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Optimization of Friction stir Welding Parameters in Joining Dissimilar Aluminium alloys using SPSS and Taguchi

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Abstract: **Optimization of welding parameters on dissimilar friction stir welded joints between AA6061 T-651 and AA7075 T-651 aluminium alloys. Experiments are conducted by varying the welding parameters namely rotational speed and welding speed related to three pin profiles are optimized with response as ultimate tensile strength. Aluminum and its alloys have been used in recent times due to their light weight, moderate strength and good corrosion resistance. It is difficult to weld aluminium and its alloys using Friction stir welding. An attempt was made to weld using this technique. In order to formulate the equation between important welding parameters like rotational speed and welding speed related to three pin profiles (predictors) and tensile strength (response) linear regression was chosen and validated this model using SPSS and process parameters are optimized by using taguchi.**

1. INTRODUCTION

The preferred welding processes for fabricating the AA7075 alloy are frequently friction stir welding process due to their comparatively easier applicability and better economy. but alloys with high Zn-Mg and Cu content have a tendency to hot crack after welding. All the 7000 series of aluminium are sensitive to stress concentration cracking. Hence these problems associated with the welding of these different alloys of aluminium has led to the development of solid state welding processes, like the Friction Stir Welding technique, which is an upgraded version of the friction welding process. The advantages of the Friction Stir Welding process include low distortion even in long welds, no fuse, no porosity, no spatter, low shrinkage, and the ability to operate at all positions, highly energy efficient and excellent mechanical properties as proven by the fatigue, tension and bend tests.

2. EXPERIMENTAL PROCEDURE

In the present study, the welding of 6.35mm thick plate of AA7075-T6 alloy was carried out using Friction Stir Welding (FSW) process. . All the investigations were carried out in the as Welded (AW) condition. The square butt joint was used in the experiments as it yielded better results. In order to formulate the equation between the parameters, Rotational speed (RS), Welding speed (WS), Axial load (AL) (predictors) and output variable tensile strength (TS) (For FSW-Tool Geometry-1i.e.taper cylindrical threaded pin multiple regression was chosen and validated this model SPSS 16 and formulated the transfer function with interaction between predictors reported by Minitab 15.The FSW process was carried out using the machine manufactured by R.V. Machine tools, Coimbatore, India, with a motor capacity 12kw / 440AC drive, spindle speed in the range of 200 to 2000 rpm, welding speed in the range of 10 to 150 mm/min and the axial load capacity of the maximum of 20 kN.

3. MULTIPLE REGRESSION MODEL DEVELOPMENT

Regression analysis is a mathematical measure of average relationship between two or more variables in terms of original units of data. Regression is used to create an equation (or) transfer function from the measurements of the system's inputs and output's acquired during a passive or active experiment (Kazmier, 2005). Multiple regression analysis was conducted using tensile strength (TS) as a dependent variable and Rotational speed (RS), Welding speed (WS), Axial load (AL) as independent variable.

4. REGRESSION ANALYSIS FOR TENSILE STRENGTH

The measured welding parameters are analyzed using SPSS. Pearson correlation was used to analyses correlation among the seven variables. All the variables were significantly

correlated with one another at 0.001 but rotational speed is not significant in explaining the variation in tensile strength, we developed the reduced regression that excluded the variables. The reduced model has the following form:
TS = f (AL, WS)

5. EXPERIMENTAL RESULTS

	INPUT PARAMETERS				OUT PUT
S.No	SP (RPM)	AL (KN)	WS (mm/min)	TG	TS (MPa)
1	1400	8	50	1	221
2	1500	8	75	1	230
3	1600	8	100	1	244
4	1400	9	50	1	225
5	1500	9	75	1	280
6	1400	9	100	1	275
7	1400	8	50	1	268
8	1500	8	75	1	291
9	1400	8	100	1	272
10	1500	9	50	1	241
11	1400	9	75	1	281
12	1500	9	100	1	285
13	1400	8	50	1	250
14	1500	8	75	1	281
15	1500	8	100	1	285
16	1600	9	50	1	288
17	1600	9	75	1	311
18	1400	9	100	1	252
19	1500	8	50	1	281
20	1500	8	75	1	285
21	1500	8	100	1	282
22	1600	9	50	1	292
23	1600	9	75	1	311
24	1500	9	100	1	325
25	1500	8	50	1	321
26	1500	8	50	1	281
27	1400	8	75	1	230
28	1400	9	100	1	224
29	1500	9	50	1	325
30	1400	9	75	1	320
31	1400	9	100	1	282

6. STATISTICAL ANALYSIS

Pearrson correlation table was generated to find the relation between different parameters with each other.

		TS	RS	AL	WS
TS	Pearson Correlation	1	-0.022	0.513	-0.022
	Sig. (2-tailed)		0.938	0.051	0.938
	N	31	31	31	31
RS	Pearson Correlation	-0.022	1	0.612*	1.000**
	Sig. (2-tailed)	0.938		0.015	0.000
	N	31	31	31	31
AL	Pearson Correlation	0.513	0.612*	1	0.612*
	Sig. (2-tailed)	0.051	0.015		0.015
	N	31	31	31	31
WL	Pearson Correlation	-0.022	1.000**	0.612*	1
	Sig. (2-tailed)	0.938	0.000	0.015	
	N	31	31	31	31

Model Summary:

The regression model has explained the variation accounts for 44.3 percent of the total Variation seen in the experiment (Ng et al., 2004). Table 1 Shows Summary of R^2 for Regression Model.

Table 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.666	0.443	0.351	33.85233

Coefficient:

The coefficient table gives a relation between different independent variables with tensile strength.

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-408.760	220.880		-1.851	0.089
	Axial load	85.400	27.640	0.842	3.090	0.009
	Welding speed	-1.069	0.542	-0.538	-1.973	0.072

The relation is given in the form:
TS = 85.400 AL – 1.069 WS – 408.760

Anova analysis:

Table 2

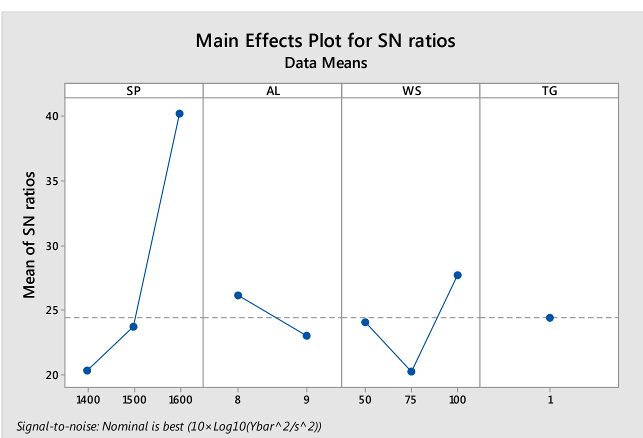
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10951.840	2	5475.920	4.778	0.030
	Residual	13751.760	28	1145.980		
	Total	24703.600	30			

The F ratio is significant at the 0.03 level, which means that the results of the regression models could hardly have occurred by chance (Chacker and Jabnoun, 2003). Table 2 shows ANOVA table for Tensile Strength. From this table we can conclude that larger is the F value, the less possibility that it occured by chance.

Taguchi:

7. RESULTS AND DISCUSSION

Taguchi's designs aimed to allow greater understanding of variation than did many of the traditional designs. Taguchi contended that conventional sampling is inadequate here as there is no way of obtaining a random sample of future conditions. Taguchi proposed extending each experiment with an "outer array" or orthogonal array should simulate the random environment in which the experiment would function.



Spindle Speed :

The effect of parameters spindle speed on tensile strength is shown in above figure for S/N ratio. Its effect is increasing with increase in spindle speed upto 1500 RPM beyond that it is decreasing. So the optimum spindle speed is 1500 RPM.

Axial load:

The effect of parameters axial load on tensile strength is shown in above figure for S/N ratio. Its effect is increasing with increase in axial load upto 9KN .So the optimum spindle speed is 9KN.

Welding speed:

The effect of parameters welding speed on tensile strength is shown in above figure for S/N ratio. Its effect is decreasing with increase in welding speed upto 75 RPM beyond that it is increasing. So the optimum spindle speed is 100 RPM.

8. CONCLUSION

The following results are obtained by multiple regression model equation:

There is a positive relationship between the axial load (AL) and tensile strength (TS) as the regression coefficient is 85.4. Mathematically, it means that the tensile strength will increase 85.4 % if the axial load increases 1% without change of all other predictors (Cao et al., 2006). Similarly, we can get the percentage of tensile strength with other independent variables. Taguchi method was conducted to get the optimal values of the independent variables.

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