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Title : An Investigation on the Friction Stir Welding of Dissimilar Aluminium Alloys

ABSTRACT

Friction stir welding (FSW) is a clean welding process capable of joining difficult to weld aerospace aluminium alloys. FSW as a joining process has great potential in promising areas. FSW of dissimilar materials faces several complexities due to variations in material properties, inequality of process forces on each material, intermetallic reactions and material consolidation. All these issues bear a close dependence on main FSW process parameters, tool design, and process strategies etc. and consequently, make the task of fabricating good quality joints difficult. The correlation between various important FSW process parameters and joint quality of dissimilar aluminium alloys is complex in nature. An experiment based study of joining dissimilar aluminium alloys (2xxx and 7xxx), which has promising applications in strategic areas, is key to indigenous technology development and is presented in this work. Influence of critical FSW parameters i.e. tool rotational speed, traverse speed and tool shoulder diameter on microstructure and mechanical properties of the joint obtained by FSW of AA2219-O with AA7475-T761 (a combination typically used in aircraft construction) has been understood and demonstrated in present work.

In the present research, FSW was performed on 2.5 mm thick dissimilar Aluminium alloys (AA2219-O and AA7475-T761) using high carbon steel tool with threaded cylindrical pin on a retrofitted vertical milling machine. Indigenous work fixture was designed and developed for efficient clamping of base materials. Three FSW process parameters i.e.

rotational speed (*A*), traverse speed (*B*), and shoulder diameter (*C*), each at three levels were considered in the experimental studies. Experiments were performed as per Taguchi's L_{27} orthogonal array (OA). Effect of the FSW process parameters on the traverse force, ultimate tensile strength, percent elongation, impact strength, microstructure, and micro-hardness was investigated. Experimental data were statistically analysed through analysis of means (ANOM) and analysis of variance (ANOVA), using Minitab software. ANOM was employed to obtain optimum combination of FSW process parameters and ANOVA was used to determine significance of the main effect and interaction effect of the process parameters. Main effect and interaction effect plots were used to explain individual and combined effects of the process parameters. Diagnostic test was also performed to check the validity of assumptions related to the residuals. Relationships between the FSW parameters and responses were established using regression model. Model equations were obtained to predict accurate values of the responses. Tensile properties, microstructure, micro-hardness, and fracture surfaces of the friction stir welded joints were analyzed. From the results of microstructural examinations, grain refinement is observed at the stir zone due to continuous dynamic recrystallization caused by severe plastic deformation. Minimum hardness was found at HAZ of advancing side for all joints due to the thermal softening. Optimum combination of the process parameters for minimum traverse force, maximum ultimate tensile strength and maximum percent elongation was obtained. Tensile test specimens were fractured from outside the weld which shows the stronger weld compared with weaker base material (i.e. AA2219). Surface morphology of the welded joints is found to be smooth with no visible defects.

Keywords: Friction stir welding, Aluminium alloys, Traverse force, Ultimate tensile strength, Percent elongation, Impact strength, Microstructure, Micro-hardness, Fractography, Rotational speed, Traverse speed, Shoulder diameter, Taguchi method.