astute®

ADVANCED SUSTAINABLE MANUFACTURING TECHNOLOGIES

TECHNOLEGAU CYNHYRCHU CYNALIADWY UWCH

2010 - 2022

EUROPEAN REGIONAL DEVELOPMENT FUND

Cronfa Datblygu Rhanbarthol Ewrop

European Regional Development Fund

Celebrating Success

Embedding Advanced and Sustainable Technologies into Welsh Manufacturing through Collaboration between Industry and Academia

Professor Johann Sienz, ASTUTE Operation Director

ASTUTE (Advanced Sustainable Manufacturing Technologies) began twelve years ago with a clear vision: to connect industry and academia so they can collaborate, share knowledge, and solve the complex manufacturing challenges brought to ASTUTE by industry. ASTUTE provides companies with exclusive access to world-class academic experts, highly qualified researchers, technology, and research facilities and encourages the stimulation of ideas through research, development, and innovation (RD&I). When it started, there was no comparable intervention available that effectively supports industry in a responsive and fast manner - it is a pioneer in the collaborate research model it delivers, and it was described as exemplar for industry-academia collaboration by others.

Initially, ASTUTE was awarded European Regional Development Funding (ERDF) for a five-year term to support companies in West Wales and the Valleys from 2010 – 2015 and was delivered by a partnership of eight Welsh Universities: Swansea University, Cardiff University, Aberystwyth University, the University of Wales Trinity Saint David, the University of South Wales, Cardiff Metropolitan University, Bangor University and Wrexham Glyndwr University. Subsequently, follow-on ERDF funding was secured and ASTUTE 2020 began operation from July 2015 in West Wales and the Valleys only, before additional funding was given to launch ASTUTE EAST in 2018. With this, ASTUTE became a pan-Wales operation led by Swansea University in partnership with Cardiff University, Aberystwyth University, the University of Wales Trinity Saint David, and the University of South Wales.

ASTUTE demonstrates the unique value that an alliance between Higher Education Institutions and the manufacturing sector can create and is a testament to the positive impact European funds have had on the economy and future prosperity of Wales. It has worked across a variety of sectors since its inception from aerospace and automotive to medical engineering and food processing. ASTUTE applies advanced engineering expertise and technologies to manufacturing challenges in three key specialist areas: 1) Advanced Materials Technology, 2) Computational Engineering Modelling, 3) Manufacturing Systems Engineering.

In this document, you will find a collection of ASTUTE project case studies relating to the specialisms mentioned above that demonstrate the power of industry-academia collaboration. They include, amongst many others, a project with Vernacare Ltd. and WRAP Cymru that resulted in the incorporation of up to 20% recycled content into the company's medical waste sharps bins. And another with Brother Industries (UK) Ltd. that led to the production of the first Brother toner cartridges manufactured from recycled materials recovered from end-of-life products.

The collaborations undertaken by ASTUTE and its industry partners have not only seen the development and delivery of many vital and valuable research projects, but also the formation of key professional and personal relationships that will continue to thrive and flourish for the benefit of the Welsh region beyond the scope of the ASTUTE operation.

The true success of ASTUTE lies with the team of devoted professionals, academics, researchers, managers, administrators, and contributors across the partner Universities and in industry who have worked tirelessly to build and maintain special relationships, exchange knowledge, and to deliver impactful progress in the manufacturing sector. I would like to thank my ASTUTE and industrial colleagues for their hard work and dedication over the years. We can be proud of the many achievements, and of the fact that each £1 of public investment led to an estimated £10 of economic impact.

I would also like to thank our industry forums– Industry Wales, Welsh Automotive Forum, Aerospace Wales Forum and MAKE UK, to name a few – and the Welsh Government who have supported ASTUTE's vision and championed the operation since the beginning, strengthening the bridge between academia and industry, and increasing economic opportunity and prosperity across Wales.

Strengthening the Bridge Between Academia & Industry

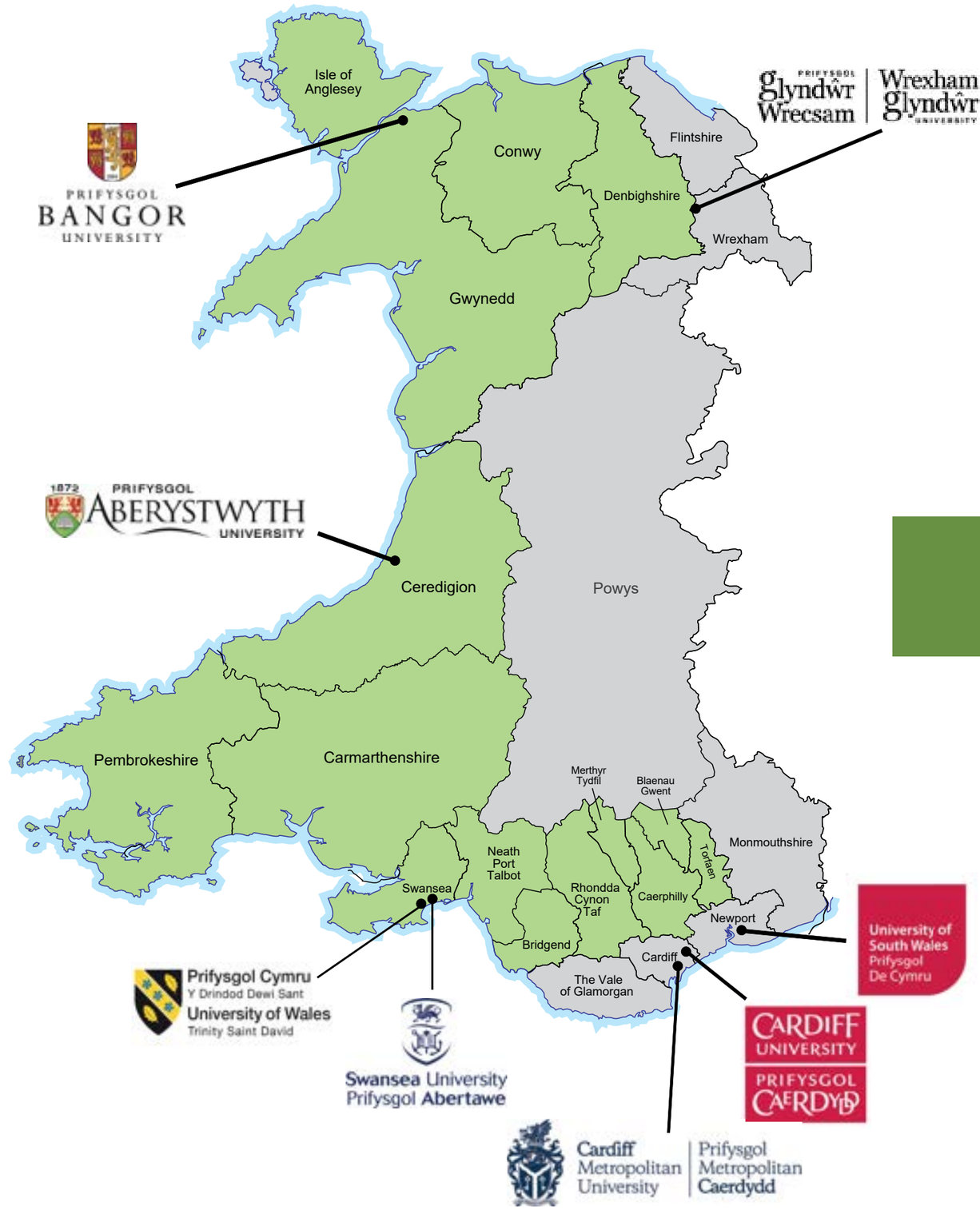
A multi-University partnership collaborating with industry experts to deliver multidisciplinary approaches and solutions to complex manufacturing challenges

At the core of ASTUTE lies a partnership of Welsh Universities that together provide expertise, experience, and research in three specialist areas – Advanced Materials Technology, Computational Engineering Modelling, and Manufacturing Systems Engineering.

The partners, some of whom have been collaborating on ASTUTE projects since 2010, offer access to highly qualified project officers, leading academic expertise, and state-of-the-art equipment and facilities can support the adoption of advanced technologies in the manufacturing industry across Wales. Covering three areas of expertise through a strong collaborative HEI partnership means ASTUTE can offer industry a comprehensive multidisciplinary package of support that is key to overcoming barriers in process or product related challenges.

The work of ASTUTE's academic and industry contributors has been transformational within the Welsh manufacturing sector creating sustainable growth, increasing competitiveness, and helping to future-proof businesses and their market offerings.

ASTUTE	2010 to 2015	Swansea University, Cardiff University, Aberystwyth University, the University of Wales Trinity Saint David, the University of South Wales, Cardiff Metropolitan University, Bangor University and Wrexham Glyndwr University	West Wales and the Valleys
ASTUTE 2020	2015 to 2022	Swansea University, Cardiff University, Aberystwyth University, the University of Wales Trinity Saint David	West Wales and the Valleys
ASTUTE EAST	2018 to 2022	Swansea University, Cardiff University, and the University of South Wales	East Wales



£541M

ECONOMIC IMPACT contributed through COLLABORATIVE RESEARCH between 2010-2022:

Every £1 of public funds has generated £10 for the Welsh economy

PARTNERSHIP

135 World-Class Academic RESEARCH PAPERS Published

540 WELSH MANUFACTURERS have BENEFITED from ASTUTE RD&I Support

8 WELSH UNIVERSITIES Powering Research, Development and Innovation (RD&I) through Industrial COLLABORATION

BUSINESS GROWTH

NEW & SAFEGUARDED Jobs across Wales

1027

New PRODUCTS, PROCESSES or SERVICES

649

RD&I INVESTMENT GENERATED by the Welsh Manufacturing Industry

+£28M

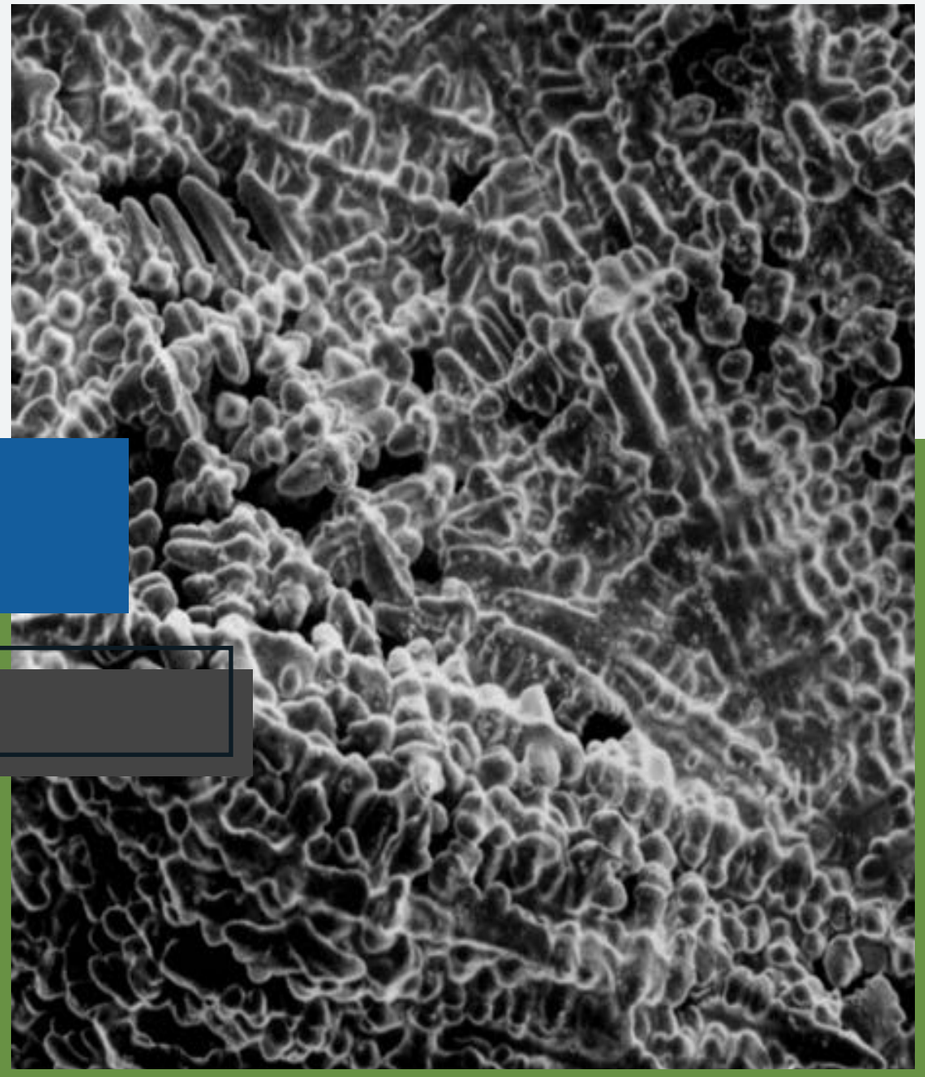
165 Items of IP DEVELOPED

EXTERNAL FUNDING Secured

+£18M

ASTUTE (Advanced Sustainable Manufacturing Technologies) operation, supporting manufacturing companies across Wales, has been part-funded by the European Regional Development Fund through the Welsh Government and the participating Higher Education Institutions. (Operation led by Swansea University in partnership with Cardiff University, Aberystwyth University, University of South Wales, University of Wales Trinity Saint David, Wrexham Glyndwr University, Bangor University, Cardiff Metropolitan University).

** The economic impact has been independently verified by Miller Research (UK) Ltd. (ASTUTE 2020 Operation External Evaluation 2022) & CIOTEK Ltd. (ASTUTE External Evaluation 2015)*



Advanced Materials Technology

Introducing new materials into products, adopting more innovative techniques for processing advanced materials, and developing a deeper understanding of a material and its behaviour

The technical expertise of ASTUTE's academic partners covers several classes of advanced materials including sophisticated multi-component metallic alloys, polymeric materials and elastomers, composites, semiconductors, and digital materials.

Our academics have the expertise to interpret a material's macroscopic behaviour, underlying structure, and phase transformation at an atomic scale. They study microstructure through advanced techniques such as high-resolution electron and optical microscopes, Atomic Force Microscopes (AFM), Energy Dispersive X-ray Analysis, and X-ray Photoelectron Spectroscopy (XPS). They are also able to study bulk degradation mechanisms such as fatigue, high-temperature creep and embrittlement, and surface degradation mechanisms such as oxidation, corrosion, and susceptibility to UV light – all of which have a critical effect on the durability of a component.

Research into advanced materials technology is delivered by Swansea and Cardiff Universities, both of whom collaborate with industrial partners to increase their understanding of materials used in existing products and processes and help to introduce new materials that could increase efficiency.

Swansea University
Swansea University conduct their materials technology research at the Faculty of Science and Engineering. They have assisted companies in need of considerable R&D assistance to integrate materials with complex direction-dependent properties and to increase company processing knowledge and capabilities.

Cardiff University
The Cardiff School of Engineering are experts in understanding and predicting how the internal microstructure of a material will influence its response when applied in the field. They specialise in the development of sustainable products and efficient and sustainable manufacturing processes within the area of sustainable design and manufacturing.

Case Study
Brother Industries (U.K.) Ltd.

Brother Industries (U.K.) Ltd. Launches Toner Cartridges Produced Using Recycled Plastics Thanks to Industry-Academia Collaboration

Brother Industries (U.K.) Ltd.

Brother Industries Ltd. is a Japanese multinational electronics and electrical equipment company headquartered in Nagoya, Japan with 37,000 employees globally.

Brother Industries (U.K.) Ltd. ("BIUK") is based in Wrexham, North Wales. They are at the forefront of the Brother Groups recycling activities, and produce printing consumables, and plastic mouldings for a diverse range of industrial and consumer electronics. BIUK has a highly developed free returns system for end-of-life Toner Cartridges. Customer returned cartridges are remanufactured, and any materials are reused or recycled.

The company is adopting the principles of 'Circular Economy', placing the business at the forefront as an ethical and sustainable manufacturer of plastic components and becoming the Recycling Technology Centre (RTC) for the global Brother Group. ASTUTE 2020 supported BIUK in investigating the technical difficulties of using recycled High Impact Polystyrene (HIPS) materials.

"Working together with an independent education institute creates credibility to evaluation results that demonstrate the use of recycled materials in new consumer products. The value adding collaboration with ASTUTE 2020 has enabled us to take the next important step – to use "end-of-life" products as a source of raw materials to produce new products. This is the Circular Economy in action".

Julian Cooper
Quality/Environmental Manager, Brother Industries (U.K.) Ltd.

Challenges

The recently published research on the feasibility of recycled plastic products presents some contradictory arguments. From this perspective, the research project addressed the following questions:

Can BIUK recycle High Impact Polystyrene materials recovered from their own end-of-life products, to make new products (closed-loop recycling)?

If so, how many times can HIPS be recycled before any change in properties becomes unacceptable?

Can HIPS received from different sources (open-loop recycling) be recycled as these have many contrasting properties?

Solution

ASTUTE 2020 worked with Brother Industries (U.K.) Ltd. to investigate the degree of degradation in a range of material properties to guarantee the quality of the recycled plastic materials is maintained, taking into account the changes in both macroscopic and microscopic properties.

In this particular case, the following effects were examined and analysed:

Multiple cycles of HIPS on the tensile, impact, and thermal properties
UV treatment properties to measure the outcome of sun exposure to the product on the materials' degradation.

The research confirmed that material properties are not adversely affected by reprocessing HIPS up to eight processing cycles nor by exposure to UV up to 500hr continuously. These behaviours can be explained by the predominance of crosslinking reactions that can promote an increased crosslink density or grafting reaction in the elastomeric phase during the injection moulding.

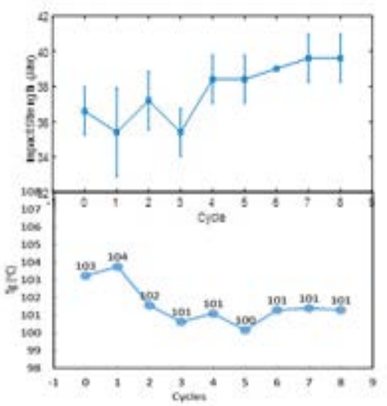
The unique collaboration between BIUK and ASTUTE 2020 has proved that blending different grades of HIPS will not dramatically decrease the blend properties and BIUK can incorporate different classifications of HIPS received from diverse sources for use at their site for further production.

Impact

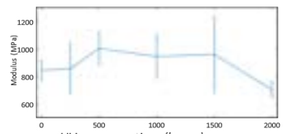
The collaboration has increased both parties' understanding of recycled materials and led to fruitful knowledge exchange on processes and technology between BIUK and the ASTUTE team.

BIUK can now transition products currently made from virgin resins to recycled resins, creating a direct environmental impact, reducing the use of raw materials, saving energy and reducing CO2 emissions from manufacturing and landfill. As a result, this will contribute to Government targets, the Paris Agreement and UN Sustainable Development Goals.

Following production and quality tests, cartridges produced using recycled material cartridges are now in full production, with the expectation as a result of the collaboration to make all cartridges from recycled material and expand this to other products such as Brother's printers, strengthening the profile of BIUK RTC as well as the company's long-term strategy to operate in North Wales.



Effects of No. cycling on different properties



Effects of UV

Case Study
Vernacare & WRAP Cymru

Research into the Development of Methodologies for Enhanced and Sustainable Profitability in Injection Moulding

Vernacare Ltd.

Vernacare are market leading suppliers of medical consumables to healthcare providers in the UK and internationally. They specialise in manufacturing sharps containers, infection prevention products and harm reduction solutions and developed the world's first purpose-manufactured contaminated sharps waste disposal units – their Sharpsafe® product range.

Funded by the Welsh Government, WRAP Cymru promote and encourage sustainable resource use through product design, waste minimisation, re-use, recycling and reprocessing of waste materials. They support manufacturers to incorporate recycled content in their products and extend their useful lifetime through capital investment via the £6.5million Circular Economy Fund.

The collaboration between Vernacare, ASTUTE 2020+ and WRAP Cymru aimed to increase the amount of recycled content in the Sharpsafe® range traditionally made using virgin plastic. To achieve this objective, the team needed to identify a suitable source of recycled material, assess its properties and possible up-rating, and determine its suitability for complete or partial replacement of virgin material.

"Vernacare has been interacting with ASTUTE 2020 since 2011, collaborating on multiple projects to optimise our sustainability, profitability, productivity and product quality.

Working in partnership with ASTUTE 2020 and WRAP Cymru –we are aiming to contribute to a greener future by increasing the volumes of recycled content in our products as sharps containers are traditionally made from virgin plastic.

This approach will hopefully not only lead to increased sales but at the same time supply our customers with both safe and sustainable infection prevention solutions."

Mark Langford
Head of Manufacturing, Vernacare

Challenges

Sharpsafe® products are required to pass two critical tests: to resist penetration and to survive a drop test to -18°C (such as may occur during refrigerated transport to incineration). These require a combination of hardness and low-temperature impact resistance, properties which are often difficult to reconcile since an increase in one of those properties generally results in a reduction of the other.

The demonstration project needed to prove the viability of incorporating post-industrial recycled materials without compromising product quality.

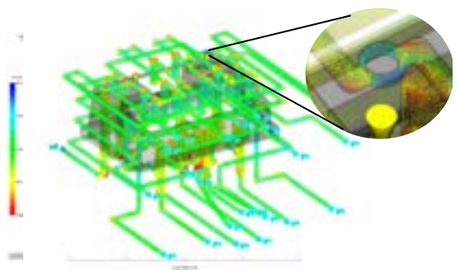
To achieve this, the team were required to:

- Identify one or more sources of recycled copolymer polypropylene providing a clean, consistent and reliable supply in sufficient volume,
- Test the suitability of the material for Sharpsafe® manufacture by a combination of lab tests and production trials,
- Examine methods for up-rating material properties as required,
- Assess the practical implications for commercial production of incorporating recycled material.

Solution

Altogether, 29 material blends were tested to identify the best option with suitable properties. ASTUTE 2020+ conducted experimental trials to simulate performance and the Vernacare team completed numerous manufacturing trials. These resulted in the identification of two blends that met the company's rigorous and comprehensive testing standards, ensuring that product quality wasn't compromised by the introduction of the recycled material.

WRAP Cymru assisted Vernacare in sourcing a reliable supplier that could consistently provide the volume of recycled materials needed for their manufacturing operations.



Flow simulation in the 13L lid tool

Impact

As a direct result of the findings of this project, Vernacare's range of sharps containers now includes up to 20% recycled materials. They have also introduced 100% recycled materials into their accessories range and product features.

Having demonstrated the feasibility of incorporating recyclate into production through the collaboration, Vernacare successfully applied for funding through the Circular Economy Fund – a Welsh Government initiative directed by WRAP Cymru – to invest in new material handling systems and quality control test & validation equipment.

Vernacare matched the funding provided by WRAP Cymru helping to further their progress towards a circular economy model and create a more sustainable future for safe infection prevention solutions.

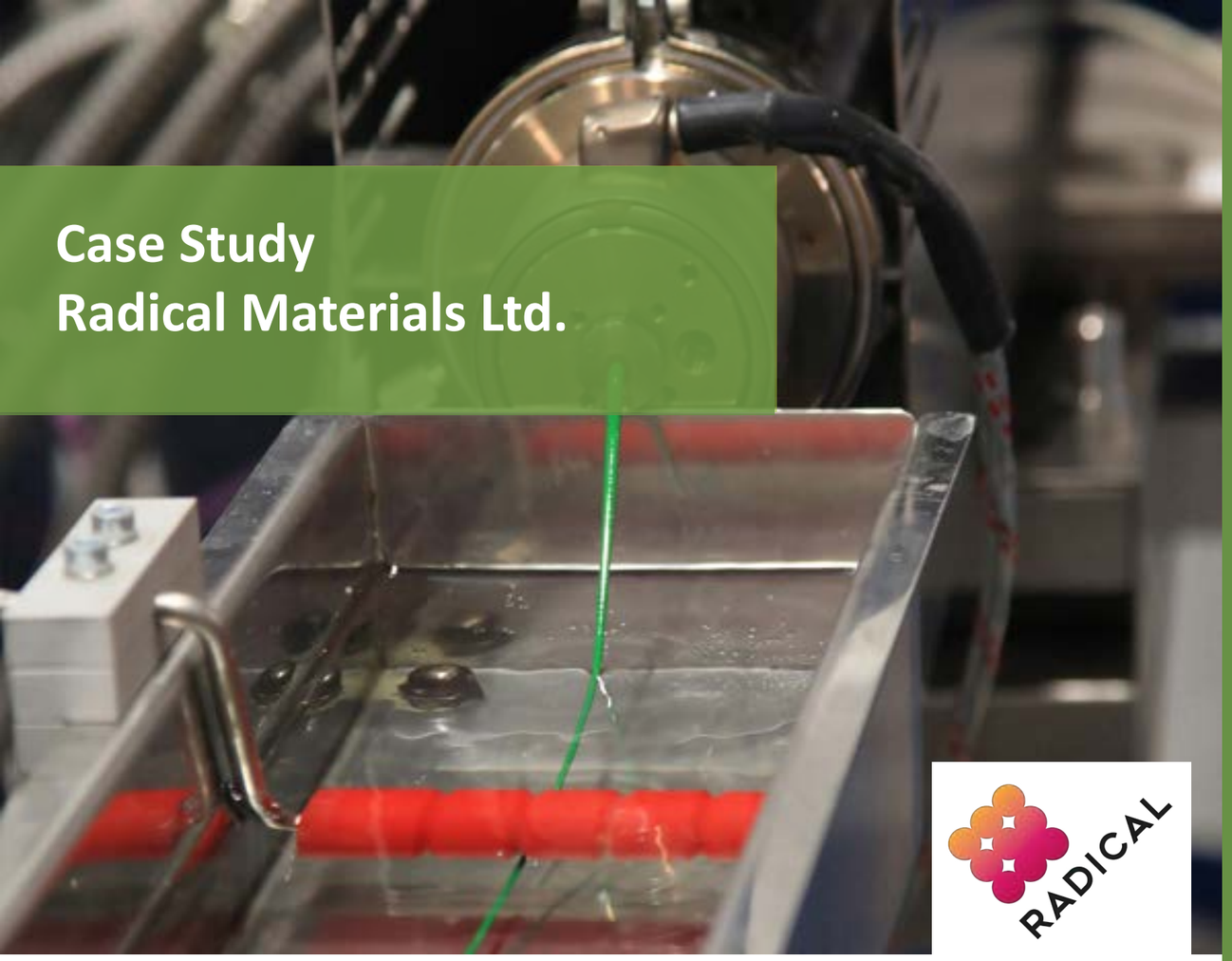
The collaboration also resulted in the following impacts and benefits:

- Nine new jobs created,
- More technical and production-based roles soon to be created to assist with processing recycled plastic,
- On target to reduce their CO_2 emissions by two and a half thousand tonnes over the next three years,
- Cycle time and energy use reduction on various processes - 20% reduction in cycle time on 9/13L lid machine
- 10g reduction of plastic per part on 9/13L lid component through process optimisation,
- Improved quality control procedures that have resulted in less wasted material,
- Technology Readiness Level of incorporating recyclate in production raised from level 3 to level 5. WRAP funding will assist with progression to a fully commercial TRL 7, bringing with it significant commercial and environmental benefits.

Additional value to the project has been a dedicated EU-Funded Materials and Manufacturing Academy (M2A) Masters student whose work is complementary to the ASTUTE 2020+ project, providing Vernacare with additional support whilst the student is participating in industrial led research training.

"This R&D collaboration aims to improve profitability by reducing manufacturing costs through energy and material savings whilst enhancing product quality. This will result in a business growth and expansion and assist with international competitiveness."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020.



Case Study
Radical Materials Ltd.

Research Collaboration on Innovative Materials for 3D Printing

Radical Materials Ltd.

Radical Materials Ltd. are material specialists based in Ebbw Vale. The company has developed a range of technical performance additives for use in industry with a variety of materials including polymers and coatings. In particular, they are market leaders in the manufacture and supply of antimicrobial additives for inclusion in a wide range of products using the brand name Steritouch®. More recently, they have developed additives to detect physical contaminates in food manufacturing (Scopic) and thermal conduction additives with applications in the automotive sector (Konduct).

The aim of the collaborative research with the ASTUTE 2020 team based at Cardiff University was to investigate whether formulations of polymer matrix composites, developed primarily for injection moulding by Radical Materials, possessed characteristics suitable for use in additive layer manufacturing (commonly known as 3D printing) using Fused Deposition Modelling (FDM). FDM is an extrusion technique by which molten material is printed in layers onto a build platform to form a 3D object following dimension data contained in a Computer Aided Design (CAD) file.

"We've found working ASTUTE 2020 very useful indeed, there are more emerging technologies that we will shortly be working with to bring very innovative products to market and would certainly consider involving ASTUTE 2020 in those developments."

Huw Durban
Director, Radical Materials Ltd.

Challenges

Developing a wider range of new materials is a key strategic trend for companies wishing to take advantage of the rapidly expanding 3D printing market. FDM is one of the most commonly used forms of 3D printing and typically uses solid filaments of polymer which are melted in layers to form the desired component. Developing polymer-matrix composites with synergistic characteristics has the potential to produce FDM materials for a wide range of industrial applications. However, the proportions of the matrix polymer and reinforcement have to be balanced to produce the desired physical properties whilst remaining suitable for extrusion into filament and subsequent FDM.

Solution

Optimisation of Parameters for Extrusion & FDM
Granules of three different polymer matrix composites (A, B, and C) were analysed to see if the optimisation of extrusion parameters could enable the filament to be suitable for FDM production. The filament needs to be smooth and flexible with a consistent diameter.

The optimisation experiments resulted in materials A and C producing filament of sufficient quality to be used for FDM. Material B produced filament but the diameter was inconsistent despite different extrusion parameters being tested. This was probably due to the mass of the reinforcement in the composite.
Experiments with FDM parameters including temperature, layer height, build speed, and fill density were carried out to enable the test pieces of materials A & C to be printed. Samples of material A were successfully produced to allow antimicrobial testing to be carried out.

Samples of low and medium levels of reinforcement of material C were printed before thermal conductivity testing. However, the filament of material C with a high reinforcement level could not successfully produce printed samples. This was probably due to increased viscosity and/or abrasion of the printing nozzle.

Testing of Key Characteristics
Samples of material A were tested by Radical Materials for antimicrobial activity using method JIS Z 2801:2000 with MRSA and E.coli. All of the samples reduced the number of colony-forming units (CFU) by 99.991 percent after 24hrs at 35°C indicating the excellent antimicrobial ability of material A.

Printed samples of material C with two levels of reinforcement underwent thermal conductivity testing using a Netzsch LFA 447 NanoFlash Instrument with Pyroceram 9606 as a reference standard. This revealed that low reinforcement levels reduced conductive properties. However, a medium level of reinforcement increased thermal conductivity by approximately 20 percent. Infill density was found to be an important parameter as trapped air had an insulating effect, as opposed to conductive influence, on the composite samples being tested.

Impact

Overall, the results demonstrated that two of the three materials tested could be further developed into FDM products. The combination of Radical Materials' in-depth knowledge of extrusion and formulation of polymer resins along with ASTUTE 2020's technical expertise in polymers, additive manufacturing and materials analysis demonstrated the feasibility of production of polymer–matrix composite filaments for FDM, but highlighted that there are additional challenges to be met before these could be manufactured on a commercial scale. The antimicrobial material A was most successful and warrants further investigation.

During this research project, FDM printers using granules instead of filament have been launched and the company may wish to ascertain whether these will eventually dominate the market before investing in filament manufacture.

Radical Materials were awarded a SMART Cymru Innovation Award to develop their thermally conductive and RF shielding materials – ASTUTE 2020 has provided them with academic contacts from Cardiff University's School of Engineering to assist with this work.

Experimental and control granules

"The development of new polymer composites for 3D printing has the potential to increase innovation in areas such as aerospace, automotive and food manufacturing. This research project with Radical Materials Ltd. has increased both the company's and Cardiff University's knowledge and technical experience in this expanding area."

Jacqueline Marsh
Senior Project Officer, ASTUTE 2020

Case Study
Dr Zigs Ltd.

Understanding the Properties of Aqueous Polymeric Solutions to Enable Product Development and Future Production Upscaling

Dr Zigs Ltd.

Dr Zigs are a North Walian manufacturer of high-quality, non-toxic, eco-friendly bubble mix that are sold as children's toys both online and in retail outlets across the world. Their giant bubble mix constitutes a polymer blend, typically hydroxyethylcellulose (HEC) and polyethylene oxide (PEO), chosen to enhance desirable properties such as elasticity, bubble forming friendliness, self-healing qualities, and colours.

In recent years they have gained increasing market traction, and as such needed to up-scale production substantially to satisfy demand and enter new markets. ASTUTE 2020+ collaborated with the company along this journey, providing insight and solutions to a wide range of manufacturing process challenges and researching together to improve their product formulas.

"Working on the Astute program and with the team from Swansea University has been a great experience for all of us at Dr Zigs. It was fantastic to get a deeper understanding into issues that have been affecting our mix and our scaling capacity. The team were both deeply knowledgeable, yet able to clearly present findings in a concise and very interesting manner that have had a huge impact on our own understanding and further development of our Bubble Mix. Astute has very much been a key contributor to our continuing success here at Dr Zigs, and I would very much recommend this program to any company."

Paola Dyboski
Bubbler in Chief, Dr Zigs Extraordinary Bubbles

Challenges

At Dr Zigs' low-volume stage, many of their manufacturing processes were carried out manually including mixing, bottling and quality testing. To increase production capacity using these manual processes would demand increased workforce and space, pushing up production time and costs. While process automation could be an alternative, the complex mixing procedures and new products under development limited this option.

Solution

Previous attempts by the company to mechanise their process had resulted in the bubble mix being compromised as it is susceptible to shearing and highly sensitive to contaminants. Therefore, it was essential for the collaborative team to understand the complex viscoelastic properties of the polymeric solution before process automation could be made possible.

Rheology of Materials
The research project began with an extensive literature review of specific polymeric solutions followed by a full characterization of Dr Zigs' bubble mix and that of their competitors. The company and ASTUTE's researchers also jointly identified a range of new polymeric solutions to be characterised.

ASTUTE 2020+ conducted advanced trials of the different bubble formulas in liquid rheology labs, and characterized the liquids using a TA Instrument AR-G2 controlled stress rheometer with parallel plate and concentric cylinder geometries. Experiments were also conducted to relate viscosity to product performance as a quality control metric – this aided formula improvement and identified any potential scale-up challenges.

Viscoelastic properties were researched and the results informed the identification of suitable equipment for automated systems that could replace the current manual procedures.

To test the robustness of the above findings and recommendations, Dr Zigs developed their in-house quality control capabilities that better reflected real-world usage and enabled the team to more accurately measure changes in product performance.

Impact

ASTUTE worked closely with the team at Dr Zigs to investigate the parameters that impacted their manufacturing process, and identify solutions to boost productivity and enable automation and future upscaling – this included sourcing sustainable ingredients, exploring new equipment options, addressing mixing challenges, and improving product formula.

The collaboration enabled Dr Zigs to rapidly progress the development of several new product formulas and identify weaknesses in, and make improvements to, their current manufacturing and quality control processes.

As a result of working with ASTUTE, the company has gained confidence in their own research and development capabilities and now holds the necessary knowledge and experience to confidently move into a large-scale production phase.

"Dr Zigs bubble solution presented a unique challenge. The elastic, viscous, complex fluid behaviours of their mixture required special handling and processes to enhance the quality of their solution and try new alternatives. It was a pleasure to see their product and R&D capabilities rapidly advance during the project."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Case Study
Amnitec Ltd.

Merthyr Tydfil Manufacturer Achieves Significant Cost Savings and Environmental Benefits Thanks to Industry-Academia Collaboration

Amnitec Ltd.

From their UK Headquarters in Merthyr Tydfil, Amnitec Ltd. is a leading manufacturer in design, development, and manufacturer of flexible metal hose and assemblies for the transfer of fluids and gases in extreme environments.

A high-pressure hose system helps solve several issues facing multiple industries including aerospace, automotive, marine and energy industries. These issues relate to flexure vibration, thermal, or pressure-related problems involving liquid and gas transfer.

ASTUTE 2020 and Amnitec's collaboration aimed to understand the metallurgical construction of a copper to a stainless steel welded joint improving consistency, enhancing the quality of these welds to eliminate leakage and reduce scrap in products that employ this welding method, thereby enhancing productivity and company competitiveness in this niche market.

"Amnitec were able to use the support and resources of Astute to successfully conduct and implement a project focusing on the reduction of scrap of a flexible hose assembly manufactured in Production.

The success of the project will be shared with other current processes and the potential to investigate future projects."

Andrew Satterthwaite
Technical & Quality Manager, Amnitec Ltd.

Challenges

The difference in mechanical and physical properties between stainless steel and copper is considered a challenge to the welding community.

First of all, the two materials have almost 315°C difference in melting points, which make the generation of a joint pool of the two metals extremely difficult. Furthermore, copper and iron are slightly soluble in each other. Therefore, stainless steel will start to solidify and form grain structures while the copper is still in a liquid state, forced between the stainless steel crystal structures.

As the weld cools further, the stainless steel grain will begin to contract due to cooling, causing the grains to pull apart. At this point, the copper is still too hot to add any structural strength to the grain structure; the weld will form large cracks, known as "hot cracking".

To achieve the highest quality joint suitable for welding and to ensure an effective joint design, ASTUTE 2020 supported Amnitec to address these challenges and enhance the quality of these welds.

Solution

ASTUTE 2020 and the Amnitec team analysed the welding process and consumables used to achieve the desired project goals. The research identified multiple welding parameters which could be altered: welding speed, interpass and post-weld cleaning and welding filler.

The company successfully altered some of these parameters by identifying the need to shift the joining technology from TIG welding to TIG brazing technique (done at a lower temperature). Changing the currently used CuSn1 to silicon bronze rod (a copper rod, containing 3% silicon and 1% manganese) was recommended and successfully tested at the company. This change had a significant impact on scrap rate reduction down to 6%.

Possible further routes for the company to explore would be looking at: the effect of torch angle , the response of Welding speed (path velocity),the use of automatic welding (Robot).

"ASTUTE 2020 team is very pleased to support Amnitec Ltd in reducing their manufacturing waste through a straight forward and cost-effective solution. This will improve profitability whilst enhancing product quality".

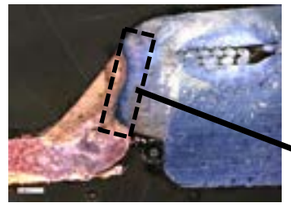
Dr Fawzi Belblidia
Technical Director, ASTUTE 2020

Impact

The collaboration between Amnitec and ASTUTE 2020 has led to significant benefits for the company and the environment through improved welding quality and lower weld temperature:

- Reduction of scrap percentage from 10-20% to 6%
- Reduction in production cost and waste
- Decrease in energy consumption, use of raw materials and CO2 emissions
- Increase in efficiency, productivity and competitiveness

TIG brazing joint using the suggested wire (CuSi3

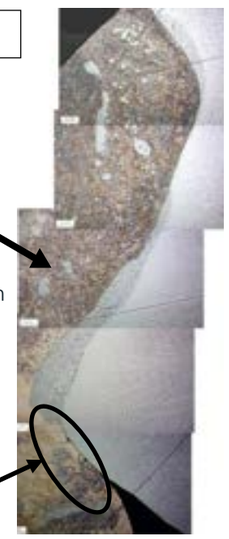


The heat input and the amount of deposited filler wire are small. The joint doesn't suffer from lack of fusion and the interface is probably contain low brittle intermetallic compounds.

Stainless/copper joint using CuSi3

TIG brazing joint using the suggested wire (CuSi3

The joint suffer from lack of fusion and the interface is probably contain many brittle intermetallic compounds



Lack of fusion defect

Stainless/copper joint using CuSn1

Case Study
Sandvik Osprey Ltd.

Main Image: Microstructure of enhanced H-X parts without cracking as a result of project.

Enhanced Powder Production Enables Crack-free High Temperature Nickel Superalloy (H-X) Parts By Additive Manufacturing

Sandvik Osprey Ltd.

Sandvik Osprey Ltd was founded in 1974 as Osprey Metals Ltd by three former Swansea University students to commercialise their newly invented 'Spray Forming' process for the manufacture of alloys with refined microstructures. Since that time it has grown to become a world leader in the fields of powder metallurgy, controlled expansion alloy solutions and advanced brazing materials.

Sandvik Osprey has accumulated over 40 years of know-how in the field of gas atomization, knowledge that it leverages today to manufacture a diverse range of high quality metal powders using its own proprietary technology. These metal powders are used in a wide range of advanced technologies including Metal Injection Moulding (MIM), Additive Manufacturing/3D Printing (AM) and metallic coatings.

Sandvik Osprey produces high temperature nickel alloy (H-X) powders for a range of industrial applications that require superior performance. In the field of AM, however, the use of H-X has been limited to date due to problems with hot cracking which occur during the laser melting process.

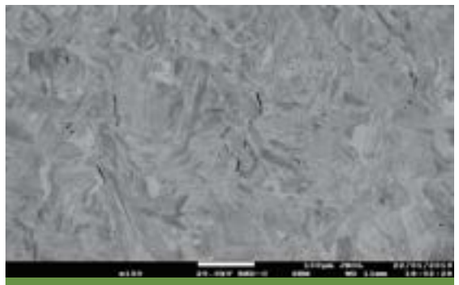


Image: Microstructure of AM fabricated H-X with cracking.

Sandvik Osprey Ltd. decided to collaborate with the ASTUTE 2020 programme to gain a better understanding of the mechanisms controlling hot cracking and to assess different approaches to the elimination of microcracks in AM fabricated H-X parts, including (1) optimization of the alloy composition and (2) use of nanoparticle additions.

Enabling the production of crack-free parts in H-X through Additive Manufacturing will open up the potential for new industrial applications which will hopefully in turn increase the demand for high quality nickel superalloy powders.

Challenges

H-X is typically used for gas turbine operations, petrochemical and structural components, manufactured from wrought or solid materials. Currently, Sandvik Osprey produces H-X powder for AM, MIM and cladding applications that require superior performance. Developing a suitable powder for metal AM would enable direct manufacture of complex-shaped parts e.g. for gas turbine components and would significantly extend the application areas for this high performance material. However, due to the hot cracking issue, H-X has not been widely implemented for metal AM.

Solution

ASTUTE 2020's expertise in Advanced Materials Technology aimed to address the current issue of material micro-cracking during the building of H-X parts via the powder bed fusion process.

To address the hot cracking issue seen in AM of H-X, the following technical approaches have been conducted between ASTUTE 2020 and Sandvik Osprey.

- Characterisation of 'Conventional' H-X by Laser Powder Bed Fusion (L-PBF). The microstructure and mechanical properties (i.e. tensile) of the L-PBF fabricated conventional H-X have been investigated to understand the mechanism of crack formation and the distribution of cracks.
- Modification of the conventional H-X powder while maintaining the required mechanical properties. In terms of the expertise in nanoparticle theory research at Cardiff University, the interactions between Ni alloy components and various nanomaterials has been considered to evaluate potential nanoparticle additions.
- Optimisation of alloying composition in different H-X variants. The optimisation was performed by measuring the relative density of L-PBF fabricated cubic samples (8x8x8 mm) using Archimedes method.

In particular, a reduction in the occurrence of hot cracking was achieved through:

- Optimisation of the processing parameters in different H-X variants.
- Optimisation of the alloy composition.
- The addition of suitable nanoparticles to eliminate micro-cracking within additive manufacturing of H-X.

In all cases, a comparison of the mechanical properties for the enhanced state was made with the initial baseline to confirm the impact on material performance.

Impact

Optimisation of the H-X alloy for Additive Manufacturing applications supports Sandvik Osprey's growth ambitions in the area of high temperature nickel alloys.

Additional benefits arising from the collaboration included:

- Increased understanding of nickel superalloy metallurgy.
- Increased expertise in laser Powder Bed fusion technology.
- Opportunities for future research and development.

The collaboration has given Sandvik Osprey a platform to support further development of its portfolio of nickel base superalloys tailored to Additive Manufacturing applications. This collaboration has enabled the ASTUTE 2020 team to use the nanoparticle technology to address hot cracking issues in other industrial superalloys, which are also susceptible to such problems.

There are few viable alternatives to H-X for extreme temperature and corrosion resistance. Manufacturing by AM can increase material utilization and reduce manufacturing scrap leading to improvements in the overall environmental footprint. By harnessing the increased design freedom that manufacturing by AM allows supports new and advanced burner designs can also be realized, delivering improved fuel efficiency and consequently reducing emissions.

"Working with the ASTUTE programme has helped us increase our knowledge in the area of AM for advanced Nickel alloys and deliver a value-added solution to a customer problem."

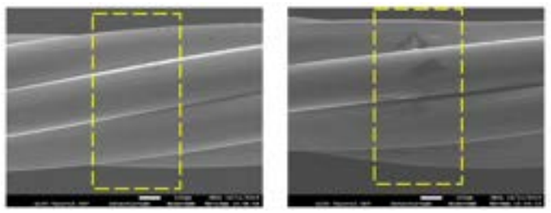
Keith Murray
Head of Global Sales, Sandvik Additive Manufacturing
www.additive.sandvik

Case Study
Spectrum Technologies Ltd.

Industry-Academia Collaboration Helps Towards Accreditation of Laser Wire Stripping Process for Aerospace Industries

Spectrum Technologies Ltd.

Spectrum Technologies Ltd. is a global market leader in the design and manufacture of advanced industrial laser systems, undertaking the design and manufacture of all of its products from the headquarters in Bridgend, Wales.



Electron microscope images of wires after laser cutting insulation, showing that no damage is seen on the conductor.

Hi-tech industries in aerospace, defence, rail, automotive, telecoms, electronics and life science sectors use Spectrum products to provide advanced manufacturing solutions in the processing of wires with unparalleled precision and efficiency compared to conventional mechanical methods.

ASTUTE 2020 has been working with Spectrum to prove and demonstrate that the process of laser wire stripping has no detrimental effect on the electrical and physical properties of the wire or cables used in the aerospace industry.

"This R&D collaboration aims to improve stripping quality of electrical wires. This will result in business growth and expansion and assist with international competitiveness".

Dr Fawzi Belblidia
Technical Director, ASTUTE 2020

Challenges

The need to minimise weight on aircraft has driven the development of thin wall insulated wires; and the introduction of lighter, higher performance electrical interconnect systems. Traditional mechanical methods of stripping the insulation requires a number of different tools to suit particular wires. With a mechanical process, there is always a risk of damage to the conductor which is strictly forbidden in the industry.

The use of laser technology for stripping wires and cables is commonly used in the electronics and medical sectors especially in niche applications where mechanical methods fail. The biggest advantage of using specific lasers and parameters for stripping is that due to the metallic conductor the laser beam simply reflects from it causing no damage.

The challenge within aerospace is that any wire stripping device has to be approved for use with the Original Equipment Manufacturers following their stringent rules.

ASTUTE 2020's research expertise in advanced materials aimed to address the technical challenges of the laser processing conditions for a defect-free stripping process.

Solution

The ASTUTE 2020 team worked closely with Spectrum to investigate the conditions under which the electrical wires could be laser stripped without causing damage to the conductors.

Optical microscopes, electron microscopes and X-ray techniques characterised and analysed the laser wire stripping performance to optimise energy use, increase speed and reduce defects. Quantitative elemental analysis determined contamination and residue and ways to minimise them.

The cutting performance was affected by several factors: cutting speed, laser power, insulation materials type and thickness.
The results were shared with the company to validate performance and optimise their laser wire stripping tools as per the requirements of the aerospace industry.

Impact

The ASTUTE 2020 collaborative project has demonstrated that the laser wire stripping process does not alter (or even mark) the surface of the conducting metallic wire or cable. The impact of the laser on different insulation materials was analysed to minimise residues and reduce post-process cleaning.

The testing and optimisation of the laser wire stripping parameters have allowed a finer tuning of the product for use in hi-tech and aerospace industries where the stripping of wires in miniaturised electronics without damaging them is becoming an increasing challenge.

Spectrum and ASTUTE 2020 have worked together to enable the company to proceed with acquiring a route to certification of the laser wire stripping for the aerospace industry supply chain which was previously inaccessible.

The collaborative project has given the company confidence in their updated laser cutting system and they have recently secured a large order from Boeing. As a direct result, four new jobs have been created at the Welsh Headquarters and several jobs have been safeguarded through the new contracts and OEM accreditation. With Spectrum introducing new to the firm and market products/ processes, there is an opportunity for the company to pursue accreditation in new markets and supply chains to optimise and improve the laser wire cutting parameters.

Examples of common aerospace specification wire and cables after laser stripping at the optimised parameters found by analysis.

"As the experimental results showed it is possible to laser strip without causing damage to the conductors; this is the key to open the route for accreditation with aerospace.

This collaboration has given us the confidence that laser stripping in aerospace is achievable. The order with Boeing has protected jobs, and we expect in early 2021 the acceptance of the technology including Boeing accreditation. We will further progress our talks with AIRBUS to obtain their approval in 2021".

Jonathan Davies
R&D Manager, Spectrum Technologies Ltd.

Case Study
Red Dragon Flagmakers Ltd.

Testing and Evaluation of the Physical Properties of an Innovative Modular All-in-One Coat and Sleeping System (ROOF)

Red Dragon Flagmakers Ltd.

Red Dragon Flagmakers (RDF) is a custom flagmaker manufacturer and social mission-led business based in Swansea. Incorporated in its original format in 1969 and re-established as a social mission-led business in 2014, RDF produced custom and generic traditional stitched and contemporary printed flags, banners and bunting and manufactures high-end premium textile goods including most recently scrubs and apparel for the Welsh Government and donation through a fundraiser to care homes in Wales and the UK in general.

RDF has developed ROOF, an all in one padded coat with integrated sleeping bag including hood and hidden pockets, designed to pack away into a crossover, lightweight and portable shoulder bag. ROOF is an intelligent survivalist outerwear garment that enables the wearer to cope with living outdoors in all weathers securely and comfortably. The production of this ROOF Coatbag offers the opportunity to build a better life through training and sustainable employment within RDF – although receiving a ROOF unit and taking up the training opportunity are not directly dependent on each other.

RDF approached the ASTUTE 2020 team at UWTSD to engage with their extensive expertise in Advanced Materials and conventional and non-destructive testing (NDT) capabilities. The request was to collaborate on the optimisation of ROOF and to establish that the garment is fit for purpose and performs in the most extreme conditions.

Challenges

ROOF was in early development stages when ASTUTE 2020 became involved; RDF's focus at the time was to deliver a fit for purpose garment suitable for unpredictable weather and social environments. This unique garment's properties are key, combining a coat and sleeping bag for which standards are individually defined. Specific analysis, materials selection, composite structure and performance investigation were necessary to ensure the sustainability and efficiency of the product as a benchmark standard in its own right.

Solution

The ASTUTE 2020 team at UWTSD aimed to research and deliver information regarding the insulation capabilities of the textile composite used in the manufacture of the ROOF garment.

The first element involved ensuring that the composite was flexible, protective, comfortable and extremely tough in relation to knife attacks.

Body armour standard KR1-E1 for UK police was considered for depth and impact measurements within the stab proofing layers of the garment for extreme scenarios. Confirmation was required concerning the chosen composite: four layers of wire knit interfaced with five aramid-based cloths. The composite needed to resist a half energy blade impact, allowing full slash proofing capabilities with the option to double the thickness to meet the standard.

ASTUTE 2020 worked with the RDF team researching the optimisation of the composite's insulation through NDT. State of the art infrared (IT) thermography was utilised – an NDT and evaluation technique - to estimate how differently constructed wads of composite made by RDM (in conjunction with a novel stab proofing composite element) would deliver the best insulation.

Alternative finishes and colours were examined to estimate insulation capabilities inside and outside of the ROOF garment. Moisture and wicking levels, movement, friction and resilience to water and fire were all assessed by UWTSD.

"The journey from design inception to initial discussions with UWTSD through to research, development and results have exceeded our expectations. We would have been lost without the patience and support of the team who delivered on ROOF".

Jo Ashburner
Managing Director, Red Dragon Flagmakers Ltd.

Impact

The impact of this research project has resulted in a significant breakthrough for RDF, allowing the business to demonstrate the unique nature of the garment and provide benchmark evidence that the combination of materials meets strict environmental and social requirements.

The novelty of the product will enable RDF to implement design improvements to ensure the garment will be:

- Water, fire and splash-proof
- Suitable and safe to wear when in freezing temperatures
- Lightweight and durable

UWTSD's unique exploration of standards and methods have provided RDF with a mechanism to advance the product and assist with the selection of materials, composite structure and benchmark performance analysis.

As a social mission-led business, RDF's specific goal with ROOF is to support people with their personal safety and ability to cope with living an outdoor life in all weathers as well as to achieve a long term objective to grow the business to enable people to escape the benefits trap associated with low paid employment and homelessness.

The advancement of ROOF has so far resulted in the employment of three dedicated machinists who assist the Production Lead in the development and production of ROOF.

ROOF is a specialist product for RDF and potentially a game-changing lifesaver for individuals and communities locally, regionally and worldwide.

Case Study
Frontier Medical Group Ltd.

Optimising Product Sustainability Results in Increased Sales and Expansion for Frontier Medical

Frontier Medical Group

Frontier Medical Group is a market leading manufacturer and supplier of high-quality medical devices to healthcare providers in both the UK and internationally.

Frontier has a long history of innovation with its product range including Sharpsafe® – the world's first purpose-manufactured, disposable plastic sharps container and Europe's market-leading brand; and Repose® – a range of unique pressure area care devices used in the successful treatment of over 3 million patients in the UK.

"This R&D collaboration aims to increase Frontier 's competitiveness by reducing manufacturing costs through energy and material savings whilst enhancing product quality. This will result in a business growth and expansion and assist with increasing UK and International sales".

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020.

Following on from a successful collaboration between Frontier and ASTUTE (2010 – 2015) on Repose® and Frontier's ongoing focus to remain competitive, utilise new materials and optimise processes, a collaborative Research and Development (R&D) project with ASTUTE 2020 was scoped.

The ASTUTE 2020 researchers and a dedicated team of seven staff members from Frotier aim to deliver the project exploring the development of methodologies for enhanced and sustainable competitiveness in injection moulding, raising Frontier's process technology readiness level towards TRL 5.

Challenges

Frontier's products are manufactured to stringent requirements under ISO 13485 for medical devices with significant operating costs attached in terms of labour, materials and energy.

The project's aim is to examine and optimise injection mould tool cooling while examining the main factory system. ASTUTE 2020 will apply expertise in scientific fundamentals of the moulding process and work with the Frontier team to develop and improve on existing practices and implement process improvements on a specific machine. Concurrently the teams will develop a road map for the rolling out of improved optimised production conditions factory-wide.

- Limited monitoring instrumentation, e.g. installation, unreliable or inconsistent readings.
- CAD files for Moldflow® simulations needed significant modification and upgrading.
- Limited opportunities to make alterations due to part or current mould designs.

Cooling of injection moulded parts can have a significant effect on the end part quality, specifically warpage. Although quality parts are being produced at Frontier there is presently no scientific approach to the monitoring of water flow consumption rates or the relevance of specific temperatures of the majority of individual moulds. The understanding and knowledge of the correlation to heat transfer coefficients are also limited so it is not established if the optimal cooling conditions are in use. However, Frontier is committed to departing from this scenario by introducing and developing a more scientific approach that provides the potential for optimising the process and further increasing product quality where possible and improving manufacturing efficiency.

Anticipated improvements are envisaged that will help towards reaching increased sustainable optimised manufacturing, lowering energy consumption and carbon emissions, reduced material usage, cycle time reduction with improved consistency, quality and understanding.

Solution

ASTUTE 2020's approach is to investigate and quantify potential benefits through knowledge transfer via round-table discussions and hands-on machine trials with data monitoring. Statistical methods for process optimisation and control will be introduced, together with sufficient understanding of the underlying physical phenomena relevant to the injection moulding process.

Experimental trials supported by ASTUTE 2020's computational simulation expertise should be able to assess the mould and the chiller cooling circuit. This would allow Frontier to make an economic evaluation of modifications to the system with recommendations on continuous monitoring methodology.

Impact

The commitment and collaboration between Frontier Medical and the ASTUTE 2020 team in the initial stages of the project have resulted in the following impact and benefits:

- Investment in a new injection moulding machine equipped with improved data monitoring capabilities and pipe flow monitoring equipment for measuring liquid throughput by Frontier.
- Bi-directional knowledge transfer for tool cooling optimisation and maintenance.
- Significant potential for cycle time reduction on other processes - 10% reduction in cycle time on the machine used for the project trials.
- A 10g (4%) reduction in the weight of the component used during the project through the development and fine-tuning of the optimisation process.
- A possible potential for a 20 - 25% reduction in the power consumption of the main cooling water circuit delivery pumps that could represent a saving in the region of £4,000 - £5,000/year in energy charges.
- New process improvement methods have reduced some process variabilities and finely tuned areas of the processing window.
- With increased sales, additional jobs have been created expanding Frontier's workforce. Further job opportunities throughout the business are expected to materialise in the coming months.
- Future improved efficiencies are expected to deliver further business growth and assist with maintaining the future UK and international competitiveness.

Additional value to the project has been a dedicated EU-Funded Materials and Manufacturing Academy (M2A) masters student, whose work is complementary to the ASTUTE 2020 project, providing Frontier with additional support while the student is provided with industrial led research training.

"A highly successful collaboration that fits in with our existing lean philosophies and further develops our own people by enhancing their knowledge and approach to the cooling fundamentals of injection moulding and lean process optimisation".

Mark Langford
Manufacturing Manager Frontier Medical Group Ltd.

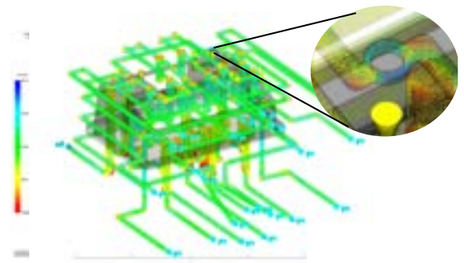
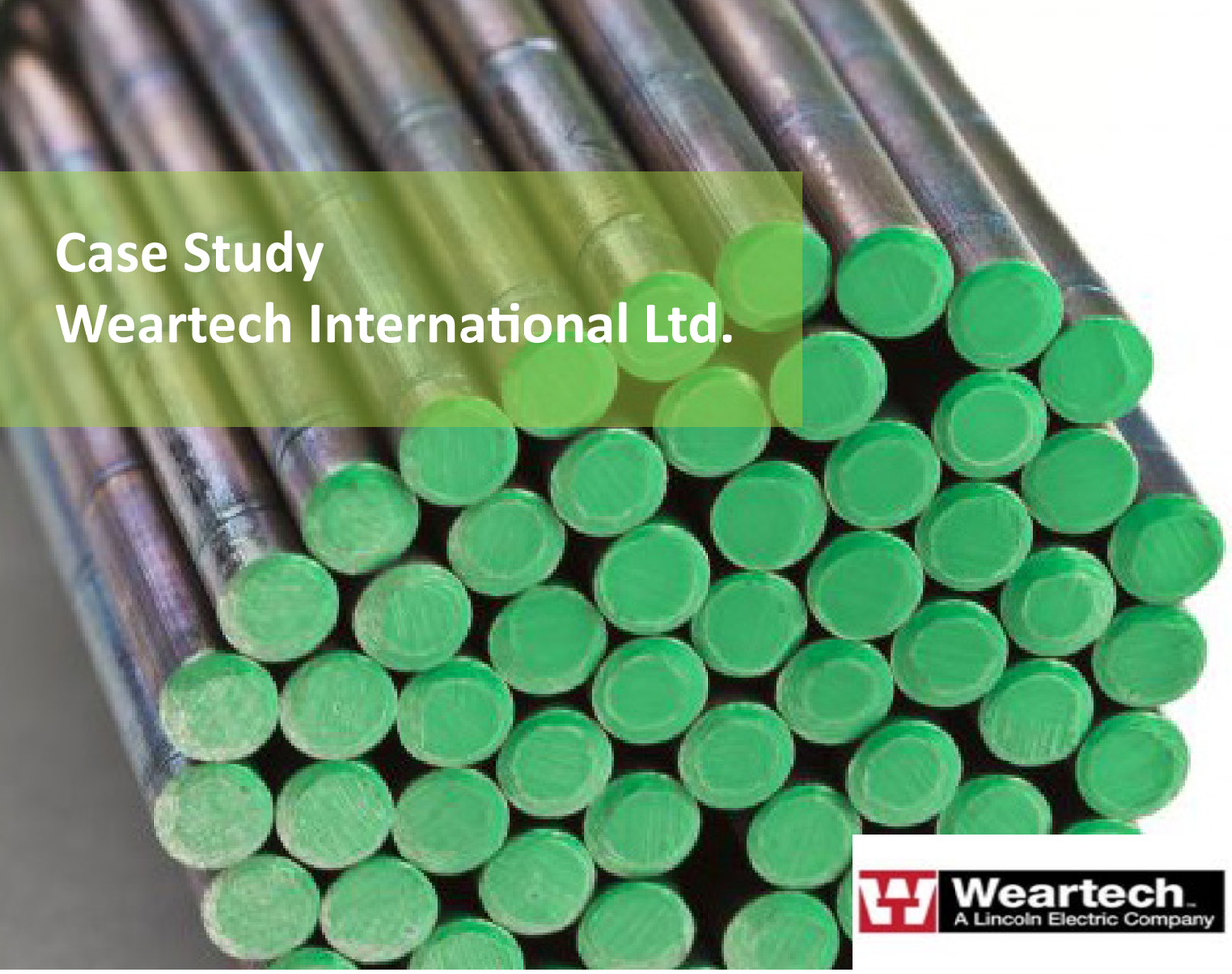


Image: Flow simulation in the chosen project tool



Case Study
Weartech International Ltd.

Evolving the Research Capacity into Wear Resistant Multicomponent Alloys – Microstructure Approach

Weartech International Ltd.

Founded in 1990, Weartech International Ltd. has a major plant in Port Talbot where they manufacture wear-resistant, hard-facing cobalt-, nickel-, and iron-based alloy consumables and components.

Weartech alloys are available in the form of bare rods, stick electrodes and small diameter wires that are manufactured through a continuous casting process, whilst wear-resistant cast components are made by centrifugal and sand casting methods.

It is expected that through engagement and collaboration with ASTUTE 2020, Weartech's advanced manufacturing knowledge will increase, and, alongside certain improvements, be applied more widely to the production, providing additional gains for Weartech.

The collaborative project will cover products that are sold across multiple sectors. e.g. steel industry, oil and gas, timber, mining, medical etc.

"Weartech International Ltd. has worked closely with ASTUTE 2020 at Swansea University since 2011 with collaborative projects proving to be rewarding for our business. Our Research & Development team have great pleasure in working with such an enthusiastic group, covering a wide spectrum of Advanced Sustainable Manufacturing Technologies."

Dean Thomas
Operations Director, Weartech Ltd.

Challenges

The proposed research project will examine the microscopic structure and mechanical properties of these multicomponent alloys when produced by continuous casting (for rods), sand casting and centrifugal casting (for components). These investigations will be supported by computational modelling of the heat and fluid flow during casting (including the effects of phase transformations during solidification). Additionally, the reverts recycling process in casting will be investigated to determine the level beyond which product quality will be affected, allowing for a sustainable manufacturing process that impacts minimally on the environment.

Solution

Computational Engineering Modelling and Advanced Materials Technology are the main areas of expertise that the ASTUTE 2020 team brings to this project. The research involves chemical and microstructural analyses of various fluidity chemical sensitivity, and reduction of slag formation taken at different stages of the process, and relating the effects observed in terms of oxidation, colour changes and brittleness to the process conditions. This will be supported by the coupled thermal and flow numerical simulations of the continuous, centrifugal and sand casting processes using available software.

Moreover, the collaboration between ASTUTE 2020 and Weartech will provide supplementary knowledge transfer on the slag formation, flux function and fluidity chemical sensitivity that will enable Weartech to develop and build research capacity into wear resistant multicomponent alloys to advance manufacturing knowledge whilst reducing waste and enhance material sustainability. This will lead to a more efficient manufacturing process and meet increased market demand for these complex, high-value alloys.

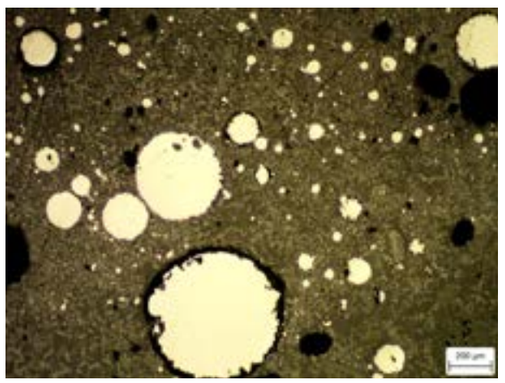


Image: Microstructure of slag

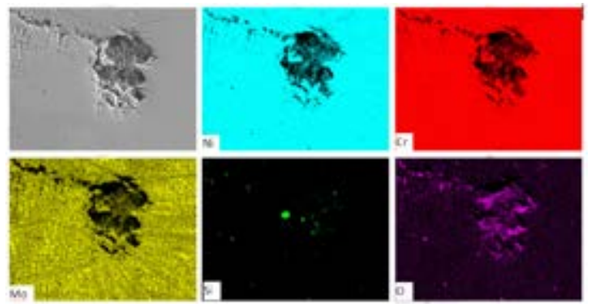


Image: SEM mapping showing presence of hot tearing in rod

"The collaboration between ASTUTE2020 and Weartech R&D teams is exemplary. It is mainly driven by improving the manufacturing casting process whilst reducing waste. Our support has enabled Weartech to meet their ambitious targets to enhance the quality of their product range and maintain a leading role within the sector."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Impact

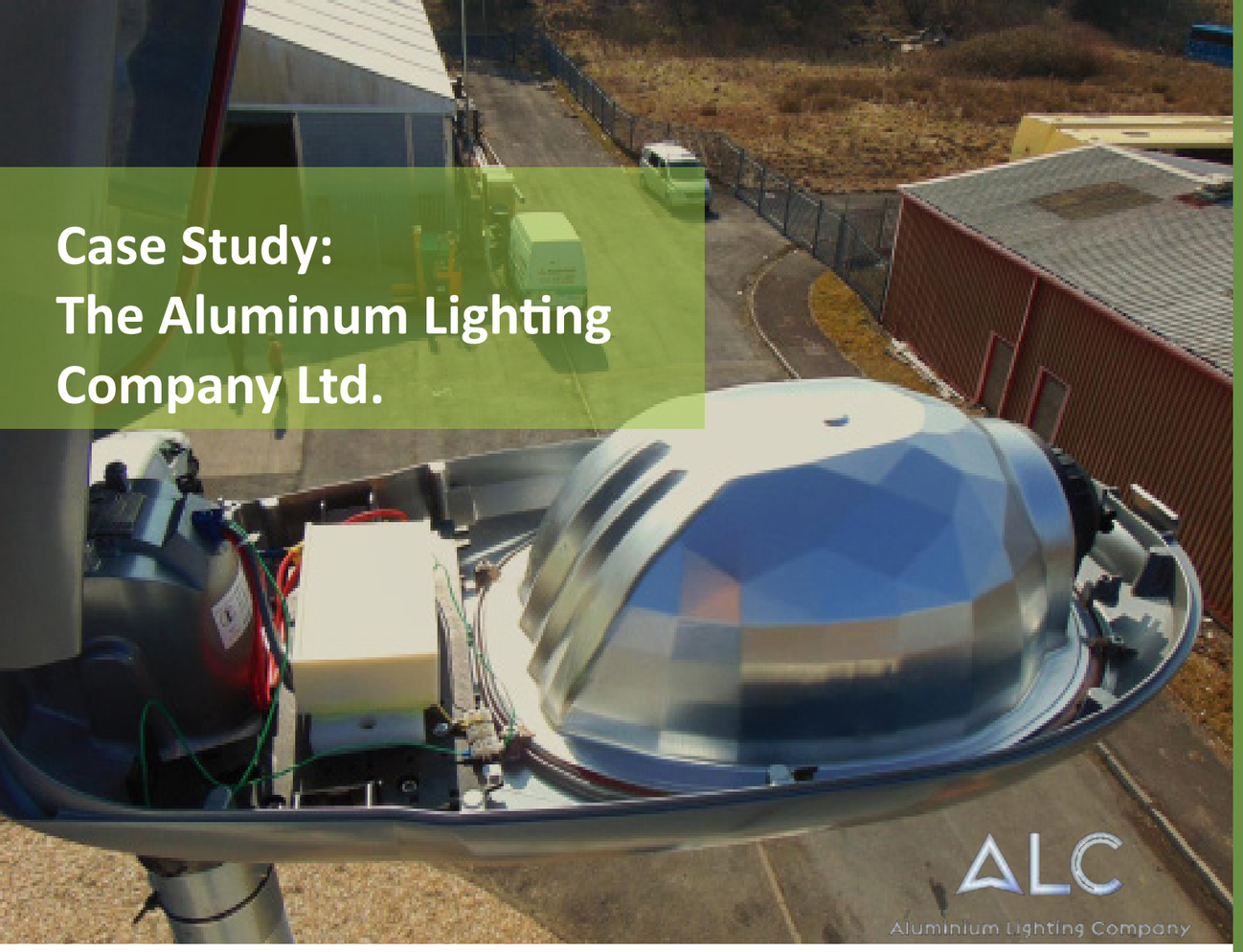
One of the aims of the proposed collaborative project is to gain a better understanding of porosity and oxidisation control, which can directly lead to reducing scrappage rates.

As part of this project, Weartech has invested in a new MagMelt furnace for the casting process. This investment will enable the project teams to investigate ways to address the slag formation as well as contribute to improved extraction, reduction in air pollution by the generated fume, and simultaneously reducing oxidation of the melt.

Furthermore, this reduction in scrapped components will aid in the reduction of energy used and associated costs for reworking.

Cutting direct manufacturing costs will allow more profitable manufacturing at the factory, increase competitiveness in the market, and thus help increase Weartech International's turnover by up to 30%, not only through a more streamlined process but also through a reputation for high quality and consistent products.

Weartech employs approximately 10 people per £1M turnover, and the expectation is to increase the workforce at Port Talbot with additional operators and technical staff as a result of the collaboration with ASTUTE 2020.



Case Study: The Aluminum Lighting Company Ltd.

Lighting Column Manufacturer's Fruitful Industry-Academia Collaboration Leads to Spin Out Company

The Aluminum Lighting Company Ltd.

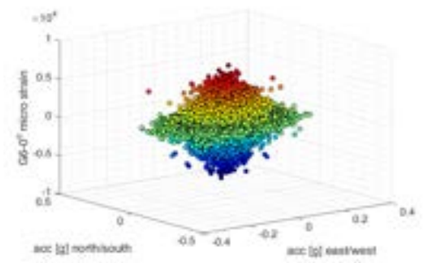
The Aluminium Lighting Company (ALC), based in Cymmer near Port Talbot, manufactures a range of aluminium lighting columns and pioneered the introduction of the benefits of extruded aluminium lighting columns into the UK infrastructure.

Continuing from successful collaborations during the 2010 –2015 funding phase of ASTUTE, ASTUTE 2020's collaboration with ALC aimed to identify more closely how a lighting column is actually performing in real time against its predicted level of performance.

"The strength of ASTUTE 2020 is that we can access theoretical expertise we haven't got and harness it to help provide commercial solutions to our industrial problems."

Craig Williams
Director, The Aluminium Lighting Company Ltd.

The aim of the project is the remote detection of whether a column is deteriorating structurally and better prediction of when a column may fail and thus would require replacing.



Challenges

Lighting columns are designed to British Standard EN 40-3-2&3. Once installed, the performance of the column naturally deteriorates over time due to corrosion, fatigue, foundation destabilisation and collision impacts.

ALC has identified a clear need for a robust method of monitoring column structural health, enabling clients to remotely assess the condition of individual columns.

The performance and structural condition of lighting columns are currently assessed using visual and physical inspection, as well as ultrasonic testing. While effective, these methods are time consuming and can cause service disruptions on roads, train lines, and pedestrianised areas.

ASTUTE 2020 supported ALC with a feasibility study during the initial stages of developing a concept for a column health monitoring system.

It was apparent that a large database of baseline data needed to be established to determine the behaviour of healthy lighting columns, to ensure that realistic threshold values can be set when the complete system is launched.

Solution

ASTUTE 2020 performed computational data analysis focussed on remotely monitoring lighting columns in real time.

Instrumented field tests on an existing column have provided measured surface stress values throughout the column height, which, together with structural finite element analysis, have been used to predict the stress levels throughout the structure and the fatigue performance of columns.

Establishing meaningful relationships between measured acceleration and the consequent stress in the column can be notoriously difficult. A variety of statistical techniques – e.g. correlations, principal component analysis and neural networks – have been used to identify these links.

The data will be used to identify those columns that have the greatest deterioration without the need for regular inspection. This will enable pre-emptive measures to be taken to replace the structure before any critical failures occur.

A state-of-the-art electronic device has been developed to collect data on the movement of columns undxer wind-loading. It is envisaged that such a device would become an integral part of ALC's future products and could be retro-fitted to existing lighting columns.

"ASTUTE 2020 R&D engagement with ALC was challenging, leading to extended fruitful collaboration driving the manufacture of the column health device for future applications."

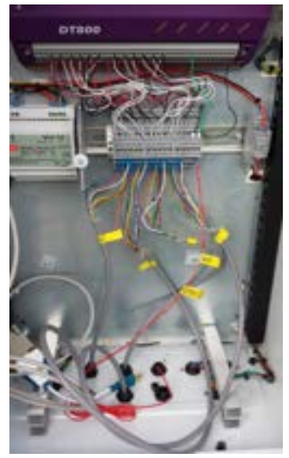
Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Impact

The proposed remote structural health monitoring system is a novel concept and it is understood that no equivalent system for lighting columns exists. Successful commercialisation of this concept could thus lead to a world-leading product and enable transformational benefits to ALC. A working model running a critical lifetime test is currently installed within a railway station.

With the development of the structural health monitoring system, ALC have incorporated a spin out company called 'Intelligent Structural Dynamics Limited' (ISD) and filed a number of patents on structural electronic measuring. As ISD expands, increased business and job opportunities are envisaged.

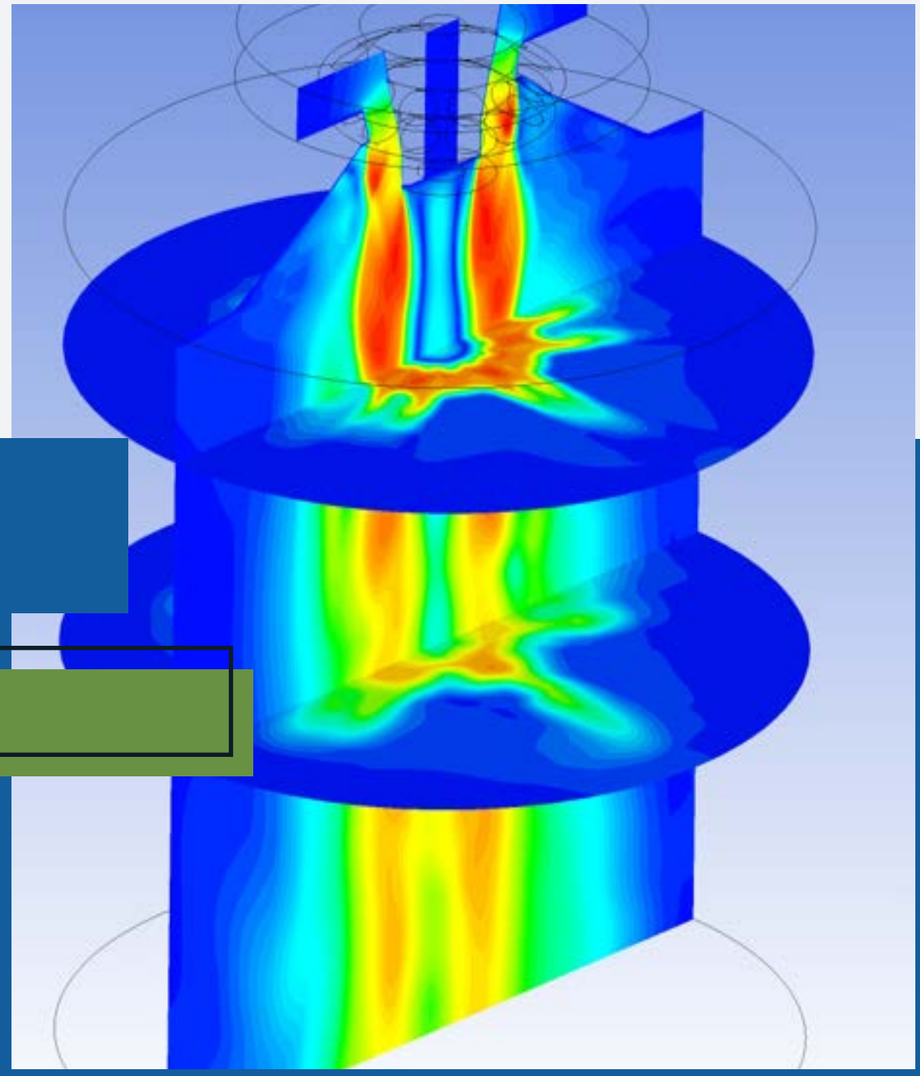
ALC column testing structure



Data logger connections

Computational Engineering Modelling

Enabling and improving manufacturing processes and manufactured products using computer simulation technology that reduces the need for costly trial-and-error approaches



Computational Engineering Modelling (CEM)
CEM is a valuable tool utilising simulation to understand and improve complex manufacturing processes and manufactured products. It minimises dependence on traditional trial-and-error approaches that are costly, in terms of staff time and materials usage, and often lengthy processes with an uncertain outcome.
Computational modelling offers predictive capabilities that can eliminate traditional approaches whilst lowering risk and shortening product lead and implementation times.

Complex Physical Phenomena
The capability and reliability of numerical simulations is dependent on an understanding of the physics that underpins it – heat transfer, gas and liquid flows, particle flows, structural mechanics, electromagnetic phenomena etc. Each can be simulated and combined in multi-physics models to understand their interactions and effects. These models can be applied to review a product's performance in its intended state of use and throughout the manufacturing process.

Swansea University
Swansea University has a worldwide reputation for its contribution to the advancement of Computational Engineering Modelling. The Finite Element Method – used for numerically solving differential equations arising in engineering and mathematical modelling – was developed into a widely useable tool by Swansea University Professor, Olgierd Zienkiewicz, in the 1960s. The Zienkiewicz Centre for Computational Engineering based in the Faculty of Science and Engineering is internationally acknowledged as the leading UK centre for computational engineering research.

Cardiff University
The Mechanics, Materials and Advanced Manufacturing department at Cardiff University conducts internationally recognised research in the field of Computational Mechanics. This is an important area of engineering that involves the use of computer models to understand real-world materials and processes.

UWTSD
UWTSD applies and develops non-destructive testing techniques to characterise the performance of materials and components relative to the Welsh manufacturing sector. They specialise in Ultrasonic, Magnetic Flux Leakage, Thermography, and Laser Doppler Scanning Vibrometry.

Case Study: TWI Ltd.

Academia Research Supports NDT Testing Specialists in Continuing to Promote Cutting Edge Engineering and Manufacturing in Wales

TWI Ltd.

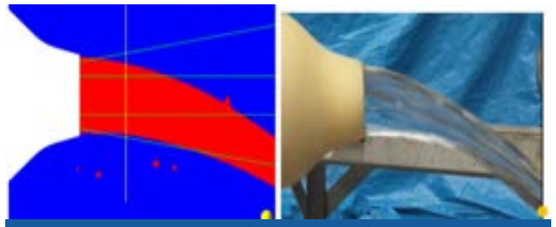
TWI Ltd. is a global company and one of the world's foremost independent research and technology organisations, specialising in welding, joining and allied processes, including Non-Destructive Testing (NDT). Established in 1946, TWI currently operates from five UK and 13 overseas facilities. Their Welsh Technology Centre, based in Neath/Port Talbot, specialises in the development and application of state-of-the-art NDT testing methods. To enable and enhance their NDT capabilities, TWI has developed a rapid NDT inspection system for complex, composite components, as part of the "IntACom" project.

TWI's "IntACom" NDT system comprises of two, 6-axis robotic arms, carrying ultrasonic probes mounted on top of water jets. The system uses water jets to transmit ultrasonic signals to the surface of a composite test piece, with the reflected signal providing information about its condition.

The water jet helps to deliver the signal to and from the surface of the test piece

For the most effective delivery and accurate receipt of the ultrasonic signal, a "couplant" water jet is required to be issued from the nozzle in a stable, laminar flow condition.

In the current system, distortion of the ultrasonic signal was attributed to turbulent water jet behaviour. Consequently, TWI sought assistance from ASTUTE 2020 who were tasked with optimising the flow dynamics of the water jet through the application of their Computational Engineering Modelling expertise, specifically Computational Fluids Dynamics (CFD). The resulting project was a collaboration between Swansea University, University of Wales Trinity Saint David (UWTSD) and TWI.



The VoF simulation of the issuing jet's behaviour

Challenges

TWI had established that the performance of their "IntACom" ultrasonic NDT device could be enhanced with an improvement in the transmission and receipt of the ultrasonic signal via the water couplant. The current water nozzle's configuration comprises of a tangential inlet to a chamber from which the swirling flow passes through a flow straightener section and finally into a converged profile which feeds the flow to an outlet.

Solution

To tackle the challenge, a novel area of research was identified that would require the development of a computational model to assess and ultimately optimise the flow dynamics of the couplant water through the nozzle. Several aspects were identified as being required in the modelling process:

- A simulation of the flow within the original nozzle design to assess and visualise the flow's behaviour prior to issuing from the nozzle;
- In addition to a model of the flow inside the nozzle, a modelling technique was required to capture the free surface behaviour of the flow on exiting the nozzle;
- Optimisation of the flow straightener section;
- An assessment of the inclusion of a sponge section into the device to aid in linearising the flow and,
- Optimisation of the outlet section's nozzle shape in order to enhance the laminar flow condition.

Swansea University developed a computational fluid dynamics (CFD) model of the flow region inside the nozzle. This allowed for the visualisation of streamlines and identified that there were aspects of the original nozzle's configuration that were contributing to non-laminar flow features. To assess the behaviour of the flow on exiting the nozzle a Volume of Fluid (VoF) modelling approach was implemented that tracked the front of the water moving through the air and helped to assess the distance and stability of the travelling water jet. Several modifications to the orientation of the tubes in the flow straightener section were considered, as well as the inclusion of a layer of sponge, simulated by the application of a porous model. Additionally, a novel outlet nozzle shape was suggested and modelled and experimental work was validated by TWI & UWTSD. From the simulation results, it was possible to create an optimised nozzle that met TWI's requirement of improved laminar behaviour.

"Excellent example of combined sharing of expertise between UWTSD & Swansea University to further research TWI's robotic Ultrasonic NDT capabilities."

Nick Couling
Research Engineer, TWI Ltd.

Velocity through the flow straightener section comparing optimised tube configurations

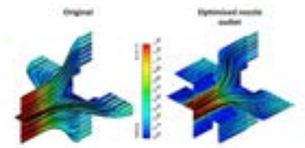
Impact

TWI are fully committed to enhancing the performance of their IntACom NDT system and intend to undertake a full testing program with the new water nozzle configuration. The engagement of both TWI and the ASTUTE 2020 team has led to extensive, mutually beneficial knowledge exchange.

As a direct result of the collaboration, two new jobs have been created at the Port Talbot facility, allowing TWI to modify the current design of their ultrasonic water couplant delivery system in the IntACom device, which will result in:

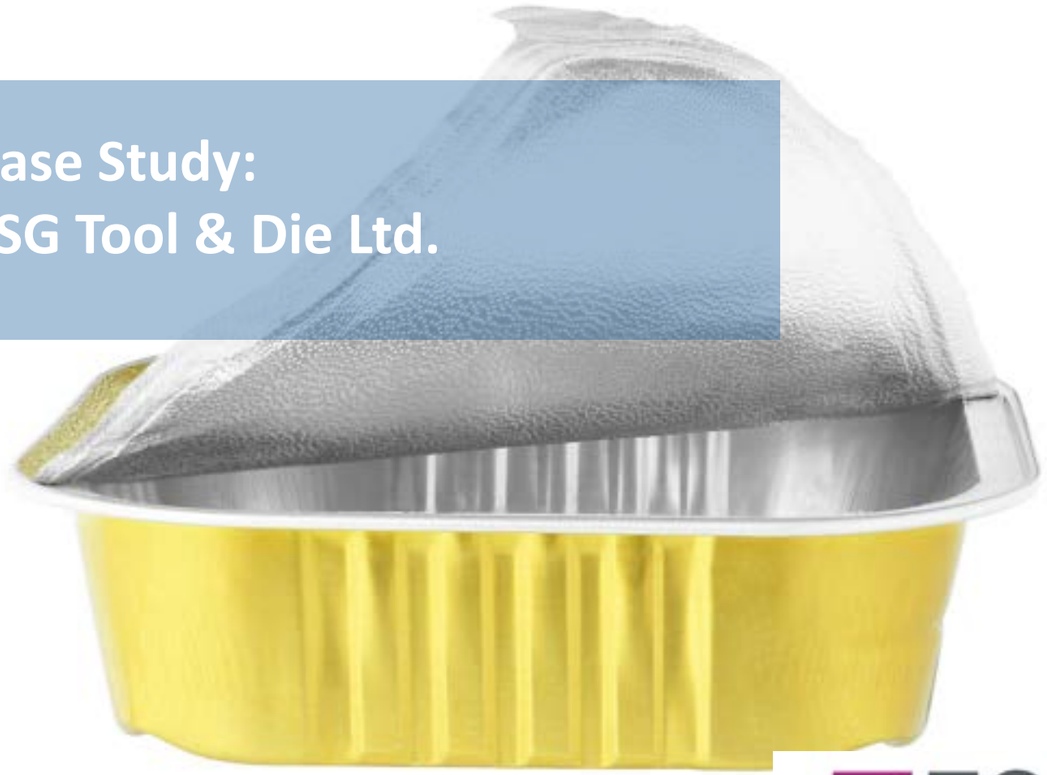
- More accurate delivery of the ultrasonic signal and interpretation of results.
- An enhancement of the imaging capabilities and defect classification of TWI's IntACom NDT system.
- The potential to generate system and software sales, in addition to increased consultancy profits for TWI from the IntACom System.
- The avoidance of unnecessary full repairs offers an environmental impact of reducing consumption of materials.
- With an improved, more stable water jet the distance between the nozzle and the test component can be increased, allowing examination of structures with more complex geometries and areas which were previously inaccessible.

The benefits of this collaborative project will ultimately allow TWI to remove significant barriers to the uptake of high value automated NDT inspection systems. Their application will benefit many industries as the use of composites is growing exponentially and the ability to reduce inspection/service times will be of great benefit. To have novel NDT technology of this type based in Wales will continue to promote cutting edge engineering and manufacturing within West Wales and the Valleys.



Velocity streamlines for the original and optimised nozzles

Case Study:
FSG Tool & Die Ltd.



FSG TOOL & DIE LIMITED

Industry-Academia Computational and Experimental Investigations into a Mould Tool for Aluminium Food Containers

FSG Tool & Die Ltd.

As toolmakers, Rhondda-Cynon Tâf based FSG Tool & Die Ltd. (FSG) has designed and built production systems for market-leading manufacturers for the last 30 years, including the design of pressing tools for the Aluminium forming industry.

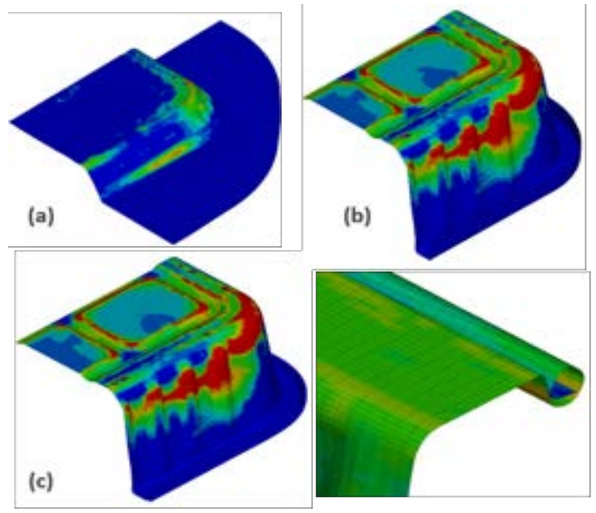
Aluminium containers are formed by combining mechanical and air pressure to force a foil blank into a shaped die cavity.

FSG sought the support of the ASTUTE 2020 team to improve the performance of the press tooling components used in the manufacture of standard and smooth wall aluminium food containers such as take-away food, frozen food, desserts and airline meals.

The containers are formed in three distinct steps: an initial pressing of the blank to form the basic shape with a lip, “wipe down” to turn the edge of the lip back on itself and finally, curling to neaten the lip edge. This is done at a rate of approx. 65 trays a minute. At this high speed, it is difficult to identify which aspects of the process are affecting the quality of the containers. Using computational simulation and material testing techniques, the ASTUTE 2020 team were able to investigate each stage of the process in detail.

“FSG has used the Computational Simulation to develop/train our toolmakers, greater knowledge sharing and the deployment of expertise to resolve technical challenges.”

Paul Byard
Managing Director, FSG Tool & Die Ltd.



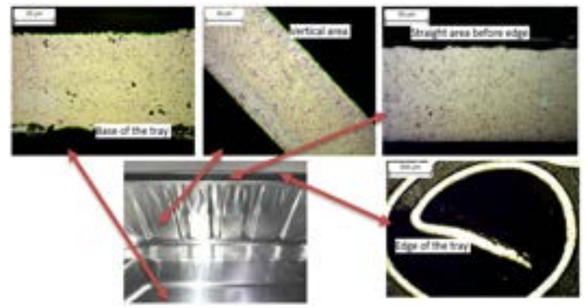
Deformation of the aluminium sheet at different stages. (a) Deep drawing (b) Wipe down (c) Curling

Challenges

The main challenge focused on resolving a common defect known as “earring” in smooth-walled aluminium containers. The defects occur randomly at the corners of the containers, with the problem thought to be with the curling process. Although small, this irregularity at the edge may prevent an effective seal being achieved if a lid or film is added to the final container leading to contamination or spillage of the contents.

Solution

Computational Engineering Modelling and Advanced Materials Technology were the main areas of expertise that the ASTUTE 2020 team brought to this project. The research involved understanding the material characteristics of the foil to determine if the properties were uniform in all directions (isotropic) or whether they had been affected by the manufacturing of the foil or container. The material was sampled for tensile testing at angles of 0, 45 & 90O to the rolling direction in both the finished tray and the base material to determine any bias (anisotropy). Using this data, ASTUTE 2020 developed a computational model that could mimic the occurrence of the curl defect, and then explore the parameters to be changed to eliminate this defect. The computational model could successfully simulate all three manufacturing steps i.e. deep drawing, wipe down, and curling and the outputs gave directions for modifications to be made to the process to improve the quality of the containers.



Microstructure feature of the tray

Defects at the corner of (a) the manufactured aluminium food container and (b) the computational model

Impact

This collaboration has allowed FSG to increase their technical understanding of the critical features of the tool production; improving the reliability of the container quality for the manufacturers and customers.

The research into the containers has allowed FSG to invest in the development of the new tool, creating new products, process and services to the firm. The improved knowledge and techniques developed from this research project will lead to increased production and orders, creating opportunities to grow the workforce at FSG at a later stage.

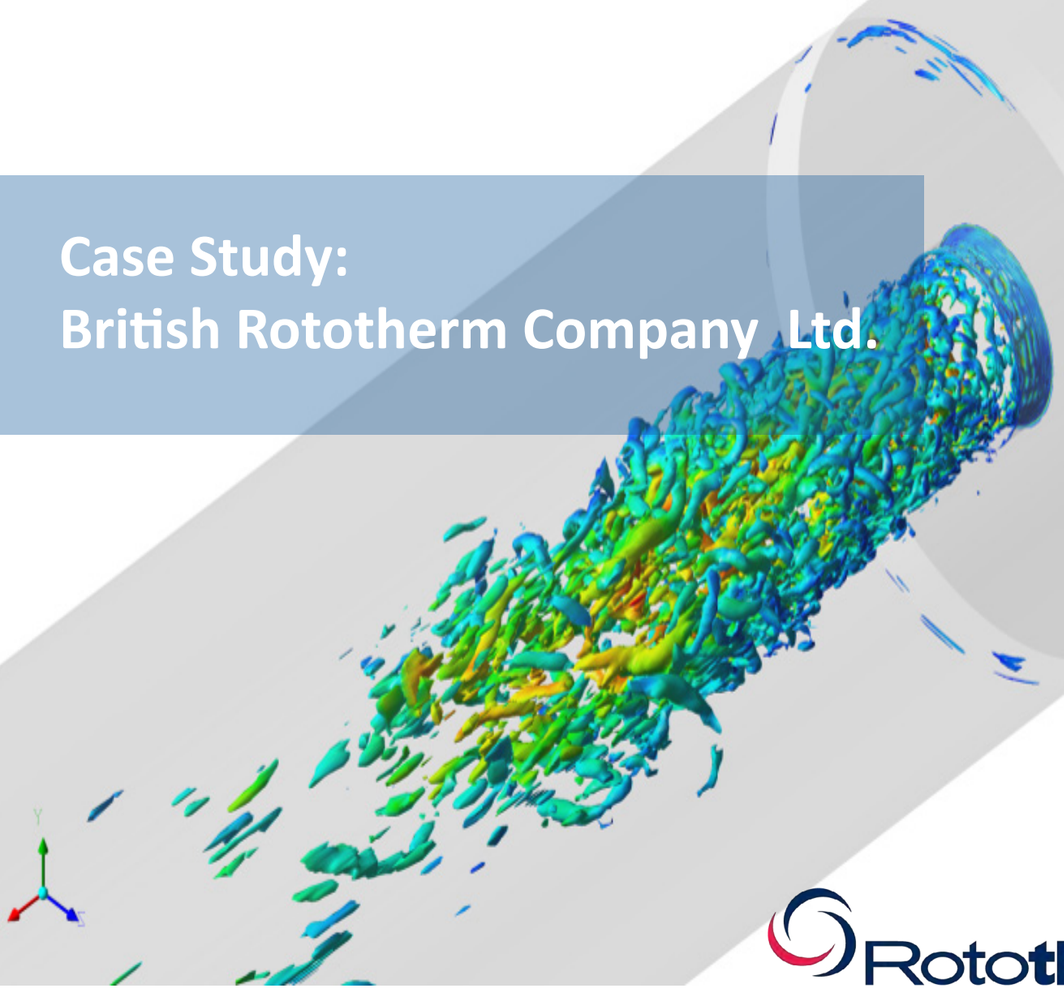
With increased market demand for deeper and multi-compartment containers, FSG is well-positioned to satisfy these customer requests and take a leading role amongst toolmakers in Europe.

FSG has continued to operate throughout the COVID-19 pandemic, repurposing their production lines to manufacture tools for visor products for the medical, pharmaceutical and food supply chain industries; highlighting FSG’s R&D capabilities to adapt production within a short space of time to support the fight against COVID-19.

“ASTUTE 2020’s R&D engagement with FSG was challenging, leading to fruitful knowledge exchange for both FSG and ASTUTE 2020.”

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Case Study:
British Rototherm Company Ltd.



Major Port Talbot Manufacturer of Industrial Instrumentation Researches World Leading Capability in Noise Level Prediction

British Rototherm Company Ltd.

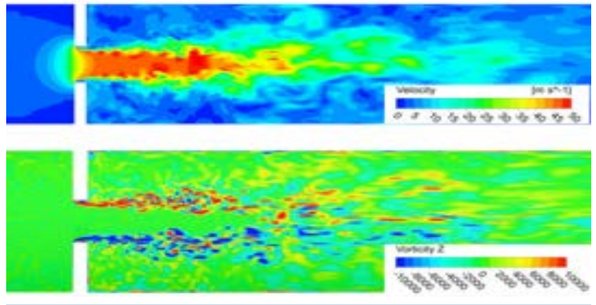
The British Rototherm Company Ltd., based in Neath/Port Talbot, is a global company that designs and manufactures a range of precision instruments for the oil, gas and other processing industries.

Their customer base, particularly in the Oil & Gas and Refining/Chemical market, have had to settle for second best solutions due to limitations on calculations used for designs. For this reason, British Rototherm wished to develop market-leading capability in noise prediction for orifice pressure reducers used for managing pressure drops of liquids and gases in pipelines.

ASTUTE 2020 has been working with British Rototherm to demonstrate the acoustic modelling capability of numerical modelling tools to predict noise levels from the pressure reducers, bringing together the company's expertise in flow control and measurement with the ASTUTE 2020 team's expertise in computational modelling.

"The ASTUTE 2020 team was challenged to investigate the noise levels and sources from pressure reducers. This was a complex problem to simulate and required the team to develop skills in the area of acoustic modelling. Additionally, an experimental rig was developed for validation. The outcome was a realistic model of the British Rototherm system which they can used for product optimisation."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020



Velocity Magnitude & (Bottom) Vorticity Contours

Challenges

There are no current design or technical practices that address noise level predictions. There is increasing demand from customers for accurate data on the noise generated by pressure reducers, as this has significant implications on health and safety in the working environment, and vibration of the pipe network leading to damage in the network. Through effective collaboration, ASTUTE 2020 and British Rototherm have developed noise prediction capability based on advanced computational engineering modelling techniques to identify a solution for the following objectives:

- The development of an experimental protocol for the investigation of noise levels and noise sources form pressure reducers and cross-reference initial noise level findings against predictions based on British Standard BS EN 60534-8-2011.
- Scope of numerical modelling methods for the prediction of noise emissions.

Solution

The research included experimental and numerical work. ASTUTE 2020 carried out research on the monitoring locations for temperature, volumetric flow rate and pressure, identified through steady-state numerical simulations. British Rototherm commissioned and invested in an experimental loop rig while ASTUTE 2020 assisted with creating an anechoic chamber to house the test rig.

The modelling feasibility for flow and acoustics custom-designed to ensure that the complex phenomenon could be captured as well as coupling of the pressure imposed by the fluid on the pipe surface into the vibro-acoustic solver. This research was paramount to ensure the smooth transition of the computational methodology when the desired operating conditions were decided.

Impact

The collaborative research on this project has supported British Rototherm to achieve market-leading capability in noise prediction for orifice pressure reducers.

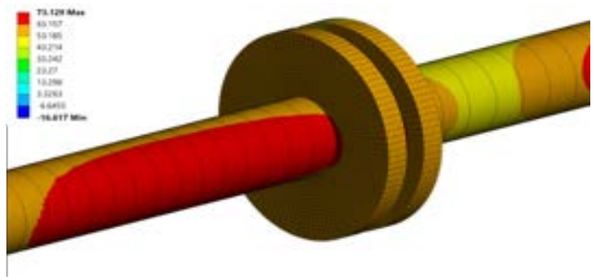
The company recognised that, in order to market and maximize the unique capability resulting from the project, an increase in British Rototherm's workforce was required to bring additional knowledge and skills to the team. Five roles were created at British Rototherm which enabled them to meet impending customers' orders.

British Rototherm have invested heavily to facilitate a successful outcome of the collaboration with the purchase and installation of a custom-designed 'Pressure Test Rig', testing machinery that is primarily used to assess the capability and performance of components.

The computational modelling enhanced the company's process in understanding the noise phenomenon and assisted in tuning the noise predictive tool that they were developing to fulfil the British Standards requirement on noise levels for industrial applications.

In addition, an M2A student was embedded at British Rototherm to undertake complementary research activities linked to the modelling of noise generation based on the planned experiments and ASTUTE 2020's modelling findings, making this collaboration a great example for the complementarity of ERDF and ESF funding for the economic benefit of local industry.

In 2019, British Rototherm were shortlisted for the 'Operational Excellence' award at The Manufacturer MX Awards, supporting diversity and innovation within UK manufacturing, won the Innovation of the Year award at the South Wales Business awards and were runner up at the Make UK Innovation awards for Wales.



Sound Pressure Level Contour

Case Study: Wall Colmonoy Ltd.

Optimisation of Metal Powder Particle Size Distribution from Wall Colmonoy's Gas Atomisation Process

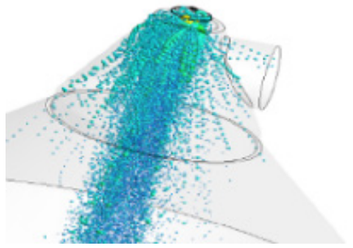
Wall Colmonoy Ltd.

Wall Colmonoy is a globally leading materials engineering group manufacturing Colmonoy® surfacing and Nicrobraz® brazing products, precision castings, coatings, and engineered components across aerospace, automotive, glass container, oil and gas, mining, energy and other industrial sectors. An important activity is the production of fine metal alloy powders used in surface coating and brazing. Determination and control of the metal powder Particle Size Distribution (PSD) is an engineering challenge due to the complex multi-physics phenomena involved in the atomisation of the molten alloy by high velocity gas jets.

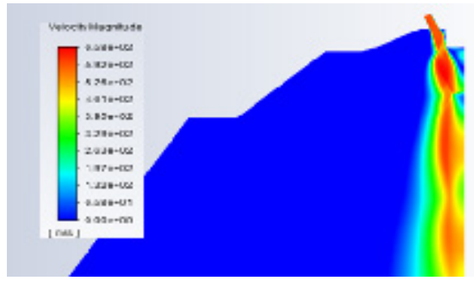
The collaboration with ASTUTE sought to achieve a better understanding of the physics of gas atomisation and the relationship between process conditions and metal powder PSD.

"This collaborative research ASTUTE2020 project with Wall Colmonoy has been an excellent opportunity to deploy team expertise in advanced computational fluid dynamics and machine learning capabilities. This helped the company in upgrading their gas atomisation facility and reducing waste."

Dr Fawzi Belblidia
Technical Director, ASTUTE 2020



CFD Model Particles diameter size



3D simulations Velocity Field

Solution

Wall Colmonoy conducted planned process runs to capture the data needed to determine the relationship between process conditions and PSD. Together with ASTUTE 2020+, they undertook a thorough review of the operational Gas Atomisation process focusing specifically on the gas extraction system that was in place. Modification suggestions were made to improve control over the atomisation process conditions.

Computational Fluid Dynamics (CFD)
ASTUTE 2020 used computational fluid dynamics to simulate the flow field of gas and molten alloy inside the atomization chamber and the formation of metal particulates. A three-dimensional model captured important flow features such as the near field jet expansion caused by high-speed gas jets, and the flow reversal that causes satellite particle formation. Furthermore, the CFD analysis showed the effect of different exhaust pressures and exhaust port locations.

Primary particle breakdown could not be accounted for using the available computational resources, but the secondary break-down was modelled using the Kelvin–Helmholtz Rayleigh-Transport model. Reasonable agreement with production PSD data was achieved.

Wall Colmonoy undertook experimental work to implement the research recommendations into their process. They conducted test runs of focusing on process conditions and nozzle geometry, and fed the performance of the suggested modifications back to ASTUTE.

Insights from Machine Learning
Based on the initial dataset provided by Wall Colmonoy, ASTUTE also developed the Wall Colmonoy Machine Learning Tool (WCMLT) – an artificial-intelligence-based software able to assist our industrial partner in predicting the PSD from the gas atomisation process without running additional experiments.

The predictions rely on a machine learning model based on the PSD data collected in previous batches and extrapolates/ interpolates that knowledge for new scenarios.

This approach is a modern alternative to rule-based systems and can be applied to virtually any kind of dataset.

Impact

The collaborative project between Wall Colmonoy Limited and ASTUTE 2020+ has enabled the company to progress in their research and development.

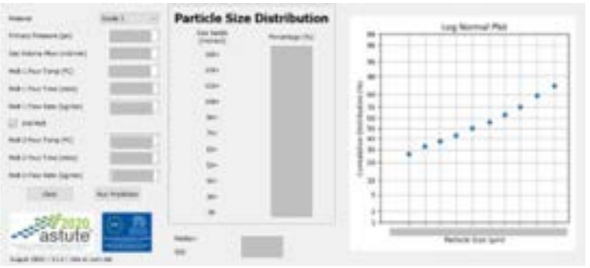
Relationships between the atomisation process conditions and the achieved particle size distribution of alloy powders have been established and clarified.

The CFD simulations allowed Wall Colmonoy to optimise the atomisation tower geometry, improving the stability of the atomising process and the morphology of the powers produced.

The WCMLT machine learning tool achieved a median percentage error of 6% for the particle size distribution prediction. For such a complex process, this accuracy is attractive as it allows the company to better understand and quickly predict the relationship between process conditions and product.

"This project has enabled Wall Colmonoy to further understand the complex multi-physics atomising process and optimise the key process variables. The Machine Learning Tool allows us to predict and optimise the particle size distribution without incurring the cost and time of processing physical batches."

Tom Roblin
Project Engineering Manager, Wall Colmonoy Limited (UK)



Wall Colmonoy Machine Learning Tool

Case Study: Styrene Systems Ltd.

Engineering Company Seeks Industry-Academia Collaboration To Develop Advanced Heat Densification Technology To Recycle Waste Expanded Foam Material

Styrene Systems Ltd.

Styrene Systems Ltd. is an SME based in Pembrokeshire. The company designs, manufactures and sells machines to compact expanded foam packaging and industrial process waste such as Expanded Polystyrene (EPS), Polypropylene (EPP) and Polyethylene (EPE). The product range includes screw and hydraulic compaction technology as well as heat densification.

Most expanded foam material is 100% recyclable, but due to its light weight (up to 98% air) it is generally considered uneconomical to collect for recycling and is largely mixed with other waste destined for landfill or incineration. This incurs high disposal costs and the loss of a non-renewable resource. The environmentally sound alternative is compaction which creates a dense block of material, as little as 10% of the original volume, ready for recycling and re use in the circular economy.

Working with the ASTUTE 2020 team, the research project focussed on performance improvement of the H100 heat densification product. This utilises a complex combination of auger and heat profile technology with a software configurable process to optimise throughput and quality of compacted material. The H100 will compact all expanded foam but is primarily aimed at EPP and EPE packaging which cannot be compacted with screw or hydraulic methods.

EPS densified using mechanical compression and heat

Challenges - Optimisation Of The EPS Densifier

The EPS foam undergoes a number of processes within the device: shredding, mechanical compaction and heating. The resulting material (shown in the figure above) is dense and now is a viable recyclate with commercial value. The optimisation of the process parameters and their interaction was vital to ensure a consistent product and develop reliable densifying machinery capable of high production throughput.

Solution – Experimental Based Statistical Analysis

Calling upon ASTUTE 2020's expertise in the mechanical, fluidic and thermal behaviour of plastic foams a "Design-of-Experiments" approach was used to carry out measurement trials to identify the most influential parameters during the processing operation.

Working closely with the Company and observing the densifier in operation, a number of recommendations was made in the light of current published research. Changes to the auger dimensions and adjustments to other geometries within the device were proposed. Modifications to the measurement sensors were also suggested to ensure that the control system was sufficiently responsive to accurately reflect the conditions within the machine.

Time was scheduled into the project plan to enable changes to be made and then additional validation testing was undertaken by the company to assess whether the predicted improvements had been achieved.

In addition, a computational simulation of the whole process was proposed, but at this stage there was insufficient data on the through process material and mechanical behaviour of the EPS to establish such a model with any confidence.

"The research collaboration has broadened our understanding of the science behind the application and linked this to a structured approach to analysing the results. The breadth of knowledge and support provided by ASTUTE 2020".

J Cable
Director, Styrene Systems Ltd.

Impact

The collaborative research project has examined the processes that the foam plastic material undergoes and examined the current technology in use to solve problems inherent from the original approach. The experimental based statistical analysis of the machine process elements and parameters has defined the importance, relevance and the impact that change has on individual stages of the total process.

One of the major benefits of this work was the transfer of knowledge to the Company through interaction with the ASTUTE 2020 team. This knowledge can enhance future product developments and allow the company to upskill their staff.

This project has assisted Styrene Systems to draw closer to their objective of preparing a package of detailed plans and expertise that can be sold or licensed to third-party manufacturers for the large scale production of these devices.

"The project highlighted that there is a clear environmental and sustainable benefit of recycling foam material through the process developed by Styrene. The enhancement of this technology with the potential of 98% volume reduction could easily be introduced within the circular economy".

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

MARINE POWER SYSTEMS

Case Study:
Marine Power Systems Ltd.

Swansea-Based Collaboration Leads to Wave Energy Innovation

Marine Power Systems Ltd.

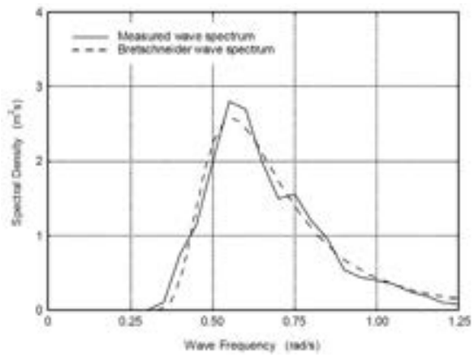
Wave Energy Converter (WaveSub) model being towed to site

Marine Power Systems (MPS), based in Swansea, is developing a Wave Energy Converter to address the challenges of extracting wave energy at viable cost. Computational research of the float structure is necessary to allow MPS to assess the suitability of the components and significantly de-risk the build and test stages. ASTUTE 2020 is working with MPS on generating suitable computational models using information supplied by MPS along with performing finite element analysis on the structure.

The WaveSub consists of a power capturing float which is tied by multiple flexible lines to a large barge like reactor.

"The device that Marine Power Systems is developing is incredibly innovative and we are very supportive of the company's work. Being brought in to engage with the Marine Power Systems team and collaborate on finite element simulations of the composite float is an exciting project and we look forward to working with Marine Power Systems until the float is ready for manufacture when the deployment stage is reached."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020



The lines are connected to a hydraulic power take-off system which is used to capture energy from the relative movement between the float and the reactor, which is then converted to electricity. There are indications that the proposed device has the potential to compete favourably with other available renewable technologies.

Challenges – Wave Energy

The proposed energy harvesting device relies on sea waves that do not fade away when the wind stops blowing, offering a level of consistency and an average power density (of about 2-3 kW/m2) superior to that of wind (0.5 kW/m2) and solar energy (0.1-0.3 kW/m2). MPS have conducted scaled sea trials and tank testing, and sought support from ASTUTE 2020 in performing computational modelling of the device when immersed in sea water.

The float is manufactured locally by a private company (Camplas Technology Ltd.). It is formed of a continuously wound glass reinforced composite construction with stainless steel bolting plates woven into the float walls. The float is attached to a barge (including the energy harvesting devices) via cables, with the fastening line tension being a direct result of net float buoyancy on the submerged float.

Solution– Numerical Analysis

Finite element analysis has highlighted the fact that the WaveSub is capable of handling the external forces experienced under working conditions. The results of this collaboration will allow confidence that the design is fit for the intended world first application and highlight improvements that could be made to the full scale device.

As a result of the collaboration with ASTUTE 2020 at Swansea University on the WaveSub, MPS were declared the winners of the Research and Development award category at the Insider's Business and Education Partnership awards in 2016 at Cardiff's Marriott Hotel. The local collaboration between academia and industry along with the potential global impact of the Wave Energy Converter proved favourable with the judges.

"We are reaching some exciting milestones in the development of our technology, specifically the deployment of a quarter-scale prototype WaveSub. We are thrilled to be liaising with ASTUTE 2020 for advanced computational modelling of the float.

With the prestigious skills and facilities available from ASTUTE 2020 at the new Swansea University Bay Campus, as well as its philosophy of innovation and advancement, we have full assurance that the research being produced by ASTUTE 2020 will confirm that our design for a power take off float is fully fit for purpose."

Dr Gareth Stockman
Chief Executive Officer, Marine Power Systems Ltd.

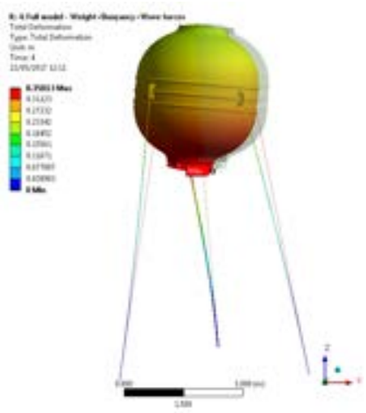
Impact

The WaveSub development is an excellent example for the complementarity of different funding streams: support through ASTUTE 2020 (ERDF Research and Innovation) together with £2.5M of ERDF (Renewable Energy and Energy Efficiency) and £200k of energy catalyst funding from Innovate UK for the modelling, design, build, test and validation has enabled MPS to progress their device from concept to prototype.

MPS have now completed a 1:4 scale WaveSub and it will be tested under laboratory conditions and then later under sea conditions. It is an important step in the journey towards commercialisation of the Wave Energy Converter.

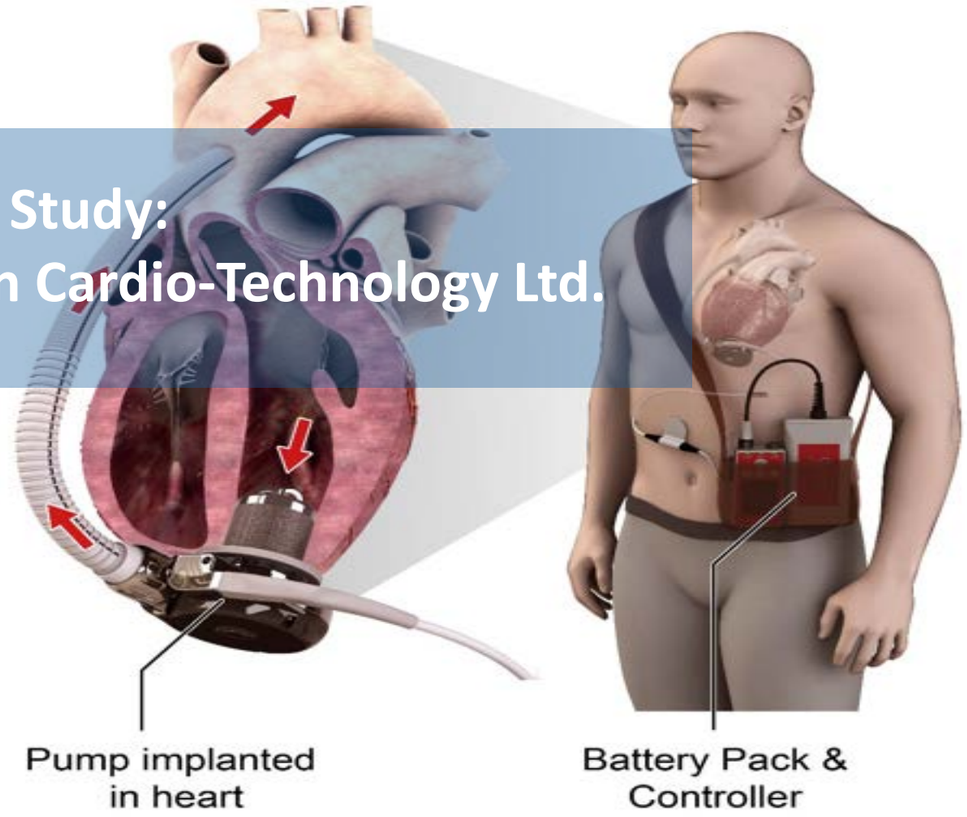
The WaveSub technology being developed by MPS has huge potential to contribute to energy security targets (wave power generating 10% of the world's electricity by 2050) and could reduce reliance on unpredictable and non-renewable energy sources.

With the continuing developments at MPS and within the wave energy sector, MPS have expanded their workforce by appointing an additional engineer, assisting with further developments of the WaveSub.



Full model of float– weight, buoyancy and wave force

Case Study:
Calon Cardio-Technology Ltd.



Next Generation of implantable heart pumps ready for clinical trials with support from industry-academia collaboration

Calon Cardio-Technology Ltd.

Calon Cardio was founded in 2007 and is located at the Institute of Life Science at Swansea University. Calon Cardio is developing the next generation of implantable blood pumps for the treatment of advanced chronic heart failure, the MiniVAD™, Miniature Ventricular Assist Device.

"Calon receives excellent support from ASTUTE 2020, ASTUTE 2020 provides the latest in CFD technologies to facilitate the development of our life-supporting MiniVAD system."

Stuart McConchie
CEO, Calon Cardio-Technology Ltd.

The full system comprises of:

1. The MiniVAD™ pump, which is being developed for implantation directly in the left ventricle of the failing heart to help provide adequate blood supply to the body, alleviate the debilitating symptoms of heart failure and improve quality of life.

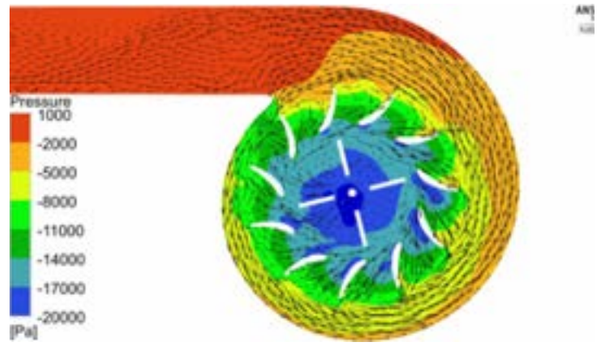
2. A controller, designed to be simple to use and easy to manage, and a compact wearable battery pack.

3. Additional devices for monitoring and support.

The Company's intent is to apply novel technology and design to produce a VAD with clear advantages over existing approaches including less invasive surgery, low blood damage, reduced thrombus formation and a control system optimized for quality of life.

"The collaboration between ASTUTE 2020 and Calon Cardio-Technology is a testament to the creative and successful application of CFD technology facilitating the optimisation of ventricular assist devices and enabling Calon to meet their ambitious targets to produce a world-class device that will improve the quality of life of many patients around the world."

Dr Haitham Yousef
Senior Technical Manager, ASTUTE 2020



Challenges

ASTUTE 2020 is collaborating with Calon Cardio on optimisation of the MiniVAD™. The aim is to achieve the following goals:

Suitability: the pump must provide the required blood flow rate to a wide range of patients at different activity levels (e.g. sleeping, reading, exercising).

Reliability: as a life support system, the pump must operate consistently 24/7 potentially for the life of the patient.

Stability: the pump must provide near silent and vibration-free operation.

Size: the overall layout must be very small and with low weight for ergonomic placement in the heart and chest cavity.

Cost: cutting edge manufacturing and assembly methods to substantially reduce cost of goods.

Blood damage: novel blood flow path that is intended to reduce the risk of blood damage and thrombus formation.

Solution

To achieve these ambitious goals advanced Computational Fluid Dynamics (CFD) technologies and sophisticated in-house post-processing tools were utilised. Multiple CFD simulations were employed to gain different insights into the pump performance and contribute towards its optimisation:

Flow simulations to construct the pump's characteristic curves (pressure head-flow rate curves) and estimate the pump's hydraulic performance.

Lagrangian particle tracking simulations to estimate the normalised index of haemolysis using exposure time and scaled shear stresses along particle tracks.

Eulerian scalar transport simulations to simulate dye displacement through the pump and visualise the pump's dynamic flow field for identifying and resolving flow recirculation areas where thrombus is highly likely to form.

High resolution transient flow simulations to estimate axial and radial loading on the impeller to help predict the rotor stability.

Coupled thermal flow simulations to estimate the temperature profiles and ensure heat generated during pump operation does not damage the myocardium or the blood.

Pulsatile flow simulations to study the effect of pressure variation across the pump (left ventricle and Aorta) on the pump's hydraulic performance.

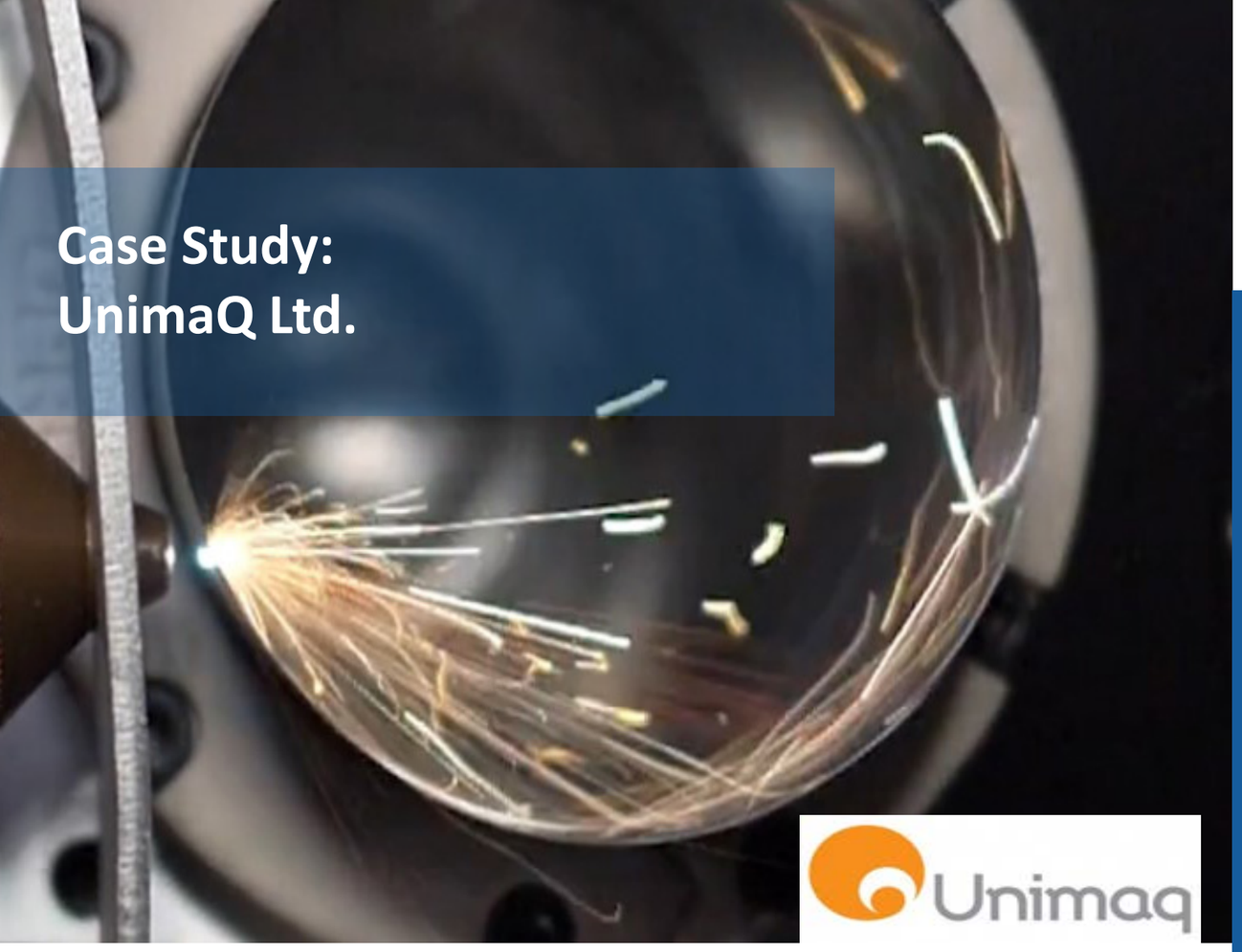
"Great team work and technical expertise through ASTUTE 2020, with every job delivered with unfailing commitment and passion."

Alessandra Molteni,
CFD Project Leader, Calon Cardio-Technology Ltd.

Impact

CFD is used to simulate the intricate blood flow inside the pump and acquire valuable information to enable Calon Cardio to successfully optimise the MiniVAD™ and achieve their goals towards the treatment of advanced heart failure.

The collaboration between ASTUTE 2020 and Calon Cardio resulted in attracting private investment that will enable the clinical trials to start in 2018 and as a result Calon expects to double the size of the company.



Case Study: UnimaQ Ltd.

Research into Improving the Laser Precision Cutting of Thin Aluminium Cylinders

UnimaQ Ltd.

UnimaQ is recognised as a global leader in manufacturing high-speed beverage can decorating machinery and equipment. The company is also committed to designing next-generation can making equipment that will not only deliver greater processing flexibility but also raise efficiency levels and reduce energy consumption.

They are currently developing an innovative laser can trimming machine and have part-created a functioning prototype. Their target is to develop the prototype into a product ready for manufacture and commercial sale, however, further investigation needs to be conducted to confirm its viability before a commercialisation phase be considered.

"ASTUTE2020 R&D engagement with UnimaQ was challenging, leading to extended fruitful collaboration driving the laser material processing technologies."

Dr Fawzi Belblidia
Technical Director, ASTUTE 2020

"The Swansea University Team has been using CFD modeling in a complex dynamic very effectively. The excellent communication and collaboration with our team resulted in a solution we otherwise would not have found."

B. de Jong
Director, UnimaQ.

Flow patterns of dust particles in the extraction systems

Challenges

UnimaQ collaborated with ASTUTE 2020 on a research-based approach to the development of their laser can trimming machine.

A literature review found that recently published research on the feasibility of laser cutting metal sheets presented contradictory arguments. With this in mind, the collaborative project decided to address and test the following research questions:

- What is the best method to effectively extract the dust particles generated during the laser cutting of thin aluminium cans?
- What are the mechanical and thermal material properties of formed aluminium cans?
- What are the cutting kerf's, morphology, and fluid dynamic properties of the dust generated during the laser cutting process?

Solution

Through the collaboration, both parties acquired new knowledge about heat conduction, material flow, and phase evolution during laser cutting of aluminium alloy, and developed the practical skills to optimise the process.

Computational modelling was used to evaluate flow pattern and analyse how efficient the collection of aluminium particles was in the dust extraction system. From the findings, the team developed the practical abilities to reduce dust generation during the cutting process and were able to suggest suitable equipment for the extraction of any unavoidable dust and fume emissions created. They also optimised the laser cutting processing parameters and the extraction and filtration system which contributed to achieving faster cutting speeds.

To validate the experiments, UnimaQ made the necessary adjustments to their prototype and captured flash images during the laser cutting process to display the flow pattern of the generated dust particles. The prototype extraction system was tested by UnimaQ under different laser powers, air nozzle velocities, and nozzle positions.

ASTUTE 2020+ also collected samples of cut cans to analyse the morphology, cutting kerf, and shape and size of the generated dust particles which stick on to, and contaminate, the cans' walls. Their findings were shared with the company to provide them with a solid understanding of the particles' fluid dynamics that can be incorporated into, and influence, any future product development.

Impact

The collaborative research project not only successfully identified the dust generation issues related to the cutting process, but was able to mitigate and overcome them.

- The project has delivered several positive impacts to the company, including:

- Development of a new sideways extraction system that improve extraction efficiency by a factor of 9.

- Mitigation of the possible fire risk associated with excess dust generation

- Mitigation of the health risk posed by dust particles to staff working with the machine

- Reduction in material waste and usage in comparison to traditional knife cutting

- Company technology readiness level raised to TRL7 (being as close as possible to the realistic environment observed in the manufacturing process within the company) from TRL 4/5 (demonstrate a fully functional prototype material validated with lab trials).

- Ability to embed the research elements from this project into their future product development

- Ability to move their product into a commercialisation phase following several years of unsuccessful trial and error pre-collaboration.

Case Study:
Kautex Textron CVS Ltd.

KAUTEX
A Textron Company

Creation of jobs and expansion of product range for Kautex through Industry-Academia collaboration

Kautex Textron CVS Ltd.

Kautex Textron CVS designs and manufactures windscreen washer systems for the automotive industry and is one of the largest automotive suppliers in the world in terms of sales volume.

With 31 facilities in 14 countries, Kautex is committed to continued developments and producing new and innovative ways of providing their customers up to date systems and solutions within the automotive industry. Kautex has identified the demand for innovative washer systems that utilise fluidic nozzles to control pressures, the flow of fluid and reduce water usage.

To fulfil this requirement, Kautex historically purchased different fluidic nozzles from a third party supplier since the company did not have the technology or knowledge necessary to be able to design their own nozzles.

Continuing from a series of successful collaborative projects during the 2010 – 2015 funding phase of ASTUTE, Kautex was able to utilise the knowledge gained from the previous projects to develop two of their own nozzle designs. To further increase Kautex's understanding of the key parameters of the nozzles, a collaborative project on the liquid flow patterns was carried out with ASTUTE 2020.

"The quality and relevance of the work undertaken by ASTUTE 2020 was very important to the development of the fluidic chip design and has given good confidence in going forward with a manufactured saleable component."

Chris Davies
Engineering Manager, Kautex Textron CVS Ltd.

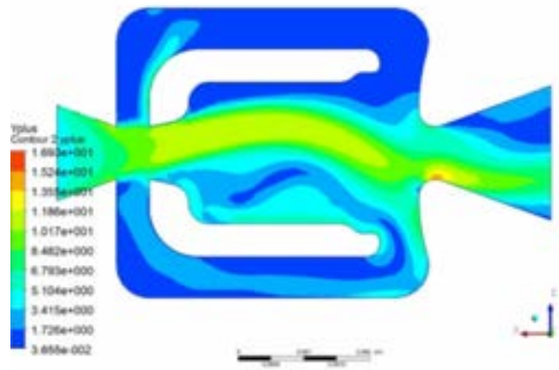


Image: CFD Simulation Result showing Velocity Contours of flow inside microfluidic nozzle developed by Kautex Textron CVS Ltd.

Challenges

Kautex have identified further investigations required to gain confidence in the flow characteristics of their fluidic nozzle designs, and determine whether changes should be made to improve flow characteristics before the nozzles are developed into mass-produced products.

The primary aims of this collaborative project were to allow Kautex to gain further knowledge to develop their nozzles into saleable products:

1. Analyse flow characteristics of the fluidic nozzles through Computational Fluid Dynamics (CFD).

2. Increase understanding of the key parameters of the fluidic nozzles to meet the required characteristics of a specification.

Solution

To confirm the performance of Kautex's nozzle designs, high-speed photography and Computational Fluid Dynamics (CFD) analysis were exploited. Through this combination of experimental and CFD analysis, a scientific understanding of the way the nozzles perform was gained. Kautex was looking for a scientific understanding of how the nozzle performs to allow them to promote and sell it to their customers as part of a new product.

The fluidic nozzles investigated during the project are manufactured by Kautex using an injection moulding process. Injection moulding was used to produce parts for experimental verification of the CFD analysis.

The CFD analysis and high-speed photography have shown that the simulation techniques developed can be used to correctly simulate the oscillation behaviour and the spray angle of the fluidic nozzles.

Impact

The combination of simulation and experimental analysis resulted in an increased understanding of the flow behaviour inside fluidic nozzles, particularly a greater understanding of the design features, which control the performance such as the relative width of channels in relation to one another. This increased Kautex's understanding, allowing suggested modifications on one of the two nozzle geometries being investigated, which allowed the nozzle to produce the required oscillating flow, where the initial version had not produced an oscillating flow.

Experimental analysis of flow from nozzles allowed the identification of differences in performance between two versions of the same nozzle, one produced by stereolithography and the other through injection moulding. Microscopic comparison between nozzles produced by the two techniques resulted in the identification of a number of potential changes required to improve the injection moulding tooling to achieve the required performance.

As a result of the research collaboration Kautex have:

1. Developed their own micro fluidic nozzle for a vehicle screen wash system to meet a customer's specification leading to potential increase in supply to the automotive sector and introducing a new product to the market.

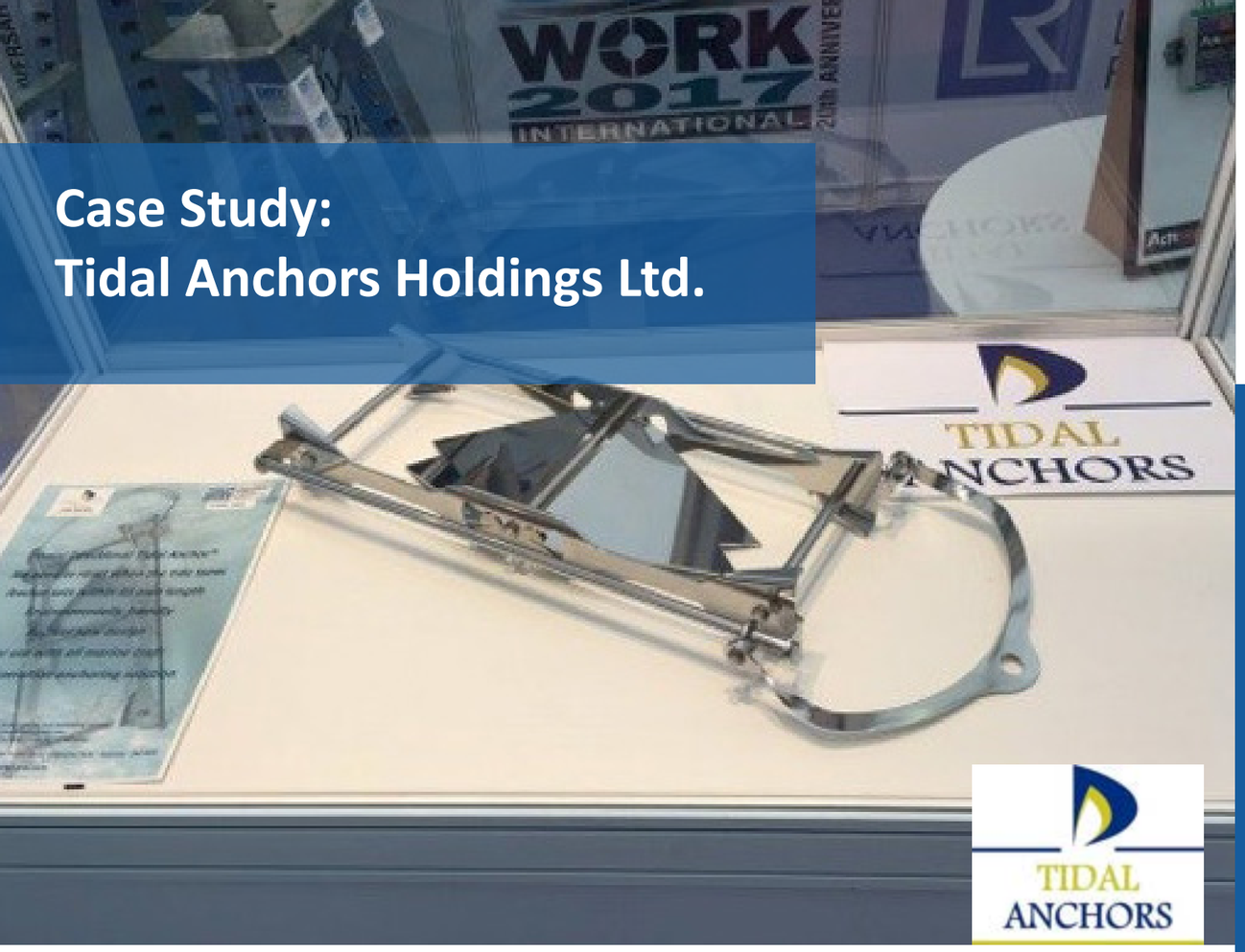
2. Additionally, continuing with developments of pro ducing future water-saving nozzles generating environmental benefits.

3. Employed two additional staff members, continuing Kautex's ability to provide worldwide services.

"This collaboration is a fine example of a project utilising computational engineering and theoretical and experimental analysis to assist a company in increasing their expertise and knowledge to enable them to develop technically advanced products."

Dr Ian Cameron
Senior Technical Manager, ASTUTE 2020

High-speed camera image capturing the analysis of the performance of a microfluidic nozzle developed by Kautex Textron CVS Ltd.



Case Study: Tidal Anchors Holdings Ltd.

Industry-Academia Collaboration Target Marine Industry with Next Generation Anchoring Solution

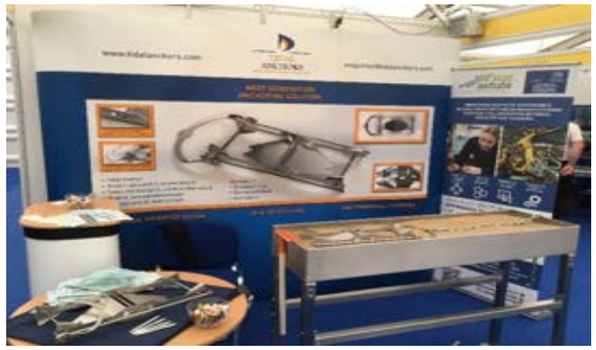
Tidal Anchor Holdings Ltd.

Tidal Anchors Holdings Ltd. are experienced in the maritime industry and recognised the need for a new type of anchor that can be accurately deployed with minimal dragging to embed it. They have developed a new novel anchor from an original idea designed for the safe, secure anchoring of marine craft in tidal waters when a change of direction in tide or wind is experienced. The twin rail design and fluke arrangement ensure immediate and accurate setting, with stability and high holding power in all directions, whichever way the anchor lands on the seabed. Not only does the Tidal Anchor® offer a superior performance anchoring solution for vessels of all sizes, but also an alternative permanent mooring option to those currently available.

The collaborative research with the ASTUTE 2020 team based at Cardiff University optimised the new anchor to deliver maximum structural performance and suitability for full-scale manufacture. The project's aim was to evaluate the performance and model key parameters, particularly how it embeds in the sea floor, to determine opportunities for further optimisation of the design and its manufacturability. Anchor design is historically empirical in nature and has seen little recent evolution. Current designs often drag for some distance before engaging sufficiently with the sea floor. This often results in anchors having to be laid several times before they are confidently fixed. This innovative anchor improves the fixing process and can be accurately positioned, eliminating practices such as the deployment of environmentally unfriendly concrete blocks.

"This was a particularly interesting project to work on. As a yachtsman, when at anchor it is impossible to sleep deeply, especially when the tide turns. Sceptical at first, because it was so radical a design, but was very impressed with the performance and therefore keen to support the fledgling company."

Andrew Hopkins
Strategic Technology Manager, ASTUTE 2020



Challenges - Wind, Tide and Ease of Manufacture

For the Tidal Anchor® to deliver superior performance compared to conventional commercially available models, it required optimisation in order to remain stable during the wind and tidal forces experienced by vessels to operate in a variety of seabed conditions. To be commercially viable it also required optimisation for ease of manufacture, particularly eliminating the need for welding, which is a potential source of weakness and corrosion.

Solution - Computational Analysis Techniques and Field Trials

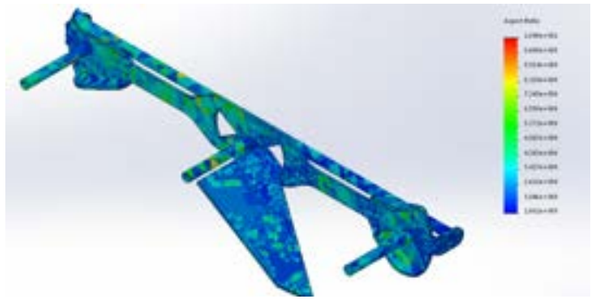
ASTUTE 2020 collaborated with Tidal Anchors Holdings Ltd. using latest computational engineering systems and manufacturing knowledge to determine performance parameters with particular reference to accuracy/ repeatability of launch position and embedding final position of the new anchor., Finite element analysis (FEA) revealed that the optimised Tidal Anchor® is capable of remaining stable during forces of wind and tide experienced under working conditions. Beach and sea trials conducted with Tidal Anchors were used to confirm the FEA results. The resistance of the anchor has been modelled, against a viscous fluid – liquid mercury, and the strength and stiffness of the anchor evaluation led to specification revisions.

A tank testing facility has enabled early feedback from several design iterations. A revised design was finalised by the company and re-modelled (against a viscous fluid) by ASTUTE 2020 for re-evaluation of strength to confirm material properties and dimensions to withstand predicted loads and required safety factors.

Testing of the anchor indicated that it set more reliably than conventional anchors in a shorter length therefore causing less environmental harm to important sea grass vegetation. This major redesign development is still within the criteria of the original patent, which was a very important consideration. In addition, manufacturability was improved and the need for welding as a potential source for weakness and corrosion was eliminated.

"Tidal Anchors Holdings Ltd. have been impressed with the level of support and commitment to the development of the project by all those involved at Cardiff University in the ASTUTE 2020 programme. CAD modelling and FEA have enabled prototype testing to be undertaken in the harsh marine environment and confirm the merits of the unique Tidal Anchor® design".

Ivor Griffith
Director, Tidal Anchors Holdings Ltd.



Finite element analysis for structural performance

Impact

Tidal Anchors Holdings Ltd. exhibited and launched their new Tidal Anchor® at Seawork International 2017 held in Southampton. This event is one of Europe's largest commercial marine and workboat exhibitions regarded as the industry's one-stop-shop for buyers, legislators and influencers in the marine market. The European Commercial Marine Awards are held at the event and the Tidal Anchor® was 'highly commended' and awarded runner up in the Marine Engineering and Construction category.

Tidal Anchors have invested heavily in protecting the IP of the novel design, which has been reviewed for maximum structural performance optimised by ASTUTE 2020.

The new anchor is environmentally friendly, due to its ability to set within its own length; it has been recognised by marine biologists as having potential to significantly reduce damage to organisms on the seabed.

The results of the successful collaboration as well as the excellent reception of the Tidal Anchor® at the Seawork International Exhibition provided the company with the confidence to invest patent applications in numerous countries. To date, and in addition to the UK, seven patents have been granted in overseas territories including Europe, Hong Kong, China, Japan, USA and Australia.

Case Study: Weartech International Ltd.

Evolving the Research Capacity into Wear Resistant Multicomponent Alloys – Computational Approach

Weartech International Ltd.

Weartech International Ltd. is a global leader in the manufacturing of wear-resistant Cobalt, Nickel, and Iron-based alloy coatings and components. Its headquarters are in Anaheim, California (USA), with manufacturing plants in Anaheim and Port Talbot (Wales, UK).

Weartech International Ltd's 2017 turnover was £12 million of combined cobalt and nickel based hard facing rod and cast components.

The collaborative project with ASTUTE 2020 aims to support Weartech's ambition to potentially increase Weartech's market share (up to 30% increase on orders), taking the company to a potential £15m turnover in the future.

It is expected that through engagement and collaboration with ASTUTE 2020, Weartech's advanced manufacturing knowledge will increase, and, alongside certain improvements, be applied more widely to the production, providing additional gains for Weartech.

"The ASTUTE 2020 team was challenged to provide practical answers to further improve the casting quality of Weartech's products. The deployed advanced computational model, supported by realistic evaluation of the material data, enhanced the understanding of Weartech's casting process, and reduced waste through very small changes to the original mould design."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Challenges

Sand casting is one of the most widely used casting techniques, accounting for more than 70% of all metal castings and is ideal for large components in small quantities. It is used for casting complex metal parts of nearly any alloy across a wide range of sizes and weights.

The main challenges Weartech and ASTUTE 2020 sought to address were:

1. Identifying the material properties of the specified alloy, e.g. viscosity and thermal conductivity;

2. Validating the numerical set-up by using specifically designed experiments;

3. Study the influence of the mould tilted angle.

Solution

The collaboration looked at the process operating conditions in the sand casting process, the filling stage and the solidification stage.

The investigation into the filling stage is critical in several aspects, for example, the configuration optimisation and the metal wastage analysis. The aim is to eliminate the surface turbulence of the molten alloy to obtain a high quality casting product. Applying the mould tilted angle is one of the most effective methods to achieve this goal, especially for large size castings.

Sand casting mould was supplied by Weartech and the collaborative research has been focussing on two main areas:

1. Molten alloy filling features for different mould tilting angles;

2. Propose an optimised tilting angle range for the current production mould.

The present study was conducted using advanced computational modelling, where the casting filling process has the following features:

1. Filling time is short and usually within 12s;

2. Temperature of the molten alloy is high and usually above 1500 °C; with temperature dependent material properties.

3. Molten alloy filling cannot be observed in the experiment as the process is covered by the sand mould.

Impact

The output of the current research could help Weartech to reduce reject rates.

The project provided Weartech with improved understanding of the computational moulding simulations applied to various casting processes, and the performance of the alloy used in the casting process.

Therefore, Weartech has the potential to cut direct manufacturing costs, improving profitable manufacturing at the factory. This could make Weartech more competitive in the market and increase their current market share not only through a competitive, streamlined process but also through a reputation for high quality products.

"Following on from a successful collaboration between Weartech International Ltd. and ASTUTE (2010-2015) on the Casting of Cobalt Alloys, and our continuous strive to advance our casting methodologies; the ASTUTE 2020 operation has allowed us to develop our close relationship, providing highly valuable knowledge and expertise; with a commitment to the ongoing research in wear resistant, cobalt and nickel based alloys."

Dean Thomas
Operations Director, Weartech Ltd.

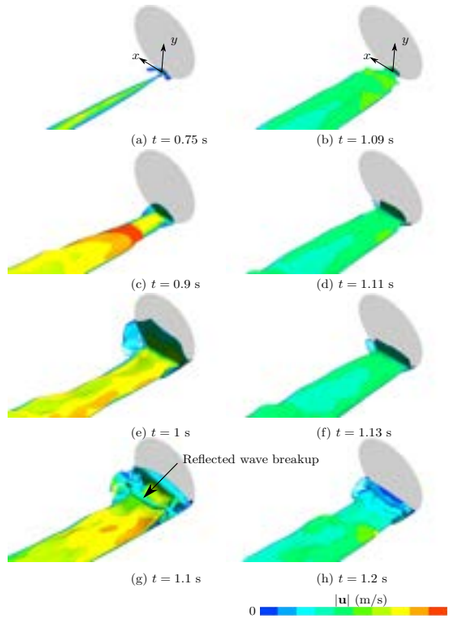
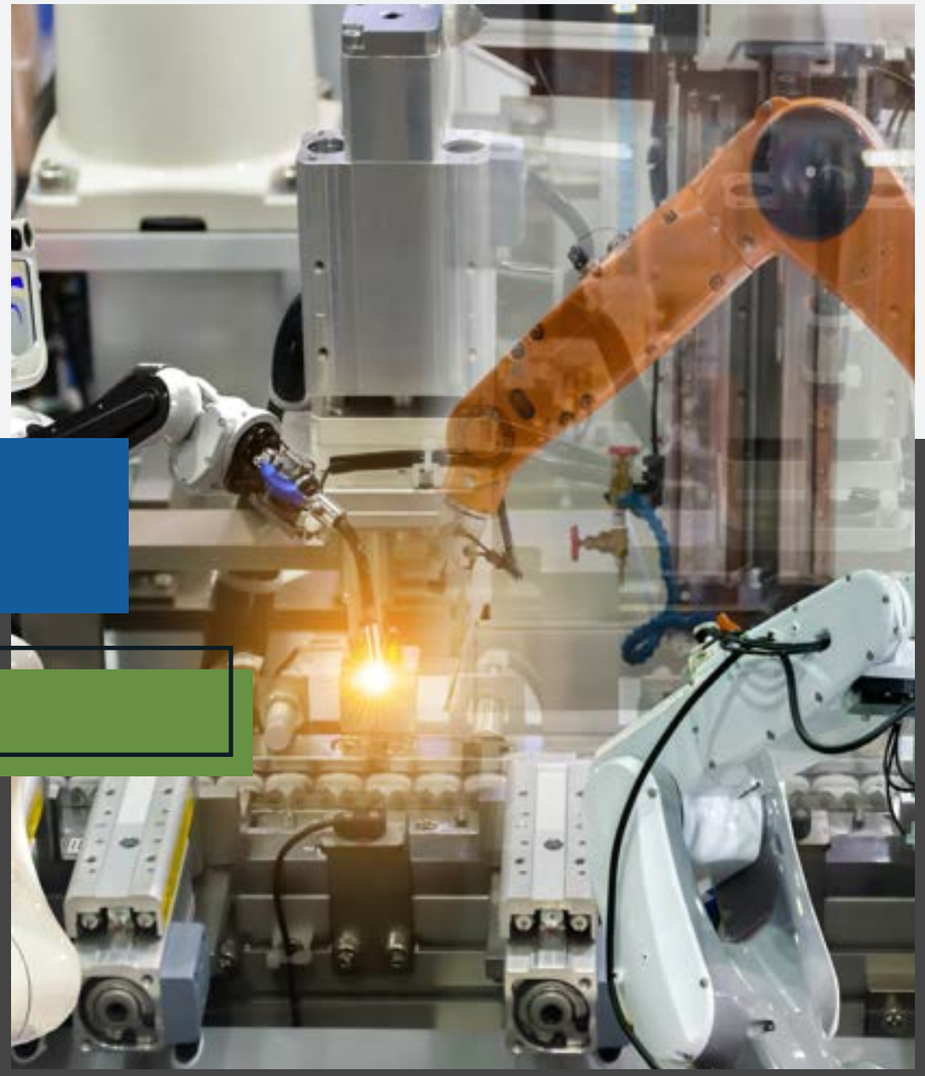


Figure 8: Velocity magnitude ($|\mathbf{u}|$) distribution at various filling time (t) plotted on iso-surface of $\gamma_L = 0.5$ for $\theta = 0°$(left) and $\theta = 5°$(right). The magnitude of reflected wave was decreased as θ was increased.

Velocity magnitude distribution at various filling time



Manufacturing Systems Engineering

Improving resource usage through process optimisation and increasing connectivity in the manufacturing process using digital technology

Manufacturing Systems Engineering plays a critical role in production process assessment and optimisation, and includes expertise in the following areas: systems engineering, operational excellence, manufacturing process improvement, production and inventory control, supply chain re-engineering and re-shoring, failure modes effects analysis and ontology, biomedical engineering, resource efficiency, life cycle analysis, Circular Economy models, remanufacturing and recycling, and sustainable supply chains.

Sustainable Life Cycle
The most effective way to make existing products and services more sustainable is by assessing and optimising their life cycle stages and supporting supply chains and logistics using a multi-disciplinary approach. This enables companies to identify and eliminate steps that do not add value thereby improving manufacturing quality, productivity, and sustainability.

Aberystwyth University
The research undertaken at Aberystwyth's Department of Computer Science focuses on intelligent systems in software and robotics. Since the ability to collect, analyse and exploit data about manufacturing performance is central to improving the potential and competitiveness of the Welsh Manufacturing industry, their work is central to the support ASTUTE provides to its industry partners.

Cardiff University
The ASTUTE team at Cardiff University help companies to develop and improve their manufacturing systems ranging from internal business processes to processes operating across supply chains and networks. This expertise is drawn from multiple schools at the University including Business, Engineering and Medicine.

Swansea University
The expertise of the ASTUTE team at Swansea University is derived from several research groups within the Faculty of Science and Engineering and includes cyberphysical systems, sensors, failure mock effect analysis visualisation, and big data related solutions for manufacturing.

University of South Wales
The University South Wales Business School contributes to ASTUTE through its expertise in manufacturing systems, quality management, operations management, supply chain and logistics, digital marketing, and business strategy.

Industry-Academia Collaboration of IoT Device that Instantly Turns Beer Kegs into Smart Containers

The Smart Container Company Ltd.

The Smart Container Company, based in Cardiff, is a technical solutions company developing the KegTracker™, a first-to-market, non-intrusive, one-size-fits-all Internet of Things (IoT) device that instantly turns kegs and casks into smart containers.

It is estimated that five billion pounds can be saved by eliminating inefficiencies in the beer supply chain each year in the UK alone. KegTracker™ aims to empower brewers, distributors, and retailers with real-time data on a keg's location, volume, temperature and motion to provide insights across the supply chain enabling new data-driven processes to reduce inefficiency and increase sustainability.

"Our collaboration with ASTUTE 2020 helped us toward our goal of using this innovative technology to encourage more use of this circular economy asset to reduce the number of single-use plastic containers needed to meet market demand."

Eduardo Garcia
Co-Founder, The Smart Container Company

Challenges – Volume Measurement and Energy Harvesting

It is recognised that a lack of data and visibility in the current supply chain leads to slower than optimal keg returns resulting in 30% to 70% more kegs being in circulation than necessary. In addition to this, there is an annual keg loss rate of 10%.

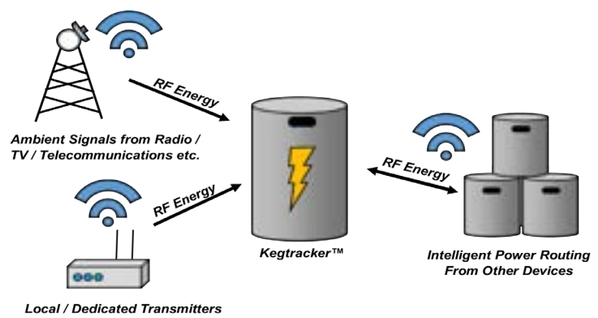
Volume measurement is key to many of the services that the Smart Container Company wish to offer with KegTracker™ including consumption insights and inventory management.

The unique collaboration between the Smart Container Company and ASTUTE 2020 has utilised renowned manufacturing systems expertise to research methods of fluid level management and establish the feasibility of energy harvesting methods for powering the IoT device through the use of sensors.

Retrieving accurate volume measurement of sealed metal containers can be extremely challenging, particularly for large, thick containers such as the kegs used for storing beer, cold brew coffee, wine, cocktails, CO2, nitrogen, etc. with factors such as sensor position, container size, and liquid level affecting sensor measurements. Furthermore, any sensing device must also be able to take measurements in an unobtrusive way that is consistent with the KegTracker™ design while using as little power as possible.

As an embedded system, KegTracker™ depends on a power supply to run autonomously throughout the keg lifecycle to meet application requirements. However, powering mobile IoT devices without a fixed power supply is problematic and devices often rely on battery technologies with a finite power supply and lifespan that are costly and inconvenient to replace, making power management the utmost concern.

Energy harvesting, the process of harvesting small quantities of ambient energy from environmental phenomena, is seen as a way of extending the operational lifetime of embedded systems although the application of such systems is challenging with many environmental and design factors to consider.



Solution

Together, ASTUTE 2020 and the Smart Container Company researched the two areas identified where advances were required for the KegTracker™ device.

A deep search across different measurement methods found a sensor capable of achieving the required sub-centimetre level accuracy while requiring only µW levels of power whilst also being applicable to KegTracker™'s design constraints.

It was also concluded that harvesting ambient or dedicated radio frequency (RF) energy with an autonomous-hybrid architecture that combined supercapacitors with primary or secondary batteries would be most suitable for maximising the operation of the KegTracker™. At present, the KegTracker™ is likely to spend a majority of its time indoors within (semi-)urban environments which typically have the most abundant ambient RF energy. The life cycle of the device also lends itself to easy application of dedicated RF power and other intelligent power management techniques.

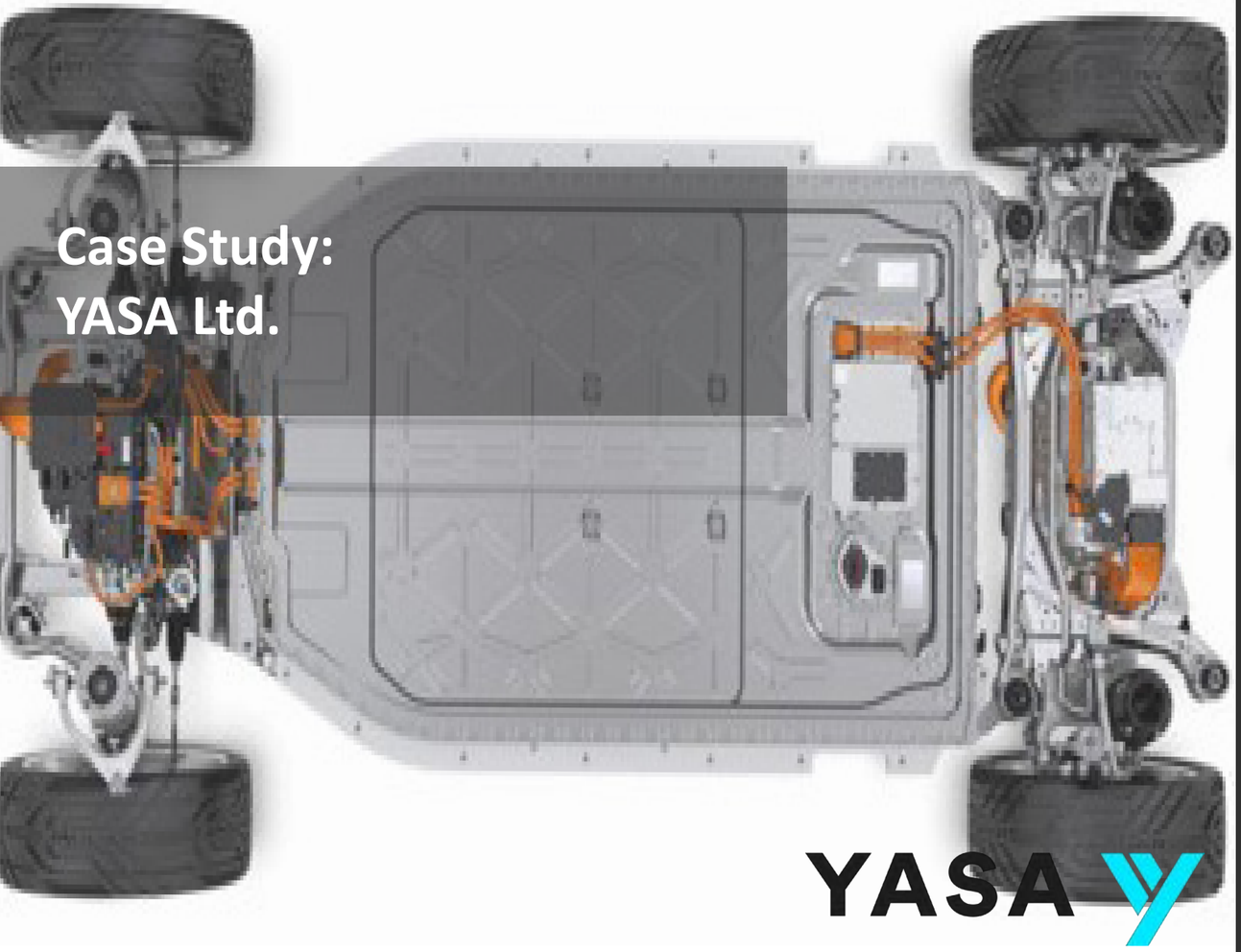
Impact

The collaborative project between the Smart Container Company and ASTUTE 2020 has enabled the company to progress in their research and development and bring the product closer to market.

By overcoming a major bottleneck in volume measurement, they have been able to accelerate the development of their prototype device with knowledge about appropriate energy harvesting techniques influencing future design iterations. The KegTracker™ will provide the data visibility to resolve and optimise the kegs and beer product in circulation, thereby reducing the number of kegs needed and lost, and reducing the CO2, energy and water requirements to enable a more sustainable supply chain and circular economy where less waste (beer, water, gas and carbon footprint) is produced.

This innovative and exciting product will revolutionise the keg & cask industry. The success of the collaboration encouraged the Smart Container Company to invest in research, development and innovation and, as a direct result, has given investors the confidence in the Smart Container Company to further develop the KegTracker™ and bring the IoT smart device to market.

Image: Radiofrequency Energy Harvesting. KegTracker™ transceiver could be used for transmitting and receiving both data and energy



Research into Electric Drive Unit System Optimisation

YASA Ltd.

YASA (Yokeless and Segmented Armature) Ltd. is a British manufacturer of electric motors and motor controllers that are used in automotive and industrial applications. Founded in 2009, it supplies world-leading Original Equipment Manufacturers (OEMs) in the automotive industry with innovative powertrain solutions that are based on their next-generation axial-flux technology and controllers.

YASA believe realising the full potential of vehicular electrification requires new, more efficient powertrain solutions than radial electric motors that are based on 50+-year-old legacy technology. Their pursuit of this goal forms the basis of the collaborative research project with ASTUTE 2020+ that explored potential improvements to their overall powertrain system through Computational Engineering Modelling techniques.

The project team created simulations of the electromagnetic, structural, thermal, cooling system, power electronic control, and overall powertrain optimisation with the aim of maximising system performance for electric vehicle (EV) applications.

"Speeding up the optimisation process has enabled more parameters to be considered, leading to more flexibility and more detailed models which in turn provides an even more optimal solutions."

Dr Simon Hart
Chief Technology Innovation Officer, YASA

Challenges – Electric Vehicle Powertrain Optimisation

The main engineering challenge faced by the collaborative team was identifying the optimal product technology and topology specification, including its key components and parameters.

Optimising the EV powertrain involved evaluating the performance, targets, and constraints of the studied vehicle model using more than twenty-five independent variables – a process that can have up to 1x1025 solutions and demands a significant amount of computation time and energy. The objective was to find the most suitable parameters for the vehicle motor, inverter, gearbox and powertrain configuration to minimise costs whilst adhering to key constraints such as battery range, acceleration time, and top speed.

This poses a very complex and computationally expensive challenge that requires advanced techniques, methodologies, and expertise in data science and computational modelling to find a viable solution.

Solution

Motor Optimisation
The solution for the electric vehicle powertrain optimisation involved a two-step cascade optimisation approach that was based on a data-driven machine learning vehicle model. The model estimated the behaviour of vehicle performance and was able to run optimisation orders of magnitude faster than YASA's previous optimisation strategy. The cascade optimiser identified the best set of input parameters from genetic algorithms that used the ML-based vehicle model and the proprietary YASA vehicle model.

The team also investigated and demonstrated the performance of a new open-source software, Pyleecan, that was used to design a radial motor. The ASTUTE team studied the software's capabilities and limitations and found relevant solutions to ensure its successful future use by the industry partner.

Reinforcement Learning: An Alternative to Traditional Machine Learning
Reinforcement Learning (RL) was identified as a way of improving the genetic algorithm-based optimisation process that was used in both YASA's existing method, and the newly-developed machine learning-based alternative outlined above.

It is a paradigm of machine learning that characterises optimisation problems as an agent interacting with an environment to achieve a goal. The agent executes actions and the environment responds by presenting new states to the agent. It returns a scalar numerical reward signal representing the desirability of the current state, and the agent learns to optimise its received reward by exploring the state-action space.

The RL team provided an alternative optimisation methodology to traditional machine learning tools used for regression, such as xgboost and randomforest approach. This provided an excellent opportunity for both teams to compare their results and led to a significant reduction in computation time.

Impact

The Research into Electric Drive Unit System Optimisation resulted in mutual benefits for both partners. Significant knowledge was exchanged in both directions, especially regarding the technical details of electric powertrains for battery electric vehicles and artificial intelligence algorithms applied to modelling complex dynamic systems.

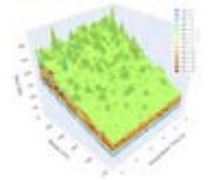
As a direct result of the collaborative project with ASTUTE 2020+, YASA has/are:

• Introduced 3 new manufacturing and prediction processes to their R&D department: machine learning tool, cost prediction tool, and modelling tool.

• In the process of recruiting 3 new full-time members of staff with roles linked to power converter topology optimisation
In the process of registering 2 new product patents

• Contributed to the global automotive industry's efforts to reduce CO2 emissions.

Model 3 motor design on Pyleecan

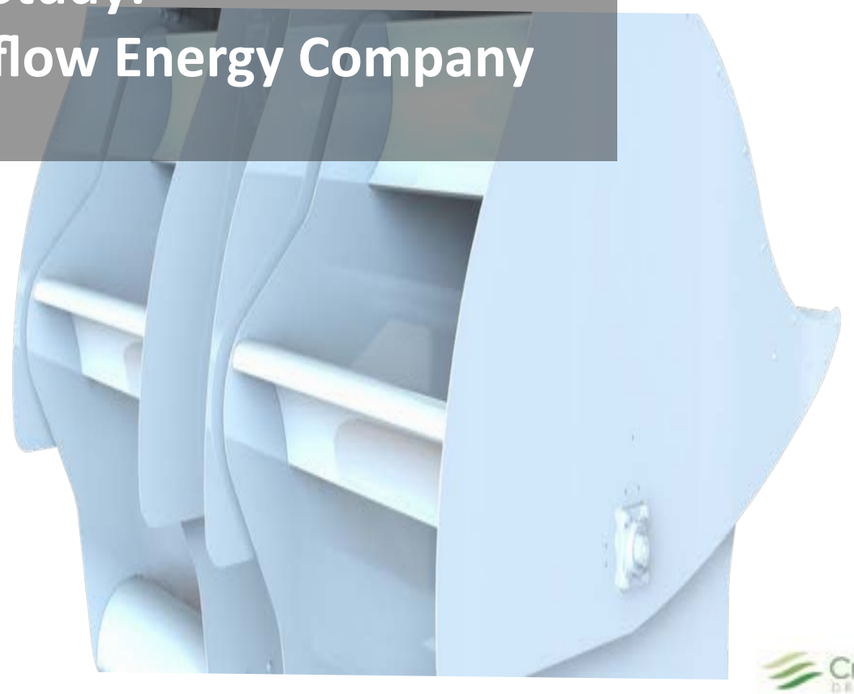


Vehicle Cost Map Design

"This collaborative research project has been an excellent opportunity to deploy ASTUTE2020 team expertise in machine learning capabilities with a focus on reinforcement learning techniques and computational powertrain optimisation to maximise the performance for Electric Vehicle applications. The research has also generated a number of scientific journal and conference papers."

Dr Fawzi Belblidia
Technical Director, ASTUTE 2020

Case Study:
Crossflow Energy Company



An Industry-Academia Collaboration on Reliable Clean Energy of the Future

Crossflow Energy Company Ltd.

Crossflow Energy are renewable energy technology specialists. They are focused on supplying wind-based energy solutions for both developing and developed countries.

By solving the issues that have inhibited the adoption of 'small wind' technology, Crossflow want to make renewable wind power a real, accessible and affordable fossil fuel alternative for developing nations.

The company also wants to open up small wind power to a wide range of industries and applications in the UK and overseas such as across commercial and public buildings, industrial and retail settings, telecoms, as part of road and rail infrastructure. Crossflow wants small wind technology to become as common place as solar and really help in the world's drive to Net Zero.

Through the ASTUTE2020+ academic partnership, both Swansea and Aberystwyth Universities collaborated with Crossflow on two independent projects; the former developed a range of novel vertical wind turbines, and the latter a portable hybrid energy systems. ASTUTE provided experimental and computational expertise that, together with Crossflow's industry knowledge and experience, were able to solve the complex engineering challenges faced by the company. This combined knowledge and collaborative approach to research, development, and innovation helped make significant inroads into Crossflow's pursuit of clean, reliable energy generation.

"The team at Crossflow Energy found working with ATUTE2020 both positive and professional. When delays occurred, the ASTUTE team were flexible and worked with us to overcome obstacles and achieve our desired outcomes."

Rebecca White
Commercial Director, Crossflow Energy Company

Challenges

Following on from a previous project between 2010 – 2015, Crossflow were seeking further support from ASTUTE2020+ to identify, from prototype trials, an appropriate method of processing turbine sensor data when at full-scale. The aim was to use this data to validate computational fluid dynamic simulations that could predict, with confidence, the impact different environmental variables would have on a turbine's energy conversion process. Swansea University worked with Crossflow on this project.

Aberystwyth collaborated with Crossflow to find a way to develop and deploy a remote monitoring system for their hybrid energy units that would alert engineers to conditions where action needs to be taken. Doing so would make it possible to deploy IES units in remote locations across the world whilst being able to access product improvement data from any geographical location.

Solution

Computational Fluid Dynamic Simulations
Crossflow commissioned a prototype turbine together with an array of sensors and a data acquisition system, and the Swansea team assisted in finding an appropriate method for data processing. Together, they deployed an advanced data reduction method that fed data from the turbine sensors into their computational fluid dynamic simulations. By conducting numerical modelling activities, they were able to formulate an appropriate dynamic response algorithm for the Physica modelling software that allowed fluctuating wind readings of different strengths and source locations to be input. The data gathered enabled Crossflow to better understand the responses and behaviors of their turbines under changing weather conditions.

Remote Conditioning Monitoring
Crossflow's team developed an innovative solution to extracting data from the hybrid energy system units using node-red and exporting it to Google Firebase. Doing so enabled the Aberystwyth team to begin designing and developing the required mobile monitoring software. Their collaborative efforts led to the new software being extended to a prototype hybrid energy system in Trinidad, where it was able to successfully monitor its systems with problems being communicated remotely to IOS and Android smartphones. This provided live details of what was happening at the site 24 hours a day.

Impact

The success of this project enabled Crossflow to move confidently to the commercialisation phase with a clear understanding of the capabilities of their turbines and how to monitor and maintain them.

The project has helped Crossflow resolve the issues which historically have inhibited the take up of small wind technology. The turbine's low rotational speed, creates minimal noise and ultra-low vibrations, extending its operational uptime and minimising maintenance. The turbine design is bird and bat friendly, addressing planning concerns, even in the most ecologically sensitive sites. It can be deployed as a standalone entity or combined with solar and battery technology to enhance renewable energy generation in either new build or retrofit applications.

As a result, Crossflow have been able to identify a wide range of potential markets for their technology. These include commercial and public buildings, road and rail infrastructure, telecoms and in challenging environments such as remote, ecologically sensitive locations.

As a first step in this commercialisation Crossflow have partnered with Vodafone in developing their turbine technology into self-powered mobile network towers to improve rural connectivity in the UK. Their first Eco-Tower is being installed early in 2022. These Eco-Towers will overcome the challenges and costs associated with connecting remote locations to the national grid, whilst also reducing energy consumption patterns and reducing carbon emissions.

As a direct result of the collaboration with ASTUTE2020+, Crossflow has:

- Introduced one new product to the market
- Created two new jobs: one role to support the commercialisation of the wind turbines, and a power engineer for the demo rig in Trinidad
- Gained the ability to install and support intelligent remote monitoring software at their plants
- Gained the confidence to move into the commercialisation phase with a better understanding of their product
- Created a partnership with Vodafone to further develop the turbine technology designed in collaboration with ASTUTE2020+

These successful projects demonstrate the power of industry-academia collaboration, and showcase their unique ability to drive meaningful, positive change through cutting-edge research and innovation. The solutions developed by Crossflow and ASTUTE contribute to global efforts to reach the 1.5 degrees global warming target agreed at COP26, providing an affordable renewable energy technology that can reduce fossil fuel dependency worldwide. Together, they have made significant progress in developing an energy conversion technology that will lead to a greener, cleaner, and more sustainable future for our planet.

Case Study: Ultrawave Ltd.

Ultrasonic Technology Research for High Quality Cleaning Results

Ultrawave Ltd.

Ultrawave Ltd., based in Cardiff, is one of the largest manufacturers of ultrasonic cleaning equipment in the UK. Established in 1990, they have 28 years' experience within the industry and have supplied over 55,000 ultrasonic cleaning systems nationally and internationally.

Ultrawave delivers innovative solutions to meet the specific needs of its customers and strives to be at the forefront of the cleaning industry. Ultrawave's customer portfolio includes the medical and automotive industries, including one of the UK's biggest vehicle production plant manufacturer, Nissan. Nissan uses the ultrasonic cleaner for the paint finish on its vehicles as they roll off the production line. Nissan reported that cleaning quality increased by 20% since adopting Ultrawave's cleaning equipment within their manufacturing processes.

Life testing simulation of new attachment methods of thermocouples for ultrasonic baths

Ultrawave approached ASTUTE 2020 as the company wanted to enhance and develop their understanding of the adhesive mechanism of thermocouples; accelerate the testing regime of a new attachment and create confidence in the new solution, improving reliability and extending service intervals.

Challenges

Ultrawave is investigating methods to improve the attaching of Pt100 thermocouples onto stainless steel surfaces. The company wanted to assess what advanced technologies were available to evaluate the adhesive properties and the ultrasonic performance of the units, utilising the latest non-destructive characterisation capabilities during in-service operations of the product.

Ultrawave sought to collaborate with ASTUTE 2020 to investigate the attachments and compare the new adhesive solution with the old methodology by utilising 3D Laser Vibrometry to determine the strain which the structure experiences during excitation at specified frequencies. The project aimed to provide the company confidence in their new solution by eliminating the requirement to run the unit continuously for 10,000 hours. A typical testing cycle could potentially be reduced to 2500 hours, a 75% saving in time.

Solution

The ASTUTE 2020 team utilised Cardiff University's 3D scanning laser vibrometer that has been used extensively to study ultrasonic wave propagation within materials; typically above 100 kHz. The technique has been used for several different applications including investigating the vibrational and acoustic performance of materials and structures.

Laser vibrometry is a non-contact method of measuring the velocity of vibration. This technique uses laser light, which is shone at the vibrating structure. As the structure vibrates, the wavelength of the laser light experiences a change in frequency, which is used to determine the velocity of the vibration.

In order to measure the underside of the ultrasonic bath, sufficient distance was required to ensure that each of the three laser heads were able to scan the whole underside. This was achieved by elevating the bath and positioning each of the laser heads on independent tripods underneath. A video camera built into the laser heads was used for the scanning of the sides of the bath. An external macro camera was used to zoom in on the thermocouples, producing a much more detailed scan area.

Ensuring the correct attachment of the temperature sensors improved the effectiveness of the manufacturing process and resulted in fewer modifications and repairs thus increasing the reputation of Ultrawave's high-quality products. The research conducted into the vibration of the two attachment methods has been analysed to determine the strain under different operating conditions. This metric was used to track the performance of the two attachment methods as well as the effect of increasing the excitation amplitude to accelerate

"Access to Cardiff University's capabilities was critical to our success."

Ian Corp
Technical Director, Ultrawave Ltd.

Impact

The collaboration provided Ultrawave with a better comprehension of the working principles during the cleaning process by understanding the displacement, stress and strain conditions of the system. The project has enhanced the sustainability of Ultrawave's manufacturing systems due to the data and knowledge exchanged between the company and ASTUTE 2020, enabling Ultrawave to continue improving the stability and efficiency of the ultrasonic baths under various operational conditions.

Ultrawave has benefited from additional sales and improved its reputation within the market place, having reduced the percentage of warranty returns.

The implementation of the new attachment method has helped the company gain confidence in their products while ensuring job security and creating two new jobs as a direct result of the project with ASTUTE 2020, therefore, contributing to the economic health of East Wales.

Additional research could be conducted on the underside of the tank, particularly focusing on areas of known cavitation. Future investigations could be beneficial to know how or if a system's performance degrades over time and if so, the causes of this.

Case Study:
Markes International Ltd.

Queen’s Award Winning Company Achieves Resilient Supply Chain Enabling Further Growth Thanks to Industry-Academia Research Collaboration

Markes International Ltd.

Markes International is one of the world-leading developers and manufacturers of scientific instruments for thermal desorption and time-of-flight mass spectrometry. In-house, advanced software development capabilities compliment Markes International’s hardware solutions and occupy a technology niche embedded in a multi-billion dollar industry. Markes International also has a worldwide presence with offices in the UK, USA, Canada, Germany and China, with over 240 employees in total.

The company has been enhancing the analysis of trace organic chemicals since 1997, focussing on R&D and bespoke solutions/ applications. Although the manufacturing, supply chain systems and processes in place have served the company well and enabled rapid growth, the company needed to tackle the step-change associated with this growth target.

The 2018 project with ASTUTE 2020helped enhance the resilience of the Markes International’s manufacturing systems and supply chain through the application of novel methodologies such as Robust Agile Lean Flexible (RALF) and dynamic capabilities.

“Cardiff University and ASTUTE 2020 have provided valuable insight and guidance, helping us achieve growth and improve our supply chain management and processes. A great team to work with.”

Napoleon Coverdale
Head of Engineering and Manufacturing, Markes International Ltd.

Challenges

After meeting the ASTUTE 2020 team at a business networking event in 2017, the Markes team started the collaboration by reviewing their business needs via a quick scan audit, and identified three clear project objectives;

• to enhance the resilience of the supply chain,

• optimised production scheduling, and

• to improve inventory control and forecasting.

In many industries and supply chains inventories are necessary for smoothing out any imbalances between supply and demand. Yet, they also represent a major economic burden as significant capital is tied-up in these.

The goal of effective production planning and inventory management in a supply chain is to have the correct inventory at the right place. However, managing production and inventory in complex supply chains is typically difficult, and decisions may have a significant impact on the customer service level and supply chain system-wide cost.

Therefore, this collaborative project took a holistic approach to the challenges by examining supply chains, production scheduling and inventory control.

Solution

The project’s goals were to:

• Enhance the resilience of Markes International’s supply chain through the application of novel methodologies such as RALF; investigation and identification of critical to quality characteristics; improving information flow linkages; processes for supply chain-oriented product research and development.

• Optimise production scheduling through multi-objective optimisation and simulation of process flow and job scheduling within a multi-skilled workforce environment.

• Improvement of inventory control through the application of advanced inventory control via forecasting systems and policies, including judgemental forecasting.

“ASTUTE 2020’s expertise in supply chain management and forecasting has helped Markes International grow sustainably”

Dr Anthony Soroka
Senior Project Officer, ASTUTE 2020

Impact

The project supported the company’s objective of realising output in line with sales growth. Capacity has doubled, maintaining rates of 5 to 10% ahead of sales revenue year on year.

This was established through:

• Identification and eradication of key production constraints.

• Introduction of five new technical staff at the facility in key areas of the fulfilment process.

• Targeted investment of capital spends aimed at supporting the previous two actions.

Markes International embarked on a radical re-development of their supply chain, following a strategy developed out of our 2018 collaboration, aimed at delivering a resilient supply base in the short to medium term. The company went on to review forecasting algorithms developed at Cardiff Business School to help to plan builds for service items of high, low or indeterminate usage.

The company also began a long-term process of cultural change, introducing the concept of continuous improvement and creating the time and opportunities for employees to participate and share knowledge.

The collaboration enabled Markes International and Cardiff University to develop closer ties, which provided opportunities for undergraduates to participate in industrial-based projects. One such example is Markes’ 2022 sponsorship of a Masters studentship at Swansea University’s WCPC Group.

Further business successes for Markes included the receipt of two prestigious Queen’s Awards for Enterprise in 2019, in ‘Innovation’ and ‘International Trade’ categories.

Case Study: Team Precision Pipe Assemblies Ltd.

Comparing Simulation and Value Stream Mapping for Cell Layout

Team Precision Pipe Assemblies Ltd.

TEAM Precision Pipe Assemblies Ltd., based in Ammanford, Carmarthenshire, manufacture a range of complex precision pipework assemblies for heating, ventilation, and air conditioning (HVAC) systems and other fluid handling components for the automotive industry.

TEAM Precision produces over five million parts per year; these pipe assemblies are supplied to a variety of companies including leading marques such as Aston Martin, Bentley, Denso (who supply Toyota), as well as Llanelli-based Calsonic Kansei.

Production cell layout at Team Precision before project.

Team Precision were seeking collaborative support from ASTUTE 2020 in gaining a better understanding of their current manufacturing capabilities and capacity, and ways to identify possible improvements.

"ASTUTE 2020 were important in helping us embark on our operational excellence journey."

Lee Davies
Senior Lean Engineer, Team Precision Pipe Assemblies Ltd.

Challenges

The pipe assemblies manufactured by TEAM Precision are formed or machined end fittings and are manipulated/ bent to meet the customer requirements. The company receive competitive pressure from low-cost economies and customers. This is in order to meet stringent quality standards whilst maintaining low unit costs. TEAM Precision had a desire to identify and implement improvements in throughput time and quality, and to reduce the need for continuous inspection effected and reduced production line effectiveness.

TEAM Precision had previously identified key areas within the business technical operations that required improvements. Therefore, the purpose of the collaborative research project was to support the company to understand and evaluate the process capability of the existing systems. In order to identify and verify performance improvements, the research took steps to improve TEAM Precision's process capability and shorten lead times through the operations processes.

Solution

With the previously identified areas, Team Precision had already begun to implement changes to the production line:

- functional layout to cellular layout in order to reduce transfer times,
- Inventory and batch sizes

However, ASTUTE 2020 identified key opportunities for current state mapping of the operations, together with future scenario planning, utilising techniques including value stream mapping (VSM) and discrete event simulations and optimisation of the manufacturing process.

Team Precision and ASTUTE 2020 examined data from different configurations and equipment from the production cell in order to identify key drawbacks of reduced production line effectiveness and the impact of these changes. The use of the different methodologies provided data to inform any necessary changes.

Besides intelligent scheduling of production lines identified, ASTUTE 2020 supported Team Precision to observe and support a VSM exercise to document, analyse and improve the flow of information or materials required on their production cell. Generating and developing such models allowed Team Precision to explore scenarios and help gain a better understanding of a process.

"ASTUTE 2020 helped enable Team Precision to successfully implement a new production cell."

Dr Anthony Soroka
Senior Project Officer, ASTUTE 2020

Production cell layout implemented as a result of project.

Impact

The introduction of a new production cell allowed Team Precision to optimise configuration and efficiency of equipment and labour. Lead-times were significantly reduced and factory floor space was freed up, enabling future investments in new production facilities.

The two-way knowledge transfer enabled the Team Precision engineers to identify opportunities for improvement and requirements for expertise. The comparative research highlighted that by combining operational excellence with simulations and finding synergies, these processes complement one another in an industry 4.0 environment.

Additional benefits arising from the collaboration included:

- Reduced scrappage rates,
- Reduced energy outputs,
- Increased company turnover,
- Opportunity for the purchase of new equipment,
- Production line re-configuration.

The collaboration has allowed Team Precision to continue developing expertise and experience in a field they had little knowledge in and will continue to drive Team Precision's future manufacturing productivity.

Optimisation of Robotic Welding Process sees Introduction of New Products and Jobs Created for Lyte Ladders

Lyte Industries (Wales) UK Ltd.

Established in 1947, Lyte Industries (Wales) Ltd. have been manufacturing a range of aluminium and glass fibre ladders and access equipment for over 65 years. Based in Swansea, Lyte is proud to be one of the few companies still manufacturing access equipment such as ladders in the UK. Their current market captures the entire UK, including major customers such as BT, Sky, Screwfix & Centrica. The quality and performance of Lyte's product range depend mainly on the quality of weld preparation and fit-up before welding starts, with all their products certified to the relevant BSI standards. Based on a previous research collaboration with ASTUTE 2020, Lyte recently invested around £300K in a robotic welding platform to speed up production and enhance product quality, demonstrating their commitment to keeping manufacturing in South Wales.

Robotic Weld Machine

"The competition between ladder manufacturers is increasing, as many small UK manufacturers have been taken over by the international giant Werner. This multi-phase R&D collaboration aimed to improve the performance and quality of welded Lyte Industries' products. This will ultimately result in business growth and assist with international competitiveness. The company is now investing heavily in equipment to achieve these goals to give them a competitive edge."

Dr Fawzi Belblidia
Senior Technical Manager, ASTUTE 2020

Lyte and ASTUTE 2020 identified three research challenges as part of a multi-phase research project where ASTUTE 2020's expertise in Manufacturing Systems Engineering, Advanced Materials Technology, and Computational Engineering Modelling were exploited to optimise the pre-weld processes, robotic welding settings and quality control protocol.

Challenges

Lyte was experiencing difficulties in optimising the robotic welding process, resulting in a high number of defective welds with the consequent waste of both material and time. The novelty and challenges of this research project were the implementation of combined techniques in developing the joint quality, focusing on the product that Lyte has had the most difficulty in integrating the robotic welding within the manufacturing process:

1. Review of current Robotics Welding Processes technology (Pre, During and Post Welding);
2. Understanding jig-clamping control for tolerance reduction in the weld preparation process;
3. Review of optimum welding spot shapes for different weld joint geometry;
4. Optimisation of welding parameters with regards to different welding patterns;
5. Development of a closed loop spatial aware control system for MIG robotic welding process, supported by the computational model.

Solution

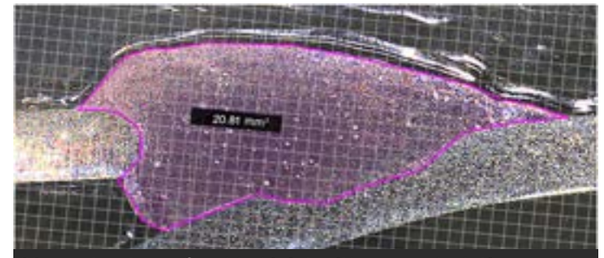
The conclusion of this research collaboration highlighted the need to improve Lyte's production technologies and products through perfecting the weld preparation based on a sound understanding of the metallurgy of aluminium alloys and advanced automation integrating advanced smart robots and sensors technology.

The research identified enhancements during the pre-welding and welding stages by identifying the most dominant parameters directly related to the welding quality and thus enhancing Lyte's production technologies and the quality of Lyte's products.

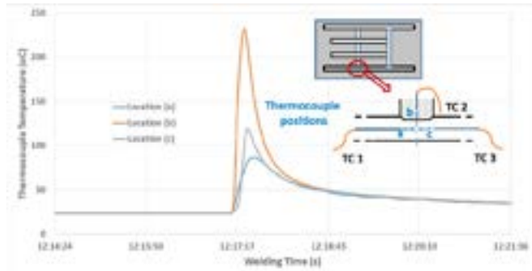
Further research into computational modelling to optimise the welding process parameters that would be applied to the robot welder resulted in increased understanding of the robotic welding platform under a variety of test conditions.

"With the expertise provided by ASTUTE 2020, Lyte has strived to build robotic weld quality in from the start, as weld joints may face loads and fatigue during product lifetime. ASTUTE 2020 have assisted Lyte to achieve an optimum weld quality by use of technological processes and actions to test and assure the quality of the welds, and secondarily to confirm the presence, location and coverage of the welds produced on the Lyte Tower Frames."

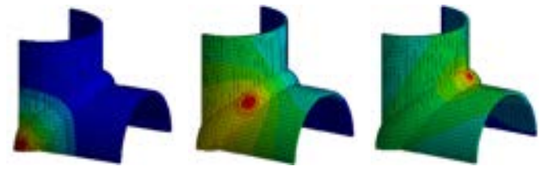
Chris Loynes
Factory Manager, Lyte Industries (Wales) Ltd.



Macrostructure of welded joint with area calculation



Measured temperature around the welding locations



Temperature modelling during welding

Impact

Lyte's commitment and implementation of the recommendations of the outcomes of this collaborative research have now been implemented into best practice followed by Lyte during the welding operation. The commitment of both Lyte and the ASTUTE 2020 team have led to extensive, mutually beneficial knowledge exchange.

As a direct result of the collaboration, Lyte has:

- Expanded their existing product range and introduced two new products to the market (Lytepod Podium and Stairlyte Stairwell Tower);
- Created seven new jobs within the operations and quality departments of Lyte;
- Invested in a durability testing machine to reduce the cost of product certification; further investment planned to acquire a laser cutting machine;
- Successfully implemented the new British Standard (BS EN 131), which conforms to the European standard.

The benefits of this collaborative project will ultimately allow Lyte to advance their manufacturing systems to evaluate and improve efficiency, quality and delivery, leading to increased sales revenue. This will form one of the building blocks for Lyte to further invest and improve the welding division of the business to ensure a long-term future for the company in West Wales and the Valleys.

Manufacturing of TPR®: Applying Advanced Technology to Improve the Product, Technology, Control and Monitoring

Affresol Ltd.

Affresol Ltd. is a green technology business committed to reducing environmental impact; their innovative range of products and structural building units (sheds, bin storage etc.) are made from a high percentage of recycled materials, delivering long-term savings to high standards with a low carbon footprint. Affresol's ethos and sustainability commitment is supported by the Carbon Trust.

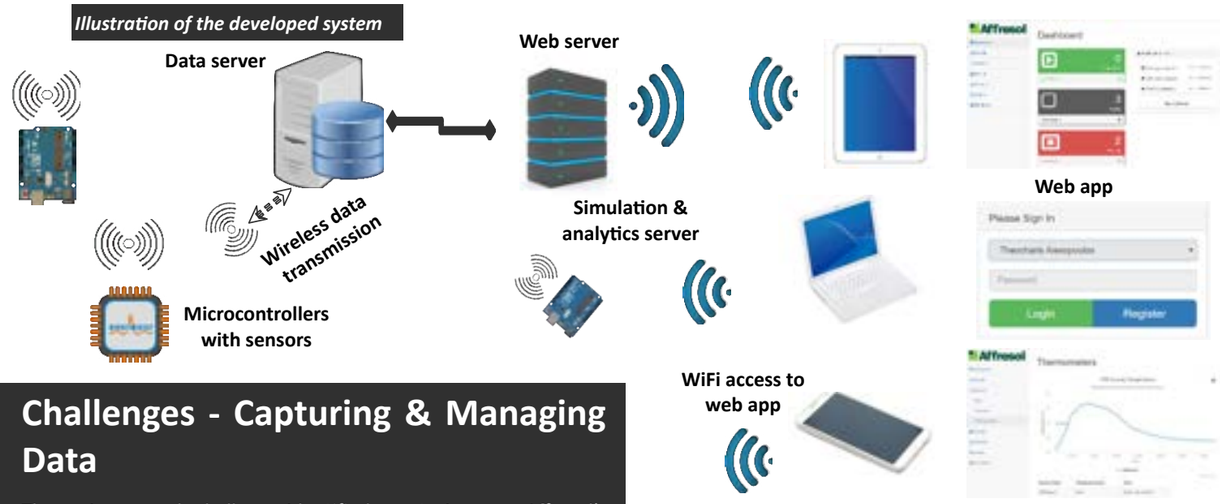
Affresol manufactures a range of products using a new type of composite material called Thermo Poly Rock (TPR®). TPR® is a non-cementitious concrete, produced from a cold manufacturing process, that uses size reduced recycled plastic waste products and minerals. The innovative mixing process produces a mouldable compound that is poured like a 'semi-dry' traditional concrete mix; soon afterwards, there is an exothermic reaction and TPR® is solid after three hours.

Cable trough made of TPR®, transparent coating

Having successfully collaborated with ASTUTE during the 2010 – 2015 funding phase, Affresol continues to strive for improvements within the company and are utilising ASTUTE 2020's expertise to develop and enhance the efficiency of the manufacturing process by improving already existing or creating new methods that are more suitable for TPR® material.

"The ASTUTE team brought a range of new and innovative ideas to the table and worked closely with our Technical Team to assess the impact and benefits. We have been delighted with the outputs from the project that have resulted in a massive improvement in control of the manufacturing process which has also has also produced a corresponding improvement in the consistency and quality of the finished product. Having access to the Cardiff University resources through ASTUTE 2020 has been a major benefit to the Affresol business and a quantifiable example of the benefits that industry can gain by working with Academia."

Ian McPherson
Managing Director, Affresol Ltd.



Challenges - Capturing & Managing Data

The main research challenge identified was to increase Affresol's current manufacturing capacity and capability by improving the monitoring and control of the manufacturing process.
The waste plastic that is being used for TPR® comprises of a wide variety of materials that differ in density and geometrical shape. At the same time, changes in environmental parameters have a strong effect on the process itself. In the case of TPR® production, there are no historical studies or documented literature available to assist the company in educating employees and production is currently based on empirical knowledge and experience to compile the designed standards. TPR® has undergone stringent testing to the highest levels set by the British Standards Institute and also meets European Standards. The aim is to make the manufacturing of TPR® more efficient and sustainable, offering TPR® products as a more competitive and improved alternative to concrete.

Solution

The project scope was to capture data and information on the production floor to create a documented background for TPR® manufacturing. An overview of Affresol's current capacity of plant production and capability to produce a wide variety of products was the first step towards enabling change for more efficient processes, focusing on the digitalisation of the manufacturing process.

Production Simulation

The manufacturing process of TPR® was modelled and simulated and various scenarios of scaling up the production capacity were assessed virtually by ASTUTE 2020 and Affresol's technical team. Simulating extreme production scenarios ensures that Affresol is equipped for unexpected events and has a good understanding of the behaviour of the processes when changes are introduced. Risks are mitigated more efficiently and Affresol is able to apply new ideas on the virtual factory floor without disruptions or product quality discrepancies.

Monitoring & Control

Establishing industrial internet of things (IIOT) practices and a community of systems that exchange data and take decisions without human interface was a key target for improved processes. The research was completed by introducing monitoring systems, which identify key parameters throughout the process and can feedback to insightful capability choices.

Intelligent Systems

Affresol's technical team and ASTUTE 2020 colleagues collaborating on the project developed a new process to collect data that is automatically processed on one software platform or for interfacing with other systems and is accessible by authorised users through any supporting devices.

The software developed within Affresol enabled data collection to be merged, identifying and storing key process indicators (KPIs) and translating technical information into meaningful information. At the same time, a number of sensors were introduced to key points of the production floor to monitor the product quality and process efficiency at all stages.

Impact

The collaborative project has had a significant impact on Affresol from its early stages. Affresol dedicated resources throughout the duration of the research and development project with ASTUTE 2020, which assisted the company in preparing the manufacturing facility for higher production rates by successfully implementing new technologies and methods that were identified.

The ASTUTE 2020 team modelled and simulated the manufacturing process to make it easier and safer to introduce changes in the production. This had an immediate effect as the production was reorganised in three main sections and data directly related to the quality of the product enhanced the digital production information. Examples of new capabilities that were developed during the project were creating quick responses to events that may cause disruption and traceability of quality issues.

The development and introduction of these systems combined human input with machine input and provided new insights into the operations of the company through the developed web-platforms and data analytics. The project has created a higher capability to respond to changing production parameters and led to expanding the plant capacity.

The most significant impact that materialised from the project was the employment of six additional staff members to the production team, enabling the scale-up of production capacity; increasing output at higher levels of efficiency.

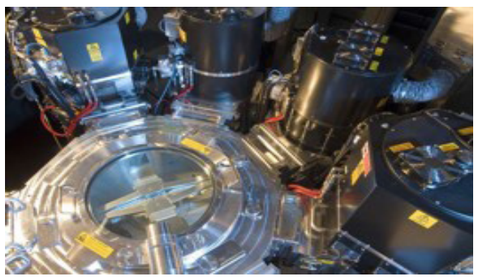
Affresol's technical staff benefited from the knowledge exchange with the ASTUTE 2020 Project Officers as well as from access to state-of-the-art technologies and bespoke software resulting in significant improvements in the control of the manufacturing process and the consistency and quality of the finished product.

Overall, the collaboration has resulted in a more efficient and technologically advanced production process for an alternative to concrete with superior mechanical properties and less impact on the environment: 70% of TPR® content is plastic waste, over 4 tonnes are diverted from landfill and use of TPR® reduces production of concrete and associated CO_2 emissions.

Case Study:
SPTS Technologies Ltd.

Extending Understanding of Electrostatic Chuck Operation to Improve Wafer Processing

SPTS Technologies Ltd.



The SPTS division of KLA provides advanced wafer processing solutions to the world's leading semiconductor and microelectronic device manufacturers. Increasing demand for semiconductor devices is driving demand for wafer processing equipment. End market applications for KLA's wafer processing equipment include microelectromechanical systems (MEMS), advanced packaging, photonics, high speed RF IC's, and power semiconductors.

The electrostatic chuck (ESC) is a key component in vacuum based wafer processing equipment. In addition to its supply within the equipment, there is also a growing demand for replacement ESCs from the aftersales market. To maintain supply of high quality ESCs, an in-depth understanding of their operational characteristics and possible failure modes is required.

The Electrostatic Chuck (ESC) is comprised of upper ceramic layers positioned on a metal body. Electrodes are attached to the ceramic to generate the charge. RTV silicone between the layers provides good thermal contact and compensates for differences in thermal expansion.

Challenge

To fully understand the operation of the ESC and to identify its possible failure modes, to ensure integrity during use and to support future developments for real time monitoring.

Solution

Three ASTUTE EAST institutions are collaborating to evaluate the manufacture and operation of the electrostatic chuck (ESC).

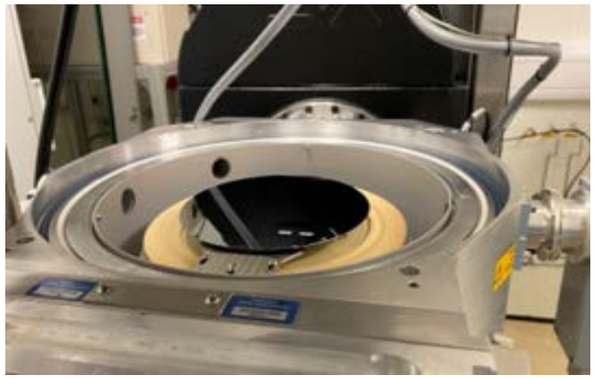
A computer model of the ESC will be developed to replicate operation, and to simulate failure conditions.

A Failure Mode and Effect Analysis (FMEA) will be carried out to identify and prioritise failure modes identified.

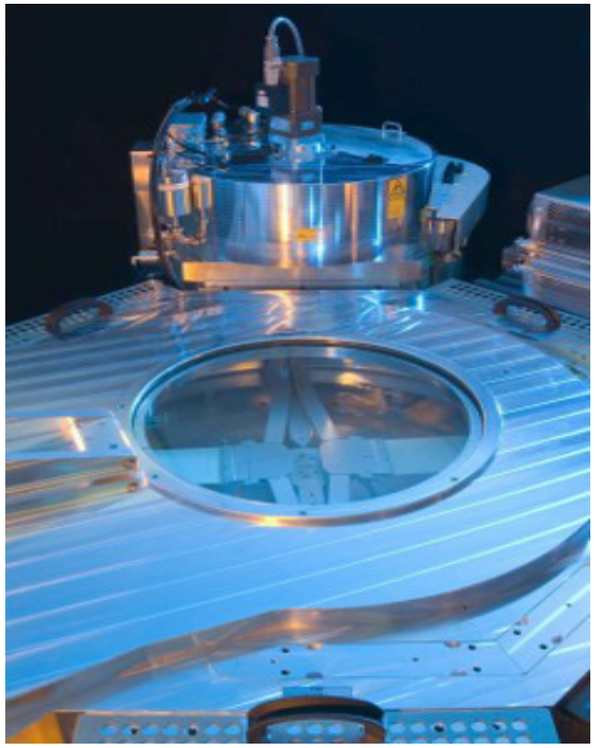
For future developments, the potential of Industrial Internet of Things (IIoT) devices linked with the equipment for real time data analytics and advanced failure information will be explored.

Impact

The impact of the project will enable KLA to remain competitive in this fast-growing market with the potential to provide enhanced diagnostics to their customers and field engineers.



The image above shows an ESC in a laboratory environment with a wafer sitting above the chuck.



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