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Influence of Key Process Parameters in Submerged Arc Welding

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Abstract

The most predominant electric curve welding forms in the businesses are Shielded Metal Arc Welding, Gas Metal Arc Welding, Flux Cored Arc Welding, Submerged Arc Welding and Gas Tungsten Arc Welding. These procedures are related with liquid metal. Liquid metal responds with the air so that oxides and nitrides are framed. All circular segment welding forms utilize a few methods for protecting the liquid weld pool from the air. The Submerged Arc Welding procedure is generally favored in light of the fact that it offers high generation rate, simplicity of mechanization, high dissolving productivity and low administrator expertise prerequisite. The nature of weld relies on upon dab geometry of the weld which thus relies on upon the procedure factors. Submerged Arc Welding (SAW) is one of the significant metal manufacture methods in industry because of its unwavering quality and ability of delivering great quality weld. The capacity to join thick plates (as thick as 1.5 inch) in a solitary go, with high metal testimony rate has made this procedure valuable in extensive auxiliary applications. It is a standout amongst the most generally utilized procedures for creation of channels, thick plates, weight vessels, marine vessels, rail tanks, ships, warm exchangers, seaward structure and so on. This procedure is monetarily utilized for welding of low carbon steel, high quality low composite steel, nickel base amalgams and stainless steel. It is conceivable to weld thin sheet of steels at more than 5 m/min with least outflow of welding smoke. Choice of process parameters has extraordinary impact on the nature of a welded association. It is important to ponder on Process Parameters of submerged curve welding for getting quality and powerful welding. Analyses are directed utilizing submerged circular segment prepare parameters viz. welding current, curve voltage and welding speed on mellow steel of 8 mm thickness, to concentrate the impact of these parameters on weld dab hardness. The tests are outlined utilizing Taguchi technique (with Taguchi L8 orthogonal cluster) considering three elements and two levels.

Keywords:*Submerged arc welding, Process Parameters, Taguchi Method, S/N Ratio.*

1. Introduction

Submerged circular segment welding is an adaptable bend generation welding process equipped for making welds with current up to 2000 Amp, substitute present or direct present, utilizing single or different (2 to 5) wires or pieces of filler metal. Despite streams going from 300 to 2000 Amp are regularly used, up to 5000 amperes Current has additionally been accounted for utilized with various bends. Most Commonly Constant Voltage welding power supplies are utilized, despite the fact that consistent current frameworks in blend with a voltage sensing wire-feeder are also available. The submerged arc welding process is widely used because of its many advantages. For the use of automatic equipment it is readily adaptable and can be carried out significantly at higher speed than those of other most of the known welding processes. SAW process is normally operated in the automatic or mechanized mode, however, semi-automatic SAW guns with pressurized or gravity flux feed delivery are also available. This process is normally limited to the Flat or Horizontal-Fillet welding positions.

Commonly, submerged arc welding (SAW) requires a continuously fed consumable solid electrode. The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under a blanket of granular fusible flux. The flux for the SAW process also cleans the molten metal pool, it cordially modifies the chemical composition of the weld metal and it cordially affects the geometry of the weld bead and its mechanical properties. It also forms a readily removable or free peeling fused slag to facilitate cleaning after use. In molten state, the flux becomes conductive, and it provides a current path between the work and the electrode.. This thick layer of flux covers the complete molten metal, thus preventing spatter and sparks as well as suppressing the intense ultraviolet radiation and fumes.

Flux plays vital role in deciding the weld metal quality. Fluxes should be provide the appropriate composition for the weld metal and illustrate good behavior of welding. By maintaining the flux ingredients within the optimum range these two requirements can be achieved. It affects the weld metal physically, chemically and metallurgically. Physically, it influences the bead geometry and shape relationships, which in

turn indirectly affect the load carrying capacity of the weldment. Chemically, it affects the mechanical properties of the weld metal.

Mechanical and metallurgical properties of the weld metal mainly depend upon the content of manganese, silicon carbon, sulphur, phosphorous, chromium and other alloying elements in the weld metal. Manganese content in the weld metal depends on the manganese content of the electrode wire, manganese oxide, and presence of the basic elements like calcium, magnesium and basicity of the flux. Apart from the chemical composition of the weld metal, the characteristics of the welds are also governed by the weld bead geometry which is further influenced by welding parameters viz. arc voltage, welding current and welding speed. A variation in these parameters changes the heat input and consequently affects the bead geometry.

The SAW process parameters are the most important factors that affecting the quality, productivity and cost of welding joint. Weld bead size and shape are important considerations for design and manufacturing engineers in the fabrication industry. In fact, there is direct effect of weld bead geometry on the complexity of weld schedules and thereby the manufacturing costs of steel structures and mechanical devices. Therefore, these parameters affecting the arc and welding bath should be estimated and their changing conditions during process must be known before in order to obtain optimum results; in fact a perfect arc can be achieved when all the parameters are in compliance with standard. The various parameters like welding current, arc voltage, wire feed speed, travel speed, torch angle and the electrode stick out are affecting on the weld quality. Grain boundary ferrite, acicular ferrite, polygonal ferrite, side plate ferrite, pearlite and bainite are the constituents of the microstructure of steel weld metal. Micro-hardness and mechanical properties are governed by the proportion and size of these micro-constituents. Submerged circular segment welding can be utilized for a to a great degree extensive variety of workpieces. This technique is proper for the butt and filet sort welding of such applications as make of weight vessels, basic individuals in boats, connect pillars, enormous water funnels, thin sheet shells and so on. Likewise, the procedure is especially successful for cladding applications, e.g. when surfacing gentle carbon steel with stainless steel materials, or while saving hard materials on a milder substrate. Submerged bend welding is by and large performed inside in creation shops. Working outside dependably conveys the danger of undesirable levels of dampness discovering their way into the joint or flux and bringing about porosity of the weld. In the event that submerged bend welding process must be done outside, exceptional insurances ought to be taken, for example, the development of a rooftop over the work region. Submerged circular segment welding is most effective if the joint can be loaded with as few goes as would be prudent. On the off chance that, when working in mellow steel, the workpiece can be turned over, and if the material is not very thick, a globule is frequently connected from each side of the joint. On the off chance that the fundamental material is alloyed steel then regularly a multi-pass system is typically essential. In fact, this outcomes in an expansion in process costs, yet for some workpieces the financial matters of the procedure are still adequately appealing for submerged circular segment welding to be more savvy than, say, manual welding utilizing covered anodes. Moreover, there will be less weld abandons with programmed welding.

2. Experimentation

2.1 Taguchi Method

Taguchi's rationality is an effective strategy for the plan of brilliant assembling framework. Dr. Genichi Taguchi, a Japanese quality administration advisor, has built up a strategy in view of orthogonal cluster tests, which gives abundantly diminished difference to the explore different avenues regarding ideal setting of process control parameters. Hence the marriage of plan of examinations (DOE) with parametric enhancement of procedure to get coveted outcomes is accomplished in the Taguchi technique. Orthogonal exhibit (OA) gives an arrangement of all around adjusted (least test runs) investigations and Taguchi's flag to-commotion proportions (S/N), which is logarithmic elements of coveted yield fill in as target capacities for streamlining. This strategy helps in information investigation and forecast of ideal outcomes. Keeping in mind the end goal to assess ideal parameter settings, Taguchi strategy utilizes a factual measure of execution called flag to-clamor proportion. The S/N proportion considers both the mean and the changeability. The S/N proportion is the proportion of the mean (flag) to the standard deviation (clamor). The standard S/N proportions by and large utilized are as per the following: Nominal is ideal (NB), bring down the better (LB) and higher the better (HB). The ideal setting is the parameter blend, which has the most astounding S/N proportion..

2.2 Process Parameters Levels

The parameters of Submerged circular segment welding process are welding current, bend voltage, welding speed, wire breadth, anode stand out, flux, warm info, extremity and current sort (AC or DC). Welding current specifically influences the entrance profundity and stretch out of base metal combination. The welding bend voltage has coordinate impact on the shape on globule and outer appearance of dot. The welding speed has articulated impact on infiltration and weld estimate for given blend of current and welding voltage. Cautious consideration is important to choose the welding procedure parameters to acquire a decent weld quality. In spite of the fact that many immediate and backhanded parameters influence the nature of weld in SAW, but the real key process parameters influencing the dab geometry are bend voltage, welding current and welding speed. In the present test, two-levels of the three procedure parameters, i.e., current, voltage and travel speed was

considered. The estimations of the welding procedure parameter at various levels are recorded in table1

Table 1.Welding Parametrs at different Levels

Sr. No.	Welding parameters	Level 1	Level 2
1	Welding current, A	300	360
2	Arc voltage, V	28	30
3	Welding speed, mm/min	200	300

2.3 Process Set-up and Procedure

The test was led on self-loader AUTO WELD MAJOR (LW) with CPRA 800 (S)Power source made by Esab India. Steel plates of measurements 180 mm (length) x 90 mm (width) x 8 mm (stature) were utilized as base metal of review ASTM 36. Automelt EH 14 copper covered cathode of 2.4 mm distance across was utilized as filler wire and fundamental fluoride sort granular flux were utilized. The compound organization of the work piece in Table 2. Three welding parameters, for example, welding current, bend voltage, welding velocity and cathode stand out were chosen for experimentation with two levels of each element. The estimation of the welding procedure parameter at the diverse levels is arranged in Table 3. Test process was led utilizing L8orthogonal cluster in Taguchi technique which has eight lines comparing to the quantity of investigations and the exploratory outcomes for the weld dab geometry and hardness utilizing the L8 orthogonal exhibit are appeared in Table 3.

Table 2. Chemical Composition of ASTM36

Element	Content
Carbon, C	0.25-.290 %
Copper, Cu	0.20%
Iron, Fe	98.00%
Manganese, Mn	1.03%
Phosphorous, P	0.04%
Silicon, Si	0.28%
Sulphur, S	0.05%

A square butt joint with a 1.6 mm root opening was chosen to join the plates in level position, keeping anode opposite to plates. Examples of 8 mm width were sliced transverse to the welding bearing from each welded plates. Theseexamples were cleaned, ground, cleaned and scratched with 10% nital (90% liquor + 10% of nitric corrosive).Weld bead profiles were traced by using an optical microscope at 10X magnification.

Fig. 2.1 Rockwell Hardness Tester

Measurements were made for depth of penetration bead width and bead hardness. The observed values of the responses are given in TableNo.3

Fig.2.2 Weld Penetration MeasuringInstrument

Table No. 3Observation Table for the test of specimen as per L8 orthogonal array

Trial No	Welding current (A)	Arc voltage (V)	Welding speed (mm/min)	BeadWidth (mm)	Bead Penetration (mm)	bead hardness(HRC)
1	300	28	200	14.9	1.26	40.5
2	300	28	300	14.7	1.89	51
3	300	30	200	16	1.64	50
4	300	30	300	14.6	1.45	49.5
5	350	28	200	14.5	1.42	39
6	350	28	300	14	1.87	43.5
7	350	30	200	19	1.53	41
8	350	30	300	19.7	1.99	46

3. Analysis and Discussion

3.1 Signals-to-Noise Ratio (S/N Ratio)

For the assessment reason for ideal parameter settings, the Taguchi strategy utilizes a factual measure of execution called flag to-commotion proportion. Dr. Genichi Taguchi built up this strategy, is an execution measure to choose control levels that best match with commotion. The S/N proportion considers both the mean and the fluctuation. The S/N proportion is the proportion of the intend to the standard deviation. By and large the standard S/N proportions utilized are as per the following: ostensible - best (NB), bring down - better (LB), and higher - better (HB). In this paper, the trademark esteems are chosen by the dab width, profundity of entrance and weld dab hardness. Since a decent outcome is acquired by the littler globule width, more profound profundity of entrance and higher dot hardness. Consequently for dab width LB is favored. For profundity of entrance the HB rule has been chosen.

3.1.1 Analysis of S/N ratio for bead width

Littler dab width is the delightful property of the weld globule joint. So if there should be an occurrence of weld globule width, Smaller-the-better choice has been decided for the count of S/N proportion. From table 4, it has been broke down that the parameter welding current is the most critical element which influence the dot width. Ideal parameters setting for littler dot width is, voltage= 28V, current= 300A, speed= 300 mm/min.

Table 4.Response table for S/N ratio (SB)

Level	Current	Voltage	Speed
1	-23.545	-23.2398	-24.087
2	-24.404	-24.7084	-23.8612
Delta	0.85	1.46	0.22
Rank	2	3	1

3.1.2 Analysis of S/N ratio for depth of penetration

Bigger profundity of infiltration is the lovable property of the weld joint. So if there should arise an occurrence of profundity of entrance, bigger the better choice has been decided for estimation of S/N proportion. From table 3, ideal parameters setting for bigger profundity is, present = 350 amp, voltage = 30 V, Speed = 300 mm/min.Table5.Response table for S/N ratio (HB)

Level	Current	Voltage	Speed
1	3.7651	4.0047	4.0223
2	4.5383	4.2987	5.0425
Delta	0.77	0.294	1.02
Rank	2	3	1

3.1.3 Analysis of S/N ratio for bead hardness

Higher globule hardness is adorable property of the weld dab joint. Since it give quality to the weld globule joint. In this way, for dot hardness, higher-the-better choice is decided for flag to commotion proportion estimations. From table 6, , it has been broke down that the parameter welding voltage is the most noteworthy variable which influence the dab width. Ideal parameters setting for higher dot hardness is, voltage= 30V, current= 300A, speed= 300 mm/min.

Table 6.Response table for S/N ratio(HB)

Level	Current	Voltage	Speed
1	33.543	32.7228	32.5513
2	33.5254	33.3455	33.517
Delta	1.01	0.62	0.96
Rank	1	3	2

4. Conclusion

- Increase in welding current straightly builds the profundity of infiltration. From the trial and result got it is realized that liquid metal beads exchanges from the anode to the plate are firmly overheated. It can be sensibly accepted that this additional warmth adds to all the more dissolving of the work piece. As present builds the temperature of the beads and subsequently the warmth substance of

the drops expands which brings about more warmth being exchanged to the base plate. Increment in current lessens the size however builds the force of the beads which on strikingthe weld pool causes a more profound infiltration or space. The expansion in infiltration as present expanded could likewise be ascribed to the way that upgraded curve compel and warm information per unit length of the weld dab brought about higher current thickness that created dissolving a bigger volume of the base metal and thus more profound entrance.

- Current is one of the key factor that impact the dot width. Dot width directly increments with current andarc voltage and reductions, with welding speed.

- Optimal parameters setting for littler dot width is, present = 300 amp, voltage = 28 V, Speed = 300 mm/min.

- Optimal parameters setting for bigger profundity is, present = 350 amp, voltage = 30 V, Speed = 300 mm/min.

- Optimal parameters setting for bigger dab hardness width is, present = 300 amp, voltage = 30 V, speed = 300 mm/min.

5. References

1) SauravDatta, A. Bandyopadhyay, Pradip Kumar Pal, “Application of Taguchi philosophy for parametric optimization of bead geometry and HAZ width in submerged arc welding using a mixture of fresh flux and fused flux”, Int. J. Adv. Manufacturing Technology, Volume 36, pp. 689-698, 2008.

2)Kolhe K.P and Datta C.K “Prediction of Microstructure and Mechanical Properties of Multipass SAW” Journal of Material Processing Technology, DOI:10.1016/j.jmatprotec.2007.06.066 Impact factor 0.67 2007, 197(1-3), Pp.241-249

3) Kolhe K P. “Welding science the need of farmers for repair of farm tools” International Journal of Agricultural Engineering (ISSN No 0974-2662) 2009, 2 (2). Pp 186-190

4) A. Patnaik, S. Biswas, S.S. Mahapatra, “An evolutionary approach to parameter optimisation of submerged arc welding in the hard facing process”, Int. J. Manufacturing Research, Volume 2, pp. 462–483, 2007.

5) S.C. Moi, A. Bandyopadhyay, P.K. Pal, “Submerged arc welding with a mixture of fresh flux and fused Slag”, Proc National Seminar on Advances in Material & Processing, IIT Roorkee, 2001.

6) E.A. Elsayed, A. Chen, "Optimal levels of process parameters for products with multiple characteristics", International Journal Production Research, Volume 31, pp. 1117-32, 1993

7) Aniruddha Ghosh ,SomnathChattopadhyaya, R.K.Das, “Effect of Heat input on Submerged Arc Welded Plates” Procedia Engineering, Volume 10, pp. 2791–2796, 2011.

8) P Kumar, A Batish, A Bhattacharya, and R K Duvedi, “Effect of process parameters on microhardness and microstructure of heat affected zone in submerged arc welding”, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, Volume 225, pp. 711-721, 2010.

9) Keshav Prasad, D. K. Dwivedi, “Some investigations on microstructure and mechanical properties of submerged arc welded HSLA steel joints”, Journal of Advanced Manufacturing Technology, Volume 36, pp. 475-483, 2006.

10) BehcetGulenc, NizamettinKahraman, “Wear behaviour of bulldozer rollers welded using a submerged arc welding process”, Materials and Design, Volume 24, pp. 537– 542, 2003.

11) R. S. Chandel, H. P. Seow, F. L. Cheong, “Effect of metal powder addition on mechanical properties of submerged arc welds”, Journal of Materials Science Letters , Volume 17, pp. 1785-1786, 1988.

12) N.D. Pandey, A. Bharti, “Effect of submerged arc welding parameters and fluxes on element transfer behaviour and weld-metal chemistry”, Journal of Materials Processing Technology, Volume 40, pp. 195-211, 1994.

13) W. Troyer, J. Mikurak, “Study of Mechanical Properties of Submerged Arc Welds after metal powder addition”, Welding J., Volume 53, pp. 494-498, 1974.

14) C.S. Lee, R.S. Chandel, H.P. Seow, “Effect of Welding Parameters on the Size of Heat Affected Zone of Submerged Arc Welding”, Materials and Manufacturing Processes, Volume 15, No.5, pp. 649-666, 2000.

15) M. Eroglu, M. Aksoy, N. Orhan, “Effect of coarse initial grain size on microstructure and mechanical properties of weld metal and HAZ of a low carbon steel”, Material Science Engg, Volume 269, pp. 59–66, 1999.

16) Y.S. Tarng, W.H. Yang & S.C. Juang, (2000) “ the use of fuzzy logic in the taguchi method or the optimization of submerged arc welding process”, international journal of advanced manufacturing technology, vol. 16, 688-694.

17) H.C. Wikle, S. Kottilingam, R.H.Zee (2001) “ infrared sensing techniques for penetration depth control of submerged arc welding process”, Journal of materials processing technology, vol.113, 228-233.

18) N. Murugun, V. Gunaraj(2005) “Prediction and control of weld bead geometry and shape relationship in submerged arc welding of pipes”, Journal of materials processing technology, vol.168, 478-487.

19) T. Kannan, N. Murugun(2006) “Effect of flux cored arc welding process parameters on duplex stainless steel clad quality”, Journal of materials processing technology, vol.176,230-239.

20) S. Kumanan, J Edwin Raja Dhas, & K. Gowthaman (2007) “Determination of SAW process parameters using Taguchi method and Regression analysis”, Indian journal of Engineering and Material Science,vol.14, 177-183.

21) Deepak Choudhary, Sandeep Jindal and N.P.Mehta (2011) "To study the effect of welding parameters on weld bead geometry in SAW welding process", Elixir Mechanical Engg. Vol.40, 5519-5524
22) Rati Saluja, K M Moeed (2012), "Modeling and Parametric Optimization using Factorial Design Approach of Submerged arc weld bead geometry for butt joint ", International Journal of Engineering Reasearch and Applications, ISSN : 2248 9622, Voulme 2, Issue 3, 505-508
23) Pranesh B. Bamankar, DR. S.M. Sawant(2013), "Study of The Effect of Process Parameters on Depth of Penetration and Bead Width in Saw (Submerged Arc Welding) Process", International Journal of Advanced Engineering Research and Studies, E-ISSN2249–8974, 08-10.
24) FarzeenShahid, Abid Ali Khan &Saqib Hameed (2015) "Mechanical and Micro structural analysis of dissimilar metal welds", IJRRAS, vol.25, Issue.1, 6-12.
S. Jindal, S. Walia, R. Goyal &Rajdeep (2015) "Prediction of bead profile parameters for submerged arc welding of structural steel pipe", International journal of emerging research in management & technology, vol.4, issue.10, 25-31.
25) A.M. Moshi, S.R. Bharthi, R. Rajeshkumar and R. Kumar (2016), "Factors influencing submerged arc welding on stainless steel: A review", ARPN Journal of engineering and applied sciences, volume.11, issue.2, 1237-1241.