Asymmetric Beam Shapes For Improving Laser Welding Performance

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Laser welding is advantageous over resistance, arc or ultrasonic methods due to a number of advantages, including speed, precision and low heat affected zones. However, there are a number of challenges to overcome to achieve accurate, functional and aesthetic joins between materials. Beam shaping allows laser spot geometry and intensity profile incident on the workpiece can be customised, and therefore tuned to improve critical parameters in the final product.

Laser-based freeform manufacturing processes allow beam shaping optics to be designed without rotational, transverse, or mirror symmetry requirements. Optics are machined in fused silica, and the laser reflow process retains the high power handling properties of the bulk material. This means complex, freeform beam shapes and profiles can be produced for multi-kW industrial laser systems using a single simple, passive, optical element [1].

Here we present recent developments in asymmetric freeform beam shapes for laser welding. Beam shapers have been designed to redistribute laser power into leading or trailing profiles around the welding keyhole. Simulated intensity profiles are compared to real measurements in welding systems. Bead on plate welding trials are demonstrated on aluminium and stainless steel samples. Metallographic observations and mechanical tests show the significance of the intensity profile modifications on the performance of the join. Additionally, new concepts for static and variable beam profiles are presented.

[1] A. D. Griffiths, C. Wreford, N. Trela-McDonald (2023) Breaking Symmetry Constraints in Freeform Design for Refractive Beam Shapers, Optica Design and Fabrication Congress 2023 (IODC, OFT), paper 1279819