ANALYSIS OF THE DISCONTINUITIES GENERATED IN MULTIPASSE WELDS IN V GROOVE FCAW AND FCAW-CW PROCESS

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Abstract. *This work studied the presence of discontinuities in two welded joints by multiple passes, deposited by the processes tubular wire (FCAW) and tubular wire with cold wire addition (FCAW-CW). The inspections were performed by non-destructive tests of liquid penetrant and ultrasound, besides macrograph in cross section of solder. The manual welding was done with a electronic source with DC + in flat position on steel joints ABNT 1020 of 350X350X16, 4 mm and chamfer V with 60 ° filled with five passes. As addition metals were used wires AWS E71T-1 and AWS ER70S-6, respectively, and diameter 1.2 mm. The protection gas was* CO_2*, at 15 L/min. The results indicated the presence of slag inclusion between the passes in the two solder cases studied, and insufficient deposition in the weld process by tubular wire. These discontinuities occurred because the cleaning and / or the manipulation of the electrode during the deposition. Although the results showed an increased incidence of discontinuities in FCAW-CW welding related to FCAW, the found level were tolerable based on criteria of standards consulted, which, by minor adjustments on equipment and welding techniques here used, can provide to the FCAW-CW process improvements in quality of welds, indicating the feasibility of the process as an alternative to increase productivity combined with low costs.*

Keywords*:FCAW,FCAW-CW,descontinuities.*

1. INTRODUCTION

The use of the tubular wire welding intensified in mechanical, naval and oil industry, both in the manufacture of structures such as the metal surfaces tooting, for its operational characteristics, versatility and high productivity.

In the process of welding with wire tubular or Flux Cored Arc Welding (FCAW) the coalescence between metals occurs by the action of an electric arc formed between the electrode (wire) and the piece to be welded (base metal).The wire is made of a metal layer with an internal flow, it is fed until the merger pool. The process can be in two ways: with protective gas - a gas used as an ionizating acting and to protect the arc, and self-protected - where gas is generated from the decomposition of the ingredients contained in the flow, with functions to stabilize the arc, adding alloy elements in the metal welding, protecting the metal welding from by the action of deoxidizer and denitrifier acting and, besides the slag formation that will protect the weld during solidification, recent work (FORTES, 2004).

The literature considers that the process FCAW is highlighted by presenting deposited metal and solder of high quality with good visual appearance. The quality of the weld will depend of the type of electrode used; method (self-protected or gas protected); conditions of the base metal conditions of the joint project and the process of welding.

The design of the FCAW-CW welding process refers to a FCAW welding version with the cold wire addition. Is the insertion of a cold wire in the atmosphere of arc generated at the type of wire electrode of the conventional process (FCAW). Thus, the cold wire melts simultaneously with the wire electrode metal to be deposited.

The proposal of the welding with cold wire is established as a technical and economical alternative for the conventional welding with continuous feeding of wire electrode. As an important difference between the dual processes of welding wire (conventional) and cold wire (in development) has the fact that the first two wire electrodes used to melt by the action of two voltaic arcs generated at its extremity in decay, while the second uses only one electrode wire for a single arc, the other wire is cold, not energized, recent work (GARCIA, 2009). As advantages of welding with cold wire are: gas economy, easy manipulation of the welding torch (Fig.1), being more compact and light, absence of the magnetic wind, reduced cost of equipment, work with different diameters of wire, reduction in emission of smoke and radiation, recent work (LEAL, 2009).

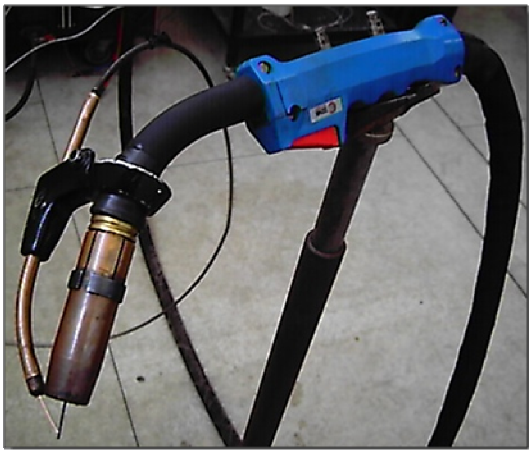

Figure 1. Welding torch connected to the feed device of the cold wire.

A discontinuity can be defined as the lack of uniformity in the structure of the weld, may be caused by poor adjustment of welding parameters, arc instability, inadequate amounts of current/voltage, incorrect handling of the electrode and inadequate cleaning of slag, and others. A welded joint will be considered defective when it submitted discontinuities whose dimensions exceed those established in the criteria for acceptance as the standard and quality standard specific to the project. This study analyzed by macrograph and non-destructive Penetrant Liquid essay and the ultrasound presence of discontinuities in welded joints by tubular wire process and tubular wire with cold wire addition. The procedures were performed with approximate values for comparison between them and also to analyze the results.

2. METHODOLOGY

The manual welding was done with a electronic source in DC^+ in flat position on joints of steel ABNT 1020 of 350x350x16,4 mm and chanfer V and 60° filled with five passes. As addition metals were used AWS E71T-1 and AWS ER70S-6 wires, respectively, and Ø 1.2 mm. As protection gas was used CO_2 at 15 L/min.

The welding of the joints, Figure 2, began with the deposition of the root pass by MAG welding process (Tab.1) and then passes by the filling and finishing as the processes studied and the parameters listed in the Tables 2 and 3. The FCAW-CW welding typically began with the opening of the arc for the wire electrode and after 2.0 to 3.0 seconds with the feed of the cold wire. The welding finishes with the interruption of cold wire feeding followed by extinction of voltaic arc, in this sequence. The welding speed was 20-25 cm/min. While the cold wire feeding speed was 40% the speed of electrode wire, as the parameters of table 3.

Table 1. Parameters of the root pass to the specimen.

Variable	Especification CP07	Especification CP17
Process	GMAW	FCAW-CW
Electrode	ER70S-6 (Ø 1.2mm)	ER70S-6 (Ø 1.2mm)
Feeding Speed (m/min)	3.0	3.6
Current (A)	93	108
Voltage (V)	26	27

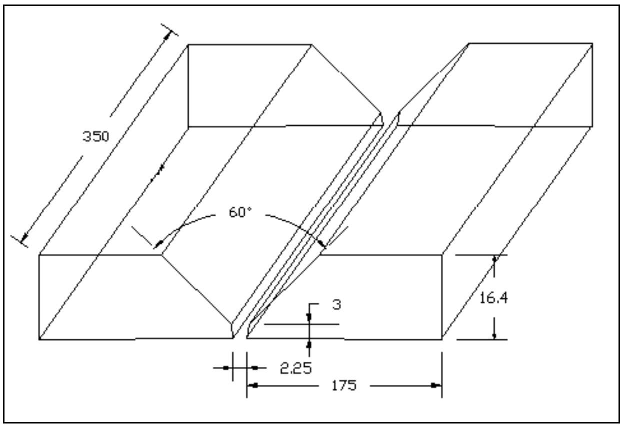

Figure 2. Details of the joint construction.

Table 2. Filler passes parameters for CP17.

Variable	Passes					
	1°	2°	3°	4°	5°	Average
Current (A)	138	145	150	145	157	147
Voltage (V)	29	29	28,5	28,7	28	28,6
Wire speed (m/min)	6	6	6	6	6	6
Welding speed (cm/min)	20,3	26,6	29,6	23,1	24,4	24,8

Table 3. Filler passes parameters for CP07.

Variable	Passes					
	1°	2°	3°	4°	5°	Average
Current (A)	160	145	145	150	155	151
Voltage (V)	27,3	28,3	28,8	27,9	28,2	28,1
ElectrodeWire Speed(m/min)	6	6	6	6	6	6
Cold Wire Speed (m/min)	2,5	2,5	2,5	2,5	2,5	2,5
Welding speed (cm/min)	27,6	33,3	29,6	21	20,8	26,5

A visual inspection was followed by liquid penetrating test on the surface of the weld, which received a pre-cleaning to remove contaminants. Was applied on the surface penetrating and the excess was removed with water after 10 minutes. Then, applying the indicator and inspection occurred after 10 minutes. In the trial of the ultrasound the examination was performed in scanning the surface of the adjacent base metal and parallel to the weld fillet. In this test, was used transducers angles 60° and 70°, with 4MHz. Finally, macrograph examined the weld fillet cut in the cross direction, and sanded with granulometry from 80 to 360 mesh and attack with Nital 2% for 20 seconds.

3. RESULTS AND DISCUSSIONS

Figure 3 shows the visual aspect of the welded joint by FCAW (CP17) and FCAW-CW (CP07), while Fig. 4 and Fig. 5 show the macrographies of the cross section welded joints. The visual test indicated the joints with a good appearance and a smooth aspect, dimensional regularity in reinforcement, in width and in overlapping of filling passes and finishing passes, they showed absence of spatter, porosities, undercutting and underbead cracks. The penetrating liquid test did not show opened defects in the surface. The ultrasound test detected some internal discontinuities in FCAW-CW welded joint, which dimensions overcame the ones established in the ASME standard sec. VIII Div.1, Div. 2 and Sec. I (Tab. 4 and Tab. 5). After that, these discontinuities were identified by the macrography analysis, Fig. 4 and Fig. 5, as slag inclusion. In FCAW welded joint, the ultrasound test did not detected any discontinuities with dimensions which overcome the standards already mentioned, and the macrography analysis identified smaller slag inclusions than the ones that were found in FCAW-CW welded joint. Macrographies analysis of welded joints, Fig. 4 and Fig. 5, showed the sequence and the number of passes, the columnar grains zone and the refined grains zone of the weld filet, besides the heat affected zone.

After the analysis of the tests results, we can say there are not significant differences between the welded joints of both processes. Thus, both processes indicated a good operational performance of the FCAW-CW welding process, which studies are still in development.

Figure 3. Superficial aspect of the welded joints by FCAW-CW welding process (CP07), and FCAW welding process (CP 17).

Table 4 – FCAW welding process ultrasound test results.

Measure Data										
Number	Weld Head	AMP. (db)	Place (mm)	length (mm)	Deep (mm)	Sound way (mm)	Reference Distance (mm)	Detection surface	Desconuities Recognition	Report
01	60	60	20	10	7	35,4	22	A	inclusion	-
02	60	60	50	30	6,3	35,2	22	A	inclusion	-

Table 5. FCAW-CW welding process ultrasound test results.

Measure Data										
Number	Weld Head	AMP. (db)	Place (mm)	length (mm)	Deep (mm)	Sound way (mm)	Reference Distance (mm)	Detection surface	Desconuities Recognition	Report
01	60	53,5	175	16	12	40,8	25	A	inclusion	-

02	60	53,5	153	15	10	41,2	20	A	inclusion	-
03	60	53,5	110	30	8,2	43,2	26	B	inclusion	-
04	70	56,5	176	15	8	44,4	30	A	inclusion	
05	70	56,5	20	15	8	45,3	30	B	inclusion	
06	70	56,5	70	25	10	60,6	47	B	inclusion	

Figure 4 and Figure 5 showed the macrographies of both sections.

Figure 4. FCAW-CW cross sectional macrography. Etched surface by Nital 2%, zoom 1,5x.

Figure 5. FCAW cross sectional macrography. The surface was etched by Nital 2%, zoom 1,5x.

4. CONCLUSIONS

i) The visual inspections showed that the welded filets have a good aspect and continuity, and a few spatter.

ii) The slag inclusion presence can be happened due to the insufficient clearance of slag between passes or the inadequate welding technical of electrode using.

iii) Due to the bigger melting rate of FCAW-CW welding process, it is necessary to watch the speeding control, because the more the deposition rate increases, the more the melting pool becomes viscous and tends to confine slag and gases.

iv) The results indicated that FCAW-CW process has requirements and great potential as alternative technique of quality and productivity for applications at production industry, if adjustments on equipment and welding techniques were implemented.

v) This new process, which is in development, requires additional studies to advance in the selection of operational package more optimized applied to filling of different kinds of chanfers.

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5. RESPONSIBILITY NOTICE

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