

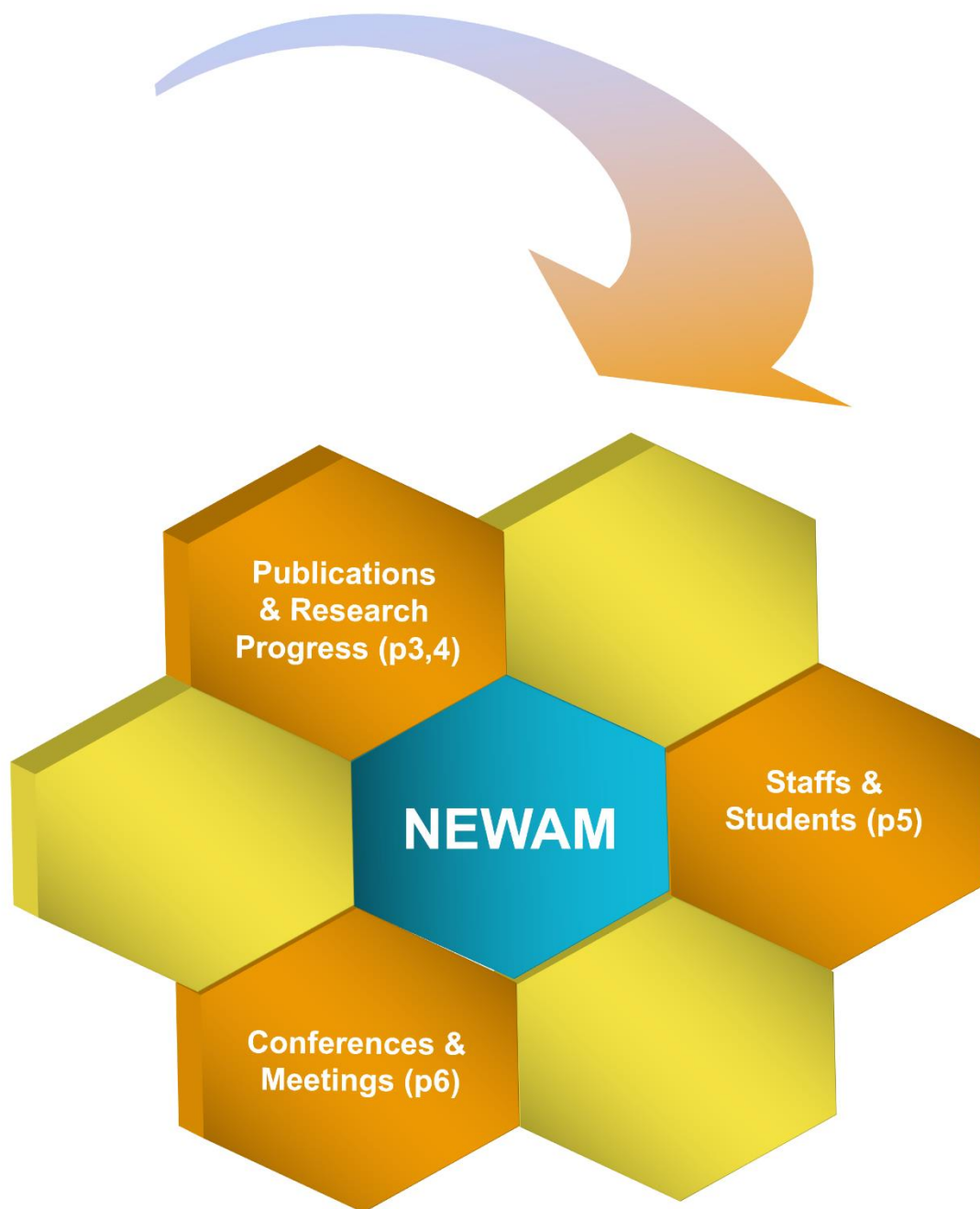
New Wire Additive Manufacturing

Newsletter (2nd quarter, 2022)



Compiled by NEWAM dissemination committee and released on 1 July 2022

Your NEWAM in April – June 2022





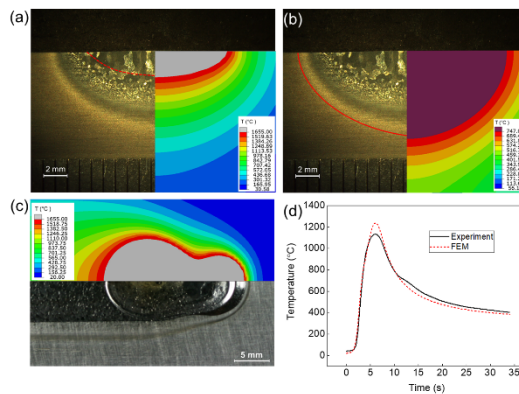
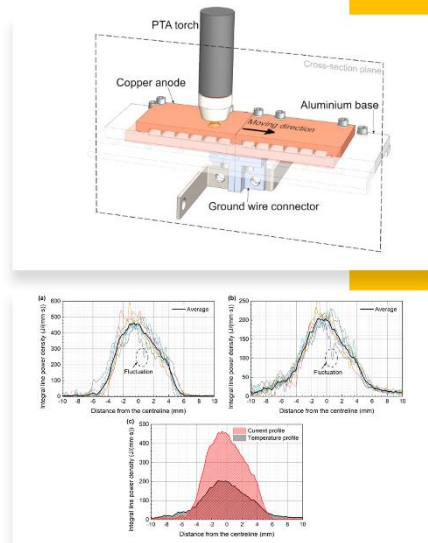
New Wire Additive Manufacturing

Publications & Research Progress

Cranfield Team's new publication on heat source characterisation

- A novel aspect of this work is the use of a laser beam with a well-defined energy profile which was first measured using a commercial laser beam diagnosis system and was used to calibrate the Split Anode Calorimetry (SAC). This confirmed the accuracy of the SAC method and its suitability for measuring the energy distribution of an electric arc if provided stably. The Plasma Transferred Arc (PTA) energy profile was observed to be distorting when crossing over the split anode interface of the SAC. This was corrected by moving the ground wire from the side to the centre of the anode.
- Detailed analysis of 130A PTA energy density profiles generated from both the current density and the temperature distribution of the arc showed that the current data generated profile is narrower than that of the temperature data generated profile. This indicates that the effective energy distribution is wider than that of the width of the arc column due to other energy transfer processes such as convection and radiation. The energy absorption distribution matched well to a Gaussian distribution model with a radius of 7 mm. The arc energy absorption rate of the copper plate was measured and found to be about 56%.

Chen, G., Williams, S., Ding, J., Wang, Y., & Suder, W. (2022). Split anode calorimetry for plasma arc energy density measurement with laser calibration. *Journal of Manufacturing Processes*, 78, 71-81.



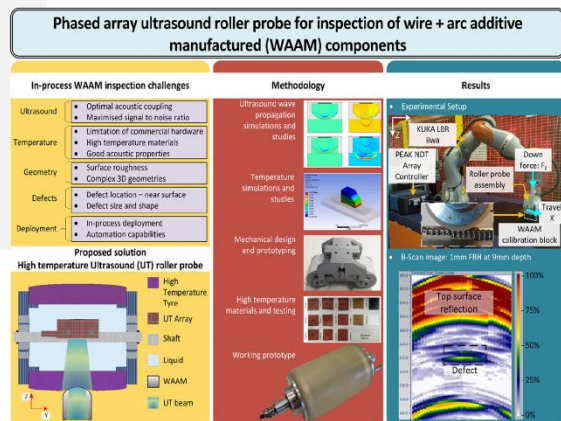
Cranfield Team's new publication on hybrid arc-laser AM modelling

- Cranfield's process modelling team recently published a paper about FE modelling for thermal analysis of the hybrid plasma arc-laser AM. In this paper, a 3D steady-state FE model was developed using a circular surface heat source and orthotropic artificial conductivity, which is more physically representative than the commonly-used volumetric heat source model. This model is easy to calibrate and enables to capture the heat source size effect on the hybrid process.
- The melt pool geometry and full-field distributions of the cooling rate and temperature gradient can also be obtained, which provided useful thermal information for process development and metallurgical analysis.

Wang, C., Sun, Y., Chen, G., Chen X., Ding, J., Suder, W., Diao, C., & Williams, S. (2022). A simplified modelling approach for thermal behaviour analysis in hybrid plasma arc-laser additive manufacturing. *International Journal of Heat and Mass Transfer*, 195, 123157. <https://doi.org/10.1016/j.ijheatmasstransfer.2022.123157>

Strathclyde Team's new publication on phased array ultrasound roller probe

- The paper presents the research, development and validation of a high temperature phased array ultrasound testing (PAUT) roller probe to perform robotically delivered in-process NDT of WAAM components.
- The experimental results confirm that the PAUT roller probe can endure surface temperatures up to 350 °C, can be autonomously deployed via a robotic arm and can detect 1 mm diameter flat-bottom holes located 6 mm, 9 mm and 12 mm deep under the unmachined surface of a Ti-6Al-4V WAAM calibration block.



Randika K.W. Vithanage, Ehsan Mohseni, David Lines, Charalampos Loukas, Euan Foster, Charles N. MacLeod, S. Gareth Pierce, Anthony Gachagan, Jialuo Ding, Stewart Williams, 2022. Development of a phased array ultrasound roller probe for inspection of wire + arc additive manufactured components, *Journal of Manufacturing Processes*, 80: 765-774.



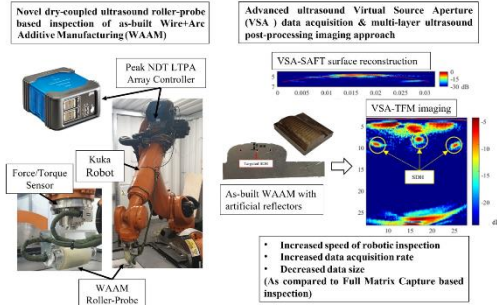
New Wire Additive Manufacturing

Publications & Research Progress

Strathclyde Team's new publication on automated ultrasonic inspection

- The paper tackled the drawbacks of Full Matrix Capture (FMC), by deploying virtual source aperture data acquisition which enabled an increase in inspection speed, decreased the size of the data set, and improved the signal strength retrieved from the sample all by maintaining the imaging quality compared to conventional FMC data acquisition.

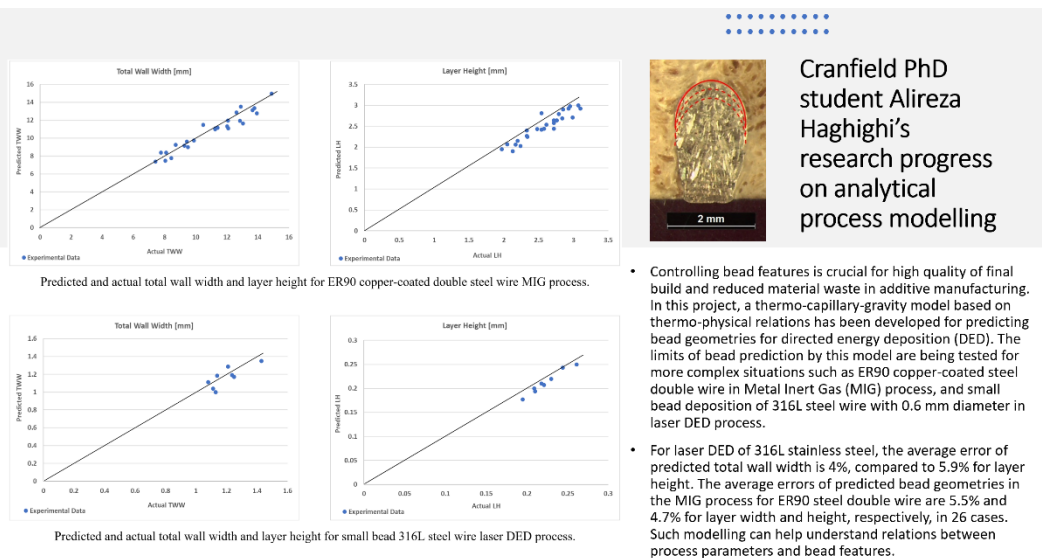
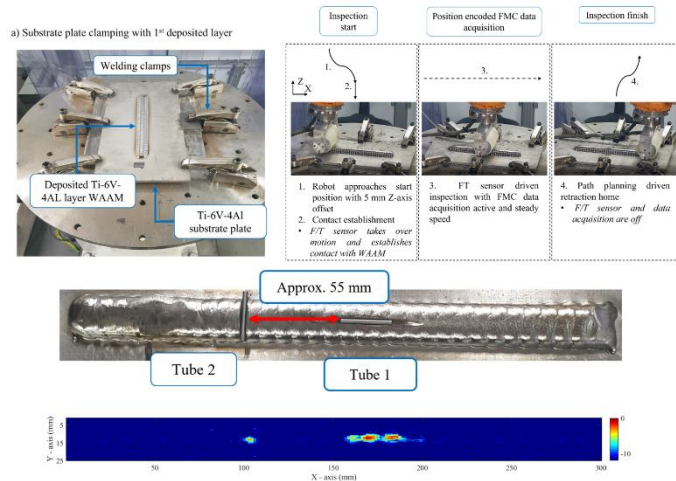
Zimmermann, R., Mohseni, E., Vithanage, R.K., Lines, D., Foster, E., Macleod, C.N., Pierce, S.G., Marinelli, G., Williams, S. and Ding, J., 2022. Increasing the speed of automated ultrasonic inspection of as-built additive manufacturing components by the adoption of virtual source aperture. *Materials & Design*, p.110822.



Strathclyde Team's new publication on In-Process Ultrasonic Non-Destructive Evaluation

- The article introduced a novel concept of WAAM & ultrasound in-process NDT cell, in which for the first time, the in-process inspection of WAAM was accomplished on an as-built titanium wall.

Zimmermann, R., Mohseni, E., Vasilev, M., Loukas, C., Vithanage, R.K., Macleod, C.N., Lines, D., Javadi, Y., Silva, E.E., Pimentel, M. and Fitzpatrick, S., 2022. Collaborative Robotic Wire+ Arc Additive Manufacture and Sensor-Enabled In-Process Ultrasonic Non-Destructive Evaluation. *Sensors*, 22(11), p.4203.





New Wire Additive Manufacturing

Staffs & Students



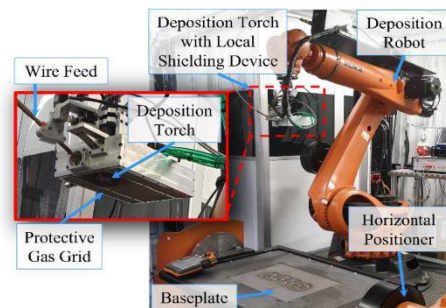
Dr Eloise Eimer was promoted to Senior Research Fellow

- Eloise joined Cranfield as a PhD student in 2015 and joined the Welding Engineering and Laser Processing Centre researcher teams in 2019. Her current role is to develop, manage, and deliver industrial and publicly funded research projects focused on alloy and process development for aluminium WAAM. She leads the aluminium WAAM research program at Cranfield and coordinates the NEWAM aluminium activities in collaboration with Coventry and Manchester University.
- She recently manufactured the first aluminium lithium component by implementing alternative current plasma deposition and inter-layer cold work (shown in the photo).



Dr Danny Dreelan joined Manchester team

- Danny Dreelan is a Research Associate within the microstructural modelling research group at University of Manchester. His PhD research was predominantly focused on meso to macro scale modelling of grain structure evolution, via epitaxial growth over multiple layers of the powder bed fusion additive manufacturing process, within the I-Form advanced manufacturing research centre in Ireland, based at University College Dublin where he also completed his undergraduate and masters education in Mechanical Engineering.
- So far his models track the competitive growth and advancement of grain envelopes via a fast and efficient cellular automata based approach, which can use simulation data from external thermal models to predict grain structure or computation of the thermal field internally in the model. His research going forward will be focused on the investigation of strategies to induce the columnar to equiaxed transition during wire-fed additive manufacturing processes with the aid of computational modelling.
- In his personal life, he likes to stay physically active and is an avid weightlifter, and enjoys hiking, mountaineering and adventure.



NEWAM PhD Student, Rastislav Zimmermann, has successfully defended his doctoral thesis at the University of Strathclyde

- The title for Rastislav's thesis was "Automated Ultrasound In-process NDE of Wire + Arc Additive Manufacture".
- Rastislav's thesis has tackled the challenge of inspecting the WAAM through the as-built surface to enable the in-process inspection using a novel dry-coupled roller-probe and hence the possibility for the potential in-process repair.



New Wire Additive Manufacturing

Conferences & Meetings

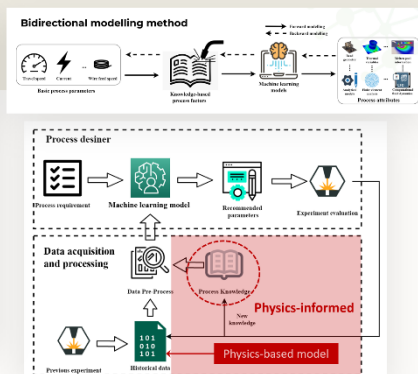


Strathclyde Team researcher Sumana attended KTP National conference at Paisley, Glasgow from 8-9th June 2022

- Hosted by the University of the West of Scotland, this 2-day conference was the first in-person National Associates' conference since 2019 and was provided an opportunity for Associates to network, learn, be inspired and, most importantly come together.
- The conference agenda has been developed based on community survey feedback from current KTP Associates across the UK. Agenda also contained inspiring stories and masterclasses spanning KTP project delivery, career planning and personal development, all delivered by KE professionals, sector leaders and current/former KTP associates.
- This also provided a venue for virtual poster competitions and project showcasing and ties into one of the conference themes – Monetising the Metaverse. Sumana also got opportunity to participate in the poster competition.

A physics-informed bidirectional machine learning model for wire arc additive manufacturing (WAAM)

Yongle Sun, Jian Qin, Jialuo Ding, Stewart Williams
Cranfield University

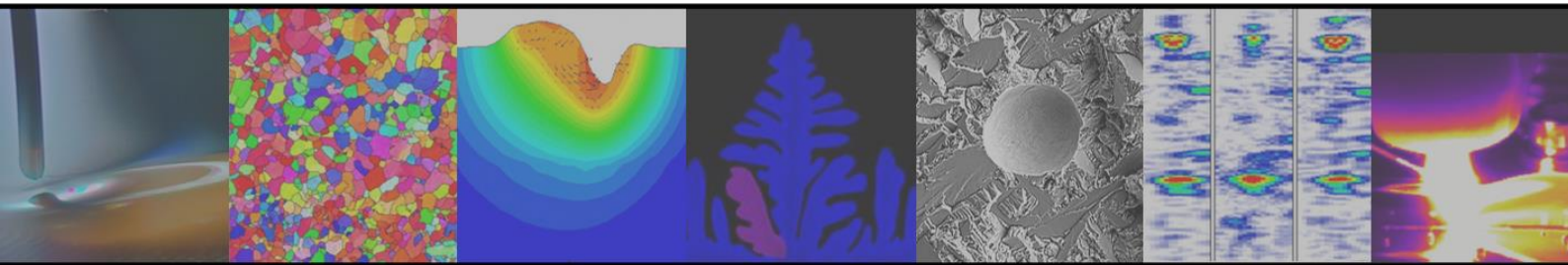


Cranfield Team Dr Yongle Sun gave a talk in the NAFEMS UK Regional Conference (7-8th June 2022)

Strathclyde researchers planned to attend several conferences



- The team is prepared to attend and present at the 49th Annual Review of Progress in Quantitative Nondestructive Evaluation (QNDE) at San Diego, USA.
- Prof. Gareth Pierce will be giving an invited talk about "Developments of in-process NDE techniques for Wire + Arc AM at Strathclyde University" at International Conference on Additive Manufacture (ICAM) held in October 2022.
- The team have submitted a list of abstracts at BINDT, 59th Annual British Conference on Non-Destructive Testing 2022.
 - Ehsan Mohseni "Automated Multi-Modal Non-Destructive Evaluation of Wire Arc Additive Manufacturing"
 - Muhammad Khalid Rizwan "Investigating ultrasound wave propagation through the coupling medium and non-flat surface of wire + arc additive manufactured components inspected by a PAUT roller-probe"
 - Theodosia Stratoudaki "Automated laser-induced phased arrays for the rapid ultrasonic inspection of as-deposited AM components"
 - Momchil Vasilev "Flexible Robotic Programming for Complex High-Value Inspection"



Further Reading

NEWAM website: <https://newam.uk/>
NEWAM LinkedIn: <https://www.linkedin.com/in/newam-epsrc-programme-grant-6617091a9/>
NEWAM ResearchGate: <https://www.researchgate.net/project/New-Wire-Additive-Manufacturing-NEWAM>

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