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Study on Friction stir Welding of Aluminium Alloy AA6061 and Magnesium Alloy AZ31

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Abstract—*Friction stir welding is a solid state welding process that uses a non-consumable tool to weld two dissimilar materials having different melting point without melting the materials. Heat is generated by friction between the rotation of tool and the work piece material. In this paper two different material like AA6061 and AZ31are friction stirred using modified milling machine. In this paper process parameters like welding speed (710 rpm, 1000 rpm, 1400rpm), tool rotational speed (20 mm/min, 31.5 mm/min, 50 mm/min) are considered and to make a butt joint of two materials of size 100 mm x 50 mm x 6 mm .The material selected for tool is high carbon steel having shoulder diameter of 18 mm and tapper pin diameter of 6 mm. This paper mainly concentrated on the study and measurement of tensile strength, hardness on the weld bead of two dissimilar metal like AA6061 and AZ31 by friction stir welding and to get the optimum solution.*

Keywords*: Friction stir welding; AA6061 Aluminium alloy; AZ31 Magnesium alloy; Tool shoulder diameter; Tensile strength, Hardness.*

1. INTRODUCTION

Friction Stir Welding (FSW) was invented at The Welding Institute (TWI) of the United Kingdom in 1991 as a solid state welding process, is a potential candidate for the joining of dissimilar materials due to the lower processing temperature over conventional fusion welding that uses a non-consumable tool to join two facing alloys without melting the work piece material. Heat is generated by friction between the rotating tool and the work piece material, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay, or dough. It is primarily used on wrought or extruded aluminium and particularly for structures which need very high weld strength. A non-consumable rotating tool with specially designed pin and shoulder is transversely fed at a constant rate into edges of sheets or plates, and traversed along the line of joint. Frictional heat is generated between the welding components and the work pieces. Movement of tool between the two materials mechanical mixes and soften without melting. Defect-free welds have now been made by FSW in the joining of different alloys. Aluminium alloys are widely used in automotive, aerospace and ship industries due to the combination of mass reduction and for high strength. Magnesium alloys are also attractive in these fields due to their lower density and high specific strength. So it can be expected that the joining of aluminium alloys and magnesium alloys needs to be solved in industrial application. Magnesium (Mg) alloys has specific properties like low density (1.74g/cm³) compared to the other like light metal, Aluminium (2.4g/cm³). No filler materials are used in Friction stir welding. The material selected or tool was High carbon steel (HCS), was designed and manufactured. The tool system is fixed to the friction stir welding machine by a support structure. The rotational tool consist no rotational shoulder and rotational pin. Pin is cylindrically tapered designed with 5.5 mm length whose major pin diameter 7 mm and minor pin diameter 3 mm. Welding tool has a shoulder diameter of 18 mm and shoulder length of 10 mm.

In this paper, material selected is Magnesium alloys and aluminium alloys. Experiments were carried out for measurements of tensile strength and hardness of weld. Fig. 1. Shows the working principle of FSW.

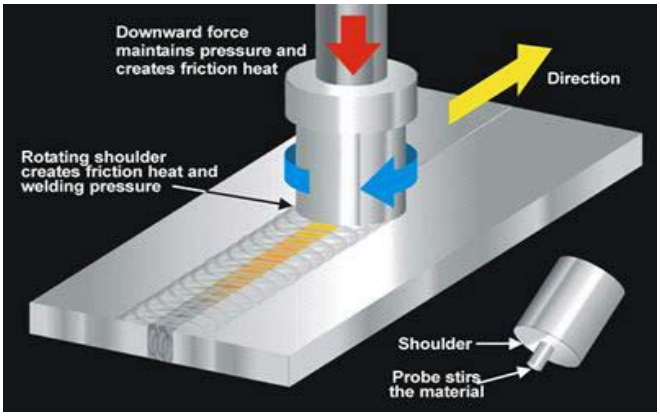

Fig. 1: Shows the working principle of FSW

2. EXPERIMENTAL SET UP:

In this paper the material selected are AZ31 Mg and Al6061 of alloys of thickness 6 mm each. The composition of AZ31 Mg alloy is 2.75% Al, 0.91% Zn, 0.001% Fe, 0.01% Mn and remaining being Mg by wt% and of Al6061 is 0.4 -0.8%Si, 0.7%Fe, 0.15-0.40%Cu, 0.80-1.2% Mn, 0.15%Mg, 0.04-0.35% Cr and remaining being Al by wt%. The dimension of plates used for this experiment 100 mm X 50 mm X 6 mm. Butt joint of these plates were made along the longitudinal direction. The welding tool is made up ofHigh carbon Steel (HCS). whose detail are given in the Table 1. The welding tool has a shoulder of 18 mm diameter and shoulder length of 10 mm. Pin is cylindrically tapered designed with 5.5 mm length whose major pin diameter is 7 mm and minor pin diameter is 3 mm. The Fig. No: 2 shows the dimension of tool Table 2.and 3. shows the chemical and mechanical properties of tool below.

2.1 TOOL DETAILS

Table 1. Details of Friction Stir Welding

Tool Material	High speed steel
Tool Inclination	0
Tool pin profile	Cylindrical Taper pin
Major Pin Diameter	7 mm
Minor Pin Diameter	3 mm
Pin length	5.5 mm
Shoulder to pin ratio(D/d)	3 : 1
Tool shoulder Diameter	18 mm
Shoulder length	10mm

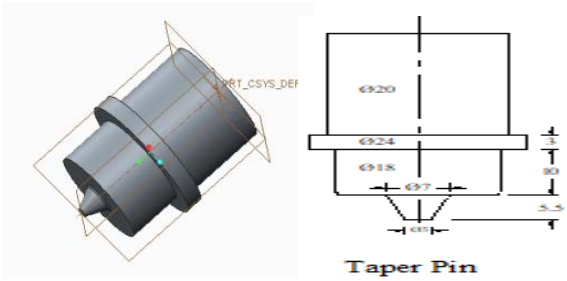

Fig. 2. Dimension of Tool (all dimensions are in mm)

2.2 CHEMICAL PROPERTIES

Table 2. Chemical properties of High Carbon Steel (HCS)

Elements	Content %
Carbon C	0.420-0.50 %
Iron Fe	98.51-98.98 %
Manganese Mn	0.60-0.90 %
Phosphorous P	0.040 %
Sulphur S	0.050 %

2.3 MECHANICAL PROPERTIES OF HIGH CARBON STEEL (HCS)

Table 3. Mechanical properties of High Caron Steel (HCS)

Mechanical Properties	Metric
Ultimate Tensile Strength	635M Pa
Yield Strength	490M Pa
Elongation at break	16%
Poisson' s ratio	0.290
Shear modulus	79.3G Pa
Bulk modulus	140 G Pa

The specification of modified milling machine on which the experiment are to be carried out is shown in Table 4.

Table 4. Specification of Vertical Milling Machine

Details of Machine Variables	Range
Power Operated Longitudinal Traverse	560mm
Power Operated Cross Traverse	250mm
Vertical Traverse Manual	160mm
No. of Speeds	12
Speed Range	45 to 2000 rpm
No. of Feeds	9
Feed Range in mm/min (Longitudinal Cross Feed)	20,31,35,80,125,200, 315,500,800

The process parameter chosen for FSW are welding speed and tool rotational as shown in Table 5.

Table 5 Process Parameter for FSW

S.NO	Welding Speed (rpm)	Tool Rotational Speed (mm/min)
1	710	20
2	1000	31.5
3	1400	50

3. RESULT AND DISCUSSION

In the future work, friction stir welding is done to determine their tensile strength by using different parameters like welding speed, Rotational speed, Transverse speed on AA6061 and AZ31 alloys using HC Steel. In this paper Hardness and Micro structure of weld bead are also to be measured. Further Nondestructive testing like radiography are to be done to find out defects in the weld.

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