INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **ENHANCEMENT OF WELD QUALITIES IN FRICTION STIR WELDING**

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SHORT ABSTRACT

The present research work started with the objective to deliver methodologies for the enhancement of joint properties in friction stir welding (FSW) process for similar and dissimilar materials as well as materials with different thickness. The role of process parameters in joining Mg alloy with FSW process is explored with emphasis on enhancement of mechanical properties of the joints. Taguchi grey relational analysis is implemented for investigating the influence of individual process parameters as well as interaction effects among parameters. Shoulder diameter is found to be the most influencing parameter for controlling the weld qualities followed by welding speed. The examination leads to the impression that defect free joints with sound mechanical and desirable microstructural properties can be achieved with low tool rotational speed, welding speed, plunging depth and high shoulder diameter. The investigation is carried a step forward towards the improvisation of weld qualities by inserting Al or Zn foil alloying elements at the faying edge of the joints. These alloying elements are selected based on the reaction feasibility with Mg. The investigation is supported with phase analysis and macro-microstructural analysis which confirms Zn as to be the most advisable alloying element for enhancement of mechanical properties of AM20 Mg joints.

In today's industrial environment weight reduction has gained significant attention and different combination of materials has been tested to achieve the same. Among those combinations Al/Cu has found to attract the joining research community for its different application. The advantages of FSW process leads to the impression that it can be successfully used for joining Al to Cu. However the research results available bring the notion that welds of Al/Cu with FSW do not yield satisfactory weld quality improvements. With the prime objective of improvising weld quality attributes in FSW of Al/Cu, the methodology developed for joining Mg alloys has been carry forward for Al/Cu joining. The investigation started with optimization of suitable process parameters associated with joining of Al/Cu using FSW process. One of the ambiguities faced in FSW of Al/Cu for the position of Cu plate is also resolved in this investigation. It has been found that placing a Cu plate towards the advancing side of the tool rotational can lead to improved weld properties. Moreover, it is also observed that improved mechanical properties with defect free joints can be achieved by proper offsetting of the tool towards the Al side. One of the difficulties arises in dissimilar joining is the formation of intermetallic compounds (IMCs) within the weld zone and the presence of IMCs deteriorates the weld quality. The formation of IMCs may be controlled using a third material at the joint interface. From the reaction feasibility and binary/ternary phase analysis Ni, Ti and Zn has been chosen for the same. Results obtained from phase analysis and metallurgical properties confirmed that Ni and Ti behaves as parting line between Al and Cu that restricts the IMCs formation within the weld zone. Whereas, in case of Zn thin, continuous and uniform IMCs are formed within the weld zone with enhanced mechanical and metallurgical properties.

Automotive industries nowadays prefer lighter body panels and structures for cost reduction and better fuel economy. Many pioneer industries in this sector made a switch to Al alloys for the fabrication of different components in automotives for weight reduction. Components weight can also be reduced by joining materials having different thickness. Implementation of the FSW process for joining different thickness Al alloy plates is performed by developing new joint configurations, namely single pass bottom flat, double pass bottom flat and single pass top flat, during this research work. Among the considered joint configurations the welds with double pass bottom flat configuration yield better mechanical and microstructural properties. The investigation shows new avenues for joining plates having different thickness for serving the purpose of weight reduction with improved mechanical properties.