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THE INFLUENCE OF THE OPERATING PARAMETERS OF THE GMAW PROCESS IN THE METALLURGICAL PROPERTIES OF THE WELDED REGION OF STAINLESS STEEL AISI 304

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Abstract. *Among the main manufacturing processes highlights the GMAW welding process (Gas Metal Arc Welding), due to its many advantages, such as being used with all commercial metals and alloys, high deposition rates, long strings depending on the feed continuous consumable wire electrodes and still easy automation. GMAW is a welding process by voltaic arc that uses a continuous feed metal (wire electrode) and an external source of gas to protect the weld pool from contamination of outside air. This work represents an analysis of the influence and optimization of operating parameters such as current, welding speed, and voltage. The steel in question will be the AISI 304. For the design of experiments and subsequent analysis of influence of the parameters, we used a statistical tool based on the project's technical and analysis of experiments, DOE, applied through the Minitab software. "The welding was simple deposition on flat plate thickness of 1/4", and the samples with dimensions of 65 x 150 mm. After welding, the samples were prepared for macro and micrographic analysis in order to find the best combinations of parameters for a more refined microstructure with the presence of more equiaxed grains.*

Keywords: *Welding, GMAW, Microestructure, DOE, AISI 304.*

1. INTRODUCTION

The soldering is one of the most important manufacturing processes and present in the industrial field. It is very wide its use in various industries, especially for use in petrochemical and shipbuilding industries, which are increasing with the oil exploration. As other techniques developed by man in need of detailed studies and approaches welding is a process that requires development and study, especially in point of searching for quality. Today the search for improvement in process quality, especially in welded joints of great responsibility as pipes, vessels, tanks, steel structures, automobiles structures, among others, is constant and is necessary.

The matter regarding welding is very wide, there are many existing processes, to be used in different situations, depending on the needs. Among the various processes, the GMAW welding process has proven to be very advantageous over other processes. The increasing of its participation is related to the applicability in a wide range of materials, as well as high productivity and its good flexibility (the welds can be made in all positions) and costs, being very suitable for mechanization.

In welding with inert gas (GMAW) is common the use of gases Ar (Argon), He (helium) or mixtures among them complemented with O2 or CO2. These gases do not react chemically with the weld pool, acting only in the protection of the regions involved and the opening and maintenance of the arc. According to Villani (2006), with the proper choice of shielding gas, electrodes and welding variables most commercially important metals can be welded by GMAW process.

The GMAW process is influenced by certain variables, such as: welding current, arc voltage, welding polarity electrode length, electrode position, direction of the electrode joint type, electrode diameter, shielding gas and characteristics welding speed (Hermans, 1999)

The knowledge and control of variables in the electric arc welding process are essential for obtaining satisfactory quality welds. These variables are not completely independent and require these changes in a change in one or more from the others to produce the desired results. Considerable skill and experience may be required for selection of parameters for each application. The optimum values are affected by the type of base metal, the electrode composition, the welding position and the quality requirements. So there is no single change in the parameters that leads to a good result in each case (Vieira, 2006).

According Lancaster (1999), variation of temperature, cooling medium, the base metal chemical composition and chemical composition of the weld metal, directly influence the microstructural characteristics of the material welded, and consequently can compromise the mechanical properties service. Thus, this paper aims at an assessment of the influence of the main operating parameters of GMAW process, such as current, voltage and welding speed on the microstructure formed in AISI 304 steel.

2. MATERIALS AND METHODS

For the tests we used the wire (electrode) solid AWS ER-308Lsi with 1.0 mm diameters, and Argon gas to protect the weld pool. The wire composition is presented in Table 1.

Table 1. Chemical composition of electrode AWS ER-308Lsi.

C	Mn	P	Si	Cr	Ni	Mo
0,023	1,55	-	0,75	20,0	10,1	0,17

Source: http://www.esab.com.br

The specimens were made of stainless steel AISI 304, with 65x150x 6.35 mm. Table 2 you can check the chemical composition of steel used.

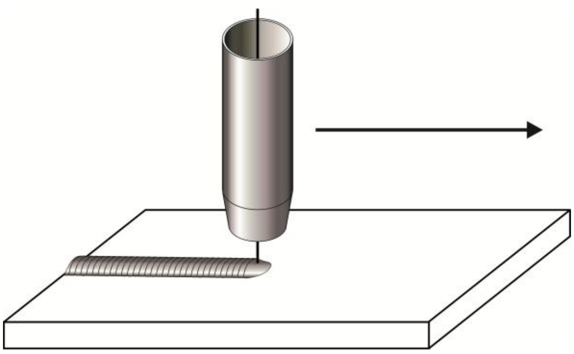
Table 2. Chemical composition of stainless steel AISI 304.

C	Mn	P	Si	Cr	Ni	S
0,8	2,00	0,045	1,00	18,0 - 20,0	8,0 – 10,5	0,030

Source: http://www.eutetic.com/catalogoinox_parte1.indd

The welds were performed in the bead on plate (BOP) in the longitudinal direction of the specimen and the welding torch remained perpendicular to the face to be welded, as shown in Figure 1.

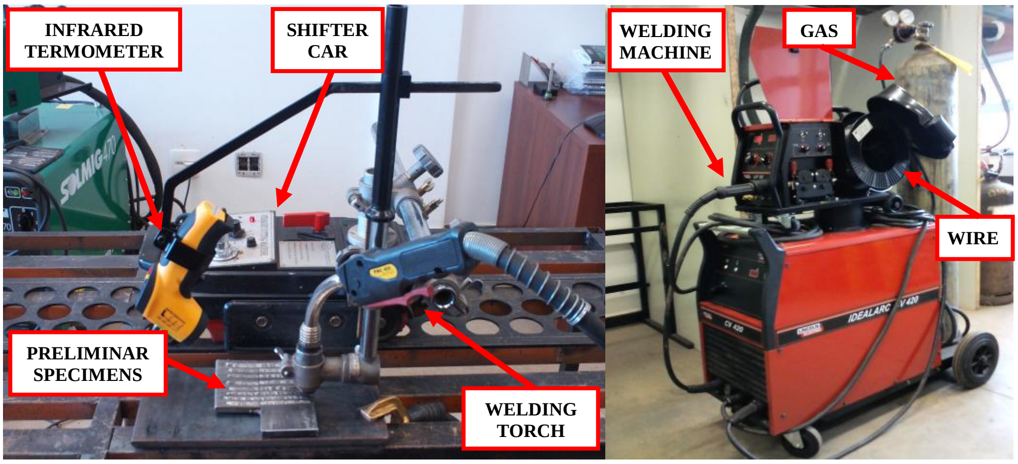
Figure 1 – Torch positioning of the scheme in relation to the plate.



Source: The author.

To cater to proposed objectives for this parer was set up a test bench consists of a mechanized system of torch displacement (SB1-30, mark: Soldas Brazil) and welding equipment (Idealarc CV-420, mark: Lincoln Electric) with level control current and welding voltage, among other pertinent variables (Figure 2).

Figure 2 – Testing bench.



Source: The author

The design of experiments (DoE) was obtained by the Minitab software using a full factorial design, ranging three factors at three levels each, obtaining a planning 3^3.

Current levels and voltage used was chosen by preliminary tests conducted as recommended by the manufacturer of the wire, to which the voltage is between 15 V and 32 V, and the current between 100 A and 225 A. After the tests set the values current and voltage that have generated strands with better geometric aspect and ranged up less or more within the range of acceptable values, as shown in table 3.

Table 3. Factors and levels to be varied.

Variable	Level 1	Level 2	Level 3
Current (Ampere)	111	116	120
Voltage (Volt)	22	24	25
Speed (mm/min.)	325	390	465

Source: The author

3. RESULTS AND DISCUSSION

The transfer mode obtained was a short circuit in all beads. As a result of the DoE was generated Table 4, which lists the three factors with their respective levels of variation. These were the setting parameters of the equipment for the tests. The results column, where you see the penetration values, was obtained after macrographic analysis (Fig. 3) of the welded specimens and inserted later to analyze the results.

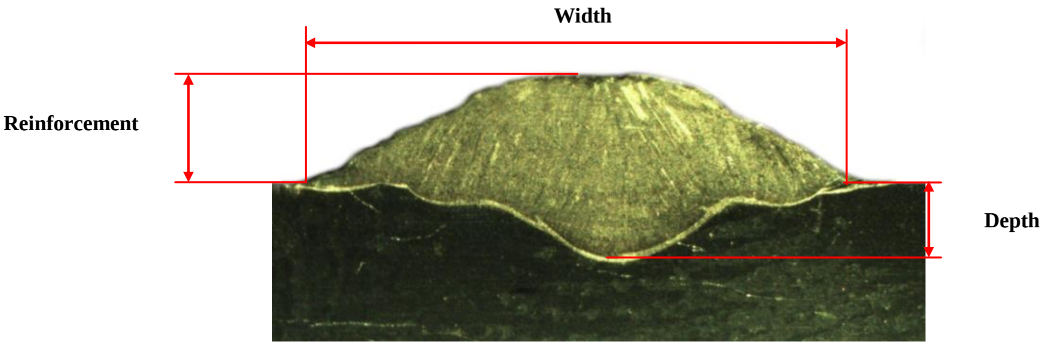
Table 4. Design of Experiments

Specimen's execution order	Input Variable			Results	Specimen's execution order	Input Variable			Results
	Speed (mm/min.)	Current (A)	Voltage (V)	Depth		Speed (mm/min.)	Current (A)	Voltage (V)	Depth
01	325	111	22	0,59	15	390	116	25	0,82
02	325	111	24	0,41	16	390	120	22	0,98
03	325	111	25	0,75	17	390	120	24	0,49
04	325	116	22	0,95	18	390	120	25	1,00
05	325	116	24	0,64	19	465	111	22	0,56
06	325	116	25	1,34	20	465	111	24	0,85

07	325	120	22	1,24	21	465	111	25	0,72
08	325	120	24	0,98	22	465	116	22	0,61
09	325	120	25	0,76	23	465	116	24	0,46
10	390	111	22	0,74	24	465	116	25	1,26
11	390	111	24	0,82	25	465	120	22	0,61
12	390	111	25	1,00	26	465	120	24	0,36
13	390	116	22	0,48	27	465	120	25	0,88
14	390	116	24	0,52	-	-	-	-	-

Source: The author

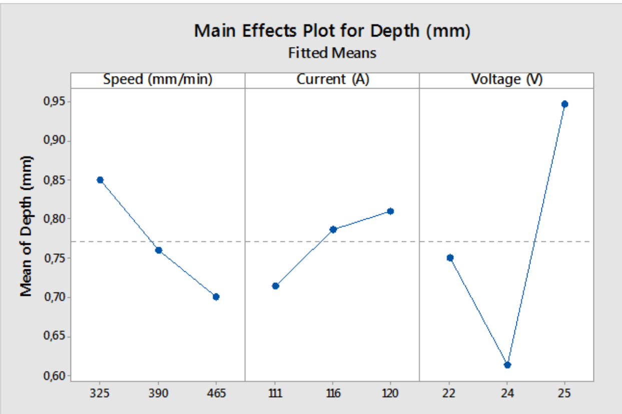
Figure 3 - Macrography Specimen 06 with 10X magnification.



Source: The author

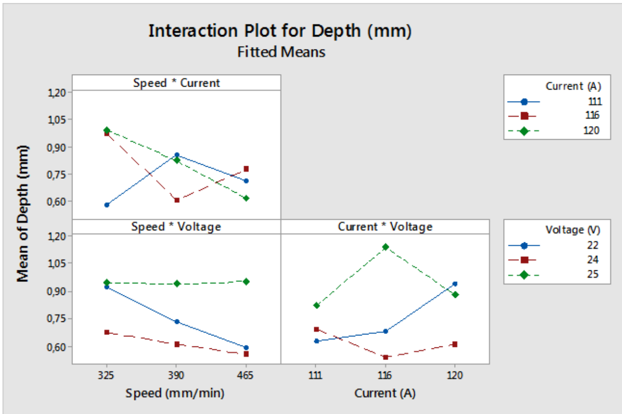
Having the data generated by the DOE was performed analysis of the same, through the which was possible to obtain the influence of each parameter in the penetration of the weld bead as well as the influences exerted by the interaction between them. The following figures, Figure 4 and Figure 5 show the results of the analysis.

Figure 4 - Effects of the main parameters penetration.



Source: The author

Figure 5 - Interaction of the main parameters penetration.



Source: The author

The graphs shown in Figure 4 demonstrate the effects of the main variables on the penetration of the bead, allowing an individual assessment of the parameters used. The graphs in Figure 5 show the effects caused by the interaction between the variables, and demonstrate how a change in one parameter requires a changing others to ensure good geometry in the deposited weld bead.

4. CONCLUSION

Through analysis of the data generated we conclude that the effects caused by the speed and the current on the penetration are very characteristic of the process and were expected. The penetration is lower for high values of welding speed, and larger for high values of the welding current. As to the pressure, it is observed that there isn't a linear relationship with the penetration. The same can be seen in the interaction between variables, which showed no distinguishable feature, suggesting that other factors may have influence on the weld geometry, such as the temperature, which requires analysis and studies more detailed.

5. ACKNOWLEDGEMENTS

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