Experimental Investigation Effect on Saw using Response Surface Methodology (RSM)

Hinal B. Thakker [1] Prof. A.J. Patel[2]
[1]M.E. Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Ahmedabad Institute of Technology

Abstract— Submerged arc welding is preferable more its inherent qualities like easy control of variables, high quality, deep penetration, smooth finish. The quality of weld depends on the bead geometry of the weld which in turn depends on the process parameters. To automate a welding process, which is the present trend in fabrication industry, it is essential that mathematical models have to be developed to relate the process variables to the weld bead parameters. Selection of process parameters has great influence on the quality of a welded connection. Welding input parameters play a very significant role in determining the quality of a weld joint. In this present work, the effect of Response Surface Methodology approach for experimental investigation of submerged arc welding parameters Viz. Current, Voltage, Travel speed and Electrode diameter on weld bead geometry has been studied. Response surface methodology (RSM) technique is applied to determine and characterize the cause and effect relationship between true mean responses and input control variables influencing the responses.

Key words: Submerges Arc Welding; Response Surface Methodology (RSM); Weld Bead Geometry; Process Parameters; Weld Quality

I. INTRODUCTION

Sub-merged arc welding is most efficient if the joint can be filled with as few passes as possible. If, when working in mild steel, the work piece can be turned over, and if the material is not too thick, a bead is often applied from each side of the joint. If the basic material is alloyed steel, a multi-pass procedure is normally necessary. Admittedly, these results in an increase in process costs, but for many work pieces the economics of the process are still sufficiently attractive for submerged arc welding to be more cost effective than say, manual welding using coated electrodes. In addition, there will be fewer weld defects with automatic welding. The SAW process can be operated in semi-automatic and automatic modes. All commercially important materials such as carbon steel, low and high alloy steel, stainless steel, quenched and tempered steels and nickel-based alloy can be welded in all positions by this process if appropriate welding parameters are chosen.

II. LITERATURE SURVEY

A. Application of response surface methodology for predicting weld bead quality in submerged arc welding of pipes (V.Gunaraj et al.)

V. Gunaraj, N.Murugan (1999) present paper on "Application of response surface methodology for predicting weld bead quality in submerged arc welding of pipes." This paper deals with the response surface methodology, to determine and represent the cause and effect relationship between true mean responses and input control variables influencing the responses as a two or three dimensional hyper surface. This paper presents the use of RSM by designing a four factor with five level central composite rotatable design matrixes (CCD) with full replication for planning, conduction, execution and development of mathematical models. They developed mathematical models for the submerged arc welding of 6 mm thickness with the size of each specimen was 300*150 mm for I.S. 2062 carbon steel plate. They were using ESAB SA1 (E8) copper coated wire of 3.15 mm diameter in the form of a coil and ESAB G.S.-0.2-1.16 (equivalent to DIN 8557), granular flux was used for welding[1].

B. Prediction and comparison of the area of the heat affected zone for the bead-on-plate and bead-on-joint in submerged arc welding of pipes (V.Gunaraj et al.)

V. Gunaraj, N.Murugan (1999) present paper on "Prediction and comparison of the area of heat affected zone for the bead-on-plate and bead-on-joint in submerged arc welding of pipes." This paper reveals that the models developed for bead-on-plate for predicting weld bead qualities need further modification. Before applying to the actual joining of metals by welding, for this investigation, they were using the response surface methodology, with the central composite rotatable design matrix. For this experiment, they developed mathematical models for the submerged arc welding of 6 mm thickness with the size of each specimen was 300*150 mm for I.S. 2062 carbon steel plate. They were using ESAB SA1 (E8) copper coated wire of 3.15 mm diameter in the form of a coil and ESAB G.S.-0.2-1.16 (equivalent to DIN 8557) granular flux was used for welding[2].

C. Effect of heat input on submerged arc welded plates (Aniruddha Ghosh et al.)

Aniruddha Ghosh, Somnath Chattopadhyaya, R.K.Das (2011) present paper on "Effect of heat input on submerged arc welded plates." This paper is applied to derive an analytical solution to predict the transient temperature distribution on the plate during the procedure of submerged arc welding. This type of an analytical solution is derived from the transient three dimensional heat conduction equations. The energy input which is applied on the plate is taken as the volume of heat lost from the electric arc and the kinetic energy of filler droplets specifically driven by gravity, electromagnetic force, arc drag force, carring mass, momentum and thermal energy. The observed values which predicted values are in good agreement with the experimental results. The HAZ width calculation is also done with the help of the analytical solution of the transient three dimensional heat conduction types of equations. This paper present also analyses of micro structure changes between parent and weld-HAZ plates[3].

D. Sensitivity analysis of submerged arc welding process parameters (Serdar karaoglu et al.)

Serdar karaoglu, Abdullah secgin (2008) present paper on "Sensitivity analysis of submerged arc welding process parameters."This paper deals with the mathematical relations between submerged arc welding process parameters and other weld bead characteristics were constructed based upon the experimental data obtained by three parameters using three levels of factorial analysis. These equations simulating the SAW process approximately were carried out by multiple regression analysis and sensitivity equations were derived from RSM model basic. This present study mainly focuses on the determination and sensitivity characteristics of design control parameters and the prediction of fine-tuning requirements of these parameters in SAW process. They developed mathematical model for the submerged arc welding of 10 mm thickness with the size of each specimen was 180*80 mm for mild steel plate. They were using 3.2 mm diameter electrodes. They were using semiautomatic submerged arc welding machine with a constant current power source was employed for this study[4].

E. Effect of increasing deposition rate on the bead geometry of submerged arc welds (R.S. Chandel et al.)

R.S. Chandel, H.P.Seow, F.L.Cheong present paper on "Effect of increasing deposition rate on bead geometry arc welds." This paper reveals the effect of input control variables on the output variables by using software, which predicts the weld bead geometry and melting rates of both the submerged arc welding which is based on the algorithms developed by their own mathematical models. In this study, they were using low-carbon steel plates[5].

III. PROBLEM DEFINITION

In SAW welding, the selection of parameters plays a main role in producing good weld bead geometry. This research aim is to experimental investigate by using the RSM method, the proper selection of parameters in SAW for machining mild steel and studied these selected different parameters which are able to deliver better results in terms of weld bead geometry of mild steel. After studying the literature review, regarding the submerged arc welding, there was found that study of bead geometry influenced by current, voltage, travel speed and electrode wire diameter all together have not been mentioned. So, in this present research work it is proposed to study the effect of current, voltage, travel speed and electrode diameter on the bead geometry.

IV. EXPERIMENTAL SETUP

I have selected four input factors for experimental like (1) Arc current (2) Arc voltage (3) Travel Speed (4) Electrode wire diameter. I have selected base metal as mild steel. In my experimental DOE method selected 2 levels of each input process parameters. I have selected material for Experiment runs Mild steel base metal having 16 mm thickness. I have cutting 31 standard test coupon for SAW welding before I following, first 31 test coupons having size 150*150*16 mm edge preparation is required so, by grinding each surfaces after doing gas cutting operation. The procedure for selecting weld joint for SAW welding, I have selected standard Square Butt Joint.

Symbol	Control Unit factor	Unit	Level 1	Level 2
C	Current	Amperes	350	450
V	Voltage	volt	27	29
S	Travel Speed	m/hr	24	30
D	Electrode wire Diameter	mm	3.2	4

Table 1: Process Input Parameters and their Levels"

A. Measuring Equipment's used for Results:

(1) Visual Inspection:

In result inspection of 31 Test Coupons with the help of necked eye, for weld quality

Inspection if there is any defect in weld ment on specimen.

(2) Bead geometry measurement:

- For measurement of Bead Width and Reinforcement Height, I am using Digital Vernier Caliper

V. ANALYSIS OF RESULTS

Run Order	Current (ampere)	Voltage (volts)	Travel Speed (m/hr)
1	350	29	30
2	450	27	30
3	350	27	24
4	300	28	27
5	450	29	24
6	350	29	30
7	400	28	27
8	400	28	27
9	400	30	27
10	400	28	33
11	400	28	27
12	450	27	30
13	400	28	27
14	450	27	24
15	450	29	30
16	450	29	24
17	400	28	27
18	400	28	27
19	500	28	27
20	350	27	24
21	400	28	27
22	350	29	24
23	400	26	27
24	350	29	24
25	450	29	30
26	400	28	27
27	350	27	30
28	400	28	21
29	450	27	24

30	400	28	27
31	350	27	30

Table 2: Experimental data obtained from the CCD Runs

Electrode wire Dia. (mm)	Penetration (mm)	Bead width (mm)	Reinforcement (mm)
3.2	6.69	9.87	2.98
4.0	3.97	12.35	3.43
4.0	4.12	12.92	2.87
3.6	5.04	10.93	1.98
4.0	4.11	12.49	3.79
4.0	4.02	12.43	2.45
4.4	3.94	13.90	3.42
3.6	4.67	11.46	3.41
3.6	4.39	11.49	3.35
3.6	4.26	11.38	3.39
3.6	4.19	11.12	3.59
3.2	5.29	10.02	4.01
3.6	4.55	11.32	3.79
4.0	4.15	12.45	4.04
4.0	5.27	12.32	4.07
3.2	5.46	10.35	4.09
3.6	4.38	11.28	4.05
3.6	4.40	11.21	3.94
3.6	3.97	12.96	2.76
3.2	6.54	10.43	2.93
2.8	6.83	8.58	3.86
4.0	4.07	12.75	2.63
3.6	4.29	11.47	3.68
3.2	6.35	10.47	2.87
3.2	5.32	10.12	3.89
3.6	4.38	11.53	3.76
3.2	6.42	10.14	2.87
3.6	4.01	11.72	3.54
3.2	5.59	10.24	3.43
3.6	4.38	11.28	2.69
4.0	4.15	12.71	2.87

Table 3:

A. Analysis of Variance [ANOVA] For Penetration:

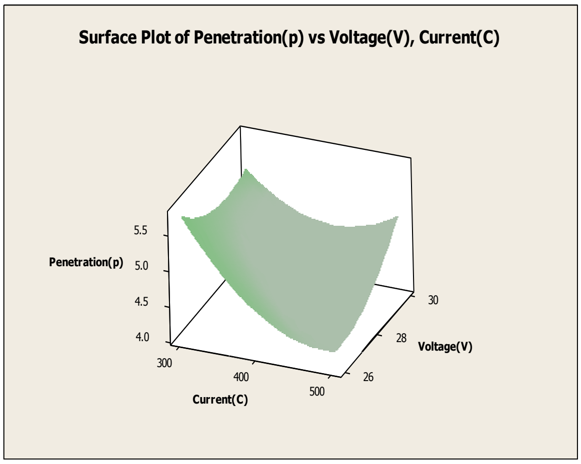

Fig. 1: Surface Plot of Penetration

The preferred wire diameter is governed by the welding current required for a particular application. From response surface it is observed, for a given welding current, small diameter wire gives increased current density resulting in narrower and more deeply penetrating weld beads and metal deposition rates compared to a larger diameter wire. Arc starting and stability may also be improved with smaller wire diameters. The electrode size principally affects the depth of penetration for fixed current. Small wires are generally used in semiautomatic equipment to provide flexibility to the welding gun. The result shows penetration will be at maximum value when welding current and arc voltage at their maximum possible value and welding speed is at minimum value.

B. Analysis of variance [ANOVA] for Bead Width:

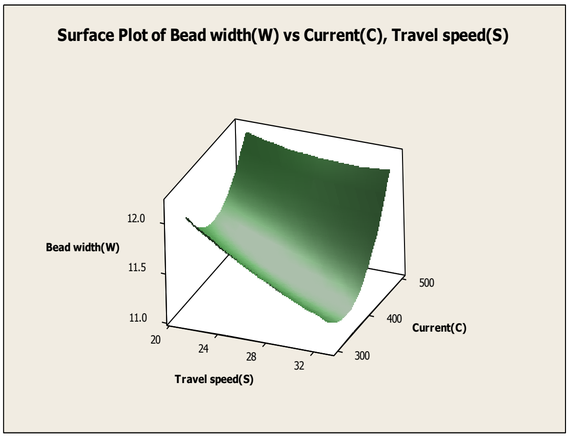

Fig. 2: Surface Plot of Bead Width

Bead Width response surfaces shows that Current is main factor influence the bead width. Bead Width almost linearly increases with arc voltage and current and decreases, with welding speed. Interaction effects show that the effect speed on bead width is low at lower voltages and high at higher voltages.

C. Analysis of variance [ANOVA] for Reinforcement

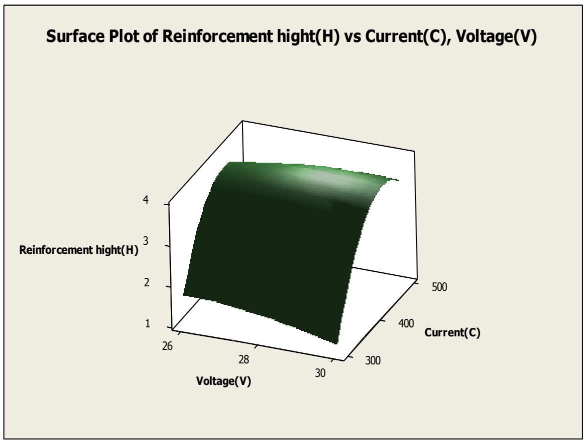

Fig. 3: Surface plot of Reinforcement

As the voltage increases, reinforcement decreases and bead width increases. Because voltage increased reinforcement decreased, because voltage is directly to the length of the current path between the welding wire and work-piece.so as the wire diameter increases voltage is also increases, due to that bead width is gradually increases and reinforcement is decreases. Surface plots shows that the direct effect of voltage on reinforcement, it is clear that voltage having negative effect on reinforcement. Whereas voltage having positive effect on bead width.

VI. CONCLUSION

1) Increased in welding current increases the depth of penetration. It is known thsat molten metal droplets transferring from the electrode to the plate are strongly overheated. It can be reasonably assumed that this extra heat contributes to more melting of the work piece.
2) As current increases the temperature of the droplets and hence the heat content of the droplets increases which results in more heat being transferred to be base plate. Increase in current reduces the size but increases the momentum of the droplets which on striking the weld pool causes a deeper penetration or indentation.
3) The increases in penetration as current increased could also be attributed to the fact that enhanced are force and heat input per unit length of the weld bead resulted in higher current density that caused melting a larger volume of the base metal and hence deeper penetration.

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