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Research Article

Investigating the Effect of Friction Stir Welding Parameters on Hardness of Al 3003 and Al 5052

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Abstract

Friction welding is the process in which the heat required for welding is obtained by friction occurs between the ends of the parts to be joined .One of the part to be joined is rotated at a very high speed and the other part is axially aligned with the first one and pressure applied against it. In this study, the effect of welding parameters on hardness of Al alloys weld were investigated. Three levels of Rotational speed, travelling speed & Tilting angle were taken to weld specimen of aluminium alloys. This paper investigates the influence of friction stir welding based on Taguchi method so as to obtain optimum value for hardness. It was found that hardness response displaying a decreasing trend with an increase in the value of Rotational speed. The maximum value of hardness response is at the first level of Rotational speed & second level of Travelling speed & Tilting angle parameters.

Keywords: *Taguchi Design, Orthogonal Array, Friction stir welding, traveling speed.*

1. Introduction

Friction welding is the process in which the heat required for welding is obtained by friction occurs between the ends of the parts to be joined .One of the part to be joined is rotated at a very high speed and the other part is axially aligned with the first one and pressure applied against it. The friction between the two parts increases the temperature of both the ends. Then the rotation is stopped and the pressure on the fixed part is increased further so that the joining takes place. This is called as Friction Welding. A.S. Vagh , S.N. Pandya *et al*. (2014) carry out the Friction welding orthogonal technique is used to evaluate the effect of process parameters Tool Pin Profile and Tool Traverse Speed. From the technique, it can be concluded that the Tool Design is the main factor that has the highest influence on Tensile strength and hardness. It is also found that there is a very less variation in the mechanical properties by changing the Tool travelling speed. Sivakumar, Vignesh Bose, D. Raguraman, D. Muruganandam *et al*. (2012) have investigated the occurrence and importance of flaws in friction stir welds. In particular, the influence of tool design on flaw occur and the development of NDT techniques to find flaws in lap and butt welds would be helpful. Metal flow model may have a role to play here though capturing the aspect of the thermo -mechanical behavior remains a challenge. Woei Shyan Lee & Tao Hsing Chen *et al*. (2008) concluded that the strain rate sensitivity increases but the activation vol. decreases with an increasing in work hardening. WM Thomas *et al*. (1999) experimentally find that unlike aluminium and non-ferrous materials, which show little visible change during FSW due to increase in temperature, a colour change occurred when welding steel. The temperature was dependent on rotation speed, & increasing with increasing rpm. H. J. Liu , H. Fujii , M. Maeda, K. Nogi *et al*. (2003) concluded that a softened region, of weld and two heat affected zones, clearly occurred in the friction-stir-welding joints of the aluminum alloy, thus the tensile strengths of the joints are lower than those of the base metal. The welding parameters show significant effects on the tensile strength and fracture locations of the joints.

2. Methodology used

First pilot experiments were done on the workpiece using random values and then from those pilot experiments the suitable values of these parameters were selected. On the basis of observations from the pilot experiments these levels were found suitable for the experimentation.

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2.1 Factors and their levels observed from pilot experiments

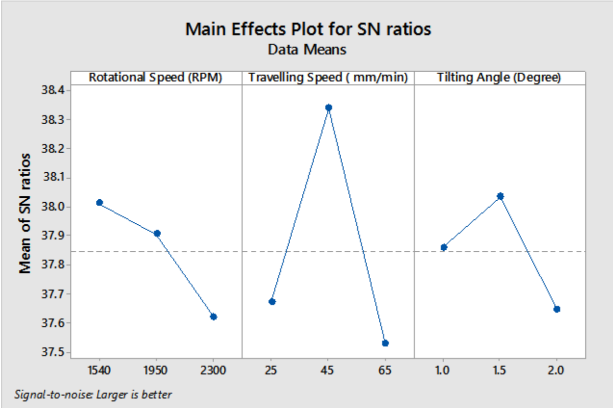
Table 1 Factors and their levels

Sr. No.	Factors (Units)	Levels		
1	Rotational Speed (RPM)	1540	1950	2300
2	Travelling Speed (mm/min)	25	45	65
3	Tilting Angle (Degree)	1	1.5	2

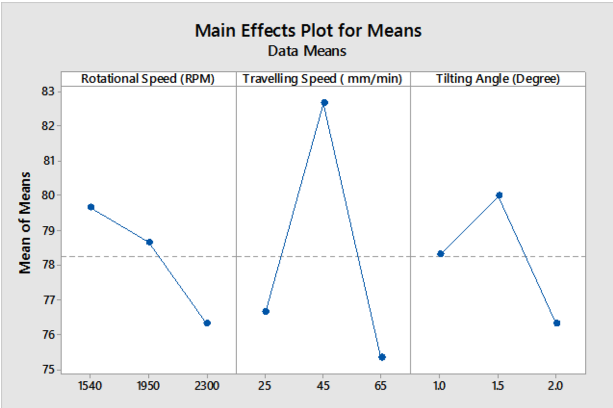
2.2 Analysis of Hardness Response

Table 2 Taguchi Analysis: Hardness

Sr. No.	Rotational Speed (RPM)	Travelling Speed (mm/min)	Tilting Angle (Degree)	Hardness	SNRA1	MEAN1
1	1540	25	1	74	37.38	74
2	1540	45	1.5	85	38.59	85
3	1540	65	2	80	38.06	80
4	1950	25	1.5	84	38.49	84
5	1950	45	2	77	37.73	77
6	1950	65	1	75	37.50	75
7	2300	25	2	72	37.15	72
8	2300	45	1	86	38.69	86
9	2300	65	1.5	71	37.03	71



Graph 1 Main effects plot for SN ratios



Graph 2 Main effects plot for Means

2.3 Effect of Input Factors on Hardness Response

The S/N ratios & Means for each level of welding parameters are summarized and referred to the average effects response table of S/N ratios and mean table for hardness. For hardness the calculation of S/N ratio follows Larger the Better model.

Table 3 Response Table for Signal to Noise Ratios (Larger is better)

Level	Rotational Speed (RPM)	Speed (mm/min)	Angle (Degree)
1	38.01	37.67	37.86
2	37.91	38.34	38.03
3	37.62	37.53	37.65
Delta	0.39	0.81	0.39
Rank	2	1	3

Table 4 Response Table for Means

Level	Rotational Speed (RPM)	Travelling Speed (mm/min)	Tilting Angle (Degree)
1	79.67	76.67	78.33
2	78.67	82.67	80.00
3	76.33	75.33	76.33
Delta	3.33	7.33	3.67
Rank	3	1	2

The value of hardness shows a decreasing trend with an increase in the value of Rotational speed. But as we increase the value of Travelling speed and tilting angle the value of hardness first increases and the decreases. Max value of hardness response is at first level of Rotational speed & second level of both Traveling speed and tilting angle. The trend is observed same in both SN Ratio and Mean Plot.

2.4 Analysis of variance (ANOVA) of Hardness

The purpose of ANOVA is to find out which parameter significantly affects the hardness response.

Table 5 Analysis of Variance for SN ratios

Source	DF	SS	MS	F	P
Rotational Speed (RPM)	2	0.2453	0.1227	0.15	0.870
Travelling Speed (mm/min)	2	1.1117	0.5558	0.68	0.597
Tilting Angle (Degree)	2	0.2253	0.1127	0.14	0.880
Residual Error	2	1.6448	0.8224		
Total	8				

Table 6 Analysis of Variance for Means

Source	DF	SS	MS	F	P
Rotational Speed (RPM)	2	17.56	8.778	0.13	0.884
Travelling Speed (mm/min)	2	91.56	45.778	0.68	0.594
Tilting Angle (Degree)	2	20.22	10.111	0.15	0.869
Residual Error	2	134.22	67.111		
Total	8	263.56			

Conclusions

It is interesting to note that hardness response displaying a decreasing trend with an increase in the value of Rotational speed. The maximum value of hardness response is at the first level of Rotational speed & second level of Travelling speed & Tilting angle parameters.

Table 7 Optimal combination for Hardness

Physical	Optimal Combination		
Requirements	Rotational Speed(RPM)	Travelling Speed (mm/min)	Tilting angle (Degree)
Maximum Hardness	1540	45	1.5
	Level-1	Level-2	Level-2

Real Life Application & Future Work

Real life application of this study is that, the results and conclusion will be beneficial for providing the optimal combination for hardness & Tensile Strength of friction welded joint, so that welded joint can be designed for maximum hardness & Maximum Tensile Strength. This will be very beneficial for industrial purposes as this can be applied as a new technique for joining different types of metals.

In future the experimentation can be done on various grades of Aluminum Alloys 0f 6-Series, 7-Series and Copper.

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