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Optimization of MIG Welding process Parameters for Weld peneteration in AISI Grade 304 SteelUsing Taguchi Design Method

Gaurav Kumar[1], Hitendra Bankoti[1] and Deepankar Chandra Agri[2]
[1]Asst. ProfessorME Dept., Amrapali Institute of Technology Haldwani, (Uttrakhand), India.
[2]Assistant Professor, ME Dept., P.S.I.T. Kanpur, (Uttar Pradesh), India.

ABSTRACT: One of the most basic process of manufacturing various products, components and assemblies in the automotive field is welding. Metal Inert Gas welding is one such welding process which is used extensively in the manufacturing field due to its simplicity, versatility and capability to produce neat and strong joint with a higher speed which results in higher production. With the rise in the economy recent research on welding is focused on the techniques to get the optimum results for maximum production with minimum investment. The most important factors which affects the quality, strength, productivity and cost of manufacturing are the welding parameters. This paper presents the effects of different welding parameters such as welding current, Welding voltage and welding speed on weld quality and strength of 304 Stainless Steel. The parameters are optimized by Taguchi analysis to get the best possible combination for the most appropriate quality. Design of experiment is based on the Taguchi Analysis to achieve the desired outcome. L_9orthogonal array is used to convert responses in to signal to noise (S/N) ratio's and analysis of variance (ANOVA) iscarried out to get the optimum results followed by the confirmation test which shows the effectiveness of the analysis.

Keywords: AISI steel 304; MIG; Taguchi; Signal/Noise; ANOVA

I. INTRODUCTION

MIG welding which is an abbreviation for Metal Inert Gas Welding is a process where coalescence is produce by an arc produced between an electrode which is consumable in nature and the workpiece. The arc formed between the consumable electrode and workpiece is shielded by an inert gas to protect it from the contamination caused by the atmospheric gases like oxygen and nitrogen. That is why it is also called Gas Metal Arc Welding. Inert gases argon, helium or an argon-helium mixture are used for shielding. In the MIG welding no filler material is necessary as the metallic electrode provides the arc as well as filler material. Determination of optimum values of parameters is an area of great interest for the researchers, engineers and manufacturing companies as these parameters play an important role in weld strength and quality. The weld parameters like welding current, welding voltage and welding speed have great impact on the process and their optimum value should be estimated to maximize the quality of the weld.

II. TAGUCHI METHODOLOGY

One of the most convenient tool to optimize various parameters with less experimental runs in design of experiment is Taguchi Method. This method is a powerful approach to improve the productivity with high standard of quality at lowest cost possible. Dr. Genichi Taguchi of Nippon T*elephone and Telegraph Company (*Japan*),* recommends an experimental design as a tool which makes the products more robust sensitive to the noise factors. He gave a method which is based on orthogonal array and gives much reduced variance with optimum settings of the control parameters. The orthogonal array provides a set of minimum experiments and signal to noise ratios which are a log function of desired output act as objective function for optimization. These functions helps in data interpretation, data analysis and prediction of optimum result. The term signal in the Taguchi's method represents the desired value for the output characteristic while the term noise represents the undesirable value which could be the environmental conditions for the output characteristic. Signal to noise ratio is thus used to measure the quality characteristic which deviates from the desirable value. The signal to noise ratio or S/N ratio is defined as $\eta = -10$ log (mean square deviation).

To obtain optimal welding performance, larger-the-better quality characteristic of S/N ratio for penetration should be taken. It can be expressed

$$M.S.D = \frac{1}{m}\sum \frac{1}{P_i^2}$$

Where p_i is the value

III. EXPERIMENTAL DETAILS

(a) MATERIAL

AISI type 304 steel of size 300 mm x 150 mm x 6 mm is used for the experiments. AISI grade 304 steel is the most versatile and most widely used steel in the manufacturing industries. This material is used for making heat exchangers, food processing equipment, kitchen sink, chemical containers, springs, automotive parts etc. AISI grade 304 steel consists of high chromium and low carbon percentage which minimize the chromium carbide precipitation during welding.

The chemical composition of the material is shown in the table.

Table 1: Chemical Composition of AISI grade 304 steel.

C	Mn	SI	P	S	Cr	Ni	N
0.08	2	0.75	0.045	0.030	18	8	0.10

(b) Design of Experiments

Taguchi's L_9 orthogonal array is used to carry the experiments which consist of total 9 combinations of the factors voltage, current and welding speed. Three process parameters with three finite levels has been taken according to Taguchi Analysis. Minitab 17 software is used for design of experiments and Taguchi Analysis.

Table 2: Design of experiment using L_9 orthogonal array.

Test	Parameter 1 (Current)	Parameter 2 (Voltage)	Parameter 3 (Speed)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	2
9	3	3	1

(c) Process Parameters And Their Levels

The selected process parameters and their levels are given in the table below.

Table 3: Process Parameters and respective levels.

Parameters	Levels		
Welding Current (Amp)	50	80	110
Welding Voltage (Volt)	22	25	28
Welding Speed (mm/min)	2	4	6

IV. RESULT AND DISCUSSIONS

The welding has been done according to L9 orthogonal array with all the three process parameters and their respective levels. The weld penetration has been observed by a special microscope to get the clear picture of weld penetration depth in different welding samples. The data then obtained is fed into the statistical software "MINITAB 17" for further calculation of Signal to Noise ratio with analysis of variance(ANOVA). The result of the acquired data is shown in the table.

Table 4: Experimental Values obtained by statistical tool.

S.NO	Current	Voltage	Speed	Penetration	SNRA1
1	50	22	2	1.5	3.5218
2	50	25	4	5.33	14.5345
3	50	28	6	5.02	14.0141
4	80	22	4	1.7	4.609
5	80	25	6	4.95	13.8921
6	80	28	2	2.77	8.8496
7	110	22	6	1.2	1.5836
8	110	25	4	3.72	11.4109
9	110	28	2	5.15	14.2361

(a) Response Table For Signal To Noise Ratio

S/N ratios are calculated using 'Larger is Better' function.

Table 5: S/N Ratio Response table for weld penetration.

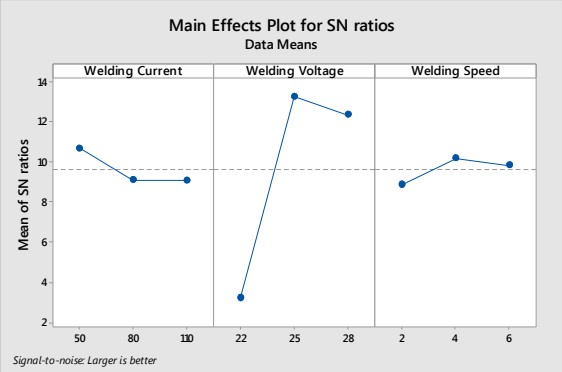
Level	Current	Voltage	Speed
1	10.690	3.238	8.869
2	9.117	13.279	10.185
3	9.077	12.367	9.830
Delta	1.613	10.041	1.316
Rank	2	1	3

(b) Analysis Of Variance (Anova)

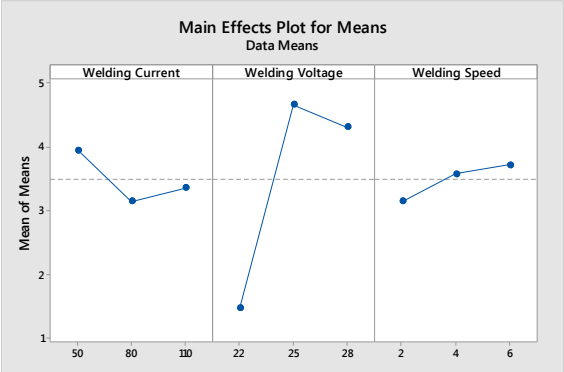
Table 6: ANOVA Table for weld penetration.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Current	2	1.0551	0.5275	0.29	0.778
Voltage	2	18.2901	9.1451	4.96	0.168
Speed	2	0.3782	0.1891	0.10	0.907
Error	2	3.6911	1.8456		
Total	8	23.5928			

(c) Main Effect Plot For S/N Ratio



IV (d) Main Effect Plot For Means



V. CONCLUSION

Taguchi method was used to optimize the welding parameters which are affecting the weld penetration. An orthogonal array of Taguchi's design is used to find out the Signal to Noise ratio which is then followed by analysis of variance(ANOVA). According to the result obtained from the statistical software it has been found that maximum penetration is 5.33mm which has obtained from the second combination of L'9 array used in the experiment. The S/N ratio obtained for the particular combination is 14.5345. According to the ANOVA table none of the factor is found to be significant as all the P-Values are greater than 0.05.

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