Measuring the Effect in Dependent Parameters for Arc Welding on the Quality Welding

Zuher Hassan Abdullah

Technical Institute of Babylon, IRAQ.

Zuherhassan7477@yahoo.com

ABSTRACT

This research dealt statistical analysis of the data that obtained from process of the electric arc welding for samples of the medium carbon steel which its hardness is equal to (156 HB). All welding pieces were produced by changing the practical Parameters, where tolerances of the electrode diameter were (2.5, 3.25, 4) mm and thickness of the steel pieces were (4, 4.25, 4) mm. This research aims to, first the variance analyses of the independent parameters versus quality of hardness in the welding zone. Second, optimization parameters find that effect in the quality of hardness that result from welding by signal-to-noise ratio (Taguchi method). Statistical analysis software (Minitab -16.0) used to generate graphs relative to the experimental results that obtained from tests. Results showed that the thickness and electrode diameter have significant effect in the hardness. Third level of both parametrs got predicted hardness (188.64 HB) and conformed test (186.35 HB) that were $A_3 = 4\ mm$, $B_3 = 4\ mm$.

Keywords: Quality, Taguchi method, optimization

INTRODUCTION

Arc welding (AW) is a fusion-welding process in which coalescence of the metals is achieved by the heat of an electric arc between an electrode and the work. A generic AW process is shown in Figure1.Anelectric arc is a discharge of electric current across a gap in a circuit. It is sustained by the presence of a thermally ionized column of gas (called a plasma) through which current flows. To initiate the arc in an AW process, the electrode is brought into contact with the work and then quickly separated from it by a short distance. The electric energy from the arc thus formed produces temperatures of 5500_C^o (10,000_F) or higher, sufficiently hot to melt any metal. A pool of molten metal, consisting of base metal(s) and filler metal (if one is used) is formed near the tip of the electrode. In most arc welding processes, fill metal is added during the operation to increase the volume and strength of the weld joint. As the electrode is moved along the joint, the molten weld pool solidifies in its wake[Mikell P.,2010]. [Ugur Esme, 2009] an investigation of the effect and optimization of welding parameters on the tensile shear strength in the resistance spot welding (RSW) process. The experimental studies were conducted under varying electrode forces, welding currents, electrode diameters, welding times, and estimated individual parameter contributions and conclude more information.[S. V. Sapakal and M. T. Telsang,2012]study the influence of welding parameters like welding current, welding voltage, welding speed on penetration depth of MS C20material during welding. A plan of experiments based on Taguchi technique has been used to acquire the data. An Orthogonal array, signal to noise (S/N) ratio and analysis of variance (ANOVA) are employed to investigate the welding characteristics of MS C20 material & optimize the welding parameters. Finally the conformations tests have been carried out to compare the predicated values with the experimental values confirm its effectiveness in the analysis of penetration.

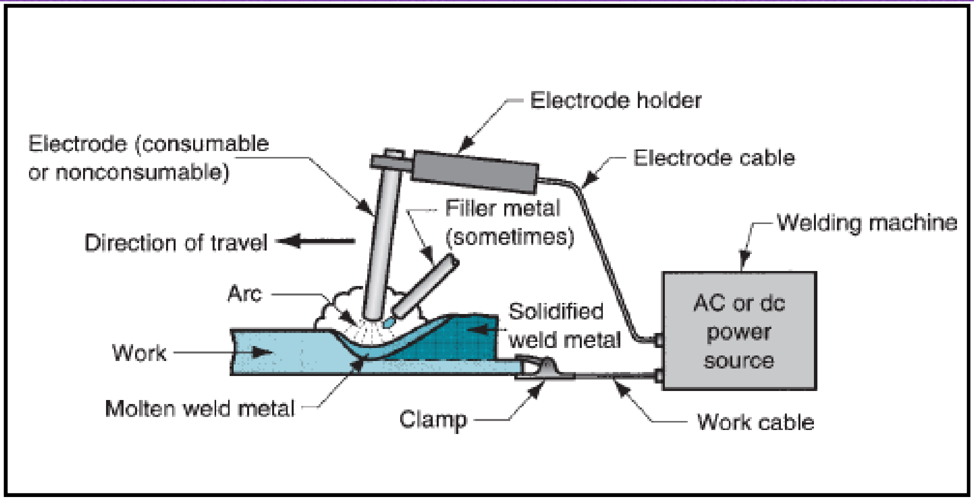

Figure 1. The basic configuration and electrical circuit of an arc welding process[Mikell P.,2010]

TAGUCHI'S DESIGN METHOD

Taguchi Technique is applied to plan the experiments. The Taguchi method has become a powerful tool for improving productivity during research and development, so that high quality products can be produced quickly and at low cost. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results. Taguchi method stresses the importance of studying the response variation using the signal – to – noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter**[Ross P J,2005]**. The hardness was considered as the quality characteristic with the concept of "the larger is better". the S/N ratio η_i used for this type response is calculated as**:-**

$$\eta_i = -10 \log \left(\frac{1}{n} \sum_{i=1}^{n} \frac{1}{y_i^2} \right) \qquad (1)$$

where:

yi isthe experimental value of the quality characteristic, and n is the number of tests**[K. Y. Benyounis, 2008].**

CONFORMATION TEST

Once the optimal level of design parameters has been selected, the final step is to predict and verify the improvement of the quality characteristic using the optimal level of design parameters**[MONTGOMERY D C., 2006]**.The estimated S/N ratio $\hat{\eta}$ using the optimal level of the design parameters can be calculated as:-

$$\hat{\eta} = \eta_m \sum_{i=1}^{n} \left(\bar{\eta}_i - \eta_m \right) \qquad (2)$$

Where: η_m is total mean of S/N ratio, $\bar{\eta}$ is the mean of S/N ratio at the optimal level, and n is the number of main welding parameters that significantly affect the performance[K. Y. Benyounis, 2008].

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Work Material and Experimental Procedure

The pieces had used of the medium carbon steel, cleaned and carried out the following processes:-

1-initial sample had prepared without welding for the purpose of comparison its dimensions(6cm * 5cm * 4.5mm) and Chemical analysis was conducted to determine the appropriate electrode to welding process as shown in Table 1.The Brinell device has used to test the hardness.

Table 1.Chemical composition of the base metal

Hardness(HB	%CU	NI%	%MN	%SI	%C
156	0.57	0.13	0.65	0.2	0.2

2-eight samples had prepared each one equal to dimension of initial sample and byan electric arc welding has done(8)ribbons depending on the thickness of the weld piece, which has three levels(4.00,4.25,4.50), in addition to electrode diameter which also has three levels(2.5,3.25,4),and after cooling all the pieces by air, the slag was removing from welding zone by grinding process.

RESULTS AND DISCUSSION

Analysis Of Mean Hardness And S/N Ratio

The Samples had sequentially examined in welding zone by brinell testing, where each sample had three observations of an examination. To obtain optimal welding performance, the larger is better quality characteristic for hardness must be taken. The mean hardness and S/N ratio for each level of the welding process parameters are summarized in table 2.

Table 2.Orthogonal array for L9 with response (mean and S/N ratio)

No of trials	Input parameter		codes		Mean value (η_i)	S/N ratio (η_i)
	Thicknesss A	Diameter B				
1	4.5	2.5	A_1	B_1	162.41	44.21
2	4.25	2.5	A_2	B_1	173.11	44.77
3	4	2.5	A_3	B_1	178.82	45.05
4	4.5	3.25	A_1	B_2	172.25	44.72
5	4.25	3.25	A_2	B_2	180.57	45.13
6	4	3.25	A_3	B_2	183.49	45.27
7	4.5	4	A_1	B_3	182.07	45.20
8	4.25	4	A_2	B_3	184.00	45.30
9	4	4	A_3	B_3	185.87	45.38
The average of Mean values and S/N ratios					178.066	45

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The optimal level of the process parameters is the level with the greatest of main effects of hardness (mean and S/N ratio). The total mean of the hardness and S/N ratio for 9(L_9) experiments is calculated and listed in table 3.

Table 3. Main effects of the hardness (mean and S/N ratio)

Process parameter	*Level*	*Means (response)*		*S/N ratio*	
		A	*B*	*A*	*B*
Average value	L1	171.45	172.24	44.68	44.71
	L2	178.77	179.23	45.04	45.06
	L3	183.98	182.73	45.29	45.23
Mean (response-η_m) =178.066				45	

Conformation Experiments

Three confirmation experiments had conducted at the optimal setting of the welding process parameters. The average value of hardness was found to be 86.35 HB and that for predicted hardness as 88.64 HB. These results are within 95% confidence interval of the predicted optimal values of the selected welding characteristics, hence, the optimal settings of the process parameters as predicted in the analysis can be implemented.

Analysis Surface And Scatter Plots

1- The surface plot relating the hardness to the process parameters Figure 2.It was observed that the hardness into the welds increases as the diameter of electrode increases, but not linearly, and it decreases as the thickness of sample increases, and it does seem to have significant effect on the hardness during the welding process.

2- According to figure 3.Thickness of piece was found to be the major parameter affecting the hardness (49%), whereas electrode diameter was found to be the second ranking parameter (35%). The percentage contribution of interaction and error are much lower being (8.26%, 7.74%).

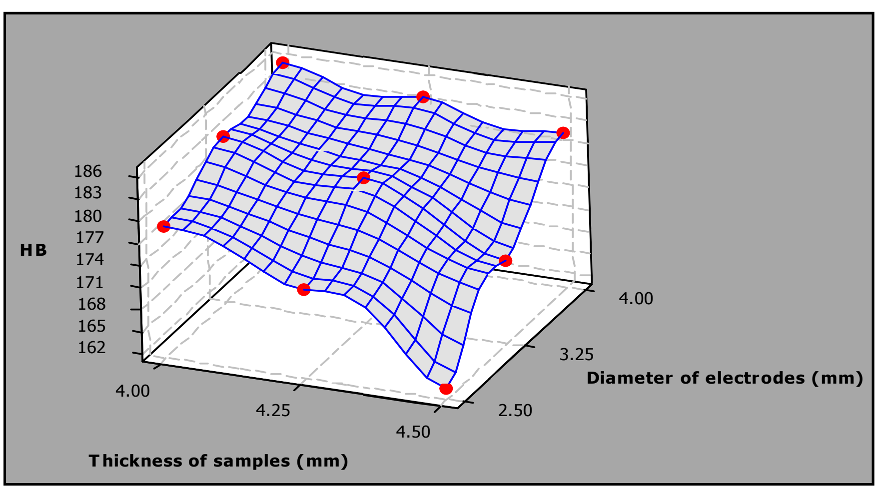

Figure 2. Surface plot of hardness vs. Thickness of sample and diameter of electrode

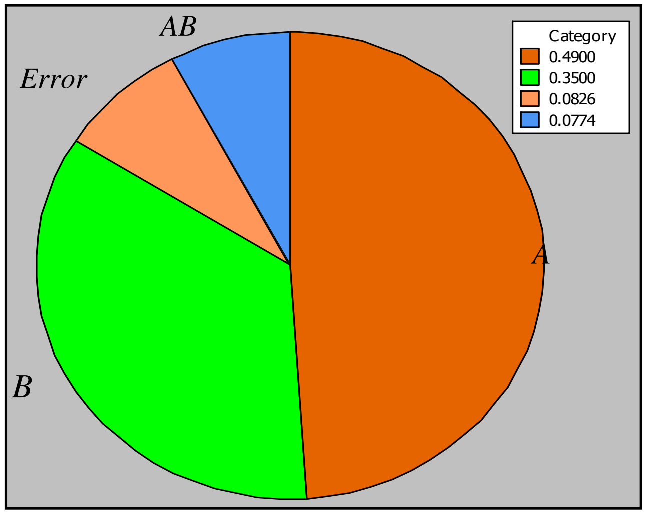

Figure 3. Percentage contributions of parameters, interaction and error on hardness

CONCLUSIONS

1- The diameter of electrode and thickness of sample in affecting the variation of hardness are more significant effect compared with an interaction and error.

2- The experimental results confirmed the validity of the taguchi method for optimizing the welding parameters in electrical arc welding processes.

3- The optimum parameters have found which are thickness at level 3 (4mm), and diameter of electrode at level 3 (4 mm).

4- The predicted and confirmed hardness were in range of confidence interval.

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