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INVESTIGATION OF TENSILE BEHAVIOUR OF TIG WELDED 316 STAINLESS STEEL USING TAGUCHI TECHNIQUES

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ABSTRACT

This works aims at the analysis and optimization of joining similar grades of stainless steel by TIG welding. TIG welding may use a filler material. There is a variant in the process which does not require filler material. Such process is known as Autogenous TIG welding process. The parameters like current, welding speed and gas flow rate are the variables in the study. The objective of this research is to determine the influence of various welding parameters on the weld bead of 316 SS by using Taguchi technique. A plan of experiments based on Taguchi technique method has been carried out. Orthogonal array, signal to noise (S/N) Ratio, Analysis of variance (ANOVA) are employed for studying the welding characteristics of material & to optimize the weld parameters. The result obtained are the output from each parameter, through which optimal parameters are found out for maximum tensile strength. It is found that -welding current followed by welding speed are major parameters influencing mechanical properties of welded joint.

Keywords: *TIG Welding, SS-316 and Taguchi Techniques*

1. Introduction

Welding is one of the fabrication processes that is used for joining the metals, by causing coalescence which replaces other joining process like bolting, riveting. A good joint will be obtained through TIG welding and preferred by the most of the manufactures for mechanical assemblies. TIG welding is applied to weld sheet, tube, pipe, and casting. Such fabricated products are used in shipbuilding, power generation, aerospace, and other industries. TIG welding may use a filler material. There is a variant in the process which does not require filler material. Such process is known as Autogenous TIG welding. Generally, a single pass autogenous TIG welding is used to weld materials up to 3 mm thick. For welding thicker material multi-pass weld is required.

Stainless steels are essentially alloys of iron, chromium and carbon with Cr content exceeding 12 % and carbon content being small. The term “stainless” implies resistance to staining, rusting and pitting in air, moist and polluted conditions. This stainless property of all stainless steels attributed to the chromium addition. Thus, stainless steel possesses excellent corrosion resistance along with other properties like tensile strength, good workability and abrasion resistance which make them suitable for a variety of applications.

2. Literature Review

M. Tanka [1] studied that effects of surface-active elements on weld pool formation using TIG arcs oxygen and halogen elements. The roles of activating flux are precisely the aforementioned and oxides, such as TiO_2 and Cr_2O_3, which are the main composition of activating flux, become the supply source of oxygen after being dissociated within the weld pool.

H Hirata & K Ogawa [2] Studied that effect of chemical composition on weld ability in fabrication However the present circumstances are that the relationship between Al and O has not been defined quantitatively and a unified view on Al action mechanism has yet to be established.

R.-I. Hsieh et al. [3] investigated the effect of minor elements and shielding gas on Penetration in TIG Welding. The former contains increased soluble oxygen content in the weld pool, and the latter produces an arc that is hotter than that produced by pure argon.

A. K. Pandey et al [4] used Taguchi method for optimization of process parameter such as welding strongly recommends for multiple runs, is to use the signal-to-noise (S/N) ratio for the same steps in the Analysis. Ugur Esme [5] studied that application of Taguchi method for the optimization of resistance spot welding low carbon steel is extensively used for deep drawing of motor car bodies, motor cycle parts, and

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other domestic applications. The confirmation tests indicated that it is possible to increase tensile shear strength significantly by using the proposed statistical technique.

3. Taguchi's Design Method

Optimization of process parameters is the key step in the Taguchi method for achieving high quality without increasing cost. This is because optimization of process parameters can improve quality characteristics and the optimal process parameters obtained from the Taguchi method are insensitive to the variation of environmental conditions and other noise factors. Basically, classical process parameter design is complex and not easy to use. A large number of experiments have to be carried out when the number of process parameters increases. To solve this task, the Taguchi method uses a special design of orthogonal arrays to study the entire process parameter space with a small number of experiments only. A loss function is then defined to calculate the deviation between the experimental value and the desired value. Taguchi recommends the use of the loss function to measure the deviation of the quality characteristic from the desired value. The value of the loss function is further transformed into signal-to-noise (S/N) ratio.

3.1 Signal-to-Noise Ratio

There are 3 Signal-to-Noise ratios of common interest for optimization

(I) Smaller-The-Better: n = -10 Log10 [mean of sum of squares of measured data.

(II)Larger-The-Better: n = -10 Log10 [mean of sum squares of reciprocal of measured data

(III)Nominal-The-Best: n = 10 Log10 (square of mean)/ Variance

3.2 Work Material

The work material used for present work is stainless steel 316, the dimensions of the work piece length 75 mm, width 75mm, thickness 3mm. Argon-helium is used as a shielding gas. The chemical composition of work material SS 316 is given in Table 1

3 .2 Orthogonal array Experiments

In the present study, three 3-level process parameters i.e. welding current, welding speed and gas flow rate are selected as shown in table 2.

The total degrees of freedom of all process parameters are 8. The degrees of freedom of the orthogonal array should be greater than or at least equal to the degrees of freedom of all the process parameters. Hence, L9 (3 3) orthogonal Array was chosen which has 8 degrees of freedom. The tensile tested specimens are shown in figure 1

Table 1. Chemical Composition of base material 316

Alloy	Weight in (%)
Chromium	16-18
Nickel	10-14
Carbon	0.08
Manganese	2
Phosphorus	0.045
Silicon	0.75
Nitrogen	0.10
Molybdenum	2-3
Sulphur	0.03

Table 2. Important process parameters and their levels

Process parameters	Level 1	Level 2	Level 3
Current (A)	150	160	170
Welding speed (mm/min)	180	190	200
Gas flow rate (l/min)	10	15	20

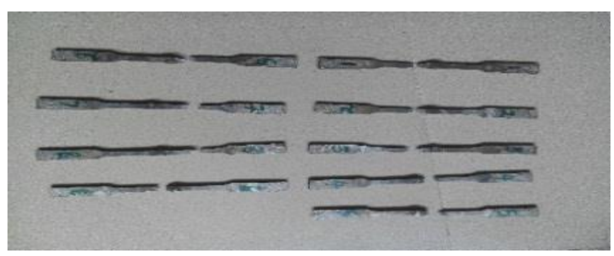

Fig. 1 Tensile Tested Specimen

3.3 Analysis of S/N Ratio

In the Taguchi Method the term "signal-to-noise" represents the desirable value (mean) for the output characteristic and the term noise represents the undesirable value (standard Deviation) for the output characteristic. Therefore, the S/N ratio will be the mean to the S. D. S/N ratio used to measure the quality characteristic deviating from the desired value. The S/N ratio S is defined as S= -10 log (M.S.D.) where, M.S.D. is the mean square deviation for the output characteristic. To obtain optimal welding performance, higher-the better-quality characteristic for Tensile strength must be taken [6]. The M.S.D. for higher-the better-quality characteristic can be expressed.

$$MSD = \frac{1}{R}\sum_{j=1}^{R}(y_j - y_o)^2$$

Where R = Number of repetitions

Table 3. Experimental result for tensile and S/N ratio

Si.No	Current (A)	Welding speed (mm/min)	Gas flow rate (L/min)	Tensile strength (Mpa)	s/n ratio
1	150	180	10	447	53.0062
2	150	190	15	547	54.7597
3	150	200	20	390	51.8213
4	160	180	15	593	55.4611
5	160	190	20	553	54.8545
6	160	200	10	500	53.9794
7	170	180	20	599	55.5485
8	170	190	10	572	55.1479
9	170	200	15	559	54.9482

Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio. [7&8]. The S/N response table for Tensile strength shown in table 3.

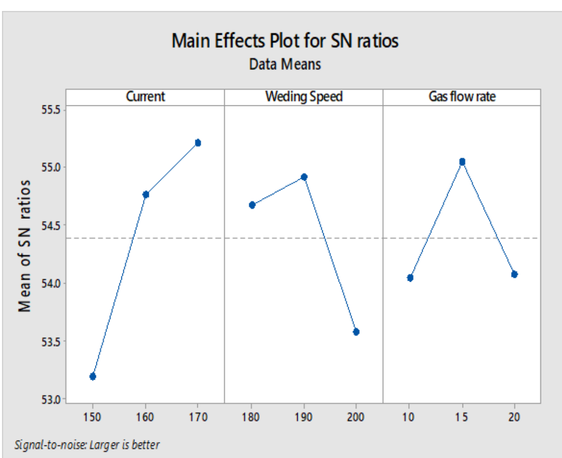

Fig. 2 Main Effects Plot for SN ratios

3.4 Analysis of Variance (ANOVA)

Table 4 shows the result of the analysis of variance (ANOVA) for the Tensile strength. The analysis of variance was carried out at 95% confidence level [10]. The main purpose of analysis of variance is to investigate the influence of the design parameters on Tensile Strength by indicating that which parameters is significantly affected the quality characteristics. Based on the experimental, S/N ratios of Tensile Strength is tabulated in Table 4. For S/N ratios, all the factors and the interaction terms are significant at and α-level of 0.05.

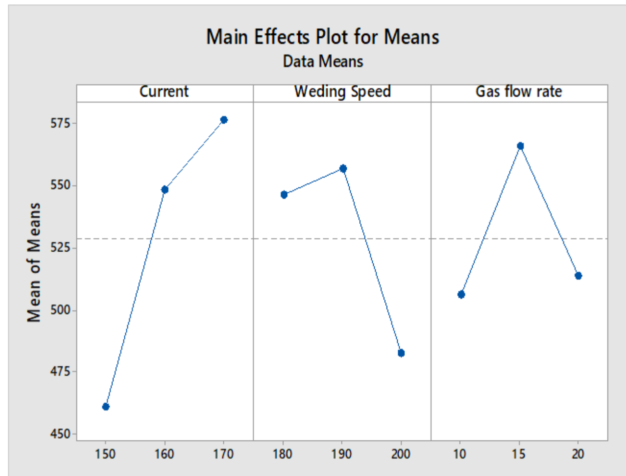

Fig. 3 Main Effects Plot for Means

Table 4. Result of analysis of variance for tensile test

Source	DF	Adj SS	Adj MS	F-value	P-value
Regression	3	26057.5	8685.8	3.22	0.120
Current	1	19952.7	19952.7	7.40	0.042
Welding speed	1	13016.7	13016.7	2.23	0.195
Gas flow rate	1	5088.2	5088.2	0.03	0.864
Error	5	1473.4	1473.4		
Total	8	39531			

For S/N ratio, Selected parameters Arc Current (p=0.042), Arc Speed (p=0.195) & Gas Flow Rate (p=0.864) are significant because their p-values are less than 0.05. The purpose of ANOVA is to investigate which welding process parameters significantly affect the quality characteristics.

This is accomplished by separating the total variability of the S/N Ratios, which is measured by the sum of squared deviations from the total mean of the S/N ratio, into contributions by each welding process parameter and the error. The percentage contribution by each of the welding process parameters in the total sum of the squared deviations can be used to evaluate the importance of the process parameter change on the quality characteristic.

4. Conclusions

The research is to determine the influence of various welding parameters on the weld bead of 316 SS by using the Taguchi analysis It is concluded that Arc Current significantly affects the tensile Strength of weld Zone, parent Metal & heat Affected Zone with contribution of 50.47% followed by arc Speed with contribution of 32.92 % and Gas flow rate with contribution of 12.87%. From the ANOVA table it is observed that the most influencing Welding parameter is welding current and followed by welding speed and Gas flow rate.

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