SOFTWARE MANAGEMENT OF GTAW WELDING PARAMETERS WITH AN 8-AXIS ADAPTIVE ROBOTIC SYSTEM BY ANALYZING THE RESULTS OBTAINED ON SAMPLES AND TEST PIECES

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ABSTRACT: The objective of the article is to briefly detail the main aspects that can influence the accuracy, reliability, flexibility and productivity of a robotic welding system. The article describes the welding process used by the robotic system to obtain experimental data. The welding parameters that have been managed in the software program of the robotic system are presented in order to obtain satisfactory samples and test pieces. The experimental part followed the study of samples and test pieces obtained after managing the welding parameters by their software implementation. For the selected experimentation scenario, the article establishes the values of the welding parameters implemented in the software program of the robotic system.
KEYWORDS: **robotic system**, **welding parameters**, **software program**, **samples**, **test pieces, management**

1. INTRODUCTION

The selection of materials for a particular welding process in the manufacturing process, must take into account the advantages / disadvantages that they involve. For welding technologies in general, they are listed below [1]:

- **Advantages [1]:**
  - Reduction of metal consumption (30-50%);
  - Increased productivity (2-20 times);
  - Achieve superior mechanical properties compared to cast pieces or riveted and bolted pieces.
  - Realization of structures of practically unlimited complexity.
  - Making rational forms adapted to the mechanical demands.
  - Obtaining watertight joints.
  - The use of semi-finished products and typical elements for the construction of welded constructions.
  - Possibility of mechanization and automation,
  - Reducing the cost price.
  - High flexibility and mobility.
  - Reduced pollution and low energy consumption.
- **Disadvantages [1]:**
  - The appearance of defects that are not easily identified.
  - The appearance of stresses and deformations after welding.
  - Local modification of the properties of the base metal, the characteristics of mechanical resistance, corrosion resistance etc.

An arc welding robot system should be on a firm foundation so that any vibrations will not produce a shaking effect on the system. Also, the emergency switch button (having the colour of yellow and red) should be located at a position that is easily accessible. The switch should stop the robot without shutting off the power. There should also be a safety fence to protect the work force from spatter and arc flash. For safety, the robot operator should have a rigorous training on robot speed, working range, emergency stopping, and functions of teach pendant.[2]

2. DESCRIPTION OF THE WELDING PROCEDURE USED IN EXPERIMENTS IN ORDER TO MANAGE THE SOFTWARE PARAMETERS

The welding process chosen is by melting, at which the addition metal and the edges of the base metal joints melt under the influence of the heat source, forming the welding bath, which by crystallization forms the welded seam.

The welding equipment generates power to generate the arc for welding. One of the most important characteristics is stability of power. It is recommended that the welding equipment generates a short arc with less spatter for a good welding quality even at high speeds. The arc sensor detects the current value so that the power source can supply the correct amount of power to the wire feeder, which then controls the wire feeding speed. The wire feeder has wheel rollers to advance the wire. Some feeders have four rollers speed sensors for more accurate wire feeding by push-pull action. Also, a wire feeder with shorter length to the torch is better in terms of a response time. Therefore, a good location for the wire feeder for a robot system is at the end of the upper arm of the robot.[2]

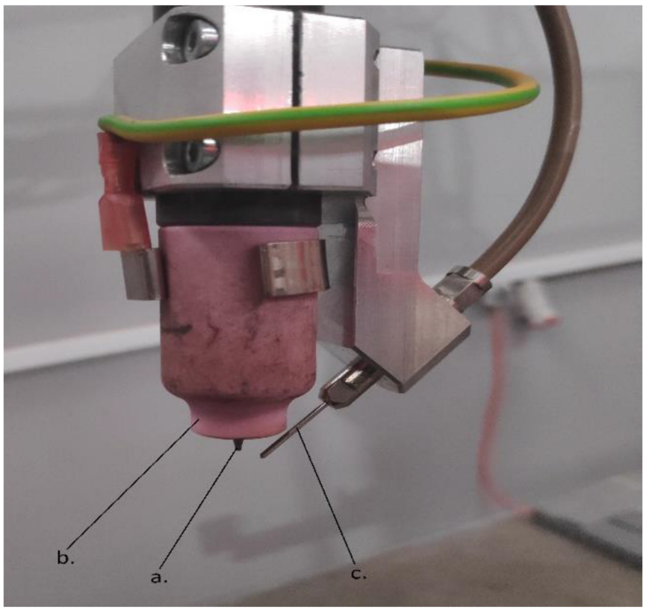

Figure 1. Structure of the welding head of the robotic system: a. Tungsten electrode, b. Ceramic nozzle, c. Addition wire

It is also important to have a cooling system (a circulating water, in general) to protect the torch against heat deformation. All the connections for welding, such as, electric power, the wire, and the coolant are usually integrated into one cable unit. It is recommended that the cable unit be as short as possible for a quicker response and a better reliability.[2]

The GTAW process is used especially in the aerospace industry for materials with small thicknesses (0,8 ÷ 3 mm): stainless steels, superalloys, aluminum and magnesium. Often the process is used to form the root or to deposit the first layer when welding materials of greater thickness.

The use of the GTAW process is explained by the fact that the resulting welded joint is more resistant and of better quality, the molten metal bath being well protected by the argon flow.

The type of jointing of the two components (samples and test pieces) is head-to-head, the welded cord being executed from three passes (2 passes to the outside and one pass to the inside), specifying that the welded cord for the pieces is not linear, but it has a snake shape resulting from the shape of the semi-pieces made by pressing. The thickness of the semi-pieces being 3,2 mm, the joint processing will be done in "I", with an opening as uniform as possible by 2 ÷ 3 mm. It is admitted that the joints can be processed in "Y" (1,6 mm x 30 °) in areas where the distance between pieces is less than 1 mm.

The programming of the robotic system is flexible by allowing for rapid changes and controlling as many variables as possible. A great advantage are the robots whose teach pendant (control panel) is provided with a joystick that allows the rapid positioning of the robotic system at the desired point, thus significantly reducing the programming time.

The use of the operating system and the programming language of the robotic system ensure both the reduction of programming times as well as the flexibility of the system and the easy control of the welding parameters.

The welding process chosen, welding with non-fusible electrode in an inert gas protective environment, GTAW, is an electric arc welding process that uses a non-fusible electrode made of tungsten alloyed with thorium, caesium or lanthanum, because tungsten has a very high melting temperature, around 3422 ° C, which means that the electrode is not consumed during the welding process. The melting or accidental infestation of the molten metal bath with tungsten is a defect that must be eliminated.

The protective gas of the molten metal bath is argon, which provides protection against the action of gases in the atmosphere (oxygen, nitrogen, hydrogen) that can cause defects of jointing, respectively pores, cracks or corrosion of materials. The argon gives the welding cord a high quality and good appearance. Another protective gas that can be used is helium, used especially in the USA, where it is much cheaper, which increase the penetration in the joint and the welding speed to welding of materials with high thermal conductivity, such as copper and aluminum. Various gas mixtures can also be used, such as argon + helium or argon + hydrogen, which improve various welding parameters: welding speed, welded joint quality or joint penetration. If necessary, in the molten metal bath you can also add material in the form of rods (manual welding) or wire in coils (automatic welding).

3. SOFTWARE SETUP PARAMETERS OF THE ROBOTIC SYSTEM

Regardless of the choice of the manual or robotic GTAW joint, the main process management parameters are as follows.

3.1 Welding Speed

This parameter is valid for manual and robotic welding. The welding speed "Vsud" has as a unit of measure cm / min. Low welding speed means higher linear energy introduced into the joint, resulting in overheating of the welded cord. Too low speed can lead to punching the joint. Too high speed can lead to non-penetration and non-alignment of the base material.

3.2 Base current

This parameter is valid for manual and robotic welding. The basic current "Ibaza" has as a unit of measure the Ampere. The intensity of the current causes the heating and finally, the formation of the molten metal bath. The value of the base current is established and calculated for the normal conditions of the welded joint: the nominal thickness of the components, the average distance between the components and the theoretical welding section. A higher value of the current intensity produces an overheating of the welded area, an excessive penetration of the two components and finally it can produce the bath punching. A small amount of current intensity results to an incomplete penetration.

3.3 Main current

This parameter is valid only for robotic welding. The main current "Ipuls" has as a unit of measure the Ampere. The value of the main current is the value established and calculated for the less most favourable conditions of the welded joint: the maximum thickness of the components, the lack of distance or a distance smaller than the average calculated between the two components or the minimum section of welding. The value of the main current is always higher than the value of the base current.

A higher than necessary value of the main current intensity leads to an overheating of the welded area, an excessive penetration of the two components and finally, it can cause punching of the bath. A small value of the main current results to an incomplete penetration.

3.4 Oscillation amplitude

This parameter is valid only for robotic welding. The oscillation amplitude "Apend" has as a unit of measure mm. Its value allows the management of the oscillation width motion of the welding head so that it can fill with additional material even the largest section of the welding joint. A high value of the oscillation amplitude generates wide welding cords with excessive material addition. A small value of the pendulum amplitude generates welding cords with marginal notches.

3.5 Pulse frequency

This parameter is valid only for robotic welding. The frequency of pulses "Fpuls" has as a unit of measure Hz. Its value indicates pulse frequency between the main current and the base current. A weld cord with uniform width and super elevation can be obtained only in the case of the same distance between two semi-pieces. Any deviation from the shape and the nominal size of the distance between the two semi-pieces is corrected by this parameter.

3.6 Oscillation frequency

This parameter is valid only for robotic welding. The frequency of oscillation "Fpend" has as unit of measure Hz. Its value indicates the frequency of the oscillation movements of the welding head on the ideal trajectory. Any deviation from the nominal shape and size of the distance between the two pieces is also corrected by this parameter.

3.7 Wire feed

This parameter is valid for manual and robotic welding. The advance of the feed wire "Vsarma" has as a unit of measure cm / min. The feed rate of the wire must ensure uniform filling of the molten metal bath. Too low speed leads to the appearance of concave welds and marginal notches. Too high speed results in the super elevation of excess filler material.

Robotic welding involves very precise tolerances and even minute variations in the wire feed process can result to unacceptable welds; it is important to choose a wire designed to feed smoothly through the drive rolls and liner. Wires engineered specifically with robotic applications in mind often provide better feeding characteristics than those designed for all purpose use. A wire that produces unreliable and inconsistent arc starts can negate the productivity benefits of a robotic system by creating substantial down time, or downstream rework.[3]

In addition to the seven welding parameters described above, we must also remember:

- The time of the protective gas purging before starting of the arc (Gas Pre-Flow) is the time in seconds at which it is allowed to start the electric arc after the beginning of the protective gas purging in order not to oxidize the molten metal bath. The parameter is valid for manual and robotic welding.

- The time of the protective gas purging after the fade of the arc (Gas Post-Flow) represents the time in seconds at which it is allowed to stop the supply of protective gas after the fade of the electric arc in order not to oxidize the molten metal bath. The parameter is valid for manual and robotic welding.

4. EXPERIMENTAL RESULTS ON SAMPLES AND TEST PIECES DEPENDING ON THE SETUP PARAMETERS

Software management of the GTAW welding parameters increases the accuracy of the Adaptive Robotic System in 8 axes. Reaching the optimal parameters will be achieved, in this case, by analysing the results obtained on samples and test pieces and inserting different parameter values.

For this purpose, tests were made on samples of 3,2 mm thick sheet metal, made of 304L material and welded with ER308L filler material with 1,2 mm diameter.

At the same time, the results obtained on test pieces were verified.

Table 1. Set I and II of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
19	78	128	0,7	10	2,78	20,8
19	78	128	0,7	10	2,78	19,5

The conclusion is that the joint is predominantly 1,6 mm, but has varied between 1,5 mm and 3,1 mm.

The result is a hole that was produced in the joint area of 2,6 mm to the exit, but the piece was not drilled at the maximum joint of 3,1 mm.

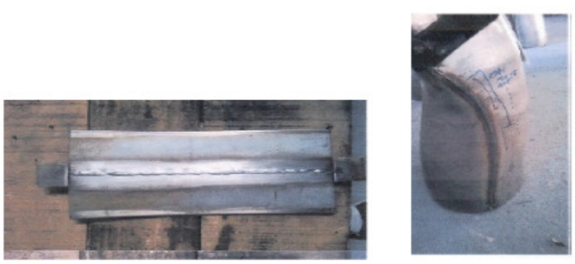

Figure 2. Test sample and test piece according to table 1

Table 2. Set III of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
16	145	185	0,7	10	2,78	17

As a result, the penetration is unsatisfactory and the cord has a concavity in the middle.

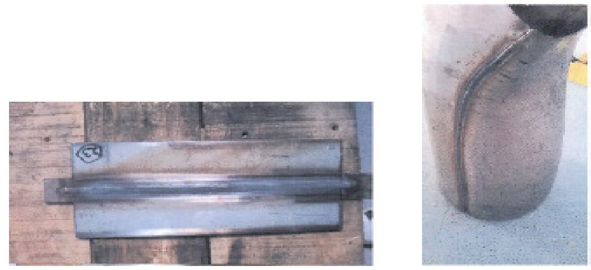

Figure 3. Test sample and test piece according to table 2

Table 3. Set IV of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
14	145	185	0,7	10	2,78	17

The result is excessive penetration at the beginning of the cord. The penetration is insufficient at middle of the cord.

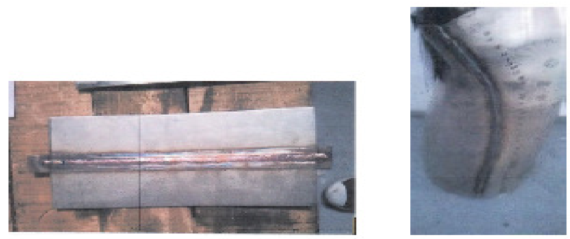

Figure 4. Test sample and test piece according to table 3

Table 4. Set V of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
16	120	160	0,7	10	2,78	15

The joint is predominantly 2 mm. Since the middle of the cord, Ibaza and Ipuls have changed to Ibaza = 125 A and Ipuls = 165 A. The flow rate of the argon backing is 12 l / min. The electrode piece distance is 4 mm. The result is insufficient penetration.

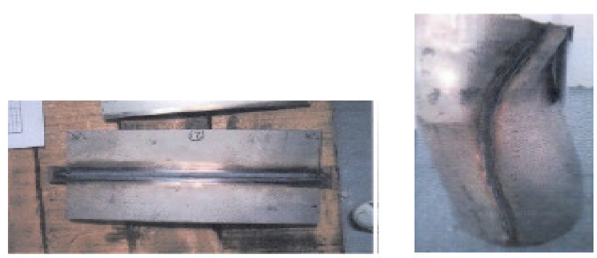

Figure 5. Test sample and test piece according to table 4

Table 5. Set VI of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
16	135	175	0,7	10	2,78	17

The result is insufficient penetration. The cord is inconsistent on the centre.

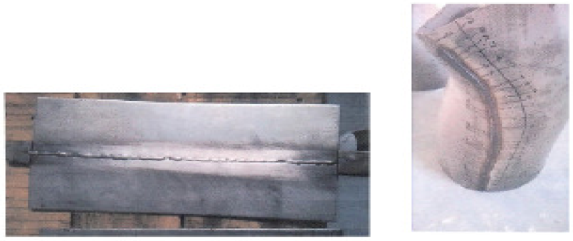

Figure 6. Test sample and test piece according to table 5

Table 6. Set VII and VIII of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
20	145	185	0,7	10	2,78	20
24	145	185	0,7	10	2,78	20

For the VII set of parameters, the penetration is good. A concavity appears on the centre of the cord.

For the VIII set of parameters, the electrode piece distance is 5 mm. The result is insufficient penetration. A concavity appears on the centre of the cord.

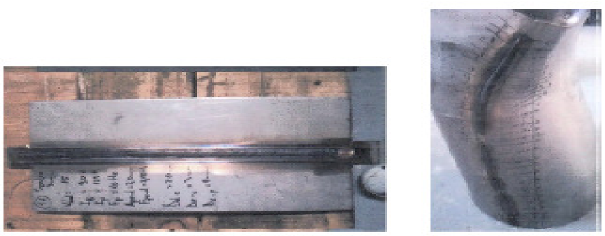

Figure 7. Test sample and test piece according to table 6

Table 7. Set IX of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
14	145	185	0,7	10	2,78	13

The electrode piece distance is 3 mm. As a result the penetration is insufficient in the middle. The cord is therefore wide.

Figure 8. Test sample and test piece according to table 7

Table 8. Set X of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
14	100	140	1	10	2,78	20,5

There is a joint area between 1,95 mm and 2,3 mm. As a result, the joint area between 1,5 and 1,95 was penetrated. The penetration is good.

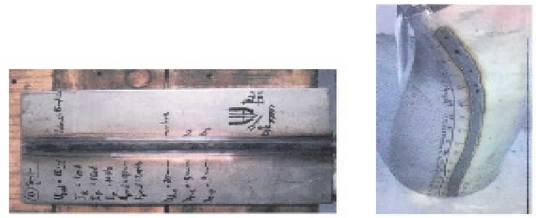

Figure 9. Test sample and test piece according to table 8

Table 9. Set XI of welding parameters managed in the software program for the robotic system

Vsud	Ibaza	Ipuls	Apend	Fpuls	Fpend	Vsarma
12	100	140	1	10	2,78	20,5

As a result, the joint is between 1,5 mm and 1,95 mm. The penetration is good.

Figure 10. Test sample and test piece according to table 9

4. CONCLUSIONS

In order to manage the appropriate software parameters of the Robotic System necessary to weld the proposed test piece, experiments were performed on a number of 9 test samples having 3,2 mm thickness. After the test samples, experiments on 9 test pieces were performed. The optimal software parameters to the robotic system were determined in Table 9. Using these parameters it was determined that the penetration is in conformity and the joint should be between 1,5 mm and 1,95 mm. The piece was welded optimally in this way by the Robotic System.

5. REFERENCES

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