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Friction Stir Welding of Two Dissimilar Mg alloys like AZ31 and AZ91

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Abstract—*Friction stir welding is a solid state welding process that uses a third body tool to weld two materials. In this paper two different Magnesium alloys like AZ31 and AZ91 are welded by FSW using modified vertical milling machine. In this paper following process parameters like welding speed (710 rpm,1000 rpm,1400 rpm,) , tool rotational speed (20 mm/min, 31.5 mm/min,80 mm/min,) are considered and to weld a butt joint of two materials of size 100 mm x 50 mm x 6 mm each . The material selected for tool is Stainless Steel having shoulder diameter of 16 mm and pin diameter of 5.5 mm. This paper mainly concentrate on the measurement of tensile strength, hardness on weldments of two dissimilar materials like AZ31 and AZ91 by friction stir welding and to get the optimum solution.*

Keywords*: Friction stir welding; AZ31, AZ91 magnesium alloys, 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 joining technique and was initially applied to aluminium alloys. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of plates to be joined and subsequently traversed along the joint line. Movement of tool between the two materials makes mechanical mixes and softens without melting. Magnesium (Mg) alloys has

Specific properties like low density (1.74g/cm³) compared to the other like light metal, Aluminium (2.4g/cm³). The demand for light weight structures in automobile, aerospace and marine industries has triggered the research on light metals particularly on Magnesium (Mg) and its alloys. In this paper, material selected is two different Mg alloys and experiments were carried out for measurements of tensile strength and hardness of weld. The principle behind joint formation of FSW was explained by Mishra. FSW does not melt the base material and therefore completely eliminates the problems associated with solidification that usually appear in fusion welding. Joining dissimilar metals, particularly Mg alloys, by fusion welding process is difficult. From Literature survey it is identified that less work had been done on FSW of Mg alloys. Fig. 1. Shows the working principle of FSW.

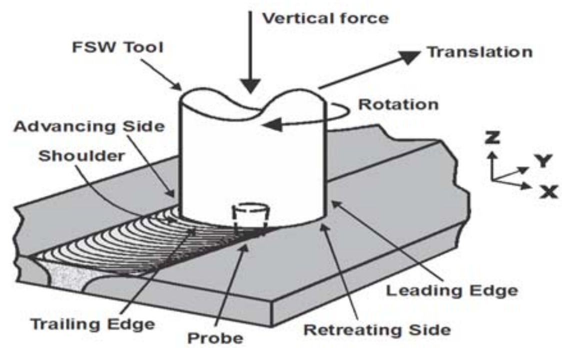

Fig. 1: Principle of Working of FSW

2. EXPERIMENTAL SET UP:

In this paper the Material selected are AZ31 and AZ91 Mg alloys of thickness 6 mm. The composition AZ31 Mg alloy is 2.75% Al, 0.91% Zn, 0.001% Fe, 0.01% Mn and remaining being Mg by wt% and of AZ91 Mg is 8.67%Al, 0.85%Zn, 0.002%Fe, 0.03% Mn and remaining being Mg by wt%. The dimension of plates used for this experiment were 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 of Stainless Steel (SS) and itsareStainless Steel whose detail given in the Table 1. The welding tool has a shoulder of 16 mm diameter and shoulder length of 15 mm. Pin is cylindrically designed with 5.5 mm diameter and of 18 mm length. The Fig. No. 2 shows the dimensions of tool. And Table 2. and 3shows the chemical and mechanical properties of tool, respectively.

2.1 TOOL DETAILS

Table 1. Details of Friction Stir Welding Tool

Tool Material	Stainless Steel
Tool Inclination	0
Tool pin profile	Cylindrical pin
Pin Diameter	6mm
Pin length	5.5mm
Shoulder to pin ratio(D/d)	3.2 : 1
Tool shoulder Diameter	18mm
Shoulder length	14.4mm

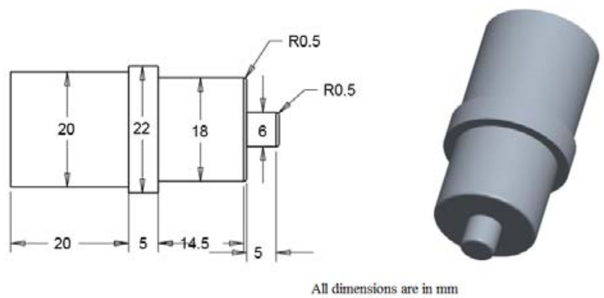

Fig. 2. Dimensions of Stainless Steel tool

2.2 CHEMICAL PROPERTIES

Table 2: Chemical properties of Stainless Steel

Elements	Amount (wt. %)
Carbon C	0.15%
Manganese	2.00%
Silicone	1.00%
Chromium	19%
Nickel	8.0/10%
Phosphorus	0.045%
Iron, Fe	78%
Sulphur	0.03%

2.3MECHANICAL PROPERTIES OF STAINLESS STEEL

Table 3. Mechanical properties of Stainless Steel

Mechanical Properties	Metric
Ultimate Tensile Strength	505 M Pa
Yield Strength	215 M Pa
Elongation at break	70%
Poisson' s ratio	0.305
Shear modulus	77.2 G Pa
Bulk modulus	163 G Pa

The experiment are to be carried out in Modified Milling machine whose specification is shown in Table 4.

2.4 SPECIFICATION OF VERTICAL MILING MACHINE

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 Feed	9
Feed Range in mm/min(Longitudinal and 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 parameters of FSW

S.NO	Welding Speed (rpm)	Tool Rotational Speed (mm/min)
1	1000	31.5
2	1400	50
3	2000	80

3. RESULT AND DISCUSSION

In the future work, friction stir welding of AZ31and AZ91 is to be done using different parameters.as shown in Table 5.The weld strength, hardness and microstructure is to be tested. The optimal parameters are determined using Design of experiments. Further Nondestructive testing like radiography are to be done to find out defects in the weld.

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