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Pivotal Study on CVN Value of Friction Stir Welded Magnesium AE42 Alloy at Different Tool Rotation and Transverse Speed

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Abstract- In this work, the friction stir welding process parameters- tool rotation and transverse speed on the CVN (Charpy V-Notch) value of 3mm thick weldments on cast magnesium alloy AE42 has been studied and investigated. Fourrotation speed (400, 600, 800 and 1200rpm) and four transverse speed (35, 40, 80 and 100 mm/min) were selected for the friction stir welding of alloy condition. At room temperature 34°C or 93.2 F or 307.15 kthe resistance of weldments to sudden loading has been studied using CVN test. The resistance of weldments to sudden loading has been investigated using the Chrapy impact test with standard V-notched specimens at room temperature. It has been observed during this work that the total impact energy increased in the friction stir welding of magnesium alloy AE42 especially at 1200 rpm and 100mm/min with respect to the base metal while rotation and transverse speed have a small effect on the impact value.

Index terms: Friction Stir Welding (FSW);Magnesium alloy; AE42;Similar; Mechanical Property;ASTM methods.

1. INTRODUCTION

Magnesium alloys are the lightest commercial alloys, 30% lighter than aluminium alloys. Magnesium alloys are used in practical applications like aluminium alloys to be great utility as light structural materials. Fig-1 which is based on the results obtained when FSW (Friction Stir Welding) a, solid state welding method that makes welding possible at temperatures much lower than fusion welding [1]. This process consists a rotating tool with pin and shoulder is inserted in the material to be processed, and traversed along the leading edge. The heating is localized and generated by friction between the tool and the work piece [2]. Due to the advantages of FSW over the traditional joining techniques such as no melting, versatile…etc., the process has been successfully applied to aerospace, automobile, ship manufacturing and etc. After FSW, a processed zone known as friction Stir Zone (FSZ) is produced by movement of material from the front of the pin to the back of the pin. The FSZ changes completely the cast microstructure and morphology [3, 4].The present aim was carried out on a range of magnesium alloys with variations in the FSW process parameters such as tool rotation and transverse speed and vertical load.

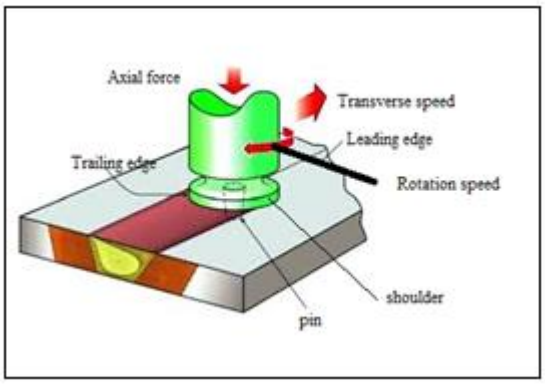


Fig 1 Schematic diagram of Friction Stir Welding process

2. EXPERIMENTAL SETUP

AE42 magnesium alloys sheets (Parent metal-PM) of 3mm thickX75mm width X120mm long were prepared and used for the FSW experiments. These sheets were investigated from die-cast ingots. Chemical composition of the alloy (nominal and measured) are given in Table-1. The tool shape was a shoulder 12mm in diameter and pin diameter 2.5 mm (with thread 1mm pitch) and the tool materials was H13. The tool was rotating in the clock-wise direction and was tilting 2° with respect to a vertical axis in order to maintain more pressure on

the plasticized material behind the tool to produce high quality welds. All of these were applied with the FSW machine in DMRL, Hyderabad. FSW experiments were carried out with the process parameters listed in Table-2. After processing, FSW was separated and samples for Charpy V notch test were made magnesium AE42 alloy. Samples before welding and after welding with above parameters were tested out. Fractography analysis were carried out using SEM (Scanning Electron Microscope) after sample preparation with standard metallographic techniques.

Toughness test was Charpy V notch test, as a standardized high strain rate test which is important to judge the effect of FSW samples before and after. On magnesium alloy was carried out with a sub-size sample. Sub-sized standard was 3 mm thickness X 5mm width X55mm long. With a v-notch 1mm depthprepared and tested in accordance with ASTM E23 standards using a standard pendulum impact tester. Samples were prepared such that the V-notch lay at the centre of the weld nugget facing the direction of welding [5]. Test was carried out on the machine with a capacity in the range of 0-50 joules.

Table 1 Chemical Composition of the base metals (Wt. %)

Alloy	ElementsAl	Zn	RE (Ce+Nd+La+Th+Pr)	Mn	Mg
AE42	Nominal	9	1	2	(1.2+0.4+0.6+---+0.1)
		---Bal.			
	Measured	4	---	2	(1.2+0.4+0.6++0.1)0.3
		Bal.			

Table 2 FSW process parameters

Alloy	Tool rpm	Transverse speed	Vertical load	Tool profile
AE42	400	35	4kn	
600	404kn	Conical, 2.5mm dia pin and	12 mm	
800	60	4kndia shoulder		
1200	1004kn			

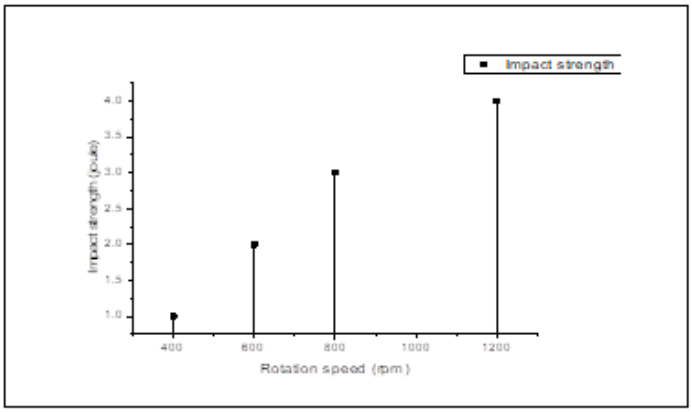


Fig 2 Variation of Impact strength

3. TESTS AND ANALYSIS

Impact test results

Impact tests were carried out a low temperature of 307.15 k (34°C) using small type impact testing machine of lab [6]. Mg-rare earth alloys, yield strength increased while ductility decreased as the testing temperature decreased [7]. Yield load and absorbing energy by impact test can be related to yield strength and ductility by tensile test [8]. These results are shown with the reference [6]. This impact test shows relationship of ductile to brittle transition in absorbed energy at a series of temperatures. From the impact test results shown in Table-3 it is well established that the FSW before and after welding improves the toughness of the magnesium alloy AE42.

Table 3 Impact test values of the Magnesium AE42 alloy

S.No	Condition of sample	Rotation speed (Rpm)	Travel speed (mm/min)	Impact energy value (J)
1	BM	---	----	5.6
2	FSZ, At temp 34°c	400	25	1.5
3	FSZ, At temp 34°c	600	40	2.5
4	FSZ, At temp 34°c	800	60	3
5	FSZ, At temp 34°c	1200	100	4

4. RESULTS AND DISCUSSIONS

4.1 Microstructural results

The detailed analyses of microstructural results from the figures 3, the grain refinement by FSW and the precipitate AL-RE are proved. The cast alloy (BM) has a coarse and networked microstructure which result in poor toughness.

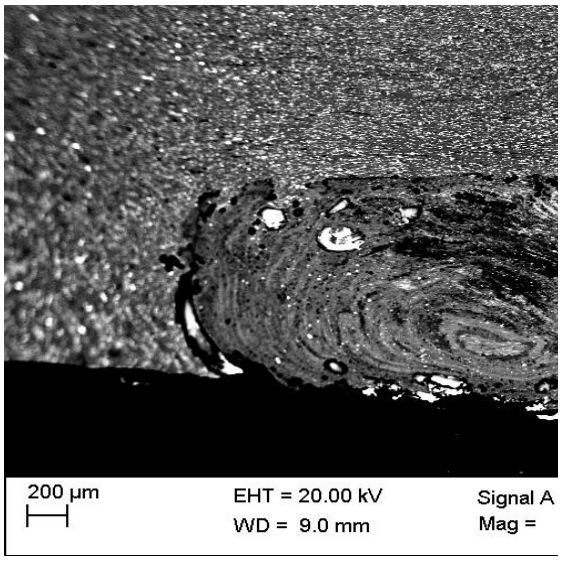


Fig 3 Macrostructure of Magnesium AE42 alloy

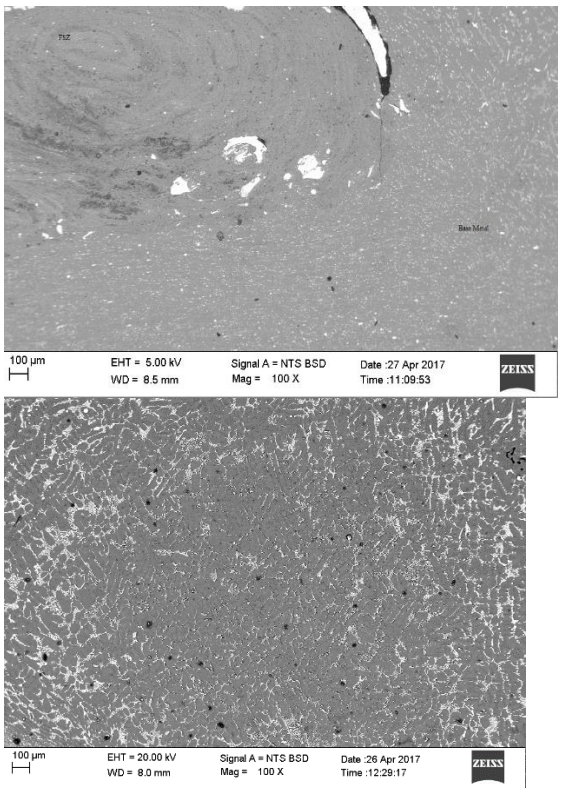
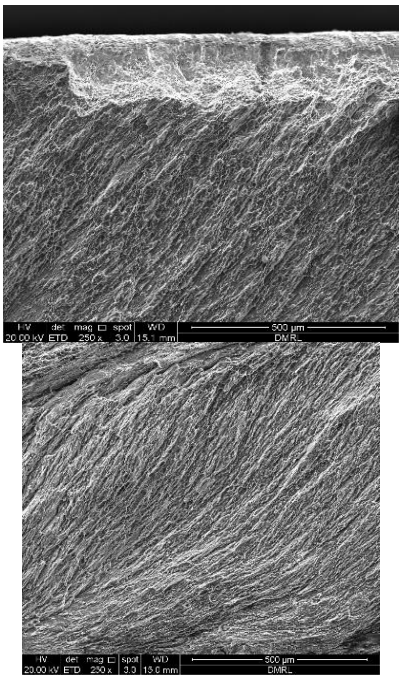


Fig 4 Light Optical microscopy of Magnesium alloy AE42 at 100X
a) FSZ b) Base Metal



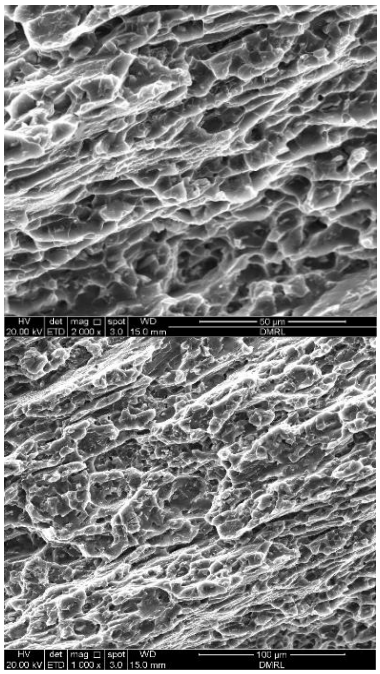


Fig 5SEMFracture studies on broken coupons from CVN tests. From left to right: Cleavage fracture of Magnesium AE42. The top row is the entire surface and the bottom row is 1000 X and 2000 X magnification of SEM.

5. CONCLUSION

In this study impact test and fracture studies are concluded for Magnesium alloy AE42, which impact toughness and fracture morphology was investigated and evaluated fundamentally.

The results of this work can be summarized as follows.

1. The transverse speed of FSW of Mg alloy AE42 100 mm/min at rotation speed of 1200 rpm to give good impact value.
2. Both rotation speed and transverse speed have a small effect on the impact value for Mg alloy AE42.
3. The relation between speed combination and the input heat which effect on the impact value is seems to be complex and depend on the material properties being welded.
4. The numerous size precipitates resulted in improving the toughness of magnesium alloys by 100%.
5. The process combination can be used to make commercially viable engineering parts using these alloys due its light weight with enhanced toughness.

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