OPTIMIZING THE PROCESS PARAMETERS OF FRICTION STIR WELDED JOINT OF MAGNESIUM ALLOY AZ31B

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Abstract

This paper deals with Friction stir welding of AZ31B Mg alloy by using H13 Tool at different rotational speeds and welding speeds .Experiments were conducted according to L4 Orthogonal array which was suggested by Taguchi. Optimum parameters for optimum Tensile strength, Hardness and Ductility were found with the help of S/N ratios. Therefore optimization of input process parameter is required to achieve good quality of welding. In this experiment the effect of process parameters on welded joint was studied and optimizes the parameter by using Taguchi method and stated regression equation for tensile strength and hardness. Assigns the rank to each factor which are having more influence on the mean of tensile strength and hardness.

Keywords: -*FSW, Taguchi, DOE, Tensile Strength, Hardness, Ductility*

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1. INTRODUCTION

To produce a joint stronger than the fusion arc welded joint, the Friction Stir Welding process (FSW) can be used. Many applications such as aerospace, automotive and ship building industries, [1] widely use the friction stir welding to weld the lightweight materials, such as aluminum, magnesium and titanium. More effective welding and joining techniques are essential, however for further usage of magnesium alloys. Commonly encountered defects in fusion welded joints [2] such as oxide inclusions, porosity, cracks and distortions surrounding the tool must be hot, so that a successful can be reduced using the joining technique of (FSW), because it has a great potential for magnesium alloys. To develop quality joints, the process variables like the rotational speed, travel speed and tool geometry are vital [3].

2. OPTIMIZATION USING TAGUCHI BASED GREY RELATION METHOD

To design a high-quality system, a powerful tool also known as the Taguchi method, can be used. Not only does this method provide an efficient approach, but it provides a systematic approach to optimize designs for better performance and quality [4]. A design that has minimized the number of experiments is the orthogonal array experimental design. To determine the improved performance of the process parameter which increases the quality of the characteristics, the S/N ratio can be used. The characteristics of the S/N ratio performance can be divided into many factors: the smaller the better, if nominal the best, the factor larger the better was picked, which optimized the tensile strength and hardness.

Base material AZ31 Chemical Composition:-

Alloy	Zn	Mn	Si	Fe	Cu	Ni	Mg
%	0.72	0.30	0.08	0.005	0.05	0.005	Remainder

Tool H13 Chemical composition

Elements	C	Mn	Cr	Mo	V	Si	Fe
%	0.40	0.35	5.20	1.30	0.95	1.00	Remainder

INPUT Variables for 4Runs, 2Lvels and 2 Factors:-

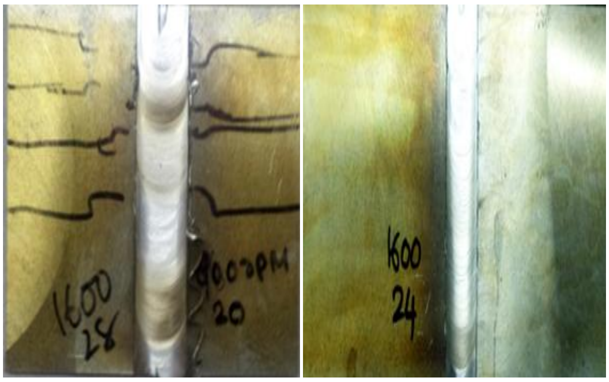
Runs	**Speed(R.P.M)**	**FEED (MM/MIN)**
1	1200	24
2	1200	28
3	1600	24
4	1600	28

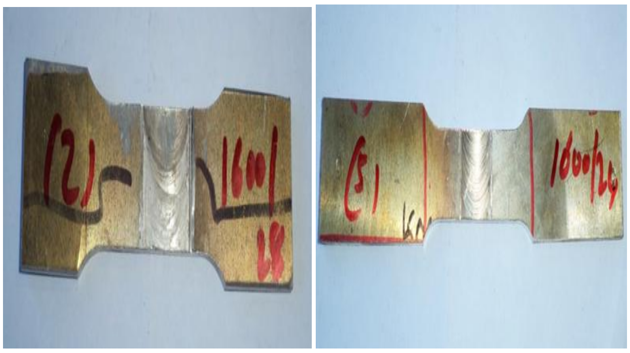
Levels of factors:-

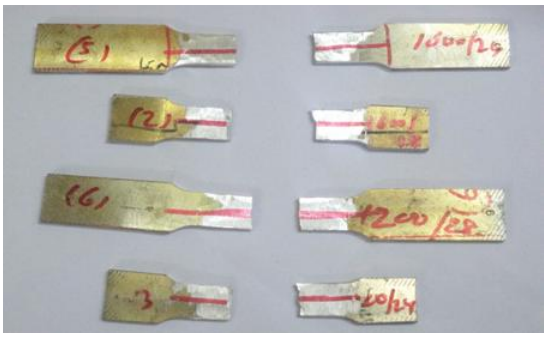
Levels / Factors	**High**	**Low**
Speed (R.P.M)	1600	1200
FEED (MM/MIN)	28	24

3. EXPERIMENTAL SETUP

A sheet of Magnesium AZ31B alloy with 100 mm length, 100 mm width and 4 mm thickness was used in this study. The base material's chemical composition is given in Table 1. FSW of the parts were carried out on a study of Vertical Milling machine Special clamping methods were used to have a firm gripping of the work pieces. The Ultimate Tensile Testing machine and hardness testing machine were used to test the tensile strength, elongation and hardness. The Table 2 below shows the identified process parameters and their levels. The L4 orthogonal array is selected as per standard suggested by Taguchi approach and is shown in table







4. RESULTS AND DISCUSSIONS

RUNS	Speed (R.P.M)	FEED (mm/min)	Breaking or MAX. Load (KN)	Ultimate Tensile Strength (N/mm^2)	Hardness	% of Elongation	Bend Test
1	1200	24	8.80	120	56.3	1.06	
2	1200	28	12.30	148	62.4	1.18	Failed at 90^0
3	1600	24	11.90	148	95	1.96	
4	1600	28	6.10	76	56.3	0.42	

Larger is better for tensile strength and hardness
S/N= -10 log [1/N ∑ 1/yi2]
Smaller is better for Ductility
S/N= -10 log [1/N ∑ yi2]

Response Table for Signal to Noise Ratios

RUNS	**S/N RATIO for Ultimate Tensile Strength**	**S/N RATIO for Hardness**	**S/N RATIO for Ductility**
1	41.58	35.01	-0.506
2	43.40	35.90	-1.437
3	43.40	39.55	-5.845
4	37.61	35.01	7.53

Signal to Noise Ratios for each level of factors

Levels Factors	**Tensile strength**		**Hardness**		**Ductility**	
	1	**2**	**1**	**2**	**1**	**2**
Speed (R.P.M) (**A**)	42.49	40.50	35.45	35.45	-0.97	0.84
FEED (mm/min) (**B**)	42.49	40.50	37.28	35.45	-3.17	3.04

Interpretation: - From the above signal to noise ratios of each level of factor it is concluded that the optimum factor level to achieve Optimum tensile strength is A_1 and B_1 which are having maximum s/n ratios i.e speed is 1200 R.P.M and Feed is 24 mm/min and Optimum factor level to achieve Optimum Hardness is A2 and B1 which are having maximum s/n ratios i.e speed is 1600 R.P.M and Feed is 24 mm/min.optimum factor level to achieve optimum ductility is A2 and B2 Which are having maximum s/n ratios i.e 1200 R.P.M and Feed is 24 mm/min

The regression equation of tensile strength and hardness:-

Tensile strength = 343 - 0.055 SPEED - 5.5 FEED

HARDNESS = 116 + 0.0407 SPEED - 4.08 FEED

Interpretation: - Tensile strength = 343 - 0.055 Speed - 5.5 Feed. In the output above, if the speed variable increases by 1 unit and the other variables stay the same, Tensile strength decreases by about 0.05 units on average. If the Feed variable increases by 1 unit and the other variables stay the same, Tensile strength decreases by about5.5 units, on average. **,** hardness increases by about 0.0407 units on average. If the Feed variable increases by 1 unit and the other variables stay the same, hardness decreases by about4.08 units, on average.

Response Table for Means of Tensile strength

Level	Speed	FEED
1	134.0	134.0
2	112.0	112.0
Delta	22.0	22.0
Rank	1	1

Response Table for Means of Hardness

Level	Speed	FEED
1	59.35	75.65
2	75.65	59.35
Delta	16.30	16.30
Rank	1	1

Interpretation: - From the delta values it assigns the rank to each factor which are having more influence on the mean of hardness, but in this for both factors rank was same so it concluded that both factors are having same influence on the mean of hardness.

5. CONCLUSIONS

A study of friction stir welding for magnesium alloys has been conducted, in which alloys have been welded to themselves and to each other. It has been possible to develop procedures giving sound welds for all combinations, and initial indications are that mechanical properties will meet expectations.

1) Observed that the both factors are having same influence on the mean of tensile strength. And Mean of Hardness
2) Observed that the 1200 r.p.m and 24 mm/ min feed were best to maximize the tensile strength.
3) Observed that the 1600 r.p.m and 24 mm/ min feed were best to maximize the hardness.
4) In bending test all 4 pieces were failed at 90^0 , it means that after friction welded joint , that weld portion becomes brittle

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