Available online at www.elixirpublishers.com (Elixir International Journal)

Mechanical Engineering

Elixir Mech. Engg. 83 (2015) 32979-32982

ISSN: 2229-712X

Parametric Effect in Submerged Arc Welding

Ravinder Pal Singh, R.K.Garg and Dinesh Kumar Shukla
Dr.B.R.Ambedkar National Institute of Technology, Jalandhar, Punjab, India.

ARTICLE INFO

Article history:
Received: 21 April 2015;
Received in revised form:
25 May 2015;
Accepted: 3 June 2015;

Keywords
Submerged Arc Welding,
Parametric Effect,
Weld Bead Geometry,
Weld Quality.

ABSTRACT

Higher quality and cost effective welds can be achieved by understanding the weld metal properties and influence of welding parameters. Submerged arc welding is preferred process for the higher productivity and better finishing of deposited metal. Welding input parameters have significant role in determining the quality of a weld joint. The joint quality can be assessed in terms of weld bead geometry and weld metal properties. Investigation has been made on influence of welding input parameters on weld bead geometry and metallurgical properties.

Introduction

Welding is one of the most common fabrication techniques which is extensively used to obtain good quality weld joints for various structural components. The advantage of welding has been well recognized by the designers and the fabricators, therefore there is hardly any industry which has not been benefited from the welding [1]. The present trend in the fabrication industries is to automate a welding process to obtain high production rate. Welding process can be automated by establishing the relationship between the process parameters and weld bead geometry to predict and control the weld bead quality [2]. These relationships can be developed by using of experimental design techniques [3]. High reliability, deep penetration, smooth finishing and high productivity made submerged arc welding a preferred process over other methods of welding [4]. Due to high deposition rate, excellent surface appearance and lower welder skill requirement submerged arc welding process is widely used in fabrication of pressure vessel, marine vessel, pipelines and offshore structures [5]. It has also been revealed that slag produced in the process can also be reused [6]. So, these qualities have made this welding process as a preferred choice in industries for fabrication.

Submerged Arc Welding Process

Submerged arc welding (SAW) is a mechanized and high deposition rate welding process. It is a fusion welding process in which heat is produced by maintaining an arc between the work and continuously fed filler wire electrode. Submerged arc welding process employs a continuous bare electrode wire in solid form and a blanket of powdered flux. The flux mount is of sufficient depth to submerge completely the arc column so that there is no spatter or smoke and the weld is shielded from the atmospheric gases. Weld bead geometry and load carrying capability of weld metal is influenced by the flux used in the welding process [7, 8]. It also affects the mechanical properties and microstructure of the weld metal [9, 10]. The heat produced by the arc is used to melt the work piece. Hence a weld bead of good quality of desired composition is obtained by above process without the application of pressure.

Experimental Work

Experiments were performed on submerged arc welding machine as shown in figure 1. Extensive experimental runs were made on the base material to obtain the working parameters. Experiments were performed in random manner as per design matrix to avoid any systematic error. Upper limit and lower limits were coded as +1 and -1 respectively. Specimen plates were prepared by making beads on mild steel plates of dimension 300 x100 x12 mm^3 using the EL-8 electrode of 3.2 mm diameter.

Figure 1. Submerged Arc Welding Machine Used For Experimental Work

The composition of the base metal, electrode and Ok 10.71 flux used for the experimentation is mentioned in the table 1, 2 and 3 respectively. After performing the inspections of plates for any visible defects the specimens were cut from the welded plates. Further mounting were made on automatic specimen mounting press from the specimen sectioned on abrassive cut off machine. Specimens thus obtained were ground, polished on automatic multispecimen polishing machine and then etched with 2% nital solution [11, 12, 13]. Bead geometry of polished and etched specimen thus obtained was measured. Parameters selected for study were wire feed rate, arc voltage, travel speed and contact tip to work distance which are mentioned in Table 4. Process parameters which were chosen for experimental work are mentioned in the table 4. Range of the selected parameters was decided by carrying out trial runs in which one parameter was changed whereas all the other parameters were kept constant.

Tele:
E-mail addresses: rps.syal@gmail.com

Result and Discussion

Weld quality of the weld joint can be assessed in terms of bead geometry and shape relationships which influence mechanical and metallurgical properties of the weld. Bead geometry and shape relationship measured from sectioned specimens of respective welded beads obtained by performing the experiments as per design matrix at selected parameters are shown in the table 5. It has been observed that if the wire feed rate is increased there is increases in bead width, penetration and reinforcement as depicted in figure 2. Increase in dilution has also been observed. Increase in arc voltage resulted in decrease in penetration and reinforcement but bead width was increased. As far as dilution is concerned decrease in dilution has also been observed with increase in arc voltage as shown in figure 3. Decrease in travel speed resulted in marginal increase in reinforcement whereas increase in bead width has been observed. Increase in contact tip to work distance decreased penetration marginally whereas small increase in bead width was observed. Reinforcement increases but small increase in dilution has been seen with increase in contact tip to work distance. Variation of shape factors viz weld penetration size factor which is ratio of bead width to penetration and weld reinforcement form factor ratio of bead width to reinforcement also tabulated in table 5.

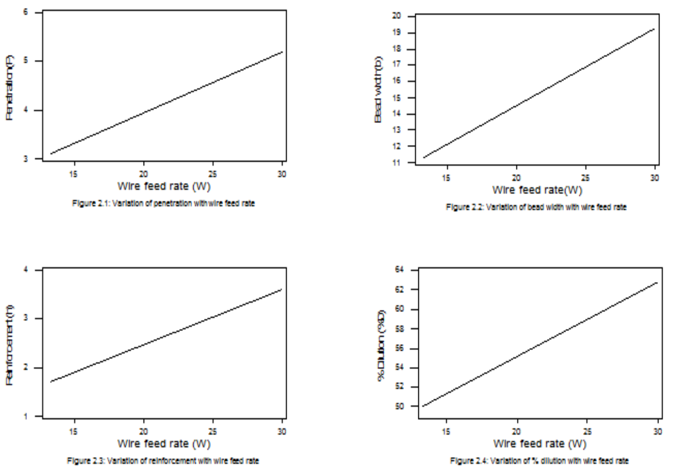

Figure 2. Effect of Variation of Wire feed rate on Weld Bead Characteristics

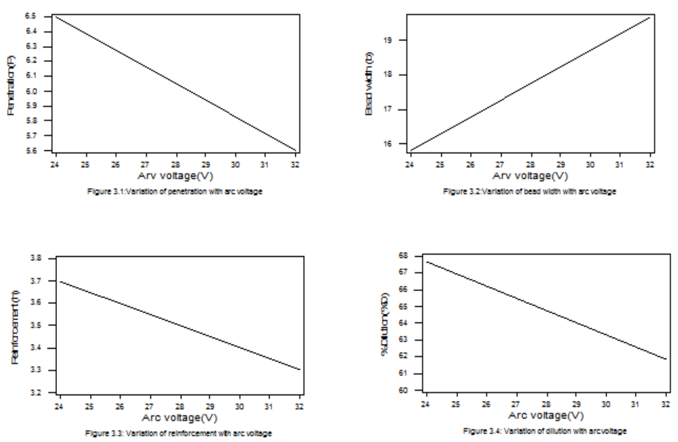

Figure 3. Effect of Variation of Arc voltage on Weld Bead Characteristics

Microstructure Survey:

Microstructure of base metal and weld metal are shown below in Figure 4 and 5. Micrograph of base metal shown in Figure 4 indicates that presence of ferrite and pearlite in normal ferrite pearlite steel having the 0.243 percent of carbon.

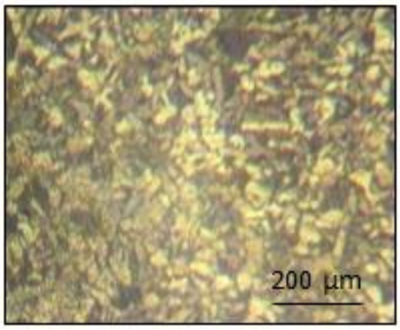

Figure 4. Microstructure of Base Metal

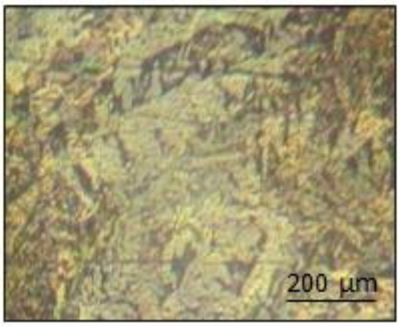

Figure 5. Microstructure of Weld Metal

Micrograph of weld metal in figure 5 revealed that solidification of weld is composed of columnar grains with grain boundary ferrite and islands of the polygonal ferrite. The structure is as per the chemical analysis which indicated the low percentage of carbon and manganese. Further it possesses relatively low hardness measurement. The low content of carbon and manganese in weld metal confirmed the presence of grain boundary ferrite and polygonal ferrite.

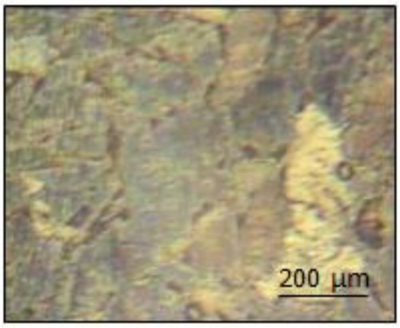

Figure 6. Microstructure of Weld Metal with Coarse Grained Structure

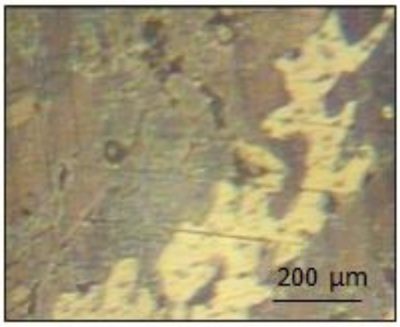

Figure 7. Microstructure of Weld Metal with Acicular Ferrite

The microstructure of the weld metal obtained at welding input parameters which pertain to higher heat input is shown in figure 6 which indicated that with increase in heat input coarse grained structure is obtained which resulted in low hardness and ductile weldment which is in confirmation with aksoy et al [14].

Table 1. Percentage Composition of Base Metal

Element	C	Mn	Si	S	P	Cu
Wt %	0.24	0.48	0.15	0.038	0.047	0.14

Table 2. Percentage Composition of Electrode

Element	C	Mn	Si	S	P	Cu
Wt %	0.08	0.5	0.05	0.018	0.018	0.25

Table 3. Percentage Composition of Flux

Element	C	Mn	Si	S	P	Cu
Wt %	0.10	1.0	0.20	0.018	0.018	0.25

Table 4. Process Parameters Selected For Study

Input Parameter	Units	Lower Level -1	Upper Level +1
Wire feed rate (W)	mm/s	13	30
Arc voltage (V)	Volts	24	32
Travel speed (T)	mm/s	5.83	9.16
Contact tip to work distance (N)	mm	25	35

Table 5. Measured Average Values of the Weld Bead Geometry Characteristics

Run no.	W	V	T	N	Bead Width b (mm)	Penetration P (mm)	Reinforcement h (mm)	Weld Penetration Size Factor WPSF	Weld Reinforcement Form Factor WRFF	Percentage Dilution %D
1.	1	-1	1	-1	19.3	5.2	3.6	3.7	5.3	62.87
2.	-1	-1	1	1	11.3	3.1	1.7	3.6	6.6	49.94
3.	1	-1	-1	1	15.8	6.5	3.7	2.4	4.2	67.69
4.	-1	-1	-1	-1	11.2	2.6	1.7	4.3	6.5	48.96
5.	1	1	1	1	14.9	6.1	3.1	2.4	4.8	69.30
6.	-1	1	-1	1	11.9	2.2	1.9	5.4	6.2	49.45
7.	1	1	-1	-1	19.7	5.6	3.3	3.5	5.9	61.85
8.	-1	1	1	-1	11.7	2.1	1.9	5.5	6.1	48.56

In addition amount of grain boundary ferrite is also reduced. Figure 6 also revealed that amount of acicular ferrite is also increased at the expense of grain boundary ferrite with increase in carbon content (0.12) and manganese (0.82) in the weld metal as found from chemical analysis of weld metal. The results are in good agreement with Kanjilal et al [15]. Since characteristics of weldment also depends upon size, shape and pattern of the distribution of micro constituents and inclusions. The fine and evenly distributed inclusion has also been found in the microstructure of the weld metal as shown in figure 7 which resulted in better properties of weldment. This is as per findings of the Stuck et al. [16] and Shultz et al [17].

Microhardness Survey

Micro hardness testing carried across the cross-section of the specimen cut from the weld beads is shown in figure 8. The micro-hardness profile shows that variation of hardness of weld metal, base metal and heat affected zone across the weld bead. It has been observed that there was more variation of hardness in the weld metal zone. The average range of the weld metal and base metal had been found to be 173-202 Hv and 199-227 Hv whereas heat affected zone possessed the micro-hardness range of 206-257 Hv. Hardness of the weld metal was found to be lower than the base metal.

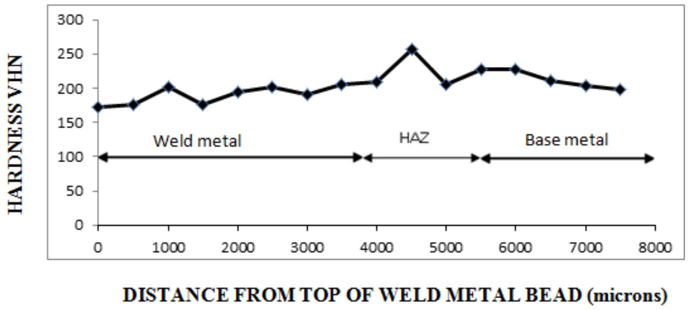

Figure 8. Microhardness Profile Across Weld Bead (100g)

Thus, it can be revealed that process variable strongly influence the weld bead properties which is further assessed in terms of weld bead geometry and shape relationships. Apart from effect of wire feed rate on other weld bead characteristics, increase in value of shape factors had also been observed with the increase in wire feed rate which affected the strength of the weld. Travel speed and contact tip to work distance showed marginal variation in weld bead characteristics. Arc voltage strongly affected the bead width and penetration was significantly affected by wire feed rate. As far as effect of welding parameters on microstructure is concerned, parameter which imparted high heat input and low cooling rate resulted in coarse grain structure which further led to low hardness which was confirmed by micro hardness measurement across the weld. So, selection of parameters is essential to understand the influence of welding input parameters on weld metal properties to obtain the weld joints of desired quality.

References

[1] Jeffus Larry. Welding Principles and Application. Fifth Edition, Thomson Delmar Learning, 2004

[2] Parmar, RS Welding Processes and Technology. Khanna Publishing Company, New Delhi, 1997

[3] Montogomery, DC. Design and Analysis of Experiments. John Wiley Pvt. Ltd, Singapore. 2001

[4] Houldcraft P and John, R. Welding and Cutting. A Guide to Fusion Welding and Associated Cutting Processes, Industrial Press Inc. Newyork 1989.

[5] Chandel RS , Seow, HP and Cheong FL. Effect of Increasing Deposition Rate on Bead Geometry of Submerged Arc Welds. Journal of Material Processing Technology 1997; 72: 124-129.

[6] Singh K and Pandey S. Recycling of Slag to Act as Flux in Submerged Arc Welding. Resources, Conservation and Recycling 2009; 53: 552-558.

[7] Gunaraj V and Murugun N. Application of Response Surface Methodology for Predicting Weld Bead Quality in Submerged Arc Welding of Pipes. Journal of Material Processing Technology.1999; 88: 266-275.

[8] Datta S , Bandyopadhyay A and Pal PK Grey Based Taguchi Method for Optimization of Bead Geometry in Submerged Arc Bead-on-Plate Welding. International Journal of Advance Manufacturing Technology 2008; 39: 1136–1143.

[9] Pandey ND, Bharati A and Gupta SR. Effect of Submerged Arc Welding Parameters and Fluxes on Element Transfer Behavior and Weld Metal Chemistry. Journal of Material Processing Technology 1994; 40: 195-211.

[10] Dallam CB, Liu S and Olson DL. Flux Consumption Dependence of Microstructure and Toughness of Submerged Arc HSLA Weldments. Welding Journal.1985; 140s-151s.

[11] A Technical Manual Published by All India Council for Technical Education. Welding Engineering - Metal Arc, NITJ Library. 1993; Chapter 6:124-126 Acc. No.51094.

[12] ASTM Standard-A Guide for Metallographic Examination E2014; 67-77.

[13] Avner HS. Introduction to Physical Metallurgy, Tata McGraw Hill publishing Company Limited, New Delhi, 1997; 15-17.

[14] Aksoy M, Ero M and Orhan N. Effect of Coarse Initial Grain on Microstructure and Mechanical Properties of Weld Metal and HAZ of Low Carbon Steel. Material Science and Engineering1999; 269 (1): 1-9.

[15] Kanjilal P, Majumdar S and Pal TK. Predictions of Acicular Ferrite from Fux Ingredient in Submerged Arc Weld Metal of C-Mn Steel. ISIJ International.2005; 45(6): 876-885.

[16] Shultz BL and Jackson CE .Influence of Weld Bead Area on Weld Bead Mechanical Properties. Welding Journal, 1973; 26s-37s.

[17] Strunck S and Stout RD. Heat Treatment Effects in Multipass Weldment of High Strength Steel. Welding Journal.1972; 508s-514s.