Cranfield University

Manufacturing and materials week

The green recovery

30 November-3 December 2020

Report

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Foreword

Professor Mark Jolly
Director of Manufacturing,
Cranfield University

Manufacturing and materials week included a mix of live debates, lectures, workshops and pre-recorded videos, looking at the challenges the industry faces right now, as well as how we must adapt and innovate to support future global challenges such as achieve a Net Zero manufacturing sector by 2050.

The inaugural week-long event that built upon long standing events such as the Manufacturing alumni awards, the National Manufacturing Debate and Manufacturing 2075 gave the opportunity explore the pivotal role of manufacturing in everyday life. Taking these events to the next level, the week showcased that society needs to accept manufacturing as part of our lives and how it can support our future. Our digital devices, tables and chairs, right down to our pots and pans – all part of manufacturing! But they use resources, materials and energy, and so as a population, we must be responsible custodians of our planet for the sake of future generations.

Through research and teaching, Cranfield University, alongside industry is working to solve problems of the future. Post Covid-19, manufacturing has the potential to address important psychological and social challenges.

Introduction to the Manufacturing and materials week

Rosa Wilkinson
Communications Director,
High Value Manufacturing Catapult

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Against the backdrop of Cranfield University's Aerospace Integration Research Centre, Rosa Wilkinson of the High Value Manufacturing Catapult opened the Manufacturing and materials week in a pre-recorded introduction.

Setting the scene for the event in what has been the most unusual of years, Rosa posed questions that would be reflected on during the week. How can we move beyond Covid-19? How can the UK work to become a more productive, more competitive manufacturing industry? How are we going to master the challenge of decarbonising and achieving the net zero targets by (if not before) the Government's deadline of 2050? What technologies can we harness to boost our productivity, and how can we ensure the skills we need to apply these new technologies are readily available?

With a momentous week of events ahead for the Manufacturing theme at Cranfield University and one that seeks to shape the industry for the future, Rosa's message to everyone attending: "There are some huge opportunities here - let's seize them together."

In conversation with Rosa Wilkinson

"The Ventilator Challenge was one of manufacturing and engineering's finest hours."

Dick Elsy CBE
Chief Executive Officer,
High Value Manufacturing Catapult

CATAPULT
High Value Manufacturing

Having led the HVMC through an extraordinary year, Dick has been at the forefront of the UK's Ventilator Challenge, where we saw the industry produce 20 years of ventilators in just three months. This alone demonstrates just what our industry is capable of.

The year has exposed some strengths and weaknesses. Our drive towards a model of globalisation, which sees us waiting for a vital component from a factory on the other side the world, showcases the fragility of our supply chains. It has made the industry, and now also the Government, think carefully about the need for sovereignty over key elements of the UK's manufacturing capability.

However, it is clear that the sheer vigour of British engineering is still there, despite what the press might say. Many nations, including the United States, tried to repurpose manufacturing capabilities from areas such as aerospace and automotive, to make complicated medical devices, such as intensive care ventilators, but they could not. The combination of the UK manufacturing industry's can-do spirit, together with amazing capabilities and a rich seam of advanced engineering in the motorsports industry created a potent mix. There is clearly a juxtaposition between our quite considerable vulnerabilities but also our strengths that we must now build on.

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In March 2020 the Government acknowledged that Covid was set to overwhelm the NHS and there would not be enough intensive care ventilators across the UK. The Ventilator Challenge was a Government ask to industry to repurpose itself to make as many ventilators as possible in a short space of time. Dick helped to set up the consortium along with a small anaesthesia equipment company, Penlon, who configured a system to fast track through to production. The consortium built factories in just four weeks and 11,600 ventilators in the space of 12 weeks.

In reality it was a relatively small number of firms who worked together on this challenge. Rosa posed the question, how can we ensure more of our manufacturers are able to harness some of the skills exhibited in those crucial 12 weeks. Dick explained that the skill sets used in the challenge are not unreachable. Teamwork and empowering people to do the right thing were the core elements. In business we tend to put barriers, such as levels of authority or decisions by committee, to doing the right things. In this case, the consortium didn't have the chance to do this - giving an enormous sense of empowerment to the individuals involved. The area where the UK needs to up our game is in programme management. There is a lot of untapped resource in business, especially in younger people willing to take a little more risk.

"Recovery will favour the bold and the brave. Restoring normality and simply stopping here won't help us, this is the opportunity to go beyond that."
Dick Elsy CBE, Chief Executive Officer, High Value Manufacturing Catapult.

Reflecting on the ambition for net zero, Dick provided insight on how we can help businesses to achieve that vision. In general terms the UK industry needs to embrace the digital revolution. The Ventilator Challenge was an accelerated move to a new place in which digital solutions solved some critical challenges. For example, augmented and virtual reality were used to train more than 3,000 people who couldn't physically be in one location. For example, augmented and virtual reality were used to train more than 3,000 people in Broughton, Airbus who couldn't physically be in one location due to the pandemic. At HVMC this is something they had been aspiring to for a while but industry has never been quite ready. When forced to take the risks, they were well-rewarded by this decision, achieving things in extraordinary spaces of time using digital tools.

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In terms of zero carbon, if you're in one of the big primary industries such as steel making or cement, this is quite a challenging scenario. Yet other industries have to focus on the rapid move to electrification. There are many technologies that are in a commoditised environment to help achieve this. Vehicle fleet electrification, local space heating, heat pump technology - it can all start now. Companies need to look at anything they are burning and see if they can electrify.

The Ventilator Challenge created the compelling rationale to save human lives. At a macro level the climate emergency is no less of an emergency than Covid, and for the bigger companies, this has been a wake up call, creating real determination to focus on reducing their environmental impact. For smaller businesses the road to recovery ought to be made a project in its own right. Business as usual simply won't work so they need to be encouraged to take risks that will, more often than not, be rewarded. In the Ventilator challenge, the consortium took risks, increased resources and the activity itself - breaking down barriers, taking away constraints - created an inspiring and energising environment to work in. The determination is there for the companies involved in the challenge - Rolls-Royce, Airbus, BAE Systems, Ford. So many of them didn't see low carbon production as a nice to have, it was an essential. This should give us hope.

Dick is coming to the end of his tenure as CEO of the HVMC, having delayed his retirement earlier this year to drive the Ventilator Challenge. Rosa asked for his reflections on his career in manufacturing so far. For Dick, it has been the joy of seeing the economic benefits and value-add coming from manufacturing. One of the most wonderful experiences of his career was working on the original series one Freelander at Landrover. Even back in the 1990s, Landrover was concerned about CO_2 and sketched out the concept of a smaller, lighter and more fuel-efficient vehicle. Dick was given the rare opportunity to run the programme from start to finish, from the engineering, new supply base, building, and running the factory. This led to the production of more than 480,000 cars, pumping a massive £11 billion into the UK economy. The huge reward of turning whiteboard notes into a product that people buy and use is considerable. Financiers may pay the bills, but ultimately it's manufacturers who make the world!

Dr Alan Whitehead MP
(Labour) Southampton

As a representative of one of the UK's prime manufacturing communities, particularly focused on defence and marine, Southampton MP, Dr Alan Whitehead, reflected on how businesses in his constituency had been fairing during this unusual year. Southampton is the centre of 'edge of high-tech manufacturing' businesses, with many high-tech startups coming out of Southampton University and spreading out to the sub-region as a whole.

The port of Southampton continues to sustain a high level of employment, manufacturing and fabrication. While it is widely believed that Southampton moved into more of a service economy city, this isn't entirely the case. While the heavy manufacturing such as the Ford Works has gone, the city is home to a lot of high-tech manufacturing, particularly in defence.

The city is in a good position generally in terms of its manufacturing base, but just like the rest of the UK, Southampton has been hit by a downturn in trade and activity. While there has not been any spectacular closures or disruptions in terms of jobs yet, it remains a very hard time for manufacturing in the city.

Alan went on to consider how as businesses climb the mountain to recovery, they need to address the climate emergency. He focused on what is happening with industrial cluster plans across the UK. The Greater Southampton area is identified as one such cluster but actually has a structure rather different from the industrial clusters elsewhere. It isn't about energy intensive, 'old, brown' industries that need to transition. Here it is more about a cluster of 'sunrise' industries and a supply chain which together, in terms of shipping, defence and green manufacturing, is actually producing a substantial industrial cluster in its own right. The refinery in Fawley is already transitioning, making new products including hydrogen, to play a part in low carbon manufacturing. Green manufacturing is where the future lies to hit zero carbon emissions by 2050 or earlier. Manufacturing has got to be the driving force - the capacity and the infrastructure - to produce our net zero future. We need new projects, different supply chains, and different manufacturing sources, as much as possible in the UK, to get that infrastructure in place.

We are still a long way from the sort of synergy that goes with consistent low carbon manufacturing across the board. It is essential that the Government helps, not only with sector deals to underpin the move forward, but by taking the lead in setting up the manufacturing supply chain processes that will go into the green infrastructure. It is not just the infrastructure itself that must be low carbon, it is every part of the supply chain as well.

The Government can help by changing the way it procures goods and services. If they want to focus on revolutionising energy efficiency in homes (the UK has some of the least energy efficient homes in Europe), this means that the materials in the energy efficient homes also need to be low carbon. The supply chains are relatively short so can be regionally sourced in the UK, with the local authorities able to lead area-based moves to ensure energy efficiency in homes. This offers a complete supply chain across the UK, focused on low carbon products and supply chains - integrating a low carbon process into a low carbon outcome. This would, we hope, ensure manufacturers are creating low carbon materials to provide the right products. At the moment housing developers tend to specify high carbon materials and therefore the manufacturers don't have the market for low carbon materials. If we tackle at both ends, we can pull the supply chains through and create a captive market for the manufacturers.

Rosa agreed; now more than ever we need knowledge to transcend sectoral boundaries. Too often new ways of doing things stay within a sectoral sub segment. Sharing the lessons from manufacturing to industries such as construction, are imperative. To do this we need to ensure we have the right skill sets. How do we do this?

Alan advised that at the moment we simply don't have the medium level skills in green installation and development in this country. We need to develop low carbon skills in the further education sector and show young people that there is an exciting future for them in these new areas. There is a big onus on training and retraining our people to ensure this can work. Retraining people with high skills sets, but in the brown economy, is key to this. 'Just transition' is a term used in the energy field around retraining people in hydrogen development, carbon capture and storage and development of supply chains. Many of the skills are compatible between the two, providing a good pool of people who can contribute to the green economy and recovery.

Rosa's remark of "politicians may think they change the world, but engineers actually do" is something Alan has long subscribed to. It is clear that there are new challenges ahead as well as the green recovery. For the move to net zero, we need the skills, the know-how and the engineering capacity to make sure we get there in one piece. To manufacturing and supply chains Alan would say that they need to position themselves at the forefront of low carbon developments. This is not only about green recovery but also about creating a low carbon economy that the manufacturing industries can be at the forefront of.

Alan Howard
Design and Manufacturing Lead,
The IET

The Institution of Engineering and Technology

With mixed emotions about the pandemic's impact, Alan has seen some businesses doing very well and in some cases increasing their production (pharmaceutical for example), but it has proved more difficult for companies in aerospace and automotive. Those businesses who have been able to pivot their operations at short notice and turn to other manufactures to help a difficult situation should be applauded.

The IET has provided practical day-to-day help during the pandemic. There has also been a realisation that getting back to the way we were before isn't necessarily going to be enough. Not only can we recover and come back stronger, we have an amazing opportunity to actually leap forward. There are some big challenges ahead, with decarbonisation being one of the greatest. We know the why and the what but are less clear on the how - that is part of the purpose of the IET's support for members.

We have to reduce the impact of our operations on the environment. We now have a piece of legislation that makes it necessary for all businesses to look to the future and reduce their impacts on local communities and the environment. Part of decarbonisation is inextricably linked with many other challenges facing the UK manufacturing industry. Productivity, for example, is connected to decarbonisation. In the past we have concentrated our focus on output per worker, per hour, which may form up to 20% of total costs, yet we have not really considered non-labour resource efficiency, which could be as much as 40–50% of base cost. This should provide companies with a huge opportunity post-Covid-19.

Alan is keen for his IET members to seize these non-labour resource-efficient opportunities in stepping up to the challenge of decarbonisation; reducing energy and water consumption, reducing raw materials coming into the factory, has to be number one. These don't require a great deal of capital investment. The IET advocates creating champions in the business who can work at all sections and levels, from the shop floor to the boardroom, to take responsibility for making and embedding these changes across the business.

While there are many businesses out there harnessing the power of new technologies, there are also those who are more nervous and are slow to adopt. We need to encourage these businesses to embrace new technology and seek the right advice. Catapult centres are fantastic if there is one on your doorstep but many people struggle with where to get advice from. We need more integrators to help businesses make sense of the technology available to them. Digital technology is there as a solution to help address pain points - using data and sensors to measure what is going on in the factory for example.

However, change doesn't begin with technology, it is about the people. Catapults can share expertise and information to help companies improve their processes, their products, and customer service. We have a national service of integrators to help to address the scale of transformation needed. Academia is also a great source of knowledge to help decarbonisation but also in terms of embracing new technologies. There are quick wins to be had - basic measurements in terms of metrics that can help to identify and quantify your pain in order to address them logically. Embracing the new doesn't have to be difficult - there are some simple solutions out there.

Navigating the future, the IET is working to engineer a better world within manufacturing. It is about celebrating the sector, remembering our strengths and contribution to society. It is about galvanising ourselves to leap forward, to embrace the opportunities that decarbonisation can provide; green, well-paid, highly-skilled jobs of tomorrow. We are seeing a transformation away from metals and minerals towards other sources, such as bio. Alan sees a revolution in smart factories ahead - we'll see them on our high streets as well as our industrial estates. There is a great opportunity in UK manufacturing - we can be leaders in taking these great ideas and our people forward.

Chris Leaman
Head of Communications and Public Affairs, Cranfield University

in conversation with

Sarah Olney MP
(Lib Dems) Richmond Park

Reflecting on what manufacturing and businesses can seize on in a post-Covid (and post-Brexit) world, Sarah is most interested in how we can take that massive step forward to green our economy.

The main areas our manufacturers need to consider are around power generation and new power sources; renewables, solar and wind and hydrogen. How will the sector respond and embed these new forms of power into their processes? Secondly, it's about greening our buildings, making them more energy efficient. Using less power will help our environment but will also boost our economy. Can we make our residential, commercial and public spaces more energy efficient? Can we design energy efficiency into our new buildings? These provide a pathway as a country, and as a planet, towards net zero carbon emissions.

The role of Government in all of this is very important. We need to see initial investment into some of the more experimental technologies to help de-risk for investors. We also need to see more regulation in the building sector. If we set the challenge that all future homes need to be zero carbon, that is a challenge the sector then needs to meet. We need to develop new technologies for heating for example. If we don't have that expectation that this is what must be delivered, the housing sector aren't necessarily going to invest. It is probably going to upset some people in the housing sector but Government needs to bite the bullet in terms of the regulations to make this step change.

In 2021, Covid permitting, the UK will host COP26. Sarah is optimistic about it. Now we will have a new American President who is much more committed to tackling climate change than Trump ever was. We want to get alignment across Governments about reducing carbon emissions - it needs an international commitment so that we aren't simply exporting emissions elsewhere. Other countries will feel more emboldened to sign up to more ambitious carbon reduction targets if they know America is also committed.

With Brexit, Chris asked where Sarah sees the UK Government taking this agenda in the next few years. While the cynic could say that Boris Johnson seems to pick up the climate change agenda when he wants to avoid another subject, nevertheless, there does seem to be a genuine commitment from the Government. The two areas that need to be addressed, renewable energy and our buildings, along with a transition in our transport infrastructure, is what we need to get to grips with to reduce our carbon emissions.

One of big challenges as the Liberal Democrat spokesperson for climate change, is that Sarah cannot pin down who in Government is responsible for delivering net zero by 2050. There is some work by MHCLG, Transport, BEIS, DEFRA - but where is the coherent picture, timeline or goals to achieve it? How do we really track progress? We need one person to have that single point of responsibility for reducing our carbon emissions - the equivalent of the Chancellor in charge of year-on-year advancement towards this goal.

Is net zero ambitious enough? There is lots of discussion around whether we want net zero by 2040 or 2050, or even by 2030! It's actually more important to work out how we get there. Our policy is to make big changes early and get the bulk of the net zero emissions (by 2030 if we can). Then it's about the long tail, for those people who can't afford to change their cars or industries needing considerable investment to adapt to renewables. Make the big changes in the next 10 years. Instead of one goal of 2050, which in fact lets the current Government off doing anything at all about it right now, we should create sub goals (30% reduction by 2025 [perhaps, 75% net zero emissions by 2040) that make the Government more accountable and likely to act now.

Finally, Chris posed a scenario for Sarah to consider: it's the day after the general election, the Liberal Democrat's have swept to power, Sarah is Secretary of State for BEIS for climate change - what dwould she do on day one to shape the agenda?

With a chuckle, Sarah considers this. To help shift consumer behaviour, we need to introduce a carbon footprint onto packaging so you can see how much carbon has been used to produce the product. In the same way labelling on food packaging has driven the industry to create healthier versions of their products, this would make manufacturers really look at how they reduce their carbon and help the consumer make 'carbon-healthy choices.'

James Fudge
The Manufacturing Technologies Association

in conversation with

James Selka
CEO, The Manufacturing Technologies Association

The Manufacturing Technologies Association (MTA) is the trade association for the people and companies who create and supply all the technology at the start of the manufacturing process. Technology from sophisticated machine tools, additive manufacturing machines, robotics and automation to design and data collection software. The MTA helps their members to improve their competitiveness by reaching manufacturers in the UK.

As we emerge from the Covid-19 pandemic, James is confident that manufacturing, as a resilient and forward-thinking sector, will handle the challenges faced. The sector is such an important part of the UK - a lot of traditional overseas investment has come in because of our innovation, flexible and skilled labour force and our world class financial capability in industry.

James recounted a recent event where Chairman of the High Value Manufacturing Catapult and also of HS2, Allan Cook CBE, were speaking. Allan shared his vision for HS2, to procure at least 90% of the spend here in the UK. What a massive opportunity for UK manufacturing and industry as a whole. There probably hasn't been a better time to invest, albeit James acknowledged the irony of this statement given the current uncertainty.

Global trade is here for the long-term but Covid has exposed a lot of fragility within our supply chains. It has also highlighted the importance of having sovereign capability in critical areas - food, healthcare and defence. Manufacturing technology is a real opportunity for the UK to be really industrialised using the most advanced technology. This in itself will support long-term sustainability, reducing the need for long distance transport, overproduction and waste.

As a human race we have been rather negligent in the way that we have treated the Earth's finite resources. There is an urgent need to reduce carbon emissions in a relatively short period of time. UK engineering can be a key part of the solution. We need to make manufacturing, the processes and the factories, more sustainable in themselves. We can do this by educating ourselves, by employing technology that enables greater productivity, less waste, recycling closer to home. By increasing additive manufacturing processes that use less material, and using latest digital technologies such as digital twins, we can remove the need to make so many prototypes.

We also need to come up with innovative solutions to help reverse the damage we've already done, but also export these solutions across the globe to help other nations hit their sustainability goals and increase the wealth and welfare of people in the UK. We already have an excellent record in this country, not only in innovation but also as an example, manufacturing the windmills for offshore wind farms. This has been hugely successful over the last two decades and will continue to grow.

Manufacturing in the UK contributes at least 15% of GDP. If we seize the opportunity and continue to invest at the right rate in leadership and technical skills as well as the technology we will be able to raise the living standards of everyone in the UK.

James' tips for the next generation would be to simply to get involved. We are just starting the journey into the fourth industrial revolution and it has never been more exciting. The days of the dark industrial wastelands are long gone and this is an opportunity for everyone, from the experienced to the very young, to choose a fantastic career in manufacturing.

In conclusion, James shared the MTA's plans for the next MACH show, a national event showcasing the very latest in engineering and manufacturing technology. MACH 2022 will take place in April 2022.

Your future in manufacturing and materials

Your future in manufacturing and materials

Kicking off the first of three live sessions over the week, Mike Bayes introduced the session and the plans for Cranfield's inaugural Manufacturing and materials week.

Bringing together industry leaders, students and academics, with a mix of live debates, workshops, lectures and pre-recorded content, all focused on the green recovery and considering what the manufacturing industry will look like post-Covid-19. Mike welcomed attendees to the session, designed to help potential students find out what studying at Cranfield University is really like.

Mike Bayes
Marketing Partner,
Cranfield University

Professor Kostas Salonitis
Head of Sustainable Manufacturing Systems,
Cranfield University

Cranfield University is a leading institution in the areas of decarbonisation and sustainable manufacturing. The courses we offer integrate manufacturing and materials with management, bringing together technical skill with the all-important softer skills.

The full-time courses cover different aspects of the product lifecycle - from material extraction, processing, formation of product, through its lifecycle, and to end of life. We focus on the circular economy and remanufacturing, looking at extending the life and value of products to meet decarbonisation objectives. As well as the technical knowhow, we also focus on the development of softer skills, including managing a team and communication.

Through problem solving, identifying new methodologies and new materials, we are seeking to develop the next generation of engineers who know how to solve industry challenges but, especially in light of the current pandemic, are also adaptable and resilient. Students work together in the context of real manufacturing challenges, ensuring they leave able and ready to meet the needs of industry, integrating quickly into a working environment and immediately adding value.

Materials design for engineering for sustainability

At Cranfield, we look at how to turn raw materials into end products, as well as adding smart functionality to materials. We are operating in a world where our aims are to improve efficiency as well as reduce CO_2 emissions.

Dr Jeff Rao
Senior Research Fellow, Coatings Technology, Cranfield University

In the aerospace sector, while we have found that you can reduce CO_2 by increasing the temperature at which you burn the fuel, it also places tremendous pressure on the material to operate. At Cranfield we are looking at how to deposit smart coatings to sustain performance of engine and protect the underlying substrates. A material the thickness of just two human hairs can be used to protect materials in jet engine.

We are also looking at alternative materials and pushing the boundaries of these materials in hostile environments. Biomimetics is the emulation of the models, systems, and elements of nature for the purpose of solving complex problems. How can we form materials with nature as our template?

We have used this model as part of a design challenge for modern start-stop engines. Here the components are subject to extreme wear and we needed to maintain an oil film to increase the longevity of components. Looking to nature we have used the structure of bone, a porous yet strong exoskeleton, to create a material that has the strength of bone but offers a porous surface. By combining two materials we were able to change the material surface chemistry.

In many ways, our students are pushing materials to see what they will allow us to do. Courses such as Manufacturing Technology and Management focus on converting raw materials into viable end products.

Eva Pelazez Alvarez
Current PhD student and
Aerospace Materials MSc alumna,
Cranfield University

Following an undergraduate degree in Aerospace Engineering in her home country, Spain, Eva chose Cranfield University with the specific aim to bridge her theoretical undergraduate learnings with the industry connections and career opportunities which Cranfield is renowned for.

The MSc in Aerospace Materials was a blend of the technical and softer skills required to prepare for industry. Writing reports, meetings with industry, managing a team - the master's has been designed to prepare students for the rest of their career. While she had not planned to complete a PhD, and particularly not one focused so far from her aerospace beginnings, Eva was offered a fully sponsored PhD by an industry partner to work on the formulation of natural latex gloves.

From aerospace to latex gloves is a big leap, and one Eva admits that she needed support in key areas, such as chemistry, to progress. Yet this is what Cranfield can offer and what companies, such as MediTech, her sponsor, believe in. With so many projects, aligned to real manufacturing challenges, the opportunities at Cranfield are phenomenal.

Fine out more about the MediTech latex gloves project in this video.

Q&A

What are the main advantages of studying a PhD at Cranfield?

Professor Kostas Salonitis - Here at Cranfield we offer a range of courses within manufacturing, all in support of the technical training and softer skills. From courses on time management to report writing, the softer elements blended with the technical application are paramount. The key difference at Cranfield though is its research staff. All academics are research intensive and as a result of this, they spend the time training their PhD students to become independent researchers.

How easy is it to secure a funded PhD at Cranfield?

Dr Jeff Rao - It depends on the current requirements of our industrial partners and their long-term vision. You can search all available PhD studentships on the website and this is updated on a monthly basis.

Can you give us an example of an MSc project?

Professor Kostas Salonitis - We try to identify projects that are of interest to the companies we are working with and that give students real experience of working with industry to solve a problem.

For example, we have created digital twins, which are factory simulations that enable us to run a number of risk-free experiments. Using this technology we can experiment with new configurations without the worry of failing, and then work with industry, whether this be pharma, food or aerospace, to apply and implement.

Dr Jeff Rao - A company who made shock absorbers for motorcycles found that some were failing in year one and others were not - for seemingly no reason. Students had to establish what was happening, why and most importantly, how we could solve. It is this exposure to a range of companies with live industry challenges that helps our students to secure employment post-Cranfield.

Eva, what has been your highlight so far at Cranfield?

So far, it has been the group project presentation completed during my master's. Presenting to the industrial partners, academics and peers was an incredible experience.

During the MSc can you do an internship in a company?

Professor Kostas Salonitis - We know that many European students like to do internships as part of their study. The thesis is a four-month long project. It is possible to negotiate with a company, establishing if the project is of a master's level, and complete an internship on this basis. The key to this is applying early, both to the company and to Cranfield.

Will there be on-campus delivery of courses for upcoming master's (starting October 2021)

Professor Kostas Salonitis - At the moment, Cranfield is delivering a large percentage of courses face-to-face. We aim to do as much as possible face-to-face but we are also learning from and adopting practices from the past few months, adapting to deliver online or pre-recorded content as well as face-to-face learning. Everything we do will be designed to add value to the student experience.

If someone wants to become an expert in manufacturing though an industrialised PhD, is this possible?

Dr Jeff Rao - Here at Cranfield we have part-time PhD students who complete their studies as part of their job. Certainly there are ways to do this but you will require a sponsoring company, and a research proposal that meets academic standards.

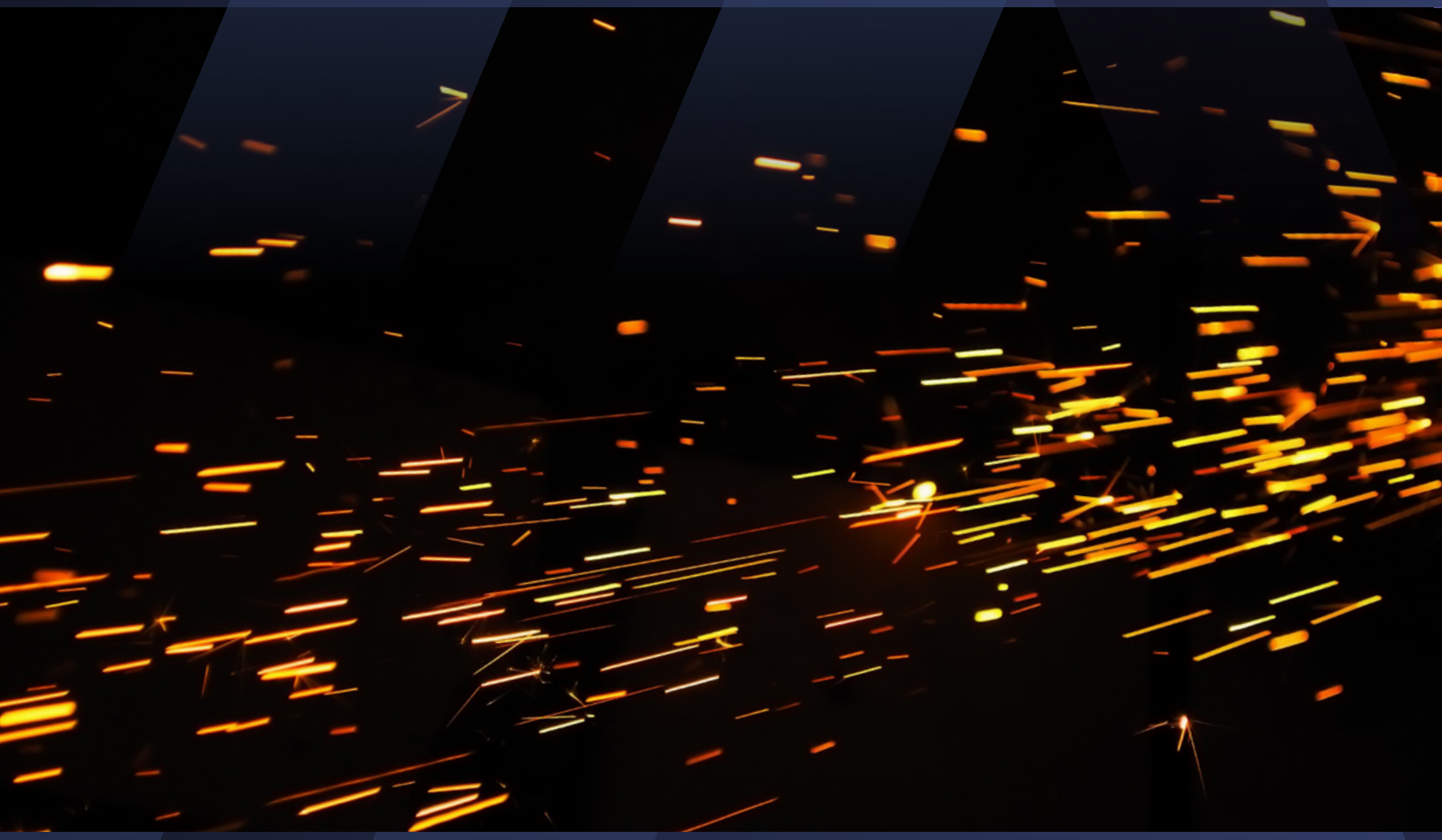
Eva, what do you hope to do after your PhD?

With two years left of my PhD, at the moment I am looking forward to continuing my current research into natural protein-free latex gloves for mass market production. I have had exposure to many areas of manufacturing here at Cranfield so far, from aerospace in my master's through to medical gloves today. It truly is a great experience.

Find out more about our manufacturing and materials MSc courses, short courses and research opportunities.

Manufacturing alumni awards and lecture 2020

The fourth industrial revolution and 21st century industries



Distinguished Manufacturing Alumni Lecture 2020

Welcome by Professor Sir Peter Gregson FREng, MRIA, DSc, Chief Executive and Vice-Chancellor, Cranfield University

Welcome

Professor Sir Peter Gregson
FREng, MRIA, DSc, Chief Executive and Vice-Chancellor, Cranfield University

While a significantly different format to previous years, Sir Peter Gregson thanked the Alumni team for their work in delivering this landmark event online. The focus for the event this year was to celebrate the achievements of Dr Ayotunde Coker (MSc Engineering and Management of Manufacturing Systems 1989), Managing Director/CEO, of Rack Centre Limited, with Sir Peter presenting him with the 2020 Distinguished Manufacturing Alumni Award.

One of the greatest advantages and opportunities of using this virtual forum has been the ability to reach Cranfield University alumni around the world, bringing together the manufacturing and materials community who have been at the very heart of the University for many years.

As a materials scientist himself, Sir Peter has a deep-routed belief that changes in manufacturing will be at heart of a green economic recovery. Over the past few months, he has considered the acute and extraordinary pressures people are all under. Sir Peter has had cause to use Cranfield's motto quite liberally in this time. It is one that resonates so much in the current climate: 'Post nubes lux' – 'Beyond the clouds light.' Sir Peter welcomed the celebration of Ayotunde's achievement as one of those 'flickers of light' sparkling on us.

In introducing Ayotunde, Sir Peter looked back at his illustrious career so far. In 1989 he completed an MSc in Engineering and Management of Manufacturing Systems at Cranfield. During his time at the University, Ayotunde won the Institute of Production Engineers Award, then going on to spend almost 20 years working for companies in the UK, before returning to Nigeria.

He was named IT Man of the Year in 2015 and IT Personality of the Year in Nigeria in 2019. His forward-thinking leadership as Managing Director and CEO of Rack Centre has built the company into one of Africa's leading data centres. His enablement of new and innovative business models to reduce the thresholds for access to emerging technology, has led to global recognition and numerous international awards for Ayotunde and Rack Centre.

Dr Ayotunde Coker
(MSc Engineering and Management of Manufacturing Systems 1989),
Managing Director/CEO, Rack Centre Limited

Ayotunde delivered an inspiring and cross-industry lecture on the Fourth Industrial Revolution and 21st Century industries, and the ongoing automation of traditional manufacturing and industrial practices using modern smart technology.

Acknowledging that today felt very special, Ayotunde confessed that he initially thought that receiving the award was a hoax, and went as far as to ask his cyber team to confirm. In a 'pinch myself' moment, he was delighted with the accolade, and that the digital format of the day enabled his family and colleagues to join the occasion from Nigeria.

Ayotunde acknowledged his time at Cranfield as a defining time in his career, inspiring him (and his fellow students at the time) to be transformational, visionary, and never constrained by someone else's view of what is possible. He concluded his thanks, dedicating the award to his parents for the values that they instilled in him.

Lecture: The Fourth Industrial Revolution and 21st Century Industries

While Ayotunde decided the subject for his lecture before the lockdown earlier this year, the events of 2020 have served to reinforce the subject's importance - finding new ways of doing business and democratising the manufacturing industry.

Ayotunde began by looking back at the three industrial revolutions prior to this, looking at how the time between each has been ever-shrinking. More than 110 years between the first industrial revolution in around 1760 (the age of steam engines, rail and telegraphy) to the second in 1870; yet from the third (1969, the advent of the microchip and main frame computing), to the start of the fourth industrial revolution (broadband, cloud computing, big data, AI, social media, 4G LTE, blockchain, VR) around 2005, is a mere 36 years. The question he posed: how short a time period before Industry 5?

The baby boomers and Generation X have lived through the third and fourth revolutions and may yet see the fifth. This is not a jump from one to the next, rather innovation that is happening in waves. In this fourth industrial revolution, we are seeing the creation of a global enabling infrastructure through undersea cables that connect across the world. This massive connection capability - carrier neutral mega data centres including those delivered by Ayotunde's Rack Centre, the leading carrier neutral data centre in Africa - ensures a broad range of services across the globe.

Cloud computing is a fundamental infrastructure which allows new technology to be accessible on demand. The infrastructure is now remarkably less elastic, with big data changing significantly over the years. Just a few years ago 1 tB of data cost $100,000, and is now just a few dollars. We now have a whole range of industries and ecosystems that interconnect.

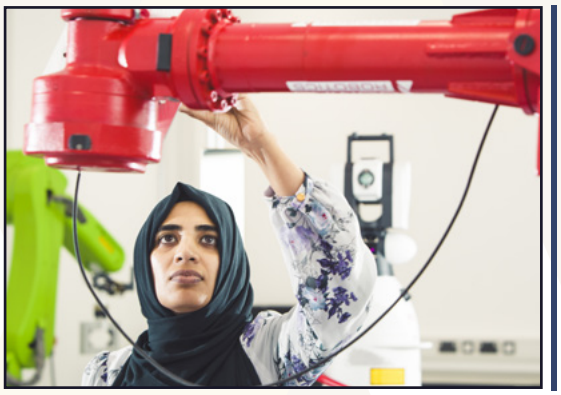
Covid-19 itself has created new possibilities. In manufacturing we now have the technology to facilitate unattended manufacturing. People can monitor sites remotely, even from the comfort of their home. These interconnected platforms allow cross-industry capability. By looking at global internet growth trends, we see a growing number of internet users, more devices, faster broadband speed, and more video viewing. By 2022 non-PC devices will drive 81% of global internet traffic. The pattern of devices is also changing, with smartphones increasing over time, tablets growing in terms of access, increasing machine-to-machine devices, as well as TV devices increasing. The average number of devices and connections per capita and per household will increase from 2.4 in 2017 to 3.6 in 2022 (average no of devices and connections per capita). By 2022 the Content Delivery Network will deliver 72% internet traffic, with the use of VR/AR increasing twelvefold.

The key is how to apply these technological possibilities in industry scenarios. Ayotunde pointed to a range of examples, including:

- In healthcare the scale of bandwidth means that experts can provide VR enabled support for keyhole surgery, helping to reduce medical tourism around the world.
- Back in 2006 Ayotunde was CTO for Criminal Justice in the UK, where he initiated pilots for virtual courts, creating the ability to prosecute guilty pleas with secure document management systems. Now with Microsoft Teams, Google and Amazon solutions, the use of technology to serve the justice system has been significantly expanded.

What about the impact of job automation?

In a review of the largest companies in 2018 versus 2008, the top five are now technology companies. The world's largest companies by market capital, you will find Microsoft, Apple, Amazon and Facebook. The technology companies are the basis for transforming other industries. We should not be alarmed by the increase in job automation. In fact, research from PwC has shown that it will actually result in higher quality job creation as well as increased choice and a better work/life balance. With technological advancement comes greater efficiency and more output. Transforming through technology to achieve a more efficient manufacturing process has always been the end goal. If we can't demonstrate efficiency in the UK, it is guaranteed someone else in the world will! It is better to be at forefront and embrace automation rather than fear it.



Industry 5 - what and when?

Ayotunde predicts that we will start to transition to Industry 5 in the next five to ten years - that is just 20 years since Industry 4. His assertion is that AI, blockchain will start the transition to the fifth industrial revolution in around 2025. Ayotunde outlined a few of the elements he believes Industry 5 will bring forward:

- Heuristic tech - human interplay,
- AI and blockchain - the perfect partners,
- Hyper-speed interconnectivity - 5G - with the interconnected ecosystem, at Rack Centre, every single mast in Nigeria is connected directly to them,
- Gargantuan data becomes big data.

Ayotunde also championed the role of technology in driving sustainability. The Covid era has seen us travel less, increasing our use of video conferencing, and using less fossil fuels. It is clear that the net impact of increasing our use of digital infrastructure has been resoundingly positive and we must continue to harness this.

Africa - set to de-risk global supply chains

There is a desire to de-risk global supply chains away from Asia to other parts of world. In doing so, we are going to see more digital supply chains move to Africa. With five of the major undersea cables linking every African country on the Atlantic coast, the infrastructure is in place to support this. Ayotunde predicts that we will see increased business process outsourcing move to Africa, with the continent acting as a digital anchor point as supply chains redistribute around the world. Yet he concluded, we will not build the world on data centres alone - there is more technology coming and we all need to be ready to embrace it.

Q&A

How ready are emerging markets, such as Nigeria and sub Saharan Africa, ready to embrace the Fourth Industrial Revolution?

Recent investments from companies such as Facebook and Google into Africa, committing to key cable landing points across continent, is a clear indicator of the likely digital infrastructure that is set to emerge in the next few years. Nigeria is an anchor point in the West, Kenya in the East, with Egypt and Morocco to the North and South Africa already a major player. The building blocks have been taking shape over the last five years and the demographics of sub-Saharan countries, with high proportion of population aged 19-22, means Africa is well placed to leapfrog other global players.

Governments often require data to be hosted locally. Is this a thing of past with cloud computing?

No, it is very much an issue of the present. Sovereign data rules need to be enforced. Nigerian data protection is modelled on the UK's GDPR. It all brings data closer to point of use albeit it can be less efficient. What we need is scalability to provide and support data requirements, with global cloud providers requiring a footprint across critical locations throughout Africa.

Mark Jolly asked a question of Ayotunde: I have heard that a Google search generates as much energy as boiling a kettle. Is this correct? Are we actually reducing CO_2 by going digital?

The impact of Covid has certainly reduced emissions. We have already seen a shift that has saved on carbon footprint and created a net benefit to the environment. Yes, data centres are power hungry, however the efficiency of data centres has increased over the years. At Rack Centre we are also looking at what power sources are used.

Closing remarks: Professor Helen Atkinson CBE, FREng, Pro-Vice-Chancellor - Aerospace, Transport, Manufacturing

This lecture has been a tour de force in pulling together Industry 4.0 and look towards 5.0. Ayotunde also succeeded in making the subject matter accessible to so many different audiences within the manufacturing world. The increasing rate at which change is happening is phenomenal, continually halving the phases of the industrial revolutions.

It is clear that we need to evolve quickly. This is something we have had to do as a result of the pandemic. Cranfield's manufacturing theme has been intimately involved in confronting key challenges of recent months, including the Ventilator Challenge and the research on natural protein-free surgical latex gloves. Across the board, digitalisation is a recurring theme, contributing to a vision that the future of manufacturing can be smart, clean and green.

Decarbonisation: opportunities for the manufacturing sector

11th National Manufacturing Debate (NMD)

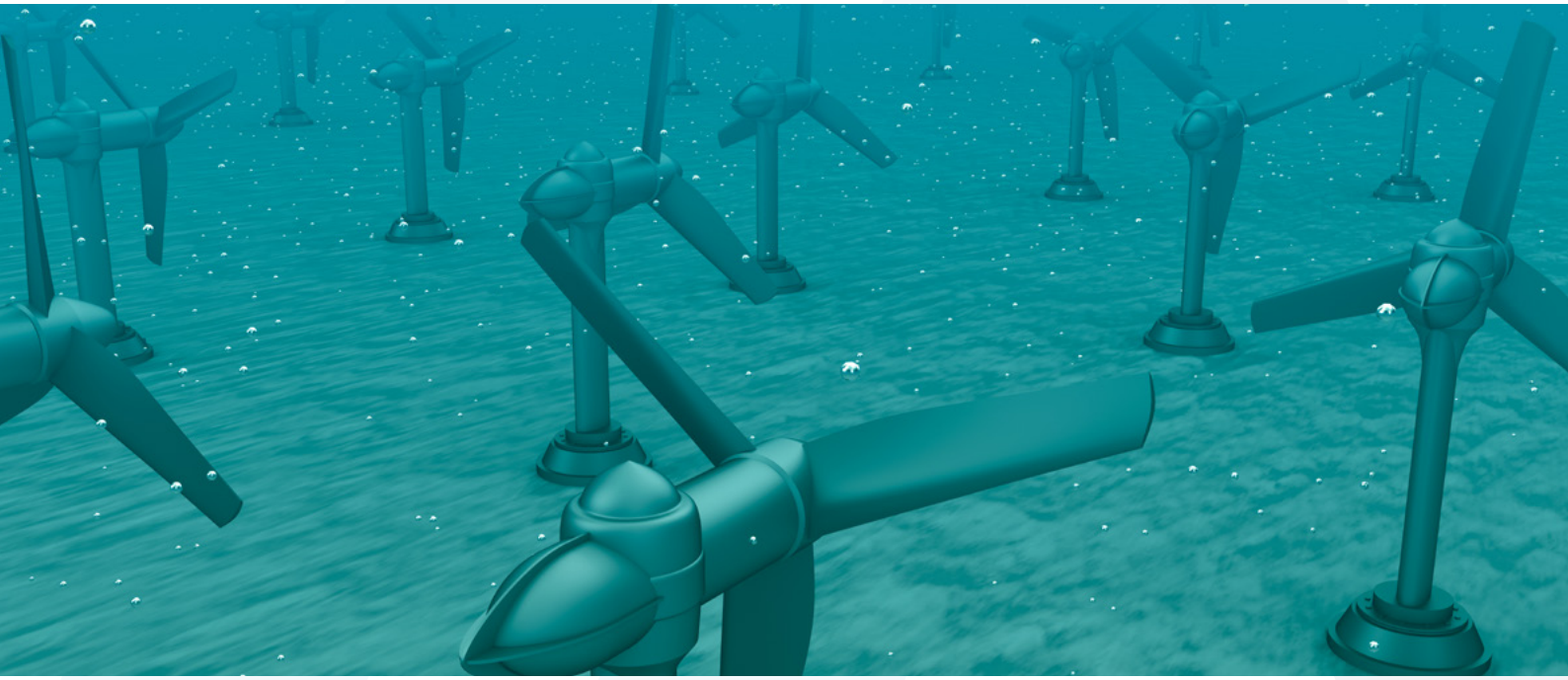
National Manufacturing Debate

Decarbonisation: opportunities for the manufacturing sector

Is British manufacturing ready to seize the net zero opportunities and is it really possible for decarbonisation to enhance the UK's competitiveness?

Who could have imagined that when we postponed this event back in the spring, that we would still have had to remain virtual in December? This, our eleventh year, was set to be bigger than ever before! However we have embraced the online format, with the week-long event allowing us to truly celebrate the work in the manufacturing and materials theme across Cranfield University.

Professor Mark Jolly
Director of Manufacturing,
Cranfield University



Introduction

Rosa Wilkinson
Communications Director,
High Value Manufacturing Catapult

Rosa Wilkinson is Communications Director at the UK's principle agent of industrial transformation, the High Value Manufacturing Catapult (HVMC). Rosa introduced the debate, proclaiming the National Manufacturing Debate as the centrepiece of this exciting week-long programme.

Despite the online format, it has attracted a strong audience from industry, academia, Government, and research organisations. The key features of the debate remain the same, with it focusing on the critical issue of decarbonisation, looking at the opportunities and challenges for the sector, and whether it can support UK competitiveness.

Rosa introduced a stellar cast of speakers who, following their presentations, answered questions posed by Rosa and the audience.

Dr Jason Jones
CEO and Co-founder, Hybrid Manufacturing Technologies

In joining the debate live from Texas, Jason proved the immediate value of the new virtual format. His focus is around driving decarbonisation within digital manufacturing with his presentation framed by something that first made him conscious of using resources wisely- a fridge magnet: Use it up, wear it out, make it do or do without.

We all use electricity and energy in various forms, and of the nine (or so) ways of generating energy, five are renewable. It is clear to all that a shift from coal to natural gas is environmentally friendly but the challenge is to make the social and economic elements work together as well. While coal is the least environmentally-friendly way of generating electricity, it remains the cheapest.

We now need to drive manufacturing by digital means - for example CNC and 3D printing - to open up huge possibilities. Additive manufacturing allows us to make unusual shapes that are otherwise impractical, enabling us to use multiple materials and creating less waste. Together with subtractive manufacturing, we create a hybrid manufacturing capability, including processes that allow us to add, subtract and inspect things.

Use it up, wear it out

Using the wisdom of a simple fridge magnet, we need to simply design and make things that last longer.

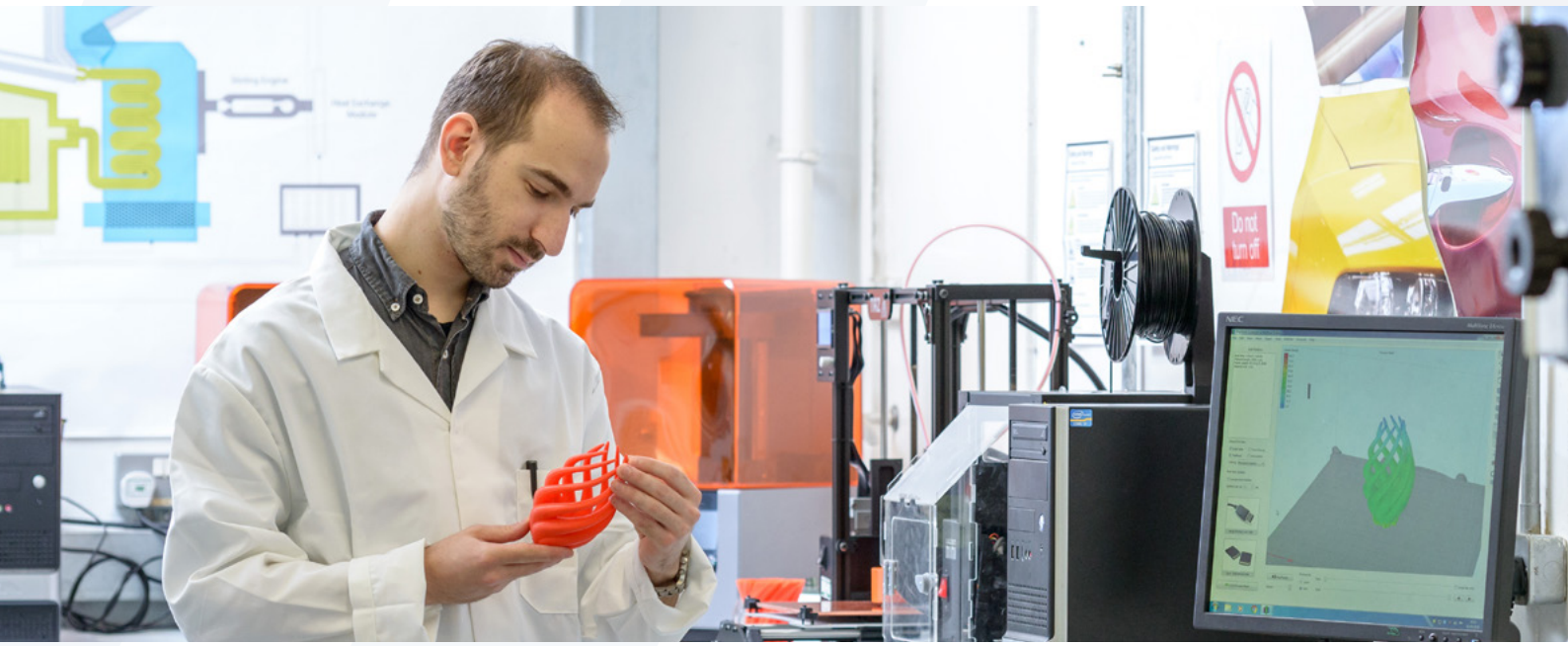
Make it do (more)

We use a fraction of the energy and materials when we rebuild and restore functionality - otherwise known as remanufacturing. Additive, subtractive and hybrid manufacturing allows us to do new things but also to leverage the capabilities we have. As an example, when repairing turbine blades, it is possible to both repair and make changes to the robot structure and efficiency of a turbine, enhancing the functionality and improving the output for each blade in the process. This resulted in an increased electricity output of 90 gigawatts per hour.

Or do without

Here the question is what can we do without? The answer: processes that consume tremendous amounts of energy. We should only heat locally where needed and use less materials. Through distributed manufacturing models we can reduce shipping and operate at much shorter scales. This can also help to avoid exporting environmental issues to less regulated regions and simply moving the problem elsewhere.

We need to take a step back and look at how we shape mindsets in the future. The mantra of the fridge magnet speaks to this - use less materials, less energy, focus on local manufacturing, and avoid exporting the environmental problems elsewhere. This is about longevity and energy conservation. We are looking for the triple win - for the environment, for society and for the economy. If people can be armed with the right information in order to spend their money wisely, they can be part of the decarbonisation solution.



While Jane's day job is focused on recycling and decarbonisation in the resilient flooring sector, the challenges and opportunities they face resonate across the entire manufacturing industry. Her presentation focused on two points: the importance of working with the entire value chain, and the need to look at the end of life of a product from the early design stage.

Jane Gardner
Managing Director, European Resilient Flooring Manufacturers Institute

Building and construction accounts for 40% of global CO_2 emissions as well as 40% of the energy consumption across Europe. Construction products, such as flooring, piping, windows and insulation, play a huge role in this. These products, many of them plastic, have a long life span of between 20 to 100 years. This longevity alone is a huge benefit, reducing the need for carbon intensive renovation.

However we need to look at the construction product value chain and examine all the factors contributing to decarbonisation. We cannot look at the manufacturing phase in isolation and must also consider logistics, distribution, building use, refurbishment, and ultimately, demolition. Within this value chain there are opportunities for decarbonisation - through the choice of raw materials, the processes we use, the disassembly design, logistics and backhaul. If we start with end of life in mind, we can consider the provision of secondary raw materials, allowing manufacturers to take back waste to ensure quality input of recycled materials into the next generation of products.

Using the distribution chain for backhauling waste is a prime example of how the resilient flooring industry is working to reduce carbon emissions. Jane shared how companies, Altro (based in Letchworth) and Polyflor (Manchester), have worked together since 2009 to collect post installation waste and uplifted flooring to increase the recycled content in their new products. They established drop off points at 57 distributors across UK, with the fitters able to drop off old flooring when picking up new products. The key success factors for this included collaboration, engagement of all the actors in the value chain, but also educating, incentivising, and rewarding the supply chain.

This example of backhauling is successfully diverting waste away from landfill and into new products. It saves waste management costs and in some cases can even make it cost neutral - backhauling materials in vehicles that would have previously returned empty. Reusing this material can have a huge impact, with Jane citing a hospital in Newcastle in which the recycled content in the vinyl flooring, rather than using 100% virgin material, saved 0.2kg of CO_2 per square metre. With more than 60,000 sqm of flooring provided, it has saved 12,000kg of CO_2 to date.

If we can start by looking at end of the product lifecycle, we will always be considering how we capture materials to use in the next product. To achieve this, as Jason explained in the presentation before, communication is key, with digitalisation and tracking becoming an essential part of the successful process.

Dr Colin Herron CBE
Managing Director,
Zero Carbon Futures

In considering how the unknown will impact on manufacturing, Covid-19 has been one of these massive unknowns and has had a huge impact on the industry this year. Using the example in the UK where some shops were allowed to open during the lockdowns, and others were not, he posed the question, how do we determine what is essential?

Colin also asked questions around how will behaviours change, pointing to the positive impact of David Attenborough's documentaries, on our impact on the environment, but also how will behaviours have to change, whether this be through taxation or through political will?

With a manufacturing career that has spanned 47 years, one which started in the shipyards on the River Tyne, Colin warned of repeating mistakes of the past. We cannot simply replace one product with another. With many Governments keen to pursue electric vehicles, we cannot ignore the issues that will remain. Of course emissions may drop but we will still require materials to build the cars, which will continue to create congestion on our roads. Seeing people using 3-4 litre vehicles for a quick trip to the supermarket, when clearly a 1 litre car would suffice, we shouldn't be wasting our resources based on ego or wealth. What might be great for an episode of Top Gear is not so for society as a whole.

There is also debate around electric vehicles and whether they will really result in zero emissions? While there is no tail pipe in the vehicle, what about the whole emission lifecycle? How do we understand what zero emissions actually mean? Surely this should be more an aspiration to use minimum carbon, rather than zero?

Colin shared his personal pet hate that the Earth's resources are being used in seemingly unnecessary products, including patio heaters and above door heaters. Surely a warm jumper would suffice? On to petrol leaf blowers where a Google search brings up hundreds of fuel-guzzling garden contraptions - why not use a broom? The question is, should we be allowed to make these products? Back to the issue of lockdown shopping, whatever is determined essential is certain to drive the political landscape

Colin reflected on his time at Nissan. When he joined the business, output was measured in Quality, Cost, and Delivery (QCD). This moved to EQCD (adding Environment up front), but has gone even further to become E2QCD; the squared (second) E stands for Ethics, something he feels our industry has not done so well to date. In addition to decarbonisation, we must also consider the ethics around manufacturing - when we see images of children mining for gold in Africa, surely we must also look at the ethical impact of our carbon footprint.

Dr Nazmiye Ozkan
Senior Lecturer in Energy Economics and Head of Centre for Energy Systems and Strategy, Cranfield University

In this increasingly complex world we need to understand how to manage the energy transition. Nazmiye reflected on a conversation a few years ago with a banker about the subject of energy efficiency. Unlike food or health and safety where corrective reactions to issues are immediate, anything with the words 'energy efficiency' are invariably dismissed by the Board if they require more than a one-year payback. This simply must change, not least because the cost of energy is certain to increase due to the increase in use of renewables required to decarbonise the power system.

Nazimye explained where she sees the opportunities to respond and take action - and where this is already happening:

1. The UK Government's focus on creating industrial clusters (Teeside, Merseyside, Humberside, Southampton, South Wales, Grangemouth) helps to create a better resource efficiency, with cost effective infrastructure being developed (hydrogen or carbon capture) and help for facilities to deal with the uncertainties in market conditions.
2. Linked to this, we can look at Local Energy Systems, using excess waste, heat and onsite generation (solar and wind) to serve local communities. Delivering great economic value, this is also ethically sound, supporting and engaging with the local communities.
3. There is a move from a Single Supplier Hub to a Multi-Gub energy market, with hydrogen set to play key role in meeting industrial energy demand. Traditionally any end user has an agreement with a supplier but in the future, we will see complex, multi-vector, energy systems, operated by separate stakeholders, including prosumers, engaging with different actors to purchase energy needs. We are already seeing large industrial users, such as Tesco and Sainsbury's making agreements with National Grid to shift energy use to out-of-hours.

Echoing the sentiments of her fellow speakers, Nazimye believes digitisation will play a key role in enabling us to address energy challenges. Data can predict onsite variable generation, taking part in demand side response, optimising the process, and helping to deliver real-time actions in response to market conditions.

Ben Peace
Head of Manufacturing, KTN

This is a period of incredible change across industry and society as a whole. It provides the golden opportunity to make changes to our industry in order to build back better.

We know that manufacturing accounts for between 20-30% of emissions and this requires us to ask some tough questions of ourselves. Here in the UK our strengths lie in specific areas, including design, the customer journey, business models, and digital technology. KTN itself has recently launched their new brand and are looking at things differently. They have refocused from a purely economic bottom line to addressing how we effect positive societal change. This has become the biggest driver of innovation.

Ben's background lies in arts and engineering....and a love of cars! He sees the car as the perfect synthesis of arts and engineering, and this inspired his career in product design. Ben was even part of the Loughborough University spinout that developed the first fuel cell motorbike, with the industry recognising this as a major breakthrough. Time magazine recognised it as the Invention of the Year as well as the World Trade Organisation identifying the company as a tech pioneer.

Against the backdrop of Brexit, the declaration of a climate emergency by 33 nations across the world, Covid-19, and lockdown(s), the Government announced its ten point plan for a green industrial revolution in November 2020. This opens up the need to ask some hard questions of ourselves, including:

- What kind of fourth industrial revolution do we want?
- Are we making the right things?
- Do we want to work long hours?
- What are we really good at?
- Is a hydrogen economy going to work?
- Is technology the answer?
- What can we learn from past?
- How do we compete globally?

The circular economy is a clear enabler of net zero. We must not lose sight of innovation and implementation and what to do with materials at the end of life. Following Jason's remarks around additive manufacturing, Ben sees remanufacturing as a major route forward. We need to make and design products that retain the value invested in them.

Ben's role at KTN is to look at how we develop the next wave of technology to put the UK at the forefront of manufacturing and establish what Industry 4 actually means for the UK. Made Smarter is a UK movement focused on digital transformation. Part of the Made Smarter agenda is around reducing emissions through supply chains. Over the next four and a half years, Made Smarter will seek to stimulate innovation, joining everything together through research and development competitions, innovation and research hubs - with the aim to make better products using better processes. Joining this up with other Clean Growth Industrial Challenge Funds, and networks including the Circular Plastics Network and Industrial Strategy Challenge Fund this is an investment of more than £1billion in the next few years. Only by bringing together this range of diverse connections can we drive positive change.

Debate: Is British manufacturing ready to seize the net zero opportunities, and is it really possible for decarbonisation to enhance the UK's competitiveness?

Rosa introduced the debate looking at the themes of the presentations; involving the whole supply chain, managing the energy transition, the importance of digital technology to address challenges, but crucially around changing mindsets and making fundamental behavioural changes.

Rosa: Is British manufacturing ready to seize the net zero opportunity and go beyond easy wins? If it is, will this enhance our competitiveness?

Colin Herron - Colin picked up on Rosa's use of the word British. In some regions such as the North East, very few truly British companies remain. Many are satellite companies producing products at unit prices in direct competition with other companies overseas. The cost of decarbonising will reduce this unit price competitiveness and therefore the industry and the policy makers need to understand and support how it will work.

Jane Gardner - As a nation of innovative entrepreneurs, this will help us deal with change. However in the end the issues are centred around the upfront investment and unit costs. Post-Brexit, British manufacturers selling overseas will face some huge challenges and we cannot ignore this fact. Instead we must use this as an opportunity to investigate if we can decarbonise and innovate and still maintain a competitive advantage. There may be ways of doing this that don't require upfront investment or could the Government provide support?

Ben Peace - At KTN we are seeing a whole spectrum of responses and solutions; blockchain to monitor impact through supply chains, additive and hybrid manufacturing. Some companies are really taking the initiative and using technology to innovate. There has been considerable investment to support innovative companies but what about those who don't know where to start and are not yet ready. We need to see support for both ends of the spectrum.

Nasmiye Ozkan - In some ways we are ready to embrace the future, but we do not yet fully understand the challenge. Digital technology will increase competitiveness. As Ben explained, some companies are embracing digitisation more than others. If we are serious about becoming net zero, there needs to be big step change. Yet there is also little incentive for some companies to do so - we need traceability of emissions and carbon impact for many to take it seriously.

Jason Jones - I don't know anyone who doesn't want to take care of our beautiful world. Some simply lack the knowledge, inspiration, and hope. Decarbonisation will make us more competitive. Small businesses are working with limited time, money, and energy. By using less energy it will be good for society, the environment, and for the economy.

People working in plastics manufacturing have an emotional commitment to support decarbonisation, but on the other hand are faced with demand for product. How can a manufacturer disentangle this and balance competing demands?

Jason Jones - We need a holistic solution. It is not genuine to say we are carbon neutral if we simply farm it out to another country or company. We need to be more creative to get lifetime values, recovering materials and putting these back into the supply chain.

Colin Herron - What is now a problem used to be seen as an asset. Using the example of fresh vegetables wrapped in plastic, this was never seen as a problem before, but now is. Let's give the engineers the challenge and empower them to solve the problem. With that, behaviours will also change.

Rosa Wilkinson - Another challenge is the impact downstream. What happens if we make the shift to electric vehicles or better yet, use fewer vehicles, to local vehicle maintenance services and others in this supply chain. We will be taking away the key building blocks of income.

Colin Herron - This is a problem and also one around the advent of autonomous vehicles. What will happen to the 200,000 taxi drivers in the UK? Society itself has created these problems. As we speak, there are factories in Bangladesh employing thousands of people making clothes we are now being told not to buy. We cannot simply shut off the supply of products as this will result in global poverty. The Government has to transition people away from products.

To this point, Rosa raisees the issue of the skills agenda, asking Ben about re-skilling to help their people and supply chains?

Ben Peace - Support is patchy at the moment. The Government want to put more into the skills agenda with Made Smarter. Some businesses will need to make wholesale changes to what they do, whereas some regions can make different things, redeploying elsewhere, and that will require new skills. Ultimately we need investment to stimulate this.

Jane Gardner - Looking across Europe there is a recognition that there will be a need for re-skilling if the transition to lower carbon production removes some roles. Jane sees this as an opportunity to provide more jobs, with the EU positive about re-skilling, with the green deal pledging to provide more green jobs in different sectors. In some ways it has always been like this - we don't know today what type of jobs our children will have in the future. It was the same for our parents.

Nasmiye Ozkan - Data and digitisation will play a big role in the future. At Cranfield we are developing an MSc qualification on digitising and embedding data into manufacturing. We need to up-skill those people at key points in their careers as well as training the next generation of engineers, academics, and policy makers. We need to look at climate change from multiple perspectives including behavioural change.

Colin Herron - We need to understand the difference between academics versus skills, something I feel the UK Government has struggled with to date. A technician in Teeside wanting to learn new skills will find it very hard to get on a course, whereas the Government investment has been going to University research and classing this as skills. This is not right and needs to be reviewed.

Rosa agreed that we need a base level of core skills today and also for future challenges. We need to support all levels new skills across manufacturing - not just at a high level.

Jason Jones - Individuals feel threatened but we must remember the quote, "Great causes are not won in a single generation." We are now looking ahead to 2050/2060. If we spend a generation preparing the next generation, it will not be quite as scary. This is a migration rather than simply saying you'll be out of work tomorrow!

Rosa asked what else should the Government be doing? Should each company be regulated to deliver a statement on their carbon footprint?

Jason Jones - Digital now provides many opportunities to make measurements - whether this is our heart rate or number of steps. Manufacturing is the same; in the next decade the burden to report carbon footprint won't actually be a burden - we will already be doing it.

Rosa is sceptical of this. Her family business, an industrial estate in Doncaster, sees very few companies using digital technology.

Colin Herron - Every project has to go through the Treasury using antiquated measurements of GVA and ROI. How do you measure investment in skills and people against green credentials? The Government has to reassess how it measures investment and this will help make projects with longer term returns more successful.

Rosa reflected on the Spending Review and how the Government is making changes to the way they measure. Are there other ways for Governments to drive decarbonisation?

Colin Herron - The industry responds to money. If we start carbon taxation, people will have to take notice!

Jane Gardner - Our members are pretty advanced in their attitudes and have been looking at resource efficiency for more than 20 years now. They take every opportunity for funding from Government, seeking to reduce the carbon impact and looking at product end of life. The whole industry is already working together and there is no longer a competitive edge to being ahead in sustainability. The Government needs to set up grants in areas such as Doncaster so that forward thinking is encouraged.

Rosa Wilkinson - How can SMEs invest in expensive green solutions? Naturally, we choose the most cost-efficient solutions.

Colin Herron - There are a range of local programmes to help industry in the North East improve performance. The reality is that many SMEs were wiped out a few years ago. The challenge is this: our parents used to save up over a long period of time to buy white goods. Now we get used to the product price coming down so much that it is not repairable, nor recyclable. Is the answer to reverse this and go back to creating higher value and higher specification products that will last longer? SMEs can survive if their products are based on high levels of service and higher value. Otherwise they cannot compete in the global market.

Rosa posed the same question to Ben, who works with many SMEs. "What might help? Tax as a stick, or the carrot as a grant?"

Ben Peace - In the not so distant past, the Government set up a Green Investment Bank - this was sold off after three years. Rishi Sunak has now announced a new similar initiative for the infrastructure sector. We need something between grants and tax to encourage adoption of existing technology. Businesses don't know what is cost-effective. Just last month Chris Stark spoke of how decarbonising is now cheaper than it was at this time last year. Businesses need support to know where to invest. Yes, they must invest in R&D, but Government must also help them to adapt by investing in support and forms of finance like the Green Investment Bank.

Rosa saw this as reassuring and crucial level of support for smaller businesses.

Closing remarks

In this debate we have covered fascinating ground in the challenge to help businesses begin their decarbonisation journey. There are some huge issues to address: where should companies invest, are they able to access the right technology and skills? There are also some difficult questions to consider around what decarbonisation means downstream in our supply chains.

We must remember that there is no quick fix, that this is something that needs to happen over generations. However there is recognition of the existential threat to future generations if we don't start to decarbonise now. If we look at how the manufacturing community came together to support the efforts against the pandemic, building 20 years of ventilators in just 12 weeks, this shows that with a clear aim and the right support, we can make a difference.

Manufacturing data: The 4IR green data challenge

John Patsavellas
Senior Lecturer in Manufacturing Management, Cranfield University

This year as part of the National Manufacturing Debate, our manufacturing master's students and the academics at Cranfield, have looked at the manufacturing data coming out of the fourth industrial revolution and its green and energy issues. The size of the prize in terms of digitalising the industry is huge. Back in 2016, German colleagues estimated that digitising industry would open up an additional cumulative value of €425 billion in Germany alone, increasing productivity by up to 30%. In the UK's Made Smarter Review in 2017 a similar number was quoted of £455 billion in the next decade. By connecting machines and infrastructure with the control systems and planning methods in factories, manufacturing and its efficiency will be transformed. It will become more flexible and responsive while driving down the use of materials and energy.

Yet at every level during the fourth revolution we need data. This data enables us to see what is happening in our own environment, increasing the visibility and transparency in a way that has never been possible. This enables the prediction of events, of demand, being able to match supply to demand and being able to respond to disturbances. This data takes us towards the creation of a self-optimising manufacturing system where automated responses could match to prevailing conditions in demand in production.

Data is crucial for the fourth industrial revolution - with the whole revolution itself based on sensors which generate data. That data, in large amounts, can lead to techniques such as artificial intelligence, reaching higher levels of maturity for predictability and autonomous responsiveness.

Increasingly affordable sensors coupled with this milestone of producing one trillion semiconductors per year globally, are the data-enablers of the fourth industrial revolution.

Through the digital transformation in manufacturing using industrial Internet of Things sensors, this data is only set to grow. Connected devices will increase exponentially over the next few years. The statistics are rather mind blowing, 90% of all data was created in the last two years - that's two and a half quintillion bytes every day. It must be remembered though that data is not free in energy terms. The estimated 10-year energy needs for 1GB of data is 2.66 kWhr to generate, transmit, store and also retransmit the data. With over 60% of electricity still generated by fossil fuels, John estimates that 1 kWhr of electrical energy emits around 544g CO_2. Therefore just 1GB of industrial data over a 10-year period would require almost 1.5kg CO_2. Looking at the adoption of industrial robots over the next few years, the team at Cranfield has calculated that for their way-finding sensors and cameras alone, these robots will generate around 200 million tonnes of CO_2 (with the pessimistic scenario more than double!).

In answer to this major concern, John and his master's students propose that green data is needed to support the fourth industrial revolution. With some of the larger cloud computing companies already moving toward this, John proposes value criteria to verify data as green, with one potential answer, the development of a green data assurance and certification scheme, that would include the following key points:

- Minimum data and maximum compression - the minimum possible amount of valuable data transmitted and stored with the maximum amount of compression along the whole lifecycle,
- Data from clean energy sources,
- Energy efficient hardware.

In this way, data can then be seen as an aid to achieving net zero and not an obstacle.

Nuclear manufacturing and net zero

Andrew Storer
Chief Executive Officer,
Nuclear AMRC

In the next 30 years, energy demand is set to increase. While nuclear isn't the only source, it has an important role to play in this journey. Many of the large reactors we have today are due to be decommissioned around 2030-2035 and so we not only need to grow our energy, we also need to replace those reactors.

In the UK we have the SMR Consortium led by Rolls-Royce. So far, the Government has sponsored £18 million, with the companies matching this to reach £36 million in total. The consortium is seeking to build 16 power stations which will generate the amount of electricity required to replace the reactors that will be decommissioned over the next decade. With the potential to create more than 40,000 jobs, it can also be exported overseas.

The opportunity for UK manufacturers is global. There is a worldwide demand for clean energy and if the UK supply chain moves fast enough, we can hold a global position for deploying nuclear reactors. The UKAEA is working closely with developers around fusion technology and the development of the Fusion Step Reactor. Companies such as Tokamak Energy, are developing methods for deploying a fusion reactor. The aim is to connect to the grid around 2040.

As well as SMR and fusion, we also have generation four advanced reactors being developed by companies such as Westinghouse and U-Battery. This would really start to increase the UK's competitiveness in an export market.

Nuclear AMRC's role is to disrupt the market and promote change. Andy shares a recent project to create heat exchangers for a nuclear pressurised reactor for Hinckley Point. In simple terms the product cost was prohibitively high and there was a risk that the company wouldn't win the order and that the contract would go overseas. Through the Nuclear AMRC, and in partnership with Rolls-Royce, 80% of the cost was taken out of the assembly process, enabling EDF and Rolls-Royce to reach an agreement on the contract, ensuring it remained in the UK.

The manufacturing process must also be considered when looking at the creation of clean energy. The Nuclear AMRC is currently manufacturing a reactor pressure vessel for a small module reactor, which is two-thirds the size of the normal vessel. Using the normal manufacturing process, 1,800kg CO_2 is produced during the manufacturing process. However the team is using a range of methods, from Electron Bean Welding to CO_2 machining, to reduce the energy consumption.

The UK has the capability but we struggle with our capacity, the scale of manufacturing, the size of buildings, and the machines that forge, to deliver gigawatt-scale reactors. Given the fact that we aren't talking about a huge volume of products, there is little incentive for businesses to invest in increased capability and capacity. However if we look at small modular reactors it's a different story. The capacity is different and we have facilities in the UK that could hold reactor pressure vessel internals.

The UK has a quicker readiness for smaller reactors if the volume is there and has encouraged investment from the supply chain. All the advanced methods that are being developed in manufacturing can be put into a smaller reactor plant that is not yet even at final design stage. While larger reactors are already designed, for the smaller reactors we are yet to determine that method and so this offers a massive opportunities for the UK supply chain.

In conclusion, while there are capacity challenges, the UK can manufacture small reactors. This will require investment through the supply chain and timing will be key; to develop the reactors against the timescale, to achieve net zero targets and to enable export opportunity. The infrastructure and innovation is already there but we need to work better and smarter towards a shared objective.

Last year 23 companies, eight Formula One teams and 30 suppliers came together for the Ventilator Challenge, producing 20 years of ventilators in just 12 weeks to fight Covid-19. This proves we can work together and overcome seemingly unbelievable challenges. Covid has proven that we have weaknesses in some of our supply chains and we need to strengthen these in the nuclear supply chain. We need to work better, with clear policies from Government that provide confidence to the supply chain. The supply chain must also invest and will do if there is a programme of work. We need a co-ordinated, almost wartime, approach like we achieved with the Ventilator Challenge, to ensure that we deliver on our mission, for us today, but also for our children and grandchildren.

Manufacturing 2075

Post Covid-19 paradigms in manufacturing of material

Manufacturing 2075

Post Covid-19 paradigms in manufacturing of materials

Welcome and introduction

This year's Manufacturing 2075 event was centred on post Covid-19 paradigms in manufacturing and materials. Welcoming a broad audience of senior business decision makers, academics, members of the industry, and Government, Krzysztof set the challenge for the day: to analyse manufacturing resilience and consider strategies to support our future.

Professor Krzysztof Koziol
Head of Enhanced Composites and Structures Centre, Cranfield University

We have learnt many lessons over the past ten months. Covid has made us stop and think about the materials we use and the products we manufacture. How can what we have learned over the past year help us to prepare for future disruptions?

Krzysztof touched briefly on his own experiences. During the pandemic, we saw an increase of 115 million in the requirement for surgical rubber gloves, presenting both a massive manufacturing challenge and creating a major environmental impact. Synthetic rubber takes over a 100 years to biodegrade and with the equivalent of 25 Empire State buildings filled with gloves used this year alone, Krzysztof and his students have been working with Malaysian company, Meditech Gloves, to create a long-term solution using natural rubber.

It is clear that in this post Covid-19 paradigm shift, healthcare will be a major beneficiary. Covid has presented opportunities for the rubber industry far beyond gloves. To make manufacturing more resilient and able to prepare for the future, we must look at the entire supply chain and create a centralised approach.

Keynote presentations

Professor Oliver Pearce
Consultant Orthopaedic Surgeon,
Milton Keynes University Hospital

In his presentation, Oliver presented the challenge of surface infections in medical implants. In the UK we complete 200,000 hip and knee replacements per year, with ten times this completed in the United States. There is an infection rate of 1%, meaning that in the UK we have to deal with 2,000 infections per year at a cost of between £20,000-£100,000 each to successfully treat. This presents an annual bill of between £40-£200 million!

While acute infections are relatively easy to diagnose, chronic or late infections are not as straight forward. Investigations to diagnose infections range from blood tests, X-rays, scans, fluid aspirations and laboratory tests. The treatments also differ depending on early or late infections of the prostheses. Early diagnosis (up to three months) seeks to preserve the prosthesis, washing out the wound and treating with IV antibiotics for up to six months. As you might expect, late presenting infections require more invasive treatment, with two stages of revisions, including an operation to remove the metal and infected tissue, and a second to re-implant the prosthesis.

It is very difficult to eradicate prosthetic infection. Bacteria on prostheses are able to defend themselves from antibiotics and the immune system. The bacteria is a biofilm that acts as a mechanical barrier to antibiotics. If the biofilm is well established, washing out the wound simply won't work.

What has this got to do with materials and manufacturing we may ask? Oliver worked with Cranfield University on an article in the Applied Physics journal on the bactericidal (kills bacteria) effects of nature - in this case a dragonfly's wing - and how we can apply these in medical treatments. The dragonfly wing, due to its surface nanopillars, is actually harmful to any bacteria it comes into contact with.

Orthopaedic nirvana

A material surface that can actually kill bacteria and stop infections - this is simply brilliant and as Oliver exclaims, "Orthopaedic nirvana!". The question is, how can we create biomimetic surfaces, those which mimic those found in nature, for our purposes here?

There are examples of super hydrophobicity (repels water, in this context preventing bacterial adhesion) in the lotus and taro leaf as well as the butterfly wing. Shark skin has antibiofouling (prevents adhesion) properties. It is not just in the organic world that we see materials with bactericidal properties. Copper and silver chemically are chemically bactericidal and can (and has) be used to coat prostheses.

On these surfaces bacterial movement results in the membrane tearing, with nanopillar heights and diameter determining whether a surface is more or less bactericidal. Bacteria is generally negatively charged and if the surface is also negatively charged, repulsion will be dominant - meaning that the more positively charged the bacteria, the more bactericidal the substrate is.

There are two types of bacteria: Gram positive and Gram negative. The former has a thicker cell wall than the latter. Therefore they exhibit different properties in response to different surface topgraphies and we may require different designs to treat different types of bacteria.

Oliver's vision for prosthetic surface topography in broad principles focus on not changing the material of the implant (cobalt chrome, titanium, stainless Steel) as these are well proven, long lasting, and bio-inert. Instead we should look at changing the surface topography of these material to be bactericidal through additive or subtractive methods.

Oliver concluded with a call to arms to the engineering community. "You are the high precision engineers and chemists. This is a scientific challenge and we, the doctors and our patients, will benefit from your help."

The UK has a quicker readiness for smaller reactors if the volume is there and this encourages investment from the supply chain. All the advanced methods that are being developed in manufacturing can be put into a smaller reactor plant that is not yet even at final design stage. While larger reactors are already designed, for the smaller reactors we are yet to determine that method and so this offers massive opportunities for the UK supply chain.

In conclusion, while there are capacity challenges, the UK can manufacture small reactors. This will require investment through the supply chain and timing will be key; to develop the reactors against the timescale, to achieve net zero targets and to enable export opportunities. The infrastructure and innovation is all there already but we need to work better and smarter, towards a shared objective.

Dr Iva Chianella
Senior Lecturer in Advanced Functional Polymers, Cranfield University

Point of care diagnostics are put simply, tests carried out via portable devices or simple kits at home or in a clinic. They do not require us to send patient tests to a laboratory. Iva's presentation focused on point-of-care diagnostics, their material requirements and the future trends.

By analysing disease biomarkers, these tests can support the detection of disease including cancer, as well as infectious outbreaks. These technologies also allow us to develop personalised care, with the quantification of disease biomarkers helping to set drug levels as well as enabling patients to self-monitor and manage a disease, resulting in an improved quality of life.

These point of care diagnostic tests need to be inexpensive and quick, easy for the patient to use and as sensitive and specific as a lab test, giving quantitative results. They also must be reliable, have a long shelf life and critically, be profitable for the companies who manufacture them.

The majority of the point of care diagnostic market share is currently covered by a bio-sensor glucose meter for diabetes. Others include pregnancy and fertility tests, as well as tests for malaria, HIV, cholesterol and as we have seen recently, the antibody test for Covid-19. These rapid diagnostic tests rely on antibodies. Cheap, quick, disposable and easy to use, however there are also high incidences of false positive and negative and by simply giving qualitative data, it does not allow personalised care or chronic disease management.

Iva's work is considering alternative support materials to determine the content or quality of a material. Can we replace antibodies with more robust receptors eg. aptamers, to reduce false positives and negatives? Can we use other materials, novel nanomaterials (quantum dots) for example, to generate a signal and biosensors to offer a simple read out system?

Bio-sensors are currently well used in clinical applications, environment, security and food. It is a device or a test which can be used to detect the presence or concentration of a biological analyte, such as a biomolecule, a biological structure or a microorganism. Bio-sensors consist of three parts: a component that recognises the analyte and produces a signal (enzymes, antibiotics, synthetic receptors), a signal transducer (electrochemical, optical for example), and a reader device (smartphone).

The glucose meter has been the most successful point of care diagnostic test developed to date. Using a simple low cost strip and a cost effective, portable reader, the test reacts with glucose presence in blood - a catalytic reaction using a strong robust enzyme generating an electrochemical signal. As there is a high concentration of glucose in the blood, the sensor doesn't need to be highly sensitive and the test is generally accurate - as such it is a highly profitable for pharmaceutical manufacturers.

What can materials do to create similar bio-sensor devices for other analytes? Biomarkers for cancer are present in smaller amounts in the body. Nanomaterials (such as metal nanoparticles or graphene) could be used to increase the sensor surface area. For cancer diagnostics we would need to quantify a group of biomarkers using a novel transducer such as photonics crystals or optical fibres. Put simply, for it to work and be worth producing, the novel material must be low cost, robust, and suitable for mass production.

In conclusion Iva considered future trends. Even prior to Covid there was a marked increase in the development of point-of-care devices. Now we are seeing an even steeper curve to create more. Yet developing these devices is not just a challenge for material scientists. We need to work with the biologists, chemists, and computing experts - it must be based on the collaboration of multiple skill sets.

In 2018 Gatwick Airport was awarded the title of 'Most Innovative Airport in Europe'. Abhi started off his presentation sharing the scary newspaper headlines we have become accustomed to over the past few months. However he then pointed out that in fact these headlines were not from 2020, rather the 2017 winter season.

Abhi Chacko
Head of Innovation and Commercial IT Services, Gatwick Airport Ltd

Over the last year, the effects of Covid-19 have been unprecedented. We have suffered from two distinctive waves, the first being one of the most devastating. As we reach the end of our second national lockdown, we must start to take personal responsibility to improve our health and immunity because, though life has changed, air travel will return and we must work together to keep a balanced perspective to restore confidence in passengers who use our services.

It is hoped that the Government will begin to ease travel restrictions, so as an innovative airport, Gatwick has been preparing for the reopening of the airport.

Airports are centred around three things: passengers, bags and planes. Across all three areas, Gatwick is looking to the future:

- **For passengers:** Robotic car parking, autonomous bus/buggy, far-UVC light for disinfection, biometric journeys, and security screening to ensure passenger safety and comfort.
- **For bags:** Cabin bag screening using AI, UV tunnels to disinfect security rays, autonomous bag transfer, as well as digital lost and found.
- **For planes:** AI enabled aircraft turn, autonomous jet bridges, electric aircrafts, and foreign object debris detection - this is just the start.

Dr Abigail Hird
Knowledge Transfer Manager,
Manufacturing, KTN

In her presentation, titled 'Back to the future' Abigail used the popular Hollywood film trilogy to remind us that the past, present and future are wholly interconnected.

"Who controls the past controls the future; who controls the present controls the past."
George Orwell, 1984

Abigail started by questioning the notion that technology is the basis for the industrial revolutions we have seen over the past few centuries. Up until 1800, productivity and population were stable, with people living in a state of constancy. The shift came with war and the need to generate money to fund these endeavours overseas. Here in the UK we had access to coal and a massive labour pool, giving us a sense of control over the world around us. The mechanisation of processes created cumulative innovation. During the second industrial revolution we built the infrastructure to support building trade with the Far East, moving away from subsistence living, towards increased consumerism and alongside this, a massive population explosion. The third revolution saw automation, and the creation of intelligent connected learning systems - one of the major drivers of this being the space race.

Looking over the past year, we saw high energy costs and low unemployment - quite the opposite of the first revolution. So was technology the primary driver? Have there been multiple industrial revolutions - or is there just the one industrial revolution, one that we are still experiencing and living through today?

With 2020 having been a 'cracker of a year', with a global pandemic, political instability, climate change, and much fake news, what might the future look like if we look ahead to 2075? Clean, low-cost energy, and diminishing raw materials?

Perhaps we need to go back in order to progress forward. Could we earn and spend less? Should we adopt older models of industry? This is maybe a romantic aspiration but consider this: local manufacturing, shorter supply chains, lower volume production, smaller firms, more focus on material lifecycles, design for disassembly and reuse, greater automation, flexible employment models - this all sounds rather positive!

Abigail concluded with her thoughts on how we can prepare for the future:

- Don't overplay role of technology as driver of change.
- Develop skills for dealing with uncertainty.
- Re-conceptualise material lifecycles.
- Seek out views and perspectives that are different to our own.

Q&A

The pandemic has had a great impact on our lives, economy and society. What lessons can we learn from antibacterial surfaces that are transferable to virology?

Oliver Pearce - There are not many antibiotic surfaces in clinical use presently. The biggest one is silver coating. For example, in treating bone tumours we have to remove entire bone and replace with metal. The infections rates for this are close to 14%! Silver coating implants are now being used and this has reduced infections to 8%. However silver does not incorporate well into bone, so infection is reduced at the expense of bone incorporation. It can also be toxic to the liver and kidneys. Changing the surface may help one area but hinder another and cause unintended consequences.

How will you balance profitability with future needs of recycling materials? How do we tackle the increase in disposable plastics?

Iva Chianella - In order to be profitable there needs to be a disposable part of test or device. In the case of the glucose meter, for example, patients need to replace strips each time. In the future we need to look at biodegradable plastic. Material engineers can address issues and look to replace non-biodegradable with biodegradable material. However we haven't reached the next stage yet.

What type of policies/laws/support do we need from UK and overseas Governments to be more prepared in potential future events like another pandemic?

Abhi Chacko - Governments need to be prepared to deal with these situations in the future. The pandemic has seen a balance between keeping the economy open and managing hospital capacity. There will be more pandemics and lockdowns and so this balance needs to be addressed carefully. In terms of travel, I would encourage some sort of revenue recovery/tax in normal times which can support the industry through pandemics especially when it is the Government imposing restrictions. In the good times we are going to see more low-cost carriers launch, and yet with the slightest disturbance they fail. We need to create some balance.

We have to care for the future for the sake of our children, but how does this affect innovation?

Abigail Hird - Engineers love technology and sometimes we can be single-minded about its development. However we can't develop technology at the exclusion of the wider environment and market. We cannot assume that technology is the answer on its own.

Workshop outcomes - briefings by session facilitators

Technology and skills development of future role models
Dr Mohammed Afy-shararah, Cranfield University

This group looked at the factors that might impact manufacturing and materials as we look towards 2075. They identified the need for technology to improve our capability to reclaim precious materials, and to accelerate hybrid and additive manufacturing. A major concern was the growing cost of energy and power, with the workshop members looking to how the circular economy could be applied effectively.

On the skills required, the group focused on systems thinking and digital intelligence, but also recognised the need for these to work alongside softer skills to encourage communication and greater collaboration.

When asked how we can foster and encourage the development of skills, there was a diverse range of votes as to the most important factor. This ranged from collaboration, to a focus on STEM teaching in our schools, to encouraging technologists to meet across organisational and sector boundaries.

Manufacturing resilience to adverse perturbances
Dr Claudiu Giusca, Cranfield University

In this workshop the group considered how manufacturing resilience will be challenged in future. A current topic, they looked at the demand on NHS and how best to control supply chains moving forward. Should this be centralised or use localised smaller suppliers across the country? In general terms they identified that the biggest challenges are around collaboration within supply chains as well as needing to encourage young people to choose manufacturing as a career path.

They went on to consider which of these would have the most impact on the three areas companies look at in terms of risk: finance, supply and demand and their people.

- Demand for NHS - we need to increase the local availability of PPE, using smaller suppliers and localised supply chains. AI should also be utilised more in healthcare.
- Collaboration through the supply chain - agreed a similar focus to the ways in which we can deal with the demands on the NHS, alongside the use of on-demand systems by smaller local suppliers
- Encouraging young people into manufacturing - since the 1970s manufacturing has been seen as blue collar work but this is not the case anymore. Machining and materials have developed and we need to focus on continuing to change the image of the sector from blue to white coats.

Design of compliant long-life implants for minimum post-op intervention
Professor Oliver Pearce, Milton Keynes University Hospital

In this workshop Oliver set a challenge to solve the problems of infection in prostheses. While under no illusion this problem would be solved in a short workshop, the group did identify some high level thoughts on how this could be tackled.

They examined ways of finding the infection, not just passively but also being more active. For example a reactive detector on the surface of the prostheses to assess PH levels; whereby the surface releases a nano chemical when it becomes acidic. It will be toxic to bacteria but not to the organism.

They considered whether this should take the form of an antibiotic or nanoparticles, for example copper or silver, used to kill bacteria but not harm the patient. These could be structures that contain chemicals that can be naturally excreted by kidneys or detoxified by liver.

Concluding remarks

Professor Krzysztof Koziol, Head of Enhanced Composites and Structures Centre, Cranfield University

It is abundantly clear that this pandemic has been a disaster for people's lives and livelihoods. However we have to consider it a wakeup call to stop and think how we prepare for the future. It is a statistical certainty that this type of event will happen again.

Yet we must not allow whatever comes next to take us by surprise again. We must be prepared. As Oliver referenced, we must design materials better to make them more multifunctional and responsive to the environment. Sustainability and the biodegradable aspect is important. We cannot use materials that will cause problems in future.

As Abigail shared, collaboration and the creation of softer skills is fundamental. As is supporting our NHS, especially in terms of the local availability of materials that we need during a pandemic. The theme of localised manufacturing and the supply chain that enables this is a whole new session in itself - one for next year perhaps?

Restoring passenger confidence in flying post COVID-19: the role of technology and materials

Dr Thomas Budd
Lecturer, Centre for Air Transport Management and Academic Lead for Digital Aviation Research and Technology Centre (DARTeC), Cranfield University

Covid-19 and the resulting travel restrictions have had a devastating impact on the global air traffic industry. The reduction in passenger numbers across the industry, with many airlines grounding their entire fleets, and airports left empty, has dwarfed any of the air travel disruption we have seen in the past.

ICAO estimate that by the end of 2020 there will have been a decline in world traffic of between 57%-61%. The hope is that the demand for air travel will recover but it is clear that things will look rather different for the industry for some time.

The key to recovery rests in restoring passenger confidence, or bio-confidence, as it is often referred to, in travel. There are significant concerns among passengers around contracting the virus at some point during their air travel journey. A recent study by the global trade body for airlines, IATA, shows that the vast majority of people still feel concerned about contracting the virus while travelling. This is despite the significant efforts by the aviation industry to communicate scientific research that shows that air travel is less risky that other forms of public transport, particularly with regards to the on-board experience. The ventilation of air in the cabin and the high efficiency particular air filters used in modern aircraft designs are hugely effective in filtering out bio aerosols and other pollutants. Yet passengers remain concerned about sitting next to an infected person, being in crowded areas, such as the buses or trains that take you to and from the aircraft, and using restroom facilities. Air travel needs to address these areas in order to restore confidence.

Not just an issue as a result of Covid, this presents the industry with an opportunity to ensure greater health and safety benefits across the passenger journey, and to try and reduce aviation's role as a vector for communicable diseases. There are three sources of infection from air travel:

- Direct contact through coughing, sneezing and talking. This is likely to occur at congested areas, such as the gate, at security, boarding and disembarking.
- Indirect contact through touching contaminated surfaces, items or people. This can occur in touchpoints along the passenger journey, such as toilets, touchscreen check-in, security and In Flight Entertainment systems (IFE).
- Vectors such as mosquitos, flies or ticks, occurring in open air spaces where they can live and breed.

The focus of Tom's presentation was around indirect contact, with materials and technology able to play their role in removing physical touchpoints. Technology and smart systems are key facilitators of this, including gesture and motion control sensors for toilet doors, IFE or elevators. This type of technology is prevalent already but we are now seeing it increasingly applied in an air transport context. Biometrics, facial or iris recognition technology can be used for border and security control. Again, these were already starting to be applied in airports prior to Covid, but now there is a real motivation to employ these to reduce queuing and touchpoints.

We are seeing existing smart technologies applied in a bio-health, Covid-19 related context. Smart systems are also being used for cleaning and service provision. Sensors can be used to detect areas that are in high use in the terminal (toilets, seating areas) and this can trigger a decision to increase cleaning and sanitation in that specific area. That could take the form of a manual cleaning team, but also automated systems via AI and robotics to clean large areas of a terminal.

Other major areas relate again to cleaning and disinfection. There are two major areas:

Active cleaning

'Enhanced' cleaning of surfaces including the use of traditional disinfectants and also the use of UV-C light, used to kill bacteria and help against the spread of the virus. Cabin design can also play a role with an increased focus on the physical design of the cabin to create smooth surfaces (seats, cabin products) that are easy and quick to clean. Ryanair has removed seat back covers that hold magazines, with this really improving and speeding up the cleaning process.

Passive cleaning

Applying antimicrobial films and adhesives to existing assets. Some airlines have applied antimicrobial layers to their tray tables, with a visual identifier to reassure the passenger that this has been done. With a limit to what can be retrofitted in this way, there may be a role for incorporating antimicrobial additives and agents into the manufacturing process of those new assets from the outset - new trays, new on-board luggage storage. This of course comes with a price tag and will take time.

There are challenges ahead but with these come huge opportunities. Research and development will require financial investment, and operationally these interventions must drop into existing regimes with anything causing major change, unlikely to be successful.

On this journey we need to remain in contact with passengers, appreciating and understanding what they perceive to be safe and a benefit to them. Aviation is rightly renowned as a safe industry, with this reputation built on a rigorous and robust safety standards process. Any changes to air travel or to an airport environment will have to undergo considerable certification procedures which will take time.

Find out more about DARTeC's 360 VR conceptualisation of the future aircraft cabins.

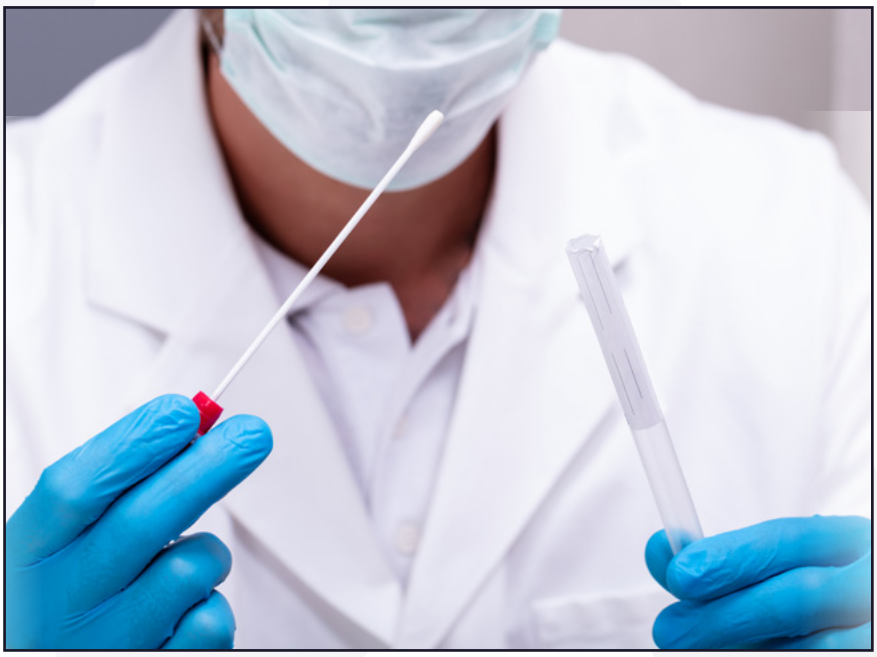
Professor Krzysztof Koziol
Head of Enhanced Composites and Structures Centre, Cranfield University

Sustainable production of rubber gloves

Cranfield is well known in terms of collaboration with industry and working to solve major problems that the industry faces. Head of the Enhanced Composites and Structures Centre at Cranfield, Krzysztof, is working on a project to sustainably produce surgical rubber gloves.

MediTech Gloves is one of the world leaders in examination and surgical rubber gloves and their aspiration was to create a sustainable process, eliminating some of the waste, both materials and energy, from the factory. The collaboration with Cranfield started more than two years ago but during the Covid pandemic this partnership strengthened significantly. MediTech found themselves in huge demand for their rubber gloves, with production doubling overnight.

There are two challenges around the creation of natural rubber gloves. One is the material and the second is the process. Cranfield's team helped MediTech improve the manufacturing process efficiency, and therefore also the time to get the final product. Rubber glove manufacturing is a complex process and to date there has been little innovation in this area, with the process taking about an hour from beginning to end.



PhD student Afiqah Salim Musa explained that the formulation of latex is critical, with some key ingredients and processes behind the formulation. In the latex there are naturally occurring protein species which can cause allergic reactions to more sensitive users. This has meant that historically people have opted for synthetic latex gloves. Yet as Krzysztof explains, natural rubber is far superior to synthetic in terms of sustainability. Synthetic gloves take more than 100 years to biodegrade, while natural latex biodegrades 100 times faster, in just one year. At Cranfield the team is working to remove the offending protein from the latex in order to encourage a greater use of natural latex gloves.

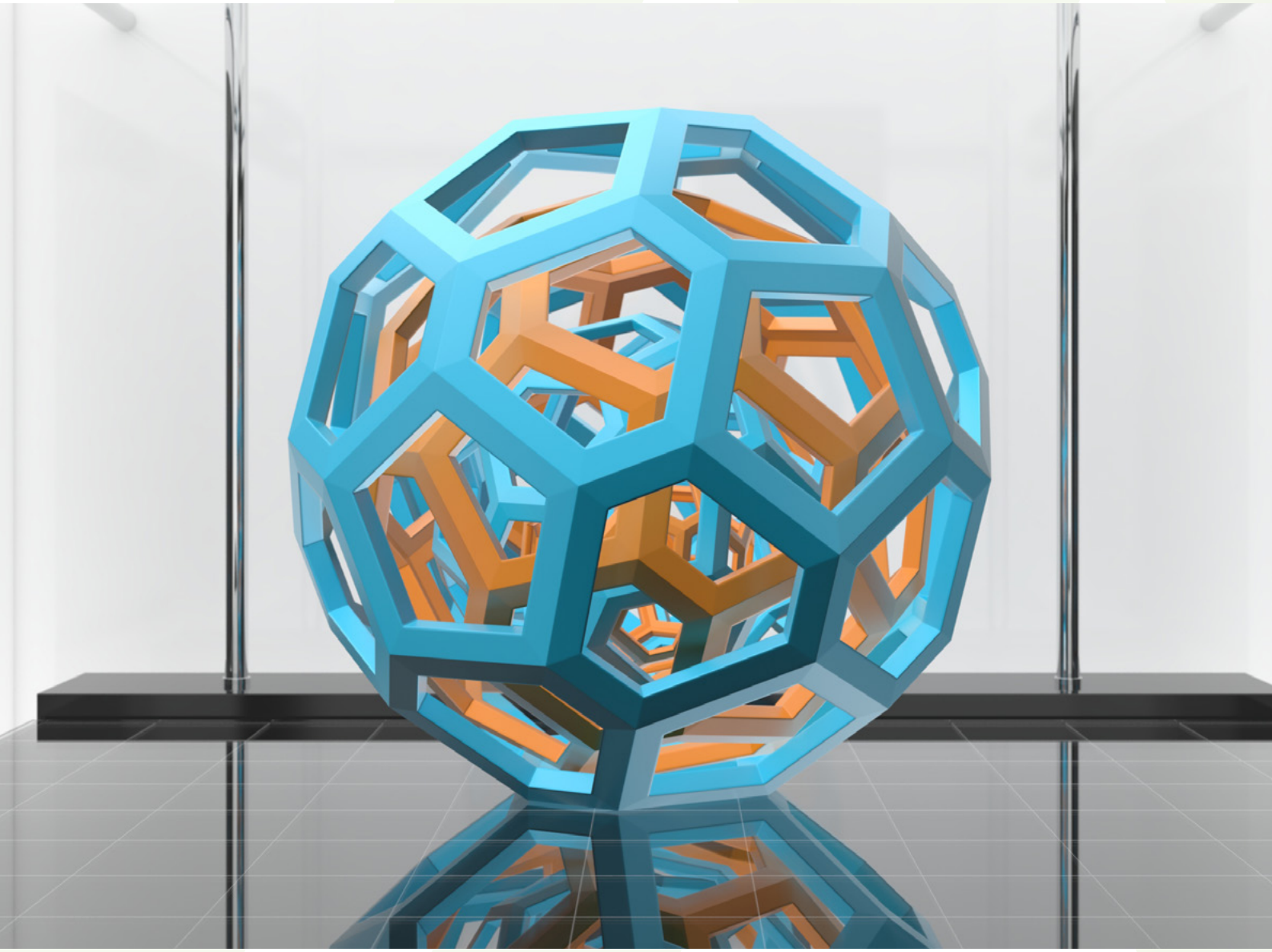
Furthermore, the team at Cranfield has perfected a new formulation for the manufacturing process that halves the time in which the gloves can be made. If there is another surge for gloves or a pandemic, the companies using the formulation from Cranfield will produce the gloves much faster. However the use of natural rubber cannot be increased overnight. We rely on plantations to produce the rubber and as such there is a whole supply chain that needs to gear up for the supply of natural rubber latex.

The latest reports show a figure of 780 billion gloves produced annually. If we were to switch entirely to natural rubber, considering the raw material and how it is made, we would save approximately 50% of the excessive CO_2 currently entering our atmosphere. It is not just about recovering from Covid, it is about aligning with our climate commitments. Natural rubber is the perfect opportunity for the industry to focus on sustainability. This clearly won't happen overnight but there is a real future in creating large enough supply chains in raw latex, not just solving the immediate problem of material availability but also providing the perfect product to support our efforts against the climate emergency. In using natural rubber as a material, the factory is as ecological as manufacturing gets - the factory itself is a tree, using carbon dioxide from the atmosphere, water from the ground, and energy comes from the sun.

Careers in manufacturing and materials

Careers in manufacturing

Career Development Manager Katrina Armstrong met with and spoke to industry professionals from Airbus, Avieco and WAAM3D. She was also joined by Professor Helen Atkinson CBE FREng Pro-Vice Chancellor of Aerospace, Transport Systems and Manufacturing.



During these sessions, the interviewees discussed their different manufacturing job roles, career paths, development opportunities, and their experience in the industry. To find out more about what support our careers team can provide please contact: cranfieldcareers@cranfield.ac.uk

Katrina Armstrong
Career Development Manager,
Cranfield University

Professor Helen Atkinson CBE, FREng
Pro-Vice-Chancellor - School of Aerospace, Transport and Manufacturing, Cranfield University

Manufacturing and materials week is a great opportunity for students to get a broader perspective of what is going on in the industry, to hear the views of industrialists and to look at the way manufacturing is developing and the future.

This is a really interesting time to be in manufacturing. The Covid pandemic has led everyone to review how they do things, what can be done better and more productively. It really focuses us on a green recovery and truly making things better.

Cranfield is heavily involved in a wide variety of fascinating work; everything from productivity-enhancing digital engineering and manufacturing, through to producing 3D printed surgical gloves in the Enhanced Composite Centre. Manufacturing can make a real difference and these are crucial areas where Cranfield can propagate outwards into industry.

Secret of her success

Helen has always said yes to opportunities. At university she discovered metallurgy and material sciences. Looking down a microscope and see the stunning structures inside the material fostered her love of metallurgy. On graduation, Helen went into a material engineering role, and then continued to complete a PhD - one that stretched her far beyond her comfort zone. Helen explains:

"Go for the things that you aren't absolutely sure you can do, and as you do them, constantly look at how to do it better."

A real turning point in her career, Helen chaired the rebuilding of the student union at her university. Not the usual role for a metallurgist, but Helen led this complex construction project, and it helped her to understand how a university operates, setting her on the course that would bring her to Cranfield.

While Helen manages the School of Aerospace, Transport and Manufacturing, she still sees metallurgy as her discipline. One of the things she has always felt about the materials side of manufacturing is what a huge impact it has on our lives; if things break unexpectedly it can have a disastrous effect on people's lives and the economic health of society.

On the question of her inspiration, Helen has always looked to learn from those who have been ahead of and around her. She is always open to insight into how to do things best. One example she cites is an overseas student Helen was tutoring at a previous university. His fees were being paid by his family back in Sri Lanka. Their family business was destroyed by the Boxing Day tsunami of 2004 and against this devastation, the student had to find a way of continuing his course. Helen was concerned about the amount of part-time work he was doing as well as his studies; his response: "I am training my body for hard work." Helen found his determination incredibly moving. He came out with a first class degree and ever since then things get tough, Helen remembers this young man. His absolute determination; and inspiration. He went on to become a teacher, taking his engineering learning into a secondary school, to help inspire the next generation.

Helen reflected on her initial interview when she joined Cranfield three years ago and offered advice on the recruitment process. Be yourself, but think hard about how you answer the questions. Preparation, practice and research are the key. On what to consider when seeking a career in the materials and manufacturing sector, it is important to not just look at what that company needs, but also to be aware that part of the reason they are recruiting is to obtain the new insights that you can bring. Project your knowledge and capacity to bring new thinking to the organisation, while also listening to their needs.

It will undoubtedly be a challenging recruitment market next year, yet Cranfield students should draw confidence from the insight they get into how industry works. We are very close to industry and there are real opportunities to draw on that can be taken to the job market.

When Helen graduated in 1981 in the midst of a massive recession, she went for a job where there were 700 other applicants - Helen got that job. If you prepare, research the role and the company you are interviewing with, believe in yourself and what you have to offer, you will be well equipped to do it

Take the opportunities you are offered. Use the industrialists we work with. Make the most of your time at Cranfield to grow, to step up to that next stage in your career.

Cynthia Adu
Sustainability Consultant, Avieco

Cynthia is a Sustainability Consultant, helping different companies, from finance to beverage manufacturers, to improve their environmental sustainability. They all face different challenges, in terms of climate change, and resource scarcity. At Avieco she helps them to reduce their impact on the environment and set targets to meet future carbon reduction goals.

Starting out as a mechanical engineer, Cynthia completed a course on Sustainable Manufacturing in the last year of her graduate degree, which was a defining moment for her career. This led her to apply to Cranfield to do an Engineering and Management of Manufacturing Systems MSc. Cynthia wanted to understand more about manufacturing, not just about making products and engines, but also seeing the full supply chain from a business perspective. Her group project focused on sustainability and improving recycling, as well as a project with Coca Cola to help set goals to reduce their environmental impact.

Cynthia went on to complete a four-year doctorate in Sustainable Materials and Manufacturing. This offered hands-on experience and the ability to implement research in a business context. Her doctorate was focused on helping companies reduce waste, as well as creating value out of waste - known as the circular economy. She applied different models and design thinking to create new materials from waste products.

Having been at Avieco for a year, Cynthia explains that learning how to be a consultant is very different to being a researcher at Cranfield. The business skills she has gained complements the research and scientific thinking that Cranfield nurtured.

Sustainability consultants come from a range of backgrounds, from physics, chemistry, manufacturing, business, and architects. The key is to be quick thinking and to have great interpersonal skills. Businesses come to consultants to get something bespoke for their own needs, to help solve specific challenges and, as consultants, they need to embed themselves in those challenges, making them their own.

From uranium manufacturers to a global tech company, the clients Cynthia works with are broad and diverse. They have huge targets in terms of reducing their environmental impact - the challenge is to blend the appetite for innovation at the same time as reducing their environmental impact, to help them to understand where they are currently, and identify ways to accelerate and progress innovation in a less harmful way.

Erika Ramos Da Silva Teixeira
Research and Development Engineer, Airbus

Erika is an R&D engineer at Airbus, working in the Manufacturing Engineering team. She works at Airbus Broughton, which is the site responsible for manufacture of wings for single aisle and long range planes (A320, A330, A350). Erika is responsible for looking for technologies that can be implemented on the shop floor to improve processes and efficiency. She works closely with the Research and Technology, and Innovation departments as well as with other Airbus sites in Spain and in France. She also looks at what can be learnt from other businesses, car assembly for example, to see how their innovations can be applied to wing manufacturing.

The role combines technical expertise with an ability to communicate across multiple teams. Erika joined Airbus in February 2020, and while she is still learning, she is keen to take a leadership position in the future. Airbus is very proactive in enabling their employees to take their career wherever they want in terms of location and also sector - from satellites and space, to aviation and defence.

Airbus has a whole programme, Wings of Tomorrow, dedicated to improving wing design and materials. As well as investing in electric-powered aircraft, they have recently launched a programme using hydrogen propulsion, seeking to launch the first zero emission commercial aircraft, Zero E.

On advice for people starting out in their career, Erika advises patience and not to give up, especially in the current climate. Cranfield has a lifelong career service for their alumni and for Erika this was crucial.

During her Aerospace Materials MSc, 40% of Erika's time was dedicated to projects with Rolls-Royce and Airbus. This presented a huge opportunity to show these industrial partners what she could do. Networking is crucial - some vacancies are created for the person because the company sees your potential. When Erika arrived at Cranfield, she was very shy, however with the support of Cranfield Careers Service, visits to various career fairs and making the most of the opportunities presented to her, Erika has built up her confidence to share her passion and to get her to the role she is in today.

Dr Filomeno Martina,
CEO and Co-Founder, WAAM3D

WAAM3D is a spinout company from Cranfield University that is commercialising the Wire + Arc Additive Manufacturing process. At the moment Filo is building the entire backend infrastructure (HR, operations, finance and accounting) to ensure they are ready to commercialise the product over the next few months.

A former senior lecturer at Cranfield, Filo was exposed to managerial responsibilities, however in moving to industry and building a company from the ground up, particularly in the midst of a pandemic, it has been interesting to say the least!

Filo's current focus is to create the best and most dedicated team, in order to get the WAAM technology out in the market. They want to change the face of manufacturing, and he recognises that this will take time and focus.

When Filo started developing the WAAM process, large scale metal additive manufacturing and 3D printing in general, he saw it as a substitute technology to established processes such as forging and casting. Some of these processes are costly, with long lead times, generating a lot of waste, contributing to CO_2 emissions in general. From the outset WAAM has focused on demonstrating benefits across the lifecycle. The use of WAAM has already shown that we can reduce waste and energy consumption, and therefore reduce CO_2 emissions, not only making the manufacturing more efficient, but also having a positive impact on the environment.

Filo's career in additive manufacturing was actually a bit of a coincidence. Fascinated by new technology, he came across the WAAM concept during his MSc at Cranfield. At that point he had the choice of continuing to do a PhD or applying for jobs. He chose to stay at Cranfield, to forge a career in additive manufacturing.

Cranfield enjoys a close relationship with a lot of well-established manufacturing powerhouses. That's something that not many universities are able to claim and it brings incredible benefits to students in terms of exposure to live industrial challenges. Spinout companies such as WAAM really benefit from having these relationships already in place, taking ideas out of the lab and turning them into a commercial success. Filo is grateful to Cranfield for developing his career at such a pace, enabling them to take some of that excellence and translate it into WAAM. It is hopefully another great showcase for the providence of Cranfield in the academic world.

In considering advice that Filo would give future Cranfield students, the most important thing is to find something you really love, that you want to make into your career. Develop and focus on your long-term goals - think of yourself as your own company, define your own strategy and consider where you want to be in 10 to 15 years. As an academic he advises to never stop learning from the people around you. It is important for even the most technically-focused engineers to develop soft skills in terms of people, communication and emotional intelligence. Finally, a good work/life balance is crucial - ambition and determination can see work expanding to take over our whole lives but it's important to have downtime in order to deliver in the workplace.

For more information on WAAM3D please visit their website: waam3d.com

Manufacturing and Materials Week closing remarks

Professor Mark Jolly
Director of Manufacturing,
Cranfield University

No one could have envisaged that in postponing our National Manufacturing Debate we would still be in lockdown in December 2020. A concept that grew out of a forced hand has opened up tremendous possibilities and led to a week of events with international speakers and audience that has benefited from the online format.

Twice this event, we heard reference to Industry 5, first by Dr Ayotunde Coker, winner of our Distinguished Manufacturing Alumni 2020, and during Manufacturing 2075 by Dr Abigail Hird of KTN. The reality is that 2075 will come around very quickly - some of you in this week's audience will be around to see and be part of it we hope! It really is up to you!

Save the dates

Manufacturing and materials week 2021
29 November–2 December 2021

National Manufacturing Debate
1 December 2021

Manufacturing 2075
2 December 2021

www.cranfield.ac.uk/manufacturingweek

Graphene commercialisation conference
15 March 2022

www.cranfield.ac.uk/grapheneconference

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