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Experimental Study on Bead Width Changes of St 52-2 Carbon Steel Welds Produced by Submerged Arc Welding Process

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Abstract: In welding industry, submerged arc welding process (known as "SAW") is recognized as a modern Fusion-Arc Welding Process. This process uses an electrical arc between consumable electrode tip and workpiece (as arc length). The electrode is continuously fed into molten region and this region is protected by a blanket of granular flux during welding process. Due to its special nature, this technology is normally used for flat-position and horizontal-fillet welding position. In this investigation, the relationship between SAW variables and bead width in a type of medium carbon steel having 10 mm thickness was experimentally studied. The welding current, arc voltage and welding speed were chosen as welding variables and welding joints were prepared for different values of selected variables. After finishing the welding process, the bead width (W) was measured for any given welding condition.

Key words: Welding variables; bead dimensions; medium carbon steel.

INTRODUCTION

Welding technology is used to join the different materials eternally. The fusion welding processes include melting the base materials and adding a filling metal to create a molten pool which is protected by gas (active or inert), slag or both of them. In continue, the molten pool is solidified and the parts are permanently bonded together. SAW is one of the oldest automatic welding processes introduced in 1930s to provide high quality of weld (Howard Cary, 1979; Nadkarni, 1988). This process is widely employed as one of the major fabrication processes in industry due to its inherent advantages of deep penetration, smooth bead and superior quality (Houldcroft, 1989). Basic of SAW process has been shown in Fig. 1.

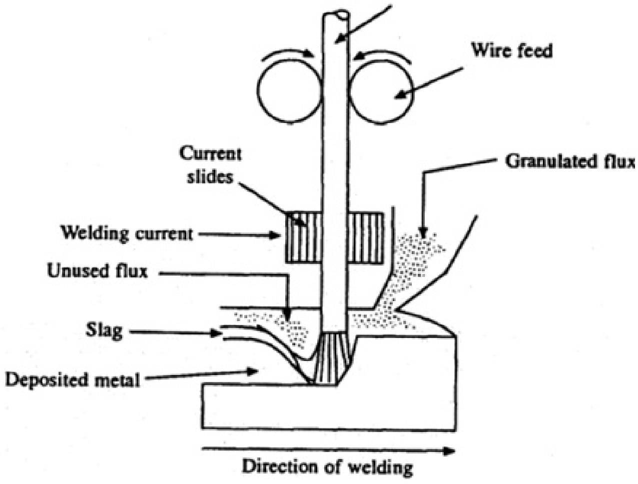

Fig. 1: A schematic of SAW process (Kumanan and *et al.*, 2007)

Since, the weld bead parameters such as depth of penetration and bead width (which have been shown in Fig 2) are directly influenced by input welding variables such as welding current (I), arc voltage (V) and welding speed (S), thus the optimization of these variables is noteworthy to obtain a desired weld bead dimensions.

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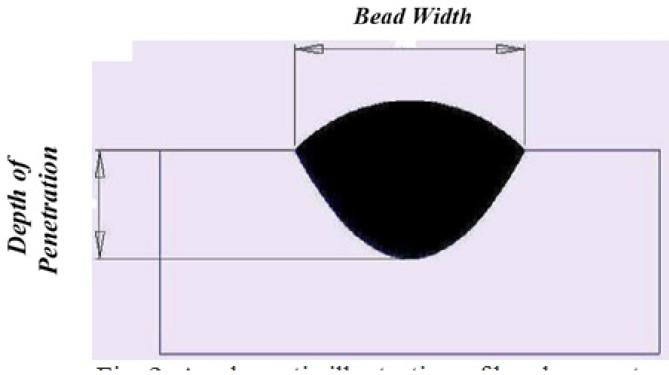

Fig. 2: A schematic illustration of bead geometry

Investigation into the relationship between the welding process parameters and bead geometry began in the mid 1900s and regression analysis was applied to welding geometry research by Lee and Raveendra (Lee and Um, 2000; Raveendra and Parmar, 1987). Many attempts have been made to understand the effect of the SAW variables on the weld bead dimensions. However, as far as our knowledge, there exists very few information about relationship between SAW variables and bead dimensions of St 52-2 carbon steel welded joints in the available literatures. Present paper has attempted to study the effect of welding current, arc voltage and welding speed on weld bead width of joints produced by SAW. The inputs variables and output result of present research have been schematically shown in Fig. 3.

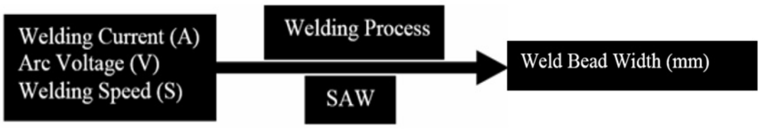

Fig. 3: Schematic of inputs and output for present research

MATERIALS AND METHODS

Due to high industrial importance, St 52-2 carbon steel plates (accordance to DIN 17100 Standard) were selected as base metal in this research. The chemical composition of base metal has been shown in Table 1.

Table 1: Chemical composition of base metal

Element	C	Si	Mn	P	S
% wt	0.22	0.52	1.58	0.04	0.033

The plates were cut into 2 strips of 1300 mm×100 mm×10 mm. For reducing the possibility of welding defects such as porosity, spattering and lack of fusion, the strips were completely cleaned prior to welding process and in order to minimize weld distortion, before welding operation base metals were located in the fixture jig. The plates were single pass butt-welded with no edge preparation. SAW operations were performed by means of an automatic XWRS 2500 machine having a working capacity of 0-700A and 0-50V ranges. The SA MS 1 89AC (EN 760 classification) was selected as flux and EM12K (AWS/ASME SFA5.17 classification) was selected as welding wire in this research. The chemical composition of flux and welding wire has been shown in Table 2 and 3.

Table 2: Chemical composition of flux

Component	SiO_2+TiO_2	CaO+MgO	Al_2O_3+MnO
% wt	45	10	40

Table 3: Chemical composition of welding wire

Element	C	Si	Mn	Cu	P	S
% wt	0.11	0.20	1	0.11	0.006	0.009

The welding variables and limits employed were given in Table 4.

Table 4: Process parameters and limits

Parameter	Limits
Welding Current (A)	330, 340, 350, 360, 370
Arc Voltage (V)	22, 24, 26, 28, 30
Welding Speed (cm/min)	32, 42, 52, 62, 72

After the welding process, the test specimens were cut perpendicular to welding direction then cleaned, polished and etched in order to measure the bead width.

RESULTS AND DISCUSSION

Totally 15 experiments with different values of welding current, arc voltage and welding speed were carried out and the weld bead width was measured for any of given conditions. The results were shown as in Figs. 4-6.

a). Effect of Welding Current on Weld Bead Width:

In Fig. 4, the arc voltage and the welding speed were fixed as 26 V and 52 cm/min and the change in weld bead width was drawn with increasing the welding current from 330 to 370 A. With increasing in welding current from 330 to 370 A, bead width increased from 10.25 to 12.8 mm and the average bead width rise was measured as 0.064 mm for each 1A welding current increment. Hence, the relationship between welding current and bead width is an compatible trend so that the maximum value of bead width (12.8 mm) was obtained in maximum value of welding current (370 A).

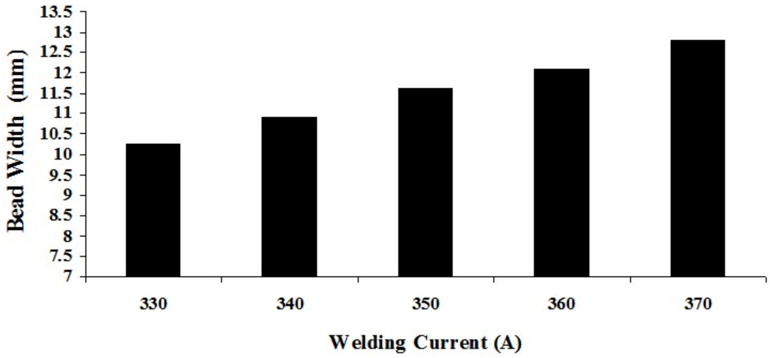

Fig. 4: Bead Width vs. welding current diagram for V=26 V & S=52 cm/min

b). Effect of Arc Voltage on Weld Bead Width:

The correlation between the arc voltage and weld bead width has been shown in Fig. 5. In Fig 5, the welding current and welding speed was fixed as 350 A and 52 cm/min. According to Fig. 5, with increasing in arc voltage from 22 to 30 V, the bead width increased from 9 to 15.2 mm and the average bead width rise was measured as 0.78 mm for each 1V arc voltage increment. Thus, similar to welding current the correlation between arc voltage and bead width is a compatible correlation so that the maximum value of bead width (15.2 mm) was obtained in maximum value of arc voltage (30 V).

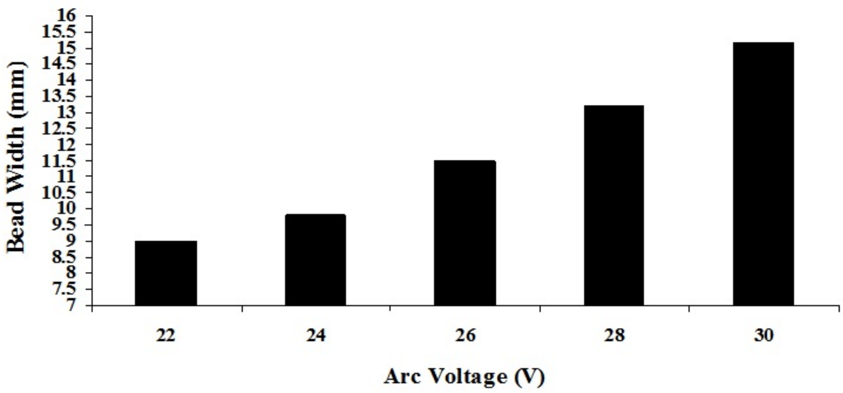

Fig. 5: Bead width vs. arc voltage diagram for I=350A & S=52 cm/min

It was clearly seen that the arc voltage has a stronger effect on bead width relation to welding current. It can be related to the welding current plays a strong rule on depth of penetration normally.

c) Effect of Welding Speed on Weld Bead Width:

The effect of welding speed on weld bead width was commented according to the results shown in Fig. 6. In Fig 6, the welding current and the arc voltage were fixed as 350 A and 26 V respectively and the change in bead width was drawn with increasing the welding speed from 32 to 72 cm/min. With increasing in welding speed from 32 to 72 cm/min the bead width decreased from 14.1 to 9.5 mm. It can be related to the increasing in welding speed result to decrease the focusing time on per unit of joint area for electrical arc. Therefore, the weld bead mass and volume decrease with increasing in welding speed. The average bead width fall was measured as 0.12 mm for each 1cm/min welding speed increment.

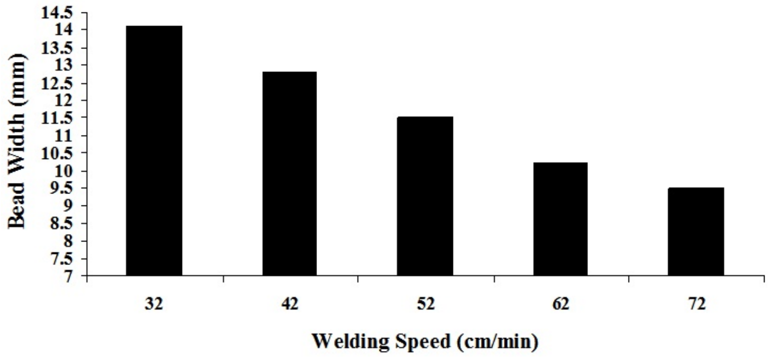

Fig. 6: Bead width vs. welding speed diagram for I=350A & V=26 V

Conclusion:

According to the results obtained from SAW applied to St 52-2 carbon steel plates having 10 mm thickness:

(1) With increasing in welding current from 330 to 370 A, weld bead width increased.

(2) With increasing the arc voltage from 22 to 30 V, weld bead width increased which this manner was similar to welding current effect but the arc voltage effect on weld bead width was stronger.

(3) With increasing the welding speed from 32 to 72 cm/min, the weld bead width decreased thus the correlation between welding speed and weld bead width is an inverse trend.

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