Invitation à la soutenance publique de thèse

Pour l’obtention du grade de Docteur en Sciences de l’ingénieur et technologie

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Optimization of the friction melt bonding of aluminium to steel: from microstructure evolution to mechanical properties

Dissimilar welding consists in joining materials presenting large differences of properties. This is the case of the aluminium-steel assemblies, of particular interest in the automotive industry due to the lightness of the former and the strength of the latter. The large differences in melting temperatures, mechanical properties and the formation of brittle Al/Fe intermetallic phases at the interface constitute major challenges.

Friction melt bonding (FMB) is a novel process, developed and patented at UCL, to join dissimilar materials showing large differences in melting temperatures. A rotating cylindrical tool pressed against the upper steel plate generates heat by friction. The temperature rise brings the melting of the underneath aluminium plate. The reaction between solid steel and liquid aluminium leads to the formation of a continuous thin intermetallic layer that keeps both plates welded. The mechanical strength of FMB joints was characterised in the present work. Hot tear defects in the aluminium plate leads to the premature failure of welds. They were thus suppressed with the control of the thermo-mechanical cycles during welding. The toughness of the joint was assessed using single lap joint testing and compared to friction stir welds (FSW). The microstructure observations and finite element modelling revealed that the weld failure is controlled by the initiation and fast propagation of a crack through the intermetallic layer. To improve the mechanical performance of the weld, the nature of the intermetallic layer was changed with addition of electroplated layers of Ni and Co at the reacting interface. It was revealed that the toughness depends on both the thickness and the nature of the intermetallic layer. The Co plating showed the largest toughness since the crack is forced to propagate through the aluminium plate instead of the intermetallic layer. Finally, the residual stresses after welding were characterised using neutron diffraction. Their distribution is related to the thermal cycle during welding but an additional contribution is related to the thermal expansion mismatch between aluminium and steel.

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