CONSTRAINTS IN VERTICAL DESCENDING WELDING PRACTICE

Lenuța Cîndea, Babeș-Bolyai University of Cluj-Napoca, ROMÂNIA
Cristinel Popescu, Constantin Brâncuși University of Tg-Jiu, ROMÂNIA
Cornel Hațiegan, Babeș-Bolyai University of Cluj-Napoca, ROMÂNIA
Marius Florian Preduș* (corresponding author), Babes-Bolyai University, Faculty of Engineering, Resita, ROMANIA

ABSTRACT: The paper contains a study based on experimental determinations regarding the quality of welded joints made during vertical downward welding in comparison with conventional welding. Throughout the welding process, several important rules were taken into account, as well as the effect of the inclination of the electrode holder tongs, in order to ensure a good quality weld. Because the welding process is a simple one in which it is actually taken into account that the welding takes place from top to bottom and that the phenomenon of gravity negatively helps the molten metal to flow downward, this phenomenon affects the penetration and shape of the weld bead. In this regard, cases of welding defects were presented and attempts were made to optimize the process by modifying the welding parameters.

KEY WORDS: vertical descending welding, welding parameters, constraints.

1. INTRODUCTION

In vertical downward welding, gravity causes the molten metal to flow downwards and sometimes causes an irregularly shaped weld bead and weld defect. This problem makes it difficult to perform a high-quality weld with a high deposition rate. From a technological point of view, problems arise related to the quality of penetration, or whether the main technological parameters are the same as in conventional horizontal welding. There are, of course, practical constraints on vertical-down welding.

These exist logically because the weld pool in this position can run down by gravity. The larger and more fluid the weld pool, the more easily it can flow off. Lack-of-fusion defects can be produced directly in vertical-down welds, or welder training can explore the limits of the "doable". This would be useful for anyone who has to discuss such defects in this type of weld.

Additive manufacturing is a processing technique in which a component can be created from 3D data without subtractive material removal from a block of material. It is possible to clad miniaturized as well as large surfaces two-dimensionally by a welding process as well as to produce three-dimensional components. The technology is used in various application areas such as aerospace, medical technology, petro chemistry, automotive and mechanical engineering. In general, the technology is used for prototyping, production of components, machine parts repairing and for functional claddings [1, 2].

In most cases a flat position is used for the deposition welding process. In other welding positions, there is a risk, that, due to the gravitational force, the molten metal will separate from the substrate and drip off [3]. A widely used process is laser metal deposition (LMD). Although a large number of studies can be found on the LMD process in flat

position, the effects that occur during deposition welding in vertical orientation (horizontal (PC), vertical up (PF) and vertical down (PG) position) are little known [4].
Chen et al. studied the effects of welding positions on droplet transfer in CO2-laser metal active gas hybrid welding. The welding torch was placed under 30◦ laterally in the forehand position and the laser beam was placed in the neutral position with respect to the substrate.
The laser beam spot is positioned in front of the base point of the arc, so that there is a trailing orientation. The welding positions studied were flat position, horizontal position welding in vertical orientation and vertical up position welding [4].

2. RULES FOR VERTICAL - DOWN WELDING

If a fillet weld is considered, which is considered the most usual and common, several aspects must be taken into account, including: limited deposition rate, limited effective thickness of the first deposited layer, more viscous weld pool, low residual stresses, by comparing the penetration with that of horizontal welding, the following were found:
In vertical downward welding, if an appropriate technique is applied, good but not deep penetration is obtained.

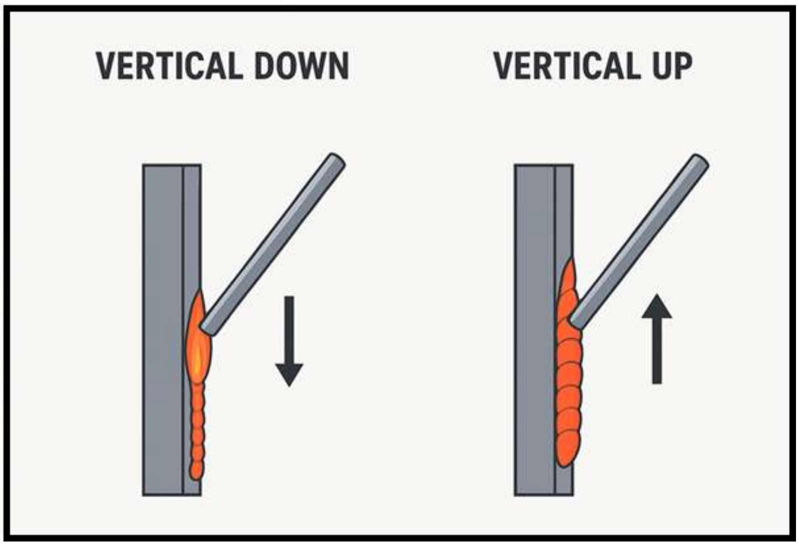

Figure 2.1. Sketch of the vertical upward and vertical downward welding process

The welding process diagram is shown in figure 2.1.
If fillet welds are performed on an inclined plane with the welding torch tilted in three positions and short-arc fine spraying is used, the main parameters of the welding regime are identical to those in Fig. 2.2 [6].
Torch position 1 corresponds to vertical-up welding on a plane inclined at 45^0. Because the bead solidifies behind the torch on the ascending plane, it becomes convex.
The penetration is deep because the weld pool does not run ahead.
Torch position 2 roughly corresponds to flat position. The weld is not convex, but the penetration is less deep.
Torch position corresponds to vertical down welding on a plane inclined at 45^0.
The weld contour is concave, and there is still less penetration.
This comparison illustrates a trend in weld geometry as the position changes from vertical up to vertical down.
Certainly it would not make sense to weld a 90° vertical-down weld at 27 V and 270 A. If penetration problems are seen, they are always due to the fluid weld pool running down to the arc attachment point. Poor heat conduction in the liquid weld metal reduces the penetration and also causes the pool to be displaced toward the weld faces.

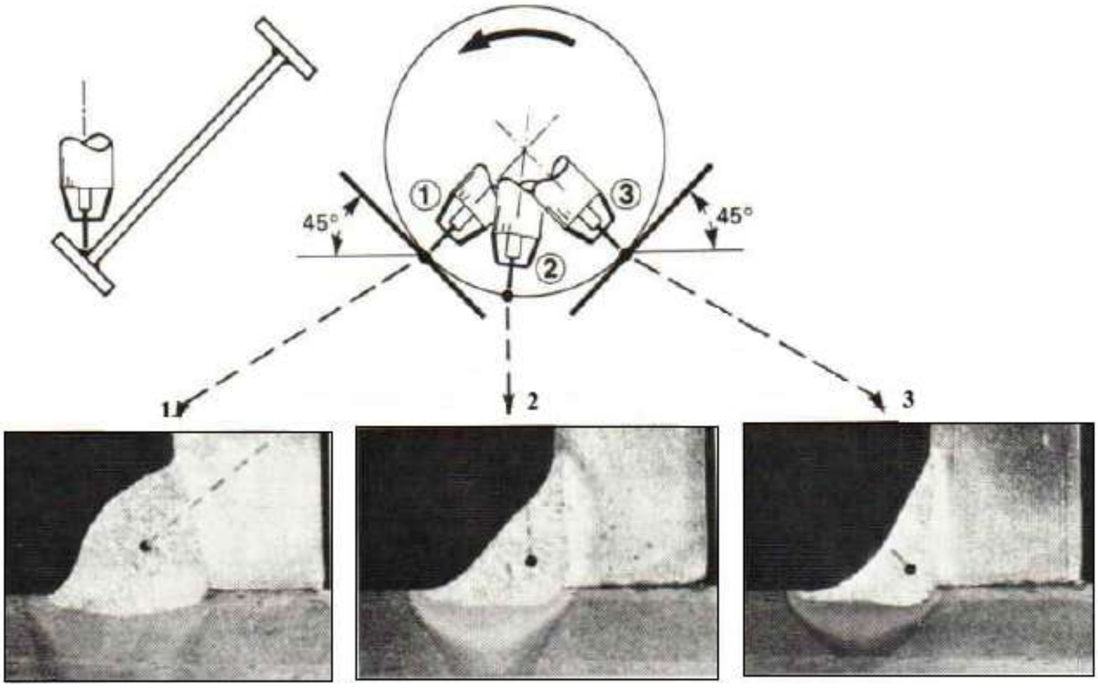

Figure 2.2. Effect of welding position on weld geometry

After meshing the geometric model, I applied different permissible load values to the free end, the other end being embedded.
By applying the load, Von Mises stress values can be visualized on the colored map.
It is observed that the Von Misses stresses have the value at the free end of 1.137x102 N/mm2, the highest value is marked in red, at the other end of the bar and is practically the most requested area for this load, Figure 3.

3. EXPERIMENTAL DETERMINATIONS

Table 3.1. presents the metal deposition rates for different thicknesses of welding wire. The diameters of the welding wires are correlated with the thicknesses of the base material. It is found that the deposition rates in the case of vertical downward welding are 25-30% lower than the values obtained in horizontal welding processes.

Table 3.1. Standard wire feed rates for vertical-down fillet welding

Material thickness (mm)	Wire Diameter (mm)	Wire feed rate m/min	Deposition rate Kg/h	
≤3	0.8	5.0 7.0 9.0	1.2 1.7 2.1	2.5 mm d=0.7
3-8	1.0	5.0 7.0 9.0	1.9 2.6 3.3	3.25 mm d=1.3
6-10	1.2	5.0 7.0 9.0	2.1 2.6 3.7	4.0 mm d=0.7

The effective throat thickness in single pass welding must also be limited.

The penetration is qualitatively good if a=3.5mm. If a=5mm for single pass welding, there is

inevitably a lack of penetration at the base and side walls. If a larger wire thickness is chosen for design reasons, the weld bead must be deposited in several layers to avoid such welding defects.
From the above, the flow of the weld pool is also influenced by the viscosity of the molten metal, in which case we must take into account that the welding arc voltage must be as low as possible, so that at the end of the welding time, a weld pool as viscous as possible is obtained.

4. EXPERIMENTAL WELDING DEFECTS

The following example shows the welding defects for a U-profile during vertical downward welding. Fillet welds were performed with a=4mm, a is the weld height, electrode wire diameter ds =1mm, wire welding speed 12.5m/min, considered high electrode wire speed.

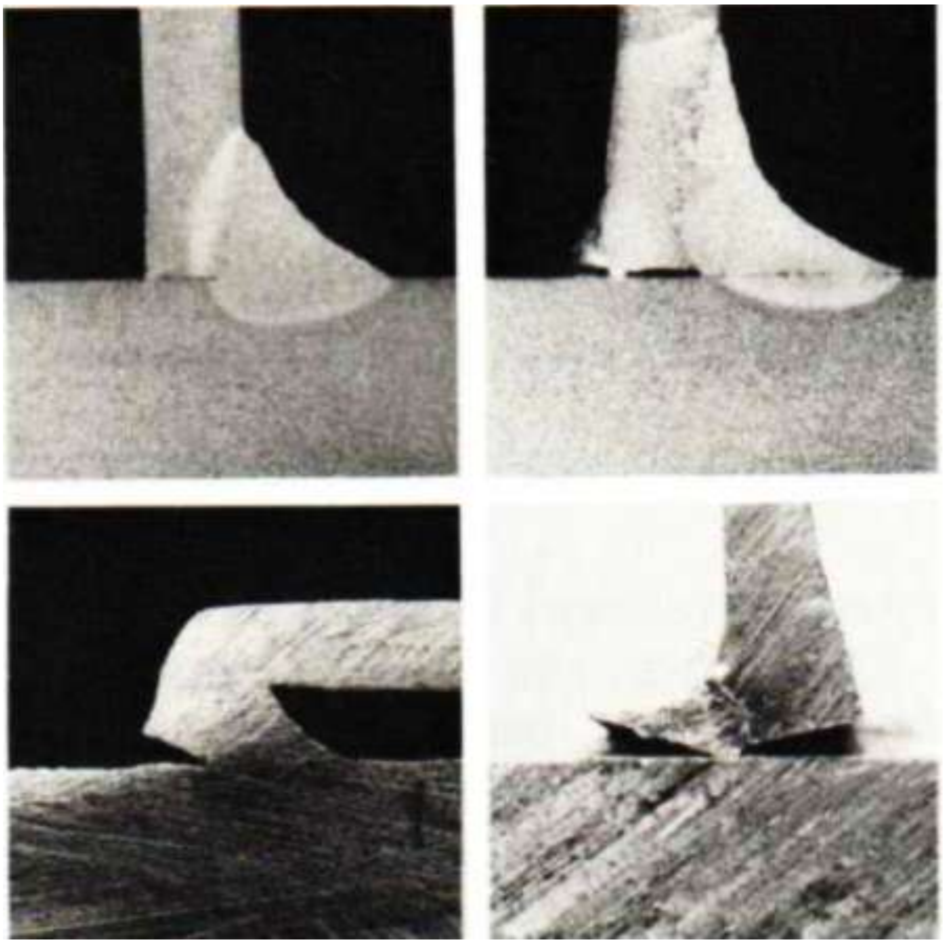

Figure 4.1. Lack of side fusion in vertical-down welds correct and incorrect

In the upper left part, a fillet weld is shown, a=3mm, welding speed v=80cm/min, and in the upper right part a fillet weld is shown, a=4mm, welding speed v=48cm/min.
When the travel speed was increased from 50 to 80cm/min, the leading weld pool was overtaken by the arc attachment point.
To optimize the welding process, tests were carried out to determine the limit between a qualitatively poor weld and a qualitatively good one. Thus, a vertically descending weld was achieved with a=5mm, welding wire with d=1.2mm, feed speed limited to 7m/min.
The deposition rate in this case was 62g/min.
Following the calculations, if the weight of the entire weld bead was 200g/min, a travel speed of v=31cm/min resulted.
In tensile tests on welded seams, it is observed that breakage is possible due to poorly executed welding.
Table 4.1 shows the values obtained.

Table 4.1. Relationship between deposited metal, weld weight and travel speed.

Wire feed rate m/min	Deposited metal g/min	Filled weld a mm	Weld weight g/m	Travel speed rate cm/min
7	62	a= 5	200	31
7	62	a= 4.5	160	39
7	62	a= 4	126	49
7	62	a= 3.5	96	65

1. CONCLUSIONS

As the travel speed increases not only does the weld thickness decrease, but concavity appears to a varying extent.

Concavity can hardly be perceived at the minimum thickness a=3.5mm, a=4.5mm, a=5mm, we can account for it in the following way:

- The large, broad weld pool solidifies from the outside in, while the still liquid middle of the weld runs down.
- The arc pressure bears on the seam allowances and forces the pool to the side.

Welding operators know to look where the weld contour is concave, because that is where lack of fusion is likely to occur.

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