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Process Parameters Optimization on Tensile Strength in Gas Tungsten Arc Welded Joints Aa7075-T6 Aluminum Alloy by Using SPSS and TORA Software

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ABSTRACT : *Aluminum and its alloys have been used in recent times due to their light weight, moderate strength and good corrosion resistance. Aluminum alloy 7075-T6 has been researched upon especially as a potential candidate for aircraft material. This alloy is difficult to weld using conventional welding techniques like GTAW and GMAW. An attempt has been made in this paper to weld 7075-T6 alloy using Gas Tungsten Arc Welding. The welding experiment was carried out on Odor, Chennai and tensile strength tested on Ministry of Micro and small and Medium Enterprises Testing Center, Government of India, Chennai for the purpose of improving tensile strength. In order to formulate the equation between important welding parameters like current (I), Voltage (V), Welding Speed (WS) and Gas flow (GS) (predictors) and tensile strength (response) so that multiple regression as chosen and validated this model using SPSS 16 and process parameters are optimized by using TORA software.*

Keywords - *AA 7075 aluminum alloy, Gas tungsten arc welding, Regression Model, Linear Programming, SPSS, TORA.*

I. INTRODUCTION

The preferred welding processes for fabricating the AA7075 alloy are frequently Gas Tungsten Arc Welding (GTAW) process due to their comparatively easier applicability and better economy. The weld Fusion Zone (FZ) typically exhibit coarse columnar grains because of the prevailing thermal conditions during weld metal solidification. This often results inferior weld mechanical properties and poor resistance to hot cracking. In the GTAW process, an essentially a non-consumable tungsten electrode is used to provide an electric arc for welding. A sheath of inert gas surrounds the electrode, the arc, and the area to be welded. This gas shielding process prevents any oxidization of the weld and allows for the production of neat, clean welds. In the present study the welding of 6.35mm thick plate of AA7075-T6 alloy was carried out using Gas Tungsten Arc welding (GTAW) process with filler wire process.

II. EXPERIMENTAL PROCEDURE

All the investigations were carried out in As Welded (AW) condition on ODOR Chennai. The GTAW was carried out manually, using HF 3000-AD and KEDLITE -40 respectively, 3 phase,210 and 240V ± 10%, 50Hz AC equipment having gas flow rate 25 to 30 litres/minute. In GTAW technique, top and bottom purging was provided with 99% pure argon. The GTAW joint was fabricated using ER-5356 electrodes and ER-5183 electrodes respectively with a root gap of 1.6 mm. The weld bead quality and full penetration was achieved by selecting suitable welding parameters.

III. TENSILE STRENGTH INVESTIGATION ON AA7075 –T6 ALLOY WELDMENTS

The tensile specimens were prepared as per ASTM E8M-04 standards. The tensile test was done in a 100 KN, Servo Mechanical Controlled Universal Testing Machine (UNITEK –UTE 40). The tensile test was carried out at the rate of 1.5KN /min as per ASTM testing specification on Ministry of Micro and small and Medium Enterprises Testing Center, Government of India. The GTAW weldments are shown in Fig .1 (a). The welding experimental set up used for GTAW is shown in Fig. 1 (b).


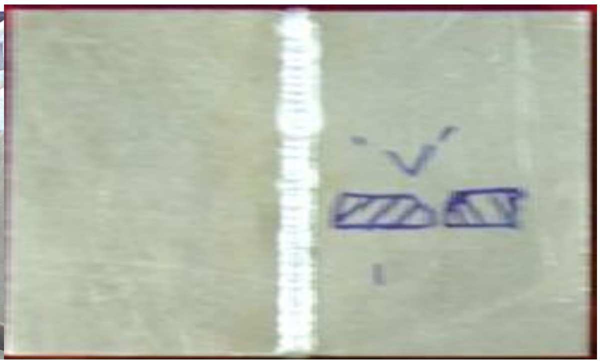

Fig .1 (a). Welding experimental set up used for GTAW   Fig .1 (b). Fabricated Weldments by GTAW

IV. MULTIPLE REGRESSION MODEL DEVELOPMENT

Regression analysis is 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 Current (I), Voltage (V), Welding speed (WS), Gas flow (GF) as the independent variables.

V. GTAW - REGRESSION ANALYSIS FOR TENSILE STRENGTH

SPSS 16 was used to analyze the response of this study. Pearson correlation was used to analyses correlation among the seven variables. All the variables were significantly correlated with one another at 0.001.

TS = f (I, V, WS, GF)

Gas flow (GF) are 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 (I, V, WS)

The summary of Regression Coefficient is presented in the table 1.

Table 1. Summary for Regression Coefficient

Variables	Unstandardized Coefficients	Standardized Coefficients			
	B	Std. Error	Beta		Sig.
	-8.772	113.619		.077	.939
Current	.417	.132	.245	.155	.003
Voltage	6.373	2.526	.459	.523	.016
Welding Speed	-.823	.478	-.305	1.722	.094

SPSS 16 based on the analysis, formulated the transfer function for tensile strength shown in the equation:

TS = 0.417 I + 6.373 V – 0.823 WS -8.772 ………………………………………… (With Constant) (1)
TS = 0.245 I + 0.459 V – 0.305 WS ……………….……………………………….(With out Constant) (2)

VI. MODEL VALIDITATION

The regression model has explained the variation accounts for R^2 89.5 percent (GTAW) of the total Variation seen in the experiment, shown in table 2 (Ng et al., 2004). The F ratio is significant at the 0.00 level, which means that the results of the regression models could hardly have occurred by chance (Chacker and Jabnoun, 2003). The quality of the regression can also be assessed from a plot of residuals versus the fitted values. The plot shows no observable structure shown in figure 2.

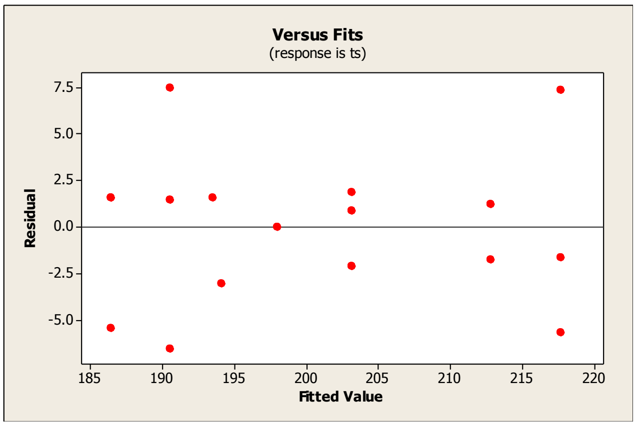

Table 2. Summary of R^2 for Regression Model

R	R Square	Adjusted R Square	Std. Error of the Estimate
.946a	.895	.886	3.96250

VII. LINEAR PROGRAMMING

Linear Programming is a mathematical technique for generating & selecting the optimal or the best solution for a given objective function. Technically, Linear Programming may be formally defined as a method of optimizing (i.e. maximizing or minimizing) a linear function for a number of constraints stated in the form of linear in equations. According to Fagoyinbo (2008) and Martin (1983) the problem of Linear Programming may be stated as that of the optimization of linear objective function of the following form:

Maximize TS = 0.245 I + 0.459 V – 0.305 WS

Subject to:
$I \geq 180$ $V \leq 32$ $WS \geq 10$
$I \leq 200$ $V \geq 30$ $WS \leq 14$

The model is analyzed using Operations Research software called TORA and the results obtained is given in Fig:3.

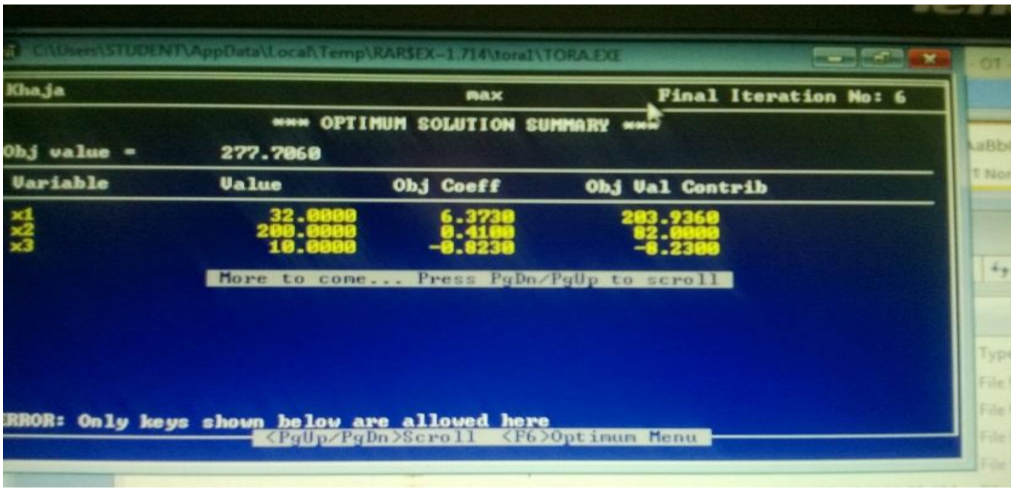

Fig 3. TORA Output

VIII. CONCLUSION

The resulting multiple regression model:

There is a positive relationship between the Current (I) and tensile strength (TS) as the regression coefficient is 0.417. Mathematically, it means that the tensile strength will increase 0.417 % if the current increases 1% without change of all other predictors (Cao et al., 2006). Similarly voltage also.

There is a negative relationship between the welding speed (WS) and tensile strength (TS) as the regression coefficient is 0.823. Mathematically, it means that the tensile strength will decrease 0.823 % if the welding speed increases 1% without change of all other predictors (Cao et al., 2006).

LP Optimum Solution: Max TS = 277.7060, I = 200, V = 32, WS = 10. Application of linear programming would have indicated to welder that the system should set 200 amp current, 32 voltage and 10 m/sec welding speed in order to make the maximum tensile strength of 277.7060.

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