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Taguchi Optimization Technique of Weld Bead Geometrical Parameters using Submerged Arc Butt Weld in Mild Steel

Sanjay Kumar Verma, Rupendra Kumar Marre, Lokesh Singh
RSR Rungta College of Engineering and Technology, Bhilai, Chhattisgarh, India

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ABSTRACT

Submerged arc welding (SAW) is usually classified as a pure slag shielded process. It is used extensively in industry to fabricate pressure vessels, pipe lines, marine vessels, bridge girders etc. Weld bead geometry is a critical component in determining weld quality, since it is determined by the mechanical characteristics of the weld metal, particularly tensile strength. Weld metal mechanical strength is influenced not only by metal composition but also by weld bead shape. In the present study attempt has been made to study the optimal process parameters for submerged arc welded mild steel plates for bead geometry and tensile strength. The experimental plan was developed using a design of experiment (DOE) with four parameters (arc voltage, welding current, travel speed, and nozzle to plate distance) and five levels (Taguchi orthogonal design). Twenty-five specimens are made to determine the joint's bead width, penetration, and tensile strength. The analysis of variance (ANOVA) approach is used to determine the magnitude of the impact of factors such as welding current, arc voltage, nozzle to plate distance, and trolley speed on bead width, depth of penetration, and weld strength on particular outputs such as bead width, depth of penetration, and weld strength.

Keywords : Submerged arc Welding, Weld bead Geometry, Design of experiment, Taguchi approach, Analysis of variance.

I. INTRODUCTION

Welding is the most commonly used method for joining at fabrication workshop. Welding is performed by targeted heating of the base metal and filler, which causes them to fuse together and produce a permanent connection. Welding is a method of joining two pieces of metal by melting them together using heat. Welding provides a number of benefits over other methods of joining processes. Nowadays in fabrication industries, SAW is usually employed to achieve high precision and production rates. For predicting best weld bead quality is important to establish a relationship between geometry of weld bead and welding parameters [3]. In case of SAW, the industries face the problem of evaluating the best SAW input parametric setting to achieve the better performance due to the influence of direct and indirect welding parameters. The direct parameters include welding voltage (v), welding wire, welding speed (s) and nozzle to plate distance. The indirect welding parameters include electrode wire electrode polarity etc. These Parameters mainly bead geometry characteristics such as bead width, reinforcement.

II. METHODOLOGY

Experimentation: IS-2062 steel has a wide range of application for industrial sectors including machinery parts, construction components, trusses etc. In this work IS-2062 steel has been chosen as workpiece with dimension 300×150×20(in mm) were used as a base metal for during the experimentation was carried out using copper coated mild steel weld wire of 3.15 mm. The composition of this piece utilized for the current work is shown as Table 1.

Table 1: Chemical Composition for IS-2062 Grade

Grade	C% Max.	Mn% Max.	S% Max.	P% Max.	Si% Max
A	0.23	1.50	0.050	0.050	0.40
B	0.22	1.50	0.045	0.045	0.40

For submerged arc welding of IS-2062 steels and best appropriate for W-1, 3.15 wires are chosen. The Chemical composition of bare wire is shown as Table 2.

Table 2: Chemical Composition of Bare Wire

Grade of Wire	Chemical Composition %					
	C	Mn	Si	S	P	Cu
W-1	0.10	0.4 – 0.6	0.03	0.03	0.03	0.4

The welded plate as shown in fig.1 which is manually on the grinder followed by fine paper and velvet cloth and after that bead geometry etched with 2% nital solution.

Fig.1: Welded Specimen

Mathematical Modelling of Response Variables: Analysis of S/N ratio based on Taguchi Method that will offer two advantages, it provides for selection the optimum level based on least variation on the average value which closest to objective comparison of two sets of experimental data with respect to deviation of the average.

According to Taguchi method, S/N ratio is the ratio of "Signal" representing desirable value, i.e. mean of output characteristics and the "noise" representing the undesirable value i.e., squared deviation of the output characteristics. It is denoted by η and the unit is dB. The S/N ratio is used to measure quality characteristic and it is also used to measure significant welding parameters. According to quality engineering the characteristics are classified as Higher the best (HB) and lower the best (LB). HB includes penetration which desires higher values. Similarly LB includes Heat Affected Zone (HAZ) width for which lower value is preferred.

$$\eta = -10\log\frac{1}{N}\sum_{i=1}^{n}\frac{1}{y^2} \text{ (Larger the best)}$$

$$\eta = -10\log\frac{1}{N}\sum_{i=1}^{n}y^2 \text{ (Lower the best)}$$

Table 3: Process parameters with their values at five levels

Parameter	Level 1	Level 2	Level 3	Level 4	Level 5
Arc voltage (volts)	24	26	28	30	32
Welding current (amp.)	375	425	475	525	575
Welding speed (m/min.)	0.25	0.30	0.35	0.40	0.45
Nozzle to plate distance(mm)	15	16	17	18	19

The experimental design by Taguchi suggests that in place of testing arrangement such as factorial design, are matrixes in L 25 array as represented in Table 4.

Table 4: Design Matrix Showing Levels of Factors

Sr. No.	Parametric Levels				Parametric Values			
	Voltage	Current	Speed	NPD	Voltage	Current	Speed	NPD
1	1	1	1	1	24	375	0.25	15
2	1	2	2	2	24	425	0.30	16
3	1	3	3	3	24	475	0.35	17
4	1	4	4	4	24	525	0.40	18
5	1	5	5	5	24	575	0.45	19
6	2	1	2	3	26	375	0.30	17
7	2	2	3	4	26	425	0.35	18
8	2	3	4	5	26	475	0.40	19
9	2	4	5	1	26	525	0.45	15
10	2	5	1	2	26	575	0.25	16
11	3	1	3	5	28	375	0.35	19
12	3	2	4	1	28	425	0.40	15
13	3	1	5	2	28	475	0.45	16
14	3	4	1	3	28	525	0.25	17
15	3	5	2	4	28	575	0.30	18
16	4	1	4	2	30	375	0.40	16
17	4	2	5	3	30	425	0.45	17
18	4	3	1	4	30	475	0.25	18

19	4	4	2	5	30	525	0.30	19
20	4	5	3	1	30	575	0.35	15
21	5	1	5	4	32	375	0.45	18
22	5	2	1	5	32	425	0.25	19
23	5	3	2	1	32	475	0.30	15
24	5	4	3	2	32	525	0.35	16
25	5	5	4	3	32	575	0.40	17

Results and Discussion: The Results obtained from the experiment were analyzed exploiting the analysis of variance that helps in predicting the importance of process parameters.

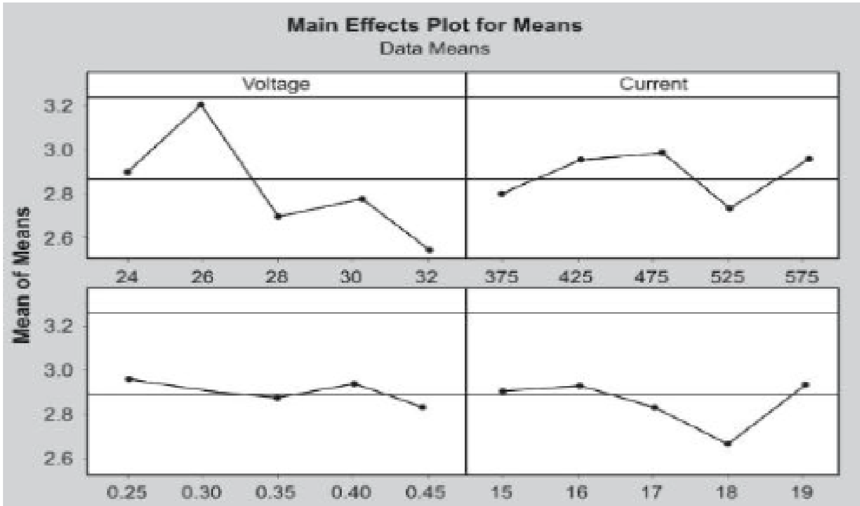

Fig.2: Mean Effects Plot for Mean Depth of Penetration

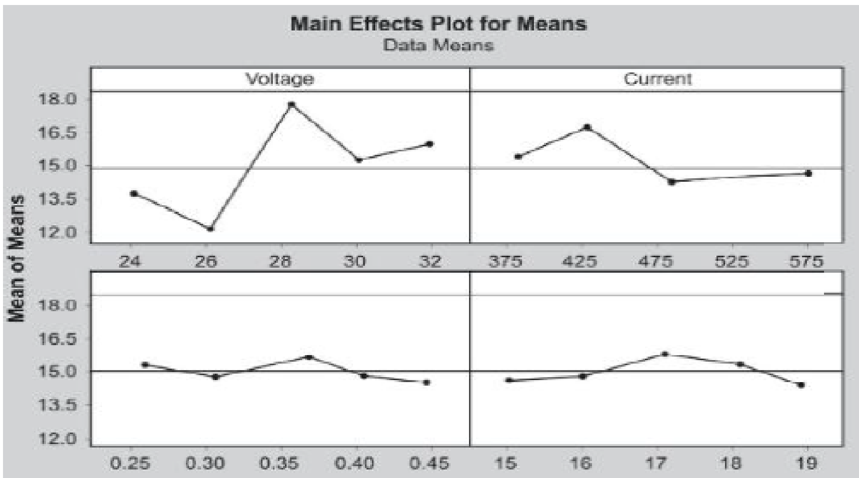

Fig.3: Mean Effects Plot for Mean Width

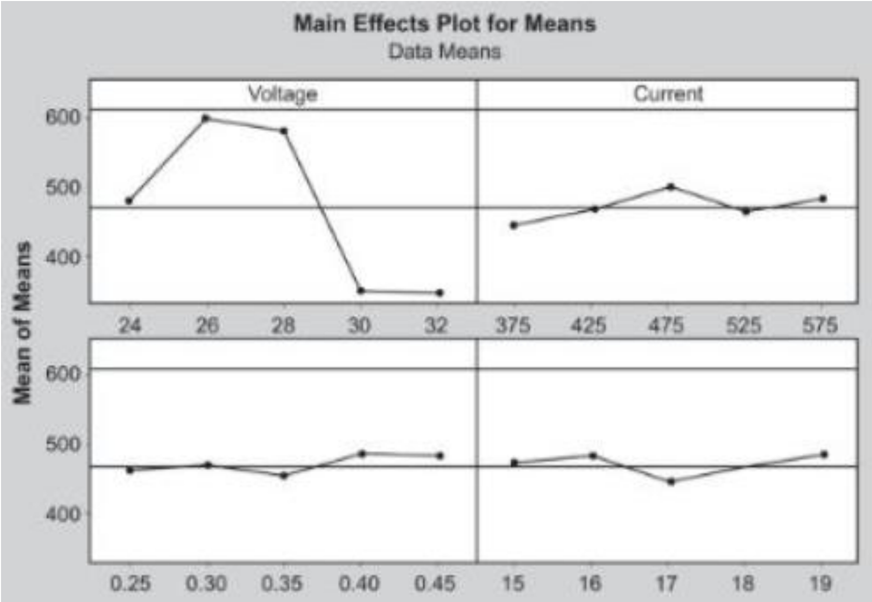

Fig.4: Plot of Mean for Ultimate Tensile Strength

III. CONCLUSION

The process of SAW in IS-2062 steel has been investigated widely in this research work. The bead geometry and tensile strength for submerged arc welded IS-2062 have been worked on varying combinations of voltage, current, trolley speed and nozzle to plate distance. The following conclusions have been arrived at after analyzing different aspects of submerged metal arc welding of IS-2062 structural steel plates.

- The optimum parameter obtained for range of parameters used in this study are: voltage as 26 volts, current as 475 ampere, speed as 0.40 m /min, and nozzle to plate distance as 19 mm are taken as set of parameters.
- With the ascent in welding voltage from 24 volts to 26 volts the mean of penetration increases. An increase in voltage prompts improved welding bead and higher current density, which results in better penetration of the greater volume of the base material.
- When current increase then increasing the bead penetration which leads to decrease in bead width.
- Increase in welding speed produces narrower weld bead. A lot of weld defects are produced because of low welding speed which leads to more melting producing large molten zones.
- It was found that at high nozzle to plate distance, depth of penetration is high because at higher nozzle to plate distance that leads to rise in penetration.

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