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COMPARATIVE STUDY BETWEEN GMAW-CW AND GMAW-EW PROCESSES WITH ADDITION OF A COLD ENERGISED WIRE

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Abstract. *In a highly competitive market, the GMAW process begins to fail to meet productivity needs, and it is imperative to seek a process with high deposition rates, reduction in welding time, and low operating costs. For surfaces that have undergone erosive processes their reconstitution is performed using Cold Wire-GMAW process, where cold wire is added to the melt pool using the thermal energy of the arc to execute the weld joint that promotes its fusion, increasing the mass of material in the joint and consequently the productivity of the process; however this increase of mass has been limited. The purpose of this work is to make a comparative analysis of the CW-GMAW processes with the EW-GMAW, which is the welding in which the cold wire is energized, varying the direction of welding (pulling and pushing), to obtain a high deposition of welded material. The results showed that welding by the EW-GMAW process showed higher deposition in pulling mode, less spatter, better wettability, good appearance, generating an acceptable aspect cord for coating purposes, with a 140% cold wire addition and a dilution of approximately 15% with current 80A.*

Keywords: *Welding, GMAW, Cold Wire, Electric Wire, Coating.*

1. INTRODUCTION

According to Marques *et al.* (2017) the process of arc welding by gas protection (GMAW) has been widely used in industries involving manufacturing and maintenance processes, as well as being used in the recovery of worn parts from metal surfaces. Cabral (2011) states that its main advantages are low cost and high productivity.

The search for increased productivity combined with the reduction of costs and time in the recovery of eroded parts and surfaces has motivated research with welding processes that present higher rates of deposition and lower dilution.

Thus, the GMAW process with the addition of cold wire (CW-GMAW) was developed to meet this demand, because according to Filho (2011) the use of an auxiliary wire in the GMAW process can increase at least two times the deposition of metal compared to the conventional GMAW process.

The CW-GMAW welding process is a variation of the GMAW process where an extra feed head is added to the non-energized cold wire connected to the welding torch, as can be seen in fig. 1 (a). This process generates only an arc, where the cold wire will take advantage of the energy generated in the melting pool to melt and increase the deposition of molten metal, but this process reduces the melting pool temperature thus reducing the penetration of the molten metal, making this welding process more suitable for coating welding (Sábio, 2007).

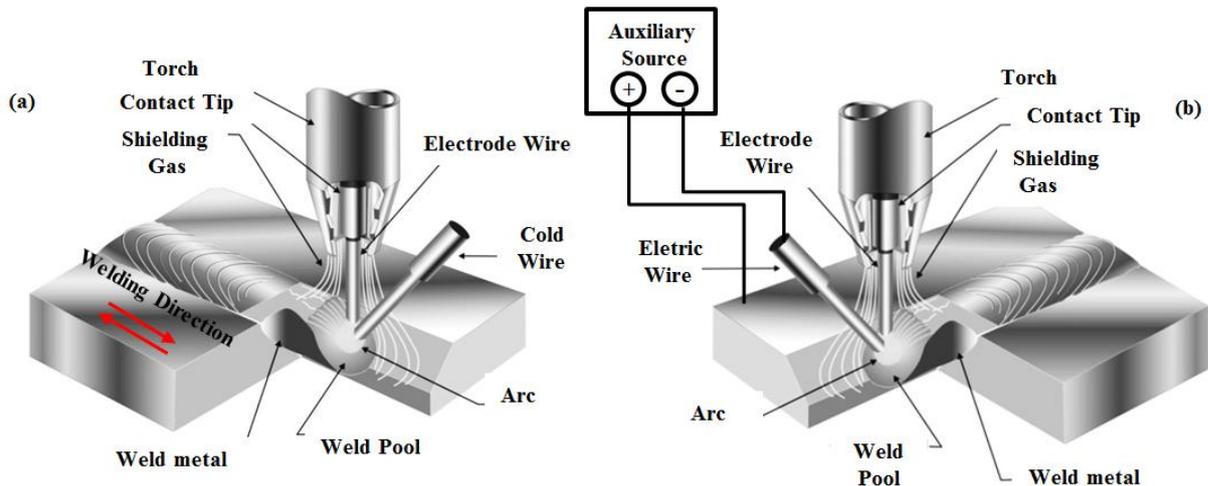


Figure 1. Scheme of the welding process (a) cold wire and (b) wire energized.

For higher material deposition to happen it is necessary to increase the current and the feed speed of the wire (Veiga, 2011). However, it was observed by Asuncion et. al (2014) that the process with addition of cold wire has been limited, because the deposition rate of 100% causes loss of mass by splash, which is sought to overcome by the addition of current in the cold wire. This process is called EW-GMAW which is a variable of the CW-GMAW process, where an extra welding source will be added that will energize the cold wire as shown in fig. 1 (b). This process will use two energized wires and a single electric arc. The main advantage of adding current in the cold wire is the possibility of potentiating the effects of the Lorentz force on the fusion pool, improving the visual and geometrical aspects of the joints. The higher the current passing through the electrode, the greater the electromagnetic force, which tends to deepen the fusion pool.

Scotti and Ponomarev (2008) state that in the case of the double-wire process, the energization of two wires can be done with one or two different sources which can generate a process with a single potential or separate potential, respectively. This method generates extreme versatility, since with the use of two wire feeders different feed speeds can be used, as well as wires with different compositions which allow a wide application range, excellent characteristics for robotization and low production of slag.

The objective of this work is to compare the GMAW process with cold wire (CW), with the process using energized wire (EW), seeking to increase the deposition rate, with wire feed rate of 140% and with current in the cold wire energized of 80 A, varying the welding direction, pulling and pushing.

2. MATERIALS AND METHODS

For the realization of the welds, a bench was used composed of: a welding source, two wire feeder head and an auxiliary source to energize the cold wire, according to fig. 2. The material used as base metal was AISI/SAE 1020 carbon steel in the form of flat bar with dimensions of 9.5 x 56.0 x 225.0 mm. As an addition metal, two AWS class ER70S-6 wires, the electrode wire having a diameter of 1.2 mm and a cold wire of 1.0 mm in diameter, according to the AWS 5.18 standard. The protection gas used was Argon with 20% of CO₂, with a flow rate of 15 l/min.

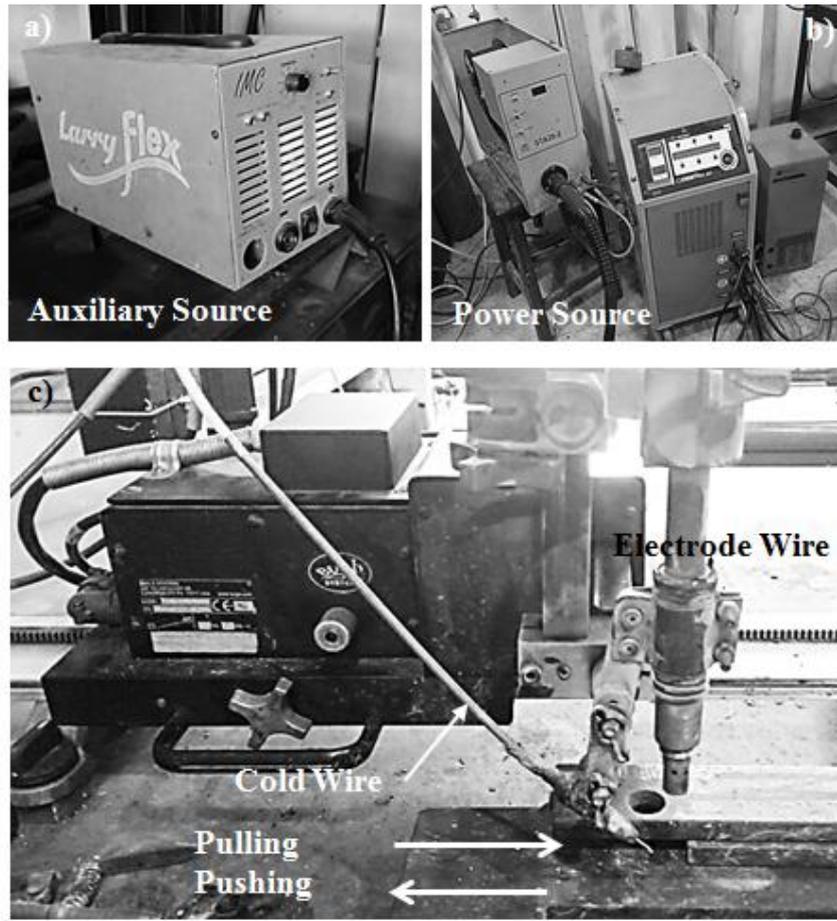


Figure 2. Structure used in the welding process

In the specimens CP 1 and 2, weld joints were deposited with the torch in the perpendicular position by the CW-GMAW (Cold Wire) process using as welding parameters, a voltage of 24 V, welding speed of 30 cm/min, Stickout of 22,0 mm and 180 A of electric current, pulling method for (CP 1) and pushing for (CP 2), using an electrode wire feed rate of 5.0 m/min, and the auxiliary wire of 7.0 m/min, which corresponds to a deposition rate of 140%. For CP 3 and CP4 weld joints were made by the EW-GMAW (Electric Wire) using the same parameters as above, but there was the addition of 80A of electric current in the cold wire, in the direct polarity, in the pulling condition (CP 03) and pushing at (CP 4), as shown in fig. 3.

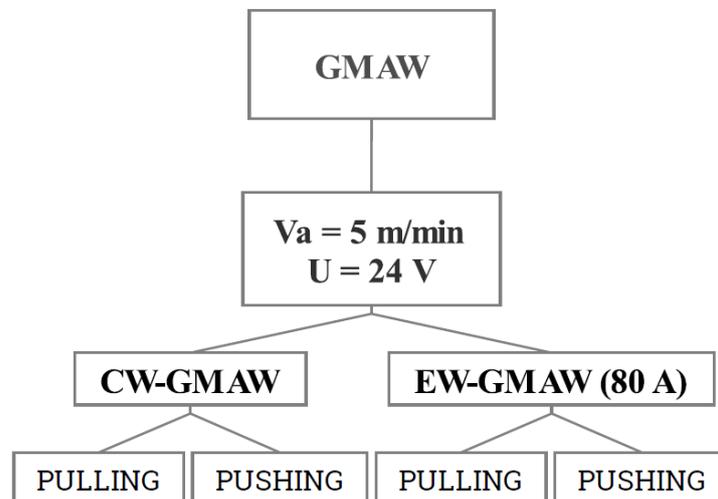


Figure 3: Scheme of the welding methodology

In each specimen a joint was run in the central position of the base metal. For the geometric analysis of the weld beads, the specimens were sectioned in the central region as shown in Fig. 4.

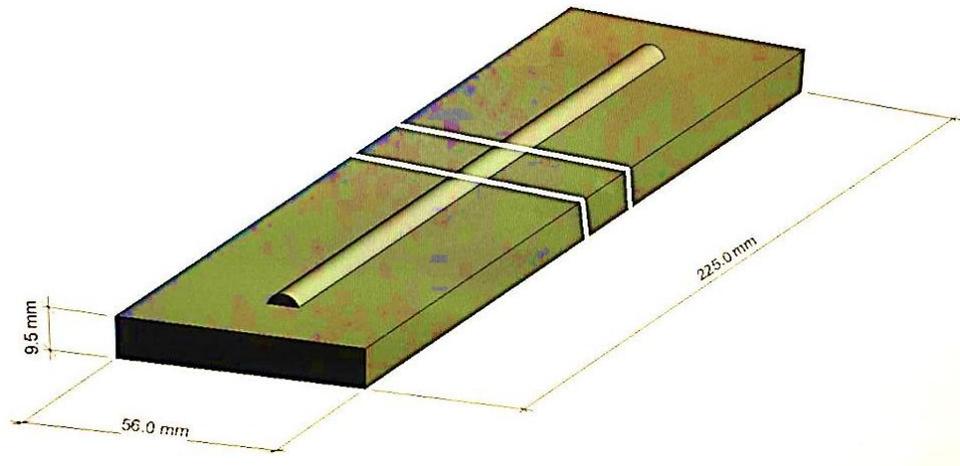


Figure 4. Dimensions of the test piece and sectioning of the welded surface.

The sectioned materials of the test bodies were embedded, sanded and analyzed under an optical microscope. With this, the width (L), reinforcement (R) and penetration (P) measurements were taken, as shown in the diagram in fig. 5, using AutoCAD® Software.

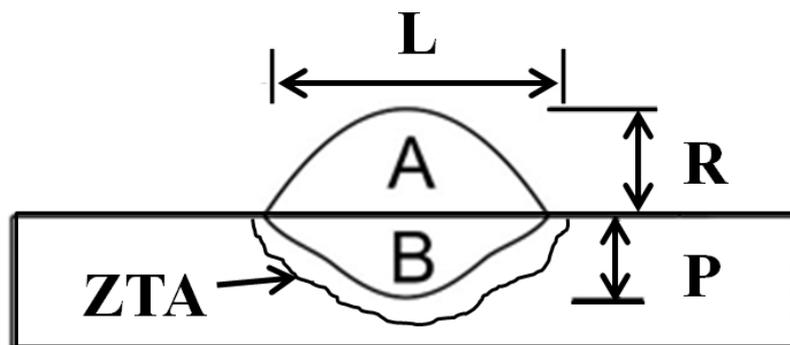


Figure 5. Model of measures.

The relative participation of Base Metal (MB) in the joint is known as the "dilution coefficient" or simply dilution, being expressed by Eq. (1), where "dilution" (δ), "A" and "B" are the areas formed in the welded joint.

$$\delta = \frac{B}{B + A} \cdot 100\% \quad (1)$$

3. RESULTS AND DISCUSSION

Table 1 shows the values of the welded joint geometry. It is observed that in the process CW-GMAW in the felt pushing (CP 2) had lower dilution, and the second lower dilution value was the CP 3 in the pulling method, the lower the dilution value the better, since this means that there was a lower interaction of the base metal in the melted zone. These results can be better visualized through the graphic representation of fig. 7, with their respective macrographs.

Table 1. Weld Joint Measurements CW- GMAW and EW-GMAW

CP	Process	Method/Current (A)	Width (mm)	Reinforcement		Penetration		Dilution (%)
				(mm)	(mm ²)	(mm)	(mm ²)	
1	CW	Pulling/ 0	10,40	4,49	37,11	1,55	7,68	17,14
2	CW	Pushing/0	10,02	4,92	36,21	0,64	3,02	7,70
3	EW	Pulling / 80	11,64	3,88	33,62	0,79	6,36	15,90
4	EW	Pushing/80	10,27	4,43	34,18	1,78	11,16	24,61

The figure 6 (a) represents the CP 1 that was welded by the CW-GMAW process, during the welding there was no complete melting of the auxiliary wire in the melted pool resulting in a tear in the weld joint after its solidification indicated by the white arrows. This was due to its position and high feed speed of the cold wire in the melt pool, as there was not enough time of its complete melting. Figure 6 (b) shows the weld joint of the CP 2 that was also welded by the CW-GMAW, where it is noticed that there was less penetration, a narrower joint, unstable welding and, consequently, more spatter indicated by the white arrows, due to the addition of a cold mass originating from the auxiliary wire in the melting pool, reducing its thermal input.

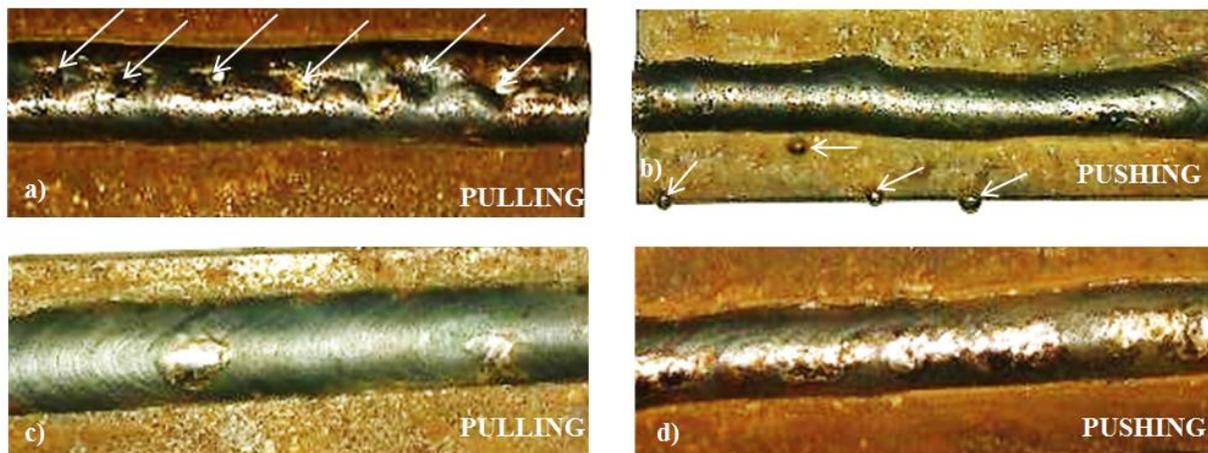


Figure 6. Weld Bead (a) CW-GMAW pulling, (b) CW-GMAW pushing, (c) EW-GMAW pulling and (d) EW-GMAW pushing

The weld joint of the CP 3 and CP 4 specimens welded with the EW-GMAW process in the pulling and pushing methods, respectively, showed better metal deposition, less spatter during execution, better wettability, good appearance making them suitable for coating purpose as show in figures (c) and (d).

It was observed in the macrographs of CP 1 and CP 2 that the dimensions of the welded regions (width, reinforcement, penetration) were not significantly different, except for the penetration value that was higher in the pulling mode. According to Modenesi (2012) the pulling welding technique presents greater penetration, which can be proven observing fig. 7 (a) and (b).

The Figure 7 (c) and (d) shows the macrographs of the weld joints of CP 3 and CP 4 respectively, where is noticed that when adding energy to the cold wire, a higher penetration was observed in the pushing method than in the pulling method, opposite effect of the CW-GMAW welding.

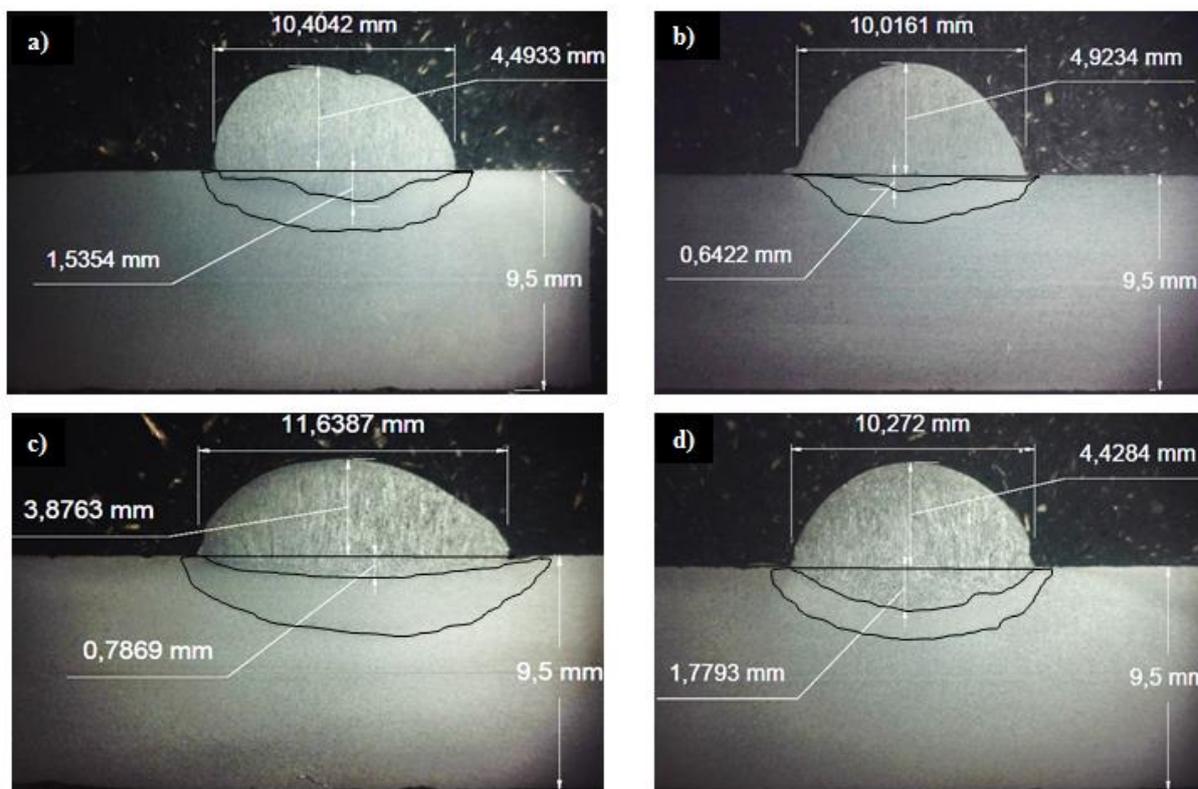


Figure 7. Cross sections of the weld bead (a) CW-GMAW pulling, (b) CW-GMAW pushing, (c) EW-GMAW pulling and (d) EW-GMAW pushing

The CP 3 shown in Figure 7 (c) showed a greater tendency to increase the width of the weld joint relative to the other specimens, the dilution of the weld cord resulted in approximately 15%, which is a reasonable value to justify its application for coatings.

4. CONCLUSIONS

The EW-GMAW process presents better fusion and deposition, for the conditions of the experiment, that is, 140% addition of energized cold wire, the coatings deposited in the pulling mode of welding presented larger values of width and acceptable reinforcement, good appearance, which may favor a reduction in the time of restoration of a metal piece or execution of coating, as it increases the mass of the deposited material and thereby the productivity of the process. In this way the EW-GMAW process is presented as a viable alternative to be used in welding operations for such purposes.

5. ACKNOWLEDGEMENTS

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