Deposition Rate and Weld Bead in Submerged Arc Welding: A Review

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Abstract— Industries focuses on increasing the production with the benefits of required properties. Different methods are employed to have as much benefits without wastage. The Submerged arc welding equipment utilizes the maximum possible heat available in comparison to other welding processes. The heat generated is utilized to melt the wire and the base material. With the addition of wire into the weld bead the heat can be utilized to increase the productivity as well as reducing the heat transmitted to the base material. In this review, study of deposition rate and the weld bead in submerged arc welding is carried out...

Key words: Submerged Arc Welding; Weld Bead, Deposition Rate

I. INTRODUCTION

The Submerged Arc Welding is mostly used in manufacture of pressure vessels, ships, massive water pipes and surfacing applications. In this process, the spark is submerged in the flux, thus utilizing the maximum heat. There are various alterations to this process which are used to increase the productivity. The key process variables are travel speed ,arc voltage ,wire feed speed ,electrode stick-out polarity and current type. The process ability to utilize maximum heat is used in places where environment contamination has to be made negligible and thereby reducing the defects.

II. VARIATIONS IN SUBMERGED ARC WELDING

A. Single-Wire Welding:

In this method, single electrode is used for operation. Current passes through the electrode and arc is generated between the electrode and the base metal, thereby melting the electrode and base metal and fusing them together.

B. Twin-Arc Welding:

In this method, two electrodes are fed by the same head and the current is shared across the two electrodes. Arc is generated in both the electrodes. The method is used to increase the productivity wherein the thickness of the base material is larger.

C. Tandem Welding:

When the wires are connected to separate power units, the process is referred to as tandem welding.

D. Cold Wire Addition:

In this process, cold wire is fed across the arc produced by the electrode. The heat generated by the arc melts the cold electrode and gets deposited along with the main electrode on the weld bead.

III. LITERATURE REVIEW

Chandel R.S, Seow H.P, Cheong F.L[1] presented theoretical predictions of the effectiveness of current, electrode polarity, electrode diameter and electrode extension on the bead height, bead width, deposition rate and weld penetration .It was found that deposition rate could be enhanced by four ways : (1). using higher current value (2) using a smaller diameter electrode (3) using straight polarity and (4) by using a longer electrode extension.

Yang L. J, Chandel R. S. and Bibby M. J [2] conducted experimentation with base material ASTM A36 plate of 19-mm-thickness .It was found that with a constant heat input of 3 kj/mm, welds being done using negative electrode polarity (DCEN), a smaller diameter electrode, low voltage, long electrode extension and high welding speed were more influential to larger deposit areas.

Tusˇek and Suban [3] found by conducting an experiment with multiple-wire submerged-arc welding and cladding with metal-powder addition found that the use of metal powder will improve the deposition rate, reduce the shielding-flux consumption and the welding-arc efficiency. It was proved that by using the metal-powder addition it was possible to clad with optional characteristic elements which could improve the weld characteristics as well as proved an important feature to lower the cost of materials.

Ramakrishnan and Muthupandi [4] conducted experimentation to study the influence of process variables and weld metal property of thick section welding in SA 299 material by using cold wire addition technology in tandem submerged arc welding for fabrication of boiler drum shell .It was found that for the constant heat input, the deposition rate in single wire is 8 kg/h and with cold wire addition ,it was almost double than that of the conventional method of welding process. There was a reduction in 30% HAZ in comparison to traditional SAW process .A reduction of 40% of passes were seen to complete a weld.

Tsuyama T. , Nakai K. and Tsuji T [5] did an experimental study by inserting an electrically heated filler wire as converting it to as a hot wire into the back side of weld pool made with leading SAW electrode. The increament in the deposition rates of weld and heat input in F-SAW were 90 and 11%, respectively in comparison to those in SAW which suggested that the weld deposit can be enhanced effectively with little increase in heat input. It was proved that F-SAW will achieve lower heat input and shorter arc time for finishing welding in comparison to those in SAW.

Kozak [6] did an experimental investigation by inserting an additional wire into the arc. It was found that when inserting an additional wire at a feed rate of 3.13–6.72 m/min, the efficiency measured by the amount of weld metal was enhanced in the range of 13.7–93.5% as in comparison with surfacing without the application of additional wire .Welding current in range of 400-800 A, lead to good smoothness of the face surface and correct penetration .

Bajcer B., Hrzenjak M., Jez K. and Pompe B [7] dealt with studying and comparison between welding with several wires in different shielding atmospheres and single-wire welding. Experiments were conducted with single-wire, twin-wire and triple-wire electrodes and gas shielded arc welding with double electrodes .It is found that there is an increment in deposition rate with the increase in number of wires in the joint contact tube with same energy consumption per wire, by a factor higher than the number of wires. Heat energy input in multiple-wire welding where the wires are arranged in a line in the same direction of welding, is more favourable than in single wire welding wherein the energy input is equal per unit length of weld.

Lu Y, Chen J. S, Zhang Y.M, Kvidahl L [8] studied the application of double electrode submerged arc welding process to achieve the same amount of metal deposition rate at comparatively reduced heat input. The process was an effective technology for filet joints in ship-building that can reduce the heat input/energy consumption and giving an assurance of the amount of metal deposited. Predictive control played an influential role in successful development of the filet welding of double electrode submerged arc welding technology.

Murugan N, Parmar R.S. and Sud S.K [9]concluded that the penetration is not affected significantly by voltage and nozzle to plate distance. The bead width is not influenced much along the process but the dilution increases with increase in voltage.

Tarng H.L.,Tsai Y.S. and Tseng C.M [10] developed a feed forward neural network to model submerged arc welding process in hardfacing. He established relationships between process parameters and welding performance for bead quality.

Konkol and Koons [11] determined the influence of SAW parameters on the dimensions of the weld zone. Experiments were done on 64 welds which were made on steel plate used for X-60 line pipe by the two-wire , AC-AC SAW process. Fused acidic flux and an EL12 electrode were used in making the welds, the welding environment were similar to those that are applied in the fabrication of pipe line .It was observed that undercutting was slightly more prevalent in the thicker plate which could have been influenced because of more rapid solidification of the weld metal and high travel speed. It was found that low voltage was a factor in promoting undercutting. The bead depth was greater at high current, high electrode angle, or low travel speed. Bead height was lower at low current, low electrode stickout, low electrode angle (forward pointing), high voltage and high travel speed. Bead width was greater at high voltage, low travel speed, and in thinner plate. It was found that overlap was not significantly affected by plate thickness but higher current and low travel speeds played an influential role.

Ambroza P, Bendikiene R ,Kavaliauskiene L [12] concluded that it was possible to obtain layers of high quality and mechanical properties, by employing process of submerged arc surfacing on the surfaces of structural steel. Layers of structural steel employed to submerged arc surfacing, by using chips of high speed steel becomes alloyed with elements presented in the chips. Thus proved that it was possible to save expensive materials used in the surfacing and coating processes.

Umrigar and Chaudhry [13] conducted an experiment on stainless steel-304 material for welding by full factorial method .It was found that with increment in plate thickness, voltage and welding speed value were influential for increase in penetration .It was noted that the percentage contribution of plate thickness is 92.20 %, voltage of 0.1 % and welding speed of 0.4 % on penetration and bead width for submerged arc welding. Bead width would increase with the increase in plate thickness, voltage and welding speed.

Kiran D.V.,Cho D.W.,Song W.H, Na S.J [14] developed a three-dimensional numerical heat transfer and fluid flow model to understand the temperature distribution and molten pool behavior in a three wire submerged arc welding process .The volume of fluid method was developed to track the shape of the free surface .A physical model was developed to estimate the arc center displacement. It was noted that by connecting the leading electrode to direct current electrode positive polarity, middle and trailing electrodes to alternating current having trapezoidal waveform, the weld penetration was mainly influenced by the middle and trailing arcs interaction and the associated droplet impact. Arc center displacement and the arc root dimension's influence on the droplet detachment proved to have a significant effect on the molten metal flow and the weld pool profile in the three wire SAW process.

Kiran D.V, Cho D.W, Song W.H, Na S.J [15] studied the behavior of leading and trailing arc root dimensions and arc interaction in the two-wire tandem submerged arc welding process by employing real-time recorded current , voltage waveforms and CCD arc images for a wider range of experimental conditions.

Kiran D.V, Basu B, De A [16] did an experimental study on the influence of leading wire current, trailing wire current pulses, and welding speed on the weld bead dimensions and mechanical properties in single pass tandem submerged welding of HSLA steel. The results depicted that the final weld bead width and reinforcement height were mainly influenced by the trailing wire current while the penetration was influenced by the leading wire current. An increment in trailing wire current pulses enhance the weld pool size that may tend to reduce the cooling rate, which in turn inhibit acicular ferrite phases in weld microstructure and result in poor mechanical properties. In contrast, increase in welding speed tends to reduce weld pool size which may lead to higher cooling rate that will encourage greater volume fraction of acicular ferrite phase and better weld bead mechanical properties.

Shen S, Oguocha I.N.A, Yannacopoulos S [17] carried out a series of experiments on specimens of submerged arc welded plates of ASTM A709 Grade 50 steel to determine how variation in heat input by employing single and double wires were influencing bead reinforcement, bead width, penetration depth, heat affected zone (HAZ) size, contact angle, deposition area, penetration area and total molten area. The bead reinforcement, bead width, penetration depth, HAZ size, deposition area and penetration area increased with increasing heat input but the bead contact angle decreased with it. The electrode melting efficiency increased initially and then decreased with increasing heat input but the plate melting efficiency and percentage dilution varied only slightly with it.

Tušek [18] established that welding gaps and welding edges can be joined by multiple-wire welded with different number of wires and a different arrangement of the wires in the joint contact tube. It was concluded that the weld geometry was influenced mostly by the wire arrangement in the contact tube.The most significant results of bridging root gaps was found in twin-wire electrode welding wherein the wires were arranged in the direction transverse to the direction of welding. In triple-wire electrode welding, larger gaps could be were filled in a single pass. With the triangular wire arrangement, asymmetric welds were obtained, which was very favourable in welding of workpieces of different masses and shapes. Multiple-wire welding showed higher energy efficiency as the energy input in the weld per unit volume is lower.

Sharma and Khan [19] dealt with the investigation to find out optimal submerged arc welding (SAW) process parameters that affected weld bead geometry and quality of welds using Taguchi method. A planned experimental investigation was carried out on a semiautomatic SAW machine. The influence of process variables and signal to noise ratios were computed and the contribution of each factor were validated by ANOVA. The response of S/N ratio with respect to penetration indicated that the welding voltage is the most significant parameter that would control the weld penetration whereas the other parameters were comparatively less influential. The contribution of voltage, current, trolley speed and nozzle to plate distance were 60.8%, 9.86%, 3.54% and 13.8% respectively. Optimum results were obtained by Taguchi method using voltage 26, current 475, trolley speed 0.25, NPD 16.

IV. SUMMARY

Submerged Arc Welding process has the maximum thermal efficiency compared to other arc welding processes. Variations are done to increase the productivity by utilizing the maximum potential of the process. The control parameters as voltage, welding current, welding speed have significant effect on the type of weld to be produced .The parameters should be optimized in a manner so that the weld obtained is of the desired quality .As without the desirable properties, the weld would not be feasible for the industries.

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