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Research Article

Effect of Friction Stir Welding Parameters on Tensile Strength of Al 3003 and Al 5052

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Abstract

Friction stir welding is a solid state joining process that uses a third body tool to join two surfaces. Heat is generated b/w the tool & material which leads to a very soft region near the tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is mostly used on aluminum alloys, and extruded aluminum alloys, In this study, the effect of welding parameters on Tensile Strength of Al alloys weld were investigated. Three levels of travelling speed, Rotational speed, & Tilting angle were taken to weld specimen of aluminum alloys (AL 3003 & Al 5052. This paper investigates the influence of friction stir welding based on Taguchi method so as to obtain optimum value for tensile strength. It was found that the Tensile Strength response displaying a decreasing trend with an increase in the value of Rotational speed & Tilting angle. But it shows a decreasing trend with an increase in the value of travelling speed. The maximum value of Tensile strength response is at the first level of Rotational speed and Tilting angle & third level of Travelling speed parameters.

Keywords: *Taguchi Design, Taguchi, Friction stir welding, traveling speed, Tensile Strength.*

1. Introduction

Friction stir welding is a solid state joining process that uses a third body tool to join two surfaces. Heat is generated b/w the tool & material which leads to a very soft region near the tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is mostly used on aluminum alloys, and extruded aluminum alloys. 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. N.T. Kumbharand, K. Bhanumurthy *et al*. (2012) performed a friction stir welding of Aluminum 5052 with Alumimium 6061 Alloys & concluded the following friction stir welding of dissimilar materials AA5052 and AA6061 was successfully performed. It was observed that at higher rotating speeds, the load and spindle torque decreased. S.K.Selvam, T.Parameshwaran Pillai *et al*. (2013) concluded that when we keep eight welding speeds for CFD, maintaining constant travel speed & optimum speed, the tool life will increase. The maximum temperature in the process can be achieved by increasing both weld speed and the rotating speed. M. Jabbari *et al*. (2013) concluded that the increase of the preheating temperature not only develops the weld quality, but also decreases the process time.

S Shankar, D Kumar Prasad, Shabbir Ali, *et al*. (2016) concluded that the lap joint of the AA6101 aluminum alloy was successfully produced by friction stir welding. The rotational and welding speeds should be kept at optimum value otherwise; it will result in line defect. Haşim Kafali *et al*. (2011) concluded that the microstructure of the welding zone in the friction stir welding AA6013 T-6 was divided into 4 zones are base material, (HAZ), thermo mechanical affected zone and weld nugget. It is concluded that both the parent material & the weld region consist of homogenous distributions of coarse & fine Mg2Si particles. Vikrant Kaushik Harpreet Singh *et al*. (2014) concluded that the Tensile strength is mainly affected by Tool speed and beside it shoulder diameter & feed rate also have a little affect. Dr. T. Parameshwaran Pillai *et al*. (2012) concluded that the maximum temperature in the process can be achieved by increasing both welding speed and the rotating speed.

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2. Methodology used

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 Tensile Strength Response

Table 2: Taguchi Analysis: Tensile Strength

Sr. No.	Rotational Speed (RPM)	Travelling Speed (mm/min)	Tilting Angle (Degree)	Tensile Strength	SNRA1	MEAN1
1	1540	25	1	158	43.97314	158
2	1540	45	1.5	179	45.05706	179
3	1540	65	2	161	44.13652	161
4	1950	25	1.5	157	43.91799	157
5	1950	45	2	127	42.07607	127
6	1950	65	1	175	44.86076	175
7	2300	25	2	148	43.40523	148
8	2300	45	1	156	43.86249	156
9	2300	65	1.5	133	42.47703	133

2.3 Effect of Input Factors on Tensile Strength 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 Tensile Strength. For Tensile Strength the calculation of S/N ratio follows Larger the Better model.

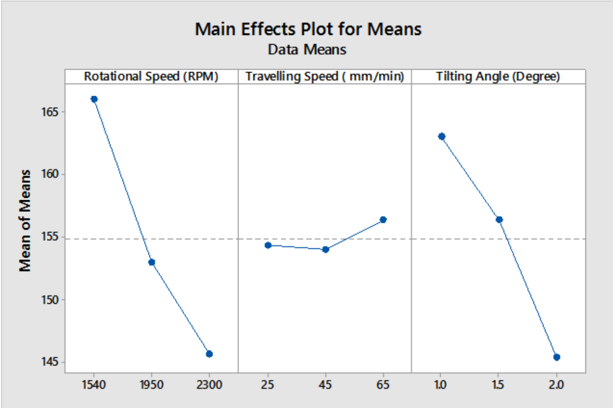
Table 3 Response Table for Signal to Noise Ratios

Larger is better

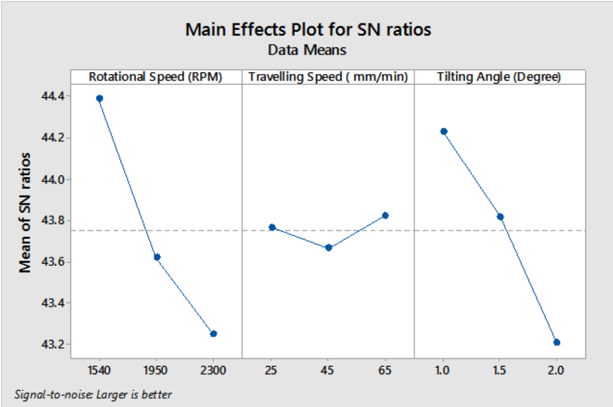
Level	Rotational Speed (RPM)	Travelling Speed (mm/min)	Tilting Angle (Degree)
1	44.39	43.77	44.23
2	43.62	43.67	43.82
3	43.25	43.82	43.21
Delta	1.14	0.16	1.03
Rank	1	3	2

Table 4 Response Table for Means

Level	Rotational Speed (RPM)	Travelling Speed (mm/min)	Tilting Angle (Degree)
1	166.0	154.3	163.0
2	153.0	154.0	156.3
3	145.7	156.3	145.3
Delta	20.3	2.3	17.7
Rank	1	3	2



Graph 1 Main effects plot for Means



Graph 2 Main effects plot for S.N Ratio

The tensile strength of the weld metal shows an increasing trend with an increase in the values of travelling speed (mm/min). But the Tensile strength of weld metal shows a decreasing trend with an increase in the values of Rotational speed (RPM) and Tilting angle (Degree).

2.4 Analysis of variance (ANOVA) of Tensile Strength

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

Table 5 Analysis of Variance for SN ratios

Source	DF	SS	MS	F	P
Rotational Speed (RPM)	2	2.03188	1.01594	0.50	0.666
Travelling Speed (mm/min)	2	0.03903	0.01951	0.01	0.990
Tilting Angle (Degree)	2	1.59893	0.79947	0.39	0.717
Residual Error	2	4.05373	2.02686		
Total	8	7.72357			

Table 6 Analysis of Variance for Means

Source	DF	SS	MS	F	P
Rotational Speed (RPM)	2	636.22	318.111	0.52	0.657

Travelling Speed (mm/min)	2	9.56	4.778	0.01	0.992
Tilting Angle (Degree)	2	477.56	238.778	0.39	0.719
Residual Error	2	1219.56	609.778		
Total	8	2342.89			

Conclusions

Tensile Strength Analysis

It is interesting to note that the Tensile Strength response displaying a decreasing trend with an increase in the value of Rotational speed & Tilting angle. But it shows a decreasing trend with an increase in the value of travelling speed. The maximum value of Tensile strength response is at the first level of Rotational speed and Tilting angle & third level of Travelling speed parameters.

Table 7 Optimal combination for Tensile Strength (Maximum)

Physical	**Optimal Combination**		
Requirements	**Rotational Speed(RPM)**	**Travelling Speed (mm/min)**	**Tilting angle (Degree)**
Maximum Tensile Strength	1540	65	1
	Level-1	Level-3	Level-1

Scope for Future Work

In future the experimentation can be done on various extruded grades of Aluminum Alloys. Moreover instead of hardness, Tensile strength number of responses like Temperature, Izod Strength, Charpy Strength can be evaluated.

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