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Estimation of Energy Distribution in Inverted type Submerged Arc Welding Process through Flux Consumption of IS 2062 Carbon Steel

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Keywords

Flux Measurement – Bead geometry – Deposition Rate – Dilution - Heat input – Mechanical Properties – IS 2062 Carbon Steel

Abstract

Submerged arc welding is most widely used method for welding thick section in down hand position and it is also a highly economical method for fabrication. As products must meet more stringent requirements of quality, requiring more flexible processes to reduce cost, further improvements is studied. Quality control aspects are also becoming more important to meet regulation and monitoring and control of welding process, and the standardized testing of joints will meet all the requirements. This paper describes theexperiment carried out in different travelling speed of electrode by keeping the flux mass as constant. By varying the travelling speed the rate of consumption of flux and energy distributed along the weldments is found out.This experiment helps to find out the amount of flux consumed during welding process and the melting of flux as slag in welding

1. Introduction

Submerged arc welding is generally performed indoors in fabrication shops. Working outdoors always carries the risk of undesirable levels of moisture finding their way into the joint or flux and resulting in porosity of the weld. If submerged arc welding must be carried out outdoors, special precautions should be taken, such as the construction of a roof over the work area. Submerged 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 alloy steel, a multi-pass procedure is normally necessary. Admittedly, this 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. This experiment helps to find out the amount of Flux consumed during welding Process and the melting of Flux as slag in welding. Submerged arc welding machine is operated at different Travelling Speed of electrode by keeping the Flux mass as constant. By varying the travelling speed, the rate of consumption of flux and energy distributed along the weldments is found out.

2. Literature Review

Shaa-hua, CAI Wei-Wei, Liu Shi Qiang, Song Tian-ge, [1], Based on simplex algorithm of optimal design, the multicomponent mixture regression model was used to investigate physical properties of submerged arc welding flux. The effect of complex interaction of seven components in agglomerated flux on softening temperature was analyzed. The results indicate that the interaction of MgO-TiO2-CaCO3-Al2O3 increases the softening temperature of flux, but the additions of CaF2 and ZrO2 can decrease the softening temperature.Kulwant Singh, Sunil Paney [2] The slag generated during submerged arc welding is thrown away as a waste. Non-biodegradable nature poses problems of storage, disposal, soil pollution and also needs landfill space for dumping. It cannot be used as a filling material in building construction or elsewhere being glassy and brittle material. The non-renewable resources are also getting exhausted fast due to continuous mining for minerals required for manufacturing of fluxes. The successful development of recycling technology that allows the use of slag as a fresh flux will surely overcome the above-mentioned problems and will also prove to be very economical.Slag was processed by replenishing it with suitable alloying elements/deoxidizers by agglomeration. This replenished slag is referred to as recycled slag. Recycled slag in combination with EL-8 filler wire was used in these investigations. The properties of weld metal deposited with recycled slag were investigated. The mechanical properties were satisfactory and satisfied AWS (American Welding Society) requirements. The chemical composition of weld metal was within the acceptance range of AWS specifications. The test plates cleared the radiographic test.Hirosisa Tanabe, Hiroyuki Hirata, Kzuhiro Ogawa, Masahiko Hamada. [3] conducted experiment on Fixed welding tests were performed to investigate deoxidization during submerged arc welding and to develop a model for it. For all the chemical compositions of the fluxes used, the oxygen content of the weld metal decreased with increasing arcing time in the initial stage of welding. The oxygen content of the weld metal eventually became constant; this is assumed to be a quasi-equilibrium state. Both the rate of reduction of the weld metal oxygen content and the oxygen content of the quasi-equilibrium condition depend on the chemical composition of flux. The weld metal oxygen content in the quasi-equilibrium condition can be estimated thermodynamically. DegalaVenkataKiran, Dae-Won Cho, Woo-Hyun Song, Suck-Joo Na [4], in the present investigation. A three-dimensional numerical heat transfer and fluid flow model is developed to understand the temperature distribution and molten pool behavior in a three wire submerged arc welding process. The model solves the equations of the conservation of mass, momentum, and energy along with the volume of fluid method. The volume of fluid method is used to track the shape of the free surface. Further, a physical model is developed to estimate the arc center displacement. For a given welding condition, connecting the leading electrode with direct current electrode positive polarity, the middle and trailing electrodes with trapezoidal alternating current waveform displayed deeper weld pools when compared to the sine waveforms. Within the range of welding conditions considered in the present work, weld width is significantly influenced by the leading arc whereas the penetration by the middle and trailing arcs. The computed weld width and penetration are in fair agreement with the corresponding experimental results.

Dae-Won Cho, DegalaVenkataKiran, Woo-Hyun Song, Suck-Joo Na [5] A three-dimensional numerical heat transfer and fluid flow model is developed to examine the temperature profiles, velocity fields, weld pool shape and size in a two-wire tandem submerged arc welding process. The model solves the equations of the conservation of mass, momentum, and energy along with the volume of fluid method. The volume of fluid method is used to track the shape of the free surface. Further, a novel scheme is proposed to handle the arc interaction and its influence on the molten droplet transfer direction. Using the computational fluid dynamics simulations, it is found that the droplet movement and arc forces from the leading electrode heavily affect the molten pool flow patterns and the resultant bead shapes, even though the same heat inputs are applied. The computed weld width and penetration are in fair agreement with the corresponding experimental results.Aniruddha gosh, somnathChattopadhyaya, R.K.Das, P.K.Sarkar [6], Submerged arc welding (SAW) is a high quality, high deposition rate welding process commonly used to join plates of higher thickness in load bearing components. This process of arc welding provides a purer and cleaner high volume weldment that has relatively a higher material deposition rate compared to the traditional welding methods. A common issue in the application of SAW process raises a concern about the uncertainties involved with the heat affected zone (HAZ) in and around the weldment. The most intriguing issue is about HAZ softening that imparts some uncertainties in the welded quality. It increases the probability of fatigue failures at the weakest zones caused by the heating and cooling cycle of the weld zone. An attempt has been made in this paper to assess the heat affected zone of submerged arc welding of structural steel plates through the analysis of the grain structure by means of digital image processing techniques. M.R.Forouzan, S.M. MirfalahNasiri, A.Mokhtari, A.Heidari, S.J.Golestaneh [7], In this paper, three-dimensional finite element (FE) simulations of double SAW and hydrostatic test processes of spirally welded pipes are carried out in two simulation steps using the ANSYS commercial software. In the first step, i.e., welding, a new method, namely, unfurl-mapping (UM) is introduced to overcome the geometrical difficulties of defining the Goldak double ellipsoidal heat source of the welding process. In the second step, the hydrostatic test is easily simulated by defining a ramped internal pressure. The method is validated using hole drilling measurements performed before and after hydrostatic test for this research. It is observed that obtained results from the FE simulations are in good agreement with the experimental measurements.U.Resigen, U.Dilthey, i. Aretov [8] studied the experiments and investigation carried on austenitic CrNi-steels and nickel-based alloys are increasingly applied in power station construction, crude oil and petrochemistry and, moreover, in industrial furnace and turbine construction. Besides the good mechanical properties of these materials also a good process ability is required. This applies particularly to welding. Due to their low heat input, TIG and MIG (pulsed) welding are the most frequently used welding methods in the case of heat-resistant nickel-base super alloys and also in the case of stainless CrNi-steels. Due to the high heat input, submerged-arc welding is, as a rule, not applied for the welding of these steels. Submerged arc welding could, however, be used as efficient alternative if process modifications are available, which ensure higher hot cracking resistance by reduced heat input. Apart from the high weld quality which is a result of submerged-arc welding, the economic efficiency which is particularly marked by the high deposition rates is also interesting.

3 Issues and Challenges Involved in the Present work

The various issues faced while welding IS 2062 using submerged arc welding are 1) multi passes are required for welding high thickness plates, 2)Flux consumption is relatively high, 3) slag inclusion of in weld bead and 4) the removal of slag from the weld bead geometry.

4Scope and Objectives of the Present Work

To Increase the metal deposition rate without increasing the flux consumption in Welding to get a good weld bead appearance and to obtain good penetration depth. To get a better fusion between weld bead and parent metal. Flux fuses with the electrode to get a better melting of electrode wire and fusing of electrode wire with base metal to obtain a sound weldments. In this process there will be good bead appearance and the variation of heat influence will be less.

5 Methodology of present work

The experimentation study has been carried using submerged arc welding machine with different kinds of current conditions with different weld speed conditions with flux weight as constant.

5.1 Base Metal

Welding experiments are carried out with IS2062 Carbon steel. This type of steel is used in fabrication of boiler components. The chemical and mechanical properties are given in the table below

Table 1. Chemical composition of IS 2062

GRADE	C %	Mn %	S %	P %	Si	C.E. %
A	0.23	1.5	0.05	0.05	-	0.42
B	0.22	1.5	0.045	0.045	0.04	0.41
C	.2	1.5	0.04	0.04	0.4	0.39

Table 2. Mechanical properties of IS 2062

Grade	UTS(MPa)	Y.S (MPa)			EI.% Min.	Bend
A	410	250	240	230	23	3T
B	410	250	240	230	23	2T & 3T*
C	410	250	240	230	23	2T
***2T-< = 25mm*3T-> 25mm**						

The selected material is used for welding by Submerged Arc Welding process. The Raw Material IS 2062 Carbon steel is polished on top surface where welding is to be carried out.

Fig 1. IS 2062 Carbon Steel

5.2 Consumables Used

A fused flux of manganese silicate type having a basicity index of 1.2 was used for carrying out wide groove welding by tandem submerged arc welding technique. For welding, an aluminate basic-type agglomerated flux having a basicity index of 1.6 was used. EL – 08(Copper Coated Continuous solid wire for Submerged Arc Welding) is used for welding.

6 Present Work

The welding was carried out with EL-08 Copper coated electrode with ESAW submerged arc welding machine with different current and % of cold wire conditions with different heat input.

7 Experimental Work details

The experiment is to analyze the amount of penetration, weld bead geometry, bead width under varying welding conditions with different welding speeds.

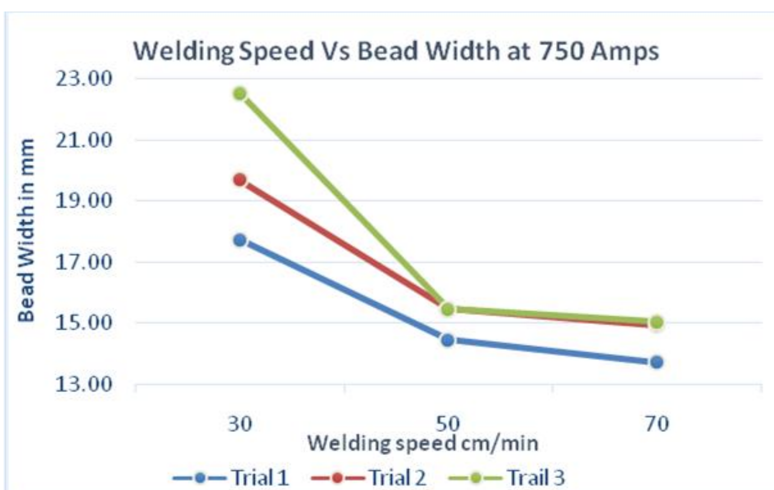
ID	Current (A)	Voltage (V)	Weld Speed (cm/min)	Heat Input (KJ/cm)	Plate Weight (Kg)			Flux Weight (gm)			Slag Weight (gm)	Width Of Weld Bead in mm	Total Penetration in mm
					Before weld	After weld	Increase in weight	Before weld	After weld	decrease in weight			
A	450	28	30	25	3.89	3.95	0.06	1000	940	60	60	19.12	4.25
B	450	28	50	15	3.76	3.795	0.035	1000	965	35	45	14.13	3.08
C	450	28	70	11	5.03	5.06	0.03	1000	970	30	30	11.27	3.09
D	600	30	30	36	4.29	4.35	0.06	1000	935	65	70	18.79	7.71
E	600	30	50	22	4.7	4.75	0.05	1000	955	45	50	16.44	5.44
F	600	30	70	15	4.49	4.52	0.03	1000	965	35	40	14.03	5.70
G	750	32	30	48	4.42	4.53	0.11	1000	930	70	65	17.73	10.93
H	750	32	50	29	4.49	4.555	0.065	1000	970	30	40	14.45	11.51
I	750	32	70	21	4.29	4.34	0.05	1000	970	30	35	13.70	9.89
A1	450	28	30	25	3.95	4.015	0.065	1000	940	60	60	16.58	4.22
B1	450	28	50	15	3.795	3.84	0.045	1000	950	50	45	14.02	3.57
C1	450	28	70	11	5.06	5.09	0.03	1000	975	25	30	11.24	2.77
D1	600	30	30	36	4.35	4.44	0.09	1000	940	60	70	18.69	7.43
E1	600	30	50	22	4.75	4.81	0.06	1000	960	40	40	16.52	7.57
F1	600	30	70	15	4.52	4.555	0.035	1000	970	30	30	14.34	6.48
G1	750	32	30	48	4.53	4.66	0.13	1000	930	70	70	19.69	11.89
H1	750	32	50	29	4.555	4.61	0.055	1000	960	40	40	15.45	10.45
I1	750	32	70	21	4.34	4.38	0.04	1000	965	35	35	14.92	8.49
A2	450	28	30	25	4.015	4.065	0.05	1000	945	55	60	18.07	3.20
B2	450	28	50	15	3.84	3.875	0.035	1000	955	45	40	15.88	3.18
C2	450	28	70	11	5.09	5.12	0.03	1000	970	30	35	13.65	2.87
D2	600	30	30	36	4.44	4.53	0.09	1000	915	85	80	21.87	6.42
E2	600	30	50	22	4.81	4.86	0.05	1000	955	45	50	16.40	5.03
F2	600	30	70	15	4.555	4.59	0.035	1000	965	35	40	13.76	5.25
G2	750	32	30	48	4.66	4.785	0.125	1000	905	95	95	22.53	10.00
H2	750	32	50	29	4.61	4.69	0.08	1000	955	45	50	15.46	9.54
I2	750	32	70	21	4.38	4.445	0.065	1000	960	40	40	15.03	9.55

8 Data Analysis
8.1 Welding Speed Vs Bead width

8.1.1 450Amps

8.1.2600Amps

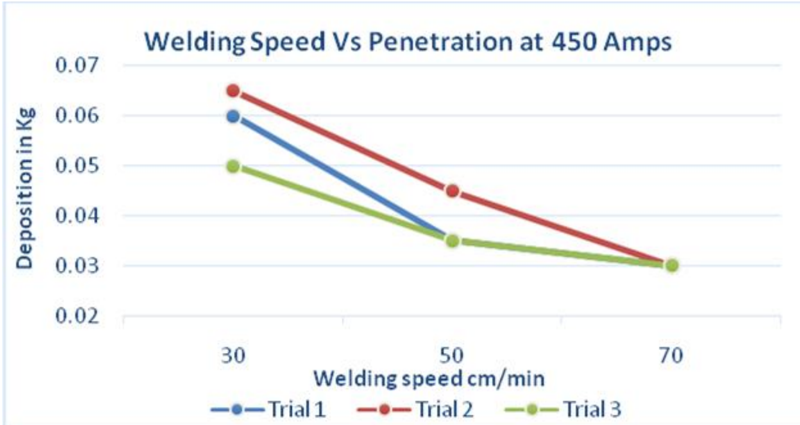
8.1.3750Amps



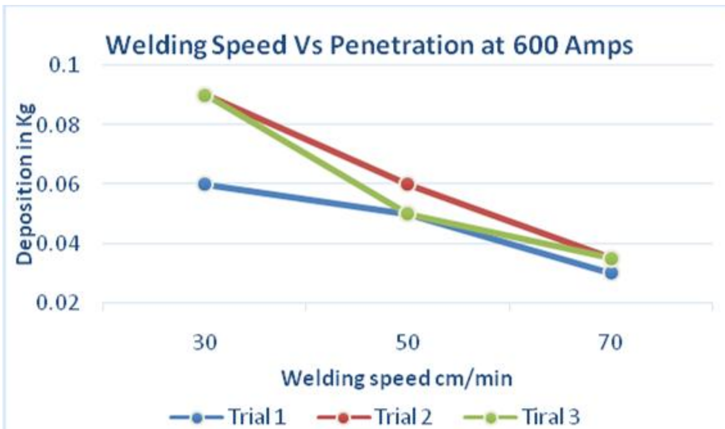
From the above three graphs weld bead increases to 19.12mm at 450Amps the maximum weld bead conditions at this current range with weld speed of 30cm/min, the graph reaches at 21.87mm at 600Amps range, for 750Amps current range the bead width reaches to maximum of 22.53mm. From the graphs it is inferred that bead width increases to maximum at weld speed of 30cm/min.

8.2Welding Speed Vs Penetration

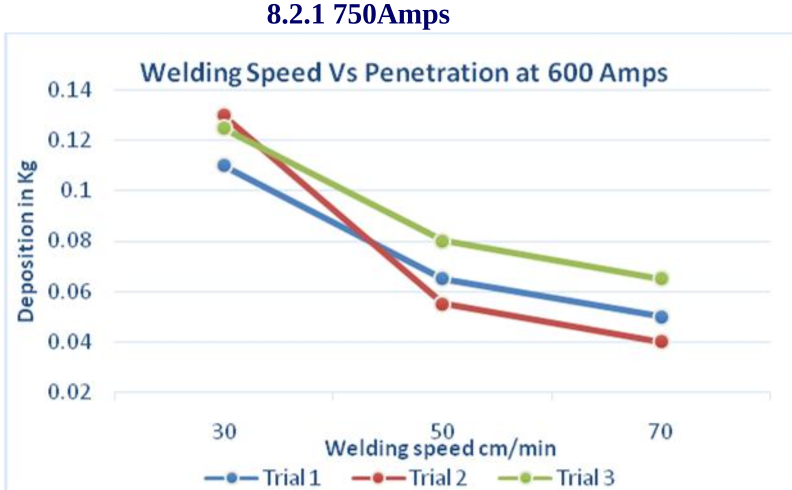
8.2.1 450Amps



8.2.2 600Amps



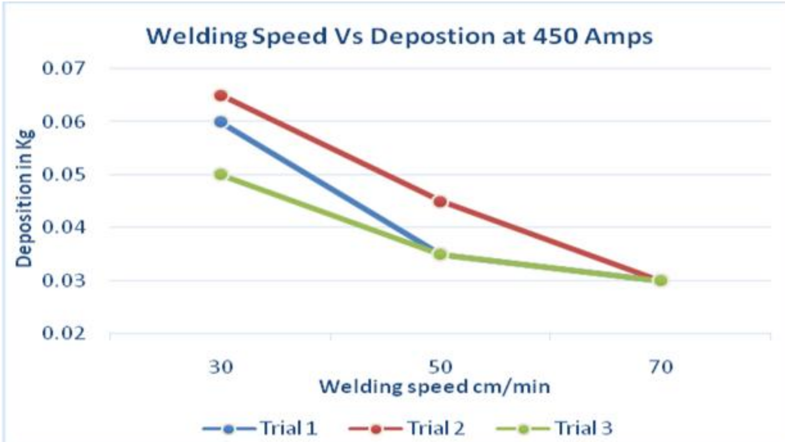
8.2.1 750Amps



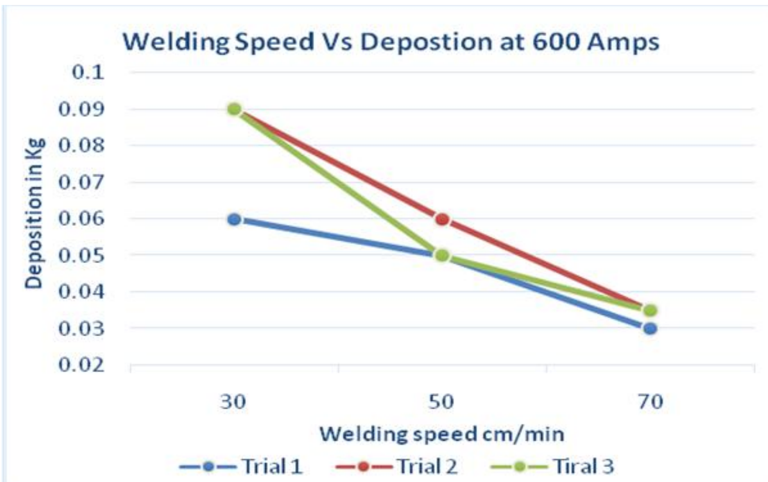
From the above graphs penetration were found out with respect to varying current and weld speed. Penetration is maximum at 30 cm/min weld speed at 450 Amps, 2) Penetration is more at 50 cm/min weld speed at 600 Amps 3) Penetration is at largest of 11.89 at 30 cm/min at 750 Amps

8.3 Current Vs Deposition Rate

8.3.1 450Amps



8.3.2 600Amps

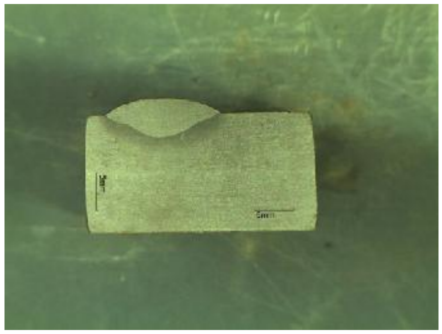
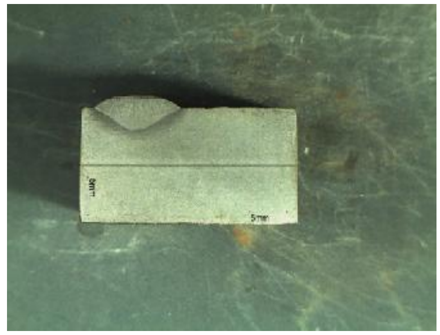


8.3.3 750Amps

From the above graphs Deposition rates are varying from 0.03 to 0.065 Kg for 450Amps, from 0.03 to 0.09 Kg for 600Amps and from 0.04 to 0.13 kg for 750Amps. It is inferred that for increase in weld speed there is increase in deposition rate. Deposition rate increases at optimum weld speed of 30cm/min

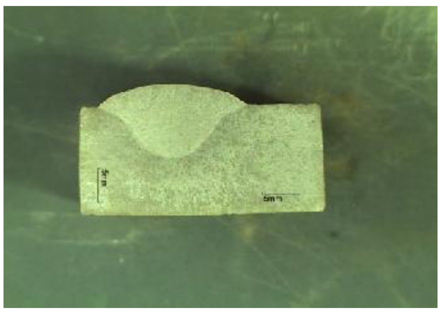
9.Microstructural Images

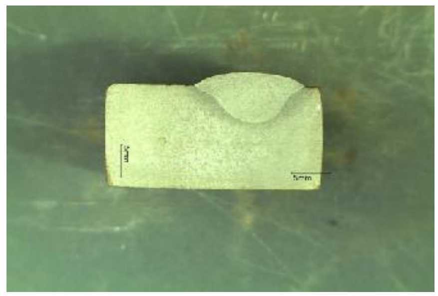
9.1 At 450Amps

Weld Speed 30 cm/min **Weld Speed 50 cm/min** **Weld Speed 70 cm/min**

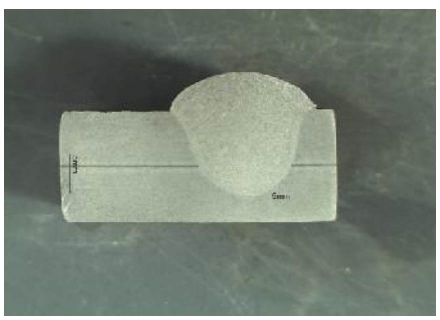
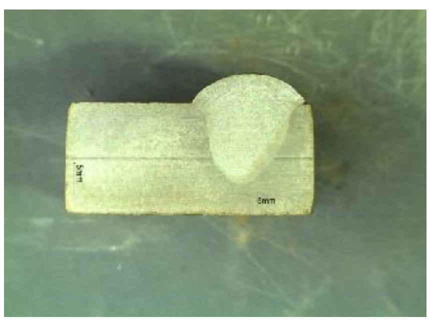
9.2 At 600Amps





Weld Speed 30 cm/minWeld Speed 50 cm/min **Weld Speed 70 cm/min**

9.3 At 750Amps


Weld Speed 30 cm/min **Weld Speed 50 cm/min** **Weld Speed 70 cm/min**

10.Results and Discussion

In this varying welding conditions, the following points are arrived

1. Bead Width increases with varying current range and good weld bead geometry obtained.
2. Penetration increases with increase in current range.
3. Flux consumption is reduced with increased weld speed and current range.
4. Slag inclusion is also reduced and consumption of flux is controlled.
5. Penetration and bead width increased with an increase in welding wire feed rate and decreased with increase in travel speed.
6. Good appearance of beads without any visual defects was observed.
7. Arc stability and slag detachability both were good with the recycled slag.

11.Conclusion

From the graghs and Microstructural images it is found that weld bead geometry is good and regular. Chance of slag inclusion in weld bead is reduced with controlled weld speed and high current range. Deposition rates and bead width also increases with high current input. The increase in bead width with increase in arc voltage is due to the fact that arc length increases with increase in arc voltage increasing the spread of arc as a result arc strikes on larger surface area which leads to increase in bead width. The decrease in bead width with increase in travel speed can be attributed to the fact that metal deposition per unit time and heat input per unit length decreases with increase in travel speed as a result smaller weld pool and hence bead width decreases.

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