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Friction stir spot welded joints for high voltage battery application

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INTRODUCTION

Modern automotive components, especially so for the case of batteries, are composed of multiple high performance metallic alloys and thermoplastic composites, which require the use of multiple joining processes during manufacture and repair processes. To ensure strong and durable joints, solid state processes such as friction stir welding (FSW) have gained importance, as they enable minimal heat input and avoid changes to the base materials.

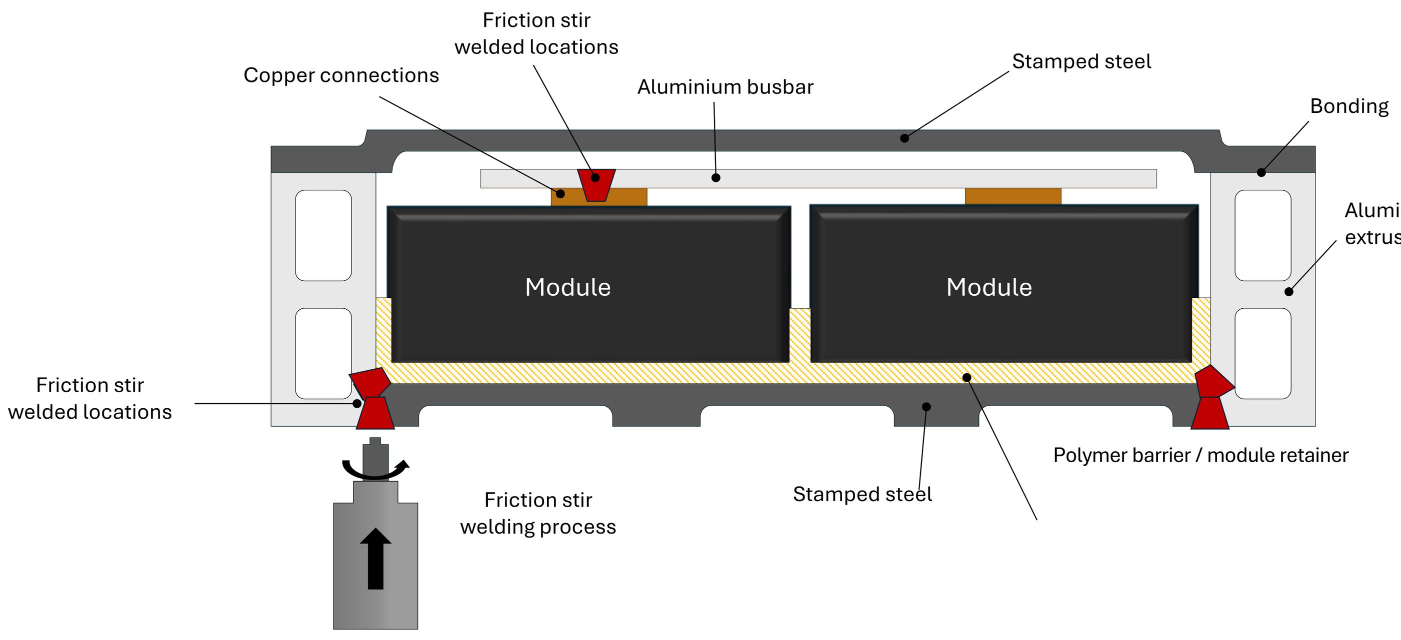

Figure 1 – Examples of multi material joints in modern vehicle batteries

MATERIALS AND METHODOLOGY

The project encompasses three main steps, designing, testing and modelling new joint concepts using aluminum, magnesium and copper alloys, combining them and comparing them with adhesive bonding. These include the structural components of the battery (steel, magnesium and aluminum) and the electrical buses (copper and aluminum)

- Joint design for dissimilar materials
  - Aluminum/steel
  - Aluminum/copper
  - Aluminum/magnesium
- Joint characterization
  - Microstructure
  - Fracture analysis
- Simulation of the process/joint
  - Thermal analysis
  - Mechanical analysis
  - Electrical analysis

COPPER TO ALUMINIUM JOINING

Copper aluminium joints are necessary for bus-bar and cell connections, where electrical conductivity and heat resistance are paramount. Joints were made using friction stir spot welding (FSSW)

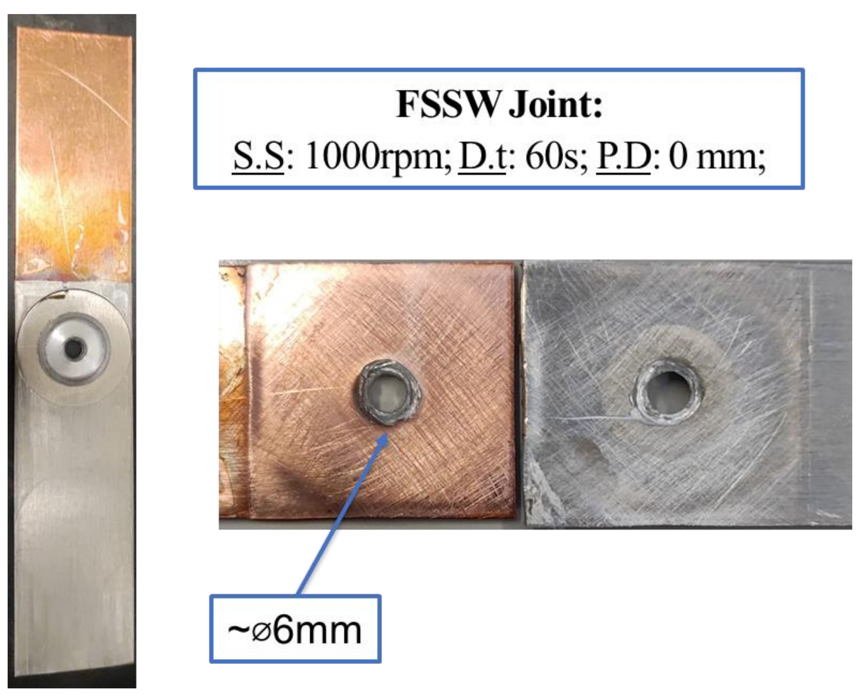

Figure 2 – Example of copper to aluminum friction stir spot welded joints and respective parameters under analysis (rotation, dwell time and plunge depth)

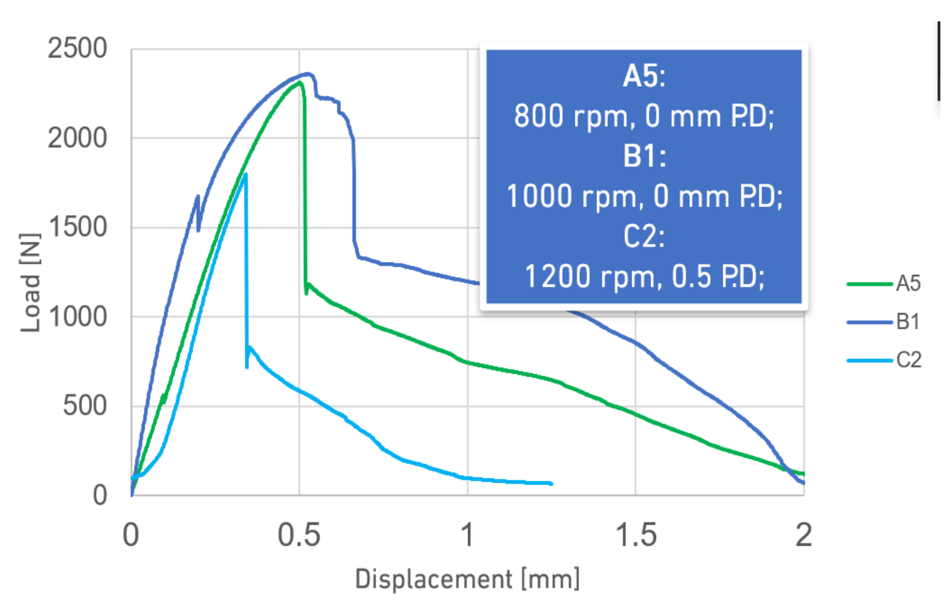

Figure 3 – Joint response to the different parameters under analysis,

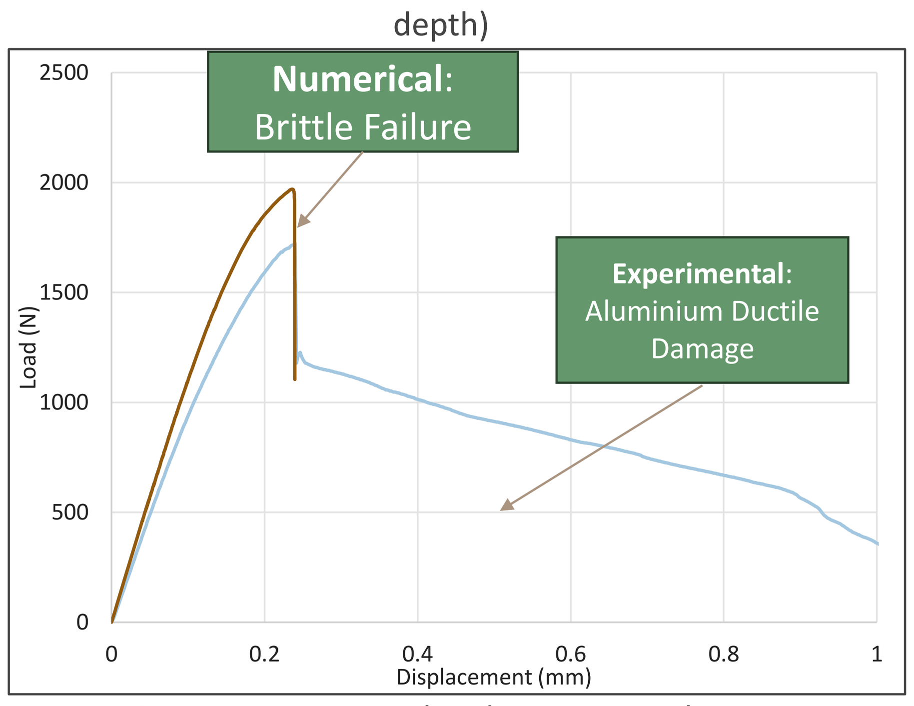

Figure 4 – Numerical and experimental response comparison

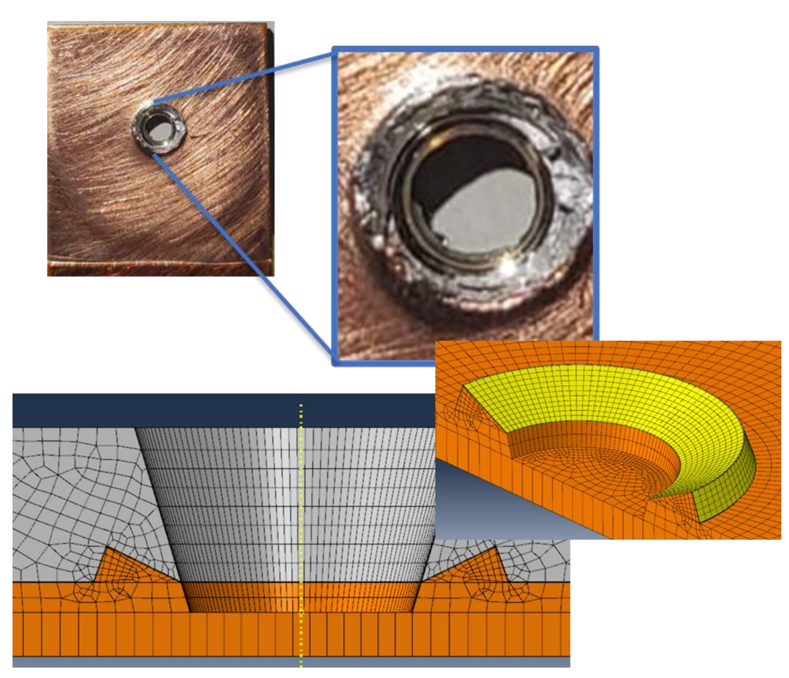

Figure 5 – Failure mode and numerical model geometry

MAGNESIUM TO ALUMINIUM JOINING

Magnesium was joined to aluminum using FSSW, bonded and hybrid approaches, exploring also the position of multiple spot weld locations along the joint, enabling the creation of performance housings.

The performance of bonded joints was above that of the FSSW joints. Hybrid joints were found to have a gentler failure process, but with limited strength and displacement.

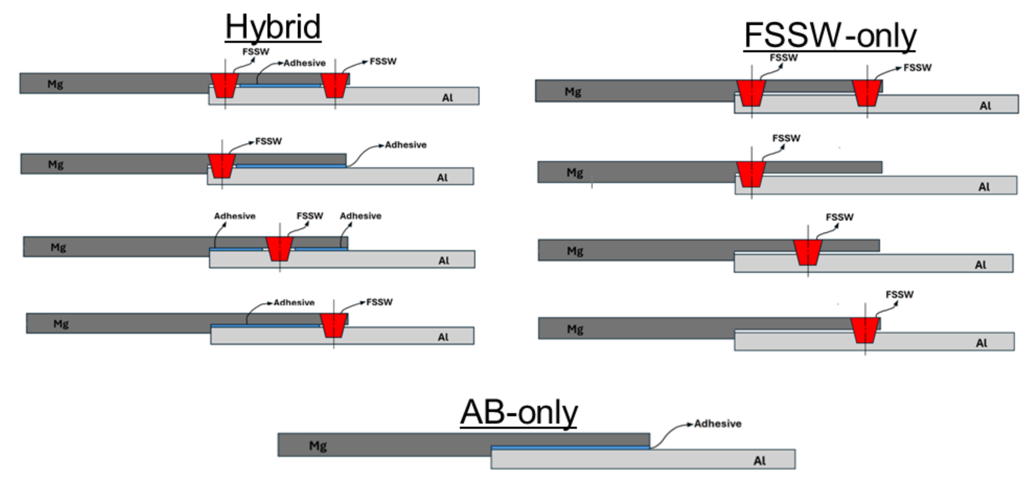

Figure 6 – Tested magnesium to aluminum joint configurations

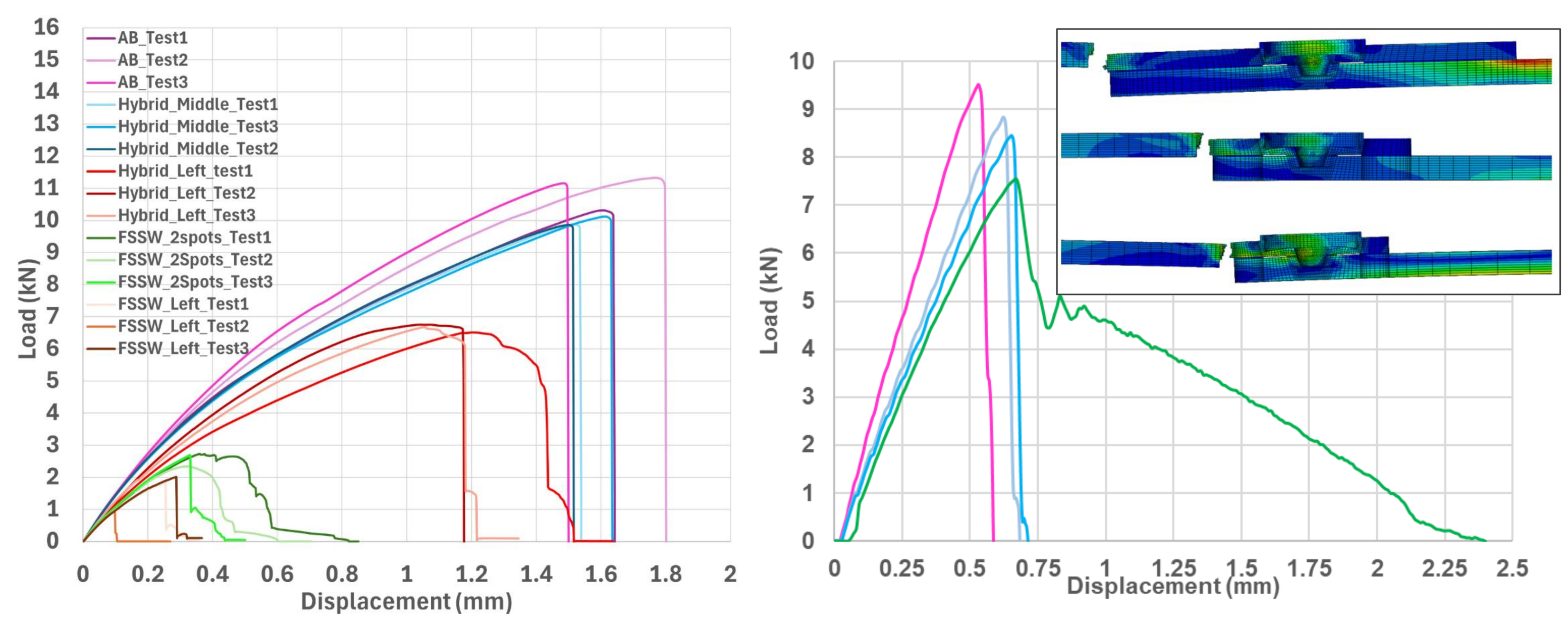

Figure 7 – Experimental response of the joints (left) and numerical curves and failure mode

ALUMINIUM TO STEEL JOINING

Aluminium to steel joints were manufactured using friction stir welding and subjected to different thermal stages, to study the influence of intermetallic compounds on joint performance. The formation of IMCs was changed, but the influence of the stages was relatively limited. These represent a novel solution for high performance connections.

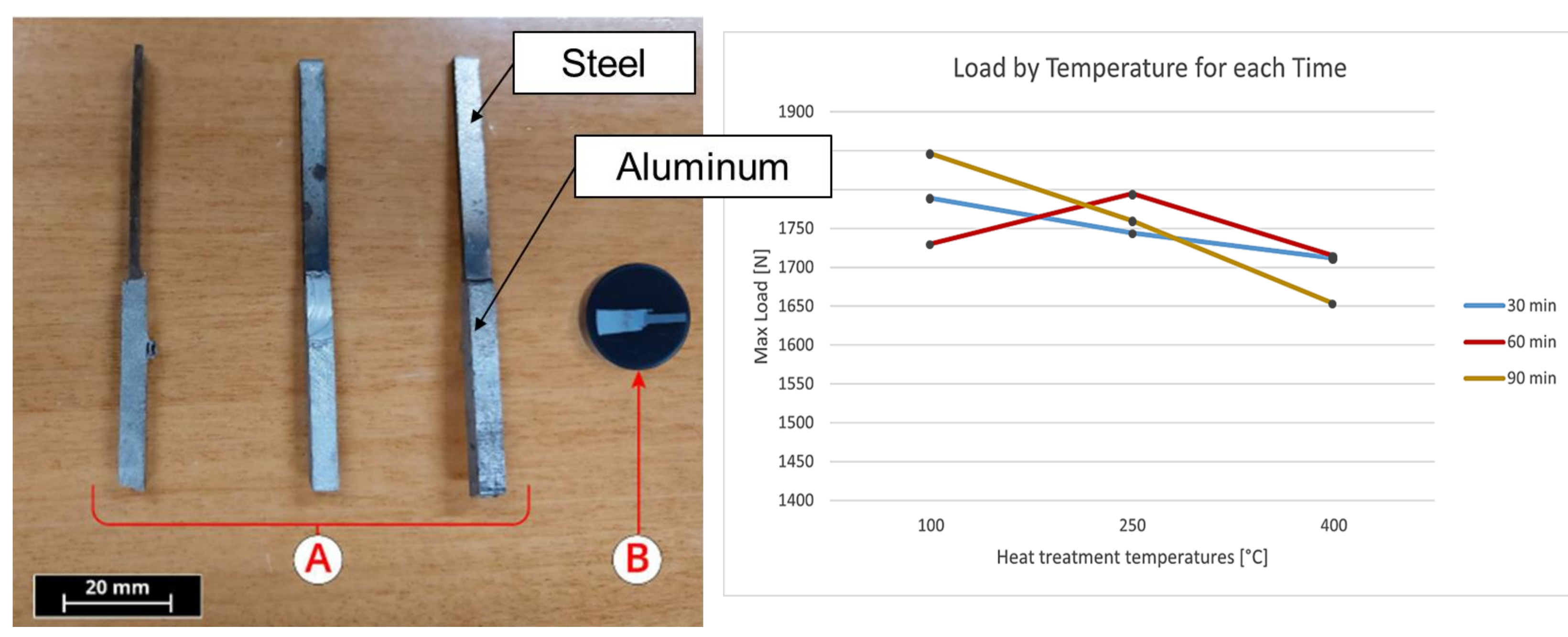

Figure 8 – Steel to aluminium specimens (left) and joint response to heat treatment temperatures and stage times (right)

CONCLUSIONS

New materials and joint concepts have been shown to be promising solutions for applications in battery design. Solid state joining appears as a valid solution, with satisfactory joint performance. For structural applications, the combination with adhesive bonding is also shown as a possible solution, although with a lower performance than the sole use of adhesive.

ACKNOWLEDGEMENTS

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