Mechanical Properties of Resistance Spot Welds in Lightweight Applications

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Academic Dissertation which, with due permission of the KTH Royal Institute of Technology, is submitted for public defence for the degree of Licentiate of Technology on Monday the 30th September 2013, at 1:15 p.m. in M37, Brinellvägen 64, KTH, Stockholm.
Abstract

This licentiate thesis is concerned with residual stresses in aluminum alloy 6061-T6 resistance spot welded joint. Several topics related to mechanical strength of welded structures are treated such as; nugget size and microhardness and microstructures of weld zone and their influence on mechanical strength of welded structure, failure load measurement using tensile-shear test, resistance spot welding simulation, residual stress measurement by X-ray diffraction method and analysis effect of welding parameters on the mechanical strength and the residual stresses.

To investigate the effect of resistance spot weld parameters on mechanical strength of welded structures, various welding parameters e.g. welding current, welding time and electrode force are selected to produce welded joints with different quality. According to the failure mode, the empirical equation was used to prediction of failure load base on nugget size and hardness of failure line. Microstructure study has been carried out to investigate microstructural changes in the welded joints. Microhardness tests are done to find hardness profiles due to microstructural changes and determine the minimum hardness.

In addition, an electro-thermal-structural coupled finite element model and X-ray diffraction residual stress measurement have been utilized to analyze residual stresses distribution in weld zone. The electrical and thermal contact conductance, as mandatory factors are applied in contact area between electrode-workpiece and workpiece-workpiece to resolve the complexity of the finite element model. The physical and mechanical properties of the material are defined as thermal-dependent in order to improve the accuracy of the model. Furthermore, the electrodes are removed after holding cycle using the birth and death elements method. Moreover, the effect of welding parameters on maximum residual stress is investigated and a regression model is proposed to predict maximum tensile residual stresses in terms of welding parameters.

The results obtained from the finite element analysis have been used to build up two back-propagation artificial neural network models for the residual stresses and the nugget size prediction. The results revealed that the neural network models created in this study can accurately predict the nugget size and the residual stresses produced in resistance spot weld. Using a combination of these two developed models, the nugget size and the residual stresses can be predicted in terms of spot weld parameters with high speed and accuracy.

Key Words
Spot Weld, Aluminum alloy, Mechanical Properties, Finite Element