ISSN XXXX XXXX © 2017 IJESC

IJESC

Research Article Volume 7 Issue No.7

Experimental Analysis of the Effect of Electrode Polarity on Weld Bead Geometry in Submerged ARC Welding Process

Karamjit Singh[1], Abhishek Pandey[2]
Assistant Professor[1], Ph.D Student[2]
Department of Mechanical Engineering
G D Goenka University, Haryana, India[1]
IIT, New Delhi, India[2]

Abstract:
Submerged Arc Welding (SAW) is a fusion welding process in which the heat is produced from an arc which is produced from a continuously fed electrode wire struck to the work piece under a blanket of powdered flux. Submerged arc welding is particularly useful in applications where thick sections are to be welded (like ship building industries). The heavy currents involved in the process lead to deeper penetration of the weld. These deep penetration welds may not be suitable when submerged arc welding process is to be used for surfacing applications where low penetration and consequently less dilution are desired. Efforts have been made in this study to achieve low penetration (and lower dilution) by varying the process parameters. Bead on plate technique was used for the experimentations. As bead geometry is directly related to dilution, the welds obtained for experimental runs were cut into suitable sizes and bead geometry was studied. Depth of penetration, bead width and reinforcement height were taken as response characteristic for all the runs. The result of the experiment was analyzed and has been presented in this paper. Of all the process parameters, the current polarity affects the dilution most significantly and straight polarity is being recommended as the desired polarity for surfacing operations.

Key words: Electrode polarity, submerged arc welding, Dilution control, weld bead Geometry.

I. INTRODUCTION

The submerged arc welding process is utilized the heat of an arc between a continuously fed electrode and the work. The heat of the arc melts the surface of the base metal and the end of the electrode. The metal melted off the electrode is transferred through the arc to the work piece, where it becomes the deposited weld metal.Shielding is obtained from a blanket of granular flux, which is laid directly over the weld area. The flux close to the arc melts and intermixes with the molten weld metal, helping to purify. The flux forms a glass-like slag that is lighter in weight than the deposited weld metal and floats on the surface as a protective cover. The weld is submerged under this layer of flux and slag, hence the name submerged arc welding. The flux and slag normally cover the arc so that it is not visible. SAW normally uses constant-voltage power supply and is self-regulating, so it can be used with a constant speed wire feeder. The current is controlled by the wire diameter, the electrical stick-out, and the wire-feed speed, while the voltage is controlled by the power supply. Direct current supply is the best choice for the high-speed welding of comparative thin steel plates.

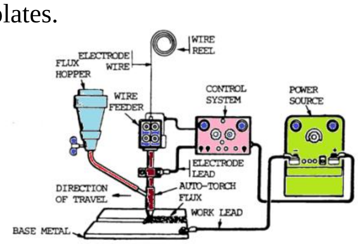

Figure.1. Submergd Arc wedlding

II. LITERATURE

[1] Elaborates the study of welding procedures generation for the submerged arc welding process. Several research works have already been carried out in the field of submerged arc welding for parametric optimization. [2] studied the effect of process parameters on output features of submerged arc weld by using Taguchi method. [3] applied grey-based Taguchi methods for optimization of submerged arc welding process parameters in hard facing. They considered multiple weld qualities and determined optimal process parameters based on grey relational grade from grey relational analysis proposed by Taguchi. [4] in his paper presented optimization & prediction of welding parameters and bead geometry in submerged arc welding. He collected data as per Taguchi"s Design of Experiments and analysis of variance (ANOVA) and experiment was carried to establish input–output relationships of the process. By this relationship, an attempt was made to minimize weld bead width, a good indicator of bead geometry, using optimization procedures based on the ANN models to determine optimal weld parameters. The optimized values obtained from these techniques were compared with experimental results and presented. [5] have adopted a modified Taguchi method to analyze the effect of each welding process parameter (arc gap, flow rate, welding current and speed) on the weld pool geometry (front and back height, front and back width) and then to determine the TIG welding process parameters combination associated with the optimal weld pool geometry. It was experimentally reported that, the four smaller-the-better quality characteristics, „four responses" of the weld pool in the TIG

welding of S304 stainless steel of 1.5 mm in thickness are greatly improved by using this approach. Laser butt-welding of a thin plate of magnesium alloy using the Taguchi method has been optimized by Pan et al. [6].They studied the effect of Nd-YAG laser welding parameters (shielding gas type, laser energy, conveying speed, laser focus, pulse frequency and pulse shape) on the ultimate tensile stress. Their result indicated that the pulse shape and energy of the laser contributed most to thin plate butt-welding. [7] have continued their investigation and studied the effect of the laser welding parameters mentioned above on the impact strength of the same joint at room temperature using the same optimizing technique. The results indicated that the laser power has the most significant effect on the impact strength. [8] have used the Taguchi method and regression analysis in order to optimize Nd-YAG laser welding parameters (nozzle type, rotating speed, title angle, focal position, pumping voltage, pulse frequency and pulse width) to seal an iodine-125 radioisotope seed into a titanium capsule. The accurate control of the melted length of the tube end was the most important to obtain a sound sealed state. [9] used Non-dominated Sorting Genetic Algorithms (NSGA) to optimize the contradicting combination of strength and toughness of steel welds. [10] applied Response Surface Methodology (RSM) for prediction and otimization of weld bead quality in submerged arc welding of pipes by stablishing mathematical models. [11] applied grey based Taguchi method for optimization submerged arc welding process parameters in hard facing. [12] developed statistical models for predicting bead volume of submerged arc butt-weld. [13] studied the effect of process parameters on output features of submerged arc weld by using Taguchi method. The relationship between control factors and performance outputs was stablished by means of nonlinear regression analysis, resulting in a valid mathematical model. Finally, Genetic Algorithm (GA) was employed to optimize the welding process with multiple objectives. [14] applied Taguchi philosophy for parametric optimization of bead geometry and HAZ width in submerged arc weld.

Selection of parameters

It is very important to select right welding parameters for designed experimental runs. Wire feed rate (F), Open circuit voltage (V), current polarity (P) and welding speed (S) were selected as welding parameters since they can be varied independently. The ranges of selected parameters were finalized after performing extensive trial runs. The working range of two levels was decided upon by inspecting the deposited bead carefully so that it was free of any visible welding defect like surface porosity, undercut, overlap, excessive convexity and cracks etc. and it had smooth and uniform appearance throughout the length. The high and low levels of the parameters were coded as +1 and -1 respectively. The actual values of parameters corresponding to the coded values are given in **Table 1**

Table 1: Parameters and their values at two levels

		L1 (-1)	**L2 (+1)**
OCV	V	33 Volts	42 Volts
Wire Feed	F	12 mm/sec	24 mm/sec
Travel Speed	S	6 mm/sec	10 mm/sec
Polarity	Po	Electrode (-)	Electrode(+)

Experimental Procedure

The experiments were planned to conduct on a power source of constant voltage. Constant potential transformer-rectifier type power source with a current capacity of 600A at 60% duty cycle and an open circuit voltage ranges from 0-56 volts was employed. The plates were chemically and mechanically cleaned to remove oxide layer and any other source of hydrogen, before welding. Weld beads were deposited using a mechanized submerged arc welding station to ensure the consistency during experimental run. The weld beads were deposited using flat position 'Bead-on-plate' technique on 250 x 90 x 10 mm mild steel flat, using 3.15 mm diameter mild steel wire electrode with agglomerated flux. The experiments were conducted in random fashion using the table of random numbers to eliminate any systematic error of experiment. The readings were recorded only after the equilibrium between welding wire feed rate and burn off rate got established and the arc was kept on to lay a weld bead of around 250 mm. the trials were repeated for many times. The welded plates were cut through its centre along the cross-sectional direction for evaluation purpose. The bead geometry viz. penetration (p), reinforcement (h), weld bead width (w) and percentage dilution (%D) were measured by using the software.

Table.2. Parameters used for Experiment

Ex. NO.	**Condition**	**Wire Feed Rate(mm/s)**	**OCV (v)**	**Polarity**	**Welding Speed (mm/s)**
1	**C1**	**3.5**	**42**	**EN**	**2.5**
2	**C2**	**2**	**42**	**EN**	**4**
3	**C3**	**3.5**	**33**	**EN**	**4**
4	**C4**	**2**	**33**	**EN**	**2.5**
5	**C1**	**3.5**	**42**	**EP**	**2.5**
6	**C2**	**2**	**42**	**EP**	**4**
7	**C3**	**3.5**	**33**	**EP**	**4**
8	**C4**	**2**	**33**	**EP**	**2.5**

III. RESULTS AND DISCUSSION:

Polarity change affects the amount of heat generated at electrode and the work piece and hence the metal depositing rate, weld bead geometry and mechanical properties of the weld metal. There is arc spread in straight polarity is more than in reverse polarity resulting in a higher bead width and less penetration with the straight polarity. The two third of the total heat was generated at the positive electrode and the one third of the total heat was generated at the negative electrode.

$$\% \text{dilution} = \frac{A_p}{A_t} 100$$

$$A_t = A_p + A_r$$

The percentage of dilution equals the amount of base metal melted(Ap) divided by the sum of base metal melted (Ap) and filler metal added (Ar), the quotient of which is multiplied by 100.

Table.3. Calculated Dilutions

POLARITY	CONDITION NO.	% DILUTION
EN1	condition 1	**39.95**
EN2	condition 2	**42.81**
EN3	condition 3	**44.38**
EN4	condition 4	**42.21**
EP1	condition 1	**49.60**
EP2	condition 2	**49.28**
EP3	condition 3	**60.85**
EP4	condition 4	**46.52**

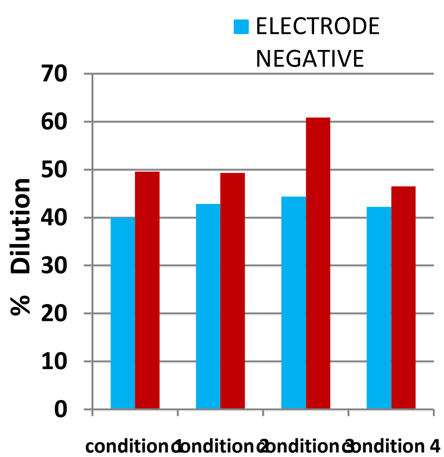

Figure.2. Effect Of Polarity On Dilution

Table 4 Measured Result Of HAZ

Samp 1	Samp 2	Samp 3	Cond.	Average haz
15.79	15.34	14.12	c1	**15.08**
18.48	17.64	17.4	c2	**17.84**
25.12	24.34	23.56	c3	**24.34**
20.1	21.44	20.56	c4	**20.70**
25.32	27.22	25.12	c1	**25.88**
22.02	24.42	23.34	c2	**23.26**
34.24	33.58	35.44	c3	**34.42**
24.34	21.12	22.32	c4	**22.59**

The HAZ and DILUTION values found to be less in case of straight polarity than in case of reverse polarity

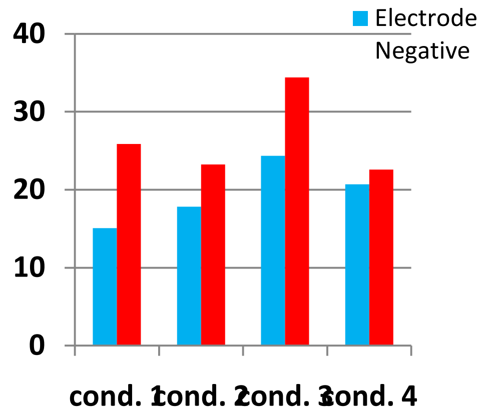

Figure. 3. Effect Of Polarity On Haz

The HAZ and DILUTION values found to be less in case of straight polarity than in case of reverse polarity.

IV. CONCLUSION:

The present work was the effort to quantify the effect of polarity on dilution and bead penetration in submerged arc welding. It is seen from the results that polarity is one of the parameter which affects significantly the bead geometry particularly in terms of dilution and bead penetration. It is also seen that welding with electrode negative polarity, wire feed rate influences penetration insignificantly. The change of polarity from electrode positive to electrode negative decreases the dilution.

V.REFERENCES:-

JOURNALS:

[1]. Dhas, R., Edwin, J., Gothman, K. and Kumanan, S. (2007), Determination of submerged arc welding process parameters using Taguchi method and regression analysis, Indian Journal of Engineering & Materials Sciences, pp.177-183.

[2].Biswas, S., Mahapatra, S.S. and Patnaik, A. (2007), An Evolutionary Approach to Parameter Optimization of Submerged Arc Weldinginthe Hardfacing Process, International Journal of Manufacturing Research, vol.2, no. 4, 2007, pp. 462-483.

[3].Chang, C. H., Juang, S. C. and Tarng, Y. S. (2002), The Use of Grey-Based Taguchi Methods to Determine Submerged Arc Welding Process Parameters in Hardfacing, Journal of Materials processing Technology, Vol. 128, pp. 1-6.

[4].K. srinivasulureddy, “Optimization & Prediction of Welding Parameters and Bead Geometry in Submerged Arc Welding”, International Journal of Applied Engineering Research and development (IJAERD) ISSN 2250-1584 Vol. 3, Issue 3, Aug 2013.

[5].S. C. Juang and Y. S. Tarng, Process parameters selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel, J. of Materials Processing Technology, Vol. 122, 2002, 33-37.

[6].L. K. Pan, C. C. Wang, Y. C. Hsiso and K. C. Ho, Optimization of Nd-YAG laser welding onto magnesium alloy

via Taguchi analysis, J. of Optics & Laser Technology, Vol. 37, 2004, pp. 33-42.

[7].E. M. Anawa, A. G. Olabi and M. S. J. Hashmi, Optimization of ferritic/Austenitic laser welded components, presented at AMPT2006 Inter. Conf. July 30 –Aug. 3, 2006, Las Vegas, Nevada, USA, 2006.

[8].H. K. Lee, H. S. Han, K. J. Son and S. B. Hong, Optimization of Nd-YAG laser welding parameters for sealing small titanium tube ends, J. of Materials Science and Engineering, Vol. A415, 2006, pp. 149-155.

[9].M. Murugananth, "Metaheuristic Multiobjective Optimization in Steel Welds", Materials and Manufacturing Processes, vol. 24, 2009, pp. 230–239.

[10].Gunarajandn and Murugan, "Prediction of Heat-Affected Zone Characteristics in Submerged Arc Welding of Structural Steel Pipes", Welding Journal, January 2002.

[11].Y.S. Tarng, S.C. Juang, and C.H. Chang, "The Use of Grey-Based Taguchi Methods to determine Submerged Arc Welding Process Parameters in HardFacing", Journal of Materials Processing Technology, vol. 128, 2002, pp. 1–6.

[12].S. Datta, M. Sundar, A. Bandyopadhyay, P. K. Pal, G. Nandi, and S.C. Roy, "Statistical Modeling for Predicting Bead Volume of Submerged Arc Butt Welds", Australasian Welding Journal, vol. 51, no. 2, 2006, pp. 39-47.Patnaik, S. Biswas.

[13].S. Datta, A. Bandyopadhyay, and P.K. Pal, "Application of Taguchi Philosophy for Parametric Optimization of Bead Geometry and HAZ Width in Submerged Arc Welding Using Mixture of Fresh Flux and Fused Slag", International Journal of Advanced Manufacturing Technology, vol. 36, 2008, pp. 689-698.

[14].P. Kumar, P.B. Barua, and J.L. Gaindhar, "Quality Optimization (Multi-Characteristics) Through Taguchi"s Technique and Utility Concept, Quality and Reliability Engineering International, vol. 16, 2000, pp. 475-485.

[15].R.S. Walia, H.S. Shan, and P. KUMAR, "Multi-Response Optimization of CFAAFM Process Through Taguchi Method and Utility Concept", Materials and Manufacturing Processes, vol. 21, 2006, 907-914.

[16].S. Datta, S. S. Mahapatra, S. Banerjee, A. Bandyopadhyay, "Comparative study on application of utility concept and VIKOR method for vendor selection", AIMS International Conference on Value-based Management, organized by Indus Business Academy–India, International Forum of Management Scholars, AIMS International, held during August 11-13, 2010 at Dev SanskritiVishwavidyalaya, Haridwar,India.

[17].G.S. Peace, "Taguchi Methods-A Hands-On Approach", 1993, Addison-Wesley Publishing Company. Massachusetts.

[18].F.C. Wu, "Optimization of Correlated Multiple Quality Characteristics Using Desirability Function", Quality Engineering, vol.17, no. 1, 2005, pp. 119-126.

[19].M.S. Huang, and T.Y. Lin, "Simulation of a Regression-Model and PCA based Searching Method Developed for Setting the Robust Injection Molding Parameters of Multi-Quality Characteristics", International Journal of Heat and Mass Transfer, 2008, DOI: 10.1016/j.ijheatmasstransfer.2008.05.016.

[20].S. Datta, G. Nandi, A. Bandyopadhyay, and P.K. Pal, "Application of PCA based Hybrid Taguchi Method for Multi-Criteria Optimization of Submerged Arc Weld: A case study", International Journal of Advanced Manufacturing Technology, vol. 45, no. 3-4, November 2009, pp. 276-286.

[21] Kulwant Singh, Sunil Pandey , "Recycling of slag to act as a flux in submerged arc Welding" . ARTICLE IN PRESS RECYCL-2124; Resources, Conservation and Recycling (2009)

[22] Kishor P. Kolhe,∗, C.K. Datta ,Prediction of microstructure and mechanical Properties of multipass SAW journal of materials processing technology 197 (2008) 241–249

[23] S.P. KumareshBabu, S. Natarajan * Solving multi-criteria optimization problem in Submerged arc welding consuming a mixture of fresh flux and fused slag.

[24] SauravDatta&Asish Bandyopadhyay&Pradip Kumar Pal Solvingmulticriteria optimization problem in submerged arc welding consuming a mixture of fresh flux and fused slag. Int J AdvManuf Technol (2008) 35:935–942

[25] Keshav Prasad &D. K. Dwivedi "Some investigations on microstructure and mechanical properties of submerged arc welded HSLA steel joints" Int J AdvManuf Technol (2008) 36:475–483

[26] N. Murugan,, V. Gunaraj "Prediction and control of weld bead geometry and shape relationships in submerged arc welding of pipes b Journal of Materials Processing Technology 168 (2005) 478–487

[27] R.S. Chandel , H.P. Seow, F.L. Cheong , Effect of increasing deposition rate on the bead geometry of submerged arc welds. Journal of Materials Processing Technology 72 (1997) 124–128

[28] Chandel R. S., Seow H. P. and Cheong F. L. (1997), " Effect of increasing deposition rate on the bead geometry of submerged arc welds", Journal of Materials processing Technology Vol. 72 pp. 124-128.

[29] Chandel R. S., Seow H. P. and Cheong F. L. (1998, April), "Using metal powders in submerged arc welding efficiently", Welding Journal, pp. 65-68