International Journal of Advanced Research Foundation
Website: www.ijarf.com (ISSN: 2394-3394, Volume 2, Issue 5, May 2015)

Investigating the Effect of Cryogenic Process on a Friction Stir Welding AZ31B Magnesium Alloy

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Abstract: **This work was focused to investigate the effect of cryogenic process by using liquid nitrogen on friction stir welded joint of AZ31B rolled magnesium alloy .Welded portion was subjected to cryogenic temperatures , it was found that mechanical properties such as ultimate tensile strength, impact strength ,hardness and percentage of elongation were varied. It has the comparison between mechanical properties of friction stir welded joint of AZ31 rolled mg alloy which were subjected to with and without cryogenic temperatures.Microstructures are studied.**

Key Words: **Friction Stir Welding, AZ31 Magnesium Alloy, Cryogenic Temperatures, Liquid Nitrogen, Mechanical Properties, Microstructures.**

1. INTRODUCTION

Magnesium alloys are the lightest structural alloys that are commercially available. Now a days magnesium alloys have gained huge interest in the aircraft and automobile industries because of the need of light weight.

Friction Stir Welding (FSW), a solid joining method (1),fig (1)can eliminate the conventional fusion welding problems like oxidation, porosity, a wide heat- affected zone and high residual stress, and has been successfully used to weld various magnesium alloys such as Mg-Al-Ca alloy(2),Mg-Al-Zn alloys (3) and Mg-Zn-Y alloys (4-5).AZ31,a widely used wrought alloy has been subjected to FSW investigations(5).This is a 'work horse' magnesium alloy whose practical application could benefit from FSW.

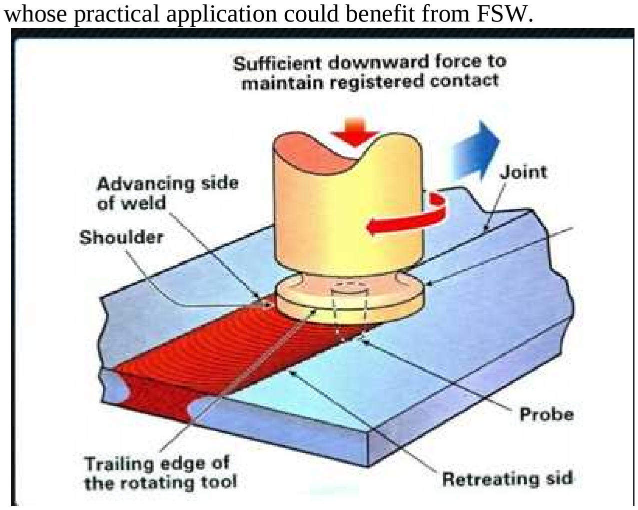

Fig 1: Friction Stir Welding process.

Most studies has been carried out on AZ31- H24 plates and joint efficiencies in the range of 60 -85 pct by changing the rotation rate and welding speed (6). Joint properties were related to the heat input, and high input was favourable for good joint properties were found by Commin*etal*. (7) Wang *etal* (8) reported that the ultimate tensile strength (UTS) of the FSW joints increased has the rotation rates increased from 500 to 1500 rpm for both the H24 and hot –rolled AZ31. Yang *etal* (9) found that because of greater heat input higher UTS was obtained with a larger diameter shoulder. Liquid nitrogen has the ability to maintain temperatures far below the freezing point of water makes it extremely useful in a wide range of application. Cryogenic cooling by liquid nitrogen on Friction Stir Welding has the ability in enhancement of microstructure. Liquid nitrogen cooling during FSP of AZ31B resulted in submicrometer grain size (10).The cooling techniques depend on continuously flooding cooling fluid on the processed area. In the present work mechanical properties and microstructures are investigated under lower temperature by liquid nitrogen.

2. EXPERIMENTAL PROCEDURE

The material used in the present study is a commercial AZ31B magnesium alloy with a nominal chemical composition of 2.9% Al and 0.72% Zn shown in Table 1.

Table 1: Chemical Composition of Base material AZ31.

Element	Zn	Mn	Si	Fe	Cu	Ni	Mg
Percentage	0.72	0.30	0.08	0.005	0.05	0.005	Reminder

Fig 2(a): CNC Milling Machine

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Fig 2(b): H13 Tool Steel


Fig 2(c): Pouring of Liquid Nitrogen on Welded Portion

The material used in this work is 4.33mm thick rolled sheets.
A bead-on-plate friction stir weld is produced parallel to the longitudinal direction of the sheet on an CNC milling machine made by Agni BMV45 fitted with an automated control system. A relatively high tool rotational speeds of 1400RPM and 1600RPM were used with feed rate of 26 and 28mm/min. The tool is fabricated from a H13 tool steel and consisted of a conical profiled pin having length of 3mm and shoulder diameter of 20mm.
Pre-cooling is achieved by pouring liquid nitrogen on welded pieces of magnesium alloy. Cryogenic cooling has some advantages pertained to changes in mechanical properties and microstructure. Liquid nitrogen is poured over the area to be cooled until the temperature of the setup reached the target value of -10^{o}c. Sheethed type thermocouples has set up to maintain temperature during the pre-cooling phase,
Tensile tests were performed after the welding of AZ31B magnesium alloy on the UTM.
Dumbbell samples are shown in fig 3.

Fig 3: (a) Tensile specimen of FSW AZ31 at 1400rpm/26 mm/min. (b) at 1400rpm/ 28mm/min.

Fig 3: (c) at 1600rpm/ 26mm/min.
(d) at 1600rpm/ 28mm/min.

Hardness tests were conducted on Brinell Hardness Test and Impact Strength was performed on Izod Test and also percentage of elongation is calculated.
The microstructures were studied on Optical Microscope (OM) which was made of QUASMOISI microscope.
Samples were ground with abrasive paper and mechanically polished with a final polishing, chemically etched in a picric acid, ethanol, acetic acid and distilled water for OM observations.

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3. RESULT AND DISCUSSION

Ultimate Tensile Strength, Impact strength, Hardness and Percentage of elongation are the mechanical properties of friction stir welded joint of Magnesium alloy AZ31B.

Table 2: Mechanical Properties of FSW joint at Normal Atmospheric Temperatures around (35^o- 40^o).

Runs	Speed (RPM)	Feed (mm/min)	Tensile Strength (MPA)	Percentage of Elongation (%)	Bend Test Failed at	Hardness (HBW)	Impact Strength (J)
1	1400	26	108	1.5	90^o	68.6	4
2	1400	28	52	3.46	Do	65.9	3
3	1600	26	67	2.86	Do	60.6	2
4	1600	28	76	0.42	Do	62.4	3.5

Table 3: Mechanical Properties of FSW joint at Cryogenic Temperature around (-10^oC).

Runs	Speed (RPM)	Feed (mm/min)	Ultimate Tensile strength (MPA)	Percentage of Elongation (%)	Bend Test Failed at	Hardness (HBW)	Impact Strength (J)
1	1400	26	22	3.34	90^o	52	2
2	1400	28	20	3.42	Do	50.5	2
3	1600	26	49	3.18	Do	50	2
4	1600	28	89	2.74	Do	62.5	2

Table 4: Comparison between mechanical properties of FSW and normal atmospheric temperature around (35^0-45^0) and cryogenic temperature around (-10^o).

Runs	Tensile Strength (MPA)			Hardness (HBW)			Percentage of Elongation (%)			Impact Strength (J)		
	At normal temp. (X)	At Cryogenic Temp. (Y)	% Z= (X-Y)/X	(X)	(Y)	%Z	(X)	(Y)	%Z	(X)	(Y)	%Z
1	108	22	79.62	58.8	52	11.5	1.5	3.3	-120	4	2	50
2	52	20	61.5	52	50.5	2.89	3.4	3.42	-5.8	3	2	33.3
3	67	49	26.8	54	50	7.4	2.86	3.18	-11.19	3.5	2	42.8
4	76	89	-17.10	56.3	62.5	-11.1	2.5	2.74	-8.1	3	2	33.3

At rotational speed of 1400rpm and feed rate of 26mm/min Ultimate Tensile Strength was increased by 79.62, hardness by 11.5, impact strength by 50and percentage of elongation was decreased to -120 at cryogenic temperatures that is at -10^oC than normal atmospheric temperatures (35^o-45^o). At 1400rpm rotational speed and 28mm/min feed rate, ultimate tensile strength, hardness, impact strength were increased by 61.5, 2.89 & 33.3 and percentage of elongation was decreased to -5.8 at cryogenic temperature.

At 1600rpm rotational speed and 26mm/min feed, ultimate tensile strength, hardness, impact strength were increased by 26.8, 7.4 &42.8 and percentage of elongation was decreased by 11.19. At rotational speed of 1600rpm and feed rate of 28mm/min, ultimate tensile strength, hardness, percentage of elongation were decreased by 17.10, -11.1, -8.4 and impact strength was increased by 33.3.

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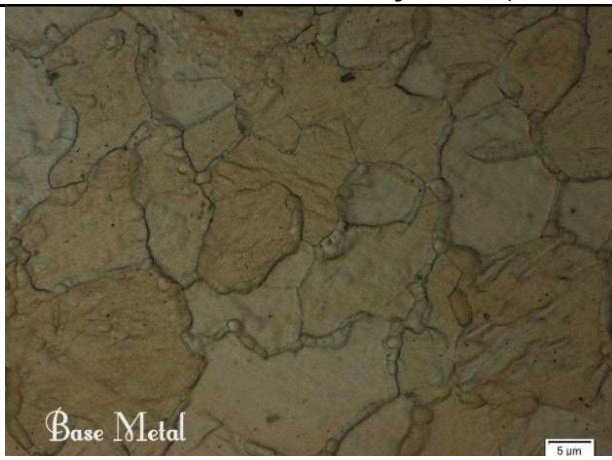

Fig 4: (a) Microstructure of Base Metal (b) Different FSW Zones, Stir Zone, TMAZ& HAZ of 1600/28

4. CONCLUSION

The mechanical properties of friction stir welded joint of AZ31B magnesium alloy which are subjected to cryogenic temperatures were decreased. Mechanical properties of friction stir welded joint are changing by cryogenic process. Considering the mechanical properties, the components which are subjected to cryogenic temperatures such as aerospace and automotives which run at cold places will be designed. To obtain a safe design the values should be at low.

REFERENCES

[1]. R. S. Mishra and Z. Y. Ma: Mater. Sci. Eng. R, 2005, vol. 50.pp. 1-78.

[2]. D. T. Zhang, M. Suzuki, and K. Maruyama; Scripta Mater., 2005, vol.52, pp. 899-03.

[3]. S. Mironov, Q. Yang, H. Takahashi, I. Takahashi, K. Okamoto, Y. S. Sato and H. Kokowa : Metall. Mater. Trans. A, 2010, vol. 41A. pp. 1016-24.

[4]. S. Mironov, Y. Motohashil and R. Kaibyshev: Mater. Trans., 2007, vol.48. pp. 1387-95.

[5]. G. M. Xie, Z. Y. Ma, L. Geng andR. S. Chen: Mater. Sci. Eng. A. 2007, vol. 471, pp. 63-68.

[6]. S. Lin, S. Kim, C. G. Lee, C. D. Yim and S. J. Kim: Metall. Mater. Trans. A.2005, vol.36A, pp. 1906-2.

[7]. L. Commin, M. Dumont, J. E. Masse and L. Barrallier :Acta Mater., 2009, vol.57, pp. 326-34.

[8]. X. H. Wang and K. S. Wang: Mater. Sci. Eng. A. 2006, vol.431, pp. 114-17.

[9]. J. Yang, B. L. Xiao, D. Wang and Z. Y. Ma: Mater. Sci. Eng. A, 2010, vol.527, pp.708-14.

[10]. M. Anwaruddin, “Achieving ultrafine grains in Mg AZ31B-0 alloy by cryogenic friction stir processing and machining”, MS Theses, University of Kentucky, 2011.