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EDITORIAL

Topical collection—additive manufacturing

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Additive manufacturing is not a new concept in the welding environment: Welded fabrication itself is an additive process and welding technology has been used for many years for surfacing, repair, and even manufacturing of components by weld deposition. The relationship with welding technology is clear and has been recognised by the adoption of the topic by the International Institute of Welding (IIW) Commission 1, and the ongoing development work on standards by the American Welding Society. The increase in interest and basic viability of additive manufacturing, 3D printing, direct energy deposition, and rapid prototyping were originally facilitated by the use of computer-aided design and manufacturing developments more than 30 years ago. These developments have been further enhanced with the availability of automated systems and robotics, together with more sophisticated joining processes and digitally controlled welding equipment.

In recent years, there have been several conferences on the topic and many of the papers in this collection were presented at the 2nd International Congress on Welding, Additive Manufacturing and associated non-destructive testing (ICWAM II), organised by the Institut de Soudure, and supported by IIW in May 2019. It is clear that many researchers are addressing the topic, and most have now moved on from the demonstration of building simple geometric shapes, to more critical application of the technology. Earlier publications reviewed the basic additive manufacturing technology, process options, comparative economics, and material feasibility and these publications are often cited in this collection. As can be seen from the current contents, attention has now turned to process improvements for increased productivity and product quality. Great interest was initially shown in manufacturing titanium alloy components for the aerospace industry, due to the poor machinability and 'buy to fly' ratio of traditional techniques. Several papers deal with these alloys, but interest has also turned to aluminium, stainless steel, copper, and nickel-based alloys, as well multi-material, in situ alloying, and functionally graded systems. Process improvements covered here include enhancements such as wire-laser-arc processes, GTAW-hot wire, multi-wire GMAW, waveform-controlled GMAW, and 3D plasma deposition. Wire Arc Additive Manufacturing (WAAM) appears to be attracting increased interest, accounting for more than 60% of the process papers at ICWAM II. Enhancements to WAAM were featured in many papers, in particular novel cooling strategies, and in situ control of layer height was investigated, as a means of improving reproducibility and productivity.

Post-deposition non-destructive testing has also been implemented to ensure freedom from volumetric defects and thermomechanical simulation is discussed as a means of investigating residual stress in the finished component. Several of the earlier systems described here used dedicated CAD/CAM control in a fixed enclosure—effectively providing an 'off the shelf' package. Most current WAAM systems use a conventional robot, an advanced welding system, and a customised software package. One supplier at ICWAM II was offering an 'all in one' WAAM package in an enclosure with appropriate software control but most of the WAAM papers presented here utilise a robotic welding approach for greater flexibility and potentially greater component volume. The development of integrated slicing, tool path planning, and topological optimisation is touched on in the papers but is clearly one of the areas still in development. Potential novel applications are also discussed in several papers. The application of additive manufacturing for large nickel aluminium bronze components for marine applications was investigated in one of the papers, and the use of AM for adding stiffeners to automotive steel pressings was the subject of another paper.

The technology has reached a stage when real applications should increase. Some of the developments presented in this collection should resolve a number of outstanding problems, but there remains a need for in situ control of part geometry

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and quality, as well as continued development of 'user friendly' software.

Additive manufacturing can benefit significantly from the accumulated knowledge of the basic welding materials and process technology, which has been generated by the IIW commissions over many years. *Welding in the World* will continue to provide a source of this underlying welding technology, which will be required for the advancement of additive manufacturing.

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