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July 2022

06

PERSONALISED MANUFACTURING

A MESSAGE
FROM THE EDITORS

We would like to acknowledge and thank the support from the following organisations:

I first learned about Additive Manufacturing at the start of my mechanical engineering studies in 2013. By that time, the technology had already matured considerably, but still it was projected that it would take 5 to 10 years for consumer and industrial 3D printing to reach the plateau of productivity. Now, almost a decade later, it is still envisioned that it will take 5-10 years to attain plateau status. So what is happening? Why does AM still appear to be running on the spot after more than 30 years since it first became commercially available? Is the technology somehow over-hyped?

Additive Manufacturing has been seen as a disruptive technology for quite some time – with the potential to change not only the manufacturing industry, but providing solutions to service, production, and prototyping. Companies utilizing additive technologies for prototyping have already seen decrease in risks and time-to-market of products. However, the full benefits of AM has still not been reached. A major issue with AM is the relative slowness of certain phases of 3D printing, one of them being post-processing. To integrate AM into a production environment and deploy it on an industrial scale, automation and integration of post-processing is key. Furthermore, when 3D printing solutions integrate with a connected smart factory for on-demand production, companies can develop an agile manufacturing strategy that supports distributed global production and multiple products with predictable costs and lead times.

So, is the hype real? In my opinion, we are on the verge of the next steps in additive manufacturing. Companies are investigating automation possibilities, high-speed production, and the inclusion of post-processing of AM parts within their process chains. All these will contribute to the integration of AM on shopfloors. The flexibility of these systems will allow customisation or fragmentation to flourish in many product categories, further reducing the market share of conventional mass production, and hence boosting AM.

This issue of InnovationNU takes a closer look at these issues and how smart, factory-connected 3D printers can simplify the manufacturing industry.

GIJS BEUMKES

Research Engineer
Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente

Gijs’ editorial really made me think. In contrast his experiences, I have been working with AM almost since the first days when it became commercially available. I was part of a group who bought one of the first ever machines in the UK, an SLA250 machine from 3D Systems, in 1992. As a (much) older engineer, I can recall what it was like before 3D printing was available. I can even recall a time before computer aided design was available, let alone in 3D solid modelling.

AM is definitely a product of the digital age. The better we are at creating 3D digital environments, the more demands we put on our digital manufacturing technologies. Not only has 3D printing developed in leaps and bounds over the last 30 years, but so have other computer-based machining technologies.

However, I do agree with Gijs that AM has been over-hyped and consequently under-delivered over the past three decades. But then again, so have many other technologies. One could say that robotics, VR and AI are also somewhat underwhelming compared to what we may imagine from their science fiction counterparts.

So let’s not be so condemning as to how these technologies have failed to deliver, because all this time they have, for sure, been improving. Maybe our timelines have been skewed and our expectations have been overly-affected by our imaginings of the future. I also, however, do not want to be overly-critical of this, since it is our imagination that causes us to seek the technological advancements for the future.

What I can say is that AM is certainly here to stay and it will continue on to serve the needs of the future. To paraphrase the words of Dr. McCoy from Star Trek, we might see, some time in the future, that “it’s AM, Jim, but not as we know it”.

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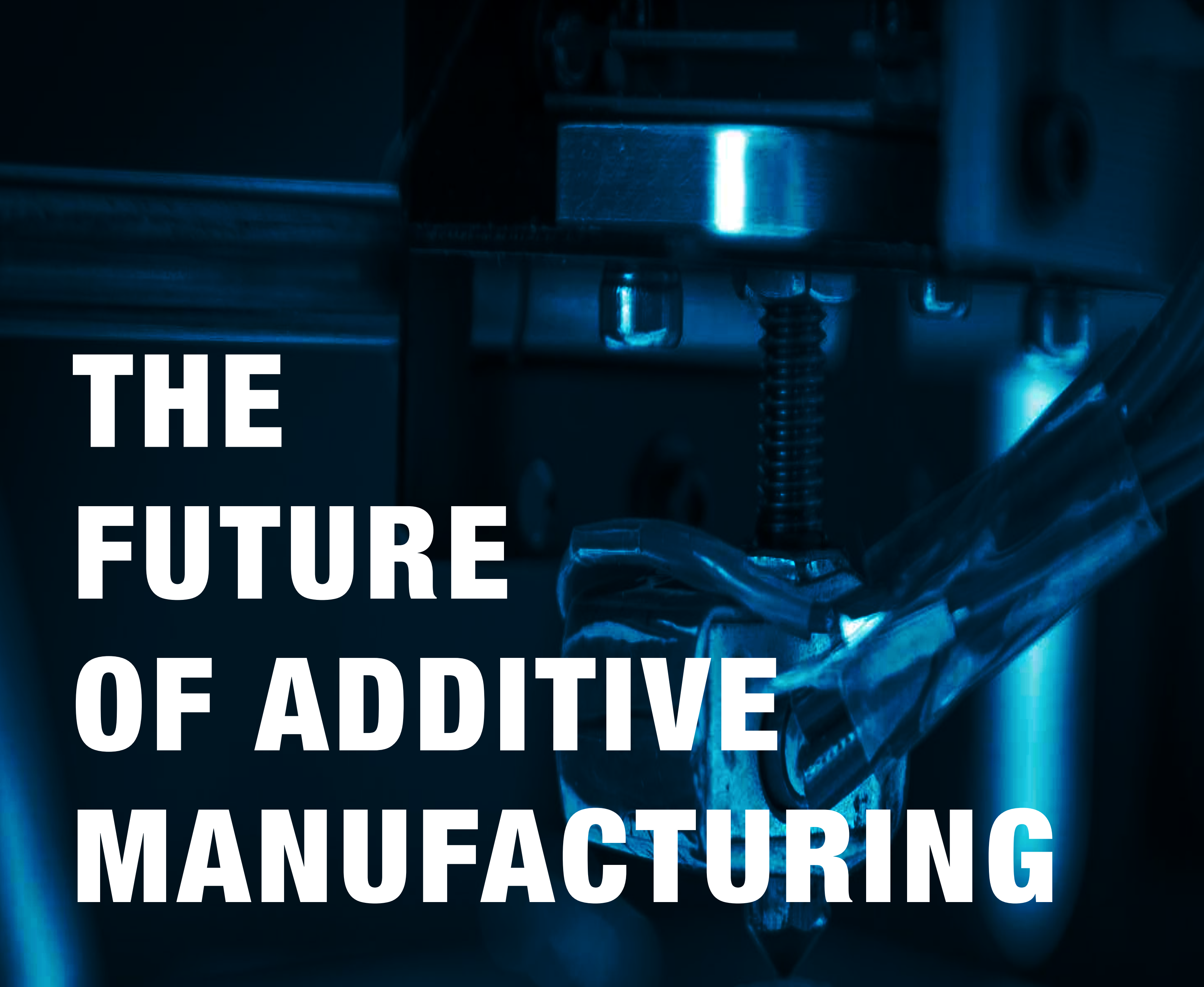


THE FUTURE OF ADDITIVE MANUFACTURING

In Additive Manufacturing (AM), a variety of different techniques essentially combine planar layers of material, sequentially to form a 3-dimensional solid object. Following the initial introduction of the key technologies, development of AM has been mostly incremental. The earliest machines included photopolymer curing, powder sintering, filament extrusion and sheet lamination. All of these technologies still exist today, with a few additions. Its continued use has seen this technology, which was primarily aimed at producing prototyping models, develop to include tooling and direct manufacture of consumer products.

All of the current commercial technologies have seen improvements in speed, part accuracy and material properties. Increasing interest and application from industry has subsequently led to reductions in machine and operating costs as well as an increase in the range of applications. Legitimisation of the industry is evidenced by the development of international standards. Further, recognition of the widening appeal of this technology has led to regular use of the term 3D printing by the general public at large.

It may be good to take a look at the current status of the technology and affected industries by addressing the following questions:

- What industries are likely to use the technologies in the future and why?
- What new materials are we likely to see in the future?
- How will we incorporate the technological advances that AM can provide at the design stage?

AM industry and applications

Fundamentally, AM technology has hardly changed in recent years. Having said that, there have been dramatic improvements in existing technology that justifies the transition from prototype production to manufacturing. This transition is a culmination of a number of evolutionary developments in materials and processes combined with the reduction in costs of the technology that has served to open it up to a wider user base. However, there has also been a change in the mind-set of users that has opened their eyes to new applications.

Development of AM technology over the years has been exemplified by three key industries for differing reasons:

Automotive manufacturers exploited the technology to help new products get to the market quicker and in a predictable manner. Small savings in time and development costs can result in significant overall savings in vehicle development. An example approach is the use of AM for small batch production before full production tooling is ready. Manufacturers of high-end, low-volume automobiles are even using AM as a preferred production process because it is the most cost-effective approach to use.

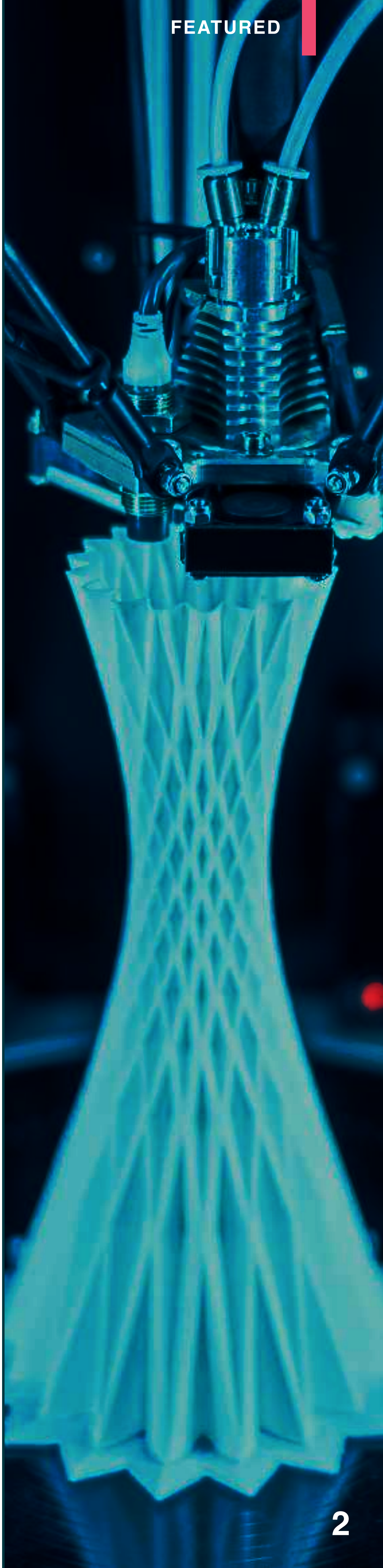
Aerospace companies are interested in AM's ability to integrate mechanical functionality, reduce component counts, create internal functionality and reduce weight. Whilst there is already a flourishing industry for making polymer parts on high-performance military aircraft, probably the greatest interest in this industry is for direct metal fabrication.

Medical industries are particularly interested in AM technology because of the ease in which 3D medical imaging data can be converted into solid objects. In this way devices can be customised to suit the needs of an individual patient. This has not taken off quite as quickly as expected however, possibly due to it being a highly regulated and risk-averse industry. Where there has been opportunity for large-scale customisation (like in dentistry and for in-the-ear hearing aids) then there has been good reward.

The major limitations to AM are speed, accuracy, nonlinearity, material properties and system cost. All of these are being addressed by machine vendors. System cost is a very subjective topic however and machines sell at a particular price partly because of their perceived value to users. If the manufacturing costs can be reduced, or the number of potential users becomes larger, then system prices will fall. There is an increasing number of low-cost systems available due to an ever-increasing competitive market. Most machines are based on melt extrusion technology since the designs are generally available and the process is easiest to synthesise. However, we can expect more powder-based and droplet-based technologies to become available in the years to come as large-scale materials suppliers and mainstream manufacturers decide the market is sufficient to accommodate the high capital costs of mass-manufacture of AM machines.

Increased use of AM technology inevitably means finding its way into more application areas. Some of these areas are very performance or safety critical, requiring careful process control and tracking to ensure high quality. Acceptance will be much easier if suitable standards are in place. Continued implementation of ASTM, ISO and other international standards will certainly assist this acceptance.

So what is the future for AM technology, beyond incremental developments that will influence new manufacturing applications?



A few predictions:

- As fabrication speed is significantly increased, parts will become available in minutes (even seconds) rather than hours. Consumers would be prepared to wait this short time for their parts to be made over the counter. Machines are likely to be seen in shopping malls and other locations where consumer parts can be made to order.

- AM can be used in conjunction with other manufacturing processes that can also be automated. Future manufacturing equipment may be designed to incorporate AM. High performance industries like Aerospace manufacturing will be the first to take advantage of this due to obvious performance gains. These hybrid additive/subtractive/formative/assembly technologies will not be as versatile as current AM machines; more likely specifically designed for particular sizes and types of product, like turbine blades or wing struts.

- An increasing number of AM systems have already demonstrated multiple material capability. We will see many more machines exploiting this capability in the future since this is not only a relatively straightforward thing to achieve with a number of the technologies, it also will result in products that may have been extremely difficult to manufacture using conventional technology.

- A new application area that is developing quickly is tissue engineering, where AM is used to generate structures that will result in biocompatible medical implants. These implants will contain cells to form human tissue inside the body.

AM Materials

From the very beginning materials engineering has been an important driving force for AM development. Like traditional manufacturing processes, the initial choice of material was tied to the process constraints. For example, photosensitive resins must be used for vat photopolymerisation AM. Improvement in intrinsic properties of AM parts can be engendered through improvements in base materials. With increased demand comes a fiscal motivation to tailor and optimise materials for best results. Examples are new formulations of photopolymer resins, development of polyamides specifically for powder-bed fusion, and the roll-out of new composite melt-extrusion materials. Of particular interest are the increasing array of metallic materials and advanced engineering polymers like PEEK and PEKK becoming available.

Application development using AM parts can be seen in so-called “conversion technologies”. Here, AM part geometry is maintained whilst a different material is substituted for the as-processed material. Examples include using AM binder methods which are burnt away to create uniformly shrunk ceramic or metal parts using a follow-up furnace stage. Further, creation of low-ash AM materials can be used to create parts that will eventually be sacrificed during a casting stage.

As AM moves into direct competition with traditional manufacturing for service parts, the need arises to match service properties. For some systems, post-processing was straightforward and comparable to traditional manufacturing.

The markets for AM have grown to a stage now that the technology is getting the attention of major materials suppliers. It is anticipated that once these major producers are convinced that the time is right, one would expect to see new materials with improved manufacturability and service properties to enter the market. Increased competition will drive down costs, which will be welcomed by both parts providers and consumers.

Design for AM

The term "design", in regard to AM, can cover several aspects. These include industrial design, mechanical engineering design, architectural design and fashion design. AM impacts all of these areas by enabling manufacture of designs that were previously uneconomical or even impossible. Examples of these designs are increasingly finding their way into the mainstream use, particularly as online consumer products. There are a few reasons why using AM is desirable such products:

- Custom-fitting to suit individual ergonomic requirements.
- Improved functionality of the product performance through adoption of complex forms, both externally and internally.
- Reduction of overall part count in a product by producing a lower number of (usually) more complicated parts.
- A desire to endow the product with specific design features that will increase its value to the customer.

Those familiar with product design will recognise that a particular design feature is capable of addressing more than one of these desires, e.g. a weight saving functional structure may also produce a dramatic aesthetic form. The implications upon design using AM are twofold. First, computer aided design software must be upgraded to handle the unique characteristics of parts designed for AM. For example, the ability to represent several materials or colours in the same model, the ability to have a gradual change from one material to another, the ability to assign a particular surface texture or pattern to a part and the ability to generate and represent complex internal structures. Many of these issues are now beginning to find their way into commercial software.

Another implication relates to designers, namely, how can they take advantage of all the opportunities that AM offers? Partly, this is a matter of education. Designers need to be made aware of the unique features of AM and encouraged to ignore the "design for manufacturing" limitations they have been used to.

There is a need for increased creativity and it could be argued that the ultimate limitation to the shapes created by AM will be the imagination of the designer. Designers, of all disciplines, must unleash their creativity to come up with product, building and fashion designs that would previously have been implausible. In essence, how are we going to get designers to think what was unthinkable in the past?

This poses a problem to designers who are expected to produce something both functional and aesthetically pleasing. Our education systems tend to produce designers who are capable of either one or the other. AM, on the other hand is uniquely capable of producing something which is both, without the need for compromise. We need "hybrid" designers who are capable of taking inspiration from nature, fashion or the built environment and then converting these into product forms that will also perform efficiently and ergonomically. Such designers already exist but for AM to reach its full potential we need them to be the norm rather than the exception.

So what might the future of design for AM be?

If the technical and human issues can be addressed, then a unique hybrid of the aesthetic and functional design disciplines might emerge. Going back to the dual purpose feature mentioned earlier, a single designer may take inspiration from nature, with calculations from software, to create visually stunning, weight- saving designs that can only be realisable using AM. Indeed, if the concept of beauty could be programmed into the software, then that hybrid designer might actually turn out to be a computer rather than a person! ■

AUTOMATED ADDITIVE MANUFACTURING

Digital tools such as simulations, additive manufacturing, and data collection are now shaping the engineering world. We are capable of collecting data from different manufacturing technologies and digital tools by networks and reciprocally exchange information. This has led to a change in the way conventional production processes work and communicate. Moreover, there is a permanent and seamless share of information, allowing machines to operate based on (historical) data. Now we are on the verge of the next phase: connecting the different manufacturing technologies to allow for integration into the overall production system, resulting into the mapping of the physical world into the digital world. This is especially critical for technologies like additive manufacturing.

For years, AM has functioned in a stand-alone mode. In order to make AM as an integrated part of a overall production system, automation is required. Through automation, AM can be deployed at a production-scale and thus better find its place in production environments. Within the Advanced Manufacturing Center (AMC) located in Enschede, an automated approach will be demonstrated, including steps as (3D) scanning, subtractive machining, and surface treatment.

Additive Manufacturing Automation

By its definition – "the process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies ", AM establishes a straightforward connection between the digital and physical product. AM starts from the digital 3D representation of the object to manufacture, then the object is oriented, sliced and paths for the laser, nozzle, or inkjet nozzle are generated. Thereafter the physical actions take place: printing, remove the printed object from the AM machine, and post-processing.
These steps heavily rely on engineers for choosing the correct orientation, removing the printed object from the machine, refilling the feedstock, and performing post-processing operations. Automating this procedure will allow this technology to enter the market on an industrial scale.

Automating additive manufacturing requires the combination of AM, robotics and/or automated handling systems for providing a degree of automation to this technology. In this sense, four main directions are currently targeted:

- **Design automation**
- **AM data sharing automation**
- **Post-processing and handling automation**
- **Automatic AM order handling**

Design Automation

The first level of automation is achieved in the design phase. Automating the selection of the optimal build orientation based on different criteria (for instance, minimization of support structures volume) is in the researchers' attention for a long time. Different algorithms and solutions were proposed. There are also software applications or plug-ins offering suggestions regarding AM parts' orientation. Other options regarding layer optimized or automatic infill based on part's geometry and functionality or automatic temperature setting as function of material also started to be included in AM software for supporting designers' work. Making the AM design steps less manual signals the continued maturation of the 3D printing industry. Design automation will help AM adopters reduce the time and costs associated with manual design processes.

AM Data Sharing Automation

The AM industry is becoming more open. The domination of closed, proprietary systems is coming to an end, as more solution providers are looking to create integrated, interoperable 3D printing workflows. One trend supporting this is the use of open Application Programming Interfaces (APIs). API is a software intermediary that allows one software application to communicate with another. APIs play a critical role in integrating disparate systems. In AM, where the workflow can be quite complicated and siloed, the industry players are recognising the importance of providing a set of APIs that enable automation and expand the use of data.

Post-Processing and Handling Automation

Regardless of whether it is a prototype, piece of tooling or an end-use product, most AM parts require some level of post-processing. This may be as simple as removing support material, but can also include sorting, dying, polishing, as well as other processes, before the final product is ready for use. Most of the post-processing tasks are almost entirely reliant on manual labour. Thanks to recent advances in machine learning and post-processing hardware and software, it is now possible to automate almost every part of AM post-processing, reducing labour costs and significantly improving process efficiency.

New systems are entering the market that allow parts to be extracted from a 3D printer's build platform automatically and then moved with the help of guided vehicles to the next post-processing station. Automating post-processing in AM completely changes the economics when scaling up the use of technology. It enables much higher flexibility in the factory layout and makes it feasible for manufacturers to adopt this technology for digital, rapid production.

Automatic AM order handling

In addition to direct costs associated with manual post-processing, there are also hidden costs such as worker's time for quoting parts and handling AM orders and operator's time for scheduling print jobs. Calculating part costs, entering data into spreadsheets and scheduling production using clunky solutions can take several hours a day of worker's time, limiting the productivity of AM. An automated AM production management process is necessary to ensure scalable growth, and greater production efficiency.

Fully Automated AM Production Line

Automation of AM processes, from design to finishing, has tremendous potential for capital savings by reducing labour costs and increasing productivity. Furthermore, automated manufacturing can introduce more consistency into the process by minimising human errors and scrap. The Advanced Manufacturing Center located in Enschede highlights the automation solutions for AM technologies and flexibility. Additive Manufacturing combined with robots and software solutions are showcased and can be used to test new production concepts, develop knowledge, starting up production concepts and develop innovate manufacturing solutions in a realistic production environment. With this, the next steps towards integration of additive manufacturing in production environments is taken, shaping the future of manufacturing. ■

WHAT IS...?

AMII

The **Additive Manufacturing Implementation Investigation (AMII)** is a business service that has been recently launched in partnership between Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT), previously known as the Fraunhofer Project Center (FPC@UT) and the Fraunhofer Institute for Production Technology (IPT) in Aachen, Germany. The initiative helps companies understand how and where to best utilise AM to add and realise value and opportunities within their organisation before they invest in new technology or business models.

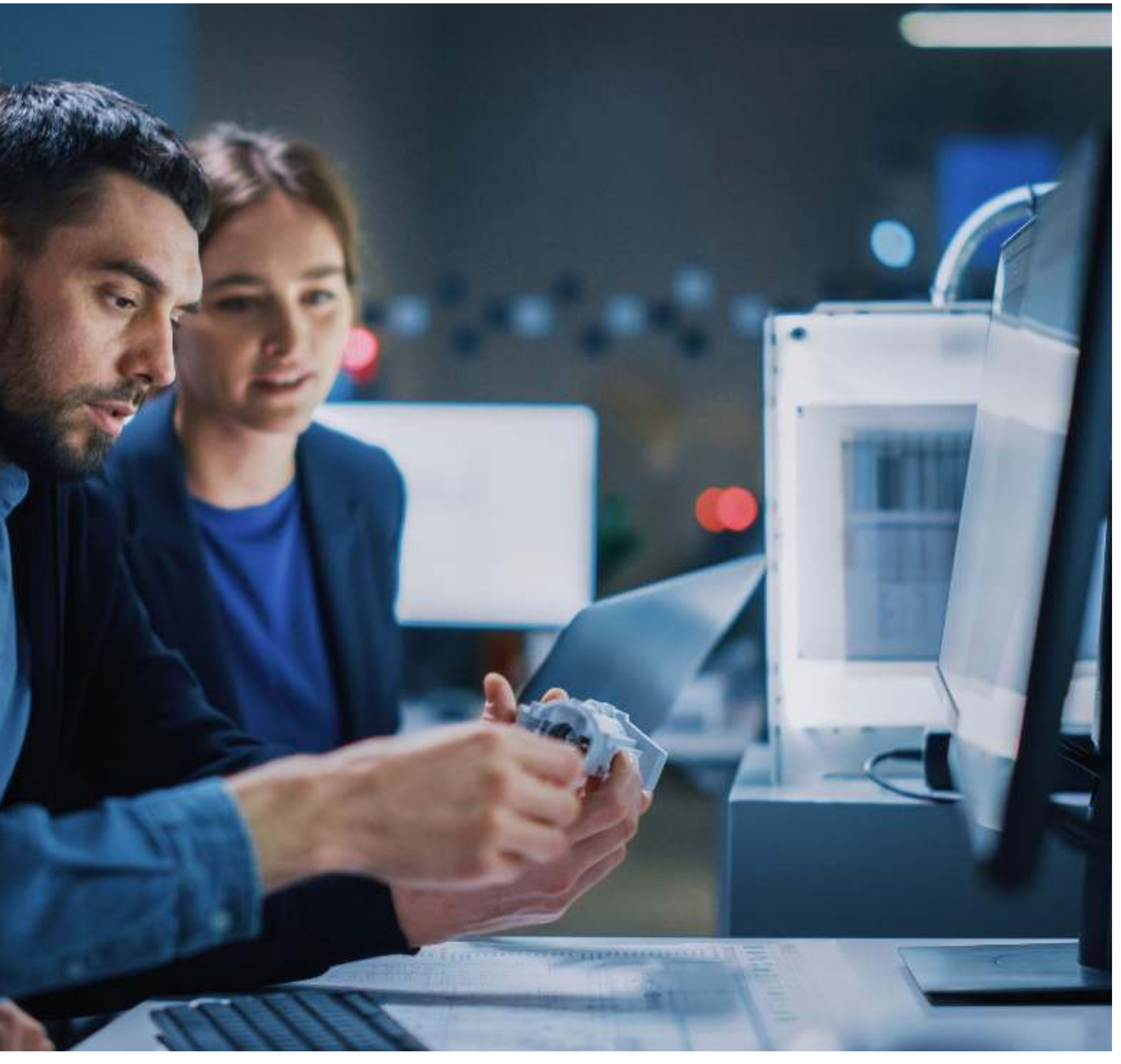
Additive Manufacturing (AM) is on the radar of many companies now as a wider technology that can change the way we produce and offer goods and services. However, many companies fall just shy of the experience and confidence through organisational learning to be able to see the clear value opportunities that lie ahead through AM application. Likewise, many companies will often only look at AM from a very narrow perspective, uninformed and unaware of the wider value streams that can be tapped into. Entering any new technology field can be daunting. From the outside it can appear overwhelming even for established mature companies. AMII was conceived to help solve this problem.

AMII comprehensively reviews a company's position, understanding and attitude towards manufacturing technology across all areas of business. Considering and involving a wide network of both internal and external stakeholders, the outcome is a tailored and unique action plan. The thorough investigation will allow any manufacturing company to get a head-start on a smooth implementation and transition to applied AM technologies with considerations that go beyond simple use-case suggestions and scenarios.

The AMII follows a staged approach to identify, present and support change throughout the organisation. Initially, a 'Current State Analysis' is performed to understand in detail the organisational and technical processes with respect to AM capabilities. Using a range of internally developed tools such as the industry QuickScan coupled with an experienced expert team, opportunities and value streams can be rapidly identified. In consideration of the companies' goals, challenges and needs numerous problems and opportunities can be identified where AM can be of benefit to the company.

From here the AMII team has been able to paint a clear picture of the organisation from both an internal and external perspective. The team gets

A scenario [...] can encompass a wider manufacturing process, machine optimisations, internal and external services, supply chains, and other aspects of the business that will benefit either directly or indirectly from AM.



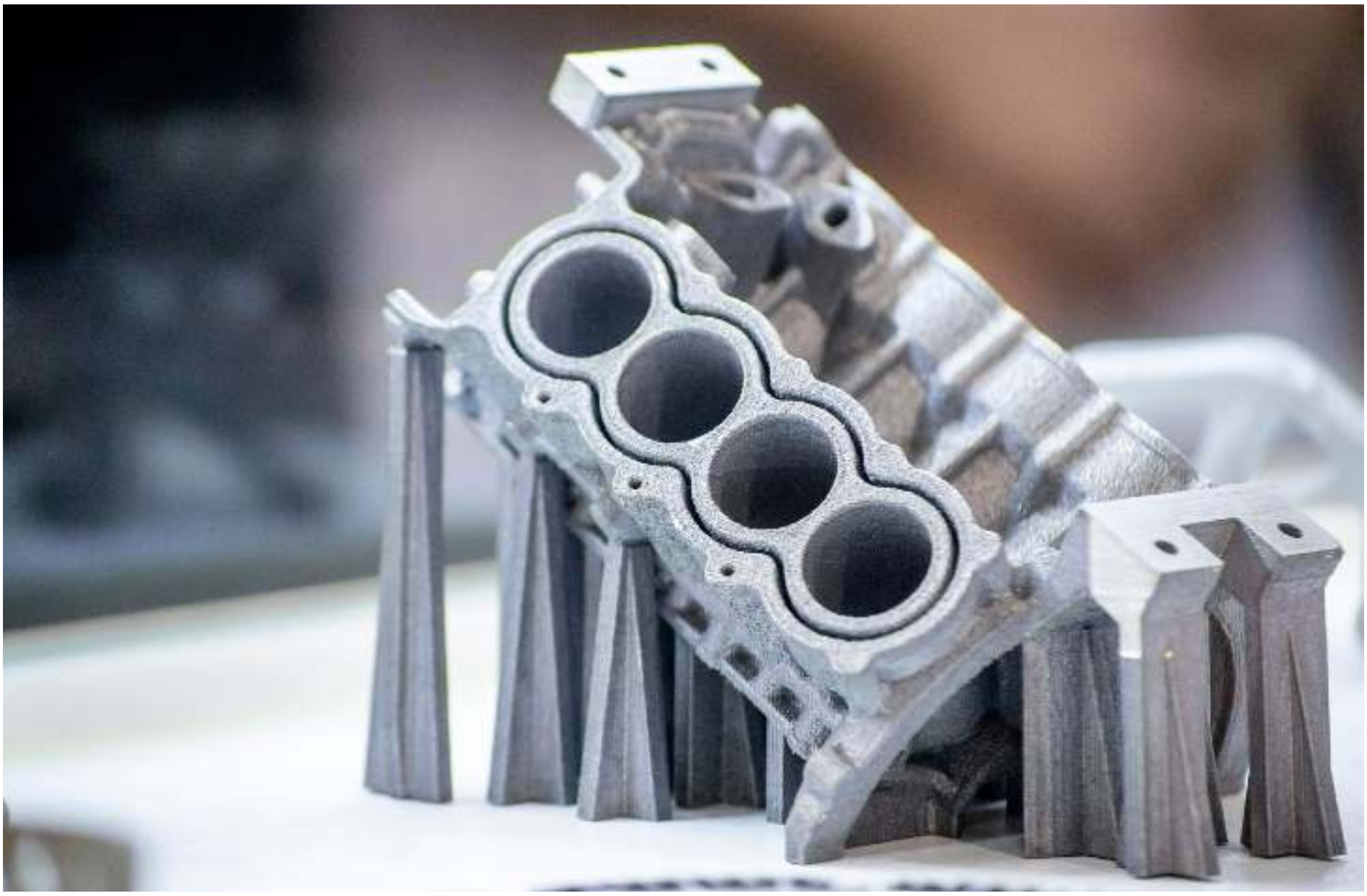
> **Entering any new technology field can be daunting. From the outside it can appear overwhelming even for established mature companies. AMII was conceived to help solve this problem.**

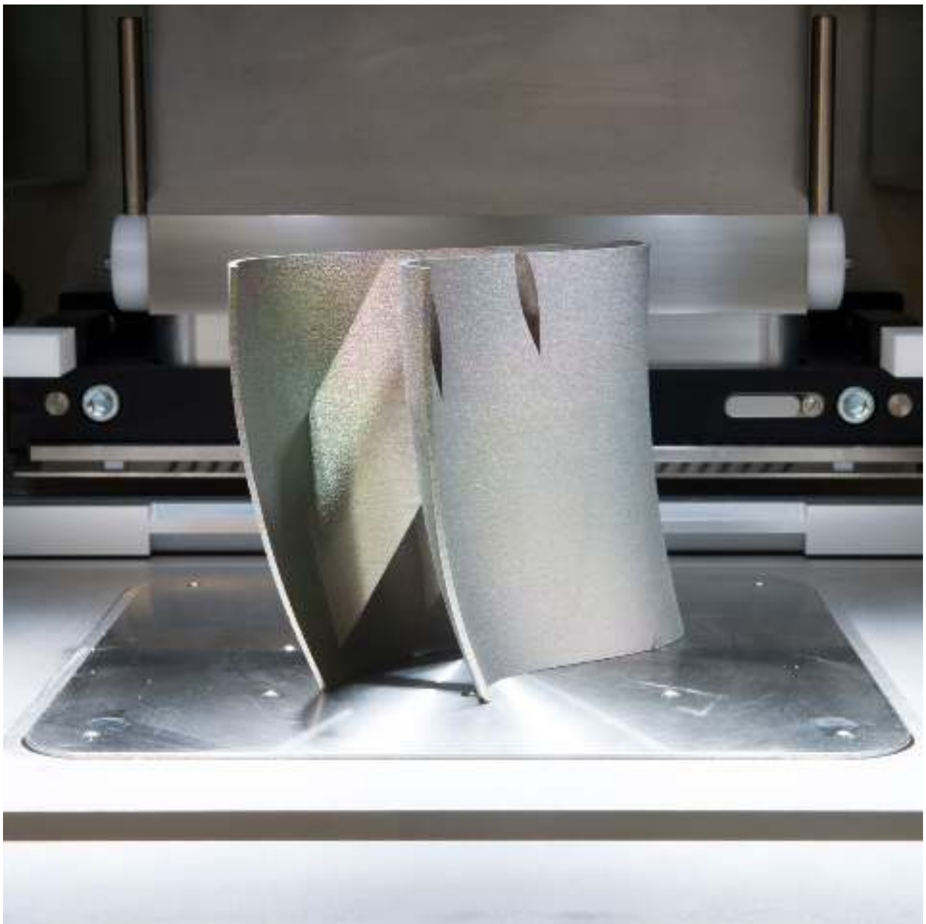
straight to work through analysing existing business practice to suggest a series of custom-tailored scenarios of how and where investment in AM can provide the best and most efficient returns. Through collaborative effort, the AMII team will then take away the top scenarios for development. A business case is produced around these highest opportunity scenarios with clear descriptions on how existing process chains will be impacted if implemented and where the core value will be realised.

A scenario is not always limited to the narrow scope of an improved product offering. It can encompass a wider manufacturing process, machine optimisations, internal and external services, supply chains, and other aspects of the business that will benefit either directly or indirectly from AM. Participants will often be surprised at the interesting and novel ways value can be realised with Additive Manufacturing, such as in creating print on demand digital asset libraries for inventory.

After successful collaborative scenario development, the team provide a technical implementation plan and roadmap. A good road map provides a path to introducing change in the wider adoption of AM. The roadmap is broken down to highlight specific per-product or process scenario actions that are required. Short, medium, and long-term implementation and transition is considered with the critical path, challenges and goals clearly communicated and considered.

To support the transition to new technology, the final stage of the investigation involves assistance offerings and suggestions. The AMII can extend into a comprehensive offering of continuing assistance such as through additional project support, extended training, and organisational knowledge building.





A company that recently engaged in the initiative was Tembo. An AMII probed and investigated deep into the company culture. Behavioural characteristics and attitudes towards change and new technology were established through a series of workshops, interviews and online surveys with key decision makers and thought leaders at the company. The dedicated team of experts from FIP-AM@UT and IPT that partnered with Tembo during the AMII were able to provide comprehensive collaborative guidance on how AM could best be implemented. Through identifying key gaps in internal knowledge, learning and process within the organisation a focused roadmap to AM was developed.

The roadmap highlighted a clear way of realising near instant value in making some entry level product and machine changes through AM to see production processes much more efficient. Product and process steps that were traditionally prone to high-cost assembly error due to part complexity were identified as prime candidates for the first steps. Alternative product models were suggested and developed that would see significant reduction in part counts of sub-assemblies making the assembly process faster and far less prone to expensive error. These tangible product scenario suggestions were also coupled with comprehensive guidance on change management and training in how to engage and involve wider stakeholders with AM technologies.

If a unique and relevant plan that offers your company tailored guidance to AM implementation and value add sound like something you need, feel free to reach out to the team at FIP-AM@UT. The expert team are there to help companies of all shapes and sizes from a variety of manufacturing industries build knowledge and get the best out of any AM investment. ■

"Additive Manufacturing (AM) is on the radar of many companies now as a wider technology that can change the way we produce and offer goods and services."

BEYOND A NAME

THE IMPORTANCE OF PERSONALISED MARKETING IN MANUFACTURING

In the early days of digital media, forward-thinking marketing teams were quick to jump on the opportunity to reach enormous audiences at very little cost. Then, along came automation to increase brand reach at low cost and massive scale.

However, these two developments ultimately resulted in a huge spike in mass marketing for brands. The problem with mass marketing is that it completely ignores audience segmentation and lacks adaptability, which means it is really only effective for products with general appeal and sold at low prices. For most manufacturers, such as those that cater to quality-conscious customers in the retail or B2B space, this is far from ideal, since it does little to build trust and form lasting customer relationships.

> **Personalised marketing gives companies the opportunity to build trust and expand their reach through engaging content. Here's what that means to manufacturers.**

The return and rise of personalised marketing

Personalised marketing is nothing new. Indeed, it has long been a staple in many industries for years, especially those that handle high-value transactions and where trust, relevance, and customer satisfaction are essential to success. However, in the context of digital marketing, it has taken on a wholly new meaning that goes far beyond just adding a name to your email newsletters or spending a bit of time tweaking the targeting options on social media advertising platforms.

Both the challenge of and the need for personalised marketing are born of the fact that every customer is different. Trying to communicate to everyone in the same way may be the cheaper and easier option, but such an approach only dilutes the power of your message. This applies to businesses in any industry, including primarily B2B sectors like manufacturing. In fact, B2B manufacturing firms have it even tougher than most, because they typically involve high-value, high-volume transactions where customers tend to take extra care before committing.

To attract customers in such an environment, manufacturers need to build trust and offer an impeccable service. Personalised marketing, which has now become an inseparable part of the entire customer experience, is paramount to that. In the manufacturing space, this typically takes the form of account-based marketing, whereby marketing and sales reps engage directly with prospects and customers to deliver a more engaging and relevant experience. As such, their primary goal is not to increase sales directly, but to do so indirectly by ensuring that their customers have an impeccable experience when dealing with them.

Personalised marketing depends on an optimal combination of technology and human impact. Technology assists with the collection of data-driven insights to drive more informed decision-making. Humans focus on tailoring content and strategies to specific audience personas, while engaging sales prospects directly. Such an approach can be highly effective for manufacturing firms, which are typically highly reliant on long-term customer relationships.

Building trust with high-value prospects and customers through personalised content

Customer experience and personalised marketing are two terms one rarely hears about in the context of manufacturing. After all, manufacturing has traditionally been focussed on products rather than how they are presented to customers, with little being invested outside of research and development.

The problem with too much automation, especially in the case of mass marketing, is that it can depersonalise a brand, and a depersonalised brand is one that customers are less likely to trust.

Given that many manufacturers rely on high-volume, high-value sales, earning customer trust needs to be a top priority. The greater the effort sales and marketing teams make to address people's unique needs and emotions, the easier it will be for them to connect with customers on a meaningful level. This, in turn, fosters more personal relationships which, once established, cultivate trust and customer loyalty.

Building those relationships and inspiring trust starts with personalised marketing and digital content created and curated for a clearly defined target audience. When it comes to content creation, whether in the form of quick updates on social media, blog posts, whitepapers, or any other format, the top priority should be to build authority. Authority, after all, is what brings forth trust. Thus, companies must be consistent with their brand stories and publish content that presents real value to their target audience, as opposed to content designed for a general, mass-market audience. In this sense, less is most definitely more.

Content can be educational or entertaining but, above all, it should keep the target audience and their preferences, needs, and pain points in mind. Finally, it should be transparent, honest and, where appropriate, incorporate social proof in the form of genuine recommendations and customer experiences.

Staying relevant in a digitally-driven business world

Success in personalised marketing typically depends on a strategic blend of automation and human intervention. In the old days, SME manufacturers generally relied on managing just a handful of partnerships with retailers and wholesalers, and marketing in its broader sense was usually not a priority. However, in the era of globalisation and digital technology, even smaller manufacturing firms now have opportunities to tap into much larger markets.

Tapping into those markets requires a degree of automation which, in turn, requires a degree of generalisation. To that end, it is simply not practical to rely solely on one-to-one outreach via social media or any other channels. Success requires finding the right balance between all of these factors.

Creating engaging content is where that all begins. With the right content, manufacturers can attract the right attention from the right people by showcasing how their products and services solve problems and align with the specific pain points of each target audience persona. This is why, rather than just talking about their own products, today's marketing teams create and share content that talks about the wider industry and the challenges and opportunities it faces. In this respect, a variety of content formats, such as whitepapers, business blogs, social media posts, and video introductions can greatly help to expand reach.

Automation can help by identifying what works and what does not. Data analytics, for example, lets you instantly identify which content is the most engaging. Automation can and should also be applied to personalisation itself. For example, most advertising platforms offer advanced targeting functions that let you home in on high-intent customers, utilise the most appropriate channels, and get your timing just right. These tools are invaluable when it comes to getting your content in front of the right audiences. Automation can also dynamically display content and calls to action based on individual user attributes, such as demographics and interests.

What privacy regulations mean to personalised marketing

Personalised marketing, especially in the context of automation and analytics, has undeniably become more challenging since the implementation of legislation like Europe's GDPR and California's CCPA.

Most companies rely heavily on audience profiling in their marketing strategies, which by definition involves the collection and processing of personal data. Now, this can only legally be done with explicit consent from the subject. In other words, people now have the legal right to opt in or out of receiving marketing emails or having their browsing activity used for profiling.

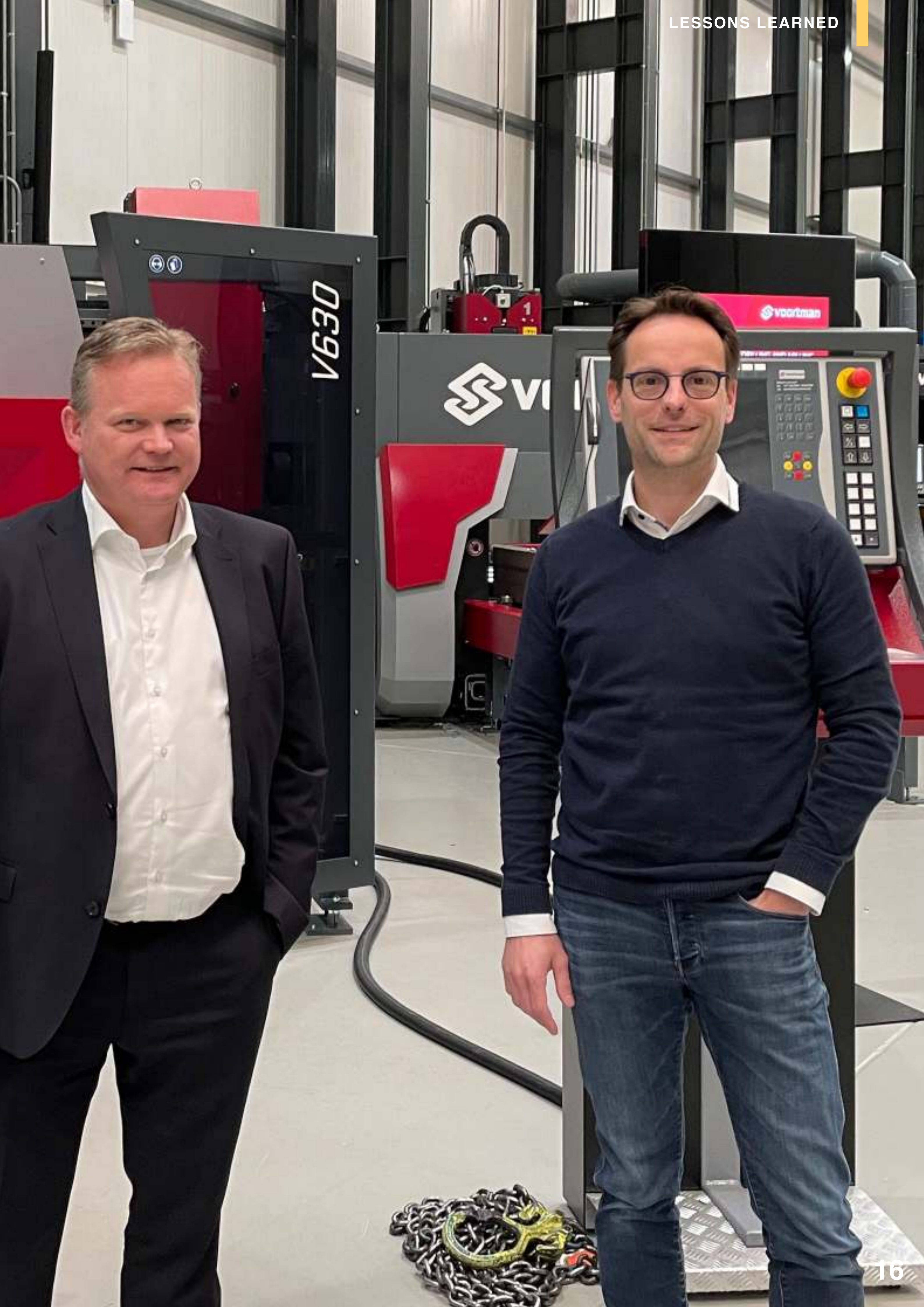
Given the ubiquity of cookie consent messages on business websites as a direct consequence of GDPR, it is hardly surprising that this has given rise to many questions around personalised marketing. However, many of these questions and concerns are a result of the fact that there remains a widespread misunderstanding of how personalisation differs from relevance. What is most important, especially in a high-touch area like the management of customer relations in manufacturing, is how relevant your marketing strategy is.

By definition, relevance is personal, but it is not necessarily unique to an individual. Personal data might be very useful for helping companies better understand their customers, but it does not change the fact that brands still need to have something of value to offer when it comes to their marketing content. Manufacturers, just like any other business, build their brands on trust and integrity, which ultimately means their marketing must be relevant and their sales reps must be equipped with the right tools and training. Automation can still help overcome the challenge of scale, but it should not be viewed as a shortcut. ■

BUILDING THE FUTURE TOGETHER

TValley is an innovation cluster for engineers to get in touch and work collaboratively on challenging projects in the field of robotics, AI, and mechatronics. The community, consisting of companies, research groups and educational institutions, enables meaningful knowledge transfer in specific domains. This aims to identify, develop, and implement new, industry-driven innovations. We spoke with Steven van Roon and Mark Voortman about TValley, Voortman Steel Group as a partner of TValley and the future and added value of collaborations between companies within the east of the Netherlands.

Steven van Roon, who has been working at TValley for two years as a programme manager, identified the challenge of taking knowledge transfer about mechatronics within the industry in the Twente region to the next level. "In 2017, TValley was officially established. The main driver of this was the Research Group Mechatronics of Saxion University of Applied Sciences. The aim was to structurally organise the cooperation between industry and the knowledge institution Saxion. This connection between those will always be there, and at the same time, we also see the need to extend our perspective to other knowledge areas. We want to take the next step and become the technology development platform around mechatronics, robotics and AI in the east of the Netherlands. This means we will innovate more, draw up roadmaps based on the needs of the industry and bridge the gaps we come across. Whereas in the past, the emphasis was mainly on mechatronics, Industry 4.0 broadens the range of important themes in education and business. Think of the usage data, and in a broader sense of robotics, Artificial Intelligence, Advanced Perception and systems engineering."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The changing market

Mark Voortman is CEO of Voortman Steel Group B.V. and chairman of the board of TValley. He tells us about the background of the successful family business: “My father started with small-scale maintenance of machines in the region. When the textile industry in Twente disappeared in the 60s, the construction sector began to flourish. From this sector arose the demand to supply steel structures.” For ten years, Voortman focused on mechanical engineering and steel construction on a small scale. The company split into two separate enterprises: one focused on steel construction, Voortman Steel Construction, and one focused on mechanical engineering, now known as Voortman Steel Machinery.

“When I took over my father’s mechanical engineering branch in the mid-90s, the company consisted of 17 or 18 people. More than 80% of what we made was custom-made. We made machines for concrete, wood, and steel industries. All nice projects, but the revenues were less exciting. For the sister company, the steel construction branch, we developed a machine ourselves at some point. That was the first product that we had realised ourselves. The demand for this machine increased more and more, so we produced a second, a third, and a fourth one. This has been the tipping point to no longer focus on speciality construction but on in-house produced

> **What is possible at this stage - and what is now needed for Artificial Intelligence in Industry 4.0 - or even higher - is just getting started.**

products. Since then, we have added a product and an (export) country to our portfolio every year. So, one could say that Voortman has grown in response to the market's needs."

Digitisation and automation in mechanical engineering

"Nowadays, digitization is one of the most important themes in the engineering process of the machines," he continues. "Where we previously did not use any modules, now all products can be modulated based on functionality. We have also developed a software tool, a configure-to-order system, that makes it possible to assemble the machine to meet the customer's unique requirements. The output of this configure-to-order system is then sent as a single source throughout the factory and this way, we have a fully automated production control."

The question of whether Voortman should develop further in automation is answered with a smile. "Digitisation, in the broadest sense of the word, is only starting just yet. And it starts going faster and faster and is therefore becoming increasingly complex." "We have now had the 'easy' automation," Steven adds. "What is possible at this stage - and what is now needed for Artificial Intelligence in Industry 4.0 - or even higher - is just getting started." A good example of this can be given by means of robot welding machines. Mark: "At Voortman, we make robot welding systems. We used to go from point A to B and if the material wasn't straight, the weld wasn't good. We couldn't fix this. Now we can. Using vision technology, we determine how a weld should be laid. Nowadays, it entails much more than simply going from A to B. But where do you get that knowledge if you don't have it in-house? This can only be done by sharing knowledge with other parties, learning from others, and developing the technology."

The added value of TValley

TValley enables this knowledge sharing. Various parties from the industry come together at TValley to exchange knowledge with each other at an engineering level. This way, there is an interaction between different groups and knowledge levels, without sharing company-specific information. Currently, the TValley network consists of 14 members, of which 10 businesses, two research groups and the two supporting organisations: Novel-T and Oost NL. In addition to Mark Voortman, the current board consists of Peter van Dam (Saxion University of Applied Sciences) and Jaap Beernink (Novel-T). With this mix, a leap forward is made. Steven: "There is quite some ambition, and there are plenty of opportunities. It is important to ensure that each involved business has a role in realising this ambition and benefits from the results. Our ambition is to be the technology development platform in mechatronics, robotics and AI in the east of the Netherlands. This is very broad, but through a good network, we can help each other to take the next step." Mark adds: "People need to know what TValley is and what we do. People need to go to TValley to solve problems and develop the technology. We are sharing knowledge with both educational institutes and other companies. Give and take, that benefits everyone".

Within the cluster, sharing knowledge for innovation is the core theme. "The added value of TValley lies in the innovation and the application of (new) technology in companies. What challenges do the companies have, and what are the common components we bring together in the Tech Roadmaps? Clustered, to jointly realise a development project within TValley," says Mark.

A look at the future

TValley has the ambition to achieve significant growth within 10 years. Steven: "We not only want to grow for the masses but also because with growth, you can demonstrate you have added value. To tackle various topics, make research groups grow, guide other knowledge institutions and the fact that companies can actually apply our innovations." Mark concludes: "It should be clear: if you're struggling with something difficult, you should go to TValley." ■

AMC NU

ADVANCED MANUFACTURING PROGRAM (AMP)

Powered by: **Regio Deal Twente**

Together with regional government and partners, the Fraunhofer Innovation Platform for Advanced Manufacturing (FIP-AM) has developed the Advanced Manufacturing Program (AMP) to establish a transitional framework towards Manufacturing 4.0 and empowering manufacturing industries in the Eastern part of the Netherlands.

The Advanced Manufacturing Program (AMP) provides subsidies through the RegioDeal supported by the Province of Overijssel and the Dutch state. It aims to encourage rapid development of Twente and other regions in the East Netherlands by forming an Advanced Manufacturing hub with an outward looking European image. With this the AMP greatly enhances the region's reputation and business climate.

Within the AMP, the Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente develops innovation projects around manufacturing technology themes. Every AMP project is built around solid industrial collaboration, empowering companies with relevant knowledge and new technological and industrial methodologies, Through the hub, these can be shared with other high-tech manufacturing industries in the region.

Member companies of the AMP can solve their specific technology problems and answer their market-oriented questions. This is achieved by developing and creating demonstrators that offer participating companies direct technological insight. FIP-AM then utilises workshops and master classes to further disseminate this newly acquired knowledge.

The Advanced Manufacturing Program (AMP) is a funding program that helps us support you in your transformation to Manufacturing 4.0. This is made possible through the Regio Deal supported by the Province of Overijssel and the Dutch State.

Rijksoverheid provincie Overijssel regio Twente Twente

PROJECT 01_

DATA-DRIVEN LEARNING ENVIRONMENT

The continuous and rapid evolution and progression of technology in all levels of the society requires the people to develop different set of skills, while many of them are still trying to overcome the knowledge gaps created with it. The new and old generation of workforce in the companies, especially those of the Industry 4.0 domain, are faced with a challenge to develop new competences and adjust to the fast changes in the market demands.

To successfully face these challenges the companies and their staff need support to quickly acclimatize to the new technology and data driven era, and to adjust the competence building (knowledge transfer) to the customer needs and desires, as well as to enable life-long learning by creating an on-demand learning environment that is merging the on-site and digital way of learning while providing hands-on experience from the comfort of peoples' homes.

With the project consortium consisting of The Virtual Dutchmen and Connec2, we are working on a tool to demonstrate the possibilities of I4.0 in a working environment.

Project activities of various types are carried out, and include research and development of the state-of-the-art knowledge transfer tools, building demonstrators that can showcase how new I4.0 technologies can enhance the learning experience (virtual shopfloor visit and interaction with machines), as well as development of onsite and online learning environment tools.

Consortia partners:
The Virtual Dutchmen
Connec2

PROJECT 02_

DRONES

Drones, also known as unmanned aerial vehicles, are becoming increasingly popular. Nowadays, drones can not only be seen in the private sector, but they are finding their ways into the industry as well. This project aims to investigate and demonstrate the application of generative and parametric design to develop models for flying sensors which can be used for various applications.

First, an optimized design is created with generative design software, and different materials and manufacturing technologies are evaluated. In this design light weighting, strength, and the carrying payload are included in the decision making. Integrated in the frame, sensors will be tested and used for various applications, ranging from measurements to inspection. The last, but most important step, will be the creation of the position awareness architecture. This technology will reduce the changes of failures, collisions, and enable in-flight human-drone interaction.

Initial discussions around this topic were held with BOLK, Clear Sky Solutions, Corvus drones, and Saxion. The consortium is open for additional partners. ■

LCA

(LIFECYCLE ASSESSMENT)

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Manufacturers face growing regulatory, societal, and business pressure to adopt sustainable production practices, hence the need for a better way to gain insights into the impacts of production processes. A lifecycle assessment, or LCA, facilitates transparent and credible environmental accounting, typically throughout the entire lifecycle of a product. It does this by breaking down the product lifecycle in various inputs and outputs at each stage of the process, such as the extraction of raw materials, logistics, production, and disposal, recycling, or reuse.

The results of an LCA span several environmental categories, such as those impacting climate change, toxicity, particulate matter, acidification, land transformation, and water use. These impact categories depend on the particular impact method used within an LCA. When an LCA focusses on a single category, such as climate change or water usage, the results are often called footprints. Normally, however, an LCA will assess the impact on several effects or categories by applying an extensive impact assessment method.

An LCA report should typically include the entire lifecycles of several products. An LCA is used to compare the impact of several similar products or different scenarios. This is called a cradle-to-grave LCA, which incorporates the end-of-life treatment of the product. Some reports may, however, be more limited in their scope. These are cradle-to-gate reports, which address the extraction of raw materials in a manufacturing stage. Cradle-to-gate reports are better-suited to intermediary products or materials, since they can be used to aggregate the impacts of the production of more complex products. An LCA can also take on other forms, spanning specific segments of a production process, such as gate-to-gate, and closed-loop production models.

LCAs are typically used to assess the environmental impact of a production process (ELCA), although other domains, such as lifecycle costing, are also possible. A lifecycle cost analysis, also known as an LCC or LCCA, follows a similar framework, albeit in the context of the total financial cost of an asset or investment throughout its service life. In the manufacturing space, this means a comprehensive analysis of the total cost of producing a final product or an intermediary one. It goes beyond the relatively simple first-cost analysis to evaluate the long-term costs and financial risks. Typical outputs of an LCCA report include the total cost of the investment in a given product, the return on investment, total cost of ownership (TCO) and the payback period.

To summarise, ELCAs and LCCAs answer different questions: one determines environmental impact and the other determines the total cost of ownership. However, by combining the two frameworks, manufacturers can build a strong business case for environmental and economic sustainability. This is particularly relevant when evaluating the effectiveness of new production methods, such as WAAM.

The key steps of a lifecycle assessment

The two most widely recognised standards governing LCAs are ISO 14040, which covers the principles and frameworks, and ISO 14044, which covers the requirements and guidelines. To validate the authenticity and accuracy of an LCA report, it must be reviewed by a neutral third party. Performing an LCA spans several key phases, which broadly cover the following areas:

The first stage concerns the goal and scope of the assessment. The main criteria to define is the part of the product lifecycles to be analysed, typically cradle-to-gate or cradle-to-grave. For a comprehensive report into the sustainability of WAAM as a production method, manufacturers should typically focus on the latter. In WAAM, this begins with the extraction of raw materials, such as crude gasses and ores. The next, and typically the broadest, stage is manufacturing itself, which includes transport, the refinement of raw materials, wire metal production, finishing, and

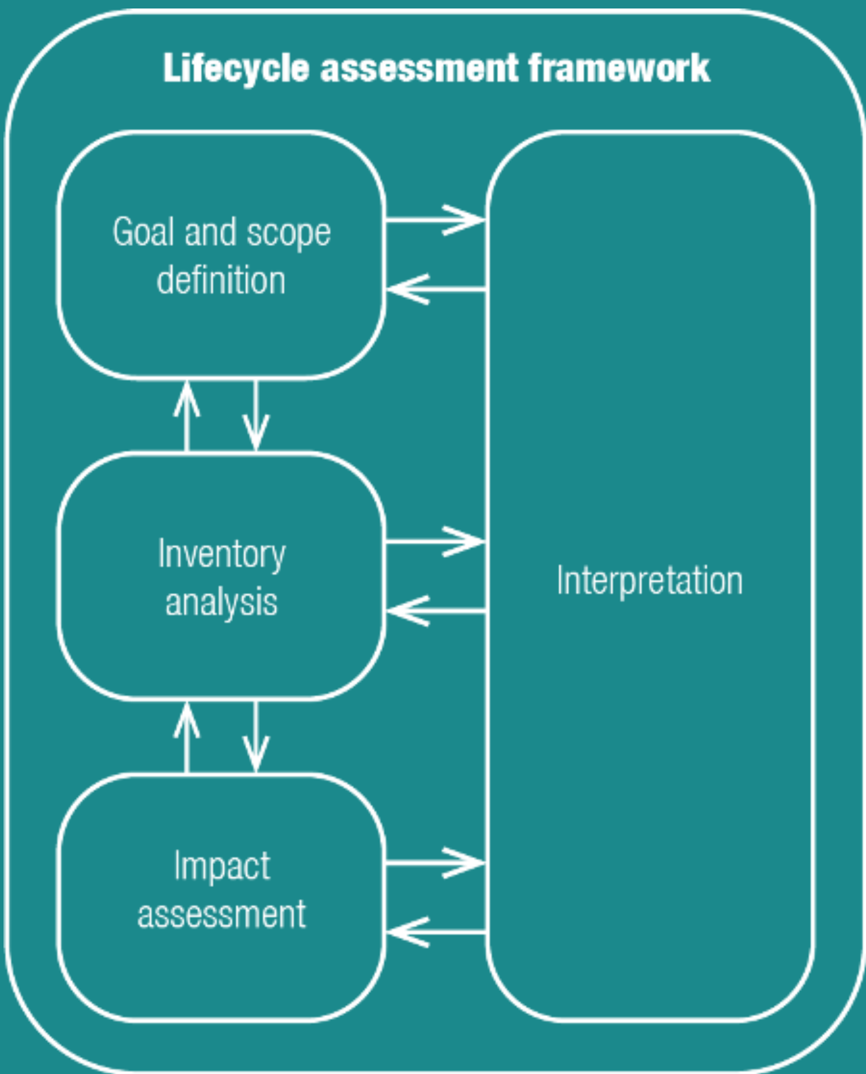

Figure 1: LCA structure according to ISO 14040

assembly of a final product. Next is the fuel or energy consumption of the finished product during use. Finally, a cradle-to-grave LCA will assess the recycling and disposal of the product at the end of its life. In the case of intermediary parts or materials, the end-of-life analysis may be consolidated into an LCA report for the final product.

The next stage is to perform an inventory analysis. This gives a comprehensive description of the materials and energy required within the production system. The lifecycle inventory (LCI) must be thoroughly documented with the accurate collection, aggregation, and validation of data. Furthermore, data must be related to unit processes and functional units to obtain a complete picture into the elementary inputs and outputs of a given production model.

The next stage is to use the information collected for the inventory analysis to create an impact analysis. The lifecycle impact assessment (LCIA) serves to evaluate the potential impact of a product and its constituent production processes on the environment and human health. Both the ISO 14040 and 14044 standards require the selection of impact categories and a thorough classification and characterisation of those impacts. Optionally, the LCIA may also incorporate the normalisation, grouping, and weighting of results under one or more lifecycle phases. Over time, many different impact assessment methods have been developed. Selecting an appropriate IAM is an important decision and one that will significantly influence the results.

The fourth and final stage is the interpretation of the LCA. This involves compiling the report and, optionally, handing it over to a neutral third party for validation and publication. This report can be presented in the form of diagrams providing visibility into the environmental performance of WAAM as compared to conventional manufacturing processes.

Carrying out a lifecycle cost analysis follows a similar process to that described above, albeit from a financial perspective. Another key difference is that an LCCA report is purely an internal document, which manufacturers can use to determine the cost advantage, if any, of adopting WAAM production processes. Furthermore, the findings from an LCA environmental report can also help to better quantify the total cost savings of adopting WAAM. After all, when it comes to environmental sustainability, the gap between what is better for the environment and what is better from a business and financial perspective is steadily closing.

What can manufacturers do with the results?

Consumers and government regulators are demanding greater accountability and attention to corporate social responsibility (CSR) and environmental sustainability. Another important reason for adopting the LCA principles and framework is the transition towards a circular economy. An LCA can also show the relations of different partners within a value chain. Manufacturing firms, particularly given their often-complex global supply chains, are under increasing scrutiny. As such, it can be highly advantageous for manufacturers to measure and communicate the environmental and social impacts of their products and services. Performing an LCA is not only a legal necessity in the case of existing manufacturing operations, but also a reliable tool for identifying new opportunities across increasingly complex supply chains and shared responsibility models. ■

GRADE 2XL

DETERMINING THE **SUSTAINABILITY** OF **WIRE AND ARC ADDITIVE MANUFACTURING**

ADDITIVE MANUFACTURING IS BRANCHING OUT TO YIELD GREATER POTENTIAL TO **REDUCE MATERIAL USAGE AND ENVIRONMENTAL IMPACT**, AS DEMONSTRATED BY **LIFECYCLE ASSESSMENTS (LCA)**

Wire and arc additive manufacturing (WAAM) is a derivative of the additive manufacturing (AM) process that uses an electric arc as a heat source to melt a wire feedstock in order to create a composite structure. It is a very promising technology that can produce large metallic structures with high deposition rates at a reduced cost compared with other competing AM technologies. Current WAAM hardware generally uses standard welding equipment, including the power source, welding torch, and wire feeding system. As it is the case with standard additive manufacturing processes, WAAM production is now largely automated using a combination of robotic systems and computer numerical control (CNC) gantries.

Although first patented almost a century ago, WAAM has only recently been investigated as a more viable alternative to traditional manufacturing processes. Its increased viability is largely a result of the growing adoption of modern computerised systems that allow for additional design flexibility, support for a broader range of materials, and extensive automation. As such, it offers a new approach to additive manufacturing that promises to be more sustainable, cost-effective, and scalable.

In spite of recent developments, however, there are still some important trade-offs to consider and inherent challenges that must be addressed. These include limitations to the volume, size, and range of materials used, as well as a data-driven strategy to drive decision-making and automation. To benefit from the adoption of WAAM, manufacturers must look beyond the traditional cost and sustainability models and metrics to determine the true impact and whether it makes sense for their manufacturing processes.

How sustainable is additive manufacturing?

WAAM is a branch of additive manufacturing, the process commonly referred to colloquially as 3D printing. Proponents of the method claim several benefits, such as reduced energy and fuel consumption, materials usage, and environmental impact. Further purported advantages include cost reduction due to better optimisation of shapes, more lightweight design, and the shorter production cycles that come with increased reliance on robotics, data, and automation.

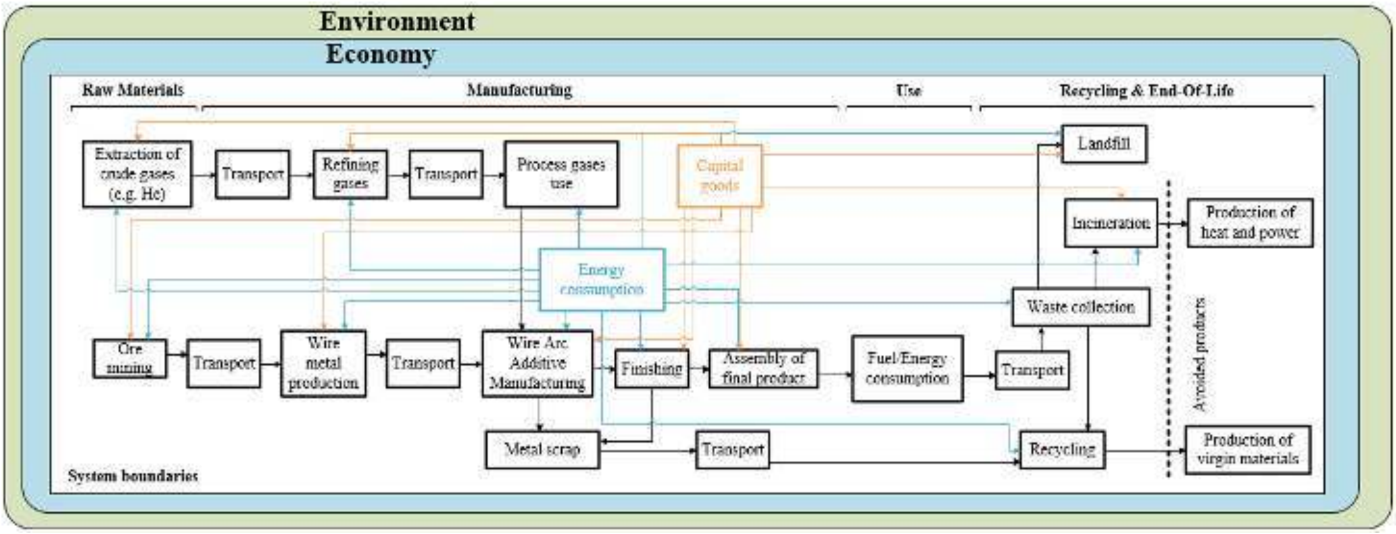

Figure 2: System boundaries considered in LCA and LCC models of Grade2XL products

However, many manufacturers continue to embrace more traditional production methods, as they have yet to be convinced that WAAM is suitable for their processes due to mainly cost and performance concerns. While these are being improved, another independent factor might be proven decisive for the broad acceptance of the technology, and this is its sustainability. Can the environmental impact of a component be reduced if produced by WAAM instead of, for example, casting? To validate the claims championing WAAM, it is important to take a life cycle perspective which addresses the environmental and economic sustainability more broadly. The ultimate aim is to tackle environmental impacts head on, while still being able to realise the cost and performance benefits of WAAM.

To achieve these goals, manufacturers can turn to industry-standard decision-support tools used to quantify the environmental and economic sustainability impact of WAAM. These are the Lifecycle Assessment (LCAs) and Life Cycle Costing (LCC), both of which explore the sustainability of manufacturing processes from the extraction of raw materials to the disposal of the product.

In the Grade2XL project, funded by the European Commission in the framework of Horizon 2020, we investigate the application of multi-material WAAM to produce and test 9 industrial demonstrator components.

These demonstrators are great cases for testing the hypotheses about AM used for LCA calculations, get accurate data for this novel way of producing metal parts and assess with confidence how sustainable the WAAM process really is. Our approach includes substituting the bulk use of expensive/ critical materials with more economically and environmentally sustainable metal combinations that can deliver equal or superior performance at a competitive price, with a reduced environmental footprint.

For all the reasons previously mentioned, LCA and LCC frameworks are currently used to compare the sustainability of all Grade2XL demonstrators to the same objects fabricated with the traditional manufacturing processes. Figure 2 below represents a generic overview of all life cycle processes considered for Grade2XL demonstrators produced with WAAM.

The processes illustrated above are included in the LCA and LCC models, which provide the environmental and economic impact of each Grade2XL demonstrators, respectively.

Our first case study focuses on the repair process of hot forging dies using the WAAM technology. Repair cases are particularly attractive for multiple reasons: 1) The service life of a component is extended, 2) the performance of the component can be enhanced after repair by using high performing materials, 3) the welding operations are performed by a machine instead of manually welding the worn surface, which protects the health of the operator.

Regarding the environmental impact, our first analysis shows that the main factors contributing to the sustainability of the process are the energy and the materials used.

For instance, Figure 3 illustrates the preliminary results of the LCA of the repair of a forging with WAAM and conventional welding for three selected impact categories, namely Global warming, Human carcinogenic toxicity, and Mineral resource scarcity.

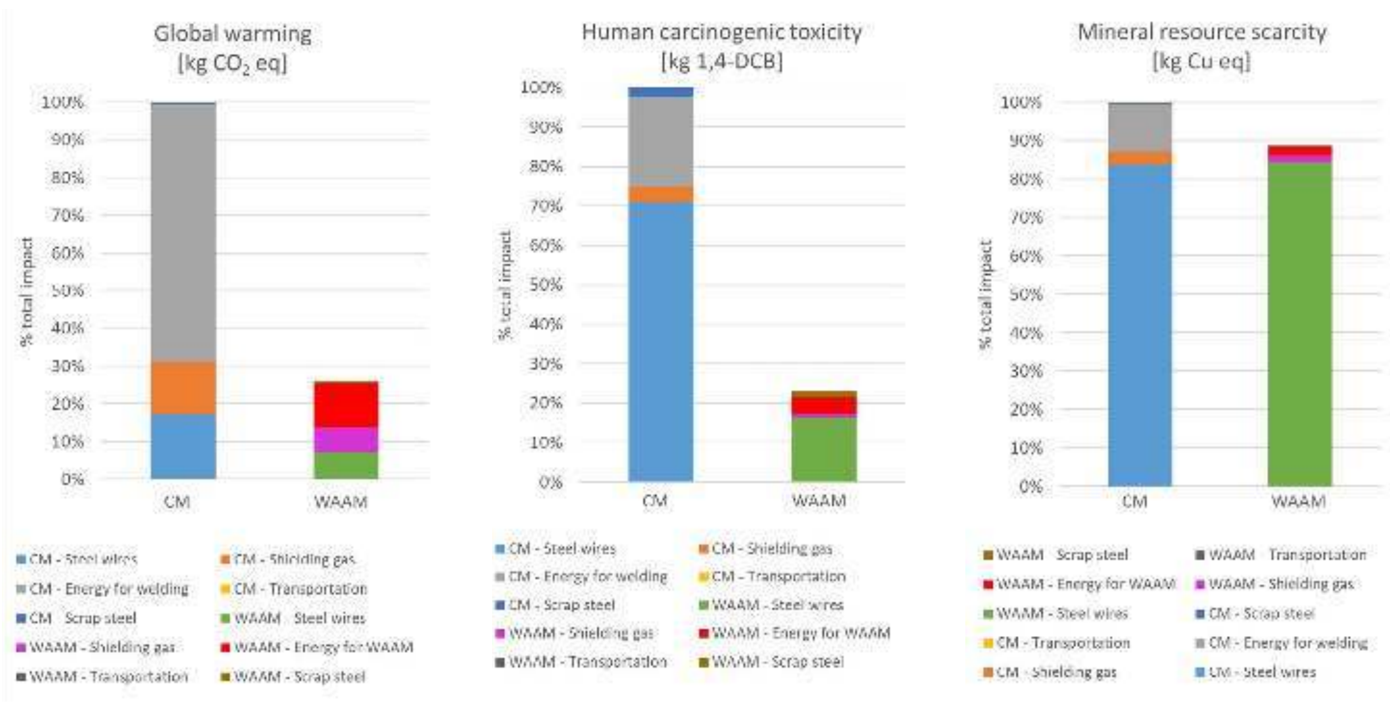

Figure 3: *Internally normalized impact score for Kuznia Jawor forging die repair by conventional welding (columns on the left) and WAAM (columns on the right) with process contribution analysis for three-selected impact categories.*

These diagrams enable to see the quite visible better environmental performance of WAAM over conventional processes. It is also clear that, in general, the steel wires and the energy used during repair are the major contributors to both type of manufacturing processes. Therefore, Wire-Arc Additive Manufacturing showed potential in terms of sustainability, which should be further investigate for different products and applications.

For the Twente region of the Netherlands, the local manufacturing industry is evolving and begins to adopt novel technologies like additive manufacturing and automation technology in their production. These technologies are constantly evolving to spur innovation, grow the regional economy, and lead the way to a more sustainable future.

That being said, local decision makers often face a complex set of information regarding manufacturing of products that includes technical, economic, and environmental information. Each novel manufacturing method comes with its own optimal set of use cases, hence the need for firms to be able to accurately evaluate their options. Demonstrating the sustainability of any given production method using a lifecycle assessment offers a standardized and proven way to do precisely that. ■

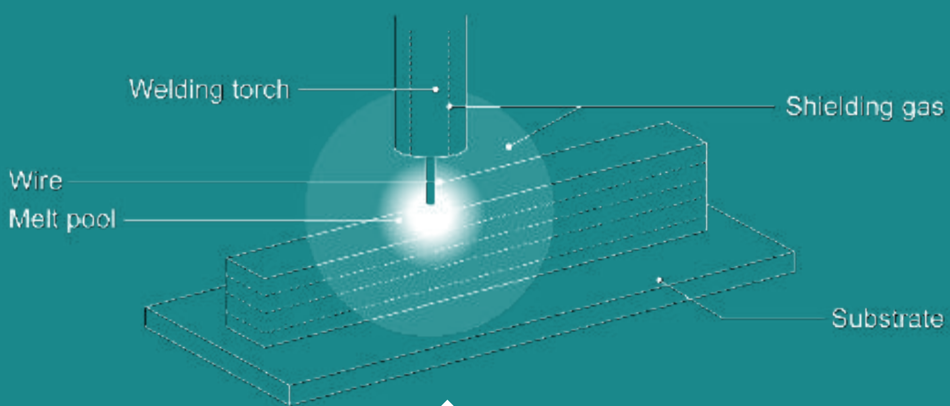

Figure 4: An example of a WAAM process

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TOWARDS AUTOMATED BATCH PRODUCTION USING WAAM

A CASE STUDY FOR THE **PORT OF ROTTERDAM**

Introduction

In the past decades, the modern technologies driven by computerized manufacturing led to the Fourth Industrial Revolution (Industry 4.0), which demands a high level of automation to achieve digital manufacturing through integrated smart machines that can diagnose, analyse and solve problems without human intervention. This also drives industries to develop new technologies to realize the transition from traditional manufacturing and industrial practices to a digitalized, sustainable, economic and environmentally friendly manufacturing. Additive manufacturing (AM) as one of these technologies, has moved from a novel manufacturing process into mainstream research and is being adopted for conventional industrial applications across multiple sectors.

In the recent years, significant effort is being put in developing a particular large-scale metal AM technology, Wire +Arc Additive Manufacturing (WAAM). WAAM research is especially advanced in the Netherlands, as companies such as RAMLAB BV in Rotterdam and MX3D in Amsterdam work together with the Dutch technical universities (TU Delft, TU Eindhoven, UTwente) to tackle the multi-faceted challenges in the process, materials and design of WAAM parts.

WAAM is an AM technique that uses an electric arc as the heat source to melt welding wire for 3D printing large metal parts. It is based on robotic Gas Metal Arc Welding, which is widely adopted by industry. As one of the Direct Energy Deposition technologies, it is the promising technology to sustainably produce large components in a short time due to its low setup cost and

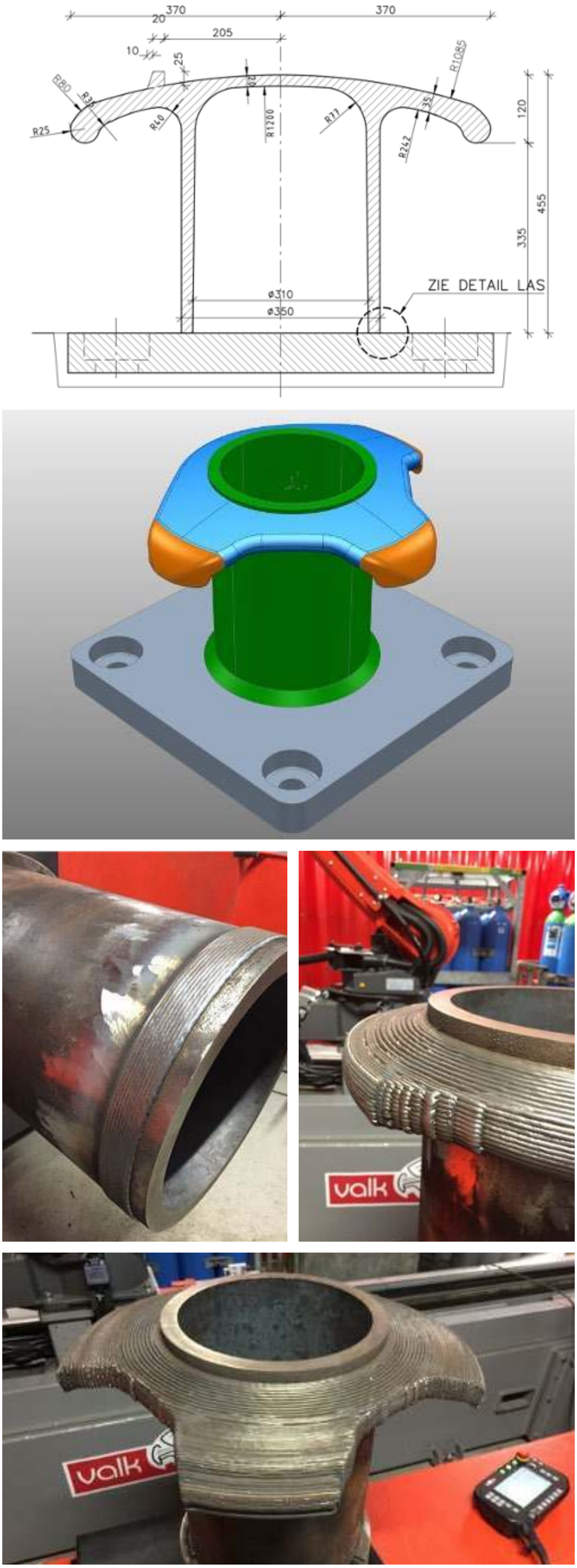


Figure 1: Example of the digital manufacturing workflow - bolder case.

Figure 2 examples on the left: WAAM 3D printed Bolder; on the right: smart bolder in the Rotterdam region.

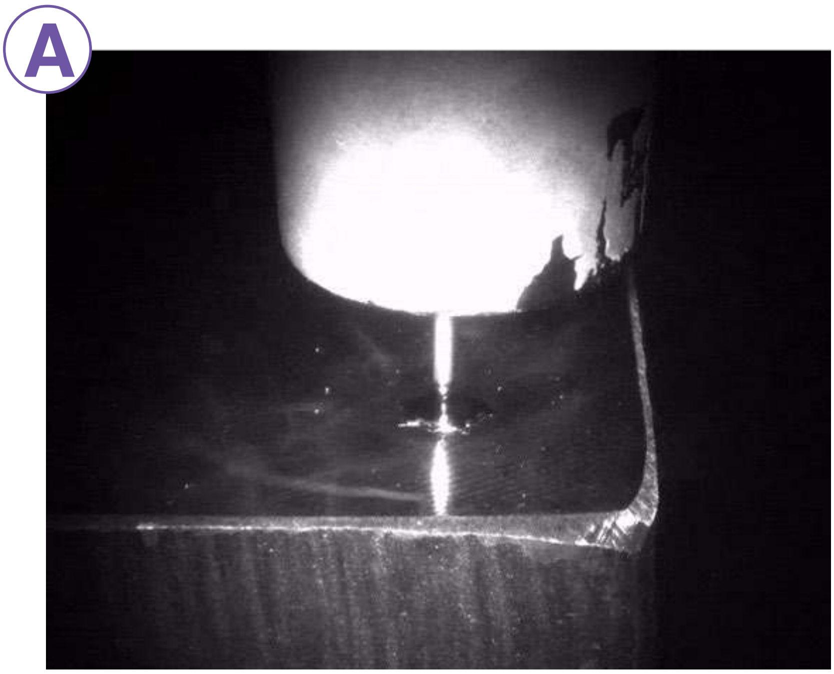
relatively high deposition rate (up to 5kg/hr). Several products have been produced as demonstrators and one-offs for civil engineering, maritime, energy and automotive applications successfully. However, to date, WAAM part production involves a great deal of human intervention for achieving the required part quality to compete with traditional manufacturing, and due to the high heat input required for the process, Additionally, due to the high heat input required in this process, long waiting times are necessary until the component reaches a temperature that is suitable for a subsequent layer deposition. These observations were the motivation to develop a process monitoring and control system that can guarantee uninterrupted and unsupervised WAAM production for single components, but also parallel production of component batches to eliminate the idle time between layers.

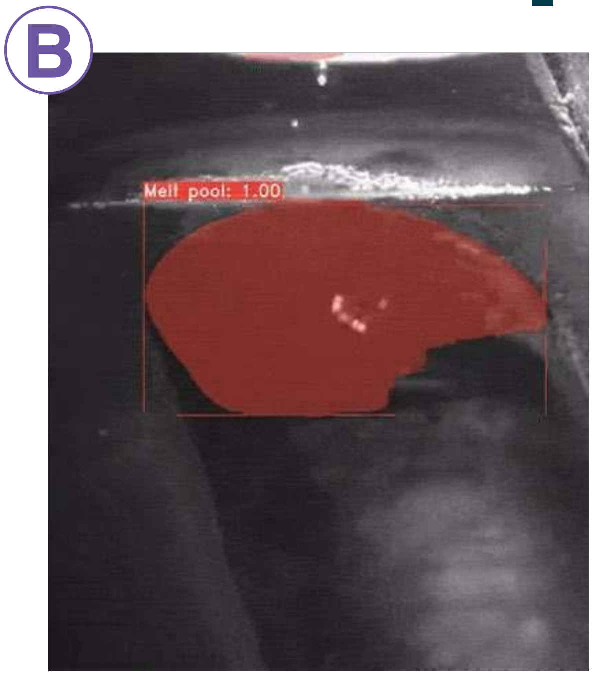
In this article we present our approach for automated WAAM batch production with the help of our in-house developed monitoring and control system. As a demonstrator, a batch of large maritime components was produced for the Port of Rotterdam authority.

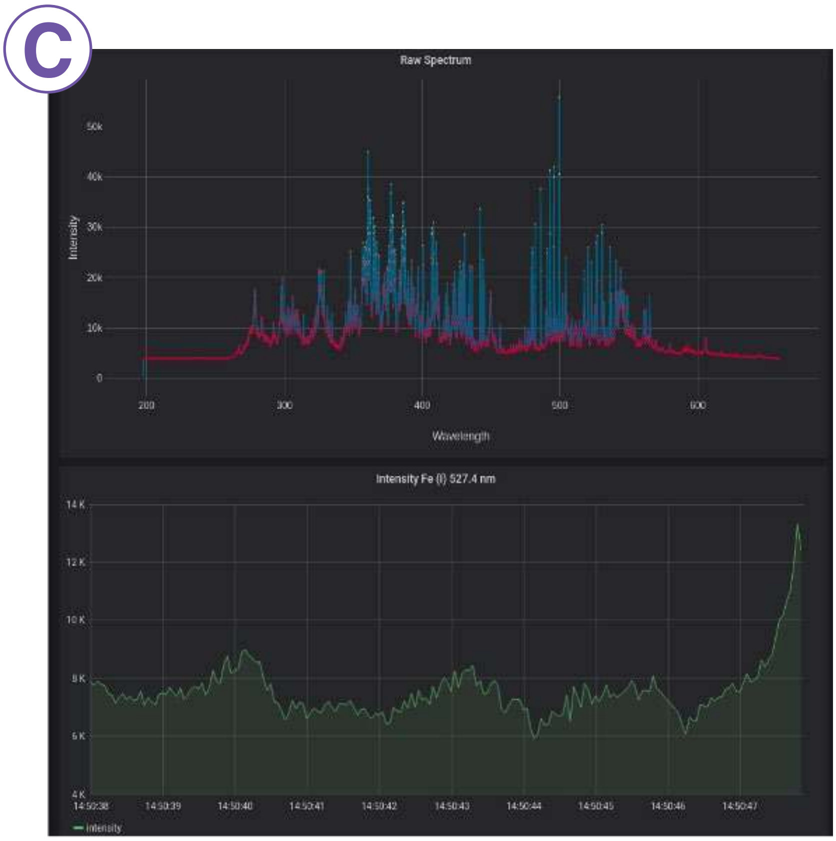
Approach

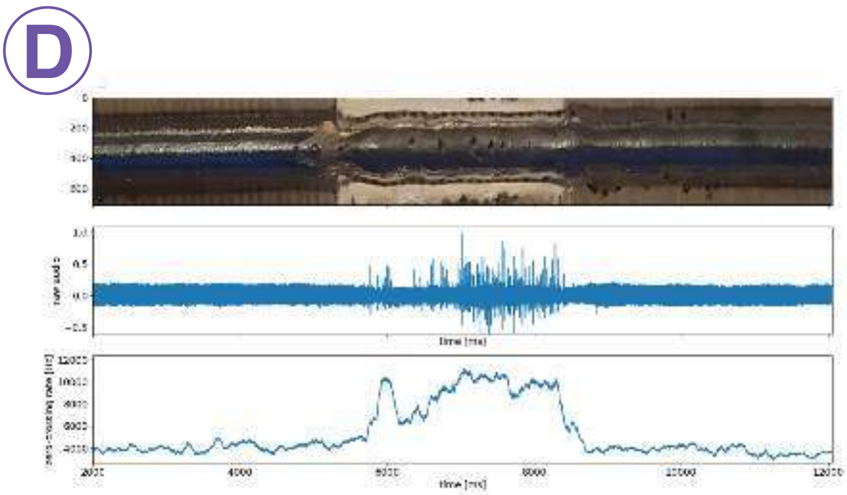
An industrial user case of a maritime component (bolder, Figure 1) was used as a demonstrator in this work. The bolder is a type of mooring bollard specially designed in the Rotterdam region with its unique and complex shape (Figure 2), which is a good case for applying 3D metallic printing to reduce the costs in long lead time and manufacturing steps. For the purpose of the study, 11 identical bolders of 60 kg each were manufactured. The CAD design was adapted and the toolpaths were created using Autodesk Powermill 2021 Ultimate. The material used to produce the bolders was 1.2 mm solid core structural high strength low alloy steel (ER70 Supramig®, Lincoln Electric) and the processing gas was a mixture of Ar, He and CO_2 (Ferromaxx Plus, AirProducts). The parts were printed using Super Active Wire Process (S-AWP) technique. for our deposition process the Panasonic TM-2000WGIII robotic welding system was used. A Time Series Database (TSDB, as part of our M&C system) was used to record more than 60 different types of data, such as welding current, voltage, travel speed, robot coordinates, temperature etc., for further big data analysis.

Figure 3 a) melt pool observation, b) melt pool dynamic tracing, c) element detection using Optical Emission Spectroscopy (OES), d) defect detection using acoustic sensor.









Results & Discussion

To achieve the quality assured in 3D printing and the requirements mentioned above, our current work focused on the digital manufacturing process chain (workflow) together with the in-house development of a monitoring and control (M&C) system to realize the automated WAAM part production process, called the MaxQ system. We have successfully produced 11 bolders following the digital workflow (Figure 1) using the WAAM process with the in-house developed M&C system. During production, we have studied the material response to the process using a dedicated welding camera. We monitored process anomalies during the process using various sensors, including a spectrometer, microphone and high sampling rate current and voltage sensors (Figure 3). We have also maintained uniform heat input through controlling the stick out and constant interpass temperature. The produced components were tested according to standard testing procedures of the Port of Rotterdam, they were approved and installed at the premises of the Port. Our work lays a strong foundation for the future of fully automated WAAM of large metallic components of critical quality, but also shows the benefits and possibilities of batch production with WAAM. Our next step will be to try the same process with parallel production of dissimilar designs and materials. ■

WHEN & WHO

DOES INDUSTRIAL ADDITIVE MANUFACTURING

PAY OFF?

THERE IS A SERIOUS BOOM IN THE BRANCH OF ADDITIVE TECHNOLOGIES. THE POSSIBILITY OF **FASTER PRODUCTION** AND **INDEPENDENCE FROM SUPPLY CHAINS** IS ESPECIALLY APPRECIATED BY THE AUTOMOTIVE, AEROSPACE, AND MEDICAL INDUSTRIES.

3D printing - unlimited possibilities for the industry

Additive manufacturing, usually referred to as 3D printing, is a group of various technologies that uses such materials as polymers, metal alloys, or composites to create the desired parts in a way of joining consecutive layers of material. Depending on 3D printing technology there are various ways of creating the physical adhesion between the layers. The common factor of all additive manufacturing technologies is that the physical object is being built layer by layer, most AM technologies assure virtually no loss of material used, and the machines needed to complete the process are cheaper than conventional manufacturing equipment.

Applications of additive manufacturing in the industry:

In industrial conditions, there are multiple fields where additive manufacturing can be used - the production sites and the whole production process can be improved in many ways. Companies discovered new possibilities:

Rapid production of the prototypes. The process of prototyping can be substantially sped up comparing to previous prototyping methods. Rapid prototyping, which translates into significant savings in time and costs associated with product development and market launch.

Quick changes of jigs and fixtures used on-site which allows fast machine conversions and changeovers between jobs. New customized tooling can be designed and printed internally within hours or days. There is no need to order it from a third-party or choose from existing market solutions that do not always exactly suit the needs.

Production of hollow parts which are not possible to produce in any other technology.

The possibility of print-in-place of prototypes and fully functional end-use parts. This unique feature of additive manufacturing allows producing already assembled structures of cooperating moving parts.

Lower the stocks of spare parts, with print on demand internal service.

Replacing heavy metal parts with lightweight polymers or composites of properties sufficient for the application.

3D printing is often used in small batch production, especially when the use of traditional injection moulding methods proves uneconomical or significantly increases the price of the final product.

Parts produced using high-temperature printing technology have increased thermal and mechanical strength, and outsourcing unit production of such components is too costly, time-consuming and requires handling logistics processes. Rapid Manufacturing can quickly and cheaply make a small batch that is ready to be used or even sold. Therefore, 3D printers can produce off-the-shelf parts that are an essential component of the finished product.

3DGENCE

INDUSTRY F421

CLASS-LEADING PRINTING SYSTEM WITH PROCESS TRACEABILITY FOR INDUSTRY CERTIFIED ULTRA -POLYMERS.

Large chamber volume gives you the opportunity to print large or many models in one run

This 3dprinter is suitable for working with the high-performance thermoplastics and composites

Best-In-Class Industry Warranty. 3 years of free limited warranty

Industrial printer features

The majority of engineering and high-performance materials require an enclosed printing chamber, preferably actively heated. To avoid printing failures the materials should be stored and handled properly, but most of all correct extrusion and print chamber temperature should be provided. 3DGence INDUSTRY line printers are fulfilling all the requirements that allow to reach or exceed nominal mechanical, thermal, and environmental properties that are promised by the filament manufacturer. The filament chamber and printing chamber are actively heated and the temperature is measured and controlled. The extrusion of various groups of materials is possible on one printer, but using dedicated interchangeable modules. Each module construction is adapted to specific requirements of materials groups, giving, as a result, the best possible print qualities.

The manufacturing process in additive technologies is simple. Typically, all we need to start manufacturing is a 3D model. As a result, we have no upfront costs and the total time to produce the part is short. An additional benefit is that manufacturing costs do not depend on the geometric complexity but on the dimensions of the part.

The industry also appreciates additive manufacturing for its low material waste compared to cavity technologies. 3D printing when designing a new product makes it much easier to make changes to subsequent prototypes, and possible mistakes are not as costly.

In which industries additive manufacturing is the most profitable

The machine production and tool line industries find great support in additive technologies due to the demand for small series, unusual geometries, or the need for after-sales service for years to come.

One more application of 3D printing in the industry is personalization. This is very important in a world where - especially in certain industries - there is an increasing shift away from mass production to individualized production. For example, the automotive industry, companies such as BMW is now taking advantage of the possibility of personalizing end products, allowing owners of mini-Coopers to customize the look of the car to their liking. 3DGence regularly cooperates with automotive companies, where personalization of production is particularly important. Product personalization is also applied in medicine. Thanks to computer tomography, the shape of the prosthesis is adapted to the specific patient. It is also possible to print out preoperative models. ■

A NEW PHASE IN PROFESSIONAL 3D PRINTING

> **Thanks to 3D printing, a design can easily be adapted to the customer's requirements and technology. 3D Printing (Additive Manufacturing) makes it possible to produce parts on-demand and it is the method to easily develop prototypes.**

3D printing can be used in all kinds of industries and markets and for countless applications. Think of manufacturers of machine parts, car parts, medical equipment and household appliances, among other things. The digital inventory simplifies supply chain management, eliminating the need for expensive warehouse storage. 3D printing also saves time and money.

3D printing is production on demand

The main advantage of 3D printing is being able to produce on demand, while controlling storage and supply chain management. By 3D printing spare parts, for example, it is possible to develop a new warehouse system that works better and more efficiently. At manufacturers of parts and spare parts, a stock of spare parts will eventually arise. These can take up a lot of space and in the worst case, this stock can even age. A physical inventory is often still preferred, while a digital inventory offers a perfect solution. Digital inventory becomes very easy by producing parts on demand with 3D printing. The spare parts do not require physical storage, but can be printed on demand when necessary. This is suitable for single pieces, but also for small batches and series. All that is needed is a suitable file for 3D printing. The use of additive manufacturing also offers an opportunity to adjust the design of a product in the meantime.

Prototyping or series production?

3D printing has little or no start-up costs, which makes producing a few pieces very interesting. Certainly in comparison with conventional production techniques, for which tooling and moulds are required.3D printing is therefore the method for prototyping and very suitable for optimizing a design. Is the design suitable? Then with 3D printing it is easy to start a series production.

3D printing for agri & food

One of the recent developments is 3D printing for the food industry and agri-sector. The choice for 3D printing within these sectors therefore offers plenty of advantages. Think of design freedom, the production of custom parts and the manufacture of complex or organic shapes. This is particularly attractive for food-related applications. It also enables small stocks and ensures rapid development from prototype to functional parts. Some applications of 3D printing within the agri- and food industry are grippers, nozzles, machine parts, prototypes, robots and drones.

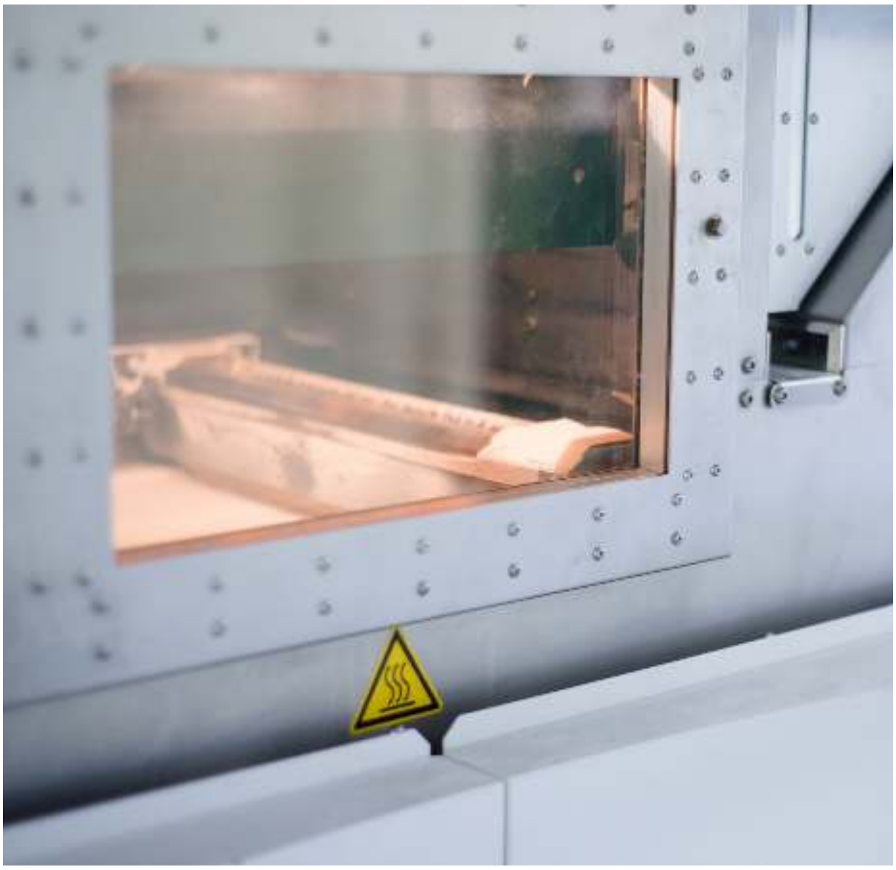
EC 1935/2004

To deliver a food-safe 3D printed product, the material must be suitable according to the requirements of EC 1935/2004 and produced in accordance with the EC Directive 2023/2006 (Good Manufacturing Process).

The choice for 3D printing within Food & Agri (EC1935/2004) offers plenty of advantages. Think of design freedom, the production of custom parts and the manufacture of complex or organic shapes. Think of grippers, nozzles, machine parts, prototypes, robots and drones.

The main advantage of 3D printing is being able to produce on demand, while controlling storage and supply chain management.

The quality policy is an important part of our company policy. Oceanz 3D printing is ISO 9001, ISO 13485 (medical) and EC1935/2004 (food grade) certified.



Oceanz's 3D printing processes comply with these regulations; the processes are included in the quality system and have been validated by external accredited parties. The material (plastic and metal) is therefore safe for production for consumption purposes or may come into contact with food. If desired, tests can be carried out for specific raw materials or circumstances (such as temperature and raw material).

Direct local 3D printing?

Direct online ordering is possible via YourOceanz.eu. Oceanz offers you a wide choice of 3D printing material (plastic and metal) and after treatments. After ordering, you will quickly receive the 3D printed products. The 3D printing is done locally in the Netherlands.

Oceanz 3D Printing is a professional 3D printing company and has been familiar with the market, industry peers and professionals for years. With acquired knowledge and concrete business cases, Oceanz has gained plenty of experience in various sectors, including Industry, Agri & Food, the Medical field, Automotive and Aerospace. Together with our customers, we develop and create 3D printing innovations that make the difference in every production process. The result: cost savings, reduction of failure costs and increasing production capacity.

The quality policy is an important part of our company policy. Oceanz attaches great importance to high quality, but also to the continuous improvement of the quality of the products and internal processes. These are secured by skilled personnel in combination with innovative machines and ERP solutions. In addition, the choice of material is also important. Within this framework, there are a number of directives and regulations within the EU. Oceanz is ISO 9001, ISO 13485 (medical) and EC1935/2004 (food grade) certified. ■

More info: **www.oceanz.eu/en/**

3D printing is of added value in all kinds of industries and markets and for countless applications. Think of machine parts, car parts, medical equipment, household appliances and more...

3D CONCRETE PRINTING

New materials and technologies are becoming accessible at a rapid pace. But how does one develop innovative products with them? At Saxion Research Group Industrial Design we aim at bridging emerging developments with current industries via applied (design) research.

In this article you can find a short introduction to Additive Manufacturing of Concrete, the approach we have to it, and the challenges in front of its adaptation in the industry. Below you can read more about several completed projects and our on the on-going research topics.

Additive Manufacturing of Concrete

Additive Manufacturing changed the game in product design by offering an alternative to complex molds and mass production. You have probably already encountered articles about the 3D printed topology optimized parts from the automobile industry, seen videos about customized prosthesis, or even have shoe soles made specifically for your feet.

But how does the picture look like when it comes to 3D printing large-scale object?

The most used material in construction is also not new to the world of Additive Manufacturing. 3D Concrete Printing (3DCP) is a technology that gathered significant popularity in the last 10 years. Many see the potential of it as it essentially could eliminate the need for expensive single-use molds, especially in the prefab industry. 3DCP is a relatively fast process as the layer height and width could be up to several centimeters resulting in 2 - 60 l/min material deposition.

Currently, the global focus is at 3D printing of housing, with projects ranging from a tiny house to multistory buildings. While housing is certainly interesting, we find the form freedom, that the technology allows, much more suitable for product scale objects.

3DCP in product design

At Saxion Research Group Industrial design we have been involved in concrete additive manufacturing since 2014. Throughout the years, we have worked with companies within the domains of civil engineering, construction, logistics, raw materials, architecture, and design. Together with our business partners, we approach every (gradually increasing in complexity) research question by firstly trying to get a good insight into the current ways of working and the visions for the future. When transitioning from traditional methods into new, automated,

Moving from technology push to technology pull, we believe that the applications should lead the future developments of the technology so we can witness more sensible, durable and better performing concrete prints globally.

and highly customized solutions, it often comes down to the change of approach: from “what is safe and easy to make” to “what is an optimal solution” or even “what is an aesthetically desirable solution”.

Combining design and production strategies for mass customization

Parametric design is when an object form is not set by sketches from the designer but by parameters(rules) that define its functions and shape. Such parameters can be the customer’s choice, material properties, surrounding constraints, etc. With such set-up, we translate complex yet flexible design rules into printable geometries. Implementing Rhino3D+Grasshopper software in the workflow also allows us to explore many options quickly as well as compare their performance, printability, and appearance in real time. While this sounds quite attractive, the reality is that it takes time for the industry to realize the potential of the methods.

Go beyond the lab

Getting out of the lab is essential to push innovation forward, make it visible and build trust. While it is essential to conduct the fundamental research needed properly, it is also very important to find suitable showcase projects which can exhibit the strengths of the technique in a safe and attractive manner.

Our first completed project is the Green Façade made in collaboration with De Witte van der Heijden Architecten, Vertico Large Scale 3D printing, and Trebbe. The façade showcased the ability to produce a structure of all unique elements with dimensions finalized a day before the production.

Using the same design language we took the idea a step further in the project Green Dome. In there we achieved a double-curved form again with all unique elements. The structure is aimed at sheltering a composting unit as a part of the project Green Dome with Twente Milieu and TWW. Such examples not only help as proof of concept but also give insight on the handling, transportation and assembly process.

While these two examples give a good insight into the possible manufacturing possibilities of 3DCP, we stay interested in what are the attractive applications from a business perspective. Such are the two cases currently in development:

1. **Spiral staircase**
2. **Fish ladder**

1 Spiral staircase

Our developments in the design of customizable spiral stairs ladder passed several lab tests. According to NEN-EN-1991-1-1, a staircase for an office location must withstand a point pressure point of 4,5kN (including the safety factor). The results show a consistent performance at started to collapse at 6kN. This brings more confidence in the design and manufacturing method and therefore 3D concrete printed stairs are one step closer to real-life application. With parametric design a staircase can be made to fit almost any setting, the client wishes all while being responsive to last-minute changes.

2 Fish ladder

Fish ladders (vispassages) are structures built along obstructed waterways to facilitate the natural migration patterns of various species of fish. But as each location is unique, so should be the design and the production strategy. The use of Parametric modeling here allowed us to iterate design choices to fit specific environments (such as 3D scanned data), resulting in highly customized solutions. Our partners at Twente Additive Manufacturing (TAM) already printed a proof of concept of the step design.

Selection Method

Working with these different applications has left us with an ever-increasing insight into finding proper applications. Based on this insight we are developing a selection method which will answer a central question for SME: “Is 3D concrete printing something for my company?”. During three sessions the SME’s values are determined and connected to the possibilities of 3DCP. By doing so in a systematic way (or methodology), application ideas are formulated that not only fit 3DCP but also make sense from a business perspective. Because the current method is at an advanced development stage, we are actually looking for companies who would like to validate the methodology with us.

In this way we hope we can contribute since it is crucial to facilitate a healthy transformation of enthusiasm from the new technology into real-life solutions relevant for the industry of today and tomorrow. The methodology can hopefully help companies identify new products, product features and markets which 3DCP can unlock or significantly improve. Moving from technology push to technology pull, we believe that the applications should lead the future developments of the technology so we can witness more sensible, durable and better performing concrete prints globally. ■

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The Saxion Betonprint Lab at Ariënsplein in Enschede has started using new software that makes it easier to make large-scale 3D concrete prints.

The Green Dome consists of a housing that can only be made by the unique advantages of the 3D concrete printer.

> **"Additive Manufacturing changed the game in product design by offering an alternative to complex molds and mass production."**

HIGH PERFORMANCE & SUSTAINABILITY

HOW **NEW ALUMINIUM ALLOYS** FOR METAL ADDITIVE MANUFACTURING PROCESSES WILL **BOOST ADDITIVE MANUFACTURING** APPLICATIONS.

Since the invention of metal additive manufacturing processes in the mid-1990s, a variety of processes and metal powders have been introduced into the manufacturing market.

Without a doubt laser powder bed fusion (LPBF or SLM) has become the most commonly used process in this field. Various metals and their alloys have become available in powder form to be used for processing with this technology. Stainless steel was one of the first available but soon after that, from approximately 2005 onwards, Aluminium could be processed to satisfy the growing demand from the manufacturing industry.

Although the accuracy and density improved, one basic problem still remained. The choice of Aluminium alloys in powder form stayed very limited. Basically, for most machines, pure Al, AlSi10Mg, AlSi12 and AlSi7Cu as well as very similar alloys were the limited choice compared to several thousand different alloys available for the casting industry.

Additive manufacturing and/or traditional casting

With a rapidly growing demand for Aluminium as a production material not only for the aerospace industry but also for the automotive industry, household appliances, shipbuilding and various other applications, there is a definite need to increase the availability and choice to enable AM-technology to produce parts for industrial applications and at industrial levels.

But how to increase performance of the end use parts compared to traditional casting?

Sailing boat front tip cover, printed with SLM-process in AlMg-alloy, courtesy Fehrmann/AMR

Meanwhile, the LPBF-process for additive manufacturing has reached a technology level to be able to influence the individual voxel of the 3D-CAD dataset which does offer significantly higher influence on the metallurgical structures of parts compared to casting.

If we now make available new high performance aluminium alloys in its powder form, the final part performance is boosted even more. AlMg alloys e.g. can boost the ductility of final use parts by up to 50% which is approximately ten times of the standard values. Please imagine the positive impact this can have on automobile crash tests with the resulting lighter parts design and less use of material which is a secondary but also very important contribution to sustainability.

New alloy designs also do enable higher corrosion resistance, easier coating and electroplating of final production parts.

The main advantage is that such new alloys are available not only in powder form but also as ingots to be used in traditional casting shops. Therefore, tests done with prototype parts from AM-processes will also resemble quality attained from series production from casting for higher amounts of parts.

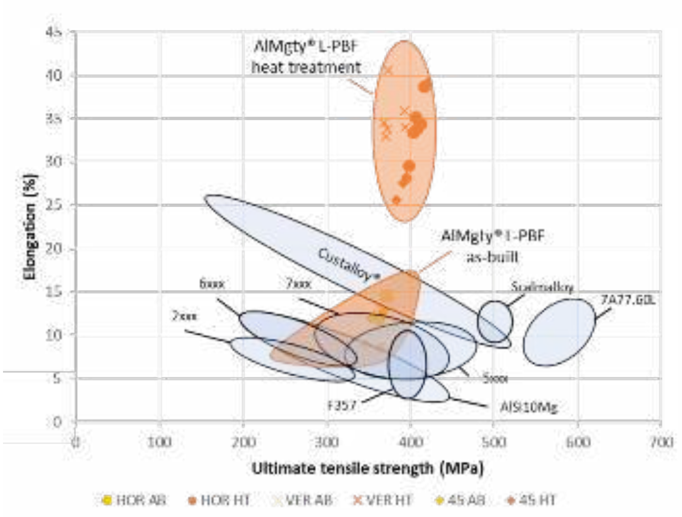
Material recycling made easy

Since the initial production of Aluminium and its alloys, it has become the best recyclable metal of all and millions of tonnes are getting recycled in the industry every year by remelting scrap. Therefore, nearly all material does stay in the circle which is an essential contribution to sustainability of production. It is notable that not more than 5% of the material is usually lost in recycling procedures.

Sustainability starts at the design already!

As often stated in previous publications, when using additive manufacturing, part complexity does come for free when designing the part. If we take this into consideration, the much higher performance values of Al-Mg and Al-Zn alloys will enable the designer to reduce weight and material even further, resulting in a significant material reduction up to approximately 30% of the part.

> **AlMg alloys [...] can boost the ductility of final use parts by up to 50% which is approximately ten times of the standard values.**



Design thinking incorporating AM-possibilities

One of the main roadblocks in enabling new parts design which will incorporate all of the above, is the traditional "manufacturing driven design approach" of education, experience and thought process of most industrial designers. Freeform fabrication design requires education and practical work experience of the capabilities that additive manufacturing can offer. Since a few years now, more universities now offer classes on AM-design and use but this is still at its infancy and is not a standard in every engineering faculty globally. This will be a major trigger to bring AM-technology into daily production for the next generation of engineers. Today, only a few percentage of all metal manufacturing is done by additive due to the above reasons. As usual, the aerospace industry is a forerunner here and already actively uses the extraordinary possibilities. Meanwhile, various parts have received flight certification and are used in daily production of aeroplanes as well as in repair. The new trend to boost rocket manufacturing for the micro launcher field for satellites is also using AM heavily as performance, complexity and weight reduction are primary considerations while costs are secondary.

The automotive industry is likely to follow this trend with the increased number of electrical vehicle designs which does shout out for lightweight materials and design due to the actual limited capacity of batteries to achieve the highest possible range of their products.

Summary

The combination of latest AM manufacturing possibilities, new high performance and lightweight alloys and corresponding design will enable not only future product solutions with better technical performance but also a forward-thinking sustainability approach in line with current international political and environmental projects and discussions. The key to success will be the combined use of all disciplines as well as the combination of traditional and future manufacturing methods. **Our future will be what we start today!** ■

Crash deformation simulation of Al-parts, left broken, right only deformed!

Written by:

Stefan Ritt
VP Market Development at FEHRMANN Materials, Hamburg, Germany

HOW BOND 3D IS UNLOCKING THE FULL POTENTIAL OF PEEK FOR 3D PRINTING

LEVERAGING INNOVATIVE **NEW ADDITIVE MANUFACTURING PROCESSES**, BOND3D HELPS BUSINESSES BUILD BETTER PRODUCTS IN LESS TIME AND AT REDUCED OVERHEADS.

Demand for 3D-printed functional components in the manufacturing sector is growing rapidly. This growth is largely driven by the availability of high-performance plastics, smarter robotics, and more data-driven manufacturing processes.

Among the most important developments in additive manufacturing is the increasing popularity of polyether ether ketone (PEEK). The semi-crystalline thermoplastic is well known for its high strength and resistance to heat and wear to the point that it can even substitute certain metals.

However, while the material is ideal for additive manufacturing, the process needs to be strictly controlled. The design and engineering team at Bond3D have developed a proven process that helps manufacturers unlock the full potential of PEEK from prototyping to production.

What are the main use cases for PEEK additive manufacturing?

PEEK is typically available as a filament for use in fused deposition modelling (FDM) machines or in powder form for selective laser sintering (SLS) additive manufacturing. PEEK is suitable for manufacturing parts with complex geometries, including various essential components for the automotive, aerospace, and electronics sectors.

With its impressive strength-to-weight ratio, PEEK can substitute various metals. It also offers high chemical resistance. Key applications include position units, seals, bearings, fasteners, and washers. Bond3D's process is also suitable for creating vital functioning components used in the automotive sector, such as transmission and braking systems.

What does Bond3D's PEEK additive manufacturing process consist of?

Bond3D's PEEK additive manufacturing process broadly consists of three phases: product design, prototyping, and production. Here is an overview of the optimal process:

#1 Product Design

#2 Prototyping

#3 Production

#1 Product design

Designing the product specifically for the PEEK process is by far the most important step, since it addresses essential tolerance requirements and the most suitable form of the material for the job.

Unlocking the full potential of PEEK requires specialised design software which Bond3D uses to create a complete digital replica of the proposed component. This helps determine the most suitable features and required dependencies of the product and saves time and money when it comes to prototyping and production.

The first stage of the design phase is creating the concept. This involves coming up with a list of potentially viable ideas that can solve the challenge you wish to address. Printing with PEEK opens up the possibility to create highly personalised, lightweight, and functional designs that can align with and adapt to your product development lifecycles.

The next stage in the product design phase is determining the materials necessary to achieve optimal functionality. Until recently, PEEK had the downside of being very difficult to apply in additive manufacturing due to high viscosity in its molten state and semi-crystalline structure in its natural state. This means it shrinks during solidification. This is why it is important to adapt the process to the material, rather than the other way round. This allows Bond3D to preserve the benefits of PEEK while leveraging the cost and performance benefits of additive manufacturing.

Finally, product design addresses tolerance specifications. PEEK has many characteristics that make it suitable for functional parts required in many industries. It is also possible to print voidless components that are isotropic in strength. That said, it is still essential to accurately determine which levels of electrical insulation, temperature tolerance, and chemical resistance are required for the final product.

#2 Prototyping

After all previous steps in the design phase have been taken, Bond3D can start printing out the first prototypes of the product. Depending on the complexity of the component being printed, there may be multiple rounds of printing, testing, and redesigning. As such, prototyping provides the answers and insights needed to begin the production phase.

The main reason for creating a prototype is to prove that the concept works. While computer-generated models can be more accurate and realistic than ever before, they are still unable to provide all the information required to evaluate a physical prototype in an actual production environment.

There are various ways to test the prototypes. For example, physical stress tests can evaluate parts for their tolerance to pressure, flexibility, and compression. Specific industries also have unique testing requirements of their own, such as testing for heat tolerance in automotive and aerospace applications. Moreover, given the speed and cost benefit of additive manufacturing, it is viable to deliberately break parts to find their limits and print new prototypes as required.

The final part of the prototyping phase is redesigning the prototype based on the test results. The results provide the insights needed to improve the designs and, if necessary, Bond3D can start from scratch to find a new solution. Because additive manufacturing offers the opportunity to apply changes quickly and cheaply, they can also iterate on changes easily, no matter how big or small the redesign is.

#3 Production

The third and last phase of Bond3D's PEEK process is to make the final product. Before they begin this phase, it is vital to have carried out all the prototyping, testing, and redesigning necessary to build parts that are ready to use in a production environment.

At this point, Bond3D's design and engineering team will create an approach for producing the parts at scale and in the order they are required. PEEK 3D-printed parts typically have a very short time to market, hence the importance of properly planning the production phase.

After the final parts have been created, the next step is post-processing. This involves adding finishing touches, such as smoothing edges, painting, or adding any extra components that might be required.

The next stage of this phase is to get everything ready for large-scale production. The design and engineering team should be able to create a perfect functioning part. However, customers often need to be able to print a much bigger series. Bond3D offers the opportunity for clients to keep all finalised products in digital stock so that they can be printed on demand.

The final step of the production process is the quality assessment. This ensures that all of the right parts are delivered with precisely the correct characteristics and that any defective parts are properly retired rather than being shipped off to Bond3D's customers.

Bond3D is redefining the engineering and manufacturing of essential parts for the automotive, aerospace, electronics, and medical sector. Based in Enschede, Netherlands, our company uses high-performance polymers and voidless additive manufacturing to significantly reduce costs and production times.

Find out more at **www.bond3d.com** ■

PRINTING THE START OF OUR JOURNEY TO THE SHOP FLOOR

In April 2022, the Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT) celebrated the launch of the construction phase of its new offices and shop floor facilities as part of the growing Kennispark industrial community in Enschede. Once complete, the premises will become the new home for the FIP-AM. The new complex will provide ample space for up to 50 employees and is expected to be completed by the end of the year.

To mark this important milestone, the FIP-AM wanted to create something to symbolise its role in driving innovation across the region's manufacturing sector. In partnership with Dutch engineering consulting firm In Summa Innovation, engineers at FIP-AM designed and created a 3D-printed brick made of titanium alloy to place within the new building as a reminder of their vision for creating a highly advanced and modern shop floor.

The FIP-AM used their MetalFab1 metal additive manufacturing machine to print the brick using high-tech materials. Designing the brick was a critical part of the process, since it included an advanced latticework structure that would ordinarily be very challenging to print using traditional manufacturing techniques. First attempts at building the brick in the machine presented some unexpected problems. In particular, creating lattices inside the machine proved time-consuming and complicated, requiring multiple sessions of numerical modelling and testing.

Fortunately, thanks to their cooperation with In Summa, the FIP-AM managed to create an optimised design using Hexagon's MSC Apex Generative Design platform. Apex GD is a leading additive manufacturing solution for designing high-precision industrial components, such as ones used in the aerospace, automotive, machinery, consumer products and medical sectors. The software reduces the time it takes to design components and export their geometry directly to 3D printing machines, all without compromising on output quality.

The FIP-AM's additive manufacturing specialists Angus Fitzpatrick and Sikander Naseem worked with Noël Bijl and Gökhan Tintin from In Summa to provide the key parameters for the design to generate a result in just a few hours. In record time, the brick design was ready for printing, though they also wanted to make sure that the end result would be right the first time in order to meet the time constraints. In addition to creating a novel and striking design, the larger but more distantly spaced struts designed in Apex GD were easier to print without compromising on strength.

The brick will be housed in the new FIP-AM building to symbolise its state-of-the-art nature. Once completed, the facility will be home to some of the world's most advanced manufacturing technologies and concepts, along with up-to-the-minute production systems. The ultimate goal is to create an optimised environment for demonstrating Industry 4.0 in action.

The new location itself is also symbolic. Located directly across from the main entrance to the Twente University campus, it clearly shows that the FIP-AM is still an integral part of the university, whilst also connecting with the broader manufacturing sectors of the Netherlands and beyond. ■

HOW TO GET THE BEST OF BOTH WORLDS

Focusing on one thing means: not focusing on another. Our abundance of experience and the project management model 'The Devil's Triangle' teaches us that. When we talk about Personalized Manufacturing, the focus is on delivering quality. Not so much in the sense of offering the best product, but in the sense of being the best in translating your customers demand into a good, functional product. Nice for your customers, but how do you ensure that it also remains interesting for your organization? How do you offer customized engineering while maintaining a high pace in the development of your production lines? Can the two even go hand in hand?

Choosing one = not choosing the other

The basic rule is that you choose a primary and secondary focus between quality, price and (delivery) time. That means that you have to accept that you will have to compromise on one of those three pillars. In Personalized Manufacturing, the focus is on the 'quality' pillar. If you, as an organization in technology, therefore opt for 'delivery time' as the second pillar, this automatically means that you are compromising on price. You then build quality products and ensure that delivery times are above average, knowing that there is a price tag attached to that. Choosing the 'price' pillar means that you will have to compromise on fast delivery times. Think about the influence this choice has on, for example, the deployment of engineering capacity, urgent deliveries of mechanical parts, personnel costs, profit margins, overtime and delivery times.

So, how do you get the best out of those three worlds?

We notice that several of our clients are making a move towards modularization. It's a hot topic. A development that

> **"People think focus means saying yes to the thing you've got to focus on. But that's not what it means at all. It means saying no to the hundred other good ideas that there are. You have to pick carefully. I'm actually as proud of the things we haven't done as the things I have done. Innovation is saying no to 1,000 things."**
>
> *- Steve Jobs*

TT ENGINEERING

Save the date

Kennisevent

VAN ETO NAAR CTO

Welke uitdagingen kom je als engineer tegen in de transitie van Engineer to Order naar Configure to Order?

Keynote speaker:

Ass. Professor Tom Vaneker

20 oktober 2022 | 13:00-17:00

www.tt-engineering.nl/Kennisevent-van-ETO-naar-CTO

In samenwerking met: Fraunhofer Innovation Platform is visible across the entire technical sector; whether you work in the automotive industry, food machinery, equipment construction or special machine construction. Although this is a method commonly used in Configure to Order, many organizations also use modularization to make the most of those three worlds. It is the golden mean between Personalized Manufacturing (Engineer to Order) and standardized products (Configure to Order).

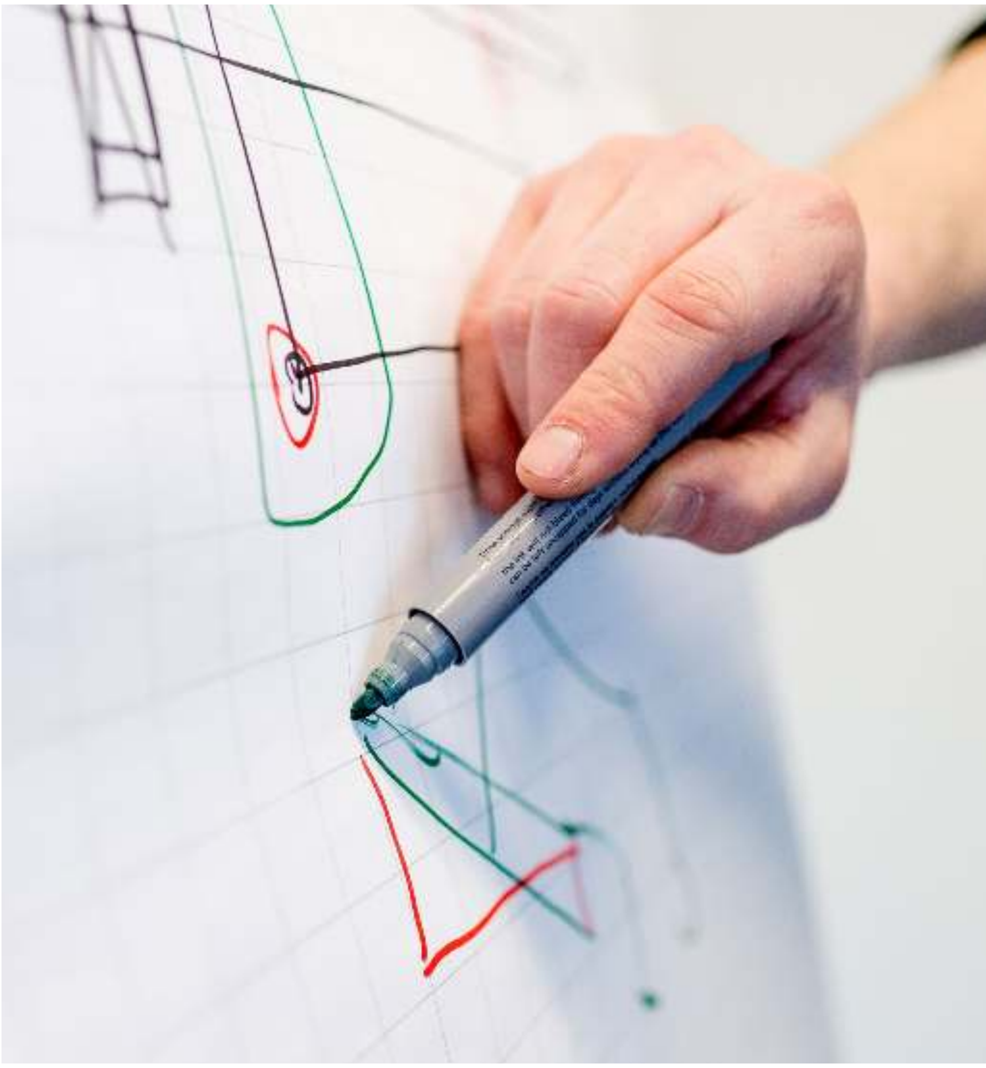
What modularization actually does, is that it forces you to define to what extent you want to focus on the pillar 'quality'. In other words: to what extent do you want customers to be able to personalize designs? Modularizing production lines can help to continue to deliver custom engineering while taking efficient steps in the engineering and production process. In this way you optimize your delivery times, without incurring additional costs on a structural basis. Of course, the switch to modularization requires an investment. In the long run, however, it means savings in engineering costs.

Does modularization offer enough room for custom engineering?

Personalized Manufacturing provides specific concept development and elaboration for each customer request. The focus lies in looking for the most effective solution for the customer's needs. Solutions are always unique and fully match the package of requirements and the wishes of a customer. This leaves room for a lot of attention for the effectiveness of the devised solution. At the same time, it also offers room for small mistakes that can sneak into the design process, due to the many revisions and adjustments.

Modularization gives you the opportunity to split and standardize production systems into various modules. This guarantees a large part of the quality and functionality of the engineering solution.

> **"Modularly constructed production lines are therefore the future."**



In addition, costs in the engineering and production process are reduced, without this being at the expense of the wide range of offered machines and equipment. Modules can be designed in such a way that they can be placed in different orders in a production line. A customer therefore already has options for personalization. Machines are also designed transparently in this way. In addition, you can of course choose to make room for customer-specific engineering on the modules itself. By building the modules largely in a standardized and yet flexible way, there is more room for innovation. Something that is welcome in a rapidly changing market.

Modularization: a basic requirement for Industry 4.0

In the past, the focus was on the net productivity of a line when purchasing machines and production lines. Nowadays customers are looking for machines and production lines that are flexible. Systems must be adaptable and machines must be variable and easy to expand. Modularization is therefore seen by some as a basic requirement for Industry 4.0. In our dynamic industry, technological developments follow each other at a rapid pace. As a result, it is becoming increasingly important to be agile and to build machines flexibly. Modularly constructed production lines are therefore the future.

What is the added value of an involved engineering partner?

Whether you focus on quality, price or delivery time: you will have to gather engineering partners around you who help build the future vision you have for your engineering department. Why is that important? If you work with a partner that focuses primarily on the fastest and most cost-effective delivery possible, handling an assignment quickly becomes a checklist. Task-oriented, putting out fires and moving on. Check, check and check. By failing to provide a sustainable implementation of the assignment, the involvement of engineers regarding the project and the long-term success of clients diminishes.

To be able to support your future vision, partners need to be aware of what you need. We call this 'deep customer knowledge'. Imagine having a partner in engineering who knows your engineering processes through and through. A partner who knows within which organizational frameworks you have room to work, play and innovate. And a partner who knows what will help you in the long and short term. Isn't that a nice way of working together in technology?

About TT-Engineering

Making development possible together is the goal of TT-Engineering. We are focused on finding the best solution, with a critical, goal-oriented, functional and solution-oriented view. We are an ambassador for collaboration in the manufacturing industry and believe that sharing knowledge is the basis for making the future possible. Together we advance in technology. ■

TT ENGINEERING
Maakt ontwikkeling mogelijk.

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Steps of an audit:

1. **Industry 4.0 Quick Scan**
   A brief investigation to develop an understanding of your specific needs, goals, and expected challenges to scope a tailored audit approach.
2. **Current State Analysis**
   Receive an expert breakdown of your current processes and Industry 4.0 competencies.
3. **Benchmark & Gap Analysis**
   Identify your competitive environment, your position within the industry, and potential gaps.
4. **Road Map Development**
   Create a custom implementation and action plan based on your vision and goals.
5. **Follow Up Support**
   If desired, implementation support and workshops are available.

The 4th **Industrial Revolution** isn't 'on its way' - **it's already here.**

Want to **stay ahead of the curve** & **solve tomorrow's problems** before they occur?

An Industry 4.0 Audit can help.

- Road Map Development
- Understand (and unlock) your full potential
- Explore new digital transformation opportunities
- Identify operational gaps and weaknesses
- Adopt new technology before your competitors
- Create a custom blueprint for continued success

Ready to get started? Call +31 (0)53 489 1818 to
schedule your FREE, no-obligation Industry 4.0 Quick Scan today.

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