INNOVATIE NU

June 2021

03

RESPONSIBLE MANUFACTURING

A MESSAGE FROM THE EDITOR

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

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As the world changes, one issue continues to affect industry: sustainability. The ongoing pandemic and increased environmental activism have made it crucial that businesses minimise wastage- not only from a financial perspective, but in terms of sustainability and reducing our carbon footprints. Nowadays, green standards that used to be a nice benefit have become an expected point of attention for manufacturers. Reducing water and energy consumption, minimising waste and decreasing emissions should be prioritised on the corporate agenda.

But this also brings a pressing paradox: how do we strive for industrial growth while also valuable our planets resources and minimize the environmental impact? The world is on a fast track to consume our planets natural resources. And the UN has also warned that CO_2 emissions must be almost halved by 2030 to protect the planet from additional threats of climate change – a target that has to be met in less than 10 years! There is no doubt that the time for change is now. Green manufacturing, sustainable manufacturing, or whatever name one would give to the process: the environmental challenges in manufacturing must be addressed on a systemic level.

There are tangible ways to promote sustainable practices, both within the production facilities, in the supply chain, and the customer base. The Industrial Internet of Things (IIOT) offers the opportunity to tap into digital innovation to do more with less and to move towards a zero waste-to-landfill framework. This potentially means a reduction in the use of natural resources and energy, lower carbon footprint, technological advances that consider efficiency, resiliency, and sustainability throughout the production life cycle and a strong basis for a global circular economy. The latter one, requires a fundamental change in the way goods are produced. The traditional trajectory of production is rather linear: a straightforward path from cradle to landfill, where products are made, used, and discarded. Sustainable manufacturing will change this status quo: it goes beyond the traditional approach towards one of “repair, reuse, refurbish, remanufacturing, and recycle”, promoting optimal resource usage and longer product life.

Sustainable manufacturing can leverage the revolutionary advances in productivity and efficiency without the drawbacks of waste or pollution. Within this issue of InnovatieNU the power of sustainable manufacturing will be revealed, the path a low-carbon reality and a green, high-tech industry.

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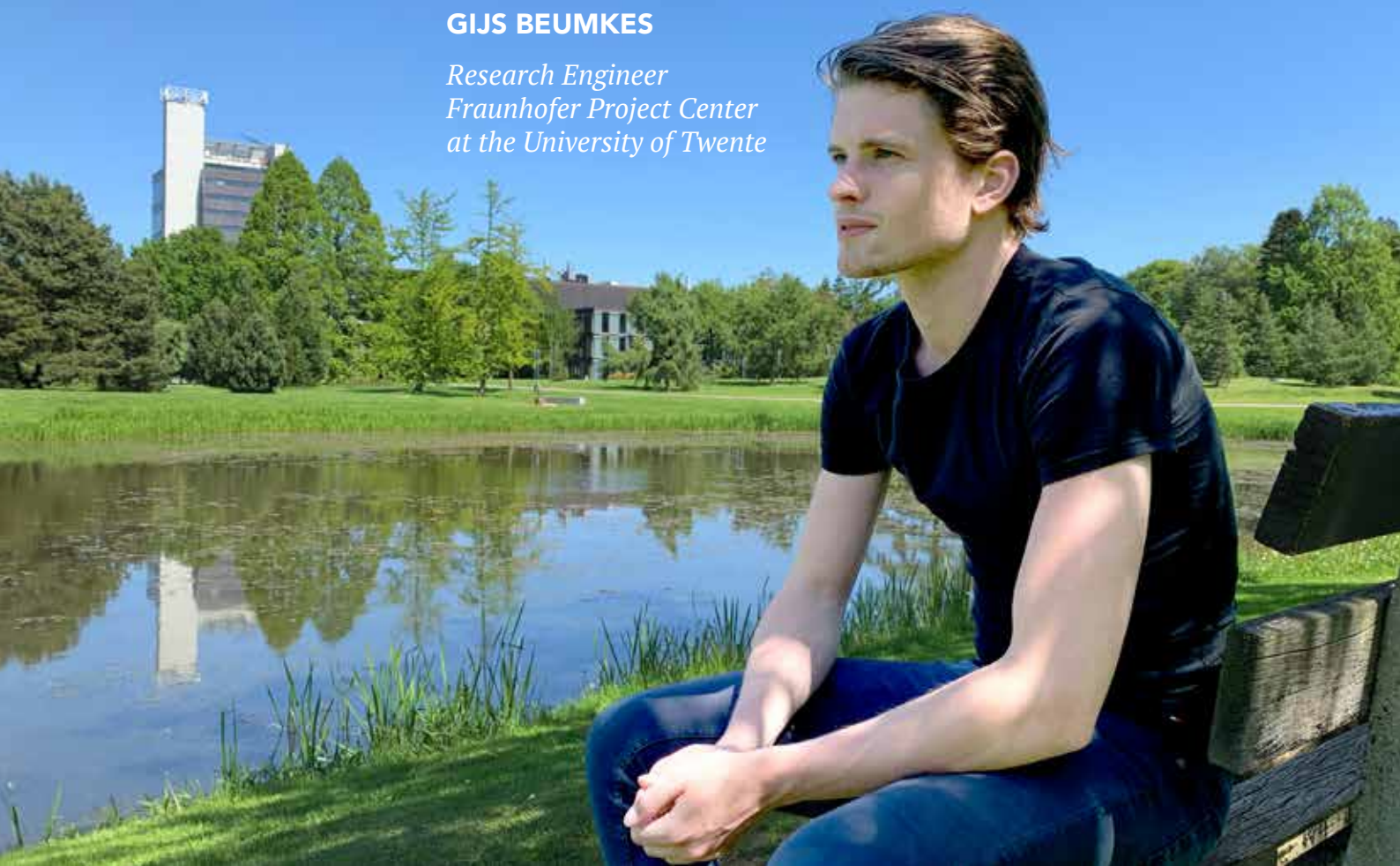

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CONTENTS

USING

DIGITISATION

TO QUANTIFY THE **TRUE COSTS** OF

PRODUCTION

Over the past 100 years, industrialisation has taken hold of almost all sectors of the economy and has been characterised by continuous cost optimisation, time savings and quality improvements. However, the resulting overproduction, besides being economically reasonable, has led to a rapid increase in resource consumption and CO_2 emissions. Although this is the reason why large parts of the population can now afford to own purchased goods such as clothing, electrical appliances, vehicles, machines or infrastructure, the production of these goods consumes energy and raw materials, the recuperation of which is often impossible.

Today, such capital- and resource-intensive productivity thinking is being overtaken by the future image of a more ecologically minded society. As a result, the capital market is changing its target as well: away from the capital-intensive business models of industry. The focus of investors is changing – toward environmental, social and corporate governance issues that are forcing manufacturing companies to make sustainable changes.

“In many areas of production, we are reaching the limits of our knowledge with conventional methods, technologies and processes. However, digitisation is now enabling us to exceed these limits. The more we know about our complex processes and their boundary conditions, the better we can identify the true costs of our products and save valuable resources”, explains Professor Thomas Bergs, Chair of Manufacturing Technology at the Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen University and member of the Board of Directors at the Fraunhofer Institute for Production Technology IPT.

Limit Overproduction and Reduce Resource Consumption

Above all, data on requirements, the development process, (serial) production and the use of goods must already be incorporated into product design and production planning so that production itself can be continuously optimised. In the upcoming years, the assessment of the performance of companies will shift significantly in all manufacturing sectors, according to the forecast of the Aachen scientists. As a result, companies are now being called upon to evaluate and optimise their range of services and their value creation on the basis of the three sustainability-related areas of corporate responsibility: Environment, Corporate Social Responsibility and Corporate Governance.

The threat of climate change and the necessary energy turnaround make it absolutely essential to look at production and all associated processes in terms of their sustainability.

Author:

Markus Meurer M.Sc.
Research Associate, Group Leader and Main Organiser of AWK'21
RWTH Aachen University

The Aachen researchers identify the so-called Internet of Production (IoP) as the most important enabler of such a production turnaround: the end-to-end digitisation and networking of machines and plants within the production and value chain. The IoP is designed to help manufacturing companies achieve greater sustainability, efficiency, productivity, quality and competitiveness. The secure availability of data, information and knowledge, at any time and any place, is considered one of the most important promises of Industry 4.0 and at the same time forms the basis for transparency along all product life cycles and stages of the value chain. This can help to ensure that production is ultimately geared to customers' actual requirements and demand quantities.

Turning Data into Sustainability

With the effects of the Corona pandemic hitting many manufacturing companies and changing the global economy in the long term, further trend-setting questions are arising around the future of production technology.

Under the guiding theme "Turning Data into Sustainability", WZL and Fraunhofer IPT will discuss these questions during the 30th Aachen Machine Tool Colloquium (AWK) on September 22 and 23, 2021: The Aachen researchers want to sharpen the entrepreneurial view of the future so that the production turnaround towards a sustainable productivity can be achieved. Aim of the conference is to enable companies to deal successfully with drastic crises and to be able to operate profitably again within a short period of time.

Hybrid Information Hub for Production Technology Trends

The AWK'21 is both a network meeting and an information hub. Accompanied by an international top-class lecture program and with thematic tours through the hosting research facilities, the conference will offer a comprehensive and interdisciplinary insight into the trends of applied research and development for specialists and executives from industry and science.

AWK'21

September 22 - 23, 2021

30th Aachen Machine Tool Colloquium

Turning Data into Sustainability Securing Future Competitiveness by Sustainable and Resilient Production

With the effects of the Corona pandemic hitting many manufacturing companies and changing the global economy in the long term, once again trend-setting questions are arising around the future of production technology:

- What is the value of the variety of recorded data for manufacturing companies today?
- How can algorithms and analyses be utilized to make reliable forecasts in order to produce more efficiently and sustainably in the future?
- How can data acquisition and machine learning lead to rapid, error-free improvements in (series) production in order to become more resilient in the face of crises?
- How do successful companies manage to emerge stronger from the crisis and quickly return to profitability?

What else does the AWK'21 have to offer?

A hybrid lecture program
Four lecture sessions - online and on-site at the Aachen Eurogress - by and for experts in the field of production technology.

On-site guided tours and 3D tours
Guided tours on selected topics such as digitalization, individualization, electrification of drive technology, Industry 4.0, blockchain, artificial intelligence or 5G on the shop floor as well as an individual digital exploration of the production technology institutes in Aachen and selected partners.

Industrial exhibition: Production 4.0 in practice
The industrial exhibition at the Aachen Eurogress and online as an insight into the sustainable production of the future.

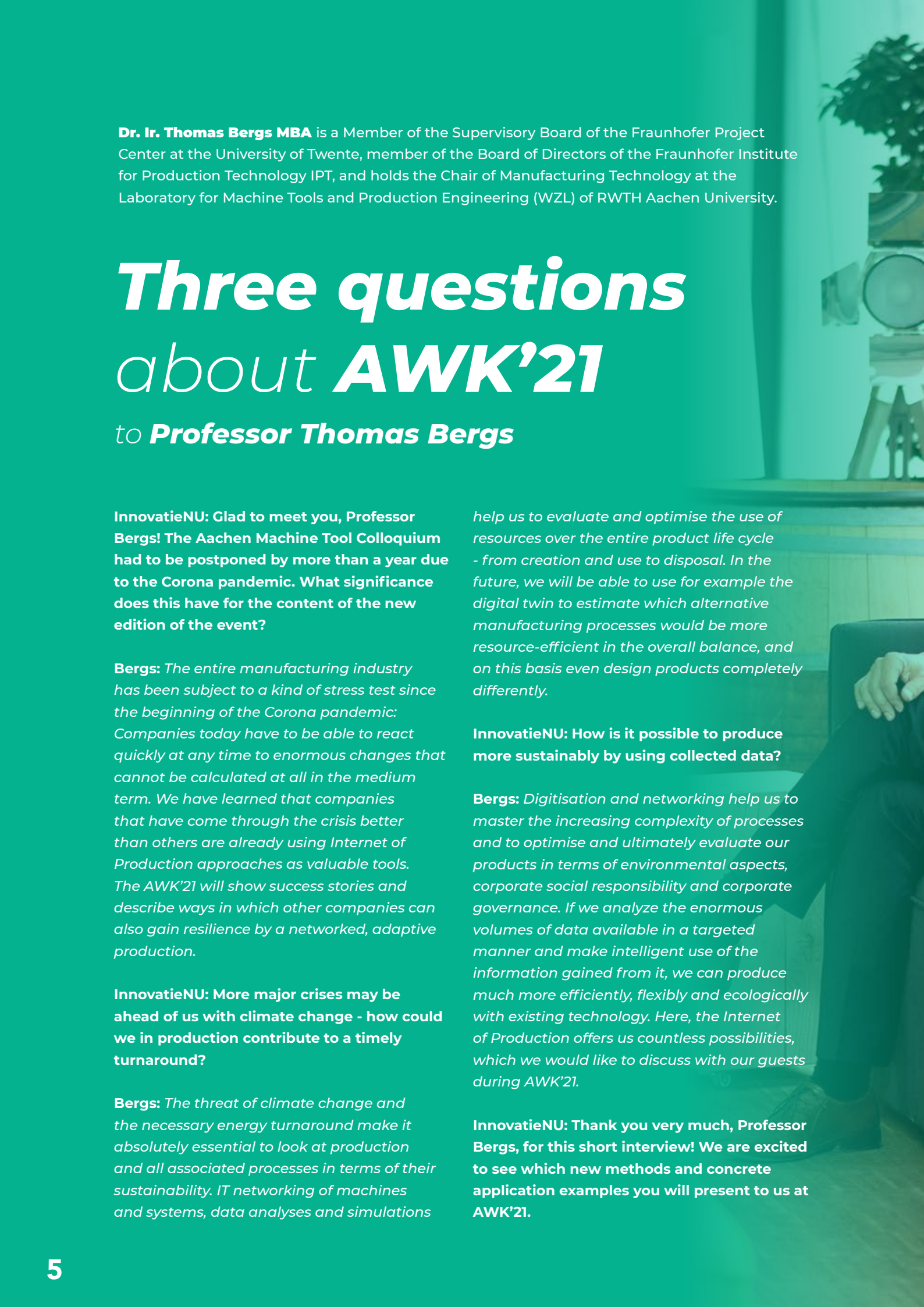
Information and registration **www.awk-aachen.com**

Fraunhofer IPT | WZL | RWTH AACHEN UNIVERSITY

Dr. Ir. Thomas Bergs MBA is a Member of the Supervisory Board of the Fraunhofer Project Center at the University of Twente, member of the Board of Directors of the Fraunhofer Institute for Production Technology IPT, and holds the Chair of Manufacturing Technology at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University.

Three questions about ***AWK'21***

to ***Professor Thomas Bergs***



InnovatieNU: Glad to meet you, Professor Bergs! The Aachen Machine Tool Colloquium had to be postponed by more than a year due to the Corona pandemic. What significance does this have for the content of the new edition of the event?

Bergs: *The entire manufacturing industry has been subject to a kind of stress test since the beginning of the Corona pandemic: Companies today have to be able to react quickly at any time to enormous changes that cannot be calculated at all in the medium term. We have learned that companies that have come through the crisis better than others are already using Internet of Production approaches as valuable tools. The AWK'21 will show success stories and describe ways in which other companies can also gain resilience by a networked, adaptive production.*

InnovatieNU: More major crises may be ahead of us with climate change - how could we in production contribute to a timely turnaround?

Bergs: *The threat of climate change and the necessary energy turnaround make it absolutely essential to look at production and all associated processes in terms of their sustainability. IT networking of machines and systems, data analyses and simulations help us to evaluate and optimise the use of resources over the entire product life cycle - from creation and use to disposal. In the future, we will be able to use for example the digital twin to estimate which alternative manufacturing processes would be more resource-efficient in the overall balance, and on this basis even design products completely differently.*

InnovatieNU: How is it possible to produce more sustainably by using collected data?

Bergs: *Digitisation and networking help us to master the increasing complexity of processes and to optimise and ultimately evaluate our products in terms of environmental aspects, corporate social responsibility and corporate governance. If we analyze the enormous volumes of data available in a targeted manner and make intelligent use of the information gained from it, we can produce much more efficiently, flexibly and ecologically with existing technology. Here, the Internet of Production offers us countless possibilities, which we would like to discuss with our guests during AWK'21.*

InnovatieNU: Thank you very much, Professor Bergs, for this short interview! We are excited to see which new methods and concrete application examples you will present to us at AWK'21.

Producing more efficiently, flexibly and ecologically through digitisation and networking.

Image source: Sarah Thelen

IMPACT OF RESPONSIBLE LEADERSHIP ON

BUSINESS GROWTH

As manufacturers emphasise sustainability and equitability as contributing factors to success, they will need to acquire a broader range of leadership skills.

> *A leader who embraces change and leads by example will naturally encourage teams to do the same, thereby fostering a forward-thinking culture that is always open to new ideas.*

Responsible leadership is about making sustainable business decisions that take into account the interests of all stakeholders in a company, as well as the environment and society at large. Efforts in leading the adoption of more sustainable and equitable business practices will result in manufacturing firms reducing inequality and minimise their impacts on the environment. In an increasingly ethically conscious generation, responsible leadership ultimately translates into greater long-term business viability and profitability.

However, responsible leadership has it challenges from within and externally. Leaders need to develop a broader range of skills across various technical, personal, and interpersonal domains. Not only must they possess business acumen –they must also become agents of change in a sector that is undergoing a radical transformation in line with shifting economic and societal priorities.

Innovating responsibly with emerging technology

As with any other sector, the digital transformation of manufacturing requires an approach that starts with leadership. Thus, business and technology leaders must become champions of change and innovation. At the same time, they must work hard to mitigate risk. For example, making the wrong technology choices or a failure to achieve alignment between business goals and digital transformation can lead to quite the opposite effect to what is hoped for. This is especially important in manufacturing, where failures in specialised proprietary machinery can be extremely costly, or worse, harmful to workers.

Responsible innovation is not about adopting new technology for the sake of it, and neither is it only about how it can increase profitability. The goal of a sustainable innovation strategy is much

broader than this. The choices leaders make as they modernise their manufacturing systems and processes can have a significant effect both on the company and broader external factors, such as society and the environment. Innovation without strategy, on the other hand, can end up increasing risk for little or no reward. Fortunately, however, emerging technologies hold at least some of the answers as to which choices responsible leaders should make.

For example, modern predictive maintenance systems can proactively reduce failures and improve safety on shop floors. Artificial intelligence can deliver valuable insights that help drive informed decision-making to betterment of everything from cycle times to worker safety. Internet-connected cameras can monitor machines from a safe distance. Centralising data and operations with an integrated business management system can reduce single points of failure and minimise a company's data and technology footprint. Augmented reality can safely guide workers operating or maintaining complex machinery.

These are just some of the use cases of emerging technologies, but leaders must prioritise responsibility and alignment when innovating.

Fostering a culture of innovation by empowering employees

The most engaged employees are those who are always learning and view their positions as opportunities for professional growth. These are the employees who believe in the organisations they work for and feel like they are a part of something special. Their work has purpose and meaning, and they are recognised and respected for their contributions. This is especially important in the case of millennials. Research carried out by Global Tolerance found that 62% of millennials prefer to work for organisations that make a positive impact1 on society and the environment.

All of these factors begin at the leadership level. After all, a company's culture is a reflection of its leadership, and it is the most important influencer of employee retention. To build such a business culture, leaders need to empower their employees with opportunities to grow and develop. Continuous workforce training and development are essential parts of that process, and innovation cannot happen without them.

Despite the central role of manufacturing in the fourth industrial revolution and the economy at large, the sector has been surprisingly slow to innovate in digital technology. An analysis from the CIO Program by Deloitte found that manufacturers spend only 1.95% of their budgets on IT2, compared to the 3.28% average across all industries. Historically, the manufacturing sector has been known for being relatively risk-averse and, as a consequence, slower to innovate.

For this to change, firms need to reconsider how their leadership interacts with employees. A leader who embraces change and leads by example will naturally encourage teams to do the same, thereby fostering a forward-thinking culture that is always open to new ideas.

Linking self-interest to the shared interests of diverse teams

The old way of doing things was, in many ways, simpler. Relatively homogenous teams would leverage their commonality to achieve shared interests together. However, this approach is no longer relevant in today's globalised world. Today's biggest challenges, such as the global need for environmental and economic sustainability, concern every business and individual on the planet. Innovation is crucial for addressing those challenges.

At the same time, human nature has not changed. Leaders should continue to recognise that everyone who joins the team does so with a degree of self-interest. Employees have their own goals and ambitions, preferred work styles, and different strengths and weaknesses.

However, self-interest is not necessarily selfish. Rather, it is an inherent and important asset of every individual team member and, in many cases, it can be beneficial to the business as a whole, too. Business leaders need to consolidate these various self-interests into a coordinated team effort. In other words, self-interest must be aligned with strong teamwork wherever possible.

One of the main characteristics of sustainable leadership is the ability to link self-interest with the shared interests of the team and the organisation itself. Shared interests are, by definition, symbiotic, in that they drive mutually beneficial relationships. This is why innovative leaders must be able to demonstrate excellent communication and collaboration skills to establish a synthesis between individual goals and company goals.

As businesses and customer habits diversify, the need for diverse teams built on the concepts of sustainability and equitability becomes clearer. For example, a priority for a manufacturing firm might be to reduce their environmental impact. However, this does not mean that team members who are less concerned about the environment and more about their daily routines should be left out. There are, after all, many ways to satisfy both sets of goals and priorities, such as by introducing solutions that automate repetitive operations and enhance workplace safety and sustainability in the process.

Final words

The reformation of the manufacturing sector has been a long time coming. Given the extreme importance of the industry and its critical position among global supply chains, manufacturing must focus on innovating quickly while driving forward its corporate responsibility. This starts at the leadership level and must be driven by flexible competency frameworks that are built around economic, societal, and environmental sustainability. These are the characteristics that will drive growth more and more in the future.

WHY IT'S TIME

FOR **EVERY MANUFACTURER** TO PRIORITISE **SOCIAL RESPONSIBILITY**

How corporate social responsibility has become essential in modern manufacturing.

When we look back on the first industrial revolution two centuries ago, the first thing that often comes to mind is a Dickensian dystopia of class stratification, child labour, and the beginnings of widespread environmental degradation. In that world, industrialist fat cats had a reputation of putting profits above everything else.

But even as far back as the 1800s, there were exceptions, just as there are still organisations to this day that place profit before the wellbeing of their communities. Manufacturing is a sector that continues to undergo substantial reforms, particularly in the case of those which have an inherently negative impact on the environment.

Today, we call this consciousness corporate social responsibility, or CSR.

What is CSR, and why does it matter?

Although responsible companies had already been around for over a century, the modern term of corporate social responsibility was coined by American economist Howard Bowen in 1953. By the 1990s, CSR became a universal practice around the world. By 2015, about 92% of the world's largest companies had started informing stakeholders and the public about their CSR practices – but that's only the beginning.

As a form of self-regulation, CSR is not required to operate a business, but it has become the standard practice across the manufacturing sector. A robust CSR policy backed up by proven actions taken to enforce it, is itself a major competitive advantage in a world where customers have more power than ever over those they do business with. In other words, what is an ethical imperative, is almost invariably good for business – especially in the longer term.

Encouraging socially responsible practices

Manufacturing firms must lead by example for the betterment of their communities, as well as the world at large. This doesn't only apply to major firms and household brand names, but also to all the countless smaller manufacturers and other organisations that make up today's supply chains. For these companies, CSR makes them more attractive to do business with, while also giving them the opportunity to have a positive impact on their local communities.

IKEA is one brand that often pops up in conversations about CSR. Back in the 80s and early 90s, the company found itself in the midst of a stream of scandals involving formaldehyde, a highly toxic chemical compound traditionally used in wood and resin production. In response to the scandals, the furniture manufacturer and retailer decided to take a proactive stance to the point of making environmental action central to its entire corporate vision. IKEA now plans to make its entire supply chain climate-positive by 2030, which means all its suppliers will need to do the same.

Attracting top-tier talent and customers

Social and environmental challenges are now top of mind, especially for younger generations. A 2019 study even found that almost 40% of millennials chose a job because of environmental sustainability. Moreover, 70% claimed that a robust sustainability plan would influence their decision to stay with the company. Some would even be happy to work for less compensation, so long as they feel they are making a positive impact on the environment and their community. In other words, employees want to be part of the solution, rather than the problem, thus making CSR essential for attracting and retaining the best talent.

Unsurprisingly, exactly the same applies to customers as well. No longer is sustainability just a gimmick promoted by half-hearted marketing agendas – it's a driver of purchase decisions in both B2C and B2B industries.

A global study by market research firm Nielsen found that two thirds of the world's consumers would be willing to spend more on sustainable products. By contrast, sales and coupons didn't even make it into the top five drivers of purchase decisions. This emphasised the fact people increasingly put their values before their personal benefits. The same applies to B2B buyers, who often choose sustainable suppliers to uphold their own commitments to sustainability.

Creating a competitive advantage

Sourcing and manufacturing are ordinarily the stages at which sustainability plays the biggest factor. But becoming a sustainable brand is about far more than just having a 'green' product. CSR has broadened and evolved to the point of incorporating environmental, economic, and social aspects as well. The tailoring sector, for example, has long been subject to controversy for capitalising on child labour and poor working conditions in poorer countries. Globalisation itself has seen ample criticism, especially when it comes to large organisations perpetuating poverty and environmental degradation all in the name of acquiring cheap labour.

Customers and business partners, including everyone in the supply chain, are now holding manufacturers accountable.

For manufacturers, this means walking the walk to set an example and becoming a champion of positive change and sustainability. In doing so, they can create a competitive advantage, while also having a positive impact on the industry as a whole. Simply paying lip service to the pressures of the market is not enough. Now that 88% of consumers want you to help them make a difference, it's time for your products and processes to reflect the values that today's society holds most dear.

For example, global coffee chain Starbucks only works with roasting houses that guarantee ethically sourced coffee. The oft-cited pioneer of social responsibility has met almost all of its CSR milestones so far, including creating a global network of sustainable farms, promoting ongoing education for its employees and partners, and contributing to community service.

Building a sustainable business model

A sustainable business model creates and delivers value for all its stakeholders without relying on practices that drain more resources that it provides. It doesn't deplete natural resources to the point it runs out, and nor does it fuel social and economic problems that would eventually become impossible to manage. These are the companies that can adapt and thrive through the challenges ahead by aligning with the most pressing concerns of today, and tomorrow.

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CASE STUDY

AUTOMATED FIBRE ARRAY SYSTEM

Figure 1: Fibre Array Assembly System

Feasibility studies pay off in the medium and long term, as they significantly reduce the risk for the entire project.

> *This strategy simplifies and makes scalable the process of aligning the stress rods that serve to maintain the polarisation in the fibres.*

PHIX worked with the Fraunhofer Project Center at the University of Twente (FPC@UT) to develop a precision assembly cell to produce fibre array units (FAUs) with polarisation-maintaining fibre (PMF). Currently, these fibres are produced using a manual labour process which constitutes 50-80% of the total production cost. To significantly reduce the cost, the project team focused on automating the process. Using a prototypical machine provided by AIXEMTEC – an Aachen-based spin-off of Fraunhofer IPT who cooperated in the project – the firms together initiated a two-part feasibility study and development project. The result was a machine that autonomously builds consistent products in minutes rather than hours.

Feasibility Study

The first part of the feasibility study involved designing a prototypical process for assembling the fibre arrays. This was successful, in that it produced small quantities of FAUs with the machine in a semi-automatic mode, though still requiring some amount of operator intervention. Spurred on by this early progress, the team decided to further pursue the concept with the goal of fully automating the assembly process.

The second part of the feasibility study analysed possible tool chains for automating fibre preparation to provide input material for the machine. The partners needed to establish an in-depth understanding of the prototypical FAU assembly machine from the first part of the study (hereafter referred to as the FAAST machine), along with the input material requirements and the boundary conditions of the fibre array assembly process. The focus was on repeatability of the fibre input material as well as the pickup and transportation of fibres between the various fibre preparation and inspection stations and eventually to the FAAST machine itself. This development work complemented the functioning assembly process from the first part of the feasibility study and established a standard working procedure for both the operator and the process engineer.

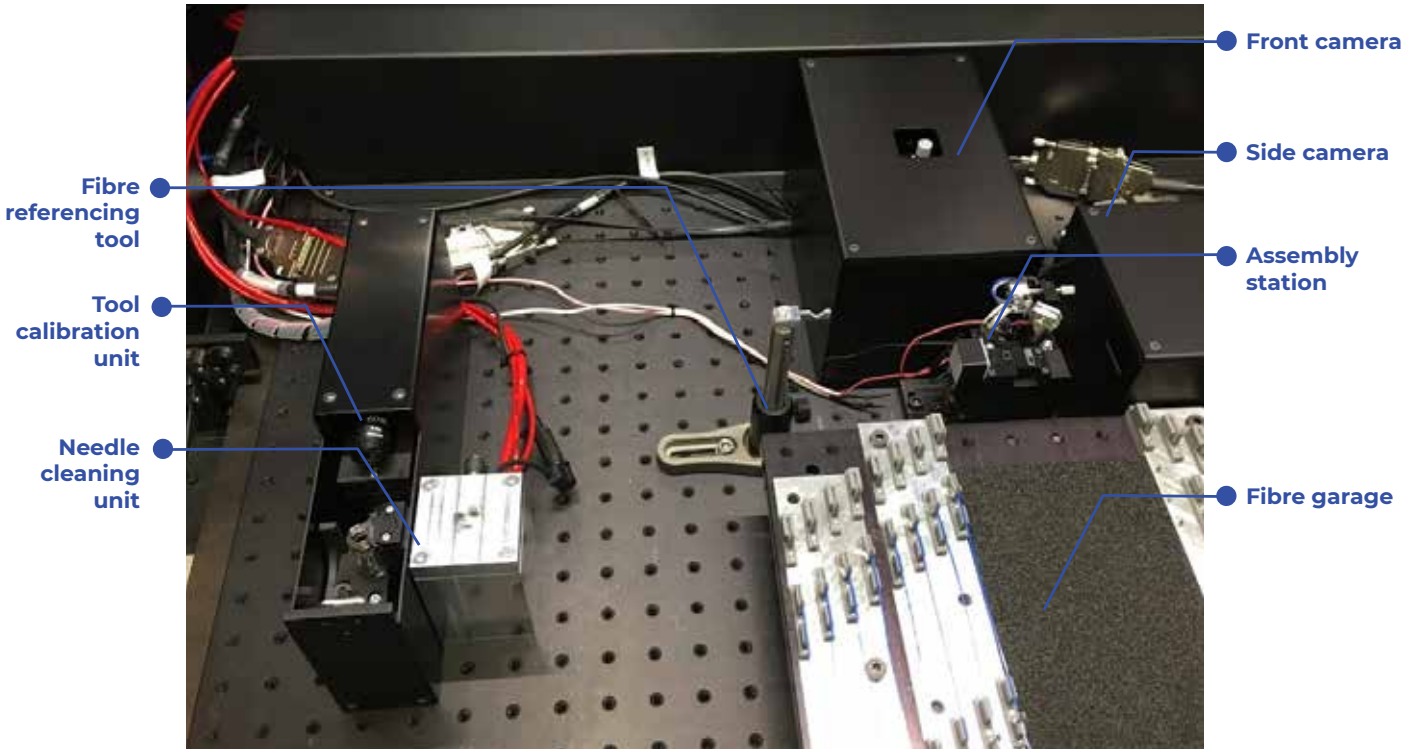

Figure 2: Optical Breadboard

Compact and exchangeable modules developed by Fraunhofer increase the machine flexibility for process development and adoption for new product related challenges.

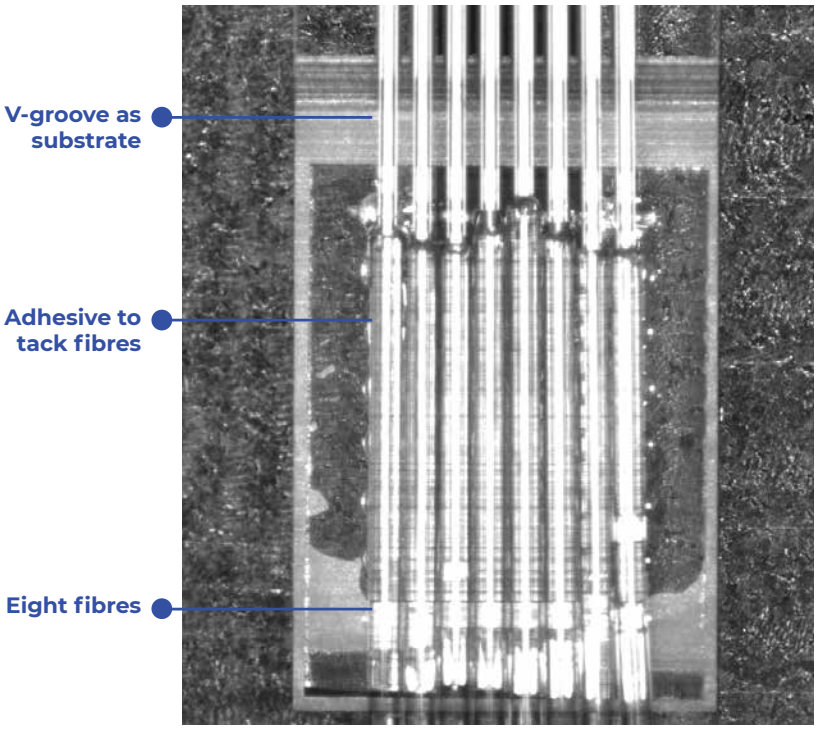

Figure 3: 8-Channel Fibre Array Before Lid Placement and Strain Relief

System Overview

The FAAST machine consists of three major systems: 1) a 3-axis gantry unit consisting of an X-Y long-travel precision linear robot using a magnetic drive and a vertical Z linear motor spindle drive, 2) a modular tool head, mounted on the Z-drive of the gantry system and equipped with a fixed pneumatic gripper, a piezo-based fibre rotator, UV illumination, a top-down camera and an adhesive dispenser, and 3) an optical breadboard with various stations where the actual FAU assembly takes place.

The functional stations of the breadboard include a fibre garage from which the fibres are picked, a tool calibration unit for referencing the global coordinate system, a needle cleaning unit, a referencing station for setting fibre pitch angle, and finally the assembly station with front and side cameras where the parts of the assembly come together to form the finished FAU.

Assembling a fibre array, at its most fundamental level, involves bringing together a base chip with precision-sawn V-grooves, the individual fibres themselves, and a lid chip that holds everything together. In comparable manual processes, the stress rods of all fibres are aligned simultaneously by rotating the fibres on their axes, and only after all fibres have been aligned is the adhesive cured. Because of this, neighbouring fibres can physically interact during the alignment process and influence the accuracy of one another. To complicate things further, this undesirable interaction increases as the fibre count in an array increase.

During assembly with the FAAST machine, the fibres are attached to the base chip one-by-one with micrometre precision and fixed in place with a UV cured tacking adhesive. This strategy simplifies and makes scalable the process of aligning the stress rods that serve to maintain the polarization in the fibres. Only after all fibres are in position is the lid placed and underfilled with adhesive to make the final, permanent bond.

Challenges

To place the fibres in the V-groove reliably while not clashing with previously tacked fibres, the fibres need to be oriented at a slight angle in the

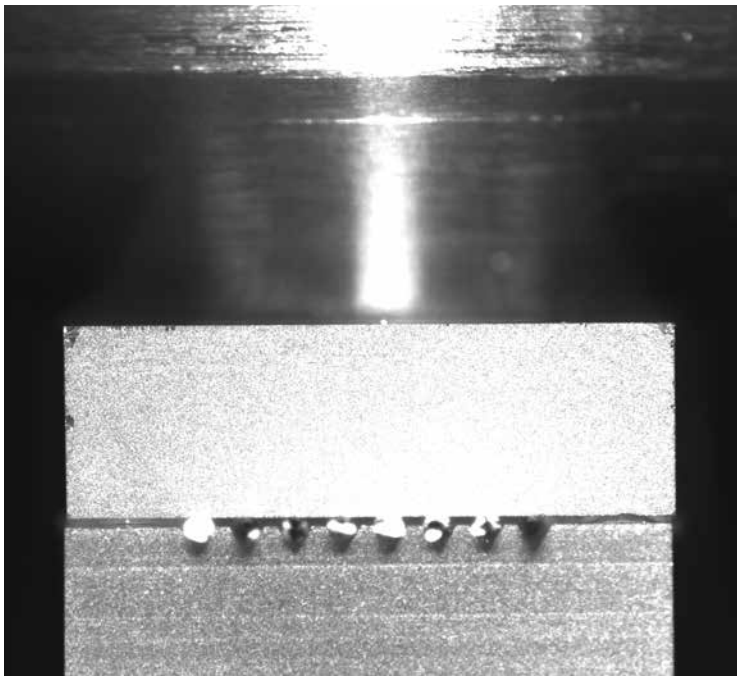

Figure 4: Front View of FAU after Lid Placement and Before Polishing

Unforeseen parameters for process development result in challenges for the automation. A well-organised project will identify and overcome these challenges easily.

pitch rotational axis. As part of the development with FPC@UT, a new fibre referencing station was introduced to the breadboard. As measured by a new process routine developed by Fraunhofer IPT using the side camera, both the accuracy and the repeatability of the fibre angle were greatly improved.
Another challenge that was encountered related to the dimensional tolerance of the fibre acrylate coatings. This resulted in unreliable tacking of the fibres. Because the tolerances come from the manufacturer and could not be influenced by the project partners, a new placement strategy had to be developed to compensate for the variations. An initial version of this strategy exhibited a new mechanism of yield degradation, but a revision of the process resolved this issue. The final strategy was demonstrated to work reliably with 8-fibre arrays and is compatible with larger fibre counts.

Conclusion

Automating the assembly of a fibre array is a non-trivial challenge, especially when considering polarisation-maintaining fibres (PMF). When performed manually, a highly skilled operator and considerable time is needed to achieve an acceptable result. There are many processes that need to be designed, tested, and optimised to automate the process. Based on initial feasibility studies and iterative improvement, a stable automated process has been delivered to PHIX. Challenges such as accurate fibre pitch angle requirements as well as manufacturer tolerances of input material have been overcome. Moreover, general process optimisations cut the overall cycle time for a fibre array assembly in half without sacrificing yield.

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PHIX is a leader in assembling **Photonic Integrated Circuits (PICs)** and **electronics** into a **single package,** both for **prototyping** and **customised full-scale production runs.**

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USING AI TO PROVIDE SUSTAINABLE SOLUTIONS

Transitioning to more sustainable practices is one of the key challenges for industry, both now and in the future. Advancements in artificial intelligence (AI) have already helped manufacturers more accurately forecast consumer demand, automate specific processes and improve control of production processes and systems in real time. Besides improving output-related performance indicators, these advancements also have the potential to greatly economise on energy and resources.

Data-based or simulation support methods are aiding in the improvement of production processes, in turn leading to an AI-based alignment of energy and resource demands within companies and production networks.

Roundtable on the Use of AI in Industrial Sustainability

With over 200 scientists currently working on and with AI, The University of Twente has been paying close attention to the development of Artificial Intelligence for quite some time. A series roundtable discussions, held over multiple afternoons, was devised to start in-depth conversations among like-minded people from academia, industry and cluster organisations on the benefits, drawbacks and future development of artificial intelligence. The purpose of these discussions was to highlight areas where AI can be of great benefit to society as a whole and to rigorously discuss any problems or obstacles that interested parties might encounter when using or attempting to use AI.

The third roundtable discussion in the series was recently organised by the Digital Society Institute, with Sebastian Thiede as expert moderator. In this roundtable, we focused on the topic of Industrial Sustainability. Approximately 40 people attended, including personnel from the University of Twente and Radboud University, representing academia. Industry was represented by NS, VMI Group and Voortman. Cluster organisations like FME and iTanks also fielded participants.

The primary goals were to stimulate the use of smart industry/industry 4.0/data & AI in industry, for the purpose of making manufacturing more sustainable; and also to discover problems, unearth opportunities and find common ground for future joint objectives.

The group determined that there were some problems relating to each of the four application areas:

- **Circularity** - Recycled materials are more expensive than virgin materials.
- **Energy & Resource Efficiency** - Stock reduction and more efficient use of materials and logistics are needed. There is also a lack of reliable optimisation models that combine desired output volumes, quality and energy needs.
- **Renewable Energy** - There are difficulties in integrating factory energy needs with renewable energy production. Balancing supply and demand would be required.
- **Design for Sustainability** - There are difficulties in integrating innovative solutions into existing design methodologies.

The most immediate and far-reaching problems are lack of urgency, lack of acceptable business models and, most importantly, lack of understanding of possible outcomes.

Based upon the problem areas they identified, the group proposed the following Joint Objectives:

- Develop effective implementation strategies to adopt AI technologies.
- Strongly encourage the implementation of sustainable solutions. This can be hastened by creating a sense of urgency, highlighting economic viability and accentuating the whole value chain.
- Answer the why. Create models that make benefits and effects clear. Linking the benefits to goals helps people visualise outcomes and take personal ownership.
- Devise easier off-the-shelf software and hardware solutions supporting AI implementation. Possibly promote AI-based solutions 'as a service' to directly generate benefits.
- Create models that support decision-making that balances costs vs. sustainability. Offer advice along different dimensions.

The overall feeling created by the roundtable discussion was overwhelmingly positive. Great strides have already been made in this field and the future looks extremely promising, with a host of new industrial applications either in the design phase, under production or already in daily use. The key takeaway is that AI can certainly play a large part in aiding companies to become more sustainable.

As more companies move towards artificial intelligence to solve their sustainability issues, more solutions are being trialled, ensuring that a greater number of better outcomes are achieved.

Author:

Marc Zinck

Impact Development Manager
The University of Twente

BIG QUESTIONS

How can AI-assisted streamlining of production processes result in reductions in materials and energy usage?

How does the adoption of a circular economy boost sustainability in manufacturing?

How do sustainable logistics lead to greater efficiency and reduced emissions in supply chain manufacturing?

How can additive manufacturing unlock unique pathways towards sustainable manufacturing?

How can AI, IoT and robotics lead to the implementation of better maintenance measures, thereby reducing energy consumption in manufacturing?

"[...] the workshop brought together quite different perspectives - it got clear that AI can actually make a significant contribution to industrial sustainability but identifying promising use cases is key."

Prof. Sebastian Thiede
Professor, Chair of Manufacturing Systems
University of Twente,
Faculty of Engineering Technology,
Dept. of Design, Production & Management

IMPORTANT *link*

IN A **TRANSPARENT** AND **SUSTAINABLE CHAIN**

We are all aware of the need to minimise our ecological footprint in order to reduce global warming, control rising sea levels, restore flora and fauna, and improve public health. It is essential to find more economical and conscious uses of energy, raw materials, water and waste to help us stop the pollution and depletion of Earth's natural resources, leaving a liveable world for future generations.

Uzin Utz Nederland is keen to do its bit. Sustainability, health and the environment are key words in everything we do, at all levels of our organisation. A leading producer of materials for the installation, maintenance, and renovation of all types of floors, Uzin Utz has prioritised emission reduction, efficient energy use, water conservation, waste separation, and the reduction of raw materials in a concerted effort to bring economical, ecological and social aspects back in harmony. To aid in this effort, we use recycled or reclaimed raw materials wherever possible.

Efficient waste separation and recycling

Sustainable and ethical entrepreneurship is a basic precondition for the long-term continuity of our company. For years, we have focused on the production and supply of value-driven, innovative and high-quality products. In the early 1980s, we took a big step forward with the introduction of healthier synthetic resin dispersion adhesives. Not long after, we were the first in the market to supply a full range of solvent-free adhesives. Ten years ago, we introduced 'Cube it Simple'; a simple bag-in-box packaging system for various types of adhesives, primers and anti-slips, with a cardboard box and plastic in-liner, which are easy to separate and recycle after use. An added advantage is that the packaging can be easily stacked, so that more kg of product can be transported per pallet, resulting in considerable transport savings.

In 2018, our sustainable packaging range was supplemented by cans made of post-consumer recycled (PCR) material, made from 100% recycled plastics. This optimisation alone has resulted in a CO_2 emissions reduction of 311 tonnes since 2018. In combination with the 'Cube it Simple' packaging, we have achieved an impressive 533 tonnes in CO_2 savings. Our ultimate goal is to save around 300 tonnes of CO_2 per year on our packaging. To make this possible, we are converting, step-by-step, other Uzin Utz products to PCR packaging in the near future.

It starts with understanding...

Several years ago, we introduced the CO_2 Performance Ladder, to gain optimum insight into our CO_2 emissions. In 2015, we were certified according to this ladder, becoming the first company to land directly on Level 5, the highest step! By making our actions measurable, we can formulate concrete, useful objectives. This then makes our actions more understandable and credible to our employees, chain partners and customers.

Since 2013, we have been internally producing an annual CO_2 footprint report, in order to clarify our CO_2 policy, progress, and objectives for the following year. In doing so, we commit ourselves to the Greenhouse Gas Protocol, the most widely used registration method worldwide to map out CO_2 emissions. The protocol defines three areas of concern: Scope 1 - direct CO_2 emissions, caused by our own building, transport and production-related activities, Scope 2 - indirect CO_2 emissions, caused by the generation of purchased and consumed electricity and/or heat, and Scope 3 - indirect CO_2 emissions, caused by the business activities of partner organisations, such as suppliers and transporters. To this we have added our CSR (Corporate Social Responsibility) objectives.

Targets for CO_2 reduction

The report makes our performance visible based on the following three criteria: (1) Green operations (mainly Scope 1 and 2), with a focus on energy, water and waste management, and lease car policy, (2) Transparent and sustainable supply chain (Scope 3), with attention to purchasing, transport/distribution, business travel, commuting and a sustainable product chain and (3) Community Centred Operations (CSR), in which we address the needs of the local community, a sustainable company site and business park, and sufficient opportunities for people distant from the labour market.

Among other things, the reports show that in 2019, we emitted over 30% less CO_2 in comparison to 2014. In 2020, it was even more impressive, with 45% less than 2014 levels, while our production increased by over 30%. This year, we aim to save 200 tonnes of CO_2 on our packaging alone. The switch to PCR packaging for our adhesives is an important contributing factor to our emissions savings. Our shift to a grey water system at the beginning of this year has also contributed to improvements in our ecological footprint. By efficiently using the rainwater from our 'green' roof for flushing our toilets, we expect to save 450 m^3 of drinking water per year.

We actively pursue a sustainable product chain, from raw materials to production, processing, use, and recycling. With the help of our Environmental Product Declarations (EPDs), the environmental impact of our products is becoming increasingly transparent. Step-by-step, we examine the entire chain. Where is the greatest impact? What should we tackle first? Who do we need to talk to?

Sustainability as a strategy

In order to continue to realise our ambitions for decreased CO_2 emissions in the future, we introduced a new corporate strategy in 2020 which we named 'Passion 2025'. Our aim is to significantly reduce CO_2 emissions levels across our entire business group. Our target is a 25% reduction of 2019 levels. We expect to achieve this by 2025.

The 'Passion Strategy' has its own sustainability targets for each of its' four pillars: Planet, People, Profit, and Products & Services. Energy plays an important role in this. With the construction of our 'green factory' in Haaksbergen in 2013, we have already switched to green energy, which is generated from renewable sources. The building is all-electric (100% gas-less) and has a high sustainability score (GPR: 8.66). An EED Energy Audit, carried out in 2020, revealed that our building has an A+ label. The only improvement we could make was in adding a number of solar panels to our roof. Now it is time to tackle more complex issues. For example, we recognise that there are still great opportunities for improvements to sustainability in mobility, raw materials, packaging materials and waste processing.

Green facades for more biodiversity

Sustainability also plays an important role in the future expansion of our production facility in Haaksbergen. Sustainability and biodiversity, in all their facets, are being addressed during both design and construction. Our ambition is to achieve BREEAM-NL Excellent certification for the entire business park, as well as BREEAM-NL Outstanding for our own building.

Our participation in AdoptIDee can provide inspiration in this respect. AdoptIDee is an initiative of PNO Consultants, in which children from grades 6, 7 and 8 are encouraged to think about innovation challenges. Working with us, 10-12 years old pupils from a Haaksbergen primary school will investigate how we can use our new façades to enhance biodiversity in our business park. Of course, we have already helped them a little. For example, we researched the most common organisms in our area. At the moment, these organisms mainly come to eat with us. How can we make sure that they also come and live with us? For the children, this is a great opportunity to get involved with nature and biodiversity, while learning how these fit into our field of expertise: flooring. For us, it is likely to provide surprising new insights!

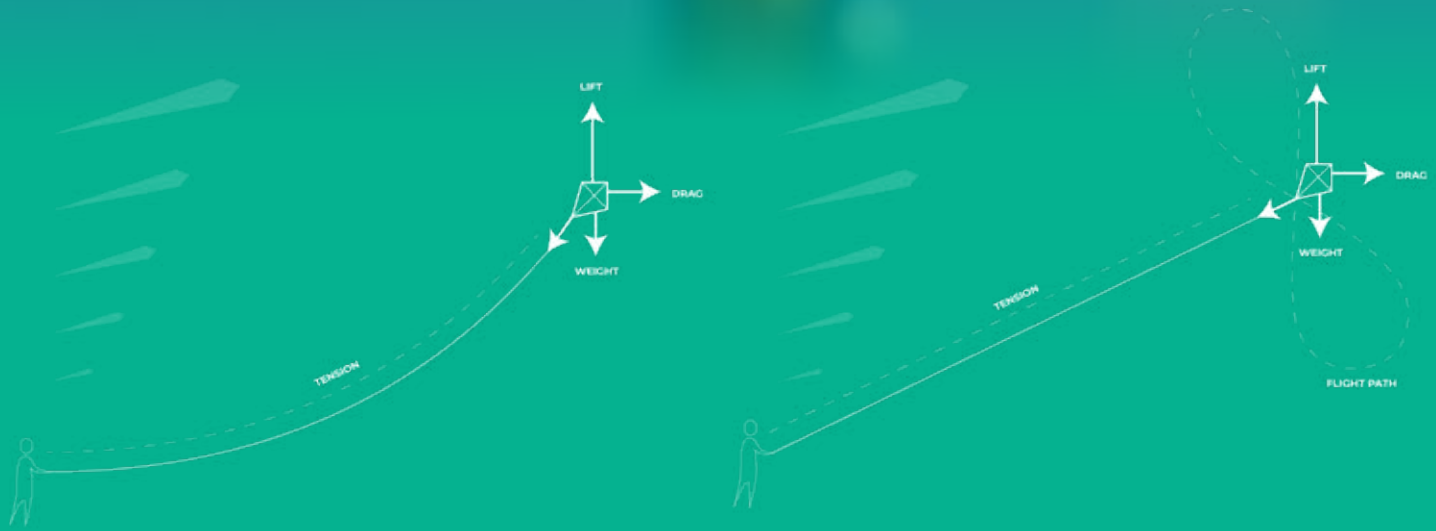
Author:

Drs Annette Schumer

Manager Sustainability Uzin Utz Nederland
(brands: Uzin, Wolff, Pallmann, Arturo and Codex)

AIRBORNE *WIND ENERGY* SYSTEMS

THE HOPE FOR A **GREENER FUTURE**



A kite moving perpendicular to the wind pulls much harder than a stationary kite.

On the constant search for sustainable energy solutions, Airborne Wind Energy Systems might be the future of renewable energy. But what are they and how do they work? They are colloquially (and a bit incorrectly) known as Kite Power Systems, in reference to the historical craft that inspired it, but with a fundamental difference. They take advantage of the almost uninterrupted availability of high-altitude winds in order to provide a solution that is more flexible than any other sustainable energy resource exploited to date.

Kites have been around since ancient times, but their potential for producing electrical energy is only recently being harnessed. And because of them, the future of wind energy is looking brighter than ever. These modern-day kites can be found in various shapes and materials ranging from wings to hoops, drones, parachutes and even small airplanes. All of them have one thing in common, they convert wind energy into electricity using autonomous tethered flying devices. They are designed for harnessing the power of high-altitude winds that are stronger and more consistent than surface winds; a resource that has never been explored before.

The principle

The idea behind these devices is simple: A kite moving perpendicular to the wind pulls much harder than a stationary kite. And a kite flown in fast loops across the wind can produce enough lift to support itself and generate a useful amount of power, significantly more than a static kite. This principle has sparked research into harnessing wind energy in the most efficient way, deviating from the traditional kite design, and resulting in varying designs of Airborne Wind Energy Systems (AWES) being commercialized today.

AWES fall in one of two types: using on-board turbines with a conducting tether, referred to as “on-board generation”, or converting the pulling power from flying devices on the ground, or “ground generation”. Designs are currently being tested for devices with soft and hard wings, each proposing its own technical challenges. While rigid wings provide more aerodynamic efficiency, soft wings are lighter. Also, in the event of an accident or rough weather conditions, they will create and sustain less damage than its hard wing counterpart.

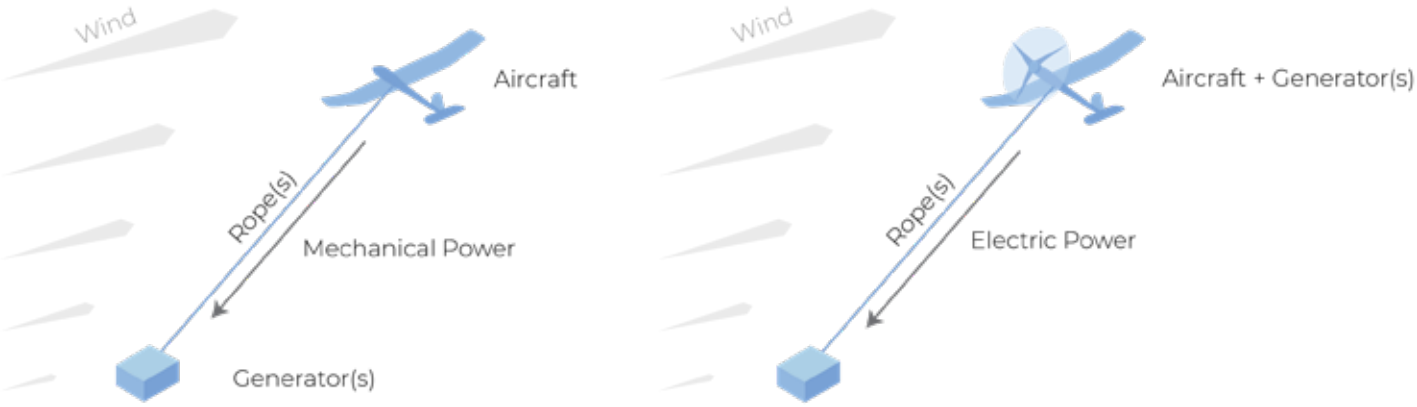
Kites have been around since ancient times, but their potential for producing electrical energy is only recently being harnessed.

Ale Sarmiento Casas
MSc IDE Student
University of Twente

Advantages of AWES:

- ***Less material:*** *lower environmental impact, reduction of carbon footprint, minimize use of resources and visual pollution*
- ***Availability:*** *capturing renewable wind energy almost anywhere in the world.*
- ***Constant energy production:*** *wind is one of the few resources that is constant and even consistent at higher altitudes*
- ***Low LCOE****: high potential for energy production at lower costs*
- ***Flexibility:*** *easier logistics, quick transport, setup and deployability*
- ***Scalability:*** *from a few kW to several MW*
- ***New markets:*** *on-shore, off-shore and high adaptability*

Image source: Ampyx Power



Example of ground (left) and on-board (right) generation systems

The system

For on-board generation systems, the basic idea is to deploy small wind turbines at higher altitudes, while ground generation systems rely on the constant spooling and unspooling of the tether. The system functions with continuous spooling cycles consisting of low-tension spooling and high-tension unspooling. The energy required for spooling is only a fraction of the total energy generated. Both are low mass alternatives to their counterparts, the traditional wind turbines, which require very specific conditions and high maintenance for operating at optimal conditions.

While all systems have advantages and drawbacks, AWES have the ability to reach previously inaccessible winds. Material consumption is reduced by as much as 90%, by using a lightweight tether instead of a tower and removing most of the mechanical constraints of the system. This keeps capital costs low. Quick set-up paired with high-power density per km² can potentially lead to a substantial cost reduction. (cost per kWh)

This makes AWES scalable and deployable to almost anywhere in the world, from remote, mountainous places, to offshore locations where wind is stronger and more consistent, or water too deep to fix a conventional turbine tower to the ocean ground. Systems can produce anywhere from a few kilowatts to several megawatts, making them very attractive for governments, policy makers and industry. They could potentially be paired with other power systems such as Solar Energy Farms, where the kites only cast tiny, transient shadows. AWES exploit a renewable resource that is less dependent on seasonal, regional and environmental factors that can affect energy output.

AWES are designed for automation in order to adjust to changing winds, climate and altitudes depending on location, thus optimizing the conditions for energy harvesting. Because flying systems are generally more complex than wind turbines, there are more possible sources of failure, particularly in launching and landing. In hurricane areas or in case of natural disasters, systems can be secured to avoid damage. Depending on the type of energy generation, parts can even be replaced at relatively low costs without compromising the integrity of the system. The long-term goal is fully automated flying, while simultaneously optimizing the conditions for energy harvesting with reliable sensors, weather prediction models, and proper maintenance.

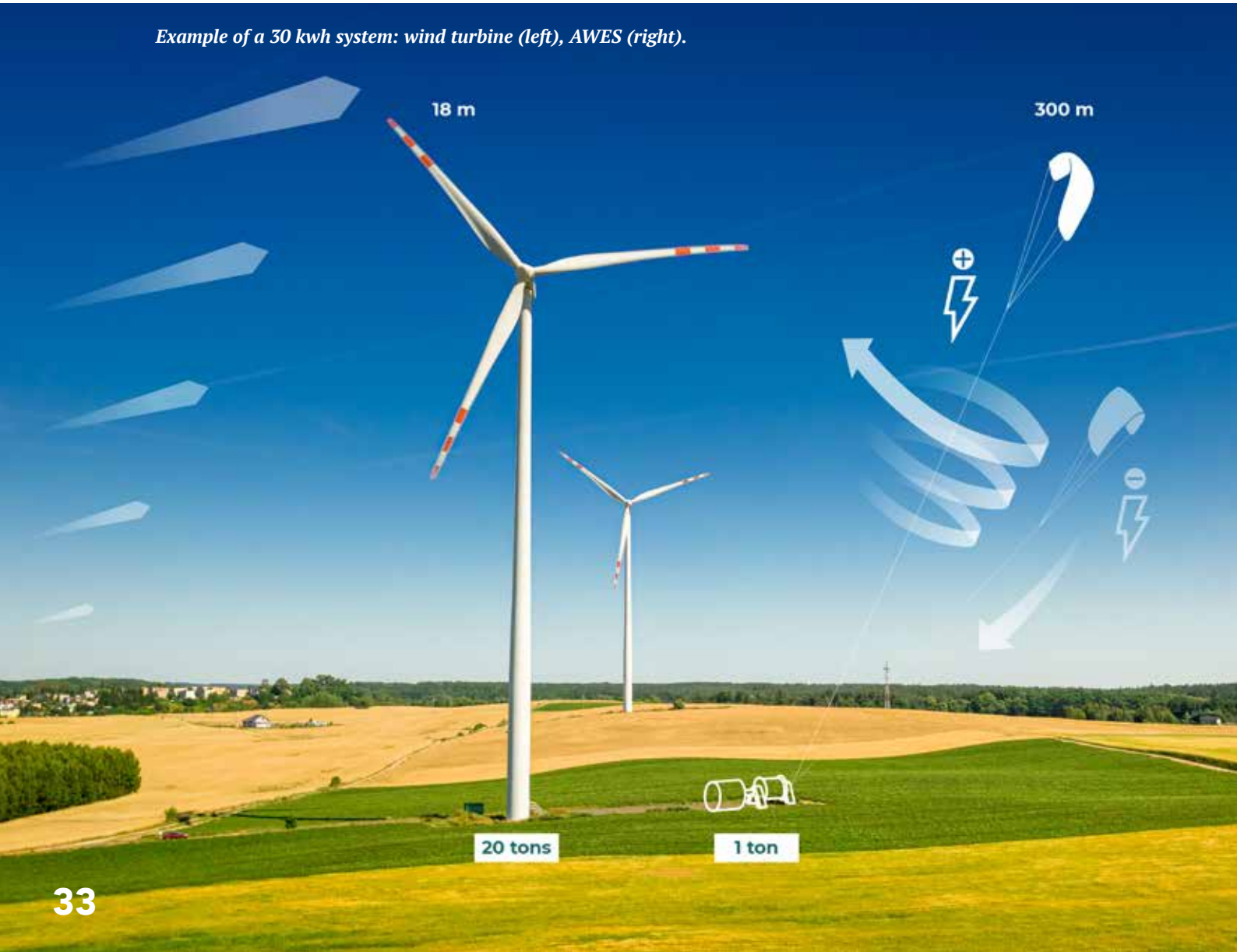
Challenges

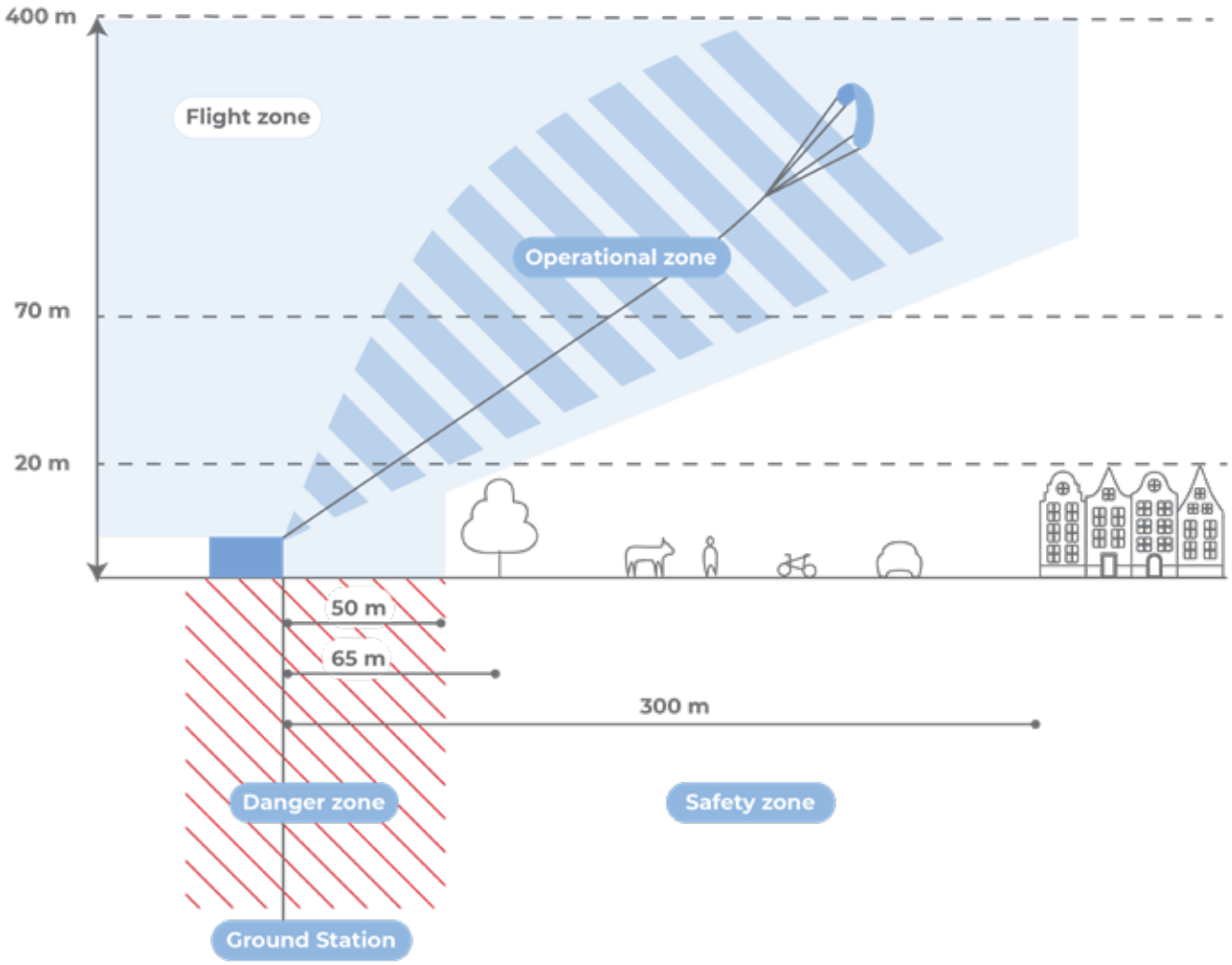
For AWES, the safety zone for operation and flight is set at 300m all around, while danger zones are considered at around a 60m radius from the ground station. This means that the danger zone will only allow for experienced personnel and light transportation while the safety zone excludes busy roads, railways and open water. It is important to understand that

all that is known for AWES has been developed from decades of operational experience, but certifications and regulations will affect these criteria while the technology becomes commercially more available. These regulations will be key for establishing safety protocols in avoiding a crash into critical infrastructure, roads, people or entering forbidden airspace. Although impact on wildlife varies per location, the fragmentation and loss of habitat have to be considered along with noise and light pollution in order to determine the true impact on wildlife. However, the most important ecological impact are mortality and disturbance of birds and bats, which is comparable to the impact from conventional wind farms. The limited studies available show that birds can survive impact with the tether and most impacts are not lethal.

A prime example of the possibilities of commercializing AWES is the AP4, a rigid wing, ground generation device developed by Ampyx Power in The Hague, Netherlands. Their goal is to produce a system that can be deployed in markets that are not feasible with current technologies, at a highly competitive cost, while meeting today's energy demands. They currently operate an off-shore test site in Ireland. In contrast, KitePower BV are developing a soft wing device in the shape of an inflatable kite paired with a ground generation system that makes the whole setup even lighter. The Delft-based company is also currently undertaking research into rigid wing devices in order to study efficiency, optimisation and challenges of both systems. These are both up-and-coming technologies that are already becoming commercially competitive in current renewable energy markets.

Example of a 30 kwh system: wind turbine (left), AWES (right).





Safety zone example for AWES.

Conclusion

Because these devices are still airborne crafts, regulations are yet to be put in place in order to avoid aircrafts colliding with these systems or with foreign objects on the ground. Remaining technical challenges consist of fully automating operations, incorporating new, durable and lightweight but flexible materials capable of sustaining a large number of load cycles. The environmental impact is yet to be assessed per system and location in order to comply with local regulations and minimize the risk of accidents and disturbance on wildlife. As the technology matures, as with any emerging technology, net capacity and the increased power production that comes with material and technological innovation will, in the end, determine the future of Airborne Wind Energy Systems. Still, the drastic reduction in mass paired with the widespread availability of high-altitude winds make them a very attractive investment and a promising alternative for energy generation.

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AMCNU

BOOSTING **INDUSTRIAL GROWTH** WITH **EMERGING TECHNOLOGIES**

Together with regional government and partners, the Fraunhofer Project Center (FPC) 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.

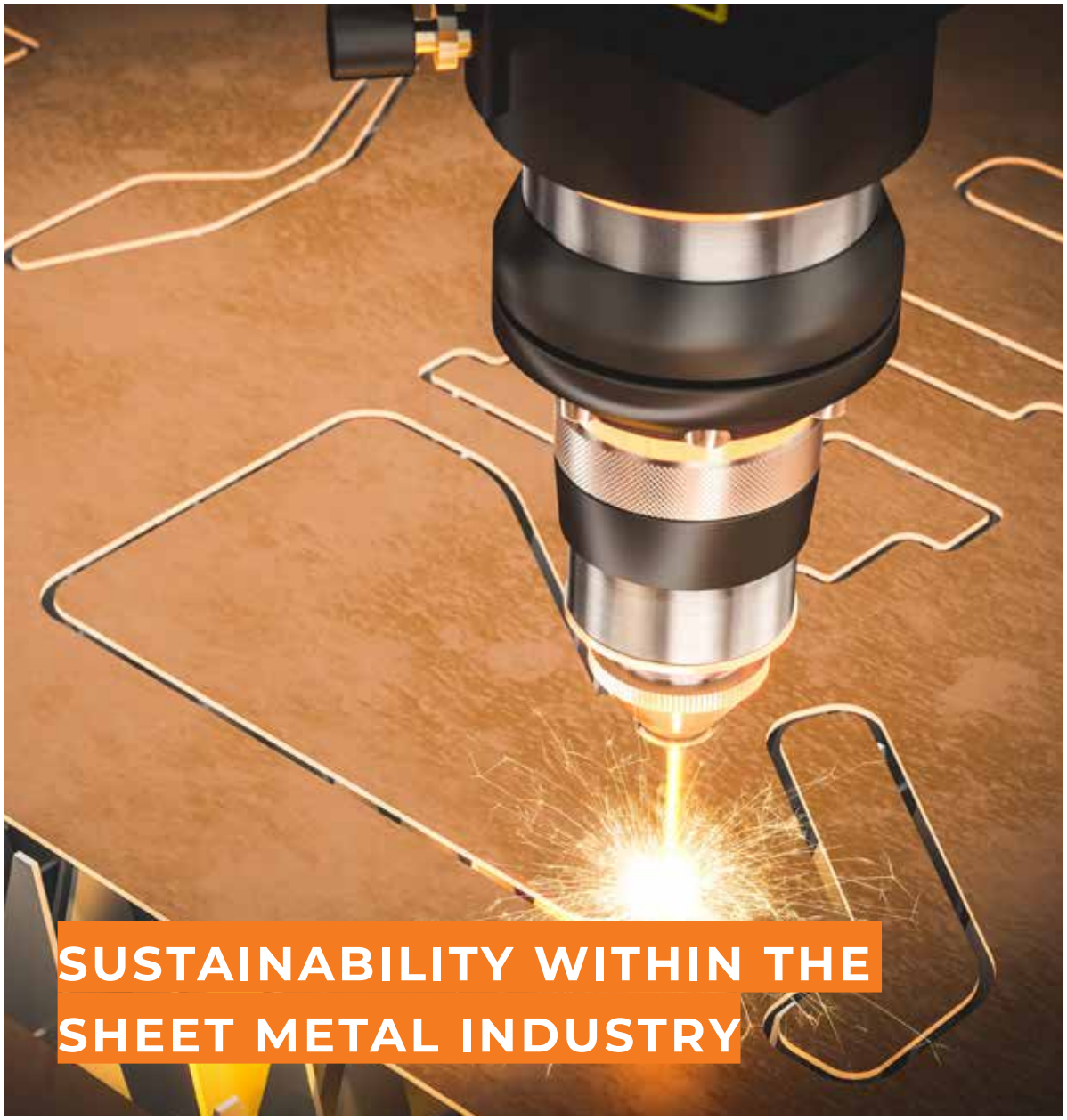
The Advanced Manufacturing Program (AMP) provides subsidies through the RegioDeal supported by the Province of Overijssel and the Dutch state. It aims to encourage rapid development of Twente and other regions in the East Netherlands by forming an Advanced Manufacturing hub with an outward looking European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

Within the AMP, the Fraunhofer Project Center 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. FPC 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. IT is made possible through the RegioDeal supported by the Province of Overijssel and the Dutch state.**

Rijksoverheid provincie Overijssel regio Twente Twente



SUSTAINABILITY WITHIN THE SHEET METAL INDUSTRY

Sheet metal manufacturers have made considerable progress, in recent years, towards improving sustainability in their industry. Reduction of waste is currently one of the key business imperatives for steel and other sheet metal fabrication industries, because waste represents a tangible loss of resources, which translates into increased unit costs and lost revenue.

Whether minimising wasted materials or keeping a lid on unnecessary consumption of energy or other resources, like water, every step of the manufacturing process needs to be carefully investigated for opportunities to reduce waste. The end result will be a more productive, profitable organisation that is able to reduce the final cost of their products, thereby delivering better value to their customers.

By investigating ways that they can minimise the amount of material wastage, sheet metal manufacturers should seek opportunities to reduce their operating costs, improve their margins, reduce the costs of disposing of their waste material and deliver cost-benefits to customers, thereby improving the long-term sustainability of their business.

What technology should those in the metal fabrication industry implement to ensure a more sustainable future?

Jellard Koers
Suplacon

We are increasingly finding ways to work more efficiently and sustainably, for example, we operate in a modern, well isolated production facility, heated by an electric heat pump. We attempt to source our workforce locally, reducing the need for travel time and cost resulting in fewer travel-related emissions per worker per day.

In production, we operate four highly energy efficient fibre lasers, reducing the resources required to run them, in comparison to earlier technologies. We are constantly looking for new and improved equipment that offers more sustainable processes. For example, we are now operating our first fully electric-powered bend presses, which are far more efficient than the hydraulic presses we formerly used. Where possible, we carefully plan our delivery routes to avoid back-tracking or single-delivery journeys, thereby improving fuel efficiency and time management.

Gert Hoekman
Hoekman RVS

Although the KORT project's objective was to optimise our production process times, sustainability remains an important topic to us. We see the marketplace changing and believe if we encourage consumers and customers to pay for usage of our products instead of paying to own them, sustainability will naturally follow. This is because the market demand will drive production. Manufacturers will have no choice but to produce better quality products because the market demands it. Furthermore, once a user has finished using a product, it is up to the manufacturer to maintain or repurpose it for further use. There is little doubt that there is a culture shift in place towards more sustainable manufacturing processes and products. We believe that those companies which satisfy consumers in this regard will ultimately succeed. We anticipate being one of them.

Arnold Hofmeijer
GS Metaal

While the KORT project actually focuses on production efficiency, there is also a link with sustainability. In general, the recyclability and recycling rate of basic material in the metal industry is well regulated. The recycling process is intensive from the perspective of energy consumption and transportation costs. Most companies processing sheet metal have implemented nesting software that ensures the best possible use of raw materials, time, and resources. Using software that helps the timing of the production process to maximise machine efficiency and provide effective workflows can not only help to reduce the chance of errors, but also the risk of damage or loss of materials. I believe that is where the KORT project and sustainability goals meet.

To become more sustainable, we decided to view things differently. For example, we see scrap not as a waste, but as a valuable basic raw material. Metal requires a substantial amount of energy in transitioning from ore (oxide) to metal. After metal is made, recycling is simply a melting and cooling process, where all heat can be recovered, making the transition from scrap to metal a potentially energy free process. Unlike plastic, concrete, stone or wood, recycling metals provides no deterioration in quality. For centuries, recycling metal has been integrated into metalworking processes, driven by the fact that scrap is valuable, making recycling a profitable process.

Our contribution to sustainability lies in the very nature of sheet metal fabrication, which is a sustainable circular activity with no waste in the process.

Guido Slump
Disselhorst Metaal BV

About the KORT project

The KORT project, an AMP project run by the Fraunhofer Project Center, aims to develop a proof-of-concept solution that supports reliable forecast of turnaround times. The KORT consortium consists of 4 companies from the region that specialise in processing steel metal plates towards products and solutions. The focus of this project is to determine the factors that influence throughput time and identify opportunities to manipulate them. In the initial stage of the project, FPC assessed the current production technology and operation processes amongst all the participating partners to recognise and categorise similarities between them, based upon their physical and digital infrastructure. The available data points were analysed to gain deeper insights into the current situation and gaps, which allowed us to identify potential challenges that influence the forecasting of turnaround times.

During initial discussions with the project partners, one of the challenges we identified was in how to make more responsible use of the input resources (i.e., metal sheets). Each company has already implemented a solution to support them in efficient usage of metal sheet plates, referred to as nesting. The challenges that come with these solutions, are often around the question of how the companies are using nesting and if the solution provides sufficient options. Are there different solutions that would be a better fit with their company processes? Nesting often influences the planning and scheduling of orders, sometimes delaying planning and throughput because, for nesting purposes, it would be more efficient to prioritise another order. Therefore, optimised planning and efficient resource usage can be identified as one of the factors that influences the reliable forecast of turnaround times. Furthermore, advanced planning for optimisation of throughput to increase the efficient use of resources, is also being investigated in this project.

In conclusion

For most sheet-metal manufacturing companies, a certain amount of scrap is unavoidable – but the key is to continually investigate ways to minimise wastage and improve efficiencies. Software support, automation, and other technologies, if implemented effectively, go a long way towards reducing waste during the fabrication process. Professional sheet metal manufacturers should continually invest in improved manufacturing processes and updated equipment to ensure their ongoing competitiveness and sustainability.

GET THE DOOR.
IT'S DOMINO'S

A PROJECT BY **FEST**

Author:

Demitriana Minassian MSc

FEST Lead & Research Engineer
Fraunhofer Project Center
at the University of Twente

The Fraunhofer Project Center Expertise Student Team (FEST) have undertaken a project with international pizza conglomerate Domino's, which required the team to come up with creative ideas to facilitate an innovative pizza-making process. Domino's has been at the forefront of innovation throughout their history, regularly adopting promising new methodologies in their ordering, cooking, and delivery systems. Domino's brief to FEST included using tailor-made technologies and solutions to improve the process of making pizzas.

Domino's defined the project's specific goals:

- improve efficiency
- ensure consistency and traceability
- increase focus on hygiene, and
- minimise errors and food waste at Domino's locations.

To improve productivity, Domino's sought to introduce Industry 4.0 solutions, using innovation through novel technologies.

FEST analysed current operations and innovations within the food industry and used the knowledge gained as a foundation to develop tailor-made concepts for Domino's. Innovations in the food industry follow similar processes as do many other industries, who use industrialisation, Industry 4.0, and robotics to reduce processing time, prevent errors and ensure standardised product quality.

In the initial stages of the project, the team accumulated a broad spectrum of ideas, ensuring that all aspects of the pizza-making process at Domino's were addressed in a creative, non-limiting approach. The resulting ideas ranged from simplified in-line weighing to fully automated ingredient mixing. Domino's pride themselves on delivering traditional hand-made pizzas. This is a major part of their branding and market appeal. They needed to maintain their ability to hand-make the dough and slice the pizza by hand. During discussions with Domino's, it became apparent that there were four key areas of focus for FEST: cheese topping, ingredient dispensing, sliceable meats and storage.

The best concepts from each of the four parts of the project were selected and the solutions were presented to Domino's. These were an automatic cheese waterfall, an automated meat slicer and applicator, an internally weighing topping dispenser, and a smart storage system. All concepts focused on precision in the pizza-making process, resulting in improved consistency, fewer errors, and reduced waste. For the purposes of efficiency and economics, it was important to ensure that the speed in which a pizza

is currently made was either improved or unchanged, because lowering speed results in less efficiency. The concepts therefore concentrated on automating the process to deliver the product as quickly and efficiently as possible.

In exploring innovative industrial environments in the commercial field and undertaking the management of this long-term project, FEST members gained valuable experience in customer communication, learning how to determine client objectives and goals. They devised methods of selecting team members in accordance with the project's requirements and timeline and formed a multidisciplinary team, with each member learning adaptability, tolerance and co-operation when working with different disciplines. They were able to recognise user experiences and customer perspectives as helpful tools, allowing them to identify different interdependencies and priorities. More importantly, the team learned the value of identifying and understanding all factors that can influence innovation in companies.

DOMINO'S:

"We needed a fresh look into our pizza-making process to see how we might integrate different kinds of technology. This is where the students from FEST came into the picture.

We liked the way their team looked into this project, gathering all the information they got from us and looking into our stores. This gave them the opportunity to have good understanding and insight into the project. They came up with a good summary and clearly understood our process. FEST provided us with a solid plan on how they wanted to manage the project from start to finish, made a clear separation of the different components, and provided us with realistic concepts within the scope and given time-frame."

DOMINO'S PIZZA NETHERLANDS B.V.

Ronald Dekker
Head of Brand Design Europe

Stephanie van der Sluis
Head of Store Development

CO_2-ZERO

Tata Steel is one of the world's leading and most CO_2-efficient steel companies. We are committed to developing high-quality new products and services that contribute to the quality of life. From lightweight cars to sustainable packaging, steel is an essential part of modern society. It is endlessly recyclable and makes an important contribution to building tomorrow's sustainable and dynamic society.

It is our ambition to make our own production processes CO_2-neutral and to make steel that is stronger, lasts longer and is produced using fewer raw materials. But also, by helping our customers to improve their operations and thus work towards greater sustainability of the entire supply chain. This is the only way we can produce steel in a sustainable way for future generations.

In the Netherlands, we continuously invest in making our production processes more sustainable in order to reduce our impact on the environment and improve our energy performance. In the annual CO_2 report of the World Steel Association, Tata Steel IJmuiden B.V. is in third place in the worldwide list of steel companies with the lowest CO_2 emissions.

Continuing this mission, Tata Steel is constantly developing ways to make the steel production more sustainable, adapt to the circular economy, and reduce energy and resources to prevent depletion of materials. Although steel can be recycled infinitely, an applied zinc coating must be removed before recycling. New processes are developed that can deal with zinc-contaminated steel, or - the easiest way - is not to apply a coating on surfaces where it is not needed. In other words, the coating needs to be applied very specifically.

A common practice to apply a coating is the process of hot dip galvanising (HDG). HDG is a process whereby a steel strip is submerged through melted zinc bath and the metal substrate is applied over the full width of the strip. Because the thickness of the zinc layer can vary over the width of the strip, excess zinc has to be applied in order to meet minimum requirements of the customer. Although equipment - such as air knives - has been improved over the last decades, a better distribution of the zinc layer is still demanded. In addition to that, some products don't require a fully coated strip. An example can be a car door, where 50% of the base coil is used.

[...] Tata Steel is constantly developing ways to make the steel production more sustainable, adapt to the circular economy, and reduce energy and resources to prevent depletion of materials.

Nando Leerentveld
Carbon Reduction Strategy Manager
Tata Steel IJmuiden B.V.

The goals:

40%

reduction of CO_2 emissions before 2030

to become a CO_2 - neutral steelmaker by

2050

98%

of all by-products are already recycled

If the metal sheet is only coated on the areas where the product is punched out, the usage of zinc will decrease significantly. One method to achieve this goal, is through the application of zinc spraying. In collaboration with the Fraunhofer Project Center at the university of Twente, Tata Steel performed research to develop a spray system that can spray a zinc coating on a very specific surface area. The thickness of the coating is proportional to the size of the produced droplets that are produced with the spray head. One single spray head can produce up to 4,6 billion droplets of 5µm in diameter per second at normal line speed. This would drastically reduce the amount of zinc used to coat a strip of steel.

In addition to the main advantage, a spray system would also support a quick change from one zinc composition (more or less Aluminium or Magnesium) to another, or even a completely different metal. In the current HDG process a change in composition would mean the introduction of a completely new bath, which is a costly investment. Furthermore, using the technique of different spraying heads, different areas of the sheet can have different layer thicknesses and compositions. Last but not least, since the submerging of the strip in the zinc bath is avoided, contaminations which normally grow in the bath cannot pollute the strip, resulting in a defect-free surface.

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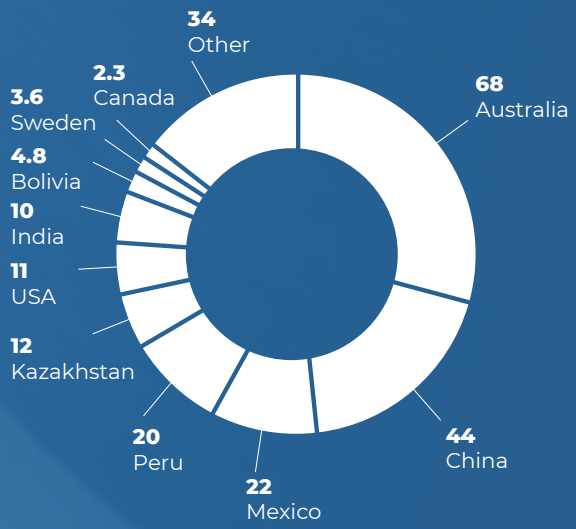
ZINC RESOURCES

The unique metallurgical and chemical properties of zinc have made it the material of choice for an extensive range of products. At the end of their useful life, the zinc can be recovered and recycled without loss of its metallurgical characteristics or value. Furthermore, while the attributes of zinc contribute significantly to sustainability during use, zinc recycling plays an important role in reducing concentrate demand and minimizing waste disposal.

The earth crusts contains an estimated 2800 million metric tonnes (MMt) of zinc. However, not all of this zinc is immediately available for extraction. The most recent estimate calculated that 250 MMt of zinc reserves are available and could be mined. Australia, China, and Mexico were among the nations with the largest zinc reserves in the world.

Zinc is now the fourth-most widely consumed metal in the entire world. Currently, 16 MMt of zinc is used per year. Out of this, 12 MMt of zinc is mined. The 4 MMt gap is supplied from secondary or recycled sources. Out of the used zinc, nearly one half is used in galvanising processes. Achievements of thin coating layers can therefore lead to significant savings in zinc. Mining and producing zinc has a significant environmental impact and needs to be avoided.



Zinc resources in million metric tonnes per country. according to USGS - Mineral Commodity Summaries 2021

WIRE ARC **ADDITIVE MANUFACTURING**

(WAAM)

Wire Arc Additive Manufacturing (WAAM) is probably the least talked about of various additive manufacturing (AM) processes. WAAM is a variation of a Direct Energy Deposition AM technology that is based on an arc welding process to print metal parts in 3D. Compared to the more common metal powder AM processes, WAAM is more capable of creating larger components by melting metal wire via an electric arc creating higher material throughput. The process is combined with a robotic arm to create shapes built on a substrate material from which the part must be removed when complete.

The development of WAAM is being driven by the need for increased manufacturing efficiency of engineering structures. Its ability to produce very near net shape preforms without the need for complex tooling, moulds or dies offers an array of benefits for companies, which include significant cost and lead time reductions, increased material efficiency and improved component performance.

Use and benefits of wire arc additive manufacturing for industries

As previously mentioned, WAAM is particularly good in the manufacture of metal parts in large-scale. Compared to laser powder bed fusion AM machines, the robotic arm of a WAAM machine has greater freedom of movement, implying that the size of a part is not so restricted by space, depending mainly on the distance the robotic arm can reach. Robot arms can indeed be very large, although another option may be to use multiple WAAM robots on a single part if required.

When it comes to the cost of materials, the welding wire used in the WAAM printing process is significantly cheaper compared to other metal AM processes. This is principally because WAAM technology is based on welding, a well-established manufacturing technology. WAAM hardware usually consists of off-the-shelf welding tools, which helps keep the system cost down. Furthermore, wire is typically easier to handle. Metal parts manufactured with WAAM are particularly notable for their high density and strong mechanical properties, which compare favorably to parts manufactured using conventional manufacturing techniques. Since wire feedstock is a 100 per cent dense input material, there is negligible porosity induced in the fabrication process, resulting in a very dense final part.

WAAM is a good choice for repair and maintenance purposes for particular components such as turbine blades, as well as moulds and dies. Worn-out parts can be repaired with WAAM by depositing new material on its surface. This can lead to decreased costs by eliminating the necessity to manufacture a new part all over again.

[...] WAAM is more capable of creating larger components by melting metal wire via an electric arc creating higher material. throughput.

Gijs van der Velden
CEO
MX3D B.V.

The need for an effective software

MX3D is a 3D metal printing company that was set up to make use of WAAM as a deposition process. Their process is composed of three base components: an industrial robot, a welding machine and an in-house developed software package 'and control system' (MetalXL) that combine to form a 3D metal printer. Over the years MX3D have developed the experience to print in almost any metal that is available as a welding wire.

As already mentioned WAAM is most appropriate for production of complex geometry metal parts on a large scale, using high energy arc welding as well as multi-axis robotics. Both of these are difficult to control and so there is need for specialist software to make the process easier. Since the hardware is generally standard equipment, the MX3D company have come to focus more on the software development.

When the company initially started with large-scale metal printing, they noted that there was no suitable WAAM software on the market. The available options usually forced the user to tie varying software snippets together, which were not initially manufactured with WAAM in mind. Moreover, the various parameter settings for WAAM were either very intricate, found using work-arounds or were completely missing in these packages, ultimately leading to low-quality prints.

MX3D-METALXL was therefore developed as a dedicated WAAM platform that supplies manufacturers with the required tools to go from CAD-design to printed part. It facilitates slicing of the original CAD model, toolpath generation, solving of the inverse kinematics of the industrial robots, monitoring and control of the process. It also provides insights into the printing process, and other features that help create an effective metal part first time round. Since many industries have their own specifications on the process, equipment and certification, MetalXL enables them to calibrate and log their own materials and processes to facilitate certification and incorporate WAAM into their production chain. This makes MetalXL a highly flexible software while ensuring a controlled printing process and quality prints for 3D metal printing.

As WAAM becomes more widespread as a direct manufacturing process, one can expect to see MetalXL becoming part of a standard that will ensure MX3D has a bright future.

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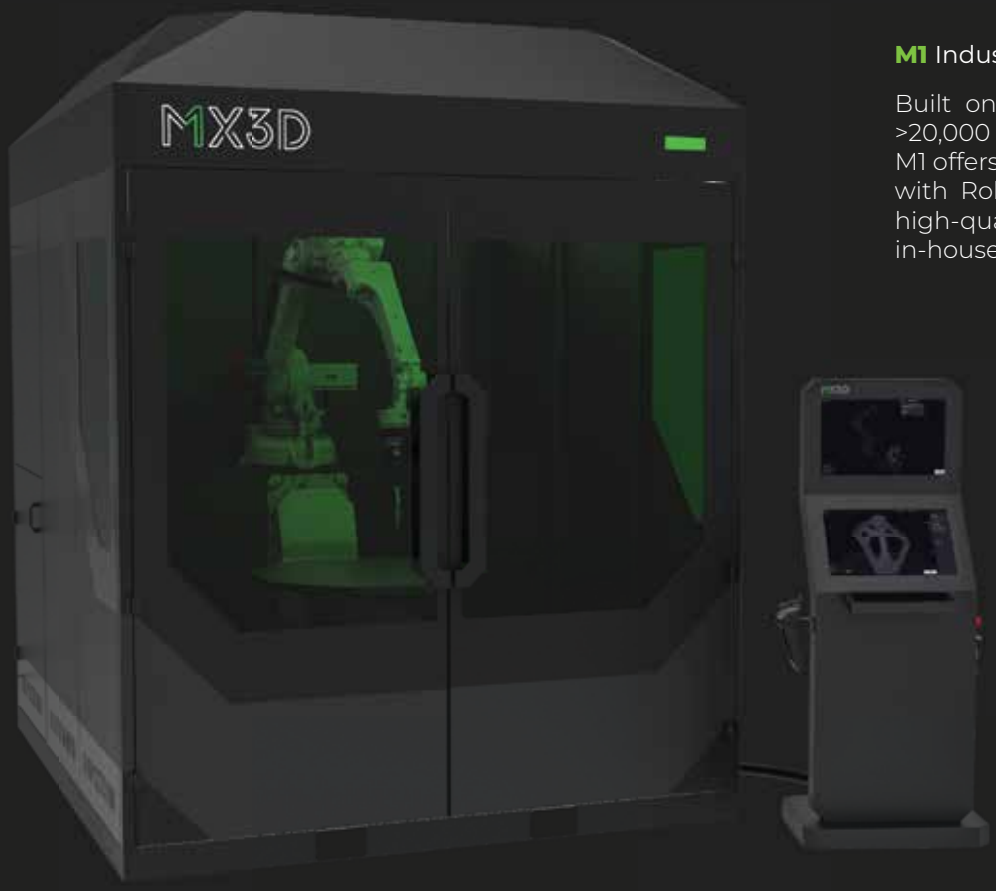
CEO
MX3D B.V.

MX3D

METAL AM SYSTEM

ROBOTIC WIRE ARC ADDITIVE MANUFACTURING



M1 Industrial Robotic Metal Printing

Built on extensive experience with >20,000 kg printed metal at MX3D, M1 offers a full solution to get started with Robotic WAAM fast and print high-quality industrial metal parts in-house.

M1 includes an **8-axis industrial robotics system** enabling complex prints, a multi-transfer mode GMAW power source for flexible print procedures, and WAAM-dedicated **MX3D Control System** for intelligent automation, real-time print mon-itoring and high-resolution data logging.

M1 | build for industrial 3D metal printing

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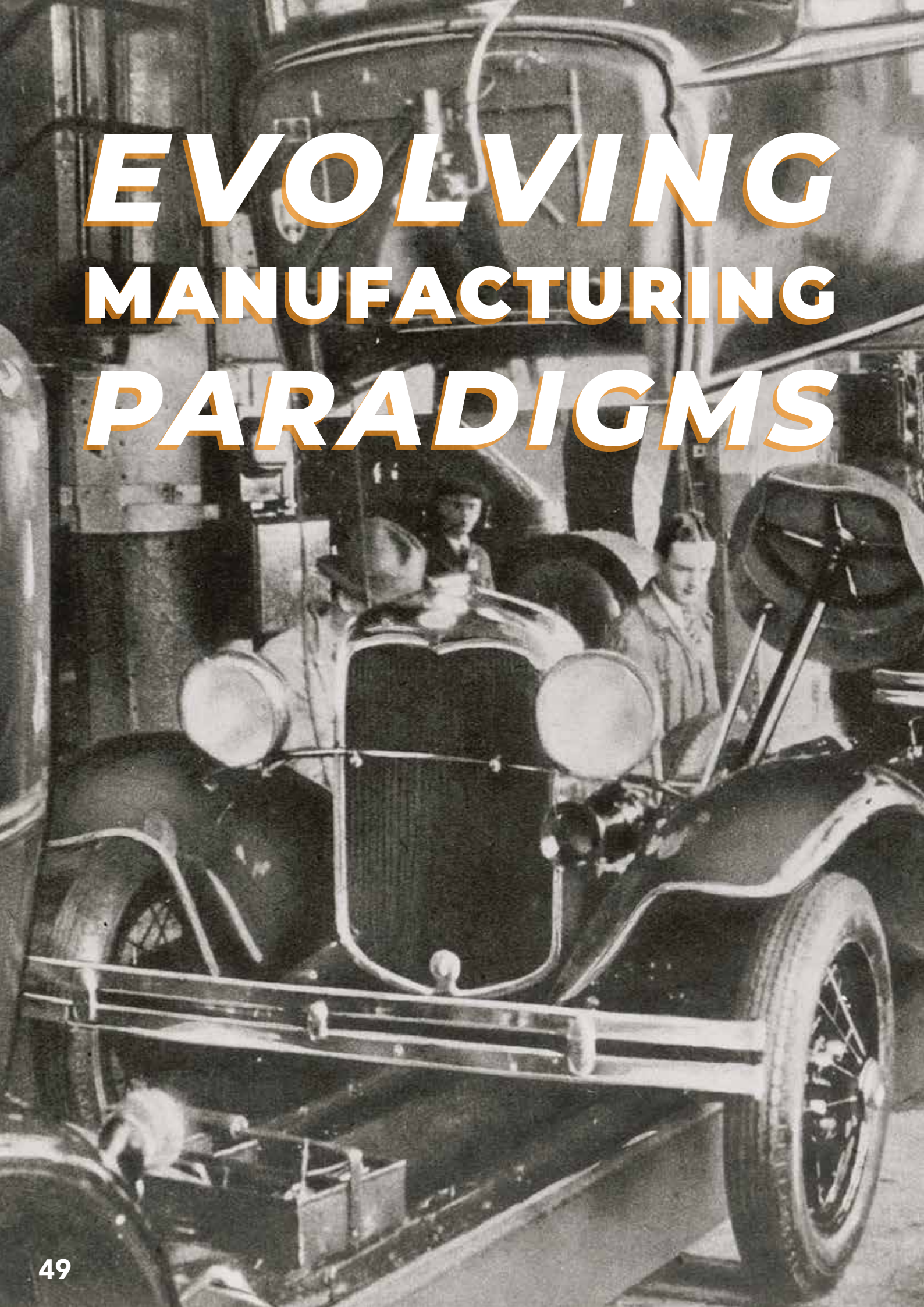


EVOLVING MANUFACTURING PARADIGMS

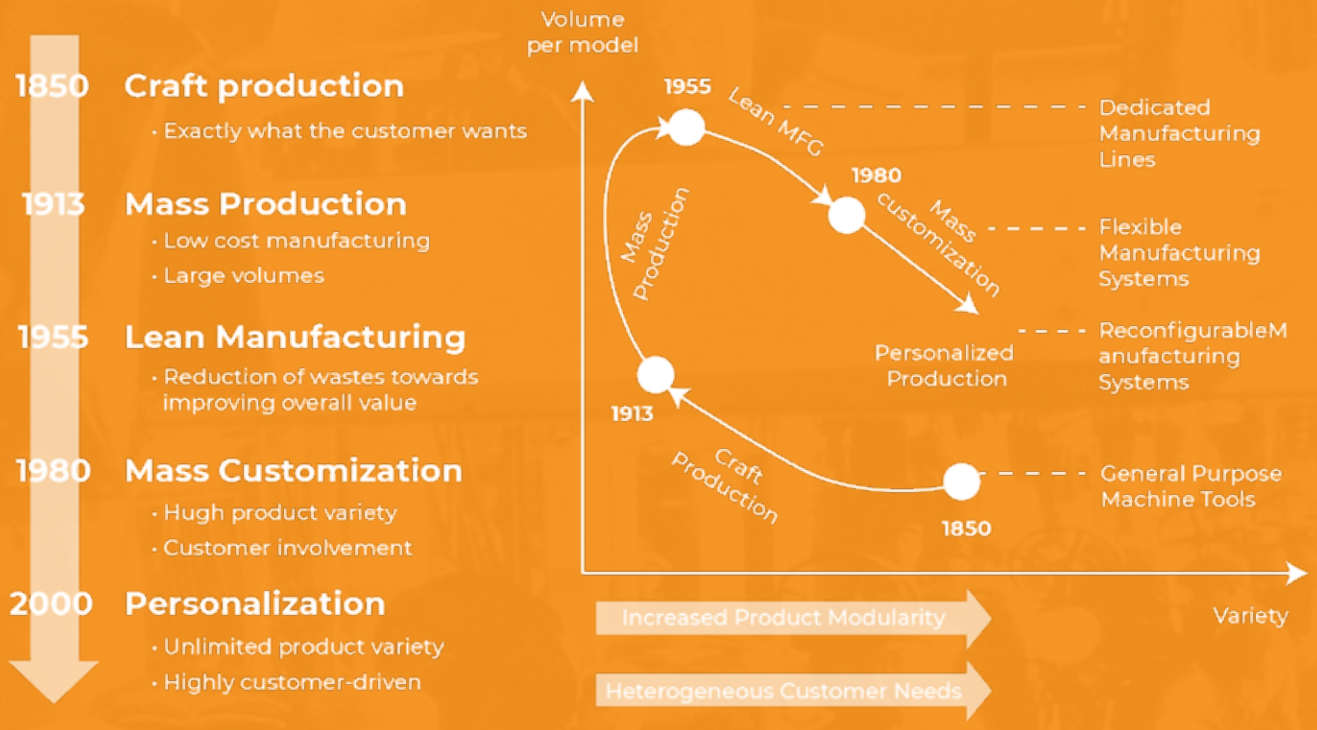


Figure 1: Changing manufacturing paradigms: change in customer demand and volume.

Since manufacturing erose two centuries ago, it has evolved through several paradigms from Craft Production over Mass Production to Lean Manufacturing and Mass Customization, addressing the needs of market and society. Craft Production as the first paradigm focused on creating the product that the customer requested. This resulted in unique products, with a high product variety and flexibility. However, the costs of these products were relatively high, since no manufacturing systems were associated with this paradigm. In the 1910s, Mass Production enabled the making of products at lower cost through the production of large volumes with limited variety all enabled by dedicated manufacturing systems. A symbol for Mass Production was Henry Ford's moving assembly line and his statement: "Any customer can have a car painted any color that he wants so long as it is black".

After the end of World War II, demands for products were very high, and the paradigm of Lean Manufacturing emerged as a necessity due to limited resources in Japan. Its manufacturing management philosophy focuses on minimizing all kinds of waste while maximizing customer value, and is still an important factor of all modern production systems. In the late 1980s, Mass Customization emerged as a response to the demand of consumers for higher product variety. Manufacturers started offering certain variations to standardized products. Especially in the automotive industry, an enormous product variety has been achieved. Nowadays, almost every industrial sector can offer high product variety to heterogeneous markets around the globe.

Manufacturing industries can now see a new trend going even beyond mass customization towards highly personalized production. These products cannot be manufactured the same way and will require different work steps and cycle times. Therefore, they cannot be efficiently produced in production lines with static tact times. Instead it is important, that - in the extreme case - lot size one can be manufactured under the same economical parameters as in large scale production systems although the production system's flexibility is much higher.

Flexible Production

As a result of the aforementioned diversifications, an innovative, flexible and scalable production system that can deal with altering demands and uncertainties has become a necessity in future production systems. Since the product is a result from evoked demands, and the production correlates to the product, the production system - in the end - is linked with the demand. Due to expensive investments in production a flexible mixed-model production is required which can deal with:

- **Product diversity**
- **Keeping a high output level simultaneously**
- **Uncertainties in respect to future demands**
- **Long term design and development**
- **Increasing use of new technologies**

Hence, future production systems should provide a high ability for flexibility. In this context flexibility can be classified as follows:

- **Market flexibility (The ability to adapt to changing market demands)**
- **Production flexibility (The range of diverse products a system currently can produce)**
- **Volume flexibility (scalability)**
- **Product flexibility (The ability to implement new products or change the current set of products)**
- **Process flexibility (The ability to reconfigure the production system)**

Considering the main issues as above, a progression of product flexibility that simultaneously renders mass customization will be the main objective in the production

industry. If time variable trends and connected fluctuations in consumer demands are additionally considered the product system also has to be flexible in volumes. This means the ability to scale the output in short terms for economic reasons. In long term the system must be able to adapt to market conditions by increasing product flexibility. This is of utmost significance in the above commented accelerating market cycles. Production flexibility, volume flexibility as well as product flexibility are all based on the ability to readjust or reconfigure existing processes. Vital demand on any innovative production system for the future will be process flexibility combined with keeping a high output level as well as a high line utilization rate at the same time.

Matrix Production

One way to achieve this target is by applying the principle of matrix production. This approach towards a resilient, cross-technology system is a combination of technologies and methods from production engineering and Artificial Intelligence (AI). The adaptive design of plant configurations and process chains derived from this can automatically switch “on the fly” to changing product types, resulting in cycle-independent flow production. The linking of several different stations, combines the economic advantages of classic flow production with the flexibility advantage of make-to-order production.

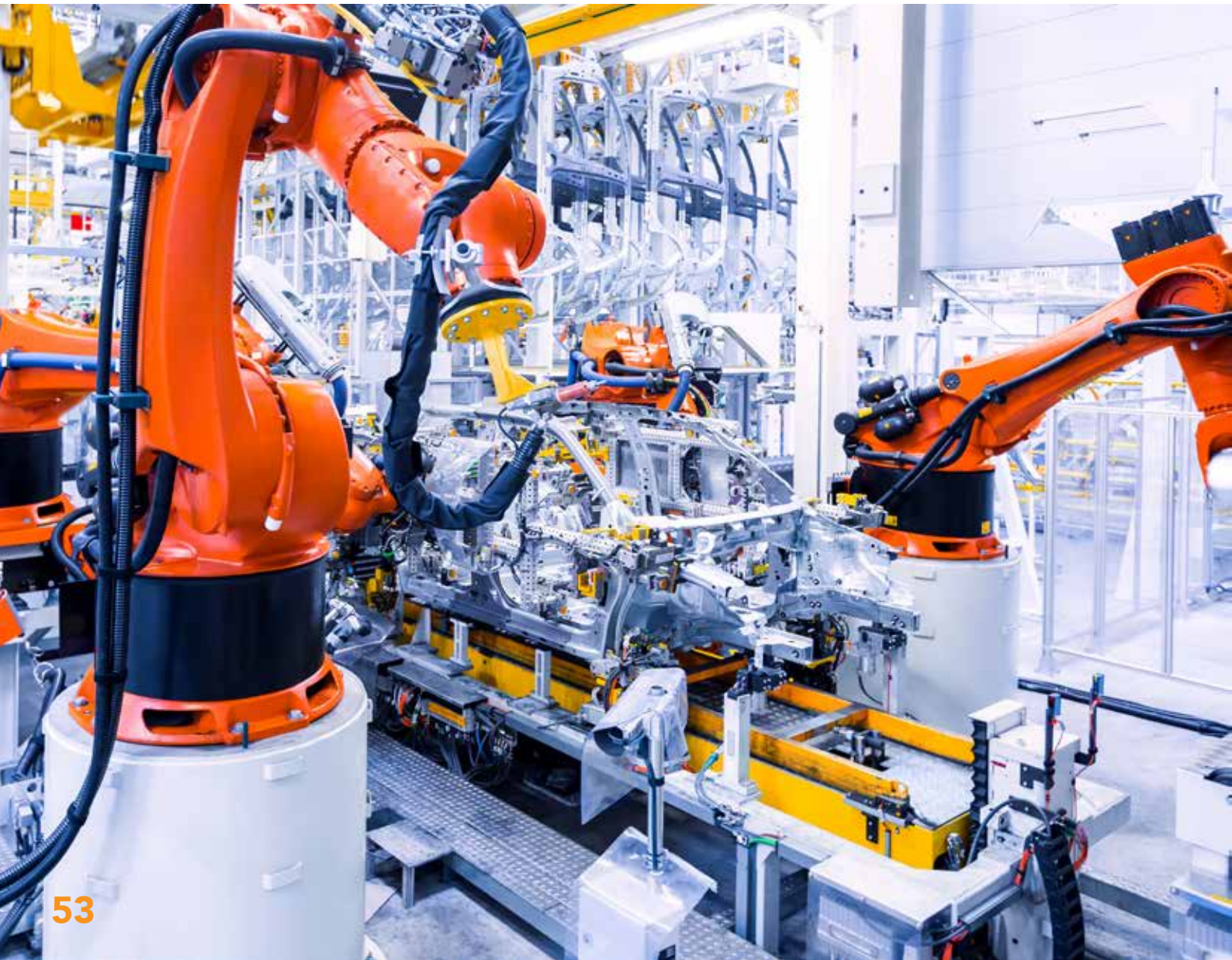
The matrix production opens up new degrees of freedom for the design, planning and control of the manufacturing system for the economic production of high volumes with simultaneous variant flexibility and volume scalability. The potential dynamic redistribution of order tasks to stations in case of changes in customer requirements or failures enables resilient production in a volatile environment. The autonomous control of the factory through an orchestration of AI modules eliminates cycle time differences and thus enables the use of synergy effects.

For enabling matrix production four interacting elements need to be considered:

1. *Flexible, cross-technology production cells*
2. *Order control in the matrix*
3. *Logistic linkage*
4. *Digital data and model backbone*

The use of reconfigurable manufacturing cells – either fully automated, a manual workplace, or a hybrid cell – enables process-oriented planning of freely linked stations and order allocation based on free capacities of the stations. Thereby, the stations can be arranged in almost any number on a grid. The production cells are equipped with product-neutral equipment and product-specific basic functionalities and can be individually adapted to the respective task by means of process-specific facilities. This use of redundant and versatile manufacturing and assembly cells enable to focus on processes, their full execution, and aggregation of similar technologies and scopes of work.

Order control includes the design and evaluation of AI submodules and heuristics regarding the prediction of order lead



times, transportation requirements, material requirements and reconfiguration requirements. To achieve this, an agent-based control algorithm based on reinforcement learning (RL) is developed and integrated into the production planning process.
The inclusion or exclusion of further cells in the process without interrupting the value chain, as well as flexible switching to other cells during peaks, implies a plant with variable parts logistics. A key driver of this is the transfer of parts, tools, and semi-finished products to the manufacturing cell using Automated Guided Vehicles (AGVs). Different components or tools are picked up and transported by individually configurable load handling devices (LAM) and navigation to the individual cells is performed by a SLAM navigation algorithm.

The associated higher volatility of shoring location, quantity and timing as an effect of matrix production implies the collection and use of a large amount of high-quality data and the digital linking of all sections. Therefore, a digital representative as backbone for adaptive planning and control is used to increase the value creation process. In particular, agile and resource-optimised control of material, control and information flows requires logistics to be logically linked to production. Not solely for order handling, but also for reconfiguration requirements.

Conclusion

The manufacturing industry always has been a source of innovation and development, with factories adopting new challenges and trends. Over the last two centuries, this resulted in several changes of manufacturing paradigms. Todays and future factories also face several evolving trends like customer demanding for highly personalised products, and an increase in product variety and complexity. As a result, large numbers of different specialised variants of products and components must be manufactured and assembled. Therefore, it is of great importance to achieve a flexible and scalable production system that can coop with high volume. Traditional assembly line concepts, however, struggle to maintain high utilisation rates when producing components with a wide range of processing times on the same line. Hence, alternative configurations are demanded. Matrix production might be the solution, since it enables the requested productivity/efficiency but also variant and volume flexibility. In combination with flexible transportation systems and a control system, high utilisation of the work cells is obtained. This resolves the discrepancies between flexibility and efficiency and allow for the application of more flexible production systems by adequate factory perspectives.

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RESILIENCE

IN THE **STRATEGIC MANAGEMENT** OF

MANUFACTURING COMPANIES

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The Corona pandemic has been revealing the fragility of the manufacturing industry for more than a year now: The often existence-threatening challenges ranged from disrupted supply chains to severe drops of demand in strategic customer segments and corresponding liquidity bottlenecks. However, events that occur unexpectedly - like the corona pandemic now - bringing with them enormous repercussions for world affairs are by no means a new phenomenon. Since Nassim Nicholas Taleb's bestseller, they have been widely known and feared as so-called "black swans".

Looking back to the financial crisis of 2008/09 or the attacks of September 11, 2001, such unpredictable events have occurred time and again in the past, depending on the industry and business. Analysts from major consulting groups such as A.T. Kearney and McKinsey estimate that there will be one exogenous shock per year and one longer-term disruption of more than one month every 3.7 years in the near future.

Such events show that companies today have varying degrees of ability to deal with external shocks and the associated turbulence. This ability, summarised under the term "resilience", is therefore increasingly becoming a competitive advantage in the volatile business environment. The Fraunhofer Institute for Production Technology IPT in Aachen has therefore examined the resilience of companies in relation to their strategies as part of a white paper and gained insights into how corporate resilience can be developed strategically.

What contribution can strategic management make to building resilience in the organisation as a whole? Here, the Aachen scientists selected four strategic starting points, which they examined in more detail: corporate strategy, technology strategy, engineering strategy and production strategy. They investigated the influence of the company's individual strategic positioning on its actual resilience. To this end, the researchers worked out which principles, for example modularity or redundancy, are responsible for higher resilience. They also took a

look at the normative goals and influences that could conflict with the development of higher resilience, such as the desire for particularly high profits or a prominent position in the market. This will now be followed by research on a systematic assessment of the level of resilience in order to derive measures for building an individual position of resilience.

System interrelationships within integrated resilience strategies

The Fraunhofer IPT white paper is intended to serve as a practical guide that companies can use to approach the systematic management of resilience within their organisation. To this end, the paper provides both a brief introduction to the theoretical framework and a guide to deriving appropriate actions. The explanations create a basis for not only setting the right priorities, but also for evaluating the impact of the measures planned in this way on the company as a whole.

From the field: Strategy work in the face of growing disruption

To find out how resilience can become a competitive advantage in a volatile business environment, the Aachen researchers at Fraunhofer IPT conducted an empirical interview study in addition to the white paper they had just completed. Here, the goal was to discover concrete examples of successful resilience strategies in industrial practice. A qualitative survey of strategists and decision-makers in various industries aimed to show how strategy work is carried out in normal operations and how - in contrast - externally induced discontinuities are dealt with strategically in the event of a crisis. In addition to the past, the current events surrounding the corona pandemic provided both an occasion and an example. In the publication, which will be available for download for free from the Fraunhofer IPT website in June 2021, case studies and best practices of strategic work are presented in order to derive conclusions for resilience-promoting corporate strategies.

INC Technology & Innovation Summit

Topic: **Resilience and technology strategies.**

June 23 & 24, 2021

The event is aimed at professionals and executives of technology-oriented companies, primarily from research and development, technology and innovation management, new business development and strategy. A special feature of the conference will be the practice-oriented presentations by speakers from industry and academia, who will present and illustrate trends in modern technology and innovation management using specific case studies.

As last year, the organizers are again offering digital participation in 2021.

For more information visit: https://invention-center.de/ti-summit/

SUSTAINABLE CONSUMPTION AND PRODUCTION POLICIES IN EUROPE

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The EU is leading global efforts in the fight against climate change, by supporting the transition to a low-carbon, sustainable economy. EU aspires to establish a financial system, which will ensure sustainable growth, formulated around the precautionary principle of 'actions that do no significant harm'. Through its empowered financial system, the EU steers the economy to a more sustainable future, by strongly supporting green investments. A considerable portion of Green investments includes the acquisition of equities of technology, manufacturing and innovation companies, which can directly contribute to a resilient and sustainable economy by promoting novel green technologies and methodologies.

As all market sectors are dependent on the financial sector, this effort directly affects different segments of the EU economy, spreading to manufacturing and consumption. When it comes to sustainable consumption and production, the European Commission is more than clear in its direction. Thirteen years ago, on the 16th of July 2008, the "Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan" was adopted, which addressed a wide spectrum of issues. The Ecodesign Directive provides the minimum standards, which European countries must adhere to, when it comes to production in Europe. Minimum standards were defined regarding the energy efficiency of the products in question, which ensure that planned obsolescence in product design becomes a thing of the past. The Energy Labelling Directive is also a step in the right direction, given that it works hand in hand with the Ecodesign Directive, ensuring proper labelling and

indication of energy-saving and consumption processes.

Furthermore, the EU has illustrated a growing commitment in integrating and managing Environmental, Social, and Governance ("ESG") concerns, implementing a series of interrelated rules towards this purpose. The EU has recently adopted regulations (EU) 2019/2088 on sustainability-related disclosures (also referred to as "SFDR" regulation) in the financial services sector and (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment (also referred to as the "ESG Taxonomy regulation"). Those recently implemented legislative pieces aim to utilise the strength of the EU financial sector towards the success of the objectives of the EU ESG policies.

In particular, the main objectives of the aforementioned regulations are:

Subsequent to the introduction of the new EU regulations, it is evident that all investors will have to enhance their internal policies to comply with the increasing governance, disclosing and reporting requirements imposed by the EU, which will inevitably reform their investment policies and objectives.

Therefore, companies seeking third-party investments for their operations, especially SME's in the technology, manufacturing, and innovation sector, can obtain a strong competitive advantage when conforming to the above described green regulations. As they ensure their classification as "sustainable assets", these companies may make themselves more attractive to investors.

Notably, both Dutch regulators have declared ESG as a priority, thus the strict enforcement of those regulations is to be expected.

- **to further orient market interest towards investing in companies which adopt the ESG principles in their capacities as investees, borrowers, and issuers**
- **to facilitate companies that comply with SFDR requirements to gradually develop a competitive advantage, thus promoting the integration of SFDR objectives in capital raising activities**
- **to promote uniformity in sustainability-related information published by companies**
- **to standardise the criteria utilised to classify a particular investment as "sustainable" (as defined therein) to avert "greenwashing"**

SHAPING

TOMORROW'S MANUFACTURING

RESPONSIBLY

ANTICIPATING HOW **EMERGING TECHNOLOGIES** AND **SUSTAINABILITY** WILL INFLUENCE **TOMORROW'S BUSINESS** AND **SOCIETY**

> *While in the past it cost to be sustainable, nowadays shifting to sustainability will have a positive effect on company finances in the long run!*

Manufacturing is no longer considered to be just the process of producing things. Changes in consumerism and societal attitude have led to a fundamental shift in the way manufacturers do business. Nowadays, manufacturers must also consider a much wider spectrum of factors ranging from research and development to design, consumer behaviour and end-of-use cycles. The responsibility and business impact no longer start and end with a single process or manufacturer but involve a multitude of industry sectors and multiple manufacturers in various supply chains.

Whilst manufacturing industry has significantly contributed to economic growth, jobs, and innovation, it is also one of the larger consumers of energy, correspondingly contributing significantly to global CO2 emissions. Therefore, the industry must take a leading role with a view towards sustainability as a business imperative in order to mitigate such adverse effects.

Building a Sustainable Future using Emerging Technologies

Responsible manufacturing practices are not merely limited to sustainable efforts. To be truly responsible, all efforts need to be conscious of processes, material sourcing and employee engagement. Furthermore, the emergence of new technologies can transform manufacturing, enabling it to become more efficient while also creating new value for industries, society, and the environment. This however comes with great responsibility and also further challenges.

Although challenging, these efforts are able to accelerate the growth of advanced manufacturing whilst helping stakeholders fulfil their social responsibilities. Innovation and emerging technologies for example are increasingly being used to improve production processes. Artificial Intelligence (AI), the Internet of Things, Cloud computing along with big data analysis, can all be utilised by responsible manufacturers to digitalise their processing. Digitalisation will in turn lead to improved operational efficiency by reducing costs and waste.

Using Emerging Technology for Social Sustainability

Aside from being used to improve efficiency and reduce waste, emerging technologies can also be used to improve social and employee related conditions. Digitalisation, and the strengthening of rights such as the right to disconnect (ability to disengage from work and refrain from engaging in work-related electronic communications, such as emails or other messages, during non-work hours) in company policies can lead to employees having more social rights, better mental health, and flexibility, thereby leading to better long term job satisfaction for their employees.

Long-term job satisfaction has long been linked to positive employee performance and efficiency, leading in turn to more company profits. Focus on sustainability can therefore benefit the manufacturers themselves, their employees, and the public in general, leading to overall better tripartite relations.

Benefits of responsible and sustainable manufacturing:

1. *Improved operational efficiency by reducing costs and waste*
2. *Long-term business viability and success*
3. *Lower regulatory compliance costs*
4. *Improved brand recognition and build public trust*
5. *Better access to governmental financing/ funding*

Governmental View

Industry must in general be encouraged to act responsibly. Governments within the European Union are increasingly taking into account sustainability when it comes to funding and financing programs. Specific funding programs are being launched with funds being made available for sustainable solutions. Manufacturers opting for such sustainable projects and solutions are more likely to find the funding and financing in relation to their projects if their proposals are sustainable rather than if they're not!

Meanwhile, current Dutch and general European regulatory compliance costs are considered to be economical when it comes to sustainable manufacturing. While in the past it cost to be sustainable, nowadays shifting to sustainability will have a positive effect on company finances in the long run!

Conclusion

As times change, so must manufacturers. Sustainability and responsibility are fast becoming the industry standard, and manufacturers must make sure to address these areas if they are to build public trust and improve their brand recognition. This is a fact that is increasingly being recognised by a number of manufacturers.

Moreover, manufacturers are also recognising the significant financial and environmental benefits from responsible and sustainable business practices. With such practices leading to long-term business viability and success, it is in their best interests to do so. However, recognising the importance of sustainable manufacturing is not enough, for action must be taken if results are to be achieved. In other words, manufacturers aiming to be at the top of the ladder must start or continue taking action. Meanwhile, it is important that all manufacturers must indeed follow suit if they are to remain profitable and competitive.

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   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

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