INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Experimental and Computational Studies on Exit-Hole-Free Friction Stir Spot Welding Processes

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SHORT ABSTRACT

This thesis contributes to understanding friction stir spot welding (FSSW) by investigating friction, heat generation and exit-hole elimination. Lubricants were applied during FSSW of aluminum alloy sheets resulting in a 44–55% reduction in torque and 12–24% reduction in plunge force requirements. More than 50% reduction in energy requirement while maintaining good joint strength is observed. This suggested the more important role of plastic deformation in heat generation as compared to friction. The study introduces an inverse approach to model friction during FSSW, utilizing finite element (FE) simulations in DEFORM 3D and validating with experiments. Further, this thesis investigates ways of producing exit-hole-free welds during FSSW. In one method the exit-hole is filled with waste aluminum chips and friction stir processing is performed over it. The process delivered 16% and 84% higher load-bearing capacities during T-peel tests compared to conventional FSSW with and without pin, respectively. A novel method of using consumable pin during FSSW is introduced to produce exit-hole-free joints. The feasibility and performance of FSSW using three consumable pin materials viz., AA6061-T6, mild steel and oil hardened non-shrinking die steel, are explored. Additionally, the research evaluates the impact of rotational speed and plunge rate on joint quality. It is found that the joint strength increases with increase in rotational speed up to 900 RPM and further increase in rotational speed decreases joint strength. A 1.7 times increase in joint strength at 900 RPM compared to 360 RPM is achieved. On the other hand, optimum plunge rate for highest joint strength is found to be 15 mm/min. A 4% increase in lap shear strength at 15 mm/min plunge rate compared to 6 mm/min, with an 8.5% decrease in energy requirements is obtained. A good match between experiments and FE simulations is obtained. Adhesive-bonded consumable pin along with application of lubrication is suggested for industrial application, which results in faster production speed and lower energy requirement while delivering good joint quality. This study provides a comprehensive understanding of FSSW, spanning friction, heat generation, exit-hole-free FSSW joints, parametric study and the integration of lubricants and adhesive-bonded consumable pins.