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Estimation of Mechanical Properties in Aluminium and Magnesium Alloy By Using Friction Stir Welding Process

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Abstract : **Multi-material lightweight structures are gaining a great deal of attention in a several industries in particular where tradeoff being the solid state material. The focus of paper is mechanical properties and process parameters in varying rotational speed and welding speed of friction stir welding for the dissimilar joint. Using aluminum alloy (AA6061) and magnesium alloy (AZ61) to determine the tensile strength and hardness strength of the weld**

Keyword :Alloys , FSW , Materials , Tool , Dissimilar Welding , Tensile Strength , Hardness Strength.

I. INTRODUCTION

Friction stir welding (FSW) is an innovative welding process commonly known as a solid state welding process, that the objects are joined below the melting point with the help of pressure. This opens up whole new areas in welding technology. It is particularly appropriate for the welding of high strength alloys which are extensively used in the aircraft industry. Mechanical fastening has long been favoured to join aerospace structures because high strength aluminium alloys are difficult to join by conventional fusion welding techniques. Its main characteristic is to join material without reaching the fusion temperature. It enables to weld almost all types of aluminium alloys, even the one classified as non-weldable by fusion welding due to hot cracking and poor solidification microstructure in the fusion zone. FSW is considered to be the most significant development in metal joining in a decade and is a "green' 'technology due to its energy efficiency, environment friendliness, and versatility.

II. EXPERIMENTAL PROCEDURE

A. Material

ALUMINIUM 6061: Aluminum alloy has gathered wide acceptance in the fabrication of light weight structures requiring a high strength to weight ratio. Compared to the fusion welding processes that are routinely used for joining structural aluminum alloys, friction stir welding (FSW) process is an emerging solid state joining process in which the material that is being welded does not melt and recast

MAGNESIUM AZ61:Magnesium alloys, normally produced by casting, may find significant applications in the automotive and aerospace industries with rapid growth particularly in die-cast vehicle components because of their better mass-equivalent properties .They are used for light-weight parts which operate at high speeds. The motivation for using FSW for magnesium alloys is that arc welding results in large volumes of non-toxic fumes. On the other hand, soli Also, many magnesium alloys in the cast condition contain porosity which can be healed during FSW

Properties	Aluminium	Magnesium
Tensile Strength	310Mpa	310Mpa
Yeild Strength	276Mpa	230Mpa
Shear Strength	207Mpa	140Mpa
Elastic Strength	68.9Mpa	44.8Mpa
Poisson's ratio	0.33	0.35

Table 1. Properties of Materials

B. Procedure

The working process of friction stir welding can be summarized as follow.First both the work plates are clamped together same as in butt joint. These both plate's weld able surfaces are in contact with one another. Now a

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rotating tool pin is inserted into work pieces at the interface surfaces until tool shoulder touched the work piece. This will deform the material plastically due to heating by friction force. This is state of the joining process in which, inter molecular diffusion will deform the material plastically due to heating by friction force.Now the rotating tool is move forward along the joint line. This will form a joint behind the tool. The tool continuously move unlit the whole weld is form. After the joining process, tool is separated from the work piece. The hole created by tool pin remains in the welding plates.

Max. Weld area	**700mm^2 (Copper/Aluminium) 315mm^2 (Alloy Steel)**
Total connected power	**55Kw**
Spindle speed	**100-4000rpm (rpm variable)**
Maximum bar capacity	**30mm Diameter**
Minimum bar capacity	**4mm Diameter**
Maximum depth spindle backstop	**250mm**
Travel head stroke	**300mm**
Maximum hydraulic pressure	**140 bar**
Maximum force	**100 KN**
Typical production rate	**200 / hour (Manual) 250 / hour (Automatic)**
Maximum weld diameter	**30mm Diameter (Cu/Al) 20mm Diameter (Alloy Steel)**

Table 2. Machine Specification

Material	**H13 tool steel**
Shoulder Diameter	**18mm**
Pin Diameter	**6mm**
Pin Profile	**Square**
Hardness	**45HRC**
Pin Length	**5.5mm**
Shoulder Length	**100mm**
Concavity	**6"**

Table 3. Specification of Tool

C. Mechanical Testing

Tensile Test

Tensile test was conducted by Universal Testing Machine (UTM).Peak load was recorded for each specimen. Failure energy was calculated from the area below the load–displacement curve of the tensile test. Failure mode was determined from the specimen, after tensile test, according to the nature of failure.

Hardness Test

The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. . After the preload, an additional load, call the major load, is applied to reach the total required test load.

III. Result and Discussions

A. Welded Samples

Figure 1. Welded Sample No.1

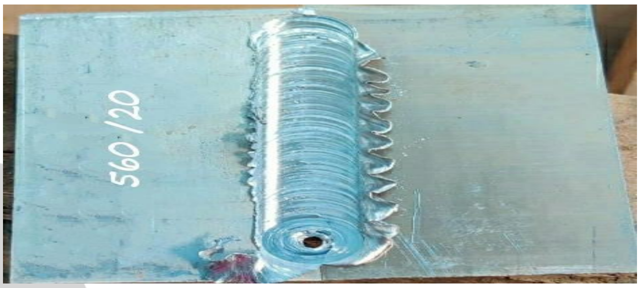

Figure 2. Welded Sample No.2

Figure 3. Welded Sample No.3

Figure 4. Welded Sample No.4

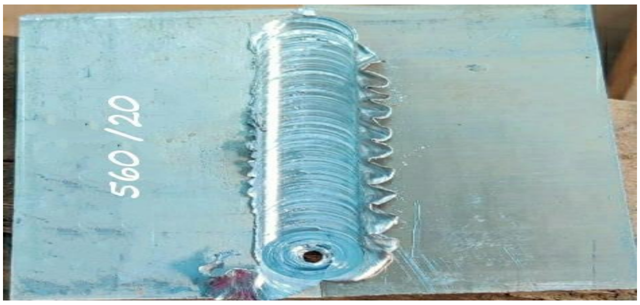

Figure 5. Welded Sample No5

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B. Tensile Test Result

Figure 6. Tensile Test Samples

Sample No	Tool Speed (rpm)	Tool Diameter (mm)	Tensile Strength (Mpa)
1	560	20	3.22
2	560	20	12.28
3	560	25	25.15
4	560	20	1.46
5	560	20	19.3

Table 4. Tensile Test Result

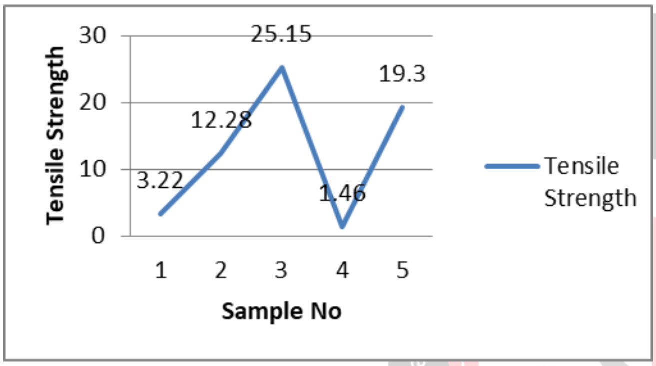

Figure 7. Graphical Representation of Tensile Result

The above graph shows that tensile strength increases constantly upto tool diameter (25mm) sample no.3,decrease for the tool diameter (20mm) sampleno.4 and increases constantly. Tensile Strength plays an major role to determine the mechanical properties of the material. It is better to understood , the tool diameter of 25mm plays an major tensile strength value.

C. Hardness Test Result

Figure 8. Hardness Test Samples

Sample No	Tool Speed (rpm)	Tool Diameter (mm)	Hardness Strength (N/mm^2)
1	560	20	77.8
2	560	20	74.8
3	560	25	112.2
4	560	20	83.3
5	560	20	70.7

Table 5. Hardness Test Result

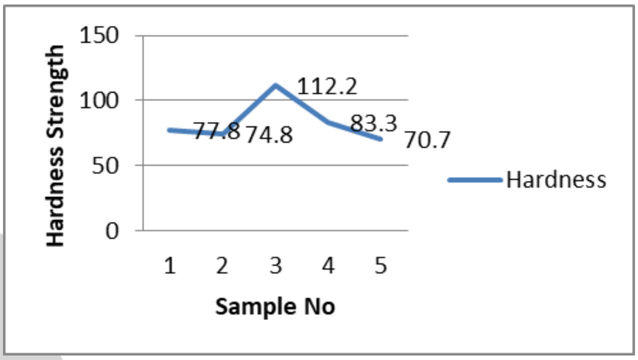

Figure 9. Graphical Representation of Hardness Result

The above graph shows that better hardness value can obtained from the tool diameter of (25mm) and decreases constantly for other values.

IV. CONCLUSION

Friction Stir Welding is the best process to welding of different alloys of aluminium and magnesium with an excellent quality. Considerable effort is being made to weld higher temperature materials such as alloys of titanium and steels by using FSW. Take the process beyond its current use of mainly simple butt and lap joint configurations and make it a much more flexible fabrication process.

In the above process of dissimilar welding joint , we obtained a high tensile and hardness strength in specimen 3.

- Tool speed - 560 rpm
- Tool diameter - 25 mm
- Tensile strength - 25.15 mpa
- Hardness strength – 112.2 N/mm^2

Test Process	Tool Speed (rpm)	Tool Diameter (mm)	Result
Tensile Strength (mpa)	560	25	25.15
Hardness Strength (N/mm^2)	560	25	112.2

Table 6. Test Result

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Friction stir welding owing to its unique characteristics: low distortion and shrinkage even in long welds, free of arc, filler metal, and shielding gas, low HAZ, free of spatter and porosity defect is emerging as an alternative to fusion welding.

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