Advanced manufacturing techniques for laser welding of automotive structural aluminium alloys

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Aluminium alloys has been becoming very important key player in the automotive industry because of their desirable lightweighting options and cost-effectiveness. However, processing of aluminium is not easy and requires some additional precautions to obtain convenient results. Thermal degradation is the most damaging consequence that an age-hardened aluminium alloy system would suffer from fusion welding. Laser welding systems allows lower heat input, when compared to conventional welding techniques, due to its inherently higher power density, which allows much higher productivity. This results in a relatively faster thermal cycle with higher cooling rate. Laser welding allows very high repeatability and ease of automation which are crucial for the automotive industry. However, the modern aluminium alloy grades for automotive structural applications are sensitive to thermal energy and degradation in the weld and associated heat-affected zone due to irreversible microstructural changes in terms of precipitate coarsening which appears in the strength profile of a welded structure.

In the presented research work, laser process fundamentals and their impact on the material properties, which result in softening, were studied. The thermal cycle that would result in significant coarsening was determined and the process modelled to identify the processing parameters that would not cause any thermal degradation. Application of advanced cryogenic cooling was designed to suppress the thermal cycle further. Application of ternary and quaternary filler wires were designed to be applied with laser and laser plus arc processing to achieve weld metal grain refinement through provision of enough nucleation sites and suppressing traditional dendritic grain structure characteristic of a fusion zone.

The experiments and analysis of data are currently ongoing to quantify the benefits that would realise through such novel and advanced design of process.