Friction Stir Welding of Magnesium All0ys Az31b

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Abstract- *The increasing global demands for energy conservation and the environmental protection have encouraged manufactures to develop and create innovate lightweight components. Magnesium alloys are characterized by unique properties and offer opportunities for new lightweight application. There is a challenge to join the materials with a variety of application along with cheaper value and high strength to weight ratio. Friction stir welding (FSW) is a solid state joining process used for light weight alloys in this paper. The recent development of the FSW of magnesium alloys are reviewed to assist researchers to develop an in-depth understanding of the current state of the friction stir welding of magnesium alloys. Friction stir welding is carried out at different rotational speeds of 1400 rpm, 1300 rpm and 1200 rpm and with tool material such as High speed steel (HSS).*

Keywords- Friction stir Welding, Magnesium Alloy, Microstructure, Rotational Speed.

I. INTRODUCTION

In late 1991, a very novel and potentially world beating welding method was conceived at TWI. The process was duly named friction stir welding (FSW), and TWI filed for world-wild patent protection in December of that year. Friction stir welding is a process in which a rotating tool is driven into a desired weld seam and traversed across the length of the seam to from a solid joint. No melting of the work piece occurs in the FSW process.In FSW process is a specifically projected as a rotating cylindrical tool, including a pin and a shoulder, is plunged into the workpiece. The tool is then traversed in the welding direction. The soften material caused by the rotating shoulder generate heat, the material under the processed zone exposes intense plastic deformation and dynamically recrystallized fine grain structure FSW offers a cost effective alternative, provided necessary research on FSW joints of AZ31B is performed.

II. MATERIAL SELECTION

Magnesium alloys are expected to play an important role as next-generation materials, with the potential to help lighten total product weight when magnesium products are used to replace aluminium and mild steel products. The specific density of magnesium alloy is 2/3 that of aluminium and 1/4 that of iron. When alloyed, magnesium has the highest strength-to-weight ratio of all structural metals. The lower formability of Mg alloys Can Be overcome by Warm Forming (stretch) process. However, at elevated Temperatures (>300ºC) Oxidation Problems complicate Manufacturing Process.In the Magnesium– aluminium – zincalloys(AZ31B, AZ61A, AZ63A, AZ80A, AZ81A, AZ91 and AZ92A), aluminium content up to about 10% aids weld ability by helping to refine the grain structure, while zinc content of more than 1% increases hot shortness, which may cause weld cracking.

III. EXPERIMENTAL PROCEDURE

The initial joint configuration was obtained by securing the plates in position using mechanical clamps. The direction of welding is normal to the rolling direction and single pass FSW used to fabricate the jointsA conventional semi-atomized FSW machine was used for friction stir welding (FSW)of magnesium alloy.The machine has a maximum speed of 800-1500 rpm and 12HP Motor. Test piece was clamped in the fixture tightly. Initially the rotating pin was inserted into a pre-drilled hole, which will facilitate the startup of welding. Processing began at spindle with the help of three speeds of 1400 rpm,1300 rpm ,1200 rpm and travel rate of 30, 40 and50mm/min.

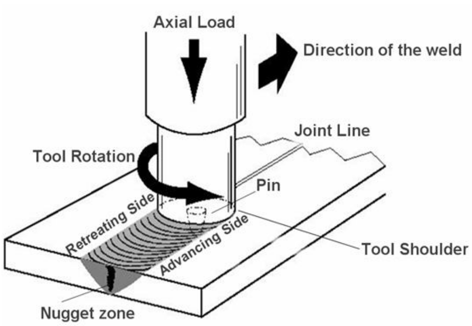

Fig 1. Principle Of Operation

Since tool plunge was to the extent of 3 mm and plate thickness being 6 mm, the same step was repeated for both sides of the plate. The result was two side welded plates. The plates where then subjected to mechanical testing. In the present work in the influence of speed, feed on the performance of FSW such as Hardness and tensile strength is evaluated at different experimental conditions.

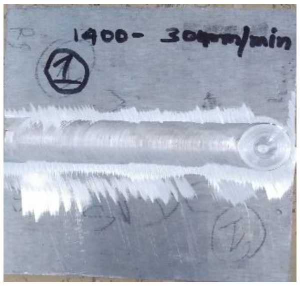

Fig 2. Sample I

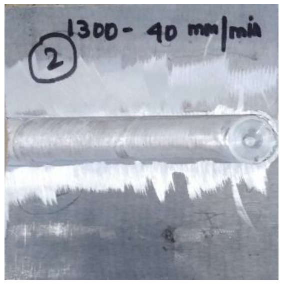

Fig 3. Sample II

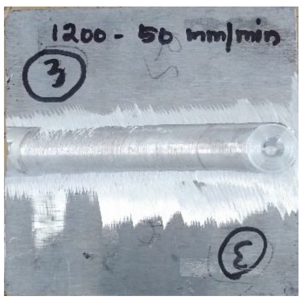

Fig 4. Sample III

PARAMETER SETTING :

SAMPLE I

Speed =1400 rpm
Tool = HSS
Welding speed = 30mm/min
Depth of penetration = 5.7mm

SAMPLE II

Speed =1300 rpm
Tool = HCS
Welding speed = 40mm/min
Depth of penetration = 5.7mm

SAMPLE III

Speed =1200 rpm
Tool = HCS
Welding speed = 50mm/min
Depth of penetration = 5.7mm

IV. TOOLDESIGN

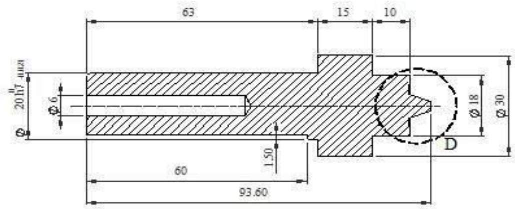

Fig 5. Design and Dimensions of Tool

Pin length - 6 mm
Shoulder diameter - 18 mm
Tilt angle - 2 °
D/d Ratio of tool - 3

The tool has been made in the hard micro-milling process. The tool design greatly influences to the plastic flow of welding material, heat generation and the uniformity of the welded joint.Generally we can assume that the ratio of shoulder diameter to pin diameters is around 3. Both the pin and the shoulder of the tool have smooth cylindrical shape.HSS and high alloy grade tool steel have a high wear resistant characteristic. The quality of tool steels depends on the heat treatment which they receive.

To attain good results, the following need to be done: Preheating,soaking or (austenitising), quenching (martensitic transformation) and tempering.

Fig 6. Stir Tool

V. RESULT AND DISCUSSION

Mechanical Properties of BaseMetal AZ31B:

Table 1. Properties of AZ31B Metal

Yield Strength (Mpa)	171
Ultimate Tensile Strength (Mpa)	215
Elongation (%)	14.7
Reduction in C-S Area(%)	14.3
Hardness (VHN)	79.3

MICROSTRUCTURE OFSAMPLES :

Thespecimensfor metallographic examination were sectioned to the required size and then polished using different grades of emery papers. A standard reagent made of 4.2 g picric acid, 10 ml acetic acid, 10 ml diluted water, and 70 ml ethanol was used to reveal the microstructure of the welded joints. Micro structural analysis was carried out using a light optical microscope.

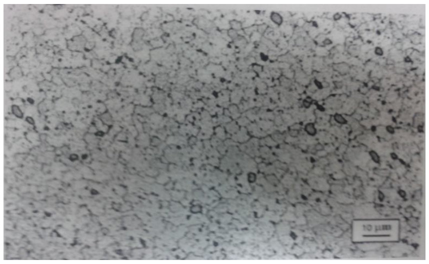

Fig 7. Micro Structure of Base Metal

1. Dynamically Recrystallized Zone (DXZ) or Stir zone :

The **stir zone** (also nugget, dynamically recrystallized zone) is a region of heavily deformed material. A unique feature of the stir zone is the common occurrence of several concentric rings which has been referred to as an “onion-ring” structure.The precise origin of these rings has not been firmly established, although variations in particle number density, grain size and texture have all been suggested.

2. Thermo Mechanically Affected Zone (TMAZ):

The Thermo - Mechanically Affected Zone (TMAZ) occurs on either side of the stir zone. In this region, the strain and temperature are lower and the effect of welding on the microstructure is correspondingly smaller.

3. Heat Affected zone (HAZ) :

The Heat Affected zone (HAZ)is common to all welding processes. As indicated by the name, this region is subjected to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ

SAMPLE I

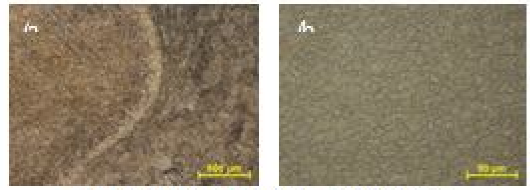

Fig 8. a)Transition Zone b) Stir Zone

SAMPLE II

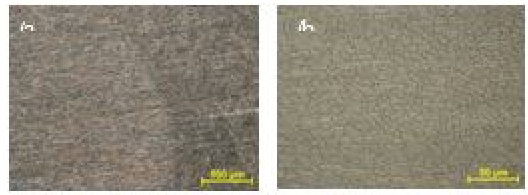

Fig 9. a)Transition Zone b) Stir Zone

SAMPLE III

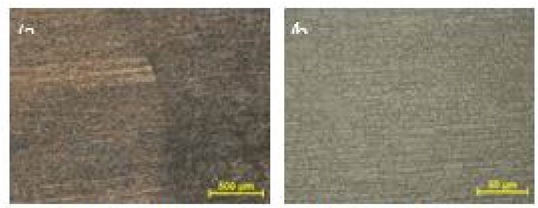

Fig 10. a) Transition Zone b) Stir Zone

LIQUID PENETRANT TESTING OF SAMPLES :

Fig 11. Sample I Fig 12. Sample II

Fig 13. Sample III

TENSILE TESTING OF SAMPLES:

Tensile test of the specimen extracted from welded AZ31BMg alloy plate. Tensile tests were conducted using a universal tensile machine with a load capacity of 100 kN. All tensile tests were carried out based on ASTM E8/E8M-11 standard at room temperature using a rate of 1 mm/min.Table gives the summary of the results obtained from all the tensile tests. All tensile test specimens failed in the heat affected zone.

Table 2. Results Obtained From Tensile Test

SAMPLES	LEVEL 1	LEVEL 2	LEVEL 3
SPEED (rpm)	1400	1300	1200
TRAVEL SPEED (mm/min)	30	40	50
TILT ANGLE	2 Degree	2 Degree	2 Degree
YIELD STRENGTH (Mpa)	129.86	139.5	139.1
TENSILE STRENGTH (Mpa)	171.12	181.94	186.76
ELONGATION (%)	2.91	4.02	5.00
FRACTURE LOCATION	WELD	HAZ	WELD


Fig 14. Welded Samples After Tensile Test

HARDNESS TESTING OF SAMPLES :

Micro hardness across the welded joint, have been carried out in polished and etched sections, as per the standard ASTM E 384-99. The hardness was carried out with MMTX3 Micro hardness tester using 0.5Kg weight. The Vickers hardness is obtained by dividing the load applied to indent the pyramidal diamond into the test piece by the area of indentation thus created. The larger the load used the larger will be the indentation created, so it is common for the Vickers to reported as wwHVxx where "ww" is the hardness number and "xx" represents the load in kilograms used to create the indentation. In principle, Vickers hardness is independent of load, but microstructural variations can cause local differences between say a 30 kg load and a 2 kg load.

Table 3.Results Obtained From Hardness Test

Specimen	Load (Kgf)	Vicker'S Hardness
Sample I	10	78 VHN
Sample II	15	69VHN
Sample III	20	83 VHN

Fig 15. Vicker'S Micro Hardness Test

VI. CONCLUSION

In the work,Friction Stir Welding of various types of Mg alloys grade has been considered.The influence of each process parameters on final weld quality, Microstructural analysis, mechanical properties.,etc have also been considered.Among various grade of Mg alloy AZ31B grade has been used in majorApplications.The process parameters selected were mainly tool rotational speed,welding speed, tool title angle etc.Thorough literature review related to Friction Stir Welding of Mg alloys has been done from 2009 to 2015 the worksofvariousresearchers has been highlighted throughout the paper. Remarks of various works are also highlighted.

VII. ACKNOWLEDGEMENT

With deep sense of gratitude, I extend my earnest & sincere thanks to our honour guide **Prof.D.NOORULLAH,** Professor and Head of Metallurgical Engineering Department for his kind guidance & encouragement during this entire project.

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