Influence of the Superimposition of Longitudinal Magnetic Field on the Weld Shape During Submerged Arc Welding

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Introduction

Although a number of reports (1-6) are available on the application of longitudinal magnetic field during submerged arc welding, it is far from clear how much is the influence of such magnetic field on weld cross section affected by the selection of welding parameters.

It is the aim of the present report to illustrate the effect of welding parameters on the influence of longitudinal magnetic field application on the cross-section of the submerged arc welds so as to enable the welder to select proper welding parameters for various purposes when using longitudinal magnetic field superimposition during submerged arc welding.

Experimentation

Welds were deposited on plates of steel St. 37 using 3 mm diameter wire S2 and welding flux LW 250 (11 by 496 according to DIN 8557) under different weld settings having different combination of arc voltage and current. Number of welds were deposited for one weld setting whereby the flux density of the superimposed magnetic field was varied from zero to 600-700 G.

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The longitudinal magnetic field was produced by allowing the magnetizing current of desired type and amount to flow through a coil placed concentrically around the welding wire. The flux density was measured at the top of the electrode wire 4 mm above the plate to be welded. While increasing the magnetic field strength at any weld setting, the voltage and current regulator switches were kept unchanged.

Results

3.1.0 *Alternating longitudinal magnetic field and welding power source with constant potential static characteristics*

3.1.1 *Effect of magnetic field on welding arc current and voltage*

As reported in (7), the welding arc voltage was found to increase with increase in magnetic field strength. The welding current decreased following the static characteristics of the power source. The increase in voltage and reduction in current was higher for low current arcs for the same voltage and high voltage arcs for the same current.

As shown in Fig. 1, the weld width b decreases with increase in magnetic flux density for weld setting 400 A/32 V and 400 A/26 V. This reduction should be attributed to relatively higher (about 2% at magnetic flux density 500 G) reduction in current intensity with increase in magnetic field strength. Fig. 2 shows the

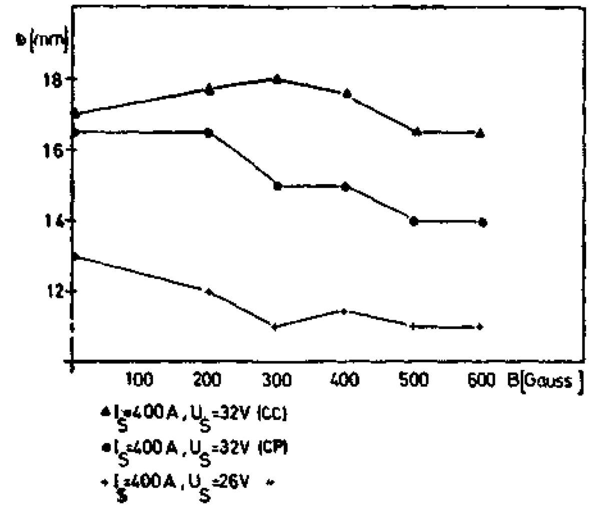

Fig. 1. Effect of magnetic flux density B on weld width b.

change in weld width with increase in magnetic flux density at current setting of 500 A for various arc voltages. Here the weld width first increases with increase in magnetic flux density upto a certain value which is higher for lower arc voltages. Further increase in magnetic flux density increases the weld width, due to combined effect of the reduction in arc current and consequent arc stability with increase in magnetic flux density. The decrease in arc current value is 12% at B=600 G.

The relative increment in weld width at this current value is maximum at 29 V at which the arc stability was found to be maximum (7) at magnetic flux density B=O G.

At weld setting of 600 A/32 V the weld width increases with increase in magnetic flux density (Fig. 3). No reduction in weld width was observed within the investigated range of B. This is because of the fact that the 600 A arc is very stable and stiff and also there is no significant reduction in current (7% at B=600 G).

3.1.3 *Effect of magnetic field on depth of penetration t*

The depth of penetration t is found to decrease with increase in magnetic flux density at all weld settings (Fig. 3, 4, 5), irrespective of arc voltage and current. However, the amount of decrease in the value of t is less at higher arc voltage (58% for 29 V and 40% for 36 V arc) for the same arc current.

The reason for enlargement in the weld width and reduction in penetration is attributed to the fact that the arc becomes bell shaped under the action of longitudinal magnetic field (3). The heat is distributed over a larger area thereby increasing the weld width and reducing the penetration. A shorter arc corresponding to low voltage undergoes such a change in shape without losing its stability. A high voltage long arc loses its stability before undergoing such change and revolves in a spiral form and finally extinguishes under the action of increasing magnetic field. Such movement and extinction of arc in the arc cavern causes a high loss of arc energy in the arc cavern. This accounts for the

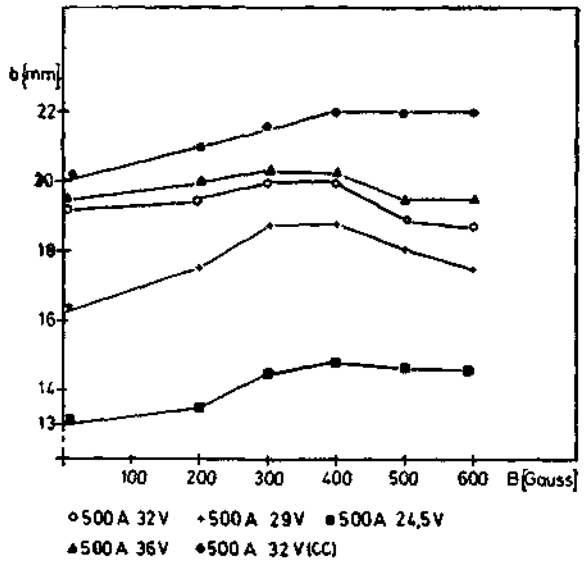

Fig. 2. Effect of magnetic flux density B on weld width b.

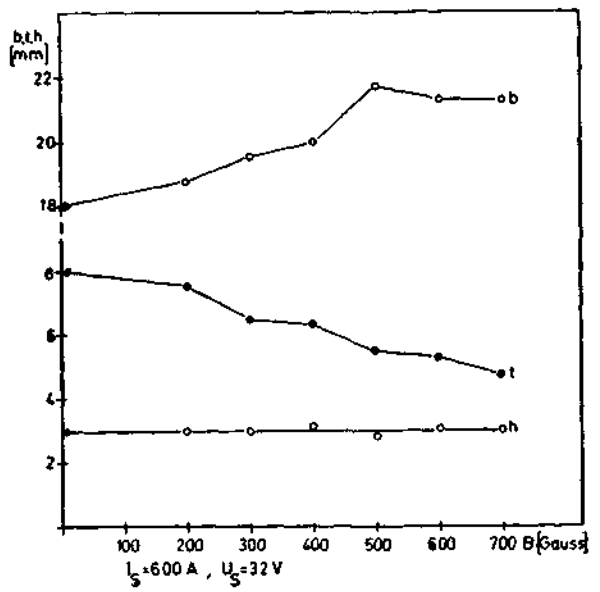

Fig. 3. Effect of magnetic flux density B on weld width b penetration t, and reinforcement h.

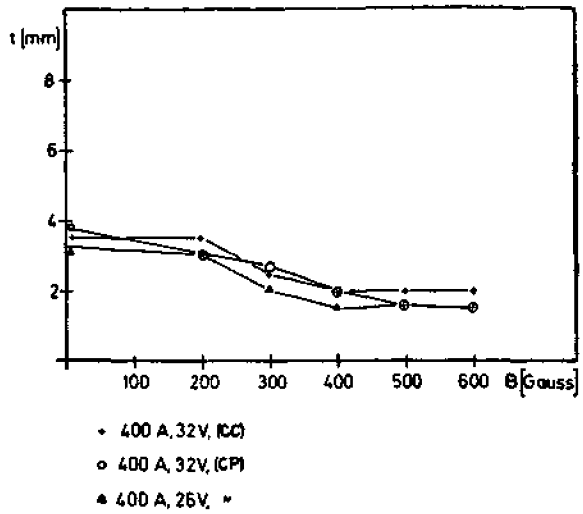

Fig. 4. Effect of magnetic flux density B on weld penetration t.

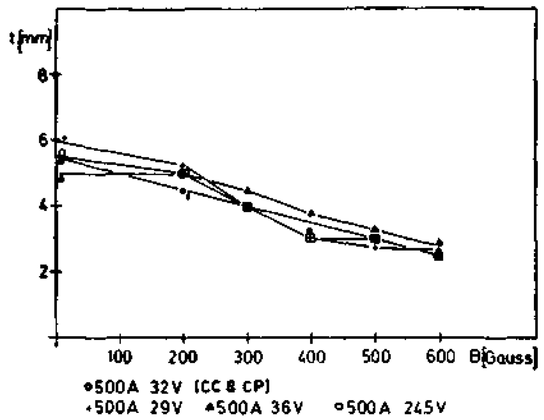

Fig. 5. Effect of magnetic flux density B on weld penetration t.

reduction in penetration even though there is no relative enlargement of the weld width as in case of 500 A/36 V arc.

The included angle of the arc cone formed under the action of longitudinal magnetic filed depends upon the arc stiffness which in turn depends upon arc current. A high current e.g. 600 A 32 V arc being relatively stiffer, results in a smaller cone angle. This provides a relatively less (40% at 700 G) reduction in weld penetration (Fig. 3).

This suggests that for surface deposition application using longitudinal magnetic field, a low voltage arc with a current intensity just enough to make it reasonably stable., should be preferred against a high current stiff arc.

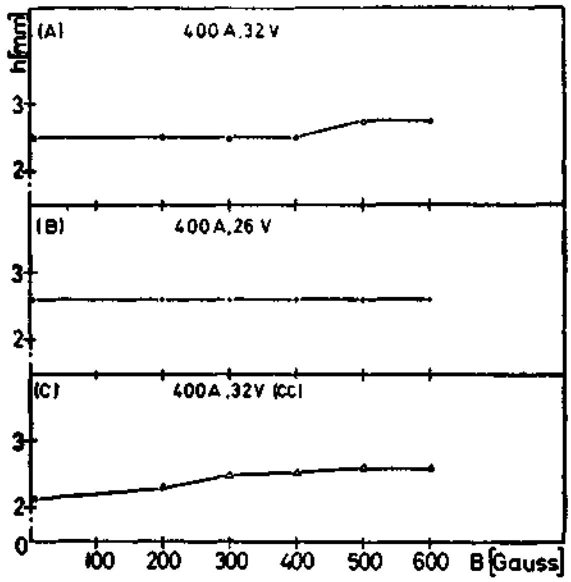

Fig. 6. Effect of magnetic flux density B on weld reinforcement h.

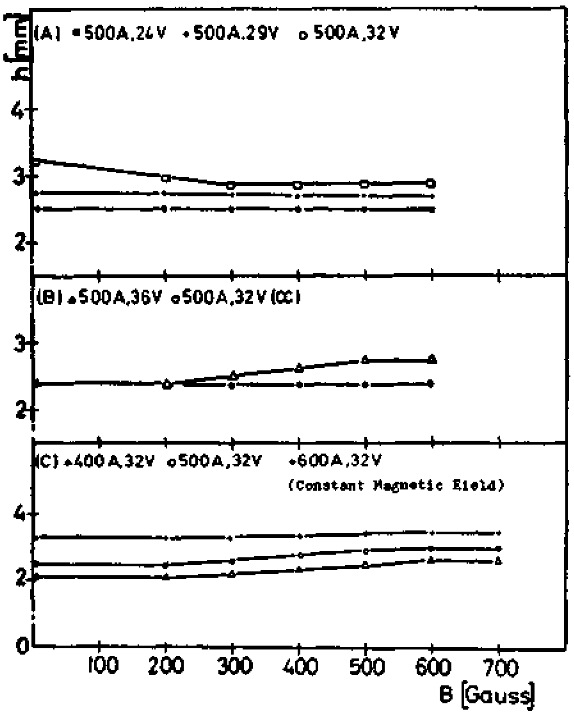

Fig. 7. Effect of magnetic flux density B on weld reinforcement h.

3.1.4 *Effect of magnetic field on weld reinforcement h*

As shown from Fig. 3, 6, and 7 the value of h increases after 200 G at 500 A/36 V and after 500 G and 400 A/32 V weld settings. This is due to reduction in the values of b as well as t on those weld settings at these magnetic flux densities.

Weld reinforcement increases in case of 500 A/24.5 V at higher magnetic flux densities. This is due to the fact that at such a low voltage the weld reinforcement was considerably high even without application of magnetic field. As the magnetic field was superimposed on the arc and its intensity increased, weld reinforcement was decreased due to redistribution of metal over a larger area under the action of magnetic field. This is confirmed by the increased weld width on these magnetic flux densities.

3.2 *Alternating magnetic field and power source with constant current characteristics*

The curves marked with (CC) represent the relationship between various parameters while using constant current power source.

3.2.1 *Effect of magnetic field on welding arc current and voltage*

As reported in (7) the arc voltage increased with increase in magnetic flux density but no increase in current was observed. This should be attributed to the constant current characteristics of the power source used.

3.2.2 *Effect of magnetic field on weld width b*

The weld width b increases with an increase in magnetic flux density till 300 G at weld setting 400 A/32 V (Fig. 1) in contrast to the decrease in weld width for the same magnetic flux density while using the power source having constant potential characteristics. This should be attributed to the maintenance of full current with increasing magnetic flux density. Above 300 G the value of b reduced slightly because of reduced stability of arc giving rise to higher arc losses in the cavern due to undesirable movement.

For weld setting of 500 A/32 V the weld width increases with increase in magnetic flux density within the applied range suggesting that a 500 A arc is stable enough at this voltage to withstand the effect of longitudinal magnetic field without any disturbance to its configuration.

3.2.3 *Effect of magnetic field on weld reinforcement h*

The value of h increases with increase in magnetic filed intensity as shown in Fig. 6 C and 7 B.

3.3 *Constant magnetic field and power source with constant potential characteristics*

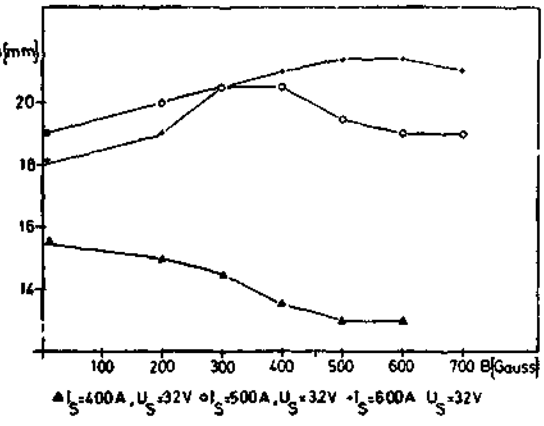

Fig. 8. Effect of magnetic flux density B on weld width b (constant magnetic field).

The curves shown in Fig. 7 (C) and 8 show the variation in weld dimensions with increasing magnetic flux density. The general trend of variation follows the same pattern as obtained during welding with alternating magnetic field. Some important features of welding with constant magnetic field were as given below;

A. The welding arc, specially at 400 A/32 V, was more sensitive to superimposition of constant magnetic field. There appeared to be a violent movement of arc inside the cavern as judged by increased noise level and movement of flux. This called for the use of a thicker flux layer in the absence of which a porous weld was deposited.

B. The weld seam was asymmetrical and the direction of asymmetry depended upon the direction of flow of magnetizing current.

3.4 *Weld current ranges*

The working current range for a given wire size can be divided in three parts as far as the influence of longitudinal magnetic field is concerned:

Low current range (around 400 A for 3 mm diameter wire)

In this current range, there appears to be no beneficial advantage of superimposing the arc with longitudinal magnetic field probably because of inherent relative instability of the arc even at low voltage (8).

Medium current range (around 500 A for 3 mm diameter wire)

The arc stability is quite good (8) within a definite voltage range. This range seems to be most suitable for

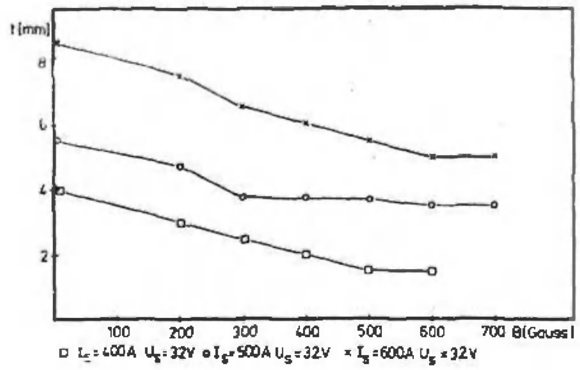

Fig. 9. Effect of magnetic flux density B on weld penetration t, (constant magnetic field).

surface deposition applications with superimposed longitudinal magnetic field.

High current range (around 600 A for 3 mm diameter wire)

In this range, the arc is not only very stable but stiff also (7, 8) Although the weld width enlarges and penetration reduces with the application of longitudinal magnetic field, weld still processes enough penetration. This makes this range most suitable for obtaining a particular weld cross-section at much higher welding speed using longitudinal magnetic field and higher electrical power.

Fig. 10 shows the cross-section of the weld deposited at welding speed of 40 cm/min without use of magnetic field. Fig. 11 shows the cross-section of the weld deposted at higher welding speed i.e. 75 cm/min using higher electrical power and longitudinal magnetic field of suitable flux density. Both the cross-sections are almost similar. It should be noted that the weld deposited using the same higher electrical parameters and welding speed but without magnetic field superimposition had deeper penetration and smaller width.

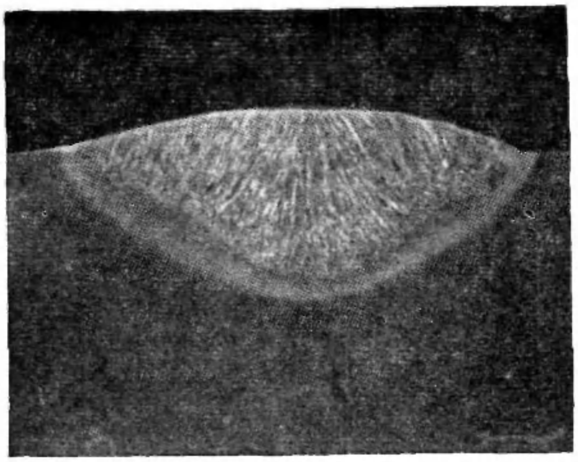

Fig. 10. Weld cross-section at : 500A, 32V. 40cm/min and O G.

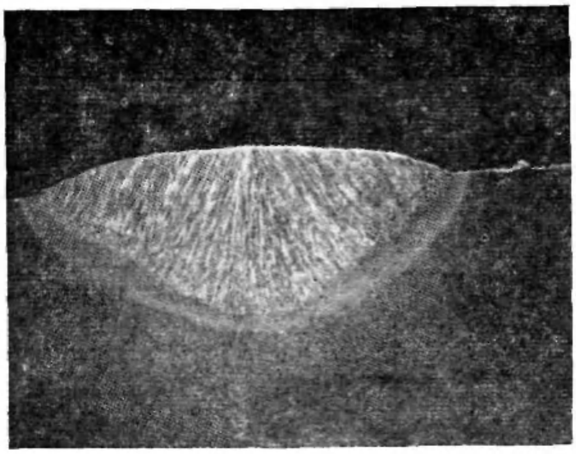

Fig. 11. Weld cross-section at : 625A, 36V. 75cm/min and 400 G.

Conclusions

1. The longitudinal magnetic field, when superimposed on a submerged welding arc, increases the weld width and decreases the weld penetration to an extent depending upon the arc voltage and current.

2. Low current arcs are unsuitable for longitudinal magnetic field applications, because of inherent arc instability relatively even at low arc voltage. Medium current arcs, with arc voltages at which the arc stability is good, are most suitable for surface deposition applications using longitudinal magnetic field. High current arcs can be successfully used for increasing welding speeds utilizing longitudinal magnetic field.

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