Optimization of TIG Welding Process Parameter in Improving Tensile Strength of S30430 Stainless Steel using DOE

Asif Ahmad[1], Shahnawaj Alam[2], A.K.Bajpai[3]
[1, 2, 3] Department of Mechanical Engineering
[1, 2] Integral University, Lucknow, India
[3] M.M.M.Govt. Engineering College, Gorakhpur

Abstract- *TIG welding is one the most important manufacturing method for joining of same or different material. Nowadays welding technology is almost used in every manufacturing sector all over the world. In the present work, taguchi methodology is used to optimize the TIG welding process parameter. It is essential to optimize the various process parameter of welding so that manufacturing industry will achieve the best quality product with zero welding defects. Taguchi methodology is used to get the optimum parameter. Design of experiment (DOE) is used to get orthogonal array. Statistical Minitab-13 software is used in this paper in which orthogonal array L27 is used for experiment, effort has been made to get optimum welding process parameter. Analysis of Variance (ANOVA) methodology integrated with Taguchi to determine % contribution of each process parameter*

Keywords- TIG welding;Taguchi methodology; ANOVA; MiniTab 13

I. INTRODUCTION

TIG welding uses a non-consumable electrode and shielded by an inert gas like helium or argon to protect the molten weld pool and red hot filler wire from atmospheric contaminants. TIG welding is a multi-objective and multi-factor metal fabrication technique. This process is applicable for joining a number of common metals of thickness 1-6mm in almost all positions [1]. The process parameters interact directly or indirectly on the weld bead geometry, mechanical and metallurgical properties of the weldments. The quality of the weld joint is dependent on the input process parameter [2]. To control input process parameters is a common problem to manufacturer to obtain a good welded joint with the required weld quality [3]. Traditionally, skilled operators or engineers choose parameters based on trial and error method which was time consuming for every new welded product to obtain a welded joint with the required specifications. Then welds are examined to determine whether they meet the specification or not [4]. Nowadays, application of design of experiment (DOE), evolutionary algorithms and computational network are widely used to develop mathematical relationships between the welding process input parameters and the output variables of the weld joint in order to determine the welding input parameters that lead to the desired weld quality. Sapkal and Teslang [5] applied Taguchi method to optimize the process parameter current, voltage and welding speed to obtain maximum depth of penetration on mild steel. Patel and Chaudhary [6] investigated the effect of process parameter on the weld bead hardness of AISI 1020 material for TIG and MIG welding processes using GRA. Balasubramanian [7] obtained mathematical model equations for pulsed TIG welding of titanium sheets and concluded that the mathematical relationships developed can be employed easily in automated welding in the form of a program, for obtaining the desired weld bead dimensions. Haragopal et al. [8] optimized the process parameters for enhancing the mechanical properties of MIG welded aluminum alloy joints.

II. METHODOLOGY

The Taguchi method is a well-known technique that provides a systematic and efficient methodology for process optimization. It has been widely used for product design and process optimization worldwide [9-14]. Lesser number of experiments is required in this method. As a consequence, time as well as cost is reduced considerably. Taguchi proposes experimental plan in terms of orthogonal array that gives different combinations of parameters and their levels for each experiment. ANOVA is a computational technique that enables the estimation of the relative contributions of each of the control factors to the overall measured response.

A. Chemical composition of base material

S30430 stainless steel sheets of dimension 100 × 150 × 0.25 mm are welded autogenously with square butt joint without edge preparation. The chemical composition of S30430 stainless steel sheet is given in Table 1.

Table 1. Chemical Composition of base material

US DESIGNATION	***% Cr***	***% Ni***	***% C***	***% Mn***	***% Si***	***% P***	***% S***
S30430	18	8	0.03	2	0.75	0.045	0.03

B. Level of process parameter

Table 2. level of process parameter

Process parameter	***Code***	***Level 1***	***Level 2***	***Level 3***
Welding current (A)	A	140	150	160
Welding voltage (V)	B	24	25	26
Welding speed (mm/min)	C	165	179	193

C. Conduction of Experiment

Table 3. Orthogonal Array L_{27}

Experiment No.	Process parameter		
	A	B	C
1	1	1	1
2	1	1	1
3	1	1	1
4	1	2	2
5	1	2	2
6	1	2	2
7	1	3	3
8	1	3	3
9	1	3	3
10	2	1	2
11	2	1	2
12	2	1	2
13	2	2	3
14	2	2	3
15	2	2	3
16	2	3	1
17	2	3	1
18	2	3	1
19	3	1	3
20	3	1	3
21	3	1	3
22	3	2	1
23	3	2	1
24	3	2	1
25	3	3	2
26	3	3	2
27	3	3	2

Table 4. Experimental Results

EXPERIMENT No.	Process parameter			SNRA	MEAN
	A	B	C		
1	140	24	165	14.3072	5.2000
2	140	24	165	*	*
3	140	24	165	*	*
4	140	25	179	14.4233	5.26667
5	140	25	179	*	*
6	140	25	179	*	*
7	140	26	193	15.29	5.86667
8	140	26	193	*	*
9	140	26	193	*	*
10	150	24	179	15.7801	6.16667
11	150	24	179	*	*
12	150	24	179	*	*
13	150	25	193	15.9846	6.3000
14	150	25	193	*	*
15	150	25	193	*	*
16	150	26	165	16.2087	6.46667
17	150	26	165	*	*
18	150	26	165	*	*
19	160	24	193	16.4775	6.66667
20	160	24	193	*	*
21	160	24	193	*	*
22	160	25	165	15.7043	6.1000
23	160	25	165	*	*
24	160	25	165	*	*
25	160	26	179	15.4603	5.93333
26	160	26	179	*	*
27	160	26	179	*	*

R denotes an observation with a large standardized residual.

Table 5. Response Table for Signal to Noise Ratios (Larger is better)

Level	Current	Voltage	Speed
1	14.67	15.52	15.41
2	15.99	15.37	15.22
3	15.88	15.65	15.92
Delta	1.32	0.28	0.70
Rank	1	3	2

Table 6. Response Table for Mean

Level	Current	Voltage	Speed
1	5.444	6.011	5.922
2	6.311	5.889	5.789
3	6.233	6.089	6.278
Delta	0.867	0.200	0.489
Rank	1	3	2

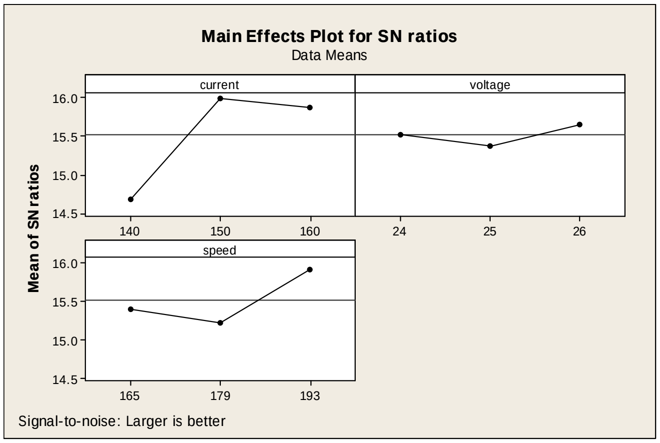

Figure 1. Main Effect plot for S/N Ratio

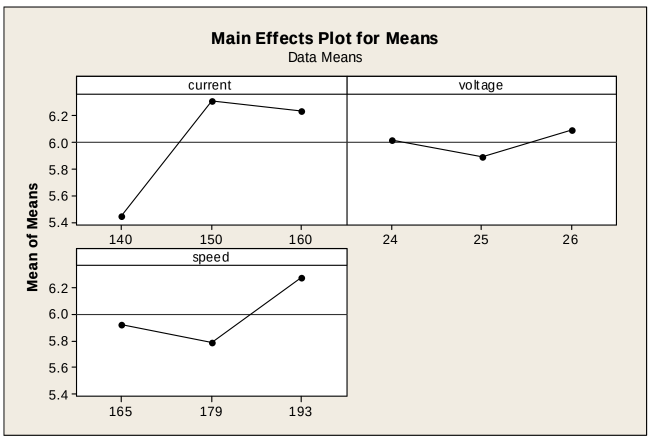

Figure 2. Main Effect plot for MEAN

III. ANALYSIS OF VARIANCE (ANOVA)

The adequacy of model and Percentage contribution of each parameter is determined by ANOVA.

Table 7. ANOVA for penetration, using Adjusted SS for Test

Source	DF	Seq SS	Adj SS	Adj MS	F	P	%
Current	2	4.13852	4.13852	2.06926	26.55	0.000	58.8 %
Voltage	2	0.18296	0.18296	0.09148	1.17	0.330	2.6 %
Speed	2	1.14963	1.14963	0.57481	7.38	0.004	16.3 %
Error	20	1.55852	1.55852	0.07793			
Total	26	7.02963					

IV. RESULT & DISCUSSSION

The response tables given above show the average of each response characteristic (S/N rations, means) for each level of each factor. The tables include ranks based on Delta statistics, which compare the relative magnitude of effects. The Delta statistic is the highest value minus the lowest average for each factor. Minitab18 statistical software assigns ranks based on Delta values: rank 1 to the highest Delta value, rank 2 to the second highest, and so on. In our experimental analysis using Taguchi' method, the ranks indicate that welding current has the greatest influence on both the S/N ratio & mean value. ANOVA methodology helps in finding the influence of each parameter, welding current have 58.8% contribution in tensile strength of welding joint.

V. ACKNOWLEDGMENT

Authors gratefully acknowledge the support & guidance of Dr. Shahnawaz Alam for providing experimental facility. Author also wishes to acknowledge the encouragement of PSIT Management during writing of this research paper.

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