ABSTRACT

KEY WORDS: Friction stir welding; AA 2219 alloy, AA 6082-T6 alloy; Process parameters; Taguchi analysis; Strengthening precipitates.

Friction stir welding (FSW) has become a favourite choice in the joining process of light weight metals. In FSW the material joining is taken place at the solid state. The process is carried out by inserting a rotating tool traversing along the faying surfaces of the material to be joined. It offers nearly defect free welds with minimized distortion and fine grain structure. However, the mechanism of welding and the process parametric combination for welds with consistent and reliable results are not clearly established. Even though FSW offers many advantages over the conventional welding processes, it is considered to be a slow process from a commercial point of view. Efforts to gather a suitable combination of parameters to produce good welds were mostly confined to lower linear speeds. There exists an ambiguity in the determination of the process parameters to produce reliable welds at higher welding speeds. Efforts to increase the welding speed resulted in defect generation because of insufficient heating during welding.

The reported efforts in the optimization of process parameters of Friction stir welding have not gone into the details of microstructural changes with variations in the parameters. The single consumable in the FSW process is the tool. The reported studies for the optimization of parameters for obtaining better results often suggested complex shape features for the tool which obviously increases the process cost. Gathering a suitable combination of process parameters with simple tool geometry, hence would have contributed much to the research in the area of FSW process.

The thesis elucidates the experimental efforts to propose an optimum combination of parameters with simple tool geometry for FSW at higher linear speeds.

Two precipitation hardenable aluminium alloys were selected as the materials for study: AA 2219 and AA 6082-T6. Both are light weight and possess high strength to
weight ratio. AA 2219 alloy is popular in the aviation manufacturing and AA 6082-T6 is a pioneer material in the structural applications. For the precipitation hardened alloys the concentration and distribution of the strengthening precipitates is most influential for the strength of the alloys. Hence the distribution and dissolution of the strengthening particles under the influence of the process parameters are crucial in the study of friction stir welds.

Taguchi analysis which is very useful for the identification of the control factors to obtain optimum results for the process was used to design the experiments and further analysis. The effect of process parameters on the microstructural changes in the weld region and on the defect formation was also investigated. The experiments were conducted with, perhaps the highest welding speed reported, so far. Through the analysis, optimum combinations of the parameters were suggested for each material at a high speed friction stir window. An analytical model was proposed from the basic theory and parameters for suggesting the process parameters and tool parameters for various aluminium alloys. The computed results of the model were validated by comparing with the reported results.

The important contributions of this work are concluded as below:

- Optimum combination of process parameters was suggested for the FSW of aluminium alloys.
- The most influential parameter for the strength and quality of the weld was identified
- The weld microstructural characterisation was carried out through optical microscopy and scanning electron microscopy.
- The effect of process parameters on the dissolution and re precipitation of the strengthening particles of the alloys was examined.
- An analytical model was proposed to gather optimum combination of process parameters at higher welding speed for various aluminium alloys and the model was validated.

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