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Effect of Various Parameters on Flux Consumption, Carbon and Silicon in Submerged Arc Welding (Saw)

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ABSTRACT: The submerged arc welding process is most widely used arc welding process for joining thick plates and pipes. The features that distinguishing submerged arc welding from other arc welding process is granually fusable material termed as flux. The flux used in submerged arc welding contributes a major part (above 50%) towards the total welding cost. The properties of weld metal have been found to be dependent upon flux-electrode-base metal-composition on welding parameters. Flux and filler metal play a central role in ascertaining property of weld metal. In the present work, the effect of operating arc voltage, welding current, welding speed and nozzle distance on flux consumption and chemical composition of carbon and silicon has been studied. Mathematical model was developed from data generated using two level half factorial technique. The experiment is conducted as per the design matrix. Design Expert software 7 is used in order to (i) the designing of a set of experiments for adequate and reliable measurement of the true mean response of interest (ii) the determining of mathematical model with best fits (iii) finding the optimum set of experimental factors that produces maximum or minimum value of response and (iv) representing the direct effects of process variables on the flux consumption, current and silicon through two dimensional graphs. It was observed that the flux consumption decrease with increase in wire feed rate and its welding speed. The flux consumption increase with increase in arc voltage. The effect of constant tip to work distance has in significant effect on flux consumption. Carbon percentage increase with increase in arc voltage and welding speed. Carbon percentage decrease with increase in welding current. Silicon percentage decrease as increase in current and voltage.

I. INTRODUCTION

Welding is the process of permanently joining two or more metal parts by melting the different materials. The molten metal are quickly cooled down and metals are permanently bonded together. Welding is comparatively a new term among the fabrication processes, though smith forging which was used to join metal pieces. Submerged Arc Welding is a fusion welding process in which the heat is produced from an arc which is in between the work and the continuously fed filler metal electrode. A thick blanket of molten flux protects the molten weld pool from its surrounding atmosphere and a slag is formed from the granular fluxing material which is pre-placed on the work. The modern submerged arc welding is an arc welding process in which one or more arc are formed between one or more bare wire electrodes and the work piece provides the heat for the coalescence. Submerged arc welding shields the weld arc using a granular flux fed into the weld zone forming a thick layer that completely covers the molten zone and prevents spatter and spark. It also acts as a thermal insulator, permitting deeper heat penetration. The process is obviously limited to welding in a horizontal position and is widely used for relatively high speed sheet or plate steel welding in either automatic or semiautomatic configuration. In fully automatic welding, the flux is fed mechanically to the joint ahead of the arc, the wire is fed automatically to the welding head, the arc length is automatically controlled and the traverse of the arc or the working is also mechanized. In semiautomatic version, the wire feed and the arc length control automatic, while the welder moves the welding gun, usually equipped with flux feeding device, along the joint at a controlled rate of travel. Similar to MIG welding, SAW involves formation of an arc between a continuously-fed bare wire electrode and the workplace. The process uses a flux to generate protective gases and slag and to add alloying elements to the weld pool. A shielding gas is not required. Prior to welding, a thin layer of flux powder is placed on the workpiece surface. The arc moves along the joint line and as it does so excess flux is recycled via a hopper. Remaining fused slag layers can be easily removed after welding. As the arc is completely covered by the flux layer, heat loss is extremely low.

This produces a thermal efficiency as high as 60% (compared with 25% for mannual metal arc). There is no visible are light, welding is spatter-free and there is no need for fume extraction. The important process variables in submerged arc welding include the welding current, arc voltage and welding speed. However, the weld bead geometry is also affected considerably by electrode-to-work angle, inclination of the work piece (uphill or downhill), joint edge preparation, electrode stick out, the kind of current and polarity, electrode diameter, and the type and grain size of the flux. The metallurgical properties of the fluxes affect the weld metal chemistry and have been classified as: Oxidizing potential and Chemical characteristics. These properties of the fluxes affect the weld metal chemistry by way of interaction between molten metal and flux. The reaction between metal and slag are essentially of oxidation – reduction type and depend upon the chemical characteristics and oxidizing power of fluxes. Although different researches have carried out studies on element transfer and oxygen content of weld metal by using commercial as well as experimental fluxes but the result are only of empirical nature. To correlate the flux type and composition with the welding behavior and weld bead chemistry Which is necessary to lay a sound scientific foundation for flux formulation and electrode selection or welding of a particular type of steel, is of utmost importance.

II. METHODOLOGY

As submerged arc welding can operate over a wide range of welding current, arc voltage and travel speed which govern the rate of heat put , size , shape and temperature of weld pool, cooling rate as a result weld metal composition get affected. During submerged arc welding, weld metal chemistry is determined mainly by welding consumable and operating variables. Significant effect of welding parameters such as welding current, arc voltage and travel speed etc, on weld metal chemistry has been reported by Kanjilal *et al.* (2006) [21] and S.K. Majumdar *et al*. (2005) also observed that welding parameters have significant effect on element transfer behavior in submerged arc welding [17]. Since the final composition of weld metal and hence the mechanical properties of weld is determined by flux and operating parameters.

Furthermore, with increasing demand of automation and stringent control of weld metal composition, the selection of welding parameters must be more specific to ensure adequate weld quality. This fact necessitates the development of model (equation between weld metal composition and welding parameters) for analyzing, predicting and controlling the weld metal composition. So, the effect of welding parameters on flux consumption and weld metal composition was investigated. EH – 14 filler wire was used. Wire feed rate, arc voltage, travel speed and contact tip – to- work distance were selected as independent controllable variable because they govern the rate of heat input which is responsible for melting of flux, filler wire and base metal. The mild steel plate used as a work material and the dimension 170 × 80 × 10 mm.

Design expert 7 has been used to identify the effects of flux consumption, carbon and silicon. Design-Expert, version 7 software (DX7) is a powerful and easy-to-use program for design of experiments (DOE). With it you can quickly set-up an experiment, analyze your data, and graphically display the results. This intuitive software is a must for anyone wanting to improve a process or a product.

III. RESULT AND DISCUSSION

A. Effects on Flux Consumption

Effect of wire feed rate on flux consumption. Fig. 1 indicates the effect of wire feed rate on flux consumption. It can be observed that flux consumption decreases linearly from 1.45 to 0.6kg/kg of weld metal deposited with an increase in wire feed rate from 250 to 300 mm/min. This decrease in flux consumption is due to the fact that with the increase in wire feed rate, the metal deposition rate increases and consequently the overall ratio of flux consumption to the metal deposited decreases.

Effect of arc voltage on flux consumption. Fig. 2 indicates the effect of arc voltage on flux consumption. The flux consumption increased from 0.87 to 1.28 kg/kg of metal deposited with an increase in arc voltage from 25 to 30 volts. The increase in slag consumption with increase in arc voltage can be attributed to the fact that the increase in arc voltage increases arc length, thereby increasing the spread of arc and hence higher amount of flux coming in contact with the arc.

Effect of travel speed on flux consumption. Fig. 3 indicates the effect of travel speed on flux consumption. The flux consumption slightly decreased from 0.12 to 0.09 kg/kg of metal deposited with an increase in travel speed from 250 to 300 mm/min

Effect of nozzle distance on flux consumption. Fig. 4 indicates the effect of nozzle distance on flux consumption. The flux consumption slightly increased from 1.0 to 1.1 kg/kg of metal deposited with an increase in nozzle distance from 18 to 24 mm.

B. Effects on Carbon

Effect of wire feed rate on carbon. Fig. 5 indicates the effect of current on carbon percentage. The carbon percentage decreased from 0.81 to 0.065% with an increase in current from 300 to 350 ampere.

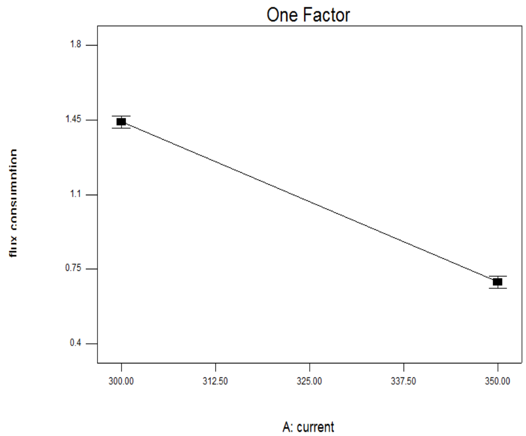

Fig. 1. Flux consumption vs Welding current.

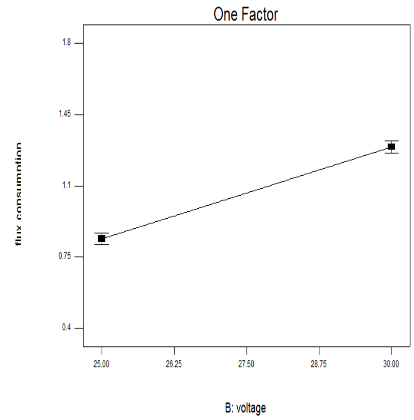

Fig. 2. Arc voltage vs flux consumption.

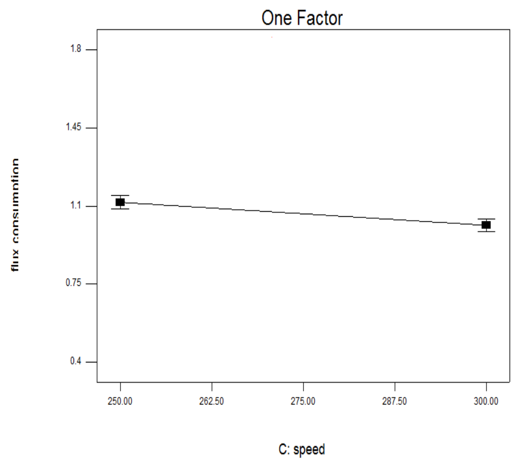

Fig. 3. Travel speed vs flux consumption.

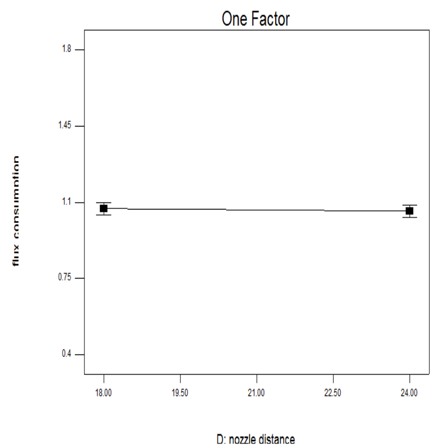

Fig. 4. Nozzle distance vs Flux consumption

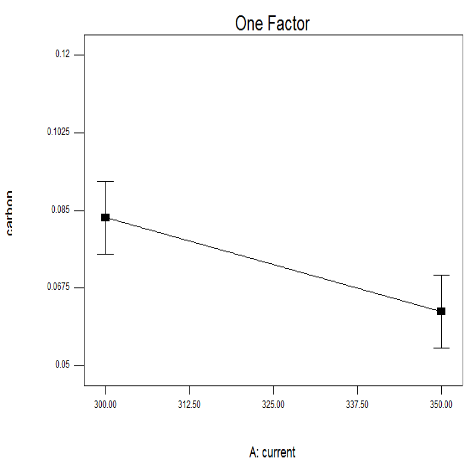

Fig. 5. Current vs Carbon.

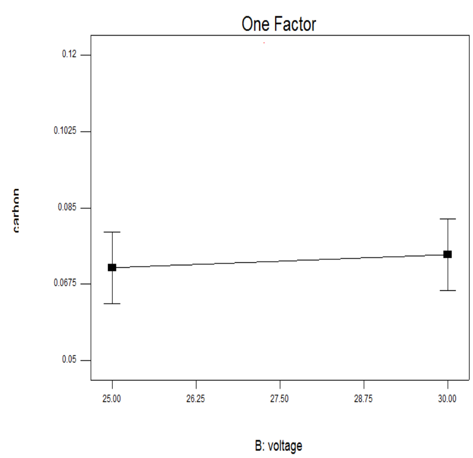

Fig. 6. Voltage vs Carbon.

Effect of voltage on carbon. Fig. 6 indicates the effect of voltage on carbon percentage. The carbon percentage increased from 0.069 to 0.073% with an increase in voltage from 25 to 30 volt.

C. Effects on silicon

Effect of Current on Silicon. Fig. 7 indicates the effect of current on silicon percentage. The silicon percentage decreased from 0.16 to 0.13% with an increase in current from 300 to 350 ampere.

Effect of Voltage on Silicon. Fig. 8 indicates the effect of voltage on silicon percentage. The silicon percentage slightly decreased from 0.14 to 0.13% with an increase in voltage from 25 to 30 volts.

Effect of Speed on Silicon. Fig. 9 indicates the effect of speed on silicon percentage. The silicon percentage slightly increased from 0.13 to 0.15% with an decrease in speed from 250 to 300 mm/min.

Effect of Nozzle Distance on Silicon. Fig. 10 indicates the effect of nozzle distance on silicon percentage. The silicon percentage increased from 0.12 to 0.15% with an decrease in nozzle distance from 18 to 24mm.

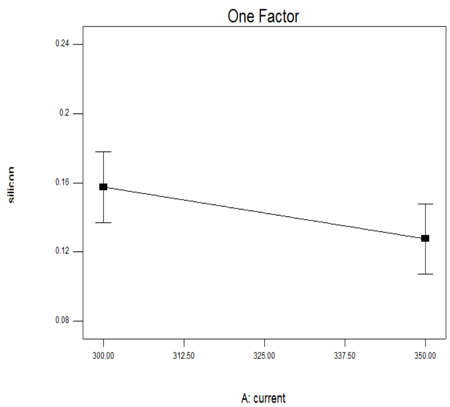

Fig. 7. Current vs Silicon.

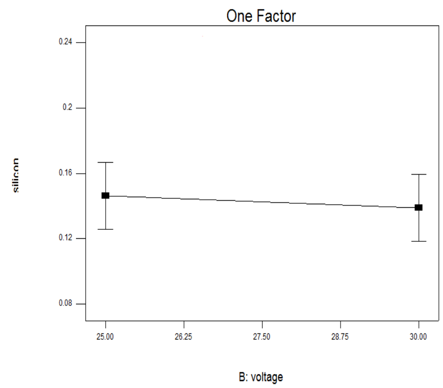

Fig. 8. Voltage vs Silicon.

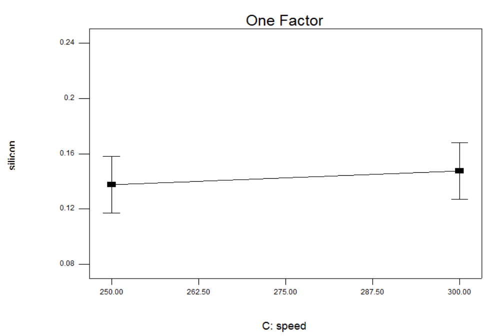

Fig. 9. Speed vs Silicon.

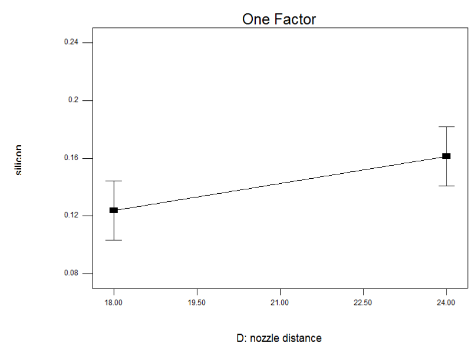

Fig. 10. Nozzle distance vs Silicon.

V. CONCLUSION

It was observed that flux consumption decrease with increase in welding current. It is due to increase in heat input, increases with increase in arc voltage due to the heat input and arc length, decreases with increase in welding speed due to high speed and the flux does not get proper time for consumption, decreases with increase in nozzle to distance due to effect of welding current and heat input decrease with increase in nozzle distance. This study also reported that carbon decrease with increase in welding current due to increase in heat input, increase with increase in arc voltage due to the heat input and arc length carbon increase with increase in welding speed increase with increase in nozzle to distance. It was also observed that silicon decrease with increase in welding current due to increase in heat input decrease with increase in arc voltage due to the heat input and arc length increase with increase in welding speed, increase with increase in nozzle to distance due to effect of welding current and heat input decrease with increase in nozzle distance.

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