INFLUENCE OF WELDING PARAMETERS ON BEAD GEOMETRY IN GMAW VERTICAL DOWN POSITION

by

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Abstract

The influence of welding parameters on the weld bead geometry in the vertical down position has been investigated with GMA welding process. Both solid and flux cored wires have been used for investigations. The results are compared with those obtained for similar investigations in the flat position welding.

Investigations have revealed that in vertical down position within a certain range of welding current, voltage and welding speed, the weld geometry is influenced in the same way as in the case of flat position. However, beyond these ranges of welding parameters the weld bead geometry is appreciably influenced by welding position. There is also an appreciable influence of flux cored wire, over solid wire, on weld geometry.

INTRODUCTION

Gas Metal Arc Welding (GMAW) is having good positional welding capability. But the main problem arises during vertical position, where in vertical up position fluidity curtails the application of high current and hence gives a lower deposition rate, while in vertical down position poor penetration leads to lack of fusion.

Flat position facilitates the application of higher welding currents resulting in increased fusion rates. Both the cross-sectional area of reinforcement and penetration increase along with the current. Higher currents also lead to an increased deposition rate and at a constant welding speed the thickness of molten metal under the arc is increased. When voltage is increased the arc length increases leading to increased bead width and reduced height of reinforcement (1). As welding speed increases, the depth of penetration increases upto some critical value, after which if welding speed further increases the penetration decreases (2).

Dilution is a key factor and it is essential to establish a procedure which will minimise its effects, consistent with good bonding and sound deposit (3-5).

The parent metal fusion rates in different positions with CO_2 welding show that vertical up welding gives a higher area of penetration zone and greater depth of penetration. As welding speed increases, the depth of penetration decreases significantly (1).

In vertical up welding, localisation of arc pressure and weight of weld pool become more important, so it is necessary to reduce the weight of molten pool. This can be achieved by using wire of smaller size with lower welding currents but relatively higher current densities (6).

Satisfactory results have been reported for vertical up single pass welding with 0.8 mm solid wire in case of mild steel plates upto 12 mm thickness. Oscillations are provided to fill the gap (5-7). More metal can be deposited in vertical up position with pulsating arc than with the continuous arc. Output is 50-80% higher when welds are made with pulsating arc (8,9).

Vertical down position welding gives lower values of penetration and larger values of bead width as compared to vertical up welding. In vertical down position, depth of penetration remains almost constant over the entire investigated range of welding speeds (1). While welding the root pass (without root face) vertical down position produces complete penetration and fusion with side walls, thus ensuring that the next pass could be welded without any lack of fusion (5).

The vertical down fillet welds cost less and are equally good in static ultimate tensile strength, and better in fatigue strength as compared to vertical up welds (10).

In the present work, investigations have been carried out to study the variation of weld bead geometry under different welding conditions in vertical down position. Welding in flat position has also been done for the comparison of results.

EXPERIMENTATION

Welding trials were made at different welding parameters in vertical up, vertical down as well as in flat positions. Taking into consideration relatively better arc stability and weld bead by appearance, the parameters were selected for experimentation.

Except for some typical welding conditions, highly irregular beads were obtained both with solid and flux cored wires with vertical up position. So vertical down position was selected for investigations, in which with solid wire above 180A welding current and with flux cored wire above 160A and 26V it was not possible to weld due to flowing down of the molten metal or flux.

On the above considerations, the following parameters were selected.

1. Welding current - 100-180A in step of 20 or 30A for solid wire and 100-160A in step of 20A for flux cored wire.
2. Welding voltage - 18V-26V in step of 4 volts.
3. Welding speed - 15-30 cm min^{-1} in step of 5 cm min^{-1}
4. Electrode stickout - 10 mm
5. Angle between torch and place in vertical position - 60°.

Weld beads were deposited in flat and vertical down positions on properly cleaned 10 mm thick plates using CO_2 as shielding gas and 1.2 mm solid and rutile type flux cored wires.

During welding the plates were clamped on rotating table and the welding torch was fixed to a mobile device. Three weld beads were deposited for a particular set of welding parameters in both positions. Two samples from each bead were selected from the middle of the bead to avoid any nonuniformity due to cold start and crater. After polishing, the samples were etched and dried. The depth of penetration, weld width and height of reinforcement were measured with the help of stereo microscope. The average of values obtained from six samples, has been taken in each case.

RESULTS AND DISCUSSIONS

Depth of Penetration

For solid wire the depth of penetration is generally lower for higher welding voltages upto a certain range of current, and beyond this range the penetration increases for higher voltages in both the flat and vertical down positions. This can be observed in **Fig. 1**. Further, at around 150 A current the penetration is found to be almost same for all voltages for 15 cm min^{-1} speed in both the positions. However, this current range decreases with the increase in speed for flat position, while no appreciable change is observed in vertical down position.

For 30 cm min^{-1} welding speed, there is no appreciable change in penetration for different voltages in flat position. However, in vertical down position some difference in penetration exists depending upon the voltage, except that at around 180A current the penetration is almost same for all voltages.

For flux cored wire, the depth of penetration increases with the increase in current for all voltages and speeds for both the positions. Further, penetration is generally higher for 26 V as compared to 18 V welding voltage over the entire range of welding current, again in both the positions as shown in **Fig. 2**.

The trends obtained for both solid and flux cored wires indicate that

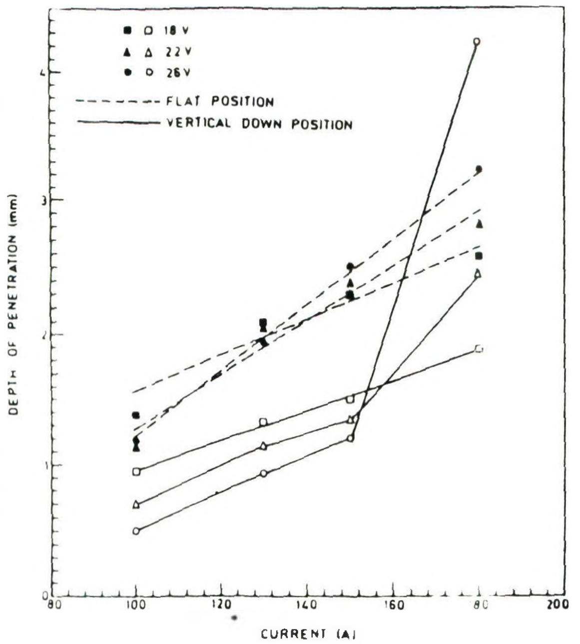

Fig. 1 : Influence of welding current on depth of penetration with solid wire in vertical down and flat positions for 20 cm min⁻¹ welding speed.

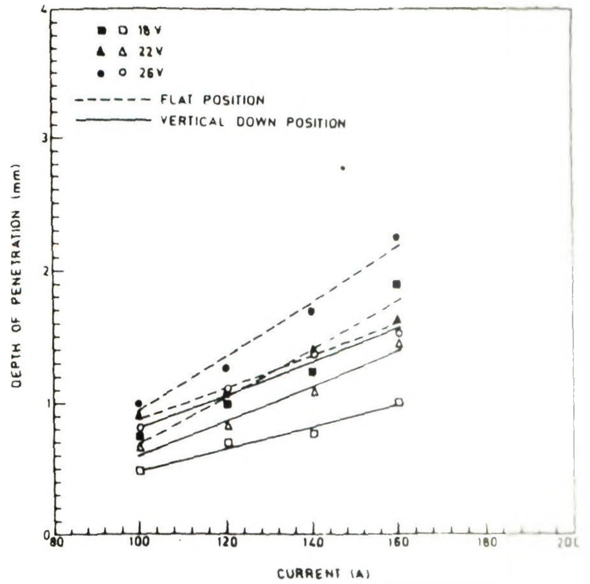

Fig. 2 : Influence of welding current on depth of penetration with flux cored wire in vertical down and flat positions for 25 cm min⁻¹ welding speed.

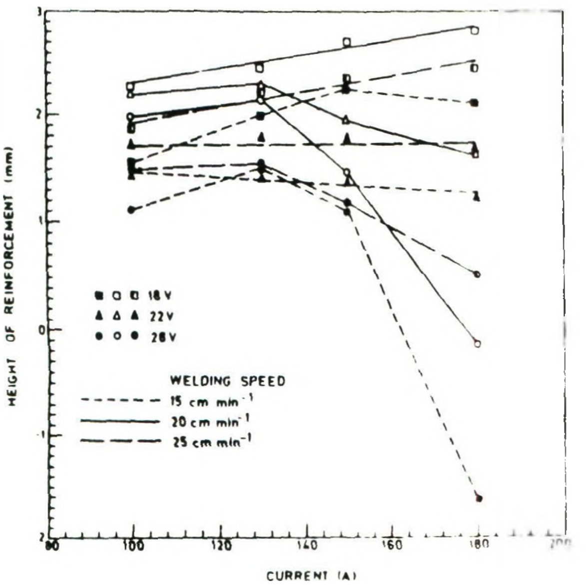

Fig. 3 : Influence of welding current on reinforcement with solid wire in vertical down position for different welding speeds.

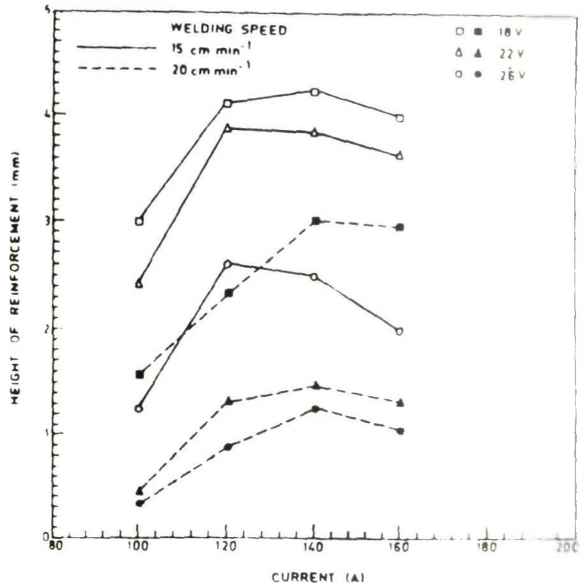

Fig. 4 : Influence of welding current on height of reinforcement with flux cored wire in vertical down position.

welding current, speed and voltage are influencing the depth of penetration to a certain extent in both the positions, except with 30 cm min^{-1} speed where the welding parameters do not seem to influence the depth of penetration in flat position.

The increase in the depth of penetration with an increase in the welding current is an established fact. But in the case of changing voltages, the trends of variation of penetration may be due to particular combinations of welding parameters. For lower voltage and relatively higher currents, the metal deposited may be large which may be acting as a barrier for the arc to penetrate into the metal leading to reduced penetration. When voltage is increased then weld width increases and deposited metal spreads over a larger area reducing the thick layer of molten metal between arc and parent metal. This may increase penetration beyond a certain range of current in combination with other parameters.

Height of Reinforcement

For flat position with solid wire, the height of reinforcement increases with the increase in welding current and decreases with the increase in welding voltage and speed. In vertical down position the reinforcement normally slightly increases for lower welding voltages as well as lower current (120A), for all speeds as employed in flat position. However, reinforcement either decreases or remains constant for 22 and 26 V depending upon the welding speed above 120A current as shown in **Fig. 3**.

At 180 A welding current for 26 V welding voltage and lower welding speeds i.e. 15 and 20 cm min^{-1} in vertical down position, instead of reinforcement we observed depression which is indicated by a negative value and can be seen in the above figure.

This depression is caused by the flowing-down of molten metal due to the formation of a large weld pool with lower welding speeds. The trends observed in the vertical down position for reinforcement with the increase in either welding current or speed, are totally different from those obtained in flat position, probably due to the above reason.

In case of lower welding voltage, upto a limited range of current, the large weld pool is not formed and, therefore, the molten metal does not flow down leading to the increased reinforcement, but beyond a certain level of current it seems that the molten metal starts flowing down. The reduction is observed with higher welding voltages at lower welding speeds.

With flux cored wire, the height of reinforcement increases with increased welding current for all voltages at different speeds in flat position. Further, for lower welding voltages the reinforcement is higher than that for higher voltages over the entire range of current. These trends are almost similar to those observed with the solid wire in flat position. In vertical down position with flux cored wire, the reinforcement increases with the increase in welding current upto a certain level and then slightly decreases with 15 and 20 cm min^{-1} speeds. The level of current upto which the increase in reinforcement is observed, increases with the increase in the welding speed (**Fig. 4**). For welding speeds above 20 cm min^{-1}, reinforcement increases over the entire range of welding current for all voltages.

The reasons for the above phenomenon may be same as in the case of solid wire as discussed earlier. However, for higher welding voltage with higher speed the trends are different as compared to solid wire. This can be attributed to the fact that the amount of molten metal in weld pool may be more with the solid wire, as compared to flux cored wire, for a particular set of welding parameters because of flux in the wire, which may cause reduced downward flow of molten metal as compared to the case of solid wire.

Weld Width

The weld width with solid wire in flat position, increases with the increase in welding current and is also higher for higher welding voltages. But the weld width decreases with the increase in welding speed.

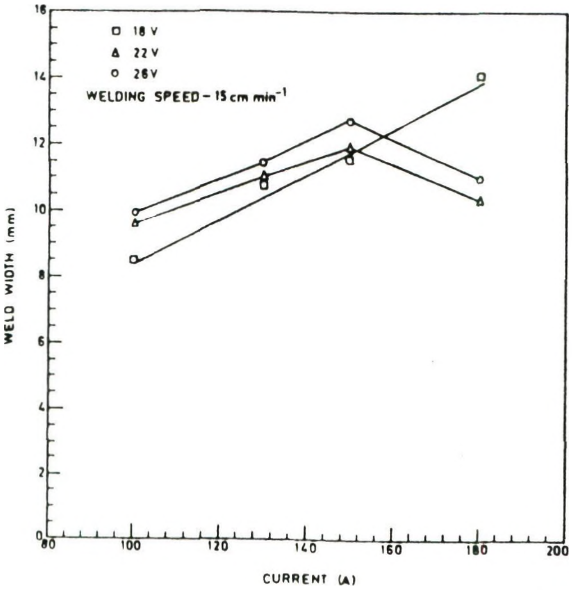

Fig. 5 : Influence of welding current on weld width with solid wire in vertical down position.

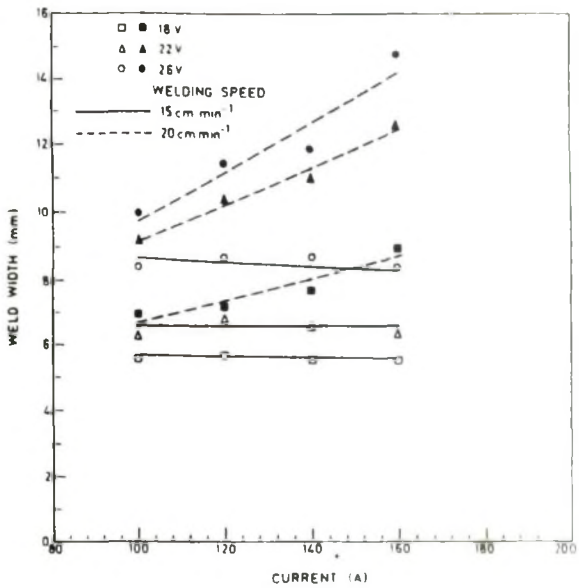

Fig. 6 : Influence of welding current on weld width with flux cored wire in vertical down position.

Fig. 5 indicates that in vertical down position with solid wire at 15 cm min^{-1} welding speed, the weld width continuously increases for 18V, but for 22 and 26 V, first it increases and then decreases after a certain level of current. At 20, 25 and 30 cm min^{-1} welding speeds, the weld width generally increases with the increase in the welding current for all voltages. Also the weld width is invariably higher for higher welding voltages.

The decreasing trend of welding wdith after a certain level of current with higher voltages at 15 cm min^{-1} speed may be due to the reason that perhaps the weld pool becomes relatively large, and also that due to higher energy input at low welding speeds, the molten metal will not be able to solidify quickly and therefore, metal from a larger weld pool may flow down because of gravity resulting in the decrease of weld width.

It has been observed that with flux cored wire the weld width in flat position generally increases with the increase in welding current for all welding speeds and voltages. The weld width is however higher for higher welding voltages as compared to low voltages. The above observations are almost similar to those in the case of solid wire in flat position.

Fig. 6 depicts the influence of welding current on weld width for flux cored wire in vertical down position. For 15 cm min^{-1} welding speed, weld width either remains constant or first slightly increases and then decreases. This trend is more or less similar to that observed in the case of solid wire in vertical down position with 22 and 26 V for 15 cm min^{-1} speed. At 20 cm min^{-1} speed the weld width increases with the increase in welding current for all voltages and speeds. Similar trends are observed for higher speeds also.

For the phenomenon with 15 cm min^{-1} welding speed, the reasons may be the same as given for solid wire. In addition to those reasons, probably another reason may be that the larger amount of molten flux flowing down with flux cored wire may act as a barrier between the arc and parent metal, thus causing lesser melting of parent metal on the sides and resulting in smaller weld width. The weld widths obtained in case of 15 cm min^{-1} welding speed are even lower than those obtained with 30 cm min^{-1} welding speed except in a very low current range.

CONCLUSIONS

With solid wire the depth of penetration and height of reinforcement are higher in flat position as compared to vertical down position for the same welding parameters under satisfactory welding conditions. However, the weld widths obtained with solid wire in vertical down position were generally higher as compared to flat position. Almost similar results are obtained for weld bead geometry with the flux cored wire.

REFERENCES

1. A. I. Akulov and V.V. Spitsyn, Influence of Setting and Welding Position on the Dimension of CO_2 Welds, Weld-Prod, Feb-1971, pp. 41-44.
2. American Welding Society. Welding Hand Book, Volume 2, Seventh edition.
3. John P. Stewart, The Welders Hand Book, Reston Publishing Company.
4. American Welding Society, Welding Hand Book, Vol. 4, Seventh Edition.
5. H. B. Cary, N.A. Jorgensen and L. R. Schonable, Mechanised Vertical Welding Utilizing the Gas Metal Arc Process, Welding Journal, March, 1967, pp. 187-197.
6. A. M. Gofner, I.S. Ioffer and V.I. Zeslenova, Single-Pass-Welding of Rotatable, Circumferential and Vertical Butt Joints with Cored Wire, Automatic Welding, August 1973, pp. 50-53
7. F. Z. Tenerbawm, Characteristics of the Pulsed Arc Consumable-Electrode Welding of Alloy AM6 in the Inclined and Vertical Positions. Welding Production, June 1973, pp. 33-37.
8. F. A. Vagner, et al,. Vertical Pulsating Arc Welding with Powder Filler Wire, Welding Production, May 1970, pp. 27-29.
9. V. V. Stepanov, F. A. Vagnor and P. R. Isaenko, Pulsating Arc CO_2 Welding with a Consumable Electrode, Automatic Welding, Jan 1971 pp. 40-43.
10. Harsjorg Petershagen, Strength Test on Vertical-Down Welded Double-T-Joints of Ship Building Steel, Schweissn Und Schneiden, June 1989, pp. E-101-103.

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