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COMPARATIVE STUDY BETWEENTHE PROCESSES GMAW AND GMAW-CW WITH VARIATIONS IN THE WIRE FEED TO FILL CHAMFER IN "U".

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Abstract. *With the need for increased deposition of material during the welding process Gas Metal Arc Welding (GMAW), it was developed the process Gas Metal Arc Welding - Cold Wired (GMAW-CW), with uses two wires, but being only one energized, increasing deposition rate in comparison to the GMAW process. This work was developed to analyze and compare geometric characteristics of GMAW and GMAW-CW welds, through variations on parameters of energized and cold wire feeding rate. Experimental runs were made in a flat position through automatic welding in test samples with chamfer "U" aiming the fulfilling of it with only one pass. The velocities 4,6 and 8m/min were utilized for the energized wire feed speed and for the cold wire 50%, 60% and 70% relative to the speed of the energized wire set. It was observed that by increasing the speed of the cold wire feed resulted in a reduction dilution and penetration, although increased the reinforcement, and the length of the weld. Due to the increase of deposited mass, the chamfer was more fulfilled through GMAW-CW process, maintaining a sanity surface looks similar to the one made through GMAW process, however with a higher incidence of spills.*

Keywords: *GMAW, GMAW-CW, Filling.*

1. INTRODUCTION

With the need of increased production speed, the process GMAW (Gas Metal Arc Welding) double wired were developed and used instead of the conventional GMAW. In this process, two energized wires are used in order to achieve better deposition rates and consequently better welding speed, but due to the two arcs needed to be created, it is needed two power supplies and a synchronizing system to administrate both arcs.

Double wired GMAW have high production rate, but requires more sophisticated equipments and more energy supplied (Cabral, 2011). In order to decrease the system complexity and maintain the deposition rate, the process GMAW-CW (Gas Metal Arc Welding - Cold Wired) was proposed, where it is similar to the GMAW process but with addition of a non-energized wire in the weld pool direction, denominated as "cold wire" (Sabio, 2007). This wire is intended to increase the deposition rate and consequently weld dimensions without an addition of a second power supply.

The GMAW-CW equipment is similar to the GMAW ones, however with addition of a extra weldhead and a support on the torch in order to provide constant feed in the arc. The cold wire uses the heat from the weld pool to melt, so there is no need of a second power supply and offering a simple GMAW to GMAW-CW conversion. On the other hand, this process creates new parameters to be determined before welding and is susceptible to errors due to problems in the wire insertion on the arc.

The research over the variables generated in this new process are still imperative to successful use of it. This work aims in the evaluation of both cold and energized wire feed speed parameters over geometric characteristics of the weld, applied to the "U" chamfer, since it has high importance to the naval construction at amazon.

2. MATERIALS AND METHODS

The workpierce dimensions were 150 x 100x 12.7 x 7.5 mm (length x width x depth x chamfer radius) as shown schematically in the figure 1. It was made of the steel SAE 1020 and the wires utilized during welding process were AWS ER70S-6.

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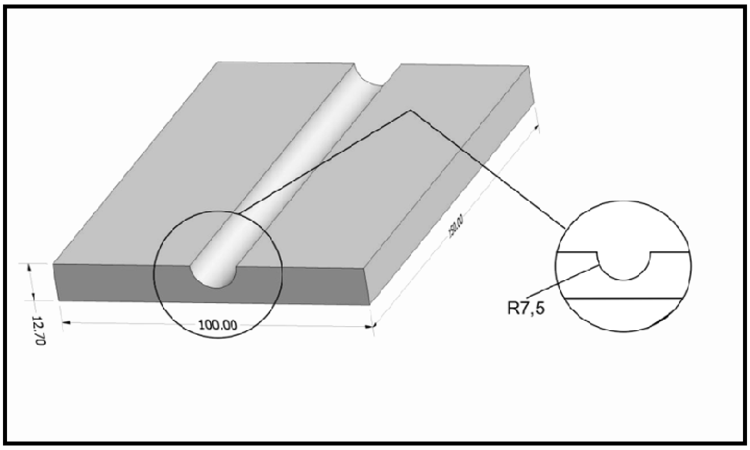

Figure 1 - Schematics of the workpierce, given in millimeters.

For the welding proceedings, the workpierce was set to be welded in plane position at a automated process. The parameters that were chosen to be constant throughout the experiments were defined through preliminary tests in order to determine its influences over the main results and offer a standard configuration for every speed input. Values of power, stickout, welding speed and CO_2 protection gas flow parameters were set as shown in the table 1.

Table 1 - Parameters maintained constant throughout the experiments.

Parameter	Used
Welding speed	15 cm/min
Protection gas flow (CO_2 100%)	15 l/min
Tension (U)	24 V
Current (I)	212 A
Energized wire diameter	1,2 mm
Cold wire diameter	1,0 mm

For the influence variables, both GMAW and GMAW-CW processes were evaluated throughout three energized wire feed speeds (4,6 and 8 m/min) and three relative cold wire feed speeds (50,60 and 70% in relation to the energized wire feed speed used). These parameters totalized 18 different variations, were during the work proceedings two of each set were made. After welding, the visual aspect of the deposited weld were analyzed and then two samples of each workpierce were retrieved to be grinded and reacted with nital 2% solution for 15 seconds.

For measures of weld height, it was considered the zero point as been the superior surface of the workpierce and by that, negatives values are possible to low reinforced welds. For the weld width, it was considered the distance between the extreme limits of the weld. Dilution was calculated as the ratio of the penetrated area and the total area of the weld. Those calculations are schematically showed in the figure 2.

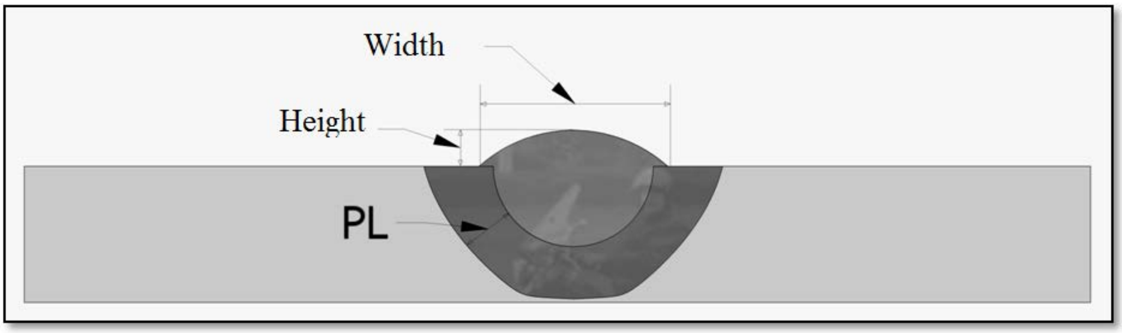

Figure 2 - Schematics of the profile utilised during geometric characteristics data obtention.

The sets of parameters used during the experimental proceedings were classified as shown in the table 2.

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Table 2 - Sequence of parameters of energized and cold wire feed speed used during the experiments.

Parameter	N1	N2	N3	N4	N5	N6	N7	N8	N9
Energized wire feed speed (m/min)	4,0			6,0			8,0		
Cold wire feed speed (m/min)[1]	2,0	2,4	2,8	3,0	3,6	4,2	4,0	4,8	5,6

[1]The cold wire feed speed values shown are relatives speeds of 50,60 an 70% of the energized ones, as described previously.

3. RESULTS AND DISCUSSION

After welding proceedings, surface characteristics were evaluated, where the process GMAW at velocities of 4, 6 and 8 m/min are represented by the figures 3 to 5 respectively and for the GMAW-CW process parameters N4 to N9 represented by the figures 5 to 11 respectively.

For all feed speed results the surface characteristics of the GMAW-CW were similar to the GMAW, probably due to the appropriate parameters that was chosen as constant in relation to the speeds evaluated, but still, high presence of weld spatter were noticed, even considering the turbulence originated from the use of CO_2 (P. Kah, 2012). There were observed as well, that any discontinuity were present. For higher wire feed speeds, either for the cold wire or the combination of the cold and the energized one, there were higher presence of weld spatter, this result can be caused due to vibration of the cold wire as it is getting in contact with the weld pool (Silva 2009) . However in this work, it was considered that the cold wire crossed the voltaic arc to the weld pool, so it got briefly energized, causing turbulence and consequently formed weld spatter (Filho, 2011).

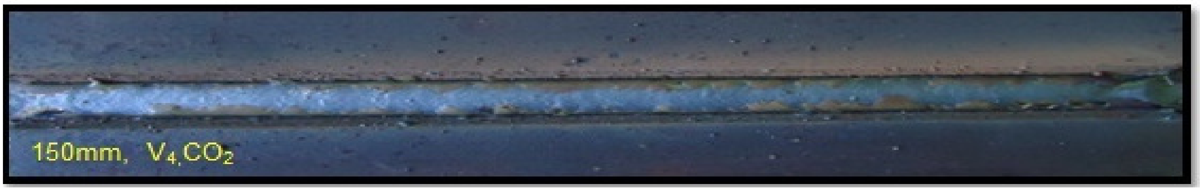

Figure 3 - Surface characteristics of the GMAW process at wire feed speed of 4 m/min.

Figure 4 - Surface characteristics of the GMAW process at wire feed speed of 6 m/min.

Figure 5 - Surface characteristics of the GMAW process at wire feed speed of 8 m/min.

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Figure 6 - Surface characteristics of the GMAW-CW process at set N4.

Figure 7 - Surface characteristics of the GMAW-CW process at set N5.

Figure 8 - Surface characteristics of the GMAW-CW process at set N6.

Figure 9 - Surface characteristics of the GMAW-CW process at set N7.

Figure 10 - Surface characteristics of the GMAW-CW process at set N8.

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Figure 11 - Surface characteristics of the GMAW-CW process at set N9.

The experiment geometric results are shown in the table 3 below, were it can be observed through the figures 12 to15 the cold wire influence at each speed set.

Table 3 - Values of width, height, penetration and dilution obtained from the experiment.

Welding process	Energized wire feed speed (m/min)	Relative cold wire feed speed (%)	Penetration (mm)	Height (mm)	Width (mm)	Dilution (%)
GMAW	4	-	1,5	-3,2	10,3	0,39
	6		2,9	-2,4	11,6	0,39
	8		3,6	-2,6	12	0,25
GMAW-CW	4	50	1,6	-2	10,8	0,28
		60	1,5	-0,5	10,5	0,11
		70	0,3	0,5	11,3	0,14
	6	50	1,6	-2,1	12,2	0,19
		60	1,27	-0,7	12,8	0,14
		70	0,2	-0,8	12,3	0,19
	8	50	2,27	-1	12,9	0,14
		60	1,69	0	13	0,18
		70	1,61	0,8	12,7	0,12

Throughout the geometric evaluation, it was observed that for any cold wire feed speed the height of the weld at the process GMAW-CW were higher than the GMAW ones. Among the cold wire speed results, it can be noticed that the height has increased, probably due to the higher mass provided at higher feed speeds either from the energized wire or the cold one. A small decrease on the height can be noticed at the velocity of 6 m/min, were at the table 4 is shown that at this point (N5 and N6 sets) the workpierce acquire a irregular shape, and then certain loss in the total height. Those results are represented by the figure 12 below, and in this parameter negative values are noticed due to the zero reference used.

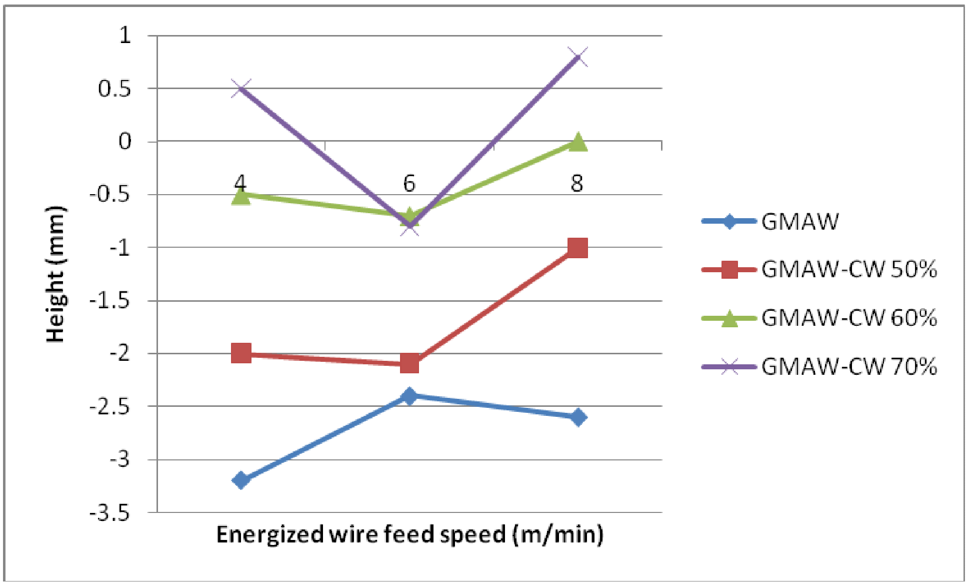

Figure 12 - Comparative graph of the weld height throughout the parameters used.

As expected, higher values of penetration were observed, since in the GMAW-CW process more energy is needed than the conventional GMAW due to the additional mass feed provided, where in this experiment the same value is used. When the energized wire feed speed were increased, the penetration increased as well, probably originated from the higher energy offered for tension stabilization, which increased the current and the welding power in order to completely melt the energized wire. It was considered that at higher cold wire speeds there were a deflection and then allowed direct contact of the arc on the workpierce, increasing penetration and causing lack of fusion in the weld, this assumptions were made through the results of the table 4 and the results of penetration on the figure 13. It was considered as well the possibility of the lower energy density due to the high cold wire speed at 8m/min of the energized wire (Modenesi, 2001).

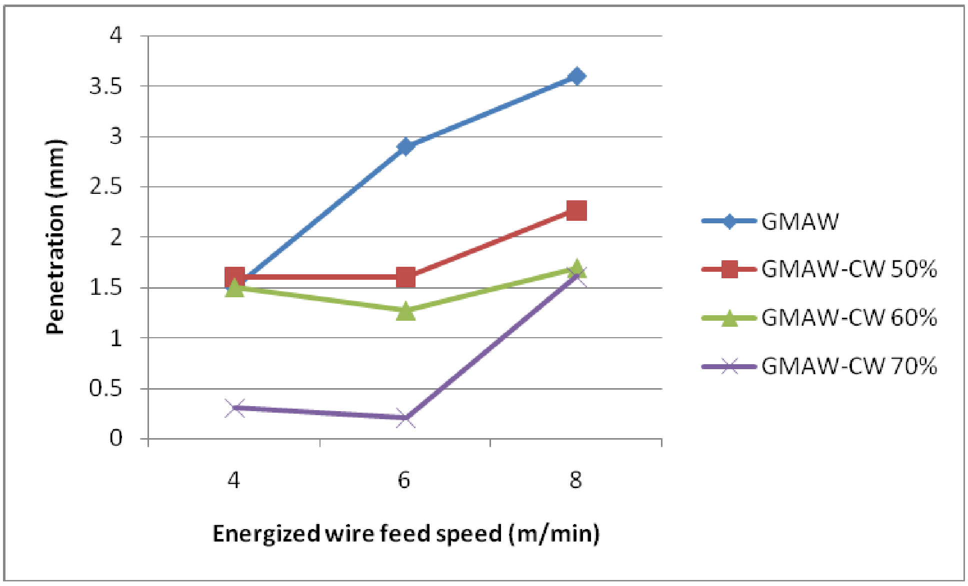

Figure 13 - Comparative graph of the weld penetration throughout the parameters used.

The weld width had small variations, probably due to limitations of the geometry of the chamfer, where at higher volume filling, the difference in the width will decrease until the total filling of the chamfer. However, the process GMAW-CW achieved higher values than the GMAW, mostly at the speeds of 6 and 8 m/min, as shown in the figure 14 below.

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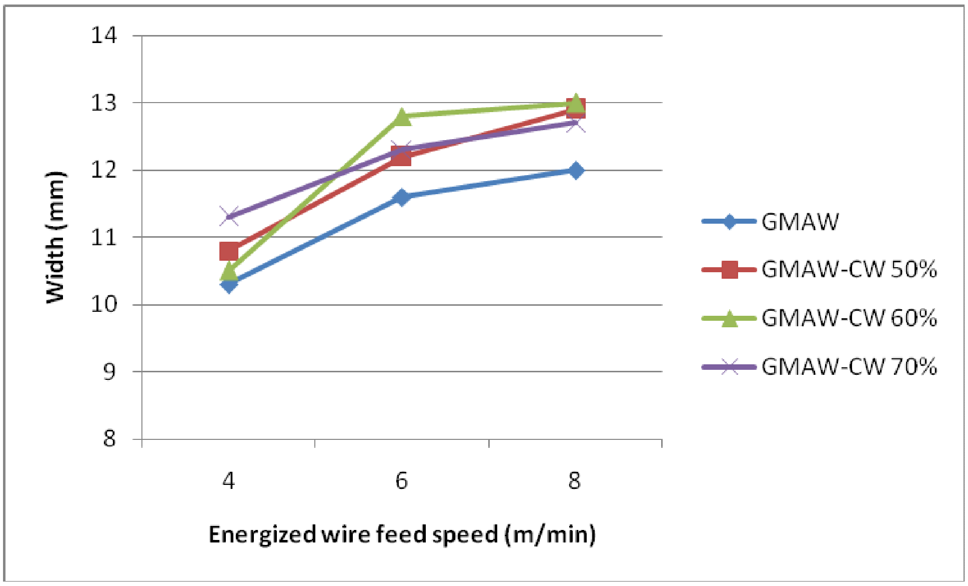


Figure 14 - Comparative graph of the weld width throughout the parameters used.

For the kind of welding experimented in this work, low values of dilution would provide better results due to higher filling possibility and then higher production rate. Lower values of dilution were observed with the process GMAW-CW, where with exception of the parameter set N1, all values of dilution among the GMAW-CW results were near each other. It was expected that at higher energized wire feed speeds the dilution would decrease, as well with the higher cold wire speed, however, in this experiment the relation to the energized one followed as expected but at the cold wire the differences were not significant. Those results are shown in the figure 15 below.

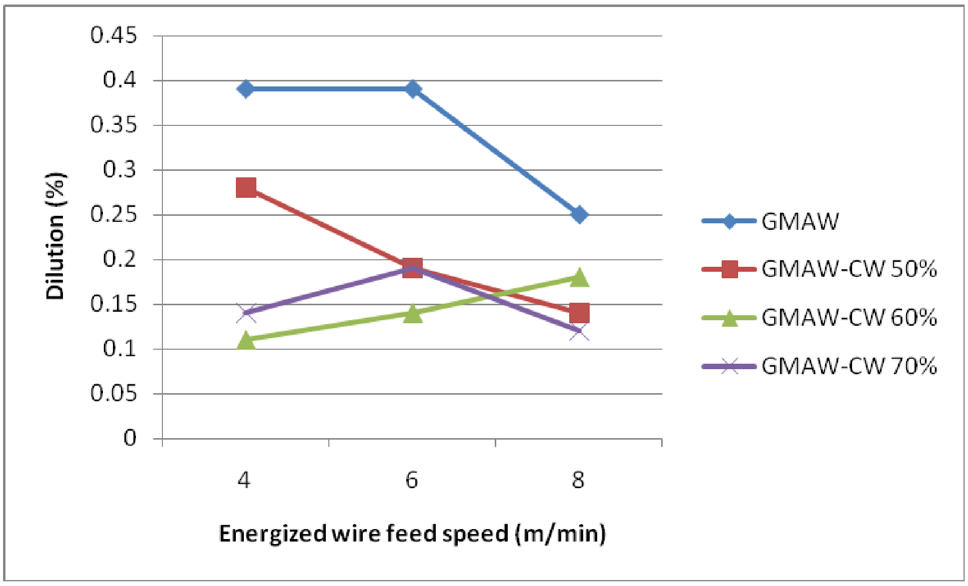
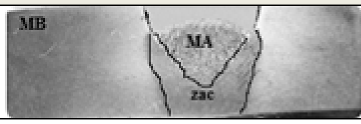
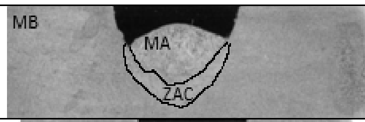
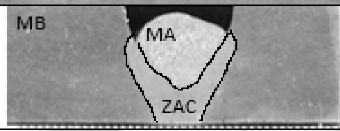
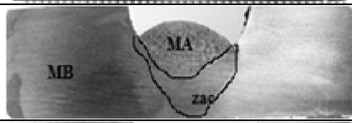
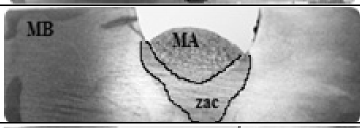
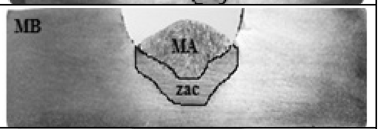
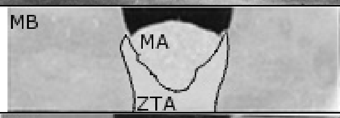
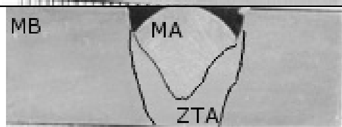
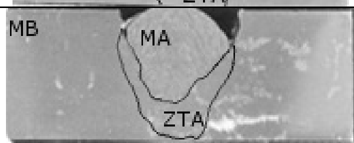
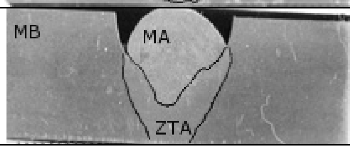


Figure 15 - Comparative graph of the weld dilution throughout the parameters used.

Table 4 - Macrographies acquired during the experiment (where: MA - weld metal; ZAC/ZTA - Thermally affected zone; MB - workpierce metal)

Welding process	Energized wire feed speed (m/min)	Relative cold wire feed speed (%)	Macrography
GMAW	4	-	

	6		
	8		
GMAW-CW	4	50	
		60	
		70	
	6	50	
		60	
		70	
	8	50	
		60	
		70	

4. CONCLUSIONS

It was observed weld spatter in both processes, but in results of dilution, width and height the GMAW-CW process acquired better results. In the N6 to N9 sets of parameters was observed lack of fusion whereas in the GMAW the almost absence of it were observed.

With increased energized wire feed speeds dilution values decreased, and with the addition of the cold wire the GMAW-CW had lower values than the GMAW. Therefore, decrease in penetration was achieved through the increase on the cold wire feed speed, result already expected due to the lower ratio of energy and mass to be melted obtained.

Finally, width values stayed similar through the different cold wire speeds on GMAW-CW, but higher than the GMAW values.

5. REFERENCES

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