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TECHNICAL AND ECONOMIC COMPARATIVE ANALYSIS BETWEEN HORIZONTAL AND VERTICAL MAG WELDING

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Abstract. The paper aims to analyze and study the technical and economic comparison between mechanized welding horizontal respectively vertical - upward using MAG standard procedures with fusible electrode, application to the execution of butt welded joints from low carbon alloy steel with access from one side of the joint, according to SR EN 10025/2. In this sense it was used mechanized welding system for horizontal and vertical welding, designed and constructed in the welding laboratory from Materials and Manufacturing department.

Keywords: mechanized welding, MAG welding, horizontal and vertical welding, technical and economic analyze

1. Introduction

Welding position is one of the important factors that significantly influence and act on the execution of welded joints both of the process and welding technology and the technically and economically. The optimum position is PA [1]. Whenever when is possible welding will be executed in this position. The most difficult welding position is vertically downward, PG because of the danger of leakage of the welding pool before spring under gravity, making it difficult to control this process leads to defects such as lack of connection (lack of melting or lack of penetration) or inclusions. As a general rule resistance welding is recommended to weld vertically upward (provides strength characteristics and quality, but the surface appearance of the weld is cluttered with large scales) and connection welds (of less importance unsolicited exploitation) using vertical downward welding (characterized by good aesthetically, but poor quality with high probability of connection defects). Vertical downward welding is commonly used when welding thin sheet because it reduces the danger of perforation material [1,2].

The two welding positions is used in general to assembly welds on site [3].

2. Prezentation of the welding installation

Welding installation consists of the following components:

- LUC 500 ARISTO (ESAB) welding power source;
- The welding vertical horizontal device;
- Vertical-horizontal positioning device.

Welding power source Aristo LUC 500, Figure 1, is part of modern sources of welding with inverter which enables to weld MAG standard and MAG using pulsed current.

Figure 1 LUC 500 ARISTO welding power source

Welding device shown in Figure 2, consists of the following components: metal support, the retainer of the piece, device advance on the vertical, device tilting, power supply device vertical advance, power supply tilting device, travel limitation, mechanical welding torch.

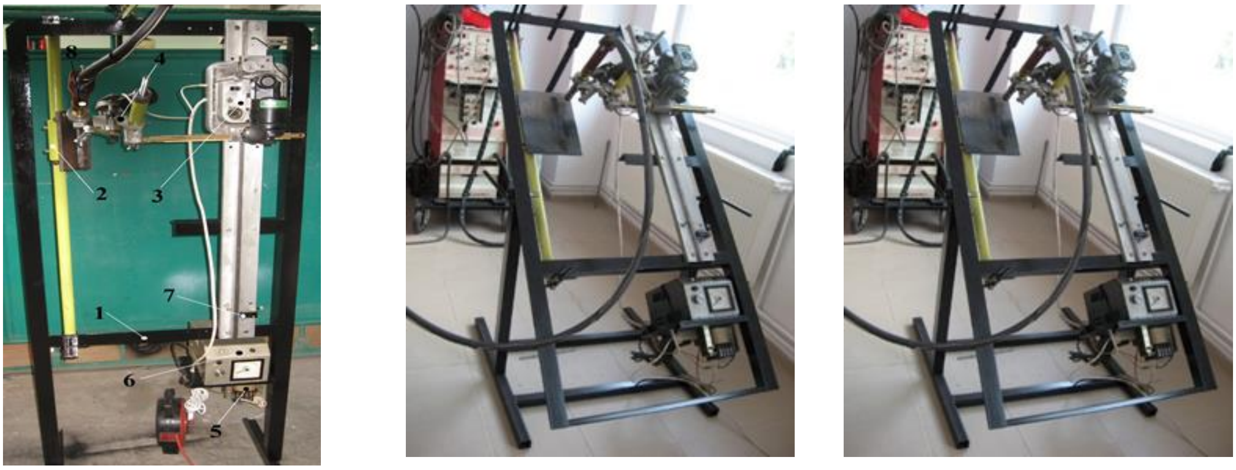

Figure 2 Welding device

Device for positioning, figure 2 to the right, has been executed to make an improvement on the system of vertical welding in order to achieve both a vertical and horizontal welds. This construction ensures mobility welding plant by tilting them allowing its position as the technological needs of different welding positions. Such facility can bring in the desired position according to the technological requirements and in turning the lever installation is lock in the position.

3. Experimental research

Experiments have the following objectives:

- Setting technology from horizontal MAG welding;
- Setting technology from vertical MAG welding;
- Technical and economic analysis of the welds performed.

The samples were made of carbon steel S235J2, cf. SR EN 10025, thickness of 8 mm, Y-welding.

3.1 Setting technology from horizontal MAG welding

Horizontal welding position is unproblematic for MAG welding. The only problem is to avoid the danger of leakage of the welding pool in front of the electric arc, which may lead to the danger that the lack of fusion and the lack of penetration. Therefore the establishment welding technology is aimed in general economic aspect, getting maximum productivity by increasing the welding current for obtain a proper weld quality without defects [1].

Table 1 shows the values of technological parameters used for horizontal butt welding.

Table 1 Technological parameters used for horizontal butt welding.

Welding position	horizontal	horizontal	horizontal
Thickness [mm]	s = 8	s = 8	s = 8
Polarity of welding current	DC+	DC+	DC+
Arc voltage [V]	Ua = 18	Ua = 17.8	Ua = 18.5
Wire speed [m/min]	Va = 2.8	Va = 4	Va = 5
Welding current [A]	Is =104	Is =148	Is =176
Welding speed [cm/min]	Vs = 14	Vs = 14	Vs = 14
Shielding gas	M21 – Corgon 18	M21 – Corgon 18	M21 – Corgon 18
Gas flow [l/min]	Q = 12 l/ min	Q = 14 l/ min	Q = 14 l/ min
Stick out [mm]	Lcl = 15	Lcl = 15	Lcl = 15
Eccentricity [mm]	e = 3	e = 3	e = 3
Amplitude [mm]	A = 4.5	A = 4,5	A = 9
The frequency of oscillation [Hz]	f = 1.54	f = 1.54	f = 1.54
The angle of torch inclination	α = 60º	α = 60º	α = 85º
Shoulder joint [mm]	c = 1	c = 1	c = 1
Opening of the joint [mm]	b = 3	b = 3	b = 3
Number of layer	1	2	3

Welding was done using transfer by short circuit, the welding current Is <200A, in three layers change from one layer to another welding current, respective parameters oscillation amplitude, respectively frequency aiming to control welding pool in terms of achieving a weld free of defects and with an appropriate aspect [3,4]. Figure 3 shows the weld appearance.

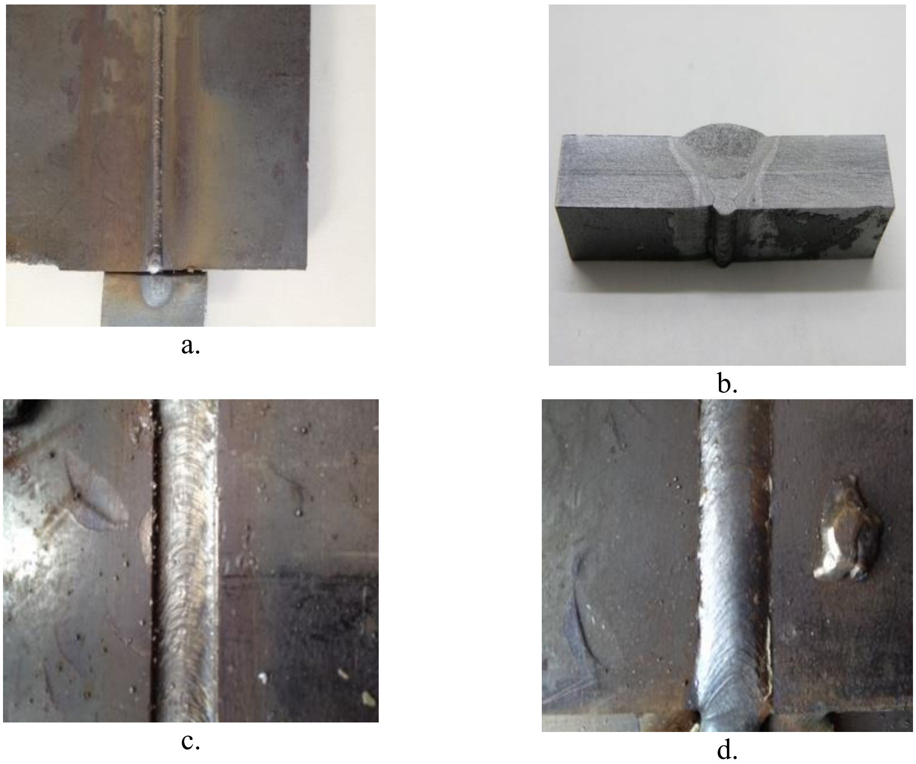

Figure 3 Weld appearance – a – root; b - macroscopic; c- second layer; d- exterior surface

3.2 Setting technology from vertical MAG welding

Vertical welding is difficult due to the danger of leakage of the welding pool and slag by gravity which makes it difficult to control the welding process that increases the incidence of defects in the welded seam.

Solving the problem is generally made by taking technological measures to limit the drain of the welding pool:

- reducing the volume of welding pool by limiting the linear energy introduced in components, by limiting the welding current;
- reducing welding pool fluidity by reducing the arc voltage to limit its stability;
- reducing the volume of the molten slag;
- use of welding materials which make a high speed solidification slag;
- by using a suitable operative techniques (welding in filiform lines without oscillation the arc at vertical downward position, welding with mandatory oscillation at vertical upward position);
- making vertical welding by experienced welders.

In MAG process following technological measures for vertically up or down welding are taken:

- using short arc transfer or pulsed arc transfer due to low and control energy input [1];
- reducing the arc voltage to limit its stability;
- using flux cored wires instead of solid wires;
- using rutile flux wires, for a given wire diameter, rutile flux wires have a wide range of welding current over which a smooth arc and good operational stability are maintained which have the positive effect of productivity;
- eliminating the human factor by using mechanized welding.

Based on the recommendations above are presented in Table 2 welding process parameters values for vertical-upward position and in figure 4 are showed the completed weld appearance [4].

Table 2 Welding process parameters values for vertical-upward position

Welding position	Vertical	Vertical	Vertical
Thickness [mm]	s = 8	s = 8	s = 8
Polarity of welding current	DC+	DC+	DC+
Arc voltage [V]	Ua = 16.8	Ua = 17,8	Ua = 17.8
Wire speed [m/min]	Va = 3	Va = 3	Va = 4
Welding current [A]	Is =108	Is =124	Is =148
Welding speed [cm/min]	Vs = 14	Vs = 14	Vs = 14
Shielding gas	M21 – Corgon 18	M21 – Corgon 18	M21 – Corgon 18
Gas flow [l/min]	Q = 14	Q = 14	Q = 14
Stick out [mm]	Lcl = 12	Lcl = 14	Lcl = 14
Eccentricity [mm]	e = 3	e = 3	e = 3
Amplitude [mm]	A = 5.0	A = 7.0	A = 12.0
The frequency of oscillation [Hz]	f = 1,8	f = 1,5	f = 1,3
The angle of torch inclination	α = 80º	α = 80º	α = 80º
Shoulder joint [mm]	c = 1	c = 1	c = 1
Opening of the joint [mm]	b = 2.5	b = 2,5	b = 2.5
Number of layer	1	2	3

a b c

Figure 4 Weld appearance; a – root; b- macroscopic; c- exterior surface

Welding using short arc transfer was done in three layers change from one layer to another welding current respective parameters oscillation: amplitude respectively frequency. It was aiming to control the welding pool in terms of achieving a weld free of defects and with an appropriate aspect.

3.3 Technical and economic analysis of the welds performed

From the analysis above welding technology for the two positions, respectively horizontal and vertical results the following main technological aspects:

- welding was done using short arc transfer in both cases from the relatively small size of the samples used in the experiment: lxbxs = 120x70x8mm;
- danger of welding pool leakage in vertical upward position limiting the welding current value under 150A;
- to increase productivity in horizontal position for welding layers of filling was chosen the value of welding current to the upper limit of below 200 A (welding speed of the wire electrode 5m / min) in the concrete conditions of welding;
- no significant technological differences to weld root layer are made, welding being carried out in similar conditions in terms of arc power from root for realizing penetration without defects lack of penetration or excess penetration;
- oscillation the welding torch is required to vertical upward position for control the welding pool; oscillation in horizontal welding position is imposed only need to melt the joint flanks;
- the necessary oscillation parameters corrections of the welding torch is necessary between the two positions to obtain a favorable geometry of the seam;

Economic calculation on the cost of welding for the two cases lies in calculating the cost of materials for welding (wire and shielding gas), labor costs, energy costs or administration cost. The calculation was made taking into consideration in both cases a welding by 1m long [1, 2].

In Tables 3 and 4 are presented the results of these calculations.

Table 3 The cost of horizontal MAG welding - experimental technology

Type of cost	Symbolization	Value	Unit
Actual time of welding	$\mathbf{t_{S1}}$	**29.64**	**min/m**
The cost of filler materials	C_{MA1}	11.72	lei /m
Labor costs	C_{MO1}	6.70	lei /m
The cost of electricity	C_{W1}	0.45	lei /m
Administration cost	C_{RE}	10.05	lei /m
Total cost	$\mathbf{C_{T1}}$	**28.92**	**lei /m**

Table 4. The cost of horizontal MAG welding - experimental technology

Type of cost	Symbolization	Value	Unit
Actual time of welding	$\mathbf{t_{S1}}$	**49.98**	**min/m**
The cost of filler materials	C_{MA1}	15.51	lei /m
Labor costs	C_{MO1}	10.39	lei /m
The cost of electricity	C_{W1}	0.54	lei /m
Administration cost	C_{RE}	15.59	lei /m
Total cost	$\mathbf{C_{T1}}$	**42.03**	**lei /m**

The analysis calculations are seen as the price for upward vertical weld in position is approximately 45% higher than when welding in a horizontal position, the major difference being on the cost of labor due to productivity because deposit rate is lower when welding vertical.

4. Conclusions

Technical-economic study compared between horizontal welding and upward vertical welding position when welding in shielding gases mechanized with fusible electrode MAG, standard wire full application to the execution of butt welded joints highlights advantages such as:

- weld quality;

- reproducibility;
- relief work for welder;

Also this study shows technological and economic differences between the two types of welding, due in particular welding position, which is one of the important factors that act significantly on the execution of welded joints.
The optimum welding position is horizontal PA. Whenever possible welding will be executed in this position.

As a general rule resistance welding is recommended to weld vertical upward (provides strength characteristics and quality, but the surface appearance of the weld is cluttered with large scales and) and connection welds (of less importance unsolicited exploitation) using vertical downward welding (characterized by good aesthetically, but poor quality with high probability of defects liaison butt). The two welding positions if they meet the general assembly welds on site [1].

The danger of leakage of the welding pool in vertically upward position determine limitation of welding current values to which it is possible to control it by welding transfer by short circuit that need to perform oscillation the welding torch which leads to increased manufacturing cost of welds compared to welding in horizontal, effect of lower productivity due to welding deposit rate and welding speed.

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ANALIZĂ TEHNICO-ECONOMICĂ COMPARATIVĂ ÎNTRE SUDAREA MAG CU SÎRMĂ PLINĂ PE ORIZONTALĂ ȘI VERTICALĂ

Rezumat

Lucrarea își propune analiza și studiul tehnico-economic comparativ între sudarea în poziție orizontală respectiv în poziție vertical-ascendentă în cazul sudării mecanizate în mediu de gaze protectoare cu electrod fuzibil MAG standard cu sârmă plină cu aplicație la execuția unor îmbinări sudate cap la cap pătrunse cu acces dintr-o parte pe oțeluri nealiate cu puțin carbon cf. SR EN 10025/2. În acest sens s-a utilizat instalația de sudare mecanizată pentru sudarea în poziție verticală, proiectată și realizată în laboratorul de sudură a departamentului IMF, instalație care a fost modificată și adaptată în cadrul prezentei lucrări de disertație și pentru aplicații la sudarea mecanizată în poziție orizontală.

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