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MECHANICAL BEHAVIOUR OF FRICTION STIR WELDING OF MAGNESIUM AZ-91 ALLOY

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Abstract—**Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. The objective of the study was to tensile strength of magnesium alloy welded by friction stir welding .The properties of the magnesium alloy at welded joint is known by performing tensile tests. If the parameters like speed and tool feed are changed, the properties of the magnesium alloy at the welded joint changes.**
Keywords: FSW, Tensile Strength, Magnesium alloy, Tool Speed

I. INTRODUCTION

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough.

II. WORKING PRINCIPLE:

In friction stir welding (FSW) a cylindrical, shouldered tool with a profiled probe is rotated and slowly plunged into the joint line between two pieces butted together. The parts have to be clamped onto a backing bar in a manner that prevents the abutting joint faces from being forced apart. Frictional heat is generated between the wear resistant welding tool and the material of the work pieces. This heat causes the latter to soften without reaching the melting point and allows traversing of the tool along the weld line. The maximum temperature reached is of the order of 0.8 of the melting temperature of the material.

The plasticized material is transferred from the leading edge of the tool to the trailing edge of the tool probe and is forged by the intimate contact of the tool shoulder and the pin profile. It leaves a solid phase bond between the two pieces. The process can be regarded as a solid phase keyhole welding technique since a hole to accommodate the probe is generated, then filled during the welding sequence

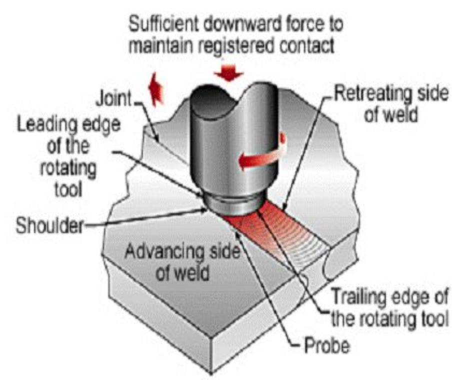

Fig-1Principle of friction stir welding

III. FSW PROCCES DESCRIPTION:

The FSW process is initiated by plunging of a rotating non consumable tool into the joint until the shoulder contacts the top surface of the work piece. As the tool translates along the joint, heat is generated by rubbing action of tool shoulder against the work piece. So it is necessary that the tool should have superior properties than that of material which is being welded. Additional heat is generated by viscoplastic dissipation of material energy at high strain rates due to interactions between tool and work piece.

The heat thus generated results in thermal softening of the material. The thermally softened material is contained at the underside by a backing plate, at the sides by non-softened parent material, and at the top side by pin force. The softened material is than forced to flow by the translation of the tool from the front to back of the pin where it cools, consolidates and results in joint formation

IV. MATERIAL:

A. *Work Piece Material:*

Magnesium alloy AZ-91 plates are welded by friction stir welding process. Dimensions of the magnesium alloy AZ-91 plate are (160X90X6) mm. 36 plates are used in the experiment, joining two each by welding 18 experiments are done.

Table 1.Composition of magnesium alloy AZ-91

Grade	%Al	%Zn	%Mn	%Si	%Fe	Mg
AZ-91	9.07	0.84	0.28	0.001	0.001	Reminder

B. *TOOL MATERIAL:*

H13 steel material is used as the tool in the friction stir welding process. The tool contains shoulder diameter 18mm and probe with 6mm dia, 5.5mm height.

Total numbers of tools used in the experiment are four Types of tools used in the experiment are:

1. Conical
2. Conical threaded
3. Cylindrical
4. Cylindrical threaded

Table 2. Chemical composition of H13 steel:

Elements	Weight in %
Carbon	0.32-0.45
Chromium	4.75-5.50
Molybdenum	1.10-1.75
Vanadium	0.80-1.20
Silicon	0.80-1.25
Sulphur	0.30 max
Phosphorus	0.30 max
Manganese	0.25-0.50
Iron	Balance

C. *TOOL DIMENSIONS:*

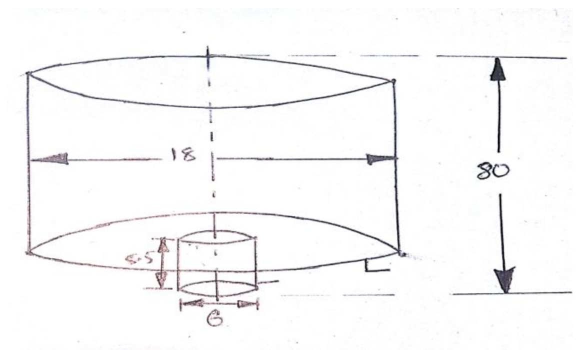

Fig-2 Tool dimensions.

V. RESULTS AND DISCUSSIONS:

TENSILE TEST:

Tensile tests are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension. The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. These measures of strength are used, with appropriate caution (in the form of safety factors), in engineering design. Also of interest is the material's ductility, which is a measure of how much it can be deformed before it fractures. Rarely is ductility incorporated directly in design; rather, it is included in material specifications to ensure quality and toughness. Low ductility in a tensile test often is accompanied by low resistance to fracture under other forms of loading. Elastic properties also may be of interest, but special techniques must be used to measure these properties during tensile testing, and more accurate measurements can be made by ultrasonic techniques.

Fig: 3- Tensile Test specimens

Table: 3 Mechanical Properties for conical tool

Sample No.	Tool Speed RPM	Tool Feed, mm/min	Ultimate strength, N/mm^2	% elongation	Yield Strength N/mm^2
1	900	25	35.11	0.9	35.11
2	900	40	46.49	1.6	46
3	1120	25	60.963	1.2	39.45
4	1120	40	114.86	0.7	87.12
5	1400	25	110.0	0.4	82
6	1400	40	47	1.6	47

Table:4 Mechanical Properties for cylindrical tool

Sample No.	Tool Speed RPM	Tool Feed, mm/min	Ultimate strength, N/mm^2	% elongation	Yield Strength N/mm^2
1	900	25	117.63	1.7	115.14
2	900	40	53.64	1.72	53.64
3	1120	25	58.749	0.6	32.85
4	1120	40	61.749	0.8	39.89
5	1400	25	61.749	0.8	39.78
6	1400	40	47.819	1.6	30.74

VI. CONCLUSIONS

1. Welding is performed at three rotational speeds of tool such as 900RPM, 1120RPM, and 1400RPM at two different feeds such as 25mm/min and 40mm/min by using the water as coolant.
2. Tensile properties (yield strength, tensile strength and % elongation) increasing with increase in rotational speed of tool.
3. Tensile properties of centered pin profile tool observed maximum values compared to offset tool.
4. During welding the welding speed is kept constant for the purpose of comparison of the weld joints properties as the function of tool profile and rotation speed only.

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