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Study of Heat Transfer Rate on Multipass Submerged Arc Welding

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ABSTRACT

In arc welding the heat flow from the tip of the electrode to the base metal. The heat transfer rate is generally based on the work material, weld material, welding process, inert gases etc. The heat transfer rate and rate of cooling in welding can directly controls microstructure and mechanical properties of welded region and base metal. The proposed study going to conduct out on multipass submerged arc welding for varying heat input. The one dimensional, two dimensional and three dimensional heat flow equation will be used for the total heat transfer rate in submerged arc welding. The corresponding mechanical properties hardness c-v-n test results tensile strength of welded joint will be studied. This process is use full in joining thick section of components used in various industries. Therewithal joining SAW can also be used for surface applications. Heat affected zone produced in within the base metal as a result of tremendous heat of arc is of big concern as it affects the performance of welded surfaced structure in service due to metallurgical changes in the affected region. The various changes in the metal can be analyzed by heat transfer rate. The various sub zones in the microstructure were observed in HAZ of SAE weld of partially transformed. The main motive of proposed work is to investigate and correlate the study of heat transfer rate on multipass submerged arc welding.

Keywords:**Base metal, Submerged Arc Welding, Stainless steel, Heat transfer rate, Microstructure of arc weld joint, Mechanical properties.**

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I. INTRODUCTION

Submerged Arc Welding (SAW) is one of the large metal fabrication techniques in industry due to its reliability and capability of producing good quality weld. The ability to join thick plates (as thick as 1.5 inch) in a single pass, with high metal deposition rate has made this process useful in large structural applications. Indeed various research works have been explored on various aspects of submerged arc welding, yet investigations are still being carried on to study the phenomenon that occurs during the process of submerged arc welding, and many other related matters, so that the process becomes controllable more precisely, and can be monitored well, both manually as well as automatically.The normal variables of submerged arc welding like required current, voltage, travel speed and bed geometry like height, width, hardness and quality. To understand the quality of specimen and mechanical properties of specimen like strength, toughness,it is important to know the microstructures and micro hardness values of the weld metal and heat-affected zone regions. The essential requirements of weldable steels are enhanced strength, toughness,better microstructure and durability of the welded structures and economy in fabrication.Boiler and pressure vessel plate are the most important structural materials for construction efficient and practical metal joining process which is widely used in industries such as nuclear, aerospace, automobile, transportation. Submerged arc welding gives the highly strong joints of the plate. Toughness is the ability of a metal to resists fracture while being loaded under the conditions that are unfavourable for energy absorption and plastic deformation, high toughness of weld and heat-affected zone are important characteristics of a weldable steel, high toughness in a certain way ensures good behaviour of the welded structures even in case of severe service conditions. Mild steel exhibits good ductility when an ordinary tensile specimen is tested. When the steel contains sharp notch and temperature is low, however a crack may initiate from the notch, causing brittle fracture of the plate.

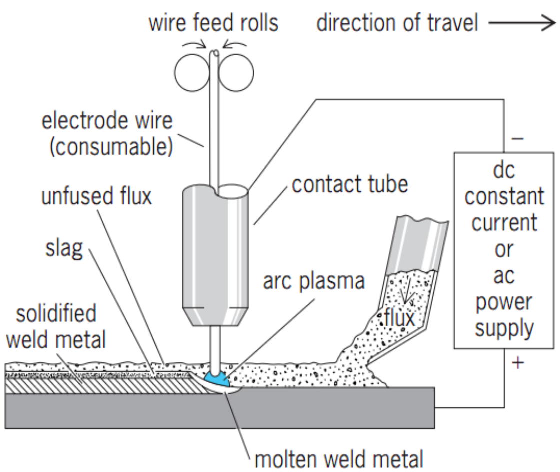

Fig: 1 Submerged Arc Welding process.

Automatic submerged arc welding is a versa-tile process, as it gives best quality, saves time, reduces cost, resurfaces wear surfaces on steel castings, improves repair procedure, process control, increases efficiency and productivity.

In submerged arc welding, various process parameters interact in a complicated ways, and their interactions influence the bead geometry, bead quality also the metallurgical characteristics and mechanical properties of the weldment. Acceptability of the weldment depends on various quality characteristics that confirm functional requirements of the welded joint in the all area of application. In almost cases, quality of the weld is left to depend upon the past experience and working skill of operator. But, with the advent of automation, it is now possible to design a machine capable of selecting optimal process parameters to provide desired yield.

II. LITERATURE REVIEW

The studies of heat input in welding investigated by different researchers are as follows.

P.J.Konkal and G.F.Koons [1] were found Optimization of the Parameters forTwo-Wire AC-AC Submerged Arc Welding on 64 bead-on-plate welds which is made up of EL12 electrodes and a fused acidic flux are analyzed statistically to determine the effects of various parameters on weld proportion and designed to quantitatively determine the effect of plate thickness and welding current, voltage, travel speed, electrode sickout and electrode angle on such types of weld-zone features as penetration and shape of the bead. The main purposes of 64 experimental runs, was to provide adjusting welding parameters to understand undesirable weld-geometry features, such as excessive reinforcement, undercutting, and inadequate joint penetration and provide information for selecting the parameters that would not able to increase in weld travel speed, thus increasing the throughput at the welding facilities. . It observed that bead depth was greater at high current, high electrode angle, or low travel speed. Bead height was lower at low current, low electrode sickout, low electrode angle, high voltage, or high travel speed. Bead width was greater at high voltage, low travel speed, and in thinner plate. The distance was smaller at low current and high travel speed. The angle between the base metal and weld bead was smaller at low current, short sickout (extension), low electrode angle, high voltage, and high travel speed. X.R.Li,*etal.* [2] were investigated penetration depth monitoring and control in Submerged Arc Welding. In the submerged arc welding process is modeled the partial penetration depth and feedback controlled based on the base metal current. The base metal current that controls weld penetration is directly reduced, and the ability to adjust the base metal current to control weld penetration without reducing deposition rate is introduced into SAW. It was found that the base metal current is the main parameter that determines weld penetration with a sufficient accuracy when other major parameters are in their stated ranges. H.Om and S.Pande [3] were studied effect of heat input on dilution and heat affected zone in submerged arc welding process has useful in joining thick section component used in the various industries and SAW can also be used for surfacing applications. Heat affected zone (HAZ) produced within the base metal for a result of extreme heat of arc is of big concern as it affect the performance of welded surface structure in service due to metallurgical changes in the affected region. This work was investigating the effect of polarity and other SAW parameters on HAZ size and dilution to found their correlation. . H.W.Ebert and F.J.Winsor [4] were studied in submerged arc welding process, parameters are current, arc voltage, travel speed and nozzle to plate distance. They all affect the microstructure and mechanical property of the welded joints. A Mechanical properties of hardness, tensile strength and toughness in arc welded mild steel plates were found to be higher in the heat affected zone and reduce to the base metal value under all the welding conditions. Impact of initial metal preheat on mechanical properties diminishes with increased temperature in the heat affected zone. Microstructures of preheated specimens differ from the no preheat specimen, showing traces of precipitation of bainite. B.Beidokhti and R.Pouriamanesh [5] were studied effect of filler metal composition on the microstructure and mechanical properties of four wire tandem submerged arc welded API 5LX65 steel were studied. Different types of tests were carried out like Micro hardness, Charpy impact, and all weld longitudinal round tensile to evaluate the mechanical properties of the weld metals. The microstructure of the specimens was studied by optical and scanning electron microscopes. The micro structural observations showed that the more acicular ferrite was formed in the microstructure; the mechanical properties were achieved better.

III. PRINCIPLE OF WORKING

A submerged arc welding machine has basic principles of to find the optimize heat in welding for fusion zone, heat affected zone and base metal. The flux starts depositing on the joint to be welded. Since the flux when cold is non-conductor of electricity, the arc may be struck either by touching the electrode with the job or by placing steel wool between electrode and job before switching on the welding current or by using a high frequency unit. In all cases the arc is struck under a cover of flux. Flux otherwise is an insulator but once it melts due to heat of the arc, it becomes highly conductive and hence the current flow is maintained between the electrode and the work piece through the molten flux. The upper portion of the flux, in contact with atmosphere, which is visible remains granular (unchanged) and can be reused. The lower, melted flux becomes slag, which is waste material and must be removed after welding. The electrode at a predetermined speed is continuously fed to the joint to be welded. In semiautomatic welding sets the welding head is moved manually along the joint. In automatic welding a separate drive moves either the welding head over the stationary job or the job moves/rotates under the stationary welding head.

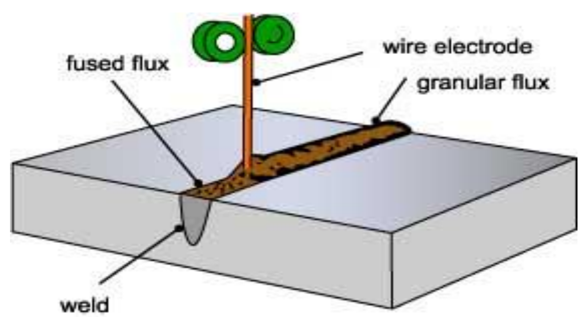

Fig: 2 Base metal welding.

In submerged arc welding, the electrode type and the flux type are usually based on the mechanical properties required by the weld. The electrode size is related to the weld joint size and the current recommended for the particular joint. This must also be considered in determining the number of passes or beads for a particular joint. Welds for the same joint dimension can be made in many or few passes, depending on the weld metal metallurgy desired. Multiple passes usually deposit higher-quality weld metal. Polarity is established initially and is based on whether maximum penetration or maximum deposition rate is required.

IV. EXPERIMENTAL SETUP

Experimental set up consist of a mild steel rectangular plate 300mm*75mm*12mm length, height and width respectively. Initially the material is cut into approximate size of the base metal as shown in figure. Then the standard joint preparation as per British standard Was made on lathe machine having 60^0 root pass was given to the joint by MMAW of 2 mm root gap with 120 A current 80V voltage. For getting good penetration inside the root and avoiding voids the joint was finished on central grinding wheel. To avoid distortion during welding the samples were fixed by using suitable clamping arrangement on gigs fixture on machine table. The detailed composition of parent metal is as given by in Table 1.

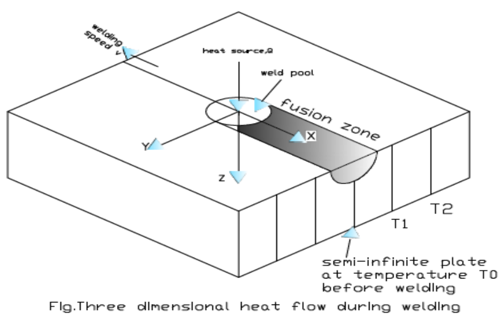

Fig: 3 3D Heat Flow during Welding

TABLE: I

Composion of metal plate

Element	C	Si	Mn	S	P
%	0.20	0.016	0.75	0.035	0.035

The welding process is to be select for present experimental work has submerged arc welding (SAW). Thermocouples (K-type) are used to measure the transient temperature distribution during welding. The thermocouples are set in the equal distance from the weld centre line. The dimensional details of plates and position of thermocouple also fixed are shown in Figure. Multipass welding was carried out at Submerged Arc Welding equipment. During multipass welding, temperature is measured with respect to time, by thermocouple for different points which is shown in the figure from semi infinite plate of the temperature T_0 to temperature T_1, T_2 respectively. These readings of temperature are useful to draw temperature distribution. Temperature distribution plays important role for finding the distortions and total heat input effect on micro hardness and microstructure. The temperatures measured at 2 minute at welding started. Precaution was taken to ensure thermocouple connections were not disturbed during flux removal. The duration of welding was noted down for each passes. The experiment can be done by using copper coated mild steel electrode. The joint can be filled five number of passes of the electrode. The different temperature distributions during experimentation were recorded by temperature meter. Parameters used during the welding process are shown in below table.

Table:II

Welding process parameters.

Parameter	Notation	Units
Arc voltage	V	Volts
Welding current	I	Amps
Welding speed	S	mm/min

To calculate heat input for submerged arc welding the following equation can be used.

$q = (V*I*60)/(s*1000)$

Where, q = Heat Input (KJ/mm)

V = Voltage (V)

I = Current (A)

S= Welding Speed (mm/min.)

From the above equation we can find out the initial heat that is heat input required to the base metal. To calculate the effect of heat transfer rate on microstructure of metal plate (mild steel) we can use the following equation.

$Q = -KA (T_0-T_1)/dx$

Where, Q = Heat Transfer Rate.

K=Thermal Conductivity.

A=Area of plate.

T_0=Initial Temperature.

T_1=Final Temperature.

dx= Thickness of plate.

The above equation can be used to obtained the effect of heat transfer is different at different point. After completion of measurement of temperature the Charpy specimen are used for checking the toughness on the Charpy V Notch testing machine for both welded region as well as heat-affected zone region. Then the mechanical properties of the materials like strength, hardness, toughness can be check out.

V. RESULT AND DISCUSSION

After conducting the experiments in the multipass submerged arc welding process parameters are to be directly affecting the number of passes on the joint of base metal. It also affects the total heat input given the parameter. The individual effect is higher to the current, voltage, speed on hardness of weld and heat affected zone. Hardness is less in the weld metal and hardness is higher in HAZ that is heat affected zone. When hardness is increases that time cooling rate also increases. During welding the temperature become increases in fusion zone and metal will be deposited from the electrode to join the weld surface. The reduction in the micro hardness is higher at the arc voltage lower and reduction in micro hardness is lower at arc voltage high. When voltage is increases the structure of micro hardness decreases. When the welding current is increased the micro hardness is reduced. Increase in to the welding current, there is a linear increase in heat input, due to that there is increased heat input the reduction in average cooling rate in every pass. And reduction in heat input causes increase in micro hardness value of the specimen.

VI. CONCLUDING REMARKS

While doing the experiment results it can be conclude that the variations in microstructures and mechanical properties are observed at each and every pass of SAW weld joint due to continuous changes in heat transfer rate in the welded metal following results were obtained. Welding parameter of the submerged arc welding can be used to control the mechanical properties of the materials. When the welding current is increased the micro hardness is reduced. When voltage is increases the structure of micro hardness decreases.

VII. NOMENCLATURES

SAW**-** Submerged arc welding.

HAZ**-** Heat affected zone.

BM**-** Base metal.

c-v-n**-** Charpy v- notch test

C- Carbon

Si- Silicon

Mn- Magnesium

S- Sulphar

q - Heat Input (KJ/mm)

V - Voltage (V)

I - Current (A)

S-Welding Speed (mm/min.)

Q - Heat Transfer Rate.

K-Thermal Conductivity

A-Area of plate

T_0-Initial Temperature.

T_1-Final Temperature.

dx- Thickness of plate.

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REFERENCES

[1] P. J. Konkol and G. F. Koons [1978], "Optimization of Parameters for Two-Wire AC-AC Submerged Arc Welding", welding research supplement, Vol.12, pp367-374.

[2] X. R. Li, Y. M. Zhang, and L. Kvidahl [2013], "Penetration Depth Monitoring and

Control in Submerged Arc Welding", welding research, Vol.92, pp48-56.

[3] Hari Om and Sunil Pandey [2013], "Effect of heat input on dilution and heat affected zone in submerged arc welding process", Indian academy of sciences, Vol.38, pp1369-1391.

[4] H. W. Ebert and F. J. Winsor [1980], "Carbon steel submerged arc welds tensile strength vs. corrosion resistance", welding journal, Vol.7, pp193-198.

[5] B. Beidokhti And R. Pouriamanesh [2015], "Effect of Filler Metal on Mechanical Properties of HSLA Welds", welding journal, Vol. 94, pp334 -391.

[6] K. P. Kolhe and C.K.Datta [2008], "Prediction of microstructure and mechanical properties of multipass saw", Journal of Materials Processing Technology (JMPT), Vol.197, pp.241-249.

[7] Dipti Jaiswal [2013], "Analysing the Effect of Parameters in Multipass Submerged arc WeldingProcess", International Journal on Theoretical and Applied Research in Mechanical Engineering (IJTARME), Vol.2, pp.60-70.

[8] R. A. Daemen And F. Dept [1970], "Submerged arc Stainless Steel Strip Cladding", welding research supplement, Vol.1, pp33-40.

