Application of laser in high speed joining of thin metallic sheets

EPSRC Centre for Innovative Manufacturing in LASER-BASED PRODUCTION PROCESSES

Laser Welding

Introduction

This project aims to explore the application of laser as a non-contact high speed joining tool for ultra thin similar and dissimilar structural alloys which will allow weight saving through design modifications.

Objectives:

- Understand how to control the weld shape (penetration depth and weld width) and correspondent heat affected zone (HAZ);
- Study the application of continuous (CW) and pulsed wave (PW) fibre lasers in achieving control of power density and specific point energy;

Research Hypothesis

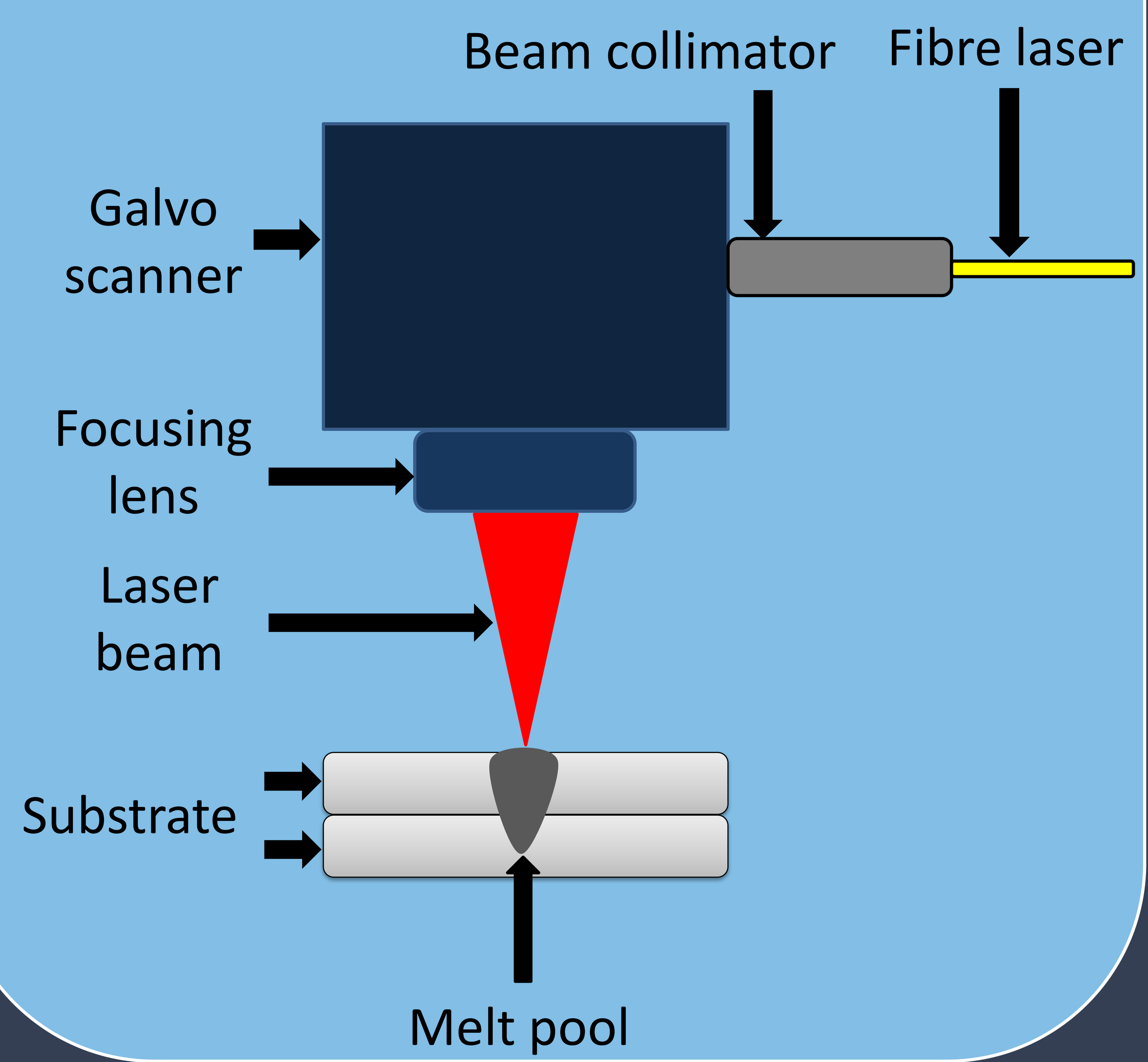
CW laser: The process is characterized by its high quality (low spatter) and it allows an easier weld shape modification. However, the peak power may be insufficient, causing coupling issues. There is also the possibility of defect generation (keyhole porosity).

PW laser: High peak power is achievable with this laser. It allows more flexibility on the energy application and control of the pulse shape. Nevertheless, very high peak power may lead to material vaporization and weld defects. The weld geometry control is less than CW laser.

Experimental set up

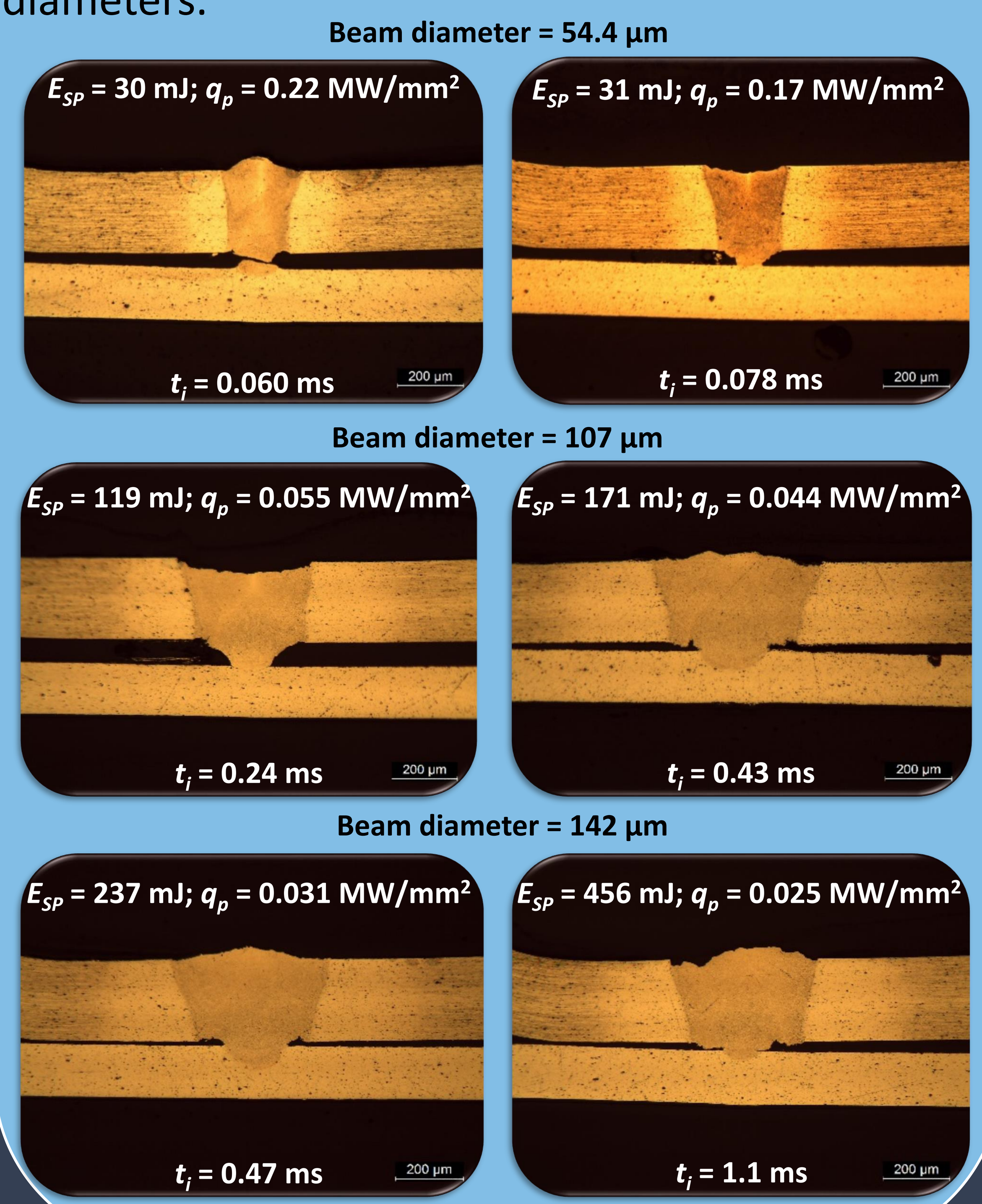
- 500 W CW fibre laser
- 100 W PW fibre laser
- Galvo scanner
- 5XXX series aluminium alloy (0.25 mm thick)
- Overlap joint configuration

The same experimental set up is applicable for both lasers and different alloys. It is possible to control power density (***q_p***) and specific point energy (***E_{SP}***), which changes the final weld shape.



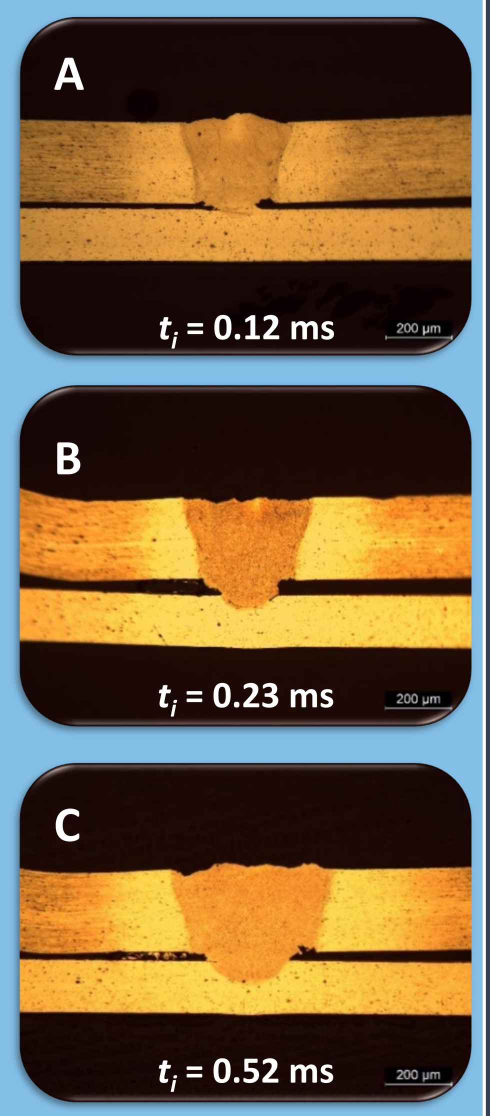
Results: micrographs

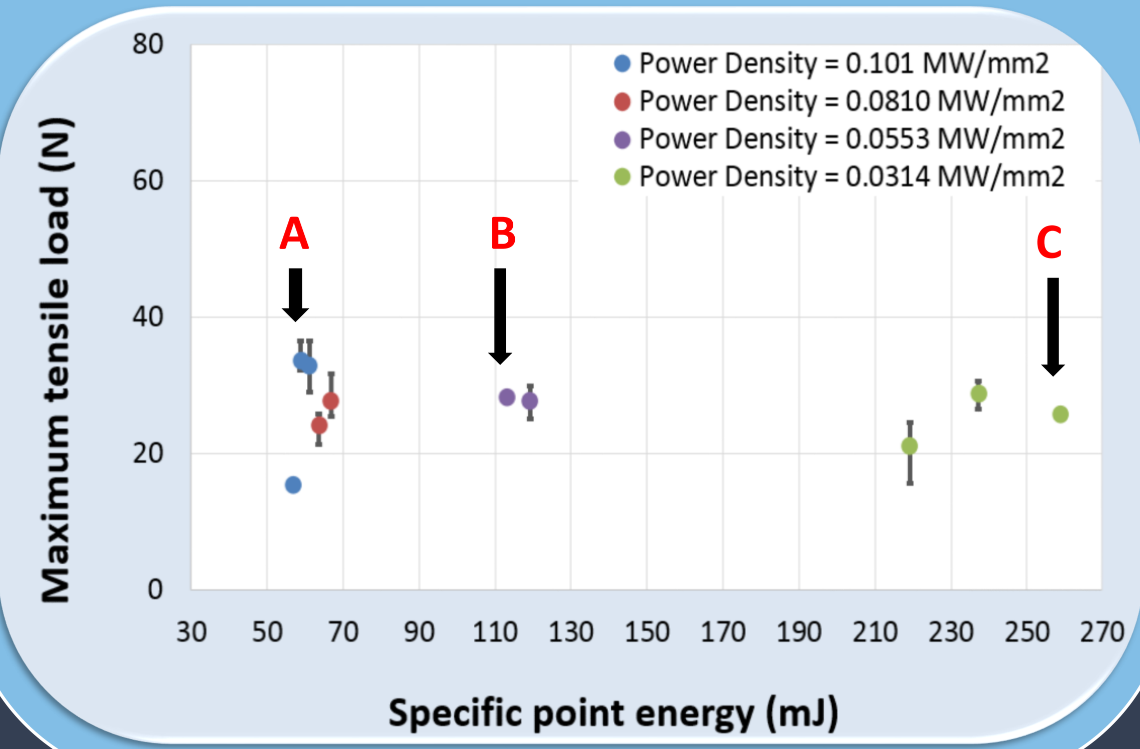
Only CW laser showed viable welds. Accordingly to the micrographs, it is possible to achieve an intended penetration depth and weld width by controlling the trade-off between power density and specific point energy, using different beam diameters.



Results: Mechanical properties

Similar tensile loads have been achieved for different weld shapes (A, B and C). A combination of low E_{SP} and high q_p minimizes the interaction time (**t_i**) between laser and material, which prevents distortions for a required penetration depth. Thus, the gap between the sheets can be reduced and the bonding area increased.





Summary of observations

- CW laser is suitable to form the joints. The weld shape is easily controlled and the seam quality is good.
- Small spot sizes cannot be used for this application, since the bonding area is not enough to provide good weld strength;
- The clamping system is vital. The gap between the two sheets should be controlled and eliminated to improve the heat transfer;

Conclusions

- CW laser, with high average power, is a viable solution to join ultra thin structural alloys with high productivity, using a galvo scanner;
- Low vaporisation temperature alloying elements (Mg) resulted in high material vaporization using high q_p with the PW laser;
- Combination between q_p and E_{SP} controls the weld shape (depth of penetration and weld width) and respective heat affected zone;
- The process is suitable for both similar and dissimilar structural alloys;

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