MICROSTRUCTURE ANALYSIS OF FRICTION STIR WELDED AA 5083 AND AA6061 T6 ALUMINUM ALLOYS

Sabitha Jannet
Faculty of Mechanical Engineering Department, Karunya University, Coimbatore, Tamilnadu, India

R. Raja
Faculty of Mechanical Engineering Department, Karunya University, Coimbatore, Tamilnadu, India

ABSTRACT

This paper is an outcome of the experimental investigations carried out on friction stir welding of AA 5083 0 and 6061 T6. Welding of dissimilar AA poses a challenge to the industry. Thus FSW is an emerging and innovative joining process which is being studied to obtain feasibility of joining various metals and replacing the conventional fusion process with this process. The work involves the joining of AA 5083 0 and 6061 T6 by FSW. The tensile behavior were elaborated. The photomicrographs of fracture were captured for various trials and analysed. The effect of process parameters such as rotating speed, traversing speed, tool pin profile and axial load on the tensile behavior of the joints were studied.

Key words: Microstructure, Fracture morphology, Wear, FSW, Process parameters.


1 INTRODUCTION

Aval et al. [1][2][3] estimated the effect of tool geometry on 5 mm thick AA5086-O and AA6061-T6 joints. It was found that the tool with a concave shoulder and a conical probe with three grooves provided more homogeneous stir zones compared to other tools due to higher heat input. The shoulder provides confinement for the heated volume of material. The tool shoulder diameter (D) is having a proportional relationship with the heat generation due to friction. If the shoulder diameter is larger, heat generation due to friction will be higher due to large contact area and vice versa [4]. Leal et al. Elaborated the influence of tool shoulder geometry on material flow in 1 mm thick AA5182-H111 and AA6016-T4 joints. A tool shoulder with a conical cavity was reported to yield an onion ring structure. Aval et al [5] used finite element software to predict the thermo-mechanical 328aluminium328 of 5 mm
thick AA5086-O and AA6061-T6 joints and compared the simulation results with the observed microstructures. Aval et al. [6][7] evaluated the thermo mechanical 329 aluminium and microstructural events of 5 mm thick AA5086-O and AA6061-T6 joints and observed that the temperature field was distributed asymmetrically resulting in larger thermally affected region in the AA6061 side. Leitaet al. [8] analyzed the tensile 329 aluminium of 1 mm thick AA5182-H111 and AA6016-T4 joints and observed that the grain size in the TMAZ and precipitate distribution influenced the tensile 329 aluminium. Leitao et al [9][10][11] assessed the formability of 1 mm thick AA5182-H111 and AA6016-T4 joints by deep drawing cylindrical cups and noticed that them is match in mechanical properties between the weld and the base materials determined the formability limits. Park et al. [12][13][14] investigated the effect of material locations on the properties of 2 mm thick AA5052-H32 and AA6061-T6 joints and a proper mixing of dissimilar 329 aluminium alloys was observed when AA5052-H32 was kept in the advancing side. Dilip et al. [15] [16][17] examined that in friction stir welding of dissimilar 329 aluminium alloys, the material placed on the advancing side dominates the nugget region. By placing the stronger of the two base materials on the advancing side, one can achieve higher joint efficiencies.

2. EXPERIMENTAL PROCEDURE

6 mm thick AA and AA was cut using EDM into pieces of dimension 100x 50 mm. The workpieces were then milled for smooth edges. The AA plates were then fixed on the Friction stir welding machine.

3. MICROSTRUCTURAL ANALYSIS

The specimen required were cut into 30x20 mm for the microstructure analysis. Then it was polished in the belt grinder. Further polishing were done using emery papers of the grade 4/0 3/0 2/0 1/0. Then after that fine polishing using twin disk polisher was done, which was followed by etching. And finally the microstructure was analysed using the metallurgical microscope and he following microstructures were found:

4. RESULTS & DISCUSSION

4.1. Microstructural Studies

![Figure 1](image.png)

Figure 1 Optical micrograph of FS welded dissimilar Aluminum alloy with [a] SS tool TMAZ adjacent AA 5083 0 (trial no 27) [b] SS tool TMAZ adjacent to 6061 T6 (trial no 27). [c] SS tool flow in the stir zone (trial no 27)
The optical microstructure of the alloy is shown in Figure 2 [a,b,c]. 6061 alloy consists of precipitates within the grain body which are mostly globular and homogeneously distributed; whereas along the grain boundary the clustering of the same has been observed. The HAZ of 5083-O has retained the same grain structure as the parent material.

The welded region is composed of fine equiaxed recrystallized grains which are formed under the high temperature and high rate of deformation in the weld nugget due to the pin stirring. Figure 2 [a] shows the grain structure fabricated at the 1475 rpm and traversing speed with tapered threaded cylinder as the tool profile. Heat generation becomes small and the grain growth of 6061 becomes sluggish. On the other hand, reduced cooling rate at slowest traversing speed lowers the residual stress and hence the degree of embrittlement. Low heat input also results in low degree of recovery and recrystallization which enhances the defect density leading to the increment in strength level. The interaction time seems to be sufficient enough for mitigating the discontinuities which is perhaps the reason why there is an absence in voids. Figure 2 [b] shows the grain structure fabricated at 1550 rpm while having the same traversing speed with threaded cylinder as the tool profile. This increases the heat input and reduces the cooling rate. The defect concentration starts to decrease and the residual stress is enhanced. This leads to a higher volume fraction of voids. Figure 2 [c] shows the grain structure fabricated at 1625 rpm while having the same traversing speed Figure 2 [a] and Figure 2 [b]. However the tool profile is square in shape. The heat input is high while the interaction time is low; hence coalescence remains incomplete and high volume fraction of voids is found.

Tool rotation and traversing speed have significant effect on microstructure of the specimens. Processing at low tool rotation and traversing speed result in fine grain size and improves consolidation to eliminate discontinuities within the weld nugget. All these factors have an effect in improving the mechanical properties of the specimens such as the tensile strength.

http://www.iaeme.com/IJMET/index.asp  
330  
editor@iaeme.com
4.2. Fracture Morphology

![Fracture Morphology](image)

**Figure 3** Fracture Morphology a) Tapered Square b) Straight Square c) Cylindrical Threaded

4.3. Wear Morphology

Figure 3 [a],[b] and [c] show the SEM micrographs of worn surface of the dissimilar FS welded aluminum alloy using TS and SS and CT tool pin profiles respectively. The worn surface temperature is increased by frictional heat which causes defects. The level of cracks developed on the worn surface is less in the dissimilar joints made by the straight tool and thus the wear resistance is more. In Tapered tool joints the wear resistance is less. This can be related to the grooves being deep and thus producing more cracks. Straight Square tool exhibits highest wear resistance due to the strong bond between AA6061 T6 and AA5083 O.

![Wear Morphology](image)

**Figure 4** Wear Morphology a) Tapered Square b) Straight Square c) Cylindrical Threaded

5. CONCLUSIONS

The tool pin profiles also significantly affected the material flow of dissimilar joints (AA6061 T6 - AA5083) produced by FSW. The grain structures were found to be very fine in the weld zone of 1500 rpm process parameter. From the tests conducted it was inferred that each FSW process parameters influenced the microhardness of the welds. Failure mode observed from the fractured surface was ductile fibrous fracture. The observed worn surface had lesser cracks and thus had lesser wear rate.
REFERENCES


http://www.iaeme.com/IJMET/index.asp 332 editor@iaeme.com


