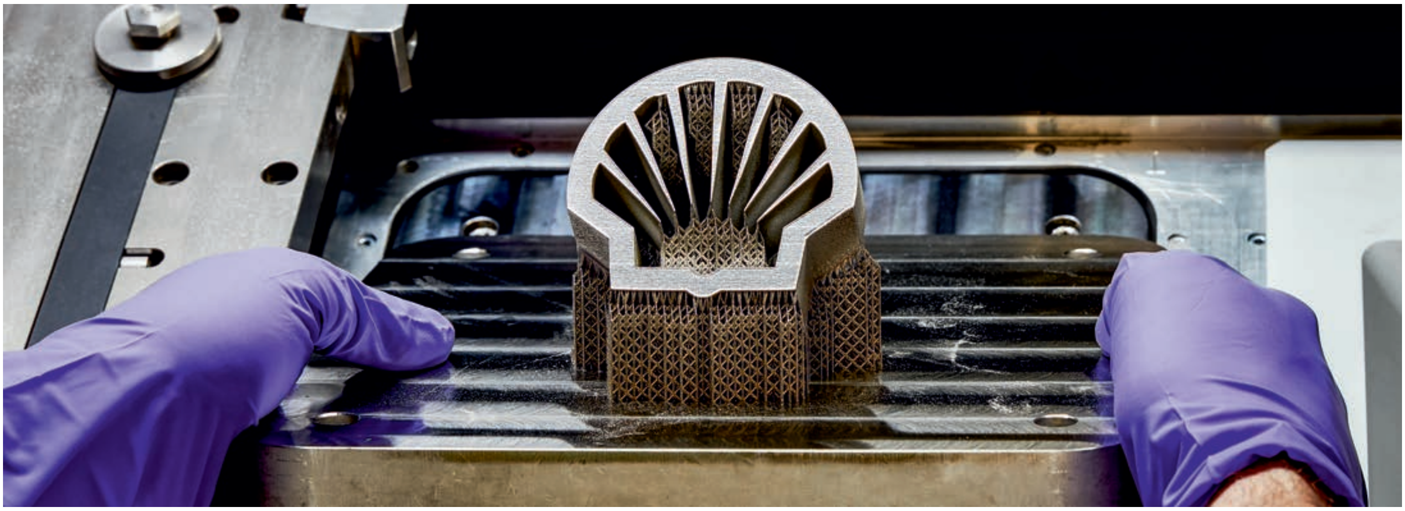
Managing Director and Founder - Intech Additive Solutions Pvt. Ltd.

Sridhar Balaram is a radical technology-driven entrepreneur. He has successfully harnessed a holistic pursuit in revolutionizing metal additive manufacturing, that is, 3D metal printing services in India, by employing innovative solutions and AM technology. Having garnered over two decades worth of experience, Sridhar has built Intech into what it is today — credited as the country's largest commercially available metal additive manufacturing facility.

A digital future for spare part management

Angeline Goh and Nick van Keulen

Shell believes that Additive Manufacturing technology can reduce the costs, delivery time and the carbon footprint of spare parts.



The process of three-dimensional (3D) printing, also known as additive manufacturing, involves creating metal or polymer objects from digital computer models. Shell believes the technology can reduce the costs, delivery time and the carbon footprint of spare parts. We are collaborating with industry leaders to push the innovation of 3D printing for the energy sector.Shell's in-house 3D printing capability started in 2011 with a metal laser-printing machine to fabricate unique testing equipment for laboratory experiments at the Shell Technology Centre Amsterdam (STCA). Today, Shell has about 15 polymer, ceramic, and metal printers located at its technology centres in Amsterdam and Bangalore.

Buoyed by success in Nigeria

Within Shell, the focus for 3D printing is on spare parts, novel designs, and visualisation objects. Although Shell has the capability to manufacture spare parts itself, we have taken the following position on sourcing of 3D printed components:

1) collaborate with an original equipment manufacturer (OEM) qualified to supply 3D printed components;
2) when an OEM is not available, and in compliance with intellectual property (IP) laws, Shell can reverse engineer the part and have a commercial supplier print it from a 3D model; and
3) in emergency cases and when IP is not an issue, Shell will print spare parts in-house.

Last year, this approach brought substantial savings in our offshore Nigeria operations, were the teams repaired a small component within a large piece of equipment for which replacement parts are no longer produced. They replaced the polymer seal cover on the mooring buoy of an offshore structure without shutting down production and without having to perform costly, complex and perilous heavy lifting at sea.The conventional replacement of the whole assembly would have taken approximately 16 weeks. Working against the clock to replace the seal before the tropical rain season, the Nigerian team modelled the component with a 3D scanner from a local supplier. Because there was no qualified local printer, the file was sent to a European printer. 3D printing reduced the final cost of the maintenance by 90% compared to a conventional replacement and it took merely 2 weeks to produce the parts.

Enabling digital warehouse together with our suppliers

Shell's 3D printing strategy is not to manufacture parts itself. Rather, it aims to develop a digital warehouse which stocks all the information required to print components whenever they are needed, in partnership between Shell's technical authority, OEMs and local partners. A digital warehouse enabled by local eco-systems would presents true lead time reduction, responsible use of resources and progress for the local communities where Shell operates.At manufacturing sites, access to 3D printing services reduces the need to stockpile components. Teams merely need to print the replacements needed, saving both time and money. For example, at Pernis refinery in the Netherlands, Shell is testing the use of 3D printing to produce impellers for a production critical, 7-stage centrifugal pump. This is the first of its kind additive manufacturing application for components used in a critical service-multi-stage pump.This project is undertaken in close partnership with Baker Hughes, who will be printing the part. This pilot – if successful – would mean the refinery could supply 3D printed pump impellers “just in time” instead of stocking the spare parts for years. We estimate that 3D printing these production critical parts reduces by 75% the time needed to supply them, compared to using conventional manufacturing processes.

> “Baker Hughes has a decade long experience in additive manufacturing and sees 3D printing as a key service pillar for our Turbomachinery & Process Solutions business. With Shell, we apply 3D printing to mitigate supply chain risks when lead time is critical. All actors in this value chain must now come together to develop the right framework where 3D printing brings enhanced value to the energy sector.”
>
> Alessandro Bresciani, Vice President, Services for Baker Hughes' Turbomachinery & Process Solutions business.

Another milestone this year was achieved when Shell and the Elliott Group successfully 3D printed an aluminium alloy impeller for a multistage high pressure liquified natural gas pump. This part is used for cryogenic hydrocarbon service, which is a novel use case for the technology in the energy sector. The teams closely collaborated to establish the technical specification of the part and qualify the printing process. The actual printing of the impeller, heat-treatment and testing were completed within 40 days, which is 85% less time that the conventional delivery time of producing such parts. Beyond this time reduction, the 3D printed impeller demonstrated better mechanical performances compared to traditionally casted impellers.

> “Working together with Shell, both organisations learned valuable lessons, confirming the significant advantages of 3D printing: precision manufacturing, lead time reduction, higher quality component. As more material choices and larger components are rapidly being developed, Elliott will continue to explore 3D printing as a preferred manufacturing method.”
>
> Derrick Bauer, Elliott's Manager of Material Engineering.

Shell's approach to 3D printing is paving the way to reduce the need for purchasing, holding and maintaining a large inventory of spare parts, which reduces cost and waste. Furthermore, printing close to the destination asset reduces the emissions associated with transportation. It also helps create shorter and more effective supply chains supported by high-skilled local capabilities.

Cross-industry collaboration towards global standards

The recent success confirmed our willingness to develop digital warehouses in the energy industry. To date Shell has installed over fifty 3D printed spare parts in the operating assets, both produced in-house as well as sourced from different manufacturers, all under the supervision of specialists from our 3D printing center and discipline engineer experts. Involving field experts – like at Pernis with Baker Hughes – is required to qualify parts for use in facilities.3D printing is becoming an established manufacturing technique in other industries, such as aerospace, automotive and medical, yet the energy industry is slow on the uptake. One of the main reasons is the lack of common accepted technical standards within the industry. Resolving this means cooperation across the whole supply chain, from end users, assurance providers to specialised printshops and OEMs.

ABOUT THE AUTHOR

Angeline Goh

3D Printing Technology Manager - Shell

She sets the strategy for the application of 3D Printing and leads the digital transformation towards novel, enhanced design with improved performance and a secure and reliable digital inventory that supports Shell's operations.

Nick van Keulen

Supply Chain Digitalisation Manager - Shell

Nick van Keulen works in a contracting & procurement role, researching & implementing digital technologies for both the procurement organization as well as the supply chains it manages.

Exploring the Orthotics and Prosthetics 3D Printing Ecosystem in UAE

Manoj Pillai

> Orthotics and Prosthetics market in UAE is mature with highly qualified professionals working very closely with Orthopedic doctors and hospitals.

Healthcare is one of the main sectors and end use application areas where there is focus in the Middle East for 3D printing. Applications of 3D printing consist mainly of implants, medical devices, surgical planning models, orthotics and prosthetics devices. The medical 3D printing market is expected to reach an estimated $4.5 billion by 2026 with a CAGR of 36% from 2020 to 2026. In this article we focus on the Orthotics and Prosthetics market of UAE and its growth prospects.

Orthotics and Prosthetics market in UAE is mature with highly qualified professionals working very closely with Orthopedic doctors and hospitals. Orthotics and Prosthetics (O&P) technicians or CPO (Certified Prosthetist and Orthotist) are providing new life to people who suffer from congenital diseases or have lost a limb in accidents or due to diseases like diabetes or sarcoma.

There are around 25 clinics in the UAE alone dealing with O&P devices. The major devices manufactured are Insoles, Ankle Foot Orthoses (AFO) Knee and Ankle Foot Orthoses (KAFO), night splints, Cranial Helmets, scoliosis braces and immobilizer devices.

(l tor) Piro AFO and Talee Cranial Helmet
(Courtesy Invent Medical)

On an average 0.7 % of the population require support devices either permanent or temporary during their life. The total market of O&P devices in the UAE is around 130 million AED annually. And with increase in diseases like diabetes the number of patients requiring an artificial limb is increasing. With growing awareness about the benefits of using insoles in managing pain and decreasing foot ulcers, the demand for insoles is also increasing. Though a lot of ready-made solutions are available for insoles, they cannot match the custom-made insoles efficacy. Since every product must be custom made, 3D printing offers a very good solution for O&P products.

Conventional Process of making O&P devices

All the clinicians in UAE, except a few, are using conventional methods to make O&P devices. The patients will visit the clinic based on the orthopedic doctor's prescription and the technician will access the condition. The technicians to take measurements rely on plaster casting or hand measurements to get the negative of the device required. Then they will pour plaster onto the negative to get the positive mold. After that they will make the necessary adjustments on plaster. In conventional methods the prosthetics are made from polypropylene sheet which is heated and laid on top of the cast through vacuum forming. This process can take around a week and if the fitting is not correct the patient will have to visit the clinic multiple times. Some of the clinics have moved to a semi conventional semi digital process. In this semi digital process, the clinicians make measurements using digital tools like a scanner. The digital model is then used to make the mold using a form utilizing a robotic arm, a desktop milling machine and makes the device through vacuum forming.

Digital O&P Process

In a complete digital process, the measurement is done using the scanner and a suitable design is made using 3D CAD software or an algorithm. This design is directly sent to the 3D printer and the orthotic device is printed. There are many advantages of converting the conventional to a completely digital process.

1) The technician saves a lot of time through 3D printing process which he can now utilize do see the patients
2) Saves a lot of space which was used earlier for keeping the plaster molds
3) The manufacturing process is repeatable and does not depend upon the skill of technician
4) The number of visits of the patients can be reduced
5) Complex shapes which were not possible earlier can be manufactured now

Process of Personalised Orthotics Manufacturing
(Image Courtesy: Jumbo Group)

6) The fitting and comfort level of patients increases 3D printing
7) The thickness can be varied according to the requirement and lightweight is possible.

Challenges in adoption

Despite all these clear advantages, the adoption level of 3D printing is not up to expectation. In UAE only a few companies like MOBILIS, Orthomena, Mediclinic adopted 3D printing in their process. There are a few reasons behind this. The key processes like patient interaction, diagnosis and assessment is going to be done by CPO even if the remaining processes are digitized. These in combination with the existing conventional manufacturing has been working very well till now and there is reluctance to change. However, the demand from customers for better products, the ease of using digital softwares will make the CPOs rethink this current process. The other major challenges of adoption are:

1) Lack of scanners which are reliable
2) Design skills
3) Identifying tested and reliable 3D printing machines
4) Cost of the overall solution

The familiarity of patients with 3D printed devices is increasing and it is a matter of few years when they start asking for 3D printed devices instead of conventional ones as they are more customised for them. The doctors prescribing the treatment also plays

Range of Scanner solutions
for Orthotic and Prosthetic Applications

a major role in adoption of this technology and bringing it into the mainstream.

Way forward

UAE is witnessing a change in the approach to 3D printing in O&P devices. Below are some of the key market interventions causing this change.

Availability of Scanner solutions.

Selecting and purchasing a suitable scanner is the first step in moving towards digital process in orthotics. There are many scanners available in the market. The price range starts from 3000 AED to 50,000 AED. The functionality and accuracy vary according to the price. For most of the applications in orthotics a structured scanner should be sufficient.

Design solutions.

The major blockage of converting or shifting to digital process is in the design. Earlier orthotist technicians used their own skills in adjusting and fabrication for their patients design so they knew what they were doing and how they were doing. Most of them are not trained in CAD software. This has led to a low adoption rate among CPO's. Many companies realized this is a problem and have come up with intelligent solutions which will bridge this gap. An interesting factor in these companies is that it is not a software company who is bringing these solutions. But orthotist technicians who understood the gap are building platforms and algorithms. The technician follows a very similar process as in conventional way except that it happens on a digital platform. Some of the solutions in the field are a) Invent medical b) Mercuris c) Rodin-4d d)Vorum, e) Spentys etc. (Details to be provided in the next article)

3D printing.

The last but the most important part in the entire process of digitization is 3D printing of the device. The selection of 3D printing technology depends on the final application. World over HP Multi Jet Fusion technology is used by the majority to manufacture and use orthotics devices. HP technology is reliable and predictable, and the materials are FDA approved for use in contact with skin. One of the big issues is the heavy investment required for setting up the manufacturing facility. The volume of devices done by the clinics does not justify the purchase of dedicated 3D printers. The alternative is to have a central fabrication facility dedicated to orthotics and prosthetics where the technicians can send the final file and get it 3D printed within one or two days. Companies like "Additive America" are following this approach and have been successfully printing orthotic parts for more than one year now.

This is a transition period for Orthotics and Prosthetics in UAE and Middle east in general. Businesses and clinics adapting to this new process will continue to improve the customer experience and market share and as they say the rest will be history. (This series will continue with more focus on the software products and comparison of features.)

ABOUT THE AUTHOR

Manoj Pillai

Business Manager, 3D printing- Enterprise Solutions, Jumbo Electronics Co Ltd (LLC)

Working closely with customers in developing business case for future investment in technology. I am responsible for developing the team, sales forecast, long term strategy, business planning, and delivering Additive solutions to customers. Customer focus and solution creation is my main expertise.

Concrete 3D Printing: A Global Overview

Dr. J. Jayaprakash and M. P. Salaimanimagudam

Concrete 3D printing, in recent years, has been increasingly utilized as a digital fabrication technology in the construction industry.

Concrete 3D printing, in recent years, has been increasingly utilized as a digital fabrication technology in the construction industry. The concrete 3D printing technology is a transformative development in the construction industry by enabling the automotive fabrication of lighter, robust, and mass customizable structures. However, the degree of customization in the construction industry, in past decades, is relatively low as compared with other industries including automobiles, consumer electronics, apparel, food, and health care. Therefore, it increases the client's scarification gap between the desired design and the manufacturable design. Engineers, generally, have limited the bespoke and mass customization to meet the economical aspects and ensure the structural stability of the structures. Thus, the application of concrete 3D printing technology in the construction industry is found to be very promising in recent years by enabling mass customization and production. Moreover, the demand for mass customization in the construction industry might be one of the main reasons for escalating the global requirement for concrete 3D printing. The essential factors for adopting digital fabrication in the construction industry are to reduce the time, cost, materials, formwork, workforce, carbon footprint, and weight of the structure, as shown in Figure 1. As a result, concrete 3D printing is utilized in various countries to fabricate sustainable structures. The adoption of digital fabrication techniques in construction in various regions of the world are discussed below.

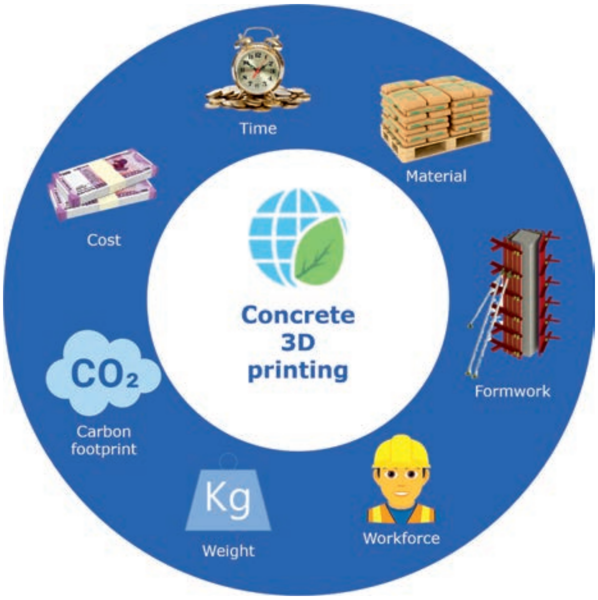


Figure 1: Factors for adopting Concrete 3D Printing Europe

Europe

The European countries, including Switzerland, Netherland, Italy, France, Germany, and Austria, have been using digital fabrication techniques to ensure sustainability and eco-friendly construction. Moreover, the European countries proudly hold the five different 3D printed bridges, as shown in Figure 2. For instance, the world's first concrete 3D printed pedestrian bridge in Spain was built in early 2016. The total length of the pedestrian bridge is 12m and 1.75m wide. This pedestrian bridge was 3D printed using microfiber reinforced concrete. The parametric design ensures the optimal material distribution with the enhancement of structural performance. Moreover, the parametric design and generative design gives organic shapes which challenge the traditional casting method. To overcome the challenges and fabrication constraints, they have adapted digital fabrication techniques.

Subsequently, the cable reinforced and post-tensioned 26 feet bicycle bridge was 3D printed and opened in the Netherlands for cyclists during 2017. The bridge was printed into six segments and structurally integrated using a post-tensioning method. The "Circular design and Trias Energetica" principle of sustainable design was used for optimal material usage and reduction in CO2 emission. Moreover, the Netherlands held the record for the world's first steel 3D printed bridge, and it was printed by four robotic arms using Wire Arc Additive Manufacturing (WAAM) method. This 12m long bridge was printed in six months using 4.5 tonnes of stainless steel. Several sensors were effectively used to monitor environmental and structural performance. The sensors were also placed to measure the strain, displacement, vibration, air quality, and temperature by enabling the engineers to monitor the bridge's health in real-time and fetch the data into a digital model. Moreover, it was opened to the public in mid of 2021.

Apart from 3D printed bridges, the European countries have set benchmarks in 3D printed housings as well. The Digital FABrication (DFAB) House was fabricated using different digital fabrication techniques in Dubendorf, Switzerland, and opened in 2019. The double curve wall was fabricated using mesh moulding, and the facade mullion was cast using a smart dynamic casting method. The smart ceiling was fabricated over a sand 3D printed mould, and other techniques are also used in the DFAB house. The Eidgenössische Technische Hochschule (ETH) fabricated the future tree using the novel eggshell 3D printing method, which integrates large-scale industrial robotic Fused Deposition Modeling (FDM) printing and simultaneous casting of set-on-demand concrete. In 2021, Germany's first concrete 3D printed two-storey residential house with 160 square meters of the living area was built in Beckum town.

Figure 2: World's 3D printed bridges

Asia-Pacific and Middle-East

China holds the longest 3D printed bridge in the world, and it was awarded the Guinness World Record. This longest Zhaozhou 3D printed bridge in Tianjin has a length of 28.15m and a span of 17.94m. Moreover, this bridge is a 1:2 scale replication of the world's oldest single arch stone segmental Zhaozhou Bridge. Several built-in sensors were embedded using an intelligent integration method for health monitoring. This bridge has broken the record of 26.3m long 3D printed bridge in Shanghai, China. China is the second country to hold two concrete 3D printed bridges after the Netherlands. Moreover, China has adopted concrete 3D printing technology to manage the pandemic situation by printing Covid Isolation Ward. India, recently, has printed its first house and doffing unit in 2021. Moreover, in Australia, researchers have developed novel strengthening concrete 3D printing methods using inspiring Lobster and Novel hollow-core extrusion to create lightweight concrete 3D printed structures. In early 2020, the world's first commercial 3D printed building was unveiled in Dubai, UAE. Moreover, Dubai is a home to the world's largest 3D printed building, which is a 6,900 square foot administrative building of Dubai municipality.

America

The United States of America has planned to use 3D printing for mars human habitations, which takes the technique to the next level. ICON 3D prints the first replicated practical Mars human habitation at NASA's Johnson Space Center in Houston for the Mars Dune Alpha mission. This simulation is carried out to support long-duration, exploration-class space missions. In addition to that, the American's military printed the largest 3D printed military barrack building of 3,800 square feet in Texas, North America. It is capable of accommodating 72 men and women during their training period in Camp Swift Training Center.

America has not only adopted and executed the 3D printing technology in the military, however they also have a footprint in 3D printed houses for civilians. For instance, America's first 3D printed house hit the market for sale in New York with 50 years of structural warranty. The 1500 square foot house with car parking facilities was constructed using 3D printing technology. However, the cost of the 3D printed house is relatively fifty percent lower than a conventional building. Thus, concrete 3D printing technology can be adapted to produce affordable housing in mass production.

Africa

Africa has developed the first 3D printed school of 56 square meters in Malawi to accommodate 50 students. The wall was printed in 18 hours with optimum material usages, and it would take several days with traditional building methods. According to United Nations Children's Fund (UNICEF) agency estimation, there are 36,000 primary school shortages in Malawi alone. Fulfilling the infrastructure demand using conventional building methods might require 70 years. However, it can be printed in 10 years while using concrete 3D printing. Thus, concrete 3D printing has the potential to fill the global educational infrastructure gap, and it also creates skilled jobs for the local people directly and indirectly by increasing the quality of living.

Concrete 3D printing is mainly used to fabricate buildings, bridges, and other structural elements due to its potential advantages include rapid fabrication, minimum material utilization, eco-friendly and sustainable. Therefore, it is possible to see the rapid growth of concrete 3D printing all around the world. Market and Markets forecasted 245.9% of Compound Annual Growth Rate (CAGR) between 2019 to 2024 before the pandemic. The Global Market Trajectory & Analytics report has estimated the market growth of concrete 3D printing by 332.6% of CAGR growth throughout 2020-2027. After considering the economic crisis due to pandemics, the growth is readjusted and revised to 275.4% CAGR for the analysis period. The Asia-pacific region plays a significant role in the concrete 3D printing market.

ABOUT THE AUTHOR

Dr. J. Jayaprakash

Professor - Vellore Institute of Technology

Dr. J. Jayaprakash is a professor in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India. He earned his Master of Engineering in Structural Engineering from National Institute of Technology, Tiruchirappalli and PhD in Structural Engineering from Universiti Putra Malaysia.

M. P. Salaimanimagudam

PhD Research Scholar - Vellore Institute of Technology

M. P. Salaimanimagudam is a PhD research scholar in Department of Structural and Geotechnical Engineering, School of Civil Engineering, Vellore Institute of Technology, Vellore, India. He completed his M.Tech in Structural Engineering from SASTRA, Thanjavur, India. He is pursuing his research in the field of topology optimized digital fabrication of concrete structures.

The Road to Industrialisation of Additive Manufacturing

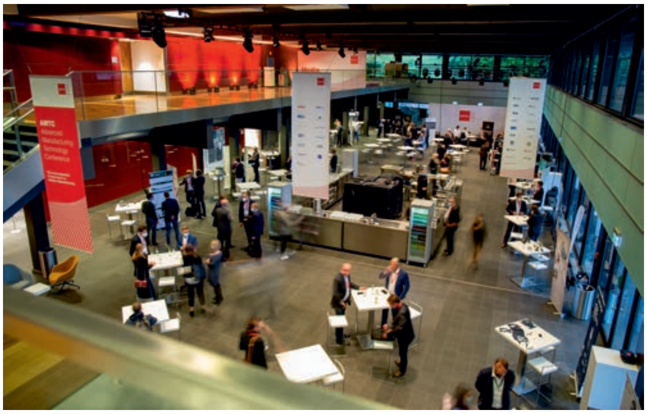
Aditya Chandavarkar

Dr Kartik Rao shares about his journey in the Additive Manufacturing industry, the challenges which need to be addressed by the industry and the role Oerlikon AM is playing in advancing Additive Manufacturing.

Kartik Rao

On the sidelines of Advanced Manufacturing Technology Conference earlier this month, I had the opportunity to speak to Kartik Rao, Head of AM Commercial and Strategy about his journey in the Additive Manufacturing industry, the challenges which need to be addressed by the industry and the role Oerlikon AM is playing in advancing Additive Manufacturing.

Kartik is head of the AM business unit's commercial strategy and leader of its business excellence team. In this newly created role, Kartik combines the knowledge and experience he brings from his previous roles as Head of AM Marketing and Head of the AM Materials business line. He enjoys working in an entrepreneurial



group within a larger established company, and particularly likes the challenge of identifying customer groups who can benefit from additive manufacturing and pairing them with the appropriate experts and technology at Oerlikon AM. Before joining Oerlikon AM in 2016, Kartik worked in business and product development at a VC-backed powder technology company in the UK. He was also responsible for technology licenses and helping raise capital for venture capitalist and strategic investors. Kartik holds a master's degree in aerospace materials engineering and a Ph.D. in titanium production from Imperial College in London.

You have been part of the Additive Manufacturing industry for over 12 years. How has your journey been and how has the Metal Additive Manufacturing material space evolved in this span of time ?

My interaction with the Additive Manufacturing industry began on the materials side. I am a powder metallurgist by background and the journey began with working towards manufacturing spherical powder, which could be used in a Metal AM printer. When I started working with metal powders, the printer technology that we had access to were small research grade printers. At that time it was not very clear how the Additive Manufacturing market was going to grow. However over the years, the technology has evolved towards larger bed platforms, more lasers with a drive towards productivity. Additive Manufacturing is no more an interesting technology, but is making its way towards becoming a production grade manufacturing technology.

My role in the Additive Manufacturing industry has changed as well from looking after the metal powder business to the service side of the business. Now in a general management role, I am taking care of the service facility in North Carolina, US which as 15+ Printers servicing the aerospace and defense industries in the US. What I have seen on the service side that the technology is maturing however it is not yet matured

completely. We are still in a position where it is highly capital-intensive industry and to achieve the next level of breakthroughs we need certainty of demand.

Additive Manufacturing over the past 12 years has evolved from being a materials science R & D Program, a business which is focused on selling powders and printers to a point now where the industry is much more focused on serializing production of parts.

What are the key challenges or concerns which need to be addressed for further adoption of Additive Manufacturing in production or serial manufacturing applications?

I will split the key challenges into three main segments based on my understanding and observations

1) **Market –** One of the greatest commercial challenges we have had in the industry is the certainty of the demand from the end user market. In the last 5 years the focus was primarily on the commercial aviation industry due to the presence of large number of narrow bodied airlines which translate into larger part counts. However due to the pandemic the entire commercial aviation industry is on pause and that has been one of the industry, which was able to provide the certainty of demand forecast. The question now is from the remaining participants from the space, defence or

power generation sector is to get a commercial visibility. This is very essential as there is large amount of investment still needed to grow this technology. The end user industry and the supply network need to work together towards identifying the long-term demand.

2) **Industrialisation –** This has been one of the key topics of debate at the earlier MTC's as well about challenges for industrialization. These can again be split into:

   a) Repeatability of production - Huge steps have been taken by various stakeholders including Oerlikon primarily drive by quality functions to make sure repeatable processes are able to to produce uniform parts.

   b) Reliability of production – This is dependent on the quality of hardware and the service thereafter. One of the things I have realized with running the service business is that the machine manufacturers need to step up in terms of service. Service levels are not quite where they need to be, to run the machines over and over again. It is very important to maximize the laser ON time. If machines are down for long durations, this is hugely damaging in terms of cost for the service provider and loss of credibility (The end users are benchmarking additive manufacturing against conventional technology, extended down times damage credibility of the process on the whole)

3) **Cost**

Each year the production costs are coming down, and we need to ensure that this curve continuous on the downward trajectory. As the production costs come down new markets will start opening up with the potential of mass adoption, example – Automotive Industry. It is very important for all stakeholders to work together to bring down the costs of the technology.

What role is Oerlikon AM playing in making the Metal Additive Manufacturing process more reliable, sustainable, cost-effective and efficient ?

AMTC

Co-creating AMTC is definitely a key role Oerlikon AM is playing in creating a forum for the AM ecosystem to share knowledge, share best practices and try and break those competitive tensions which generally hold the market back. The recently concluded AMTC in Aachen was focused on building momentum for growth. Coming out of the pandemic, there is going to be an element of bounce back. However our aim is to carry on the momentum beyond just recovering from the pandemic by building the further roadmap for growth.

Integrating the Value Chain

Linking several discrete aspects of the value chains as a I see is a strong role player by Oerlikon AM. We have been in the business of manufacturing metal powders for close to 50 years, and we also produce gas atomized spherical metal AM powders which are suitable for Additive Manufacturing. We are also one of the very few players out there who have the knowledge from powder manufacturing all the way to post-processing technologies and surface technology, along with strong linkages with the machine manufactures.

Optimising processes with Global Insights

Operating on global basis with a service business in China, USA and Europe, we are able to share knowhow between those sites and optimize the process based on that feedback. We are also able to bring those market insights back to our vendors - software manufacturers, machine manufacturers or powder manufacturers for them to improve their solutions in turn adding to the success of Oerlikon.

Sustainability

Oerlikon released their first sustainability report recently. Climate change has become more and more of a concern and we see a lot of customers focusing on this aspect, I feel Additive Manufacturing is a perfect fit with its inherent advantages in the sustainability journey. We are able to consolidate parts, which reduces weight, we are able to add coatings which can reduce weight as well leading to cost savings and reduction in carbon emissions. If you look at the Oerlikon portfolio of coatings, we are roughly able to save close to 25 MT of CO2 emissions. Oerlikon's investment in Additive is also complimentary to our sustainability drive as well

Any success stories for Oerlikon AM in specific sectors you would like to speak about ?

I would like to mention a couple of success cases at the two ends of the application spectrum. One is with a space company in the USA and the other with a cycle manufacturer in Germany.

United Launch Alliance is one of our flagship customers. They are an American spacecraft launch service provider that manufactures and operates a number of rocket vehicles that are capable of launching spacecraft into orbits around Earth and to other bodies in the Solar System. We helped them begin their Additive Manufacturing journey. Saving weight for space applications is hypercritical, every kg that you reduce, saves thousands of dollars of launch costs. We partnered with them so that they were able to design optimal components using DfAM and Oerlikon as a sole source supplier manufactured these components. The process include helping them design parts which have best functionality, consolidate parts if needed be and then taking it up one step further by manufacturing those parts for them.

Urwahn

With a rising trends towards people taking up biking, Oerlikon AM is working with a cycle manufacturer in Germany – Urwahn to rethink cycle frames. Oerlikon AM is working with them to build light and functional frames.

Great to have this interview with you on the sidelines of AMTC and it is a great line up again as usual, What would you say are the key objectives of AMTC and how is it contributing to push the adoption of AM?

This conference followed three Munich Technology Conferences and the aim of this conference was to use the post-pandemic bounce back to fuel further growth. This platform provides the perfect forum for the entire ecosystem to come together to exchange their knowledge, best practice examples, network and find business opportunities together.

For a new technology to really grow in the earlier years the ecosystem has to come together and collaborate. The regulations, standards need to be developed by all stakeholders at an industry level so that it gives the customers confidence that his technology is reliable, scalable and cost-effective. This platform provides this opportunity to the industry, academia and policy makers to come together and collaborate.

ABOUT THE AUTHOR

Aditya Chandavarkar
Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

Additive Manufacturing is disrupting the spare parts supply chain in the maritime & offshore industry

Kenlip Ong and Hakon Ellekjaer

> Over the last decade however, we have seen Additive Manufacturing (AM), or 3D printing, make its way into the maritime sector – redefining the maritime and offshore spare parts supply chain

When a vessel is in need of a spare parts, it is conventionally shipped from a central warehouse to the ship's next port destination. However, with vessels that are decades old at best, delivery and production is not always as straightforward as they require spare parts that are either no longer manufactured or require a long lead time. This process often becomes costly and inefficient.

Over the last decade however, we have seen Additive Manufacturing (AM), or 3D printing, make its way into the maritime sector – redefining the maritime and offshore spare parts supply chain and the way spare parts are made with its ability to manufacture rapidly and with flexibility. Its varied modalities have been largely proven in other sectors with improved mechanical and economic performance.

According to Jabil's research (2021), there is steady progression of industry adopters where AM accounts for at least 10% of spare parts production. The research also indicates customers placing an emphasis on design capabilities, ability to scale and companies' expertise in AM when selecting an outsourced partner for printing.

The partnership between thyssenkrupp and Wilhelmsen addresses these points specifically through their AM Fulfilment Platform. With thyssenkrupp's expertise in AM and Wilhelmsen's long standing supply chain know-how and maritime distribution network, the platform enables a more cost effective, on-demand manufacturing solution, providing just-in-time deliveries.

Vessels now have the option to print their needed spare parts upon demand to its required measurement, using the most appropriate material. With the platform's many global partners, it allows spare parts to be fabricated at locations closest to the vessel within a short lead time. There is no doubt this business model is effective in strengthening on-demand AM capabilities across the entire spare parts supply chain while increasing cost performance.

The partnership is unique in that it relies on a decentralised manufacturing approach yet provides spare parts that meet industry standards and expectations customers have come to uphold from such established global companies. A Quality Assurance Framework endorsed by DNV governs the workflow and ensures that quality and fitness-for-purpose is considered at every step of the fabrication process.

Cooperating with several Original Equipment Manufacturers (OEMs), the venture empowers OEMs to reduce their supply chain costs and improve customer experience through increased serviceability and shorter delivery times in key locations. The thyssenkrupp and Wilhelmsen partnership has since successfully printed and delivered quality parts for customers across the world through its fulfilment platform.

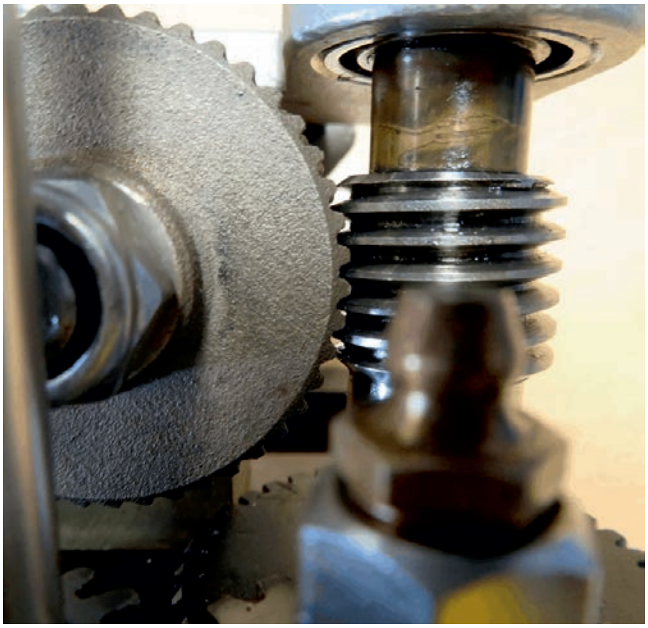
HVAC Condenser Fan Blade

The part shown is a HVAC Condenser Fan Blade, which is used to extract heated air from the condenser coil. By printing the part using fused deposition modelling, production lead time was shortened to 3 days.

The fan was fabricated using high temperature carbon fibre nylon instead of aluminium to eliminate corrosion issues. The part is not only 30% lighter but has maintained equal strength and thermal stability. This translates to quieter operation, fewer maintenance requirements and lower running costs.

Worm Gear

The thyssenkrupp and Wilhelmsen 3D printing venture has also expanded their technology capabilities to



*Identified and designed by Ivaldi

encompass metal binder jetting deposition. The spare part was done in relation to the Singapore Joint Industry Programme, together with DNV, Ivaldi, tytus3D, and a number of OEMs and end users.

The Worm Gear is part of a specialised high pressure-generating system. This obsolete part faces long lead times or, more often than not, non-availability due to the complex gear tooth profile.

Employing the binder jetting process, the Worm Gear was enhanced both in functionality and durability through passivation for extra corrosion resistance and the usage of a comparable material. With the customisable function, in terms of materials or dimensions, it allows for replacement of a damaged component instead of the whole system.

Spider Coupling

"Yinson recently received a 3D printed spider coupling for the Hydroclone Process Skid LP Pump. I would like to appreciate the quality of the material and accuracy of the workmanship provided by thyssenkrupp and Wilhelmsen. The item was also fabricated and delivered in a relatively short time" said Yinson – Maintenance Supervisor FPSO Helang

Manufacturing spare parts using AM technologies will greatly reduce both lead time and costs with greater flexibility as well as improve performance and increase service life. It can address part obsolescence, while shifting distributed supply chain and storage to a digital warehousing solution with local print-on-demand for replacement of spare parts.

With this one-stop digital manufacturing platform, thyssenkrupp and Wilhelmsen are bringing together a global footprint of partners, consisting of OEMs, end users, 3D Printing manufacturing partners and classification societies. The vast network will strengthen the feasibility for commercial adoption of AM, reshaping the maritime and offshore spare parts supply chain.

ABOUT THE AUTHOR

Kenlip Ong

Head of Additive Manufacturing – thyssenkrupp

Experienced Director Strategy Business Development with a demonstrated history of working in the mechanical or industrial engineering industry. Skilled in Strategic Partnerships, Management, and Start-ups. Strong sales professional graduated from University of California, Los Angeles – The Anderson School of Management..

Hakon Ellekjaer

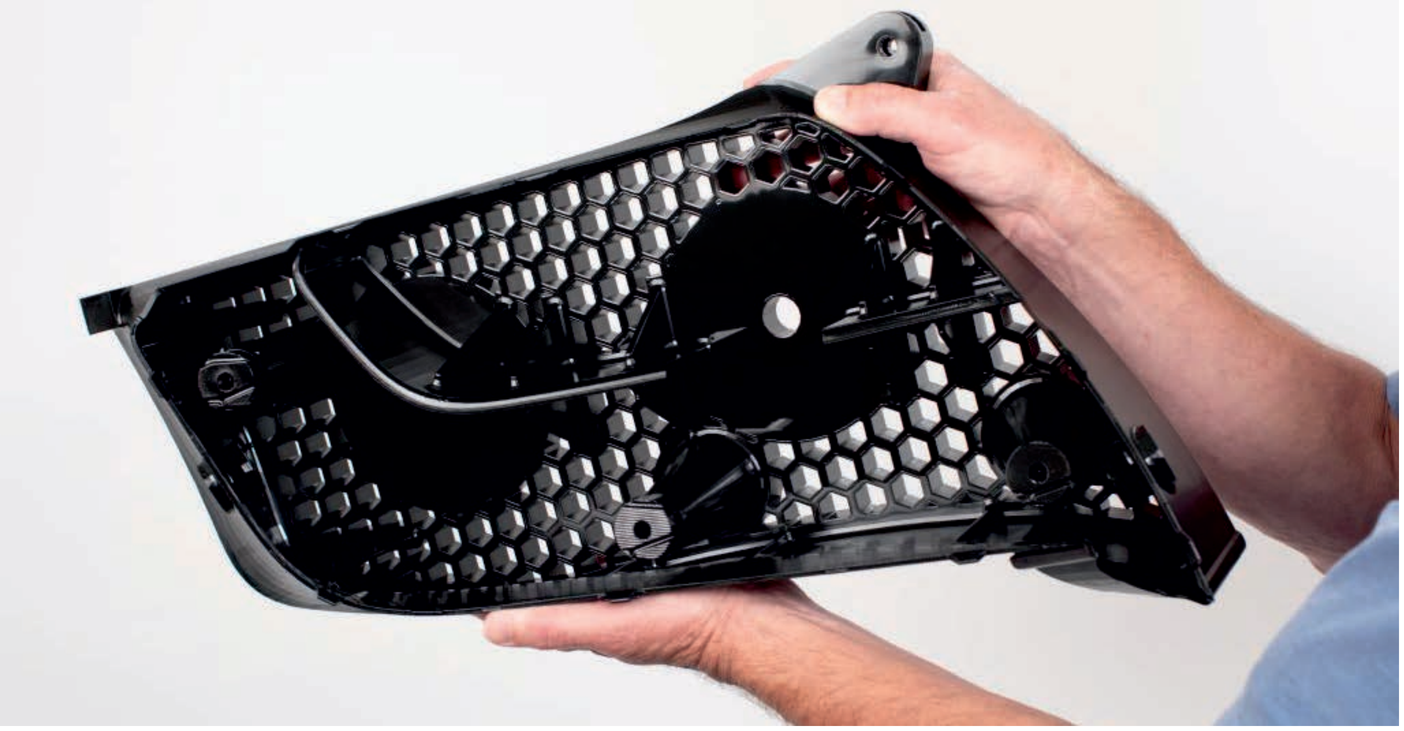
Head of Venture – 3D Printing, Wilhelmsen group

Hakon Ellekjaer is shipping and previous management consulting professional with a strong track record from transformation projects and digital ventures. Passionate about innovation and transformation – developing and bringing innovative products, solutions and services to the maritime industry. As Head of Venture – 3D Printing, he is fulfilling the vision to disrupt the supply chain for marine parts.

Redefining AM Production with High Performance Plastics and Batch Productivity

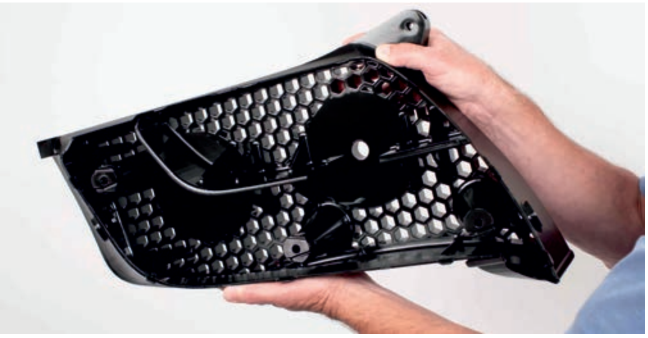
Aditya Chandavarkar

The growing speed, accuracy, and versatility of additive manufacturing positions it more and more as an ideal solution for modern industrial production needs



While additive manufacturing (AM) has traditionally been used as a prototyping tool, its rapid maturation in recent years has encouraged many manufacturers to adopt the technology for end-use production parts across a range of applications. Much has changed with the technology, including the development of additive manufacturing processes and materials that are capable of meeting manufacturers' standards for factors such as repeatability, reliability, accuracy, surface finish, and more. Specifically, advancements from 3D Systems are making it possible to rapidly iterate and produce durable, repeatable parts, not just using thermoplastics, but now also with advanced photopolymers with long-term stability of mechanical properties in both indoor and outdoor environments, which was previously not possible.

3D Systems' materials scientists are engineering materials that are expanding the applications for additive manufacturing. Its rapidly growing portfolio of production-grade industrial resins for the Figure 4 printing solution are designed specifically for both batch-run, end-use part manufacturing, as well as functional and design aesthetic prototyping applications. These materials feature long-term mechanical performance and stability – up to eight years indoor and one and a half years in outdoor environments – and are suitable for demanding applications in industries such as consumer electronics, automotive and motorsports, healthcare, industrial goods, and aerospace and defense.



TOYOTA Gazoo Racing manufactured this automotive grill CNC fixture using 3D Systems' new Accura AMX Rigid Black – achieving a long-lasting production part with smooth sidewalls & superior isotropic strength.

These advancements go beyond the Figure 4 platform. 3D Systems is also bringing these new material capabilities to its stereolithography (SLA) platforms with new production-grade acrylate resin, Accura® AMX™ Rigid Black, which was inspired in part by the advanced production application requirements of TOYOTA Gazoo Racing (TGR). This tough, long-lasting material is the first to produce large-scale additively manufactured parts with exceptional resolution, accuracy, and surface quality capable of withstanding the rigors of long-term mechanical use.

According to Alexander Liebold, group leader, production engineering & future technologies, TGR-E, Accura AMX Rigid Black allows TGR to deliver larger, complex stereolithography parts, including full-scale manufacturing aids. "Using Accura AMX Rigid Black we achieved 90% time savings and 60% cost savings in comparison to the previous handwork processes for a batch of 40 parts," said Liebold. "Unlike other additive production technologies, parts in Accura AMX Rigid Black provide very smooth sidewalls and superior isotropic strength, critical for accurate jigs and fixtures that are in constant use. Now we can turn around any large-scale part and be confident it will perform as required, for as long as we need. This is a real game-changer for production manufacturing."

Efficient Batch-Volume Production with Additive Manufacturing

Even with these advancements, there is more to being production-ready than material properties. Production volumes are also a significant piece of the equation. 3D Systems has solved for this as well with a software feature it calls high-density stacking, and it has been tested and validated as a viable production technology by the largest sporting goods retailer in the world.

When faced with a mold injection problem on a small component for shooting glasses that connects the frame to the lenses, French company Decathlon opted to test 3D Systems' new 3D stacking solution to evaluate additive manufacturing for production. The stacking feature helps users print high volume batches with an efficient file preparation workflow that results in more parts out of the printer in less time.

Decathlon's additive manufacturing lab (ADDLAB) uses 3D Systems' Figure 4 solution across a range of applications, and according to Decathlon materials engineer Gregoire Mercusot, stacking has reduced print preparation time by as much as 80-percent: "By stacking parts we are able to print in batches of 100, and

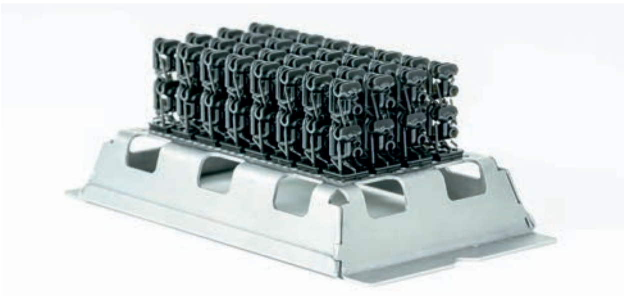


Figure 4 solution with 3D Sprint stacking feature enables batch-run production at Decatlon

have reduced the time it takes to prepare a build from 30 to 60 minutes to just six to 10 minutes," said Mercusot.

Additive Manufacturing Provides Depth and Breadth to Traditional Manufacturing

While additive manufacturing is unlikely to entirely replace traditional manufacturing modes used for the highest production volumes, advances in production-grade materials, technology and software have made it economically viable for manufacturers that require greater breadth of production; significant quantities of initial series production, post-series production, and spare parts production. This technology is also making it possible for manufacturers to increase the depth and flexibility of their production process, even as they are delivering parts with greater cost efficiency.

The mold injection problems Decathlon was having during previous production runs of their shooting glasses component are something they are now equipped to avoid. After conducting a feasibility study on the Figure 4 solution and stacking feature, Decathlon's teams confirmed the productivity and economics of additive manufacturing and decided that this solution could be considered for batch-run production of the final product.

The high-density stacking capability of Figure 4 brings efficiencies of scale to post-processing as well as part building, allowing Decathlon to treat a batch of parts the same as a single part. This means the time it would take Decathlon to clean, cure, and remove the supports from a single part remains the same, even for a batch of 100 parts. Decathlon uses the Figure 4 Modular system to print stacks of 100 parts in 85 minutes, which is equivalent to just 42 seconds per part. For Decathlon's safety glass application, it takes six minutes to clean all 100 parts, 90 minutes of hands-free time to cure them, and ten minutes to remove supports from the entire batch.

"The combination of stacking and production-grade materials makes Figure 4 ready for production," remarked Mercusot.

The growing speed, accuracy, and versatility of additive manufacturing positions it more and more as an ideal solution for modern industrial production needs — either for complex, multi-part assemblies or small yet vital single plastic components. With 3D Systems' innovative additive manufacturing technology, as well as its wide portfolio of tough, durable, production-grade plastics, it's time to consider incorporating AM into your production workflows.

ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

Additive Manufacturing Materials Enabling Circular Economy

Aditya Chandavarkar

> In this article we focus on Metal Additive Manufacturing and moreover the impact materials play in the sustainability aspect of the process.

Since the industrial revolution, humankind has been following a linear model of production and consumption. Raw materials have been transformed into goods that are sold, used and turned into waste that is many times unconsciously discarded and managed. On the opposite, the circular economy is an industrial model that is regenerative by intention and design and aims to improve resources' performance and fight the volatility that climate change might bring to businesses.

Additive manufacturing (AM) inherently generates less waste than the conventional manufacturing. AM encompasses a wide range of technologies each with its own intricacies and challenges. In this article we focus on Metal Additive Manufacturing and moreover the impact materials play in the sustainability aspect of the process.

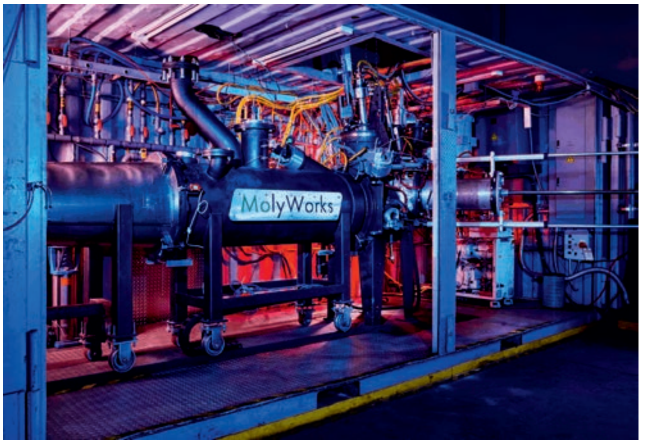
Focus on Metals

Metals are the most suitable for an optimal circular economy due to their inherent nature of being highly recyclable. Furthermore, it is shown that Powder Bed Laser Fusion is well suited manufacturing process for the circular economy, as the waste generated in the process can be efficiently recycled back into usable powder feedstock in a closed-loop, alloy specific manner. Preparing powder for additive manufacturing directly from scrap feedstock could also help to reduce the relatively high price of powders that are used today in additive manufacturing.

However, more research is needed as energy optimization is still far from the ideal values. As presented in this research, plastics are among the materials most commonly reviewed because of their higher usage in AM. Materials with better recyclability, reuse or circularity will be more feasible for future use in AM, as national policies increasingly move manufacturing toward green materials and processes.

One Company is Leading the Way

One of the leading manufacturers of sustainable metal powder is MolyWorks Materials Corporation. The company has invented a revolutionary compact recycling foundry, "The Greyhound system", that is able to upcycle scrap metals to sustainable additive manufacturing grade powder in a single step, near the point-of-need. Their mission is to create the circular economy for metal. The greenhouse gas emissions (GHGs) analysis shows that MolyWorks Titanium powder produces around 89% less CO_2 emissions than the traditional powder. Using renewable power at 90%, such as in California, the process can reduce CO_2 emissions by 99%.



The system is suitable for small batches and large-scale production of standard and custom alloys, including refractory metal powder. The technology has been demonstrated with more than 24 metal alloys and used for land, air, sea, and space applications. In addition to the ISO9001, the USA facility will be getting the AS9100 certification in early Q4'2021 to support more aerospace projects. MolyWorks has also decided to expand into Asia Pacific by locating a new foundry in Singapore that will be operational in early 2022. Embracing an ecosystem approach, the company welcomes strategic partners in Asia Pacific to co-develop new material needed to open up more industry applications using AM technology. For details, please contact Albert Sutiono, APAC Partnerships Director at asutiono@molyworks.com.

References

- Henry A. Colorado, Elkin I. Gutiérrez Velásquez, Sergio Neves Monteiro, Sustainability of additive manufacturing: the circular economy of materials and environmental perspectives,Journal of Materials Research and Technology, Volume 9, Issue 4,

- The Additive Manufacturer Green Trade Association in Collaboration with Delft University of Technology Presents: State of Knowledge on the Environmental Impacts of Metal Additive Manufacturing by Jeremy Faludi, Ph.D. and Corrie Van Sice

- https://www.thinkstep-anz.com/resrc/blogs/additive-manufacturing-re-thinking-how-we-use-materials-in-a-circular-economy/
- https://www2.deloitte.com/us/en/insights/focus/3d-opportunity/additive-manufacturing-in-lca-analysis.html

ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

TÜV SÜD now offers New Standard for Industrial Additive Manufacturing

This new standard adopts an integrated approach, which is suitable for regulated sectors, including the automotive, rail, aerospace and medtech industries.

TÜV SÜD Product Service offers certification of industrial additive manufacturing sites in accordance with the new ISO/ASTM 52920 standard. The standard describes quality-assurance requirements and forms part of the ISO/ASTM 52900 series, which is fundamental for this relatively new industry.

"Using the new standard, component manufacturers can streamline supplier audits to an enormous extent", says Simon Schlagintweit, Lead Auditor Additive Manufacturing at TÜV SÜD. "This facilitates the auditing process and ensures the quality of industrial-scale additive manufacturing throughout the supply chain." Even the tiniest deviations in feedstock or machine calibration may adversely affect component stability. Given this, ISO/ASTM 52920 defines both quality-related factors in the process chain and processes at manufacturing sites. ISO/ASTM 52920 is divided into three aspects: "Qualification of the additive system operations", "Quality assurance" and "Verification of the part requirements". Sub-aspects include data preparation, system setup and post-processing. Other essential clauses concern the continuous improvement process, part specifications and a validation plan.

Integrated Instead of Product Specific.

The new standard adopts an integrated instead of a product-specific approach, which is also suitable for regulated sectors, including the automotive, rail, aerospace and medtech industries. It applies to all methods included in the scope of the ISO/ASTM 52900 standard and was developed in a collaboration between the ISO/TC 261 "Additive Manufacturing" and CEN/TC 438 "Additive Manufacturing Processes" Technical Committees of the French standardisation institute, Association française de normalisation (AFNOR). In Germany, the "Additive Manufacturing" working committee of the DIN Standards Committee Technology of Materials was involved in the development.

TÜV SÜD supports users, customers and manufacturers in quality assurance for additive manufacturing. This includes expert personnel, implementation of defined manufacturing processes and handling of special feedstock as well as issues such as standardisation, delivery periods and reproducible quality. Represented throughout the world, TÜV SÜD experts have comprehensive industry experience and have participated in standardisation projects such as DIN SPEC 17071.

Standards are key for the adoption of Additive Manufacturing Technologies in Asia

Aditya Chandavarkar

Dr Alexander Liu helps us understand more about the benefits of standards and how the AM Community from Asia can participate in this process.

Additive manufacturing is a process of creating three-dimensional objects by the successive addition of material (plastic, metal, ceramic, composite, or other material) as opposed to conventional manufacturing which is subtractive in nature. Today, new technologies, advanced industrial Additive Manufacturing (AM) equipment, and better performance materials are driving the productivity and reliability of AM-based production. This in turn has led to adoption of this technology by diverse range of industries including aerospace, energy, automotive, medicine, consumer products, and more which

On the surface it feels that it is easy to understand and adopt this technology as it only has seven technology groups. However with subtle variations of each process, system and the diverse requirements of the end user industries, identifying the right AM roadmap and keeping up with the development for organisations can be very challenging.

As the AM industry continues to expand, standards will play a key role in ensuring sustainable growth for this technology. To understand more about the benefits of standards and how the AM Community from Asia can participate in this process, we connect with Alexander Liu, Head of Additive Manufacturing Programs, Asia Region, ASTM International.

Dr. Alex Liu

Dr. Alex Liu is Head of Additive Manufacturing Programs – Asia region at ASTM International. In his role, he works closely with key organisations in Asia to curate AM programs that contribute and lead to standards development. He has a B.Eng in Mechatronics and Robotics Automation and a PhD in Mechanical Engineering, focusing on process and materials characterization for metal additive manufacturing. He has received and managed grants more than $10M and works closely with various industries and government agencies for establishing automation and communication within an AM set up. He is also a reviewer for Materials Characterization Journal and has co-authored more than 10 peer reviewed publications with more than 35 technical and business presentations around Asia. He has received a total of 10 awards and patents in the area of additive manufacturing.

What would be the first step to participate in the AM standards development process ?

There are several activities and initiatives in AM Standardization that present the opportunity for the AM community in Asia to participate in. These activities are all on a global scale and highly relevant in Asia. It is also a learning and networking opportunity by participating in these activities, in particular, the joint ASTM F42 and ISO TC 261 bi-annual meetings.

The most convenient and direct option for anyone in Asia to be plugged into the global AM network is to sign up for ASTM annual membership. The membership can be student (free), individual ($75), or organizational ($400). One of the benefits is that upon signing up, the member will select a volume number and receive a free volume of the latest Annual Book of ASTM Standards. An ASTM member can indicate the committee/subcommittee(s) he/she wishes to join. In the case of Additive Manufacturing, it will be F42 and its subcommittees. This is the first step in paving the way to participate in AM standards development. Beyond F42, the ASTM membership also allows participation in other committees on emerging areas such as F45 on Robotics, Automation, and Autonomous Systems, and committee F38 on Unmanned Aircraft Systems.

What are the benefits of becoming an F42 member ?

As an F42 member, one can register to join in person for the ASTM F42/ISO TC261 bi-annual meetings to meet AM technical experts. In these meetings, a member will be able to attend both ASTM F42 and ISO TC261 plenary meetings. It is an ideal way to get updated with the latest standards development work on AM. It also

offers an opportunity for a member to indicate his/her interest to be a working group member for on-going areas of standardization. These meetings offer an avenue for members to also discuss and identify new areas of standardization such as AM Applications (F42.07) and AM Test Methods (F42.01).

What other activities can F42 members participate in ?

The F42 committee meets in person twice a year and there have been 24 meetings since 2009, with 10 meetings outside of the US. Till date, F42 meetings continue to attract huge interest and participation from the AM community. Besides the biannual meeting, members within each working group attend conference calls at least once every month. This practice has worked well in ASTM's standards development processes. ASTM F42 frequently receives requests from members to hold meetings at various locations and the figure shows the locations of F42 meetings since 2009.

After understanding how to be part of a global activity on AM standards development, you can contact Alex at aliu@astm.org to be involved today.

ABOUT THE AUTHOR

Aditya Chandavarkar

Co-founder - AM Chronicle

Aditya Chandavarkar is a established entrepreneur with business interests in manufacturing, innovative technology, training consulting. He is closely associated with cutting edge application industries for inkjet, 3D Printing (Additive Manufacturing) and Packaging.

Part 1: AM standards: A burden or a boost for the adoption?

Dr. Sastry Y Kandukuri

In this article we examine the need for standards and how standards adoption can help to boost technology adoption.

Standards can positively contribute to the development and adoption of a new technology such as additive manufacturing (AM), however some stakeholders in the AM industry and its supply chain may believe that the standards are a burden because it may add significant cost to product price. In this article let us examine the need for standards and how standards adoption can help to boost technology adoption.

A big challenge that the AM industry needs to address to be more widely accepted and adopted is the concern regarding the variations in part quality from build to build. Is this a mere concern or a myth or a reality? Does anybody know the answer? Well, it seems nobody knows the precise answer. Why because to know there are variations you need to first identify and quantify the variations based on certain scientific principles and compare them. How can we do that? One can do this by using relevant standards and certification.

If we look at the biggest obstacles to AM, we can think of many topics including but not limited to slow production rates, high production costs, non-automatable processing steps, big data silos, lack of skilled workforce etc. If the principal question regarding part-to-part variation remains unsettled, then the technology usage will continue to rise but trust will not grow. The loss of trust may create a vicious circle which might not be easy to break. Hidden costs we pay due to lack of trust is something we don't realize or don't know or don't want to know.

Since part-to-part quality variation is linked to production control and effective quality assurance using right standards can ensure the quality and reliability of AM parts.

Here I try to list some of the benefits of using standards-based certification

- Traceability
- Fit for purpose / it will work when needed
- Compliance with regulations
- Insurance pre requirement
- Statutory, Legal requirement
- Security, Piece of mind
- Avoid catastrophes / Risk mitigation
- Protect life, property, environment
- Protect your rights, avoid court case
- To avoid contractual conflicts
- Effective communication
- Transparency in requirements

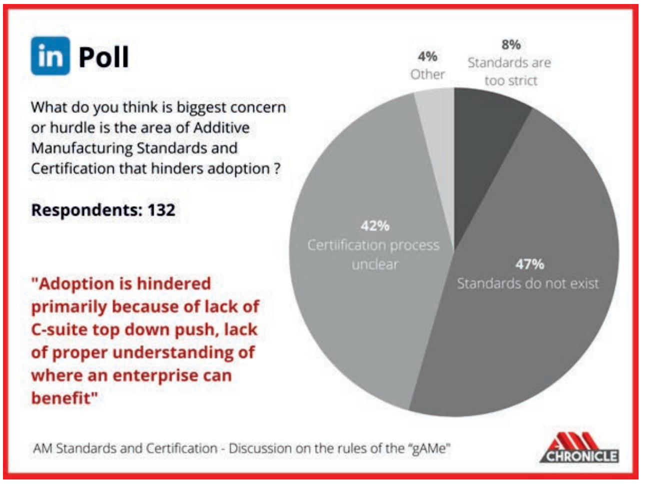
An example list of additional tasks one must think when they need to comply a standard are

- Additional documentation
- Additional audit
- Additional testing
- Additional cost
- Involving third party

Despite the additional tasks related to certification, one can achieve cost effective certification by following means :

- Understand documentation, testing, inspection requirements to avoid unnecessary work
- Choose an expert third-party organisation with knowledge and technical abilities
- Involve third-party from early planning stage for good advice on cost-effective certification and / reuse knowledge from trial testing phase

With standards, end users can compare apples to apples and make right decisions and manufacturers can prove that they deliver parts that meet the contract obligations as a result this can benefit the whole eco system.



In October 2021, we conducted an online survey on Linkedin reaching out to key stakeholers in the industry to understand the priorities of AM community.

Extracts from the comments:

- Adoption is hindered primarily because of lack of C-suite top down push, lack of proper understanding of where an enterprise can benefit
  Challenge is it has too many variables.
- The cost and knowledge barrier are very, very high now.

- A lot of knowledge and best practices are kept confidential. This is a big barrier to adoption.
  Not only do the standards not exist, I'm not sure we know what needs to be measured. The benefit of making assumptions early on, is that it allows you to progress. The downside is that some of the assumptions get confused as requirements.
- We are just starting out to understand the certification process, but it is difficult to get firm answers to tell us what to do from various interested parties.
- Unless you know what you are creating a standard for you could potentially go around in circles and spend money on R&D where only 10% of that makes it all the way through.
  Standards benefit from consensus around best practices, which are still being discovered.

Thank you to all participants for sharing their valuable insights. We will provide expert commentary on these points in our next articles of this series. Please stay tuned.

ABOUT THE AUTHOR

Dr Sastry Y Kandukuri

Senior Principal Specialist - Materials and Additive Manufacturing at DNV, Norway

Dr. Sastry Kandukuri is a passionate and experienced digital materials and manufacturing technology professional with Doctorate/Maters/Bachelor degrees in Metallurgy and Materials Engineering and Masters degree in Computer Science coupled with more than 20 years of diverse experience in Maritime, Oil & Gas and Manufacturing sectors.

AM NEWS

Materialise and Proponent sign deal for 3D printing for aerospace supply chain

Materialise and Proponent have announced a partnership that will raise the profile of 3D printing in aerospace aftermarket supply chains. Proponent, headquartered in Brea, California, is an independent distributor of aircraft parts. Materialise, headquartered in Leuven, Belgium, is a 3D printing company. With the partnership, Materialise and Proponent seek to partner with aerospace OEMs and suppliers to offer airlines and MROs a one-stop-shop solution for aftermarket parts where 3D printing is featured alongside other manufacturing technologies.

Bart Van der Schueren, Materialise CTO, said "Open solutions and a collaborative approach have always been crucial to Materialise. Today we are excited to combine our capabilities as an EASA 21.G-certified production organization with Proponent's reach and central position in the aerospace supply chain. This brings 3D printing technology right in the comfort zone of the aerospace industry's well-established supply chains."

Andrew Todhunter, Proponent's CEO, said "3D printing represents an opportunity to help our OEM and Supplier Partners to become more efficient in their supply chains and complements our stocking distribution model. Producing customised parts or small production runs through AM gives us an opportunity to source on-demand, sustainably, and avoid high minimum order quantities. Our customers get what they need, when they need it, and OEMs avoid the cost and risks that come with manufacturing these parts."

Proponent provides traditional distribution services to airlines, MROs and OEMs, as well as innovative inventory management solutions. The company ships 54 million parts per year to over 6,000 aerospace customers in over 100 countries. The majority of parts serve the aftermarket, with applications spanning cabin interiors, engines, airframe and cockpits.

Materialise manufactures 700 part series per year for diverse aerospace customers, from leading OEMs to MROs and supplier tiers. This includes an estimated 26,000 parts per year for the Airbus A350 system alone. Materialise is also currently the only supplier to offer manufacturing services in two 3D printing technologies approved by Airbus for flight-ready parts, since becoming Airbus's first manufacturer for the Selective Laser Sintering (SLS) technology in May this year.

VIT Chennai inaugurates new Additive Manufacturing Centre

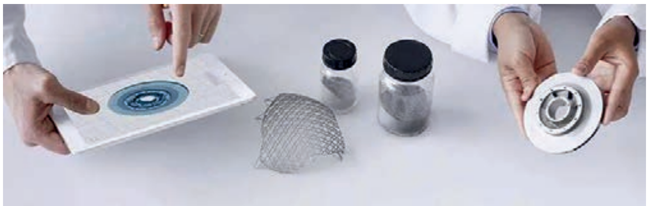
Vellore Institute of Technology (VIT) Chancellor G Viswanathan inaugurated a new building for the Centre of Excellence for Additive Manufacturing established at VIT Chennai.

The centre is getting equipped with industrial-grade 3D printers of various popularly used technologies, including Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Stereolithography (SLA), Digital Light Processing (DLP) and co-extrusion based composite printing.

The centre is expected to cater to all the academic and industrial requirements. The inauguration function was attended by Sankar Viswanathan, vice president, Dr Kanchana Bhaaskaran, Pro-vice Chancellor and Dr PK Manoharan, Additional Registrar. Addressing the gathering, Dr Viswanathan emphasized on the potential of additive manufacturing in the future.

Sandvik further strengthens its Metal AM Powder sales organization

Sandvik Additive Manufacturing is further strengthening the sales organization for its wide range of Osprey® metal powders, to meet the increasing demand for metal powder.



Dr. Martin McMahon has been appointed Head of Global Powder Sales. He has a PhD in Materials Science and Engineering from Liverpool University – and an extensive experience from the metal additive manufacturing sector, where he's held several senior positions with companies such as Renishaw and 3T Additive Manufacturing. Joining Sandvik from his most recent assignment as Business Development Director at Aluminium Materials Technologies, Martin is a pioneer in applications and alloy development, having played a key role in introducing AM to a number of industrial sectors such as aerospace, automotive, defense, oil and gas, energy, medical, and food.

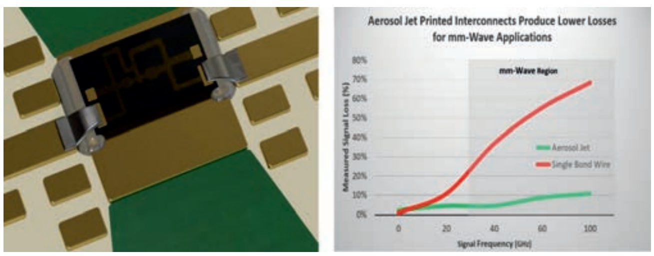
In addition, Sandvik is also reinforcing the EMEA metal powder sales team with two additional sales representatives: Manuel Winkler and Olesia Khafizova. Manuel Winkler has a Master's degree in technical management from Clausthal University of Technology, and started his career in quality management, consulting and sales related roles at international enterprises and global manufacturers for automotive and the processing industry. Formerly, he entered Sandvik Hyperion as a Sales Specialist in metal machining – and built up a successful customer portfolio which he's pursued at Hyperion Materials and Technologies up until now.

Dr. Olesia Khafizova has a PhD in Mechanical Engineering from Saint Petersburg Mining University where she majored in improving mechanical properties of welded joints. Since 2016, she has been a Market Manager for Composites and Additive Manufacturing at Shimadzu Europe GmbH, where she managed R&D projects on material testing solutions in collaboration with the global headquarter and international industrial and research partners. Olesia successfully supported the sales of products for AM materials assessment and handled aspects of the sales and post-sales process, and has also been involved in regulatory requirements such as DIN, ISO, ASTM and Nadcap.

.

3D Printed Electronics Solution by Optomec Increases 5G Signals by up to 100%

Optomec has introduced a new high performance semiconductor packaging solution for the rapidly growing mm-wave electronics market, in response to demands from its customers in the 5G, Autonomous Vehicle, Defense and Medical segments. Millimeter-wave integrated circuit (IC) use is growing at 27% CAGR, but has been hampered in many applications because



the traditional techniques used to connect the ICs to the circuits result in poor circuit performance in the form of low wireless range and/or high power consumption. Optomec's 3D Printed Interconnect solution addresses this deficiency, preserving device performance with low loss connections.

Optomec customers have reported up to a 100% increase in transmitted signal power for each circuit connection in the millimeter range. This translates to longer point-to-point range for wireless data transmission, reduced energy consumption and, because lower-power ICs can operate at lower temperatures, increased IC life. The millimeter-wave frequency band comprises 30 to 300 GHz. Whereas today's typical wireless network in the home or office operates at 5 GHz, next generation wireless mm-wave networks will operate at frequencies up to 53 GHz; automotive radar, defense applications and medical imaging sensors operate at even higher frequencies. The older methods of connecting ICs, such as the use of tiny gold wires, is less and less effective as the frequency increases, but the Aerosol Jet® method of printing the connection to ICs is much more efficient, with performance that nearly matches the etched copper traces of circuit boards.

“Our customers are reporting some very impressive performance improvements for mm-Wave interconnects.” said Bryan Germann, Optomec Product Manager. “Customers across many industries using millimeter wave frequency bands are seeing the benefits of printing interconnects in lieu of standard wire or ribbon bonds. The benefit of shorter, better impedance matched transitions lower losses for each die-to-die or die-to-board transition. This leads to improvements in overall device efficiency and performance.”

The Aerosol Jet® process works by jetting extremely fine droplets of nanoparticle conductive inks onto circuit boards and components from a distance of up to 10 mm away, yet it can produce conductive features as fine as 10 microns in width. Optomec's new Aerosol Jet® HD2 printer with ultra-high printing resolution and integrated vision-based alignment has been optimized to support this new IC solution for full production applications. The HD2 supports standardized in-line automation for direct integration into existing packaging lines. Optomec further offers its customers pre-qualified printing recipes and application libraries for a total solution that is production ready.

Protolabs to Expand Additive Manufacturing Footprint with new facility

Global digital manufacturing company, Protolabs, has signed an occupancy agreement to expand its additive

manufacturing footprint in the Raleigh, N.C., area. Breaking ground later this month, the second location will add 120,000 sq. ft. of manufacturing capacity to its current facility located nearby in Morrisville, N.C. The additional location is in response to growing demand for Protolabs' 3D printing services.

“We have experienced strong growth in our 3D printing services as more of our customers expand their applications that use additive manufacturing for both prototyping and production,” Mike Kenison, Protolabs general manager and vice president of Americas, said. “The Raleigh community has provided a great home for our additive headquarters, and we look forward to growing our presence in the years ahead.”

Protolabs worked with Capital Associates, a Raleigh-based real estate company, to facilitate the development of the manufacturing facility. Capital Associates will serve as owner of the property, and Protolabs expects to occupy the location by late 2022.

About Protolabs

Protolabs is the world's leading provider of digital manufacturing services. The e-commerce-based company offers injection molding, CNC machining, 3D printing, and sheet metal fabrication to product developers, engineers, and supply chain teams across the globe. Protolabs serves customers using in-house production capabilities that bring unprecedented speed in tandem with Hubs, a Protolabs Company, which serves customers through its network of premium manufacturing partners. Together, they help companies bring new ideas to market with the fastest and most comprehensive digital manufacturing service in the world. Visit protolabs.com for more information.

Penn State University Student helps optimize Additive Manufacturing

With several research advancements and an industry internship under her belt, Penn State graduate student Paula Clares feels prepared to make a sizable impact in the 3D-printing industry.

With projects ranging from 3D-printing ceramics to polymers to metals, she explained earning her master's from the Additive Manufacturing and Design Program is setting her up for success.

"It covers everything someone would need: design, theory and electives you can choose based on your interests," said Clares, who will be graduating in the spring. "Even after one year, I felt the program is preparing me 100% for the industry."

With multiple material options, Clares said, 3D-printing technology creates unique components layer by layer, unlocking a previously unimagined design freedom and complexity.

As a graduate researcher in the SHAPE Lab – Systems for Hybrid-Additive Process Engineering Lab, Clares explores how a mixture of particle sizes within the materials could potentially strengthen and enhance a component's use and applications.

"I was hypothesizing that if you use a mixture of different-sized particles, called bimodal size distribution, for 3D-printing ceramic, you can achieve higher density, flowability and lower porosity," she said. "By increasing these mechanical properties, at the end of the day you will have a stronger part."

She presented her results at the Manufacturing Science and Engineering Conference (MSEC 2021), which is organized by ASME, the American Society of Mechanical Engineers.

Clares explained that ceramics are an interesting material to study since their distinct characteristics, including high hardness, resistance to wear and bio-capabilities, make them attractive for many 3D-printed applications in aerospace, biomedical and automotive industries.

However, she isn't limiting herself to one material.

EOS, an industrial 3D-printing company specializing in metal and polymers based near Austin, Texas, hired Clares as an intern within their Additive Minds team this past summer. Through this experience, she extended her expertise to polymer lattice structures, which are honeycomb-like designs, as opposed to completely solid pieces, that can add unique and useful properties to 3D-printed components.

“Lattice structures have a good weight-to-strength ratio and they're great for shock absorption and impact,” she said. “For example, you can design a football helmet with a lattice structure that could absorb a hit better than a solid piece, since each structure will dampen the hit before it reaches the person.”

But to create a cutting-edge product like this, different polymer materials, designs and variables of the lattice structure need to be fully explored and defined. Leveraging the company's Digital Foam technology under the guidance of EOS' David Krzeminski, Clares designed experiments and conducted testing for a project intended to become the “guidebook” for 3D-printing these pieces.

“There are so many different parameters you can adjust, such as cell size, lattice type, and how thick they are,” she said. “All of these combinations can produce different performance and use. The main goal for my project was to collect and test the data from different lattice structures and build a database that can be a reference for additive manufacturing designers.”

So, theoretically, an engineer 3D-printing a new type of football helmet could discover which exact type of lattice structure fits their needs, without conducting their own experimentation.

“That complex, fundamental work is already done for them with this database,” Clares said.

Clares' research has been accepted for presentation at a 2022 International Sports Engineering Conference.

With the knowledge gained from her internship and her 2020 work in the SHAPE Lab, guided by Guha Manogharan, the Emmert H. Bashore Faculty Development Assistant Professor, she set out to see whether the effects of bimodal size distribution could also enhance metal-based 3D-printed parts.

This semester, she is performing computational and experimental work to help optimize the metal 3D-printing process for stronger mechanical properties.

“I wanted to explore if the responses I was getting in ceramics with bimodal size distribution applied to metals,” Clares said. “It's about expanding the scope of this knowledge and seeing what is possible.”

As a relatively new frontier in manufacturing, she explained that research in 3D printing, including her own, has the potential to influence the future of the industry and the technology's applications.

“Every discovery can have a huge impact,” she said. “It's such an up-and-coming technology, every discovery opens the door for people to further investigate and build.”

Tata Technologies upgrade 150 industrial training institutes in India

About 150 industrial training institutes (ITIs), which are being upgraded by Tata Technologies Ltd. (TTL) under UDYOGA programme, is ready to be inaugurated in two weeks.

They will begin training students with advanced courses from November 1, according to Higher Education and Skill Development Minister C.N. Ashwath Narayan. Addressing a press conference after

inspecting an ITI at Peenya in Bengaluru on Thursday, the Minister said admissions to the advanced courses were in progress.

The trades that had been permitted as part of the curriculum include Advanced CNC Machining, Basics of Design and Virtual Verification, Artisan Using Advanced Tools, Industrial Robotics and Digital Manufacturing, Manufacturing Process Control, and Automation and Mechanic Electric Vehicle, he said.

The total cost of the project was ₹4,636 crore (State Government 12% and TTL 88%) and in addition to this, the Government was spending ₹220 crore for creation of new civil infrastructure. On the technology side, the investment would bring the latest equipment such as CNC machines, laser cutting machine, Additive Manufacturing or 3D printing machine, industrial robotics, and advanced software, stated an official release.

New Swedish centre to accelerate use of Additive Manufacturing

RISE, a Swedish state-owned research institute, is opening up the Application Center for Additive Manufacturing together with industrial and academic partners to form a national ecosystem for 3D printing.

Combining additive manufacturing, or 3D printing with new sustainable materials, allows for a more flexible and resource-efficient production. But for companies to be able to fully utilise the strength of the technology, support is needed in every step along the supply chain ranging from development of new business models to product design and testing in a real production environment, said a statement.

Additive manufacturing enables a paradigm shift for the industry and is relevant for many sectors such as aerospace, space, automotive, telecom, maritime, and consumer goods to name a few. Some of the advantages are the mass customisation enabling unique tailor-made components that are produced with minimal material waste and that are optimised with regards to their weight.

The global market for additive manufacturing is expected to continue to grow, and for metallic materials the market is expected to increase by a factor of two by 2025. It is important that Sweden continues to invest in additive manufacturing to strengthen its position in this rapidly growing market.

"By gathering end users, suppliers of services, technology and materials with our researchers and experts at RISE, the Application Center for Additive Manufacturing enables us to form a robust national ecosystem for additive manufacturing in Sweden," says Seyed Hosseini, Director of Application Center for Additive Manufacturing.

In the centre, the industrial partners will have access to the latest research carried out by the research partners, test and demonstrate different additive manufacturing technologies including their pre- and post-operations, as well as access expertise and competence along the supply chain. To be successful in such an environment, collaboration, and cooperation between all partners in the Center is vital as each partner has unique competence and experience. The center creates an independent and open environment for such collaboration to take place in Sweden.

"The centre is a good example of how we gather expertise along the entire value chain and create a way to accelerate digital development in the Swedish industry. Additive manufacturing has great potential and now RISE can boost this transformation in taking important steps forward," says Pia Sandvik, CEO at RISE. "Additive manufacturing is one of the new resource-efficient manufacturing technologies that, in addition to more circular material flows, is needed to make the future industry more sustainable. The investment in the Application Center for Additive Manufacturing both broadens and strengthens Västra Götaland's position in innovation and sustainable and digital manufacturing technologies," says Kristina Jonäng (C), chair of the regional development committee in the Västra Götaland region.

15 partners are onboard from the start. The target group for the centre is manufacturing companies, both large and small and medium-sized, but also suppliers of materials, software and equipment for additive manufacturing. The partnership provides the opportunity to take full advantage of the skills and infrastructure that exist and as a partner you also contribute to the center. With the help of the center, the threshold to test and evaluate the technology can be reduced.

The centre is run by RISE together with the centre's 15 partners: AddUp, Alfa Laval, Chalmers, Digital Metal, DNA.am, Ericsson, Höganäs, Materialise, Modul-System HH, Nikon Metrology Europe, RENA Technologies Austria, Ringhals (Vattenfall), Siemens Energy, Volvo Cars, Volvo Group and through support from the Västra Götaland region, Vinnova and European Regional Development Fund. It is physically located at RISE in Mölndal but uses the entire research institute's expertise and knowledge.

Construction 3D Printing in India gets a boost with investment in Tvasta

Tvasta is a startup incubated at IIT-Madras working in the area of construction 3D Printing. As the 3D printed construction market grows, startups and nonprofits alike are beginning to leverage advances in concrete 3D printing technology to address the affordable housing crisis.

Habitat for Humanity International through its Shelter Venture Fund invested Rs 30 million ($411,000) in Tvasta Manufacturing Solutions to increase production of affordable 3D printed homes in India. Hestia Partners and Capnetic Investments joined Habitat in investing in the construction technology startup.

"The pandemic has only exacerbated the affordable housing crisis, with rising demand as well as material costs. Through the Shelter Venture Fund, Habitat is helping ensure that the most promising, disruptive technologies achieve scale, expanding affordable housing markets to reach more low-income families in need of reliable housing," said Patrick Kelley, vice president of Habitat's Terwilliger Center for Innovation in Shelter.

Habitat's investment in Tvasta builds on a multi-year collaboration, beginning when the company was one of seven startups to participate in Habitat's ShelterTech India accelerator program in 2018. ShelterTech accelerators bridge the gap between housing innovation and real-world impact.

According to UN-Habitat, an estimated 1.6 billion people lack adequate housing today, with global demand for affordable housing growing by 4000 units every hour. In order to reach more low-income households, Tvasta is working with the Government of India through its "Pradhan Mantri Awas Yojana" (Housing for All) initiative, which aims to build 20 million urban and rural homes for low-income families by 2022.

Habitat's Terwilliger Center for Innovation in Shelter launched the Shelter Venture Fund in 2017 to invest in shelter entrepreneurs operating in the pioneer gap – where early-stage companies are often considered too new or too risky for conventional venture capital firms. The intent is to accelerate those entrepreneurs' pathways to reaching low-income families with products and services that improve their housing conditions. To date, the Shelter Venture Fund has invested a total of $3 million in 11 startups with disruptive and innovative products and services.

Shapeways launches Otto Software-as-a-Service

Shapeways has announced the launch of its Otto Software-as-a-Service to make the route to industrial-grade additive production 'simpler, faster and more flexible.'

With Otto, manufacturers can gain free access to fully digitised and end-to-end 3D printing workflows that help to remove unnecessary risk and costs. Shapeways first offered a software-as-a-service solution in partnership with ZVerse in 2019, and has now launched its own purpose-built offering in Otto.

Said to be suitable for individual engineers, small businesses, large enterprises and global manufacturers operating within a range of industries, Otto has been designed to expedite each phase of the 3D printing workflow without major capital expenditure or using different software tools. Per Shapeways, the platform simplifies initial digital file uploads, product configurations, file analysis and optimisation with instant auto-correction for trouble-free manufacturability. It also gives users access to Shapeways' supply chain network of 50+ manufacturing partners, 11 3D printing technologies, and more than 90 materials and finishes. This is also supplemented by a comprehensive collection of pre and post-production capabilities, with delivery of parts enabled to more than 160 countries.

"Our goal with Otto is to make it incredibly easy and fast for any manufacturer anywhere to benefit from 3D printing," commented Shapeways CEO Greg Kress. "Enabling seamless access to world-class digital manufacturing removes the required capex and hassles of setting up dedicated production capabilities. Manufacturers can sign up for Otto free of charge and start using our services right away."

DSM, Henkel and BASF are all said to be 'accelerating their shift to digital manufacturing' through Otto, with traditional manufacturers also able to utilise the software as a white-label solution to expand their current capabilities with the addition of on-demand 3D printing.

Massivit is moving into the Composites Additive Manufacturing space.

Massivit 3D Printing Technologies Ltd has announced the introduction of its Massivit 10000 composites tooling system to the composite materials arena at

CAMX 2021 in Dallas, Texas that will take place October 19th-21st. Visitors will be able to discover this new thermoset additive manufacturing system and its range of molding applications.

The Massivit 10000 additive manufacturing system was conceived to overcome the recognized bottleneck associated with composites tooling by automating the process. It leverages thermoset polymer casting materials that provide a high HDT (Heat Deflection Temperature) and low CTE (Coefficient of Thermal Expansion). Based on the company's newly developed Cast-In-Motion (CIM) technology, it combines ultra-fast additive manufacturing with direct casting of proprietary, industrial-grade, dual-component, Epoxy-based material.

The new technology eradicates the need to produce an initial master (or plug). This consolidates existing nineteen-step molding workflows into just four steps. In addition, the Cast-In-Motion technology also offers exceptional geometry freedom for complex designs.

Massivit 3D has already penetrated the global additive manufacturing arena with a portfolio of large-scale 3D printing systems installed by its customers across 40 countries. The company plans to expand into multiple FRP arenas with its new, disruptive technology – including the marine, automotive, railway, consumer goods, sporting goods, aerospace, and other industries. With a build volume of up to 1.2 x 1.5 x 1.65 meters (3.9 x 4.9 x 5.4 feet), the Massivit 10000 is suitable for a wide range of applications for those industries that are looking to dramatically shorten lead times compared to traditional production.

The new Massivit 10000, soon to be launched, will be available at the show for pre-order via a rapidly growing waiting list. "We are thrilled to unveil our advanced Cast-In-Motion technology to the composites manufacturing arena at CAMX 2021" said Erez Zimerman, CEO at Massivit 3D. "This market is hungry for innovation that will shift the paradigm for molding so that manufacturers can finally expedite their lead times from several weeks down to just a few days. By automating the mold production process, we're able to offer manufacturers a way to dramatically cut their costs and reduce the associated material waste. The snowballing demand for this new digital molding solution is testament to the dire need for this technological milestone and we are excited to offer it to the CAMX community in the lead up to the Massivit 10000 launch."

Wabtec Expands is Metal Additive Manufacturing capability

Wabtec has upped its commitment to additive manufacturing with a new 11,000-square-foot facility at the Pittsburgh Airport Innovation Campus in an area dedicated to 3D printing technology. Wabtec has already achieved breakthrough component designs for both freight locomotive and rail transit applications.

The company opened its first additive manufacturing lab in 2019 at its Grove City, Pennsylvania plant. The new, bigger lab features an SLM 800 printer, one of just four in the United States, capable of printing large-scale parts.

The SLM 800 is the big brother to Grove City's SLM 280. These machines use the direct metal laser melting process to fuse metal powder, layer by layer, to form a three-dimensional object. They allow newly engineered component designs, with complex internal shapes and channels, which would be costly or impossible to produce with traditional methods.

Anthony Mott, additive manufacturing leader, explains that the Grove City facility works with non-reactive materials, while the Pittsburgh lab handles reactive metals such as aluminum and titanium. Aluminum reacts with water and titanium burns in the presence of oxygen, so these metals require stringent safety measures.

Mott says they developed and are now testing a new, “very complex heat exchanger” for the exhaust gas recirculation system used in Wabtec's Tier 4 Evolution Series locomotives. The heat exchanger reduces the temperature of extremely hot exhaust gases entering the engine.

The lab designed a heat exchanger that reduces the temperature of the air by several hundred degrees. Mott says it's “something that you wouldn't be able to do any other way.” When finalized, it will be produced in volume on the SLM 280 machine in Grove City.

Another product in testing is a pneumatic brake panel, used in transit vehicles. Currently produced from several pieces of milled aluminum and assembled in an oven, it's a labor-intensive process. “Instead, we're printing it all as a consolidated piece,” says Mott. The brake panels will be produced on the SLM 800 at the technology campus.

The SLM 800 machine is equipped with the SLM HUB Automatic Unpacking Station, which flushes excess metal powder from the component after it's printed, recycling it back to the printer. “There's only one of those in the United States and we have it here,” Mott tells Trains.

The HUB increases automation and improves safety in the manufacturing process by reducing exposure to residual powder.

The printed brake panels are part of Wabtec's Metroflexx integrated brake control system for transit. Singapore Mass Rapid Transit (MRT) ordered the Metroflexx brake system for 62 new Hyundai Rotem automated trains designated for MRT's 15-mile Jurong Region Line. Mott says they are developing several other parts for transit use, where aluminum has an advantage in reducing weight.

Wabtec sited its new facility in the airport campus to take advantage of the concentration of additive manufacturing firms located there. “This area is really the hotbed of additive,” says Mott. “It really comes to the partnerships with the local industry members as well as academic partners.” The additive manufacturing center on the campus, called Neighborhood 91, was developed in conjunction with the University of Pittsburgh. Wabtec also has a partnership with Pittsburgh-based Carnegie Mellon University.

Mott explains the benefits of collaboration, including cost reduction, knowledge sharing, and a tighter supply chain. “Because additive manufacturing is such an ever-evolving industry, we're watching the progress happening right in front of us,” he says.

VDMA Additive Manufacturing survey indicates Optimism

“In the additive manufacturing industry, people are looking ahead with a good dose of optimism. This is evidenced by our current economic survey.”

This is how Dr. Markus Heering, Managing Director of the Additive Manufacturing Working Group (AG AM) in the VDMA, summarizes the results of the current survey. More than 50 companies covering the entire process chain took part in the survey in September. Manufacturing service providers, suppliers and additive

manufacturing service providers were particularly well represented.

Heering is particularly pleased that more than 80 percent of those surveyed assess their business prospects for the next 24 months as positive, while only 2 percent expect their business situation to deteriorate. Even the short-term forecast for the next twelve months is positive for 60 percent of the companies. Compared with the previous survey in spring 2021, optimism has even increased. At that time, 78 percent of the companies surveyed had assessed the outlook for the next 24 months as positive. “The confidence is also based on export expectations,” explains Heering.

Export expectations increased enormously

Just under half of those surveyed expect exports to increase over the next twelve months; a further 49 percent expect business abroad to remain at least constant. Expectations for the next 24 months are significantly higher: 73 percent of respondents believe that exports will grow and 24 percent that they will remain the same. In spring, the participants were not so optimistic. At the time, just under 60 percent expected exports to grow. “You can see that the removal of the strict travel restrictions is having a positive effect on the business climate,” explains Heering.

94 percent name Europe as the most important export market. Sales in Central Europe and Western Europe are particularly high. The USA (57 percent) and China (25 percent) follow in second and third place as the most important foreign markets. Heering also sees this export orientation as evidence of the increased maturity of the technology.

Companies continue to invest in AM

The companies surveyed underline their optimism with entrepreneurial action: More than 40 percent of the participants want to increase their investments in the field of additive manufacturing and just under half of the respondents want to continue to invest as much as before. Heering sees this as evidence of the motivation and determination of the young industry. “During the crisis, additive manufacturing was perceived as a flexible and quickly adaptable technology. It has become anchored in society's consciousness that AM is tailor-made for extraordinary requirements. This, too, is likely to contribute to the overall positive mood in the industry,” he sums up.

Divergent Technologies invests in Additive Manufacturing for “fab-less” vehicle manufacturing

Divergent Technologies harnesses the power of additive manufacturing to unleash innovation in the automotive industry, making them a global innovator in the advancement of economical serial production. They have developed a state-of-the-art Divergent Adaptive Production System (DAPS®), which will now be strengthened with the addition of three production SLM NXG XII 600 systems, following a years-long development partnership with SLM Solutions. Deliveries of the machines will start in Q1 2022.

SLM Solutions and Divergent Technologies entered a Joint Development Partnership in 2017. For the last 1.5 years, Divergent has been operating with three SLM Solutions pre-production systems in its showcase facility in Los Angeles, California, which enabled them to accelerate the development and time to market of the next generation machines. The three additional NXG XII 600 systems will bring their install base for this printer to six, making them the largest shareholder of this model in the United States. This new fleet of NXG XII 600s will join their current install base of seven

SLM®500 systems, three SLM®280 systems, and one SLM®125 system.

Kevin Czinger, Founder and CEO of Divergent and SLM Solutions Supervisory Board member, commented: "The purchase of the SLM NXG XII 600 is the culmination of years of intensive joint development that completes the shift from prototyping to production of complex structures, when combined with the Divergent Adaptive Production System as the future of human-AI design and sustainable systems."

The game-changing SLM NXG XII 600 is equipped with twelve 1kW lasers, making it the fastest machine on the market. It's capable of printing at speeds 5-20x faster than that of the current state-of-the-art and features a build envelope of 600 x 600 x 600 mm3, which enables efficient manufacturing of both large and consolidated components and many smaller components in one elegant, digital step. Taken together, these and numerous other advancements of the next generation system deliver a step-change in productivity from legacy systems, widely seen as a critical step towards broader production application of digital manufacturing technology.

Sam O'Leary, CEO of SLM Solutions, highlights that the NXG XII 600 "is designed to be used in serial production for high-volume applications as well as for printing large parts. The NXG XII 600 is the modern day "da vinci", crafting masterpieces at serial production scale, making it the ideal choice for advancing Divergent's unique digital manufacturing platform for the automotive industry."

Divergent's initial factory deployment will involve the production of thousands of tons of complex, automatically assembled structures, which will be hitting the road over the next two years. This will be followed by the scale-up of its advanced facilities, specially designed for sustainable production using DAPS®, including "fab-less" vehicle manufacturing, which will begin with the fully homologated Czinger Vehicles 21C hypercar.

Revo Foods Wants To Build a 3D Printing Facility For Plant-Based Fish

We've already seen cell-cultured meat startups use 3D printing to create cuts of meat with complex fat and

tissue structures. Revo has brought 3D printing into the plant-based fish arena, and the company is betting that the resulting products will win over more seafood eaters.

This week, company CSO Theresa Rothenbücher joined The Spoon on Zoom to talk about Revo's 3D printing technology and vision for scaling up.

"3D printing is our core technology here at Revo because it gives us the possibility to produce precise structures," says Rothenbücher. With 3D printers, the team can closely mimic the appearance of a salmon fillet, with its layers of orange muscle and white connective tissue.

Revo is currently ironing out its production process, both by speeding up the actual printing, and by experimenting with other techniques that can be used to complement 3D printing.

But the company is also working on an ambitious plan to boost its production capacity. 3D printers have typically been used to produce prototypes, but Revo wants to scale up the technology. Rothenbücher describes the team's vision: A production-scale facility that houses interconnected 3D printers of varying sizes. To save space, printers could be stacked on top of each other. An automated conveyor belt system would run through the facility.

Austria already generates around 80% of its energy from renewable sources, but the team is still working on maximizing the facility's energy efficiency. “We are designing it in a way that we hope will avoid wasting energy, kind of like a closed circuit system,” says Rothenbücher. “So really, sustainability is one of our main focus points—besides having a great taste.”

The idea of producing food in a high-tech, 3D printing factory might seem like a potential turnoff for buyers, but Rothenbücher is optimistic about consumer acceptance. Revo has already produced some animated videos to introduce the technology—and brought out printers to meet consumers face-to-face.

“We usually bring one of our R&D printers to events, and then show people how the food material is transformed into the salmon products. Usually, they really like it and are fascinated with it, and if they can directly taste it, it's even better,” says Rothenbücher. “Of course, it is not a traditional way of producing food. But then, we are a new generation.”

Revo has already tested its products at restaurants in Vienna, with positive results. The company plans to launch a line of fish spreads in early 2022, and to introduce sushi and whole cuts sometime after that.

The team selected salmon as a flagship offering because of the species' popularity and environmental concerns linked to salmon aquaculture. They've also created some tuna products, and in the future, they'll consider expanding to other species. As Rothenbücher says: “There are so many different fish in the sea.”

While Revo is focused on plant-based fish products for the time being, Rothenbücher believes that there will be opportunities for the company to collaborate with cell-based companies or manufacture hybrid products in the future. With specialized, upscaled technology for printing realistic cuts of fish, Revo could position itself as a production partner for cell-cultured startups moving toward commercialization.

Digital validation for 3D printed aerospace plastics

Hexagon and Stratasys have announced a new digital solution to help validate the integrity of plastic aerospace components at the design stage.

Using Hexagon's Digimat modelling software, engineers will now be able to predict how parts printed with Stratasys' ULTEM 9085 filament should behave when made using approved Stratasys printers. The two companies jointly created a virtual material model through physical testing that includes detailed information about the material's internal microstructure. It's claimed that the new tool could help customers reduce part testing and validation from two-to-three years to as little as six months.

“The aerospace industry is continuously pushing the boundaries of performance and innovation, but current confidence in the performance of additive manufactured parts is mostly limiting its application to highly specialised metal parts,” said Guillaume Boisot, head of ICME, Hexagon's Manufacturing Intelligence division.

"We are excited that this new development in our partnership with Stratasys will help compress the design and testing phases and improve understanding of plastic behaviour and speed up innovation across the sector."

ULTEM 9085 is currently used by companies such as Airbus to produce parts for aircraft cabin interiors, such as bracketry, pieces for cable routing, covers and duct components. Certification standards for these parts are stringent, and the material benefits from flame retardant capabilities combined with high strength. The new digital tool will enable engineers to see how parts manufactured from this filament will interact with the other elements in a complex cabin system, providing more confidence at the design stage.

"The dual need to make complex parts lighter and produce low volumes economically has meant that aerospace has pulled 3D printing towards production and put the sector ahead of the curve in use of the technology," said Scott Sevcik, vice president of Stratasys' Aerospace Business Segment.

"But this also means it's the first industry to identify several challenges, a key one being the need for a digital toolset to provide confidence in 3D printed parts. Our partnership with Hexagon is a big step forward in solving that, as it gives engineers the same upfront design intelligence for 3D printing that they have for traditional processes."

Xaar to sell remaining interest in Xaar 3D Ltd to joint partners Stratasys

Xaar has conditionally agreed terms with its joint partner Stratasys Solutions Limited to sell its remaining interest in Xaar 3D Ltd.

Xaar 3D Ltd has continued to make progress this year, although delays to the development of products due to the COVID-19 pandemic meant that the business would potentially require more investment than originally planned.

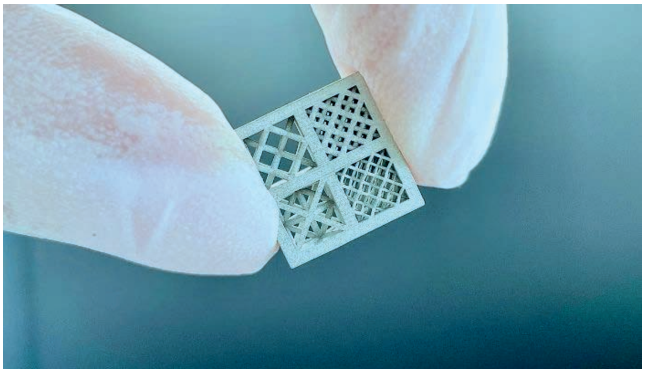
The agreement with Stratasys will provide Xaar 3D Ltd with the best opportunity to complete the commercialisation of the product range in the shortest time and enable Xaar to focus on its core business with an injection of cash. Xaar will continue to receive royalties on product and service sales.

Additive Manufacturing will continue to be an important focus for Xaar's printhead business with the needs of the sector supported by Xaar's extensive product portfolio and strong partnership approach to working with its customers.

John Mills, Xaar's Chief Executive Officer, said: "This agreement will provide Xaar 3D Ltd with the best opportunity to continue its progress and leadership in the field of industrial 3D printing. We have enjoyed our partnership with Stratasys and look forward to continuing to work with them to supply printheads to Xaar 3D and share in the long-term success of the business. The agreement will also allow us to focus on our core business and other opportunities in the market that will support our long-term growth strategy."

Incus Partners with ESA to Test 3D Printing in Micro-Gravity

Incus, an European manufacturer of lithography-based AM solutions has announced a partnership with the European Space Agency (ESA), OHB System AG and



Lithoz GmbH in a joint project using Incus' Lithography-based Metal Manufacturing (LMM) process. The project will test 3D printing in a micro-gravity environment, notably seeing whether using this technology it would be possible to create materials in the lunar base using scrap metal or existing surface materials. Ultimately, this research could help to pave the way to future lunar settlements as it could address issues related to supply chains and acquiring supplies from Earth.

Sustainability has been a large concern for many space agencies as they hope to eventually create settlements on the Moon and other planets. Being able to reuse parts and waste that already exists on the lunar surface would greatly reduce a station's reliance on Earth. This is important because a key to a long-term mission is that they should be self-sufficient as maintaining a constant supply of goods, including supplies, research materials and equipment and spare parts, is one of the major challenges in managing a station. Thanks to LMM processes, it could be possible to manufacture these necessary items and spare parts on board and on demand.

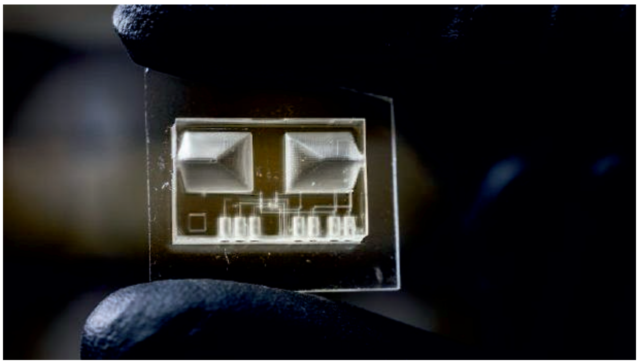
Using LMM technology is ideal for this project for a few reasons. Not only can it produce spare parts from recycled metal waste, but in many ways it is less complicated to use in micro-gravity than other metal AM processes. This is because unlike metal techniques using lasers, meaning they require gas-atomized powders and support structures, LMM uses paste or suspension. This makes it easier to use the metal from the recycled parts and also eliminates manual reworking while remaining safe for the operator. Additionally, according to Incus, the process is known for making parts with good surface aesthetics and similar material properties to metal injection molding (MIM), which is often the process of choice on Earth but which would be too complicated to use in space.

This 18 month project will test whether it is actually feasible to process scrap metals from the Moon's surface and create a high-quality final product using this zero-waste process. They will research a number of potential limiting factors such as the impact of potential contamination of metal powders with lunar dust and whether the final parts will be as optimized and reliable as they might be on Earth.

Antonella Sgambati, Human Spaceflight System Engineer at OHB System AG, concluded: “The possibility of reducing our dependence on Earth by utilizing existing lunar surface materials and recycling lunar base scrap metal represents the only solution to guarantee a sustainable settlement. This project and this novel LMM process will be important steps in making such a settlement a reality due to the fact that this technology could have a chance to operate successfully in space.”

BYU researchers have developed lab-on-a-chip devices using 3D Printers

An interdisciplinary team of researchers at Brigham Young University, led by BYU engineering professor Greg Nordin, has developed a new 3D printing technique to create the smallest ever, high resolution microfluidic lab-on-a-chip devices.



Lab-on-a-chip devices are miniaturized devices that can perform analysis usually done in a lab, like biomedical diagnostics or DNA analysis. Basically, the concept is that scientists take a biomedical lab and the diagnostic equipment that would be there and shrink it down into a tiny chip that can process and measure as a lab would.

Researchers detailed the process in a new paper published in Nature Communications.

This technology has been in development since the late 1980s and has improved cost efficiency, speed, sensitivity and consistency of biochemical detection and biomedical diagnostics. Researchers say the device can also reduce human error with automated tech, allow for more controlled testing and only require minimal fluid samples.

Developers have used microfluidic technology to create microscopic channels, pumps and valves that enable tests and reactions on picometers of liquid, like a tiny portion of a single drop of blood.

As far as tech has come in the past couple of decades, one of the biggest challenges with lab-on-a-chip devices is that they are generally fabricated in clean rooms, a lab that's free from dust and other contaminants. This process can take up to three to four days, which means that production and distribution to the market become expensive, slow and difficult.

Commercial 3D printers are not advanced enough to make the microchannels and minuscule tech for the chip. Because of this, Nordin and a team of researchers say they have built their own 3D printers for around $100,000 each that are capable of fabricating the smallest lab-on-a-chip devices yet out of a type of plastic create by photo-polymerized liquid turned into high-res, solid material layer by layer in a matter of five to seven minutes without the multimillion-dollar expense of setting up and using a clean room.

These printers only require nominal maintenance and can create valves that are only 15 microns in size.

"That's where the real innovation is," Nordin said, adding that because the prototypes of these devices are developed so quickly, they can take "a fail-fast-and-often approach to iterating a successful device," whereas in a clean room each prototype takes so long to develop that it becomes "precious."

He and his team have three 3D printers of different generations and iterations operating right now and four brand new developments in the works. They are using this technique to create a whole series of tiny pumps and valves and reaction chambers and mixtures — all on a single chip.

The low cost of development, after the initial cost of building the printer, would mean that these devices could be fabricated at a low cost, making them more available to underserved communities, he said. Their small size allows for easier handling and could be administered by a nurse, not to mention easy to distribute. It also makes developing different technologies and functions within the chip easier because prototypes are cheaper and easier to build and each chip will be able to perform multiple tests and serve multiple functions.

"This development revolutionizes (the field) in the following sense: Up to now, you don't see many commercial microfluidic devices. Through 3D printing, we can create prototypes really quickly and the manufacturing path is exactly the same as the prototyping path. Bottom line: The amount of friction is so reduced that it can really be revolutionary in developing devices," Nordin said.

He gave an example that he and one of his colleagues, William Pitt, a chemical engineering professor at BYU, are working on submitting to the National Institute of Health. It involves significantly speeding up the treatment of sepsis, a bacterial infection that is often fatal and resistant to antibiotics. Regular biomedical testing can take days between blood draws to determine which antibiotics will be effective. Using a lab-on-a-chip device instead would shrink that time down to around two hours.

"Mortality rates completely change if you can treat a person that quickly," Nordin said.

He believes that this new technique could completely change the way medical professionals run diagnostics and potentially save lives. He also wants Utahns to know that "this cutting-edge work going on at Utah universities is truly having an immense real-world impact and the education students get by being involved in that is really fantastic."

Within his team, the faculty guides and directs the research and development, but the students do most of the hands-on work. The first author listed on the paper that was published in Nature Communication is a master's student from Peru who came up with a lot of the innovative ideas, Nordin explained.

"Everyone has a role to play, and the really nice thing about it is that companies spin out of this and provide employment opportunities for high-tech employment in Utah, which is always one of our goals," he said.

Doosan Heavy builds Korea's Largest 3D Printing facility

South Korea's power plant builder, Doosan Heavy Industries & Construction Co. are building Korea's largest 3D printing fabrication facility to advance AM adoption and increase their competitiveness in the area.

The company held a completion ceremony for the 3D printing fab in a non-face-to-face format at its headquarters in Changwon, 398 kilometers southeast of Seoul.

Doosan Heavy has been applying 3D printing technologies from 2014 as part of efforts to upgrade its manufacturing capability for power components such as gas turbines.

With the completion of construction of the new facility, the company established the nation's largest 3D printing-dedicated fab with a total of five units of metallic 3D printers.

The company also has the world's largest powder bed fusion (PBF)-based metallic 3D printer, which can produce parts and components measuring 800 millimeter in width, 400 mm in length and 500 mm in height.

3D printing technology can produce complex designs, while realizing lighter components, a reduction in manufacturing costs and a shorter production period.

Cyient Enhances Its Additive Manufacturing Solutions with the Purchase of SLM®280

Cyient is a global engineering, manufacturing, and digital technology solutions company founded in India and with offices worldwide. Strengthening its design-led Manufacturing capabilities, Cyient has purchased a new SLM®280 system following international support from SLM Solutions. It will be integrated into the company's first metal additive manufacturing facility in Jupiter, Florida. With over 80 trained engineers in

design optimization, Cyient looks to further enhance its capabilities in additive manufacturing with in-house manufacturing solutions.

Referring to the new development, Rajendra Velagapudi, SVP & Global Operation Head – Design Led Manufacturing, Cyient, "Cyient has successfully designed and manufactured metal additive components for some of its key customers—our most recent achievement being the delivery of tooling components for a large aircraft engine manufacturer. The new SLM®280 will enable us to offer manufactured components directly to our customers in the aerospace, defense, medical and energy industries. This is a key milestone on our road to becoming an end-to-end additive manufacturing solutions provider."

Nicknamed The Dual-laser Trailblazer by SLM Solutions, the SLM®280 selective laser melting system offers 80% higher build rates than competitive offerings. This is accomplished with high-energy, multi-laser optics, bi-directional powder re-coating, and a 25% larger build platform that ensures consistent and repeatable part quality and best-in-class productivity.

Commenting on the partnership, Sam O'Leary, CEO, SLM Solutions, said, "SLM Solutions and Cyient share synergies across geographies and industries, which will allow us to take a global approach in supporting their growth. SLM Solutions has established expertise and customer base across aerospace, defense, medical, oil and gas, and energy, which are also critical sectors for Cyient. We are actively consulting and supporting from our Indian and US offices as Cyient Integrates into strategic manufacturing supply chains worldwide. We are thrilled to work together as it grows its product offerings with selective laser melting."

Bharat Fritz Werner to build next generation Metal AM DED Enterprise

Ashok H Varma has joined Bharat Fritz Werner India as its Executive Vice President and Global Leader for

Additive Manufacturing initiatives. Ashok is a widely recognized and acknowledged industry thought leader in Metal Additive Manufacturing. Ashok specializes in large format metal 3D printing. Directed Energy Deposition (DED), hybrid solutions for metal additive manufacturing, and building the business cases as applied to key industry verticals including Space Technology, Aviation, Defence, Oil & Gas, Energy, Tooling, and Heavy Industrials. Ashok comes with 35 years of innovation, experience, expertise, and leadership in advanced manufacturing technologies including CNC machines, real-time in-process monitoring, and cutting-edge additive manufacturing technologies and their applications. He possesses rich and diverse management experience across several cultures for successful strategy formulation and execution and global business development. Ashok is an alumnus of the Indian Institute of Technology – Kanpur, and the University of Wisconsin-Madison, USA.

Ashok commented "I am delighted to join the BFW India team in this stimulating leadership role. Unlike many recent entrants into the metal AM/3D printing arena, BFW India vision, commitment from the top management, and know-how in manufacturing technology and innovation will truly disrupt this market space with unique and creative AM Metal solutions in game-changing Metal AM platforms and Manufacturing as a Service (MaaS) domains".

"Ashok brings an incredible wealth of experience, knowledge, drive, and passion to BFW's core and emerging business focus. Ashok will lead strategic initiatives focused on creating a worldwide presence for this next generation Metal AM DED Enterprise with a clear focus on "Make in India" initiatives. This will include the creation of fully operational Equipment Showrooms/ Demonstration Centers and Assembly plant locations in the US, Europe, and Asia. With the only truly affordable and scalable Metal AM, customized, Powder & Wire Fed Product Portfolio, BFW will emerge a serious worldwide supplier in this exponentially growing Metal AM space." – Ravi Raghavan, Managing Director of BFW India

Using laser beam shaping to improve metal 3D printing

To address porosity and defects in metal 3D printing, Lawrence Livermore National Laboratory researchers experimented with exotic optical laser beam shapes known as Bessel beams — reminiscent of bullseye patterns. They discovered the beams had unique properties such as self-healing and non-diffraction, and reduced the likelihood of pore formation and "keyholing," a porosity-inducing phenomenon exacerbated by the use of Gaussian beams. Credit: Lawrence Livermore National Laboratory

While laser-based 3D printing techniques have revolutionized the production of metal parts by greatly expanding design complexity, the laser beams traditionally used in metal printing have drawbacks that can lead to defects and poor mechanical performance.
Researchers at Lawrence Livermore National Laboratory are addressing the issue by exploring alternative shapes to the Gaussian beams commonly employed in high-power laser printing processes such as laser powder bed fusion (LBPF). In a paper published by Science Advances, researchers experimented with exotic optical beam shapes known as Bessel beams—reminiscent of bullseye patterns—which possess a number of unique properties such as self-healing and non-diffraction. They discovered that the application of these types of beams reduced the likelihood of pore formation and "keyholing," a porosity-inducing phenomenon in LPBF exacerbated by the use of Gaussian beams. The work is featured on the journal's Sept. 17 cover.

LLNL researchers said the work indicates that alternative shapes such as Bessel beams could alleviate the chief concerns in the LBPF technique—the large thermal gradient and complex melt pool instabilities occurring where the laser meets the metal powder. The issues are predominantly caused by Gaussian beam shapes that most off-the-shelf, high-power laser systems typically output.

"Using Gaussian beams is a lot like using a flamethrower to cook your food; you don't have a lot of control over how heat is deposited around the material," said lead author and LLNL research scientist Thej Tumkur Umanath. "With a Bessel beam, the fact that we redistribute some of that energy away from the center means we can engineer thermal profiles and reduce thermal gradients to aid microstructural grain refinement and, ultimately, result in denser parts and smoother surfaces."

Tumkur, who also won a first place award at LLNL's 2019 Postdoc Research Slam! competition for the work, said Bessel beams significantly expand the laser scan parameter space over traditional Gaussian beam shapes. The result is ideal melt pools that are not too shallow and don't suffer from keyholing—a phenomenon in which the laser creates a strong vapor and causes a deep cavity in the metal substrate during builds, as LLNL researchers have previously found. Keyholing creates bubbles in the melt pool that form pores and leads to degraded mechanical performance in finished parts.

One other drawback of conventional beams is that they are prone to diffraction (spreading) as they propagate. Bessel beams afford a greater depth of focus due to their non-diffractive properties. Consequently, the authors observed an increased tolerance to the placement of the workpiece with respect to the laser's focal point using Bessel beams. Placement is a challenge for industrial systems that often rely on expensive and sensitive techniques for positioning an in-progress build within the focused beam's depth of focus each time a layer of metal powder is deposited.

"Bessel beams have been used extensively in imaging, microscopy and other optical applications for their non-diffractive and self-healing properties, but beam shape engineering approaches are rather uncommon in laser-based manufacturing applications," Tumkur explained. "Our work addresses the seeming disconnect between optical physics and materials engineering in the metal additive manufacturing community by incorporating designer beam shapes to achieve control over melt pool dynamics."

The LLNL team shaped the beams by running the laser through two conical lenses to produce a donut shape, before passing it through additional optics and a scanner to create "rings" around the central beam. Installed in a commercial printing machine in LLNL's Advanced Manufacturing Laboratory, the researchers used the experimental setup to print cubes and other shapes from stainless steel powder.

Through high-speed imaging, researchers studied the dynamics of the melt pool, observing a substantial reduction in melt pool turbulence and mitigation of "spatter"— the molten particles of metal that fly from the laser's path during a build—which generally leads to pore formation.

In mechanical studies and simulations, the team found that parts built with Bessel beams were denser, stronger and had more robust tensile properties than structures built with conventional Gaussian beams.

"Industry has long sought the ability to increase control of the LPBF process to minimize defects," said Ibo Matthews, principal investigator on the project prior to becoming LLNL's Materials Science Division leader. "Introducing complex structure to the laser beam adds increased flexibility to precisely control the laser-material interaction, heat deposition and ultimately the quality of the prints."

LLNL computer scientist Saad Khairallah used the LLNL-developed multiphysics code ALE3D to simulate the interaction of both Gaussian and Bessel beam laser shapes with single tracks of metal powder material. By comparing the resulting tracks, the team found the Bessel beam demonstrated improved thermal gradients over Gaussian beams, encouraging better microstructure formation. They also achieved better energy distribution with Bessel beams, avoiding the "hot spot" generation found in Gaussian beams, which produce deep melt pools and form pores.

"Simulations allow you to get a detailed diagnostics of the physics taking place and therefore allows you to understand the fundamental mechanisms behind our experimental findings," Khairallah said.

Just one of many pathways for improving the quality of 3D printed metal parts being studied at LLNL, beam shaping is a cheaper option than alternative scanning strategies because it can be done at little cost by incorporating simple optical elements and can reduce the expense and time involved in post-processing techniques typically needed for parts built with Gaussian beams, Tumkur said.

"There's a big need to produce parts that are robust and defect-free, with the ability to print very large structures in a cost-effective fashion," Tumkur said. "To make 3D printing truly compatible with industrial standards and move beyond conventional manufacturing approaches, we need to address some fundamental issues that occur at very short temporal regimes and microstructural scales. I think beam shaping is really the way to go because it can be applied to print a wide range of metals ubiquitously and be incorporated into commercial printing systems without posing significant integrability challenges as other alternate techniques tend to do."

AMGTA establishes Sustainability of Additive Manufacturing Research Fund

The Additive Manufacturer Green Trade Association (AMGTA), a global trade group created to promote the environmental benefits of additive manufacturing (AM), announced today that it had established the Sustainability of Additive Manufacturing Research Fund, a $100,000 fund which will support research at Yale School of the Environment's Center for Industrial Ecology. More specifically, the fund will support researchers examining the sustainability benefits of additive manufacturing using life-cycle assessment (LCA) tools and modeling.

"This new fund will be used to conduct LCA research that compares several conventionally manufactured metal industrial parts with those designed and manufactured via the binder jet additive manufacturing process," said Sherry Handel, AMGTA's Executive Director. "The goal of this research is to understand the environmental and economic impacts of binder jetting compared to conventional manufacturing. Using LCA tools and modeling, the research will characterize impacts related to emissions of principal greenhouse gases and other associated impacts. Through robust and independent research studies, the AMGTA will continue to publish research reports that evaluate environmental sustainability within the additive manufacturing industry."

The research report is expected to be published in the fall of 2022 and the key findings will be announced at that time.

Binder jet additive manufacturing is a method of 3D printing in which a digital file is used to quickly inkjet a binder into a bed of powder particles—such as metal, sand, or ceramic—to create a solid part, one thin layer at a time. When printing metals, the final bound metal part must be sintered in a furnace to fuse the particles together into a solid object.

About AMGTA. The AMGTA was launched in November 2019 to promote the environmental benefits of additive manufacturing (AM) over traditional methods of manufacturing. The AMGTA is a non-commercial, unaffiliated organization open to any additive manufacturer or industry stakeholder that meets certain criteria relating to sustainability of production or process.

About the Center for Industrial Ecology. The Center for Industrial Ecology at the Yale School of the Environment was established in September 1998 to provide an organizational focus for research in industrial ecology. The Center brings together Yale staff, students, visiting scholars, and practitioners to develop new knowledge at the forefront of the field. Research is carried out in collaboration with other segments of the Yale community, other academic institutions, and international partners.

AM Basics

ADDITIVE ACADEMY

AM Technology Landscape

Introduction to Additive Manufacturing

Landscape of AM Technologies

Technology Deep Dive

Introduction to Additive Manufacturing

Additive manufacturing (AM) is the technical nomenclature used to refer to the group of technologies used to build objects or parts by addition of material in layers. This technology is also widely referred to as 3D Printing, a term often used in a non-technical context synonymously with Additive Manufacturing.

AM is defined as a process to make parts from 3d model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing technologies.

Historical terms: additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, solid freeform fabrication and freeform fabrication.

Companies generally tend to market their own version of AM nomenclature using their trademark names, most of which are just subtle variations. A few companies also utilize a combination of different technologies within the different classifications (HP and their Multi Jet Fusion machines is an example), though these are far and few when compared to the other machines available on the market.

Major classification of AM technologies along with their definitions according to the ISO/ASTM 52900 Standard are mentioned below (Refer to Graph 1 for a landscape view):

Vat Photopolymerization: An additive manufacturing process in which liquid photopolymer in a vat is selectively cured by light-activated polymerization.

Material Extrusion: An additive manufacturing process in which material is selectively dispensed through a nozzle or orifice.

Material Jetting: An additive manufacturing process in which droplets of build material are selectively deposited typically using inkjet printing technology.

Binder Jetting: An additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials.

Directed Energy Deposition: An additive manufacturing process in which a focused thermal energy is used to fuse materials by melting as they are being deposited. Focused thermal energy means that an energy source (e.g., laser, electron beam, or plasma arc) is focused to melt the materials being deposited.

Powder Bed Fusion: An additive manufacturing process in which thermal energy selectively fuses regions of a powderbed.

Sheet Lamination: An additive manufacturing process in which sheets of material are bonded to form an object.

Landscape of AM Technologies

AM Technologies

- **Vat Polymerization [VPP]**
  - Stereolithography
  - Digital Light Processing
  - Continuous Digital Light Processing
- **Material Extrusion [ME]**
  - Fused Deposition Modelling
- **Sheet Lamination [SL]**
  - Laminated Object Manufacturing
  - Ultrasonic Additive Manufacturing

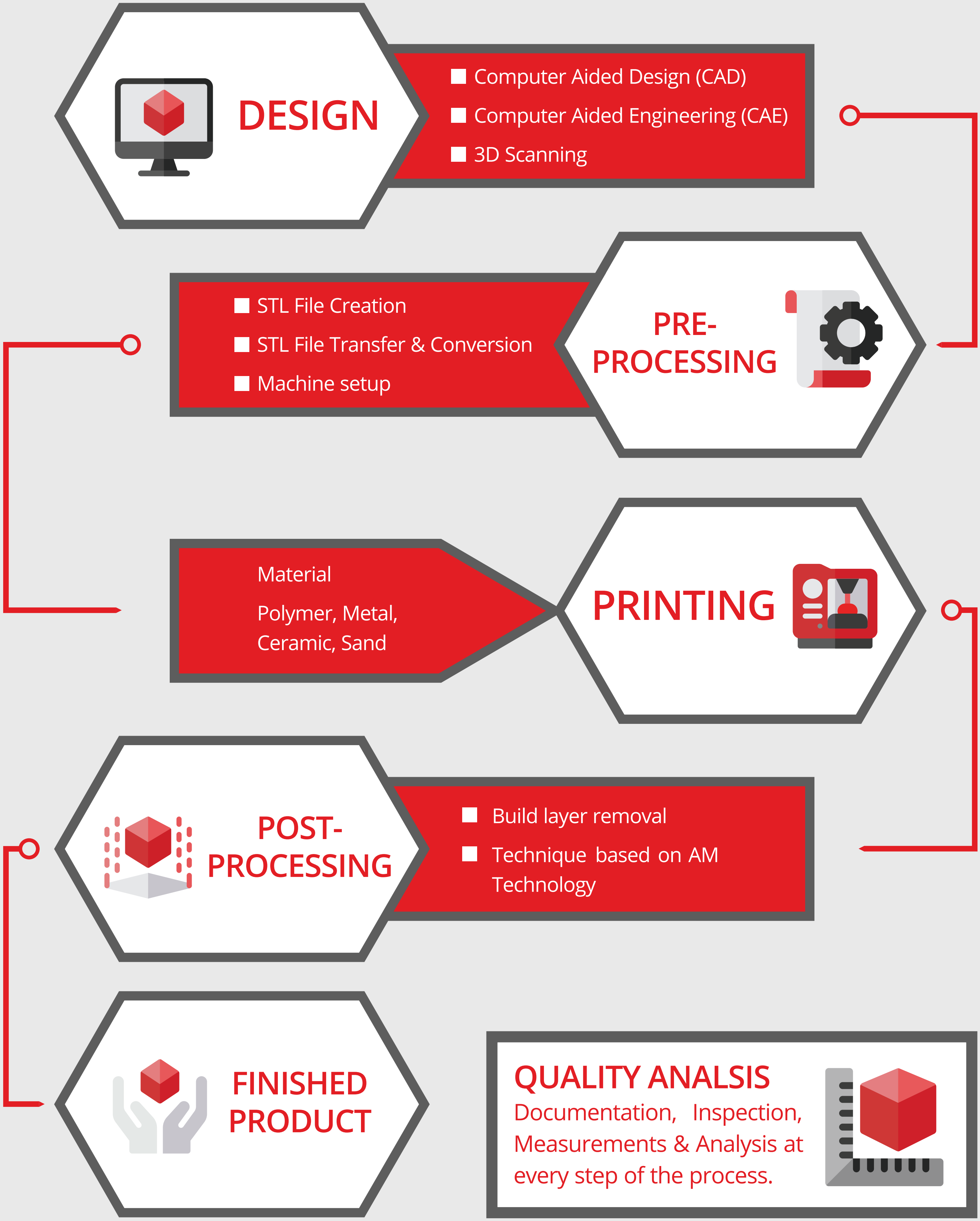
Materials Used

VPP	ME	SL
Polymer	Polymer	Polymer
	Composite	Composite
		Metal
		Paper

- Powder Bed Fusion [PBF]
  - Multi Jet Fusion
  - Selective Laser Sintering
  - Selective Laser Melting / Direct Metal Laser Sintering
  - Electron Beam Melting
- Direct Energy Deposition [DED]
- Material Jetting [MJ]
- Binder Jetting [BJ]

PBF	DED	MJ	BJ
Metal Powder	Metal Powder	Polymer	Sand
Polymer	Metal Wire	Metal	Metal
		Ceramic	Ceramic
		Wax	Polymer

AM Process Workflow



2019 Exhibitors


Organized By
CNT
Catalysing New Technologies
Indian 3DPRINTING Network
INDIA'S
ONLY DEDICATED
ADDITIVE
MANUFACTURING
EXPO
amtech Expo ®
Shaping your AM Business
6th EDITION
HYDERABAD
DECEMBER 2022
#Go3DWithAMTech
Contact - marketing@catnewtech.com
www.amtechexpo.in