

Friction Melt Bonding of Al6061 to Dual-Phase steel. Modelling and comparison to FSW for lap-joints.

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Abstract

Friction stir welding (FSW) based processes are seen as one of the main choices to replace mechanical methods in the joining of aluminium to steel for automotive purposes. Two characteristics make these processes appealing; they create a metallurgical bonding and they are energy efficient. The main drawback resides on the brittleness of the Fe/Al intermetallic bonding layer (IM) between the base materials. FSW based processes can provide a solution to this issue, thanks in part to the fine control of the energy input when creating the bonding.

In this framework a novel technique called Friction Melt Bonding (FMB) has been developed. In this process, a rotating pinless tool is pressed and displaced over the steel plate surface generating heat by friction. The heat is transmitted through the thickness of the steel to the aluminium plate placed underneath. The Al plate partially melts at the interface while the steel remains solid. As a result, bonding is achieved by the formation of a thin Fe/Al intermetallic layer. A simple finite element model have been developed to predict the thermal cycles. This model allows predicting the geometry of the IM bonding layer and the thermally affected zones of the base materials.

Subsequently, FMB is used to weld Al6061 to Dual-Phase steel. The results are compared to two variations of FSW whose difference lies in whether or not the tool pin comes into contact with the steel. Lap-shear tests performed on the welds show that the fracture happens by default at the brittle IM at similar forces independently of the chosen welding parameters. However, some of the FMB results show higher strengths and are analysed in order to identify the features that controls the behaviour of the brittle fracture.

About the author

Graduated in Industrial engineering by the Universidad Carlos III de Madrid, Norberto Jiménez Mena is currently a PhD student at the Université Catholique de Louvain in Belgium. His thesis' topic is the optimization of the novel Friction Melt Bonding process to weld aluminium to steel by combining experimental and modelling work.