APPLICATION OF TAGUCHI METHOD FOR ANALYSIS AND OPTIMIZATION OF SHIELDED METAL ARC WELDING PARAMETERS ON MECHANICAL PROPERTIES OF CARBON STEEL JOINTS

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ABSTRACT

The current study presents the effect of welding parameters on mechanical properties of AISI 304 joints produced by shielded metal arc welding (SMAW). The two circular rods were joined using welding process and strength of the joint is tested using tension test. The tension test is carried out using Universal Testing Machine (UTM) in the laboratory the most influential control parameters which affect the mechanical properties of the joint strength were determined using Taguchi method.

Keyword: - *Optimization, Taguchi method, SMAW*.

1. INTRODUCTION

The control of the process input parameters to obtain a good welded joint with the required weld quality is the requirement of the manufacturer. Therefore it is necessary to study the weldingfactorswhile welding process. The process of doing this activity is time consuming based on trial and error technique.Thereafter the welded joints are tested for betterstrength. Depending on the closeness of the acquired requirement, finally the weld parameters can be chosen. Also, the remaining requirement is achieved through an optimizationof welding parameters. In other words, there may be a more ideal welding input parameters combination is available, which can be used based on the quality of weld strength is achieved. Various optimization techniques are available to overcome this problem, and mathematical model can be developed to satisfy the relation between input and output variables. One of the approaches, such as Design of experiment (DoE) using Taguchi method is applied to carry out the optimization of the parameters.

2. LITERATURE REVIEW

In this section the work done by various researchers related to the considered field is reported. Optimization of the parameters in a pulsed metal inert gas welding process is studied by Pal et al. [1] using Taguchi approach. The appropriate factors are studied for modeling and controlling the welding process by Benyounis and Olabi[2]. Taguchi method is successfully implemented to optimize the process parameters in pulsed TIG welding of AA 5456 aluminium alloy for increasing the mechanical properties by Kumar and Sundarrajan[3]. Rao et al. [4] investigates the impact of process parameters and developed a mathematical model to predict geometry of bead in pulsed GMA welding process. A progressive neural network model using Taguchi approach is proposed by Yang et al. [6] to develop a prediction model for CO2 laser cutting experiment. Huang [8] demonstrates theimpact of welding

parameters on the geometry of weld bead, and determined the process parameters using the Taguchi method to get required quality of weld strength. The weld pool geometry in the Tungsten Inert Gas (TIG) welding of stainless steel is studied by Juangand Tarng [12] and obtained optimum process parameters.

3. EXPERIMENTAL PROCEDURE

The current work presents the impact of various weld parameters affecting the maximum ultimate tensilestrength in the GMAW for AISI 304 steel material using Taguchi method. Three important processparameters, i.e. welding current, voltage and welding rod diameter for three different levels were considered. The levels of the considered parameters were set based on theoretical and experimental viewpoints. The Table 1 shows the levels of parameters considered in the present work. The L9 orthogonal array used for the optimization of the process parameters tabulated as shown in Table2.

Table 1 shows the levels of Process parameters

Variables	Unit	Level 1	Level 2	Level 3
Current(I)	Amp	180	200	220
Voltage(V)	Volt	21	23	25
Welding Rod Diameter (D)	mm	3.15	4	5

Table 2 Experimental L9 Orthogonal array

Expt. No.	Current	Voltage	Welding Rod Diameter
1	180	21	3.15
2	180	23	4
3	180	25	5
4	200	21	4
5	200	23	5
6	200	25	3.15
7	220	21	5
8	220	23	3.15
9	220	25	4

The welding is done using a carbon steel wire ER70S-6 with a 3.14, 4, 5mm diameter. Thework-pieces of AISI 304 steel with a diameter of 12-mm are considered. The SMAW process was used forthe welding of two rods of 12mm diameter. Argon gas was used asshielding gas at a constant flow rate of 15 L/min.

Table 3 Chemical composition (wt.%) of work material and electrode wire used

	C	Si	Mn	P	S
AISI304	0.08	1	2	0.045	0.03
ER70S-6	0.10	1.00	1.70	0.010	0.015

3.1 Taguchi's design method

The plan of experiment is proposed using Taguchi Technique.The Taguchi method has become an influential tool forimproving output during research and development, so that better quality products can be producedquickly and at minimum cost. Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan hasestablished a method based on "ORTHOGONALARRAY" experiments which gives much reduced"variance" for the experiment with "optimumsettings" of control variables. Thus the marriage ofDesign of Experiments with optimization of controlparameters to find best results is attained in theTaguchi Method. "Orthogonal Arrays" (OA) gives aset of well balanced (minimum) experiments and Dr.Taguchi's Signal-to-Noise ratios (S/N), which are logfunctions of desired output, serve as objectivefunctions in optimization, help in data analysis andestimation of optimum results.The signal-to-noise (S/N) ratio for each level wasbased on the S/N ratio analysis. Based on the tensilestrength of the weld joint (larger-the-better), a higherS/N ratio produced a better quality. The standard S/Nratio formula for this type of response is:

S/N = -10log(M.S.D) ; where, M.S.D is mean square deviation for the output characteristic.

3.2 Analysis of Variance (ANOVA)

The purpose of the analysis of variance (ANOVA) isto examine which design parameters significantlyaffect the quality characteristic. This is toaccomplished by separating the total variability of the

S/N ratios, which is measured by the sum of thesquared deviations from the total mean S/N ratio, intocontributions by each of the parameters and the error.First, the total sum of squared deviations SST fromthe total mean S/N ratio nm can be calculated as

4. RESULTS AND DISCUSSION

The effect of important welding parameters on the tensile strength of welded joint ingas metal arc welding process is studied in the current work.

Table 4 Experimental result for UTS and S/N ratio

Exp No.	Current	Voltage	Rod Dia.	UTS (MPa)	S/N Ratio
1	180	21	3.15	380	61.13
2	180	23	4	400	61.58
3	180	25	5	450	62.60
4	200	21	4	395	61.47
5	200	23	5	439	62.39
6	200	25	3.15	360	60.66
7	220	21	5	430	62.21
8	220	23	3.15	356	60.57
9	220	25	4	370	60.90

Results show that among main input weldingparameters the effect of the welding rod diameter is significant. Increasing the welding rod diameter and decreasing the current increases the ultimate tensilestrength of welded joint. In this research work it wasobserved that the voltage did not contribute as such toweld strength. Regardless of the set of the qualitycharacteristic, a greater S/N ratio relates to betterquality characteristics. Therefore, the optimal level ofthe process variables is the level with the greatest S/Nratio. The S/N response table for ultimate tensilestrength is shown in Table No.5 as below.

Table 5 S/N Response table for UTS

Symbol	Parameters	Mean S/N/ Ratios		
		Level 1	Level 2	Level 3
A	Current	62.29	62.04	61.78
B	Voltage	62.06	62.08	61.96
C	Rod Diameter	61.43	61.83	62.84

Table 6 Results of analysis of variance

Sym	Para	DOF	MS	F
A	I	2	456.44	30.89
B	V	2	52.78	3.57
C	D	2	4344.78	294.01
Error		2	14.78	

From table 5, the optimum levels are A3B3C3 whichis based on larger-the-better criterion. The ANOVA is a statistical tool used to determine the level ofcontribution of each process parameter to the overallimprovement of the tensile strength of the welded joint. From the table 6, the welding Rod diameter has maximum contribution. This has been found to havethe most influence on tensile strength. Thus, a littlevariation in the welding rod diameter is expected to greatlyaffect the tensile strength of the weld. From the values of welding rod diameter and strength it can conferred that the strength is directly proportional to rod diameter.

5. CONCLUSIONS

In this research study, the mild steel failure problems encountered by loads were successfully addressed by applying the Taguchi Method. The optimization process is done using Taguchi orthogonalarray, the signal-to-noise (S/N) ratio and analysis ofvariance (AVOVA). It is clear from the findings of this work the optimum levels are A3B3C3. Among the parameters considered welding rod diameter has major impact on tensile strength of welded joints.

6. REFERENCES

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