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Morphological Characteristics and UTS of Al 5083 after FSW

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ABSTRACT
Friction-Stir Welding (FSW) is a solid-state, hot-shear joining process. This process has been utilized in aerospace parts joining process. In this research Al 5083 has been joined and micro-graph has been analysed to study morphological properties. It has been found that onion type ring has been formed during the joining. The heat affected zone (HAZ) is evaluated and the ultimate tensile strength of specimens fabricated from aluminium alloy has also been investigated.
Keywords –AL 5083, FSW, Morphology, tool pin, UTS

I. INTRODUCTION

Friction-Stir Welding (FSW) is a solid-state, hot-shear joining process. The process utilizes a bar-like tool in a wear-resistant material (generally tool steel for aluminum) with a shoulder and terminating in a threaded pin. This tool moves along the butting surfaces of two rigidly clamped plates placed on a backing plate. The shoulder makes a contact with the top surface of the plates to be welded as shown in Fig 1. The heat generated by friction at the shoulder and to a lesser extent at the pin surface and it softens the material being welded [1].

In [3], authors analyzed the FSW on AA5086-O and AA6061-T6 aluminum alloys and found that tool rotational speed significantly affects the amount of maximum tensile residual stress while traverse speed mainly changes the distribution of transverse residual stresses. In [4], authors compared the fatigue strength of FSW with the conventional arc-welding methods: MIG-pulse and TIG. The fatigue strength of FS welded AA 6082 is higher than that of MIG-pulse and TIG welds of the same material. In [5], authors have joined the Al 6013-T4 alloy and X5CrNi18-10 stainless steel and fatigue properties of FS joints were found to be approximately 30% lower than that of the Al 6013-T6 alloy base metal. The hardness value slightly decreases in the thermo-mechanical affected zone (TMAZ) at the advancing side (Al 6013-T4 alloy side).

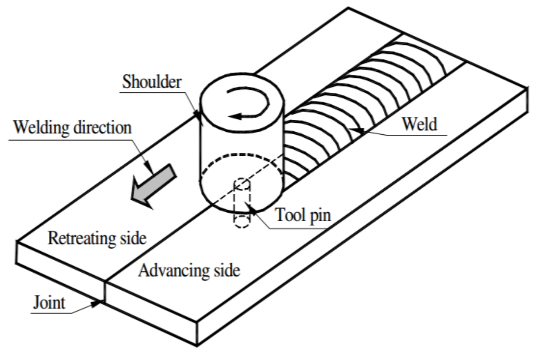


Fig.1: A Schematic representation of FSW [2].

In [6], authors optimized the welding parameters of AZ31 magnesium alloy by friction stir welded to get the best conditions for defect-free weld. The experimental results showed that faster the welding speed is, larger the pore is. In [7], authors made lap joints by FSW of AA 5754 and investigated that increasing tool rotation for a fixed tool pin diameter reduces fatigue strength of joints. Increasing tool pin diameter for a fixed tool rotation, decreases fatigue strength of joints.

Study the friction stir welding (FSW) on AA6082- T6 is made [8], with the conventional tensile tests and local indentation tests to investigate mechanical properties of dissimilar zones of FSW welded joint.

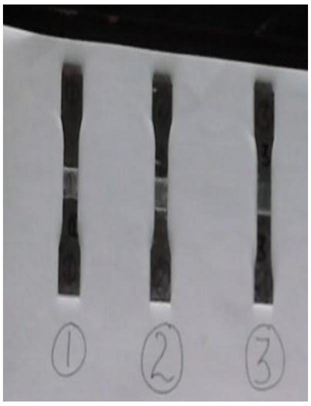
II. EXPERIMENTATIONS

Vertical Milling Machine is used for friction stir welding. 5083 and 6082 aluminium alloy is used for experimental purpose. Al 5083 is an aluminium alloy with magnesium and traces of manganese and chromium. It is highly resistant to attack by seawater and industrial chemicals. Alloy 5083 retains exceptional strength after welding.

The various process parameters used for the friction stir welding are:

Work-Piece	: 6 mm thick AA 5083
Tool pin length	: 5.8 mm
Tool pin diameter	: 6 mm
Tool tilt angle	: 2^0
Axial force	: Constant
Tool Material	: High Carbon Steel
Tool Rotation Speed	: 1950 RPM
Shoulder Diameter	: 20 mm
Welding Speed	: 25 mm/min

(a)



(b)

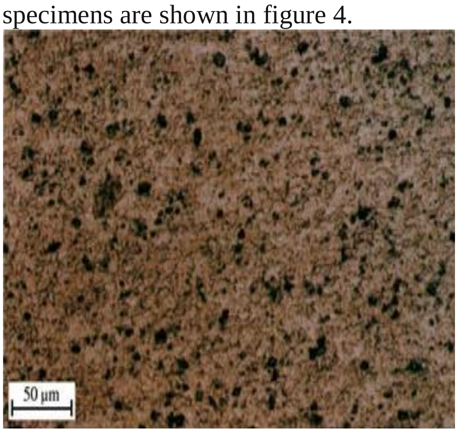
Fig 2: Specimens (a) after FSW (b) for testing

Fig. 3: Principal zones in welding of aluminum

Figure 2 shows the specimen after welding. After a fusion welding process two principal zones are identified in the welded joints named: Fusion Zone (FZ) and Heat Affected Zone (HAZ) whereas in the case of FSW three different zones are formed: stirred zone (nugget), Thermo-Mechanical Affected Zone (TMAZ) and the. These zones are showed in the macrographs of Figure 3.

III. MORPHOLOGY

Cross-sections of the weld joints under the various FSW conditions were observed. Neither cracks nor porosity was visible, showing a good quality. Optical microscopic images of stir zone of FSW specimens are shown in figure 4.



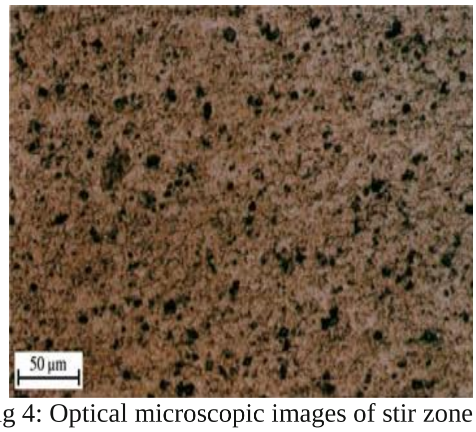


Fig 4: Optical microscopic images of stir zone of FSW specimens (AA 5083)

The microstructure of the welded joint is formally divided into four zones: base material, heat affected (HAZ), thermo-mechanically affected (TMAZ) and stirred zone. The weld nugget is composed of fine-equi-axe-drecrystallized grains, which are formed under the high temperature and high rate of deformation in the weld nugget due to the pin stirring and the size of the crystal grain is about 8ìm in different welding parameters (figure 4). From the testing, the ultimate tensile strength and percentage elongation was measured for the three specimens which were welded with the cylindrical tool pin.

From specimen (1) cylindrical pin profile tool, specimen (2) square pin profile and the specimen (3) trapezoidal tool pin profile tool, the ultimate tensile strength shown in table 1. The maximum tensile strength was obtained for the cylindrical pin tool.

Table 1: UTS according to Tool pin profile

Sr. No.	**Tool Pin profile**	**Ultimate Tensile Strength (MPa)**
1	Cylindrical	200.12
2	Square	180
3	Trapezoidal	152.86

IV. CONCLUSION

In this research work, it is observed that quasi-static mechanical properties decrease in a dramatic manner in FSW. The micro-structural transformation in the heat affected zone of very fine needle shape β'' precipitates to coarse bar shape β' precipitates produced by the thermal effect during the welding process (thermodynamic instability).

The experimental result showed that for the parameter under study, the cylindrical tool pin provides the better ultimate tensile strength as compared to square and trapezoidal tool pin structure.

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