INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Friction stir form joining of AA 5052-H32 and AA 6061-T6 sheets

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SHORT ABSTRACT

The present work is conducted to reveal better understanding about the joint strength and joint formation in a new solid-state spot joining process namely Friction stir forming and its modified variant namely Dieless friction stir forming, and to investigate the feasibility of the processes for joining dissimilar grades of aluminum alloy namely AA 5052-H32 and AA 6061-T6 sheets of 2 mm thickness. The processes involve stir heating, forging and extrusion of upper sheet metal through a pre-drilled hole in the lower sheet to enable joint formation by simultaneous mechanical interlocking and metallurgical bonding. In addition to trivial metallurgical bonding, the mechanical interlocking is achieved by the formation of a rivet head in conventional friction stir forming process and the formation of an inward collar in dieless friction stir forming process. Dieless friction stir forming is found to be better than conventional friction stir forming in both the joint strength and the quality of joint formation. The experimental investigation of the effect of process parameters such as tool rotational speed, tool plunge depth, tool diameter and geometric features such as hole diameter and multi-hole configuration on the strength and formation of above-mentioned joints are conducted. Desirable process parameter values are obtained as tool rotational speed about 500-1500 RPM, tool plunge depth about 0.45-0.5 mm, tool diameter about 14 mm and desirable geometric features are obtained as 3-3.5 mm hole diameter and single hole configuration. Appreciable lap shear fracture load of 7.42 kN, cross-tension fracture load of 2.89 kN, peel fracture load of 1.05 kN and tensile fracture load of 22.12 kN are obtained from various mechanical performance tests. The effectiveness of joint formation, metal flow evolution and identification of various zones in the joints are revealed through macrostructure analysis. The presence of annular stir zone and plastically deformed metal flow zone in the joints is identified in the present work. Microstructure analysis revealed the effect of frictional heat flux and plastic deformation on the grain structure of various zones in the joint. Zones such as stir zone possess recrystallized, fine equi-axed grains under severe plastic deformation by stirring and frictional heat flux. Zones such as heat affected zone is subjected to significant grain growth under the influence of frictional heat flux conducted from the stir spot. Considerable softening of the joint spot compared to parent sheet metal and forging of the extruded upper sheet metal under the tool plunge force are revealed through hardness measurement. The external

morphological features measured on the joints show that upper sheet bulging is directly depending on the tool plunge depth and upward deformation of the lower sheet has not grown up to the severity of hook defect. The pin hole defect and hook defect in friction stir spot welding process are successfully eliminated in dieless friction stir forming process. The critical weak zones leading to failure of the joints such as neck of the extruded pin, improper bonding, improper mechanical interlocking and upward deformation of the lower sheet are also identified in failure mode analysis. The dieless friction stir form joints show superior lap shear fracture load than conventional friction stir form joints and conventional friction stir spot welded joints fabricated on same material combination with identical process parameters.