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ANALYSIS OF THE WELDING PROCESS IN THE MANUFACTURE OF SAFES WITH USE OF ROBOTS

(ANÁLISEDO PROCESSODESOLDANA FABRICAÇÃODEC OF RESCOMUSODEROBÔS)

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Short Profile

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ABSTRACT:
due to the constant need of improvements and an increase in production in enterprises, together with the growing demand for security for workers by removing them from unhealthy areas, the use of industrial automation using robots has become as a criterion for differential competitiveness between companies in Brazil, as well as occurs in Alpha company, leader in the segment of banking automation in our country. Will be presented in this work, a description of the processes of welding MIG / MAG (Weld to electric arc with shield gas) of boxes for safes, which are the basis of an electronic box; covering, also, the programming of robots that are used to perform such activities, their basic movements, types of wire used among other features; in addition, will be described which the advantages achieved with the migration process of today done manually, for the robotized; will be presented, which security systems involved in the cells

where the robots are inserted with the use of its basic components that make up the supply chain in welding, such as the controller and machine welding, among others. In relation to the gain of time with the change of a process to the other, will be presented in the form of a comparative spreadsheet where with the use of the same were generated explanatory graphics that show the results obtained with the case study. Another significant improvement to be presented in this study in relation to the deployment and use of robots in the welding process was the highest quality on the visual appearance of the weld, leaving the parts with better finishing visible, higher linearity of weld with less amount of splashing, therefore contributing to that was obtained better and higher quality of the final product.

KEYWORDS

Welding, brazing, programming, robots.

RESUMO

Due to the constant need for improvement and increase of production in companies, along with the demand for greater security for workers removing them from unhealthy areas, the use of industrial automation using robots has become as a differential criteria of competitiveness between companies in Brazil, as well as in Alpha company, leader in banking automation segment in our country. Will be presented in this paper a description of welding processes MIG / MAG (the electric arc welding with shielding gas) boxes for safes, which are the basis of an ATM; covering also the programming robots that are used to perform such activities, its basic movements, types of wires used among other features; in addition, will be described the advantages achieved with the migration process now done manually, for the robot; will be presented, though, what the security systems involved in the cells where robots are inserted with the use of its basic components that make up the production chain of the welding sector, such as the controller and welding machine, among others. In regard to time gain with a change from one process to another, they will be presented as a comparative sheet where the use of the same were generated explanatory graphs showing the results of the case study. Another significant improvement to be presented in this study regarding the deployment and use of robots in the welding process has the highest quality in visual weld aspect, leaving the visible parts with better finishing, greater linearity weld with less spatter contributing as well so obtained were better and higher quality of the final product.

1. INTRODUCTION

Industrial automation is becoming piece as key to the development of various sectors within industries, and for processes which involve welding is also not different. Today we can see that dispense many industries, in some cases, the use of manual welders and being replaced by robotic units and cells. The robotic welding technology has been developing over the years, and today we can see automated processes in various segments of existing industries, such as automotive and two-wheeled, among others. "Some of the qualities that make robots commercial and industrial technologically important are: the ability to replace people; perform the work cycle with consistency and repeatability can not be reached by people; They can be reprogrammed; and they can be controlled by computers "(WAINER, 2013, p.103).

This work is important for demonstrating the welding process ATM safes (Auto Teller), a process restricted to only a few companies. This work focuses on showing the use of robots for welding in the production process, making a comparison of costs between the process of manual and robotic welding, identifying their environmental performance, components involved in the welding process along with the features of its elements constituents, programming and description of the basic movements performed by the robots through Aided Manufacturing Computer (CAM), Security systems involved in robotic cells among other particulars relating to this field of study of the area of Mechanical Engineering. It aims to show, also, improvements regarding the visual aspect of welding and productivity gains with the migration of manual welding processes for welding with the use of industrial robots. In this paper we will know a little more about this productive sector passing through several transformations and numerous technological developments.

2. WELDING PROCESSES MIG / MAG SAFES IN MANUFACTURING INDUSTRY

For a description of this work as a case study, based on existing theories about aspects of welding and robots, "for the case studies the development of the theory as part of the design phase is essential if the purpose arising from the study is to determine or test the theory "(Yin, 2001, p. 49). To have an assimilation of welding MIG / MAG applied in the company are required which are all known components and process variables acting thereon. The work will address the welding process with an emphasis on all active agents in the manufacturing process, ranging from an introduction to the knowledge of MIG / MAG welding; on what is a electric arc; which active shielding gases in the process; which the wire used in the manufacture of safes; how is the metal transfer to weld, among other aspects inherent to the product. Address, too, which models sheet metal used in the manufacture of safes, taking into account: the steel grade, thickness, length etc.

The benefits will be provided transfer of some processes that were once done manually by operators, to be performed by robots, because dynamism, and highest degree of repeatability and reproducibility than the quality procedures.

Regarding the use of robots, which will be described the components of the equipment involving work environment, which constituents of the robots and cleaning stations presenting the basic programming of the movements performed by the robots to create a welding path.

We present the description of the security systems that make up the performance of cells of robots, such as cell with photoelectric sensor (light barrier) for closing robot box, and security lock and pushbutton reset the tables, for the robot welding parts. They will be presented with the results obtained with the migration of manual welding processes for automated and cost processes. The transfer occurs when a short circuit is established, this happens when the molten metal at the tip of the wire touches the weld pool. In welding with a short circuit transfer are used in wire diameter of from 0.8 to 1.2 mm range, the use of robots in the most used company wires are 1.2 mm, where a molten pool is obtained from rapid solidification. In the case of welding robots in the manufacture of safes, the transfer is between the wire material for the base metal (sheet metal). Compared to the base metal, the NBR 5874/72, p. 2, defined as the "piece of material that undergoes a welding process", the robot operates in the filling plugs holes, filling with solder spaces between 4 to 5 mm thick. In welding the top of a customer's safe named "A", the Engineering project foresees the robot to complete a 3 mm space equivalent, straight with spaces determined by the robot programming.

2.1. Metal transfer in welding safes

The company studied is one of the leading companies in banking automation segment in Brazil, and uses a mixture of argon (Ar) and carbon dioxide (CO_2) or CO_2 only in his welding process MIG / MAG, both units robotic and for the manual welding process. The welding process operates on DC power normally with the wire in the positive pole, this configuration is known as reverse polarity, this factor influences the wire feed speed.

The transfer occurs when a short circuit is established, what happens when the molten metal at the tip of the wire touches the weld pool. In welding with a short circuit transfer are used wire diameter in the range 0 8 to 1.2 mm (WAINER, 2013, p.103). The use of robots in the company, the most commonly used wires are 1.2 mm, where a pool of melting rapid solidification is achieved.

In the case of welding robots in the manufacture of safes, the transfer is between the wire material for the base metal (sheet metal). The robot operates in the filling plugs holes, filling with solder spaces between 4 to 5 mm thick.

Table 1: Short-circuit current range for wire diameters

Diâmetro do arame		Corrente de soldagem (A)	
pol (")	mm	Mínima	Máxima
0,030	0,76	50	150
0,035	0,89	75	175
0,045	1,10	100	225

Source: Strong, Vaz, 2005, p.6.

The welding current applied in the process strongly controls the wire melting speed as previously. Moreover, the penetration reinforcement and the bead width tend to increase the current when the remaining variables are kept constant. Below is the relation between the applied current and the melting rate for the 1.2 mm wire, the same as is used in the company Alpha for manual welding processes for making the robot and safes.

The robot torch forward speed in the welding process is determined by the programmer who is in charge of verifying the correct speed of filler metal penetration (wire) in steel plates, this process is monitored continuously and varies whenever It is done the setup (exchange model) of a safe to the other because the thickness of the plates change from client to client, where it is up to the developer of robotic unit find what is the best way to apply the correct speed throughout the welding process, always checking the necessary tables and parameters according to the particular diameter of wire to a weld which has no cracks and with assured quality, free from porosity.

The MIG / MAG applied to the boxes of safes is made almost exclusively with direct current and reverse or reverse polarity. Accordingly, the process provides a more stable arc and greater penetration. The welding with direct polarity can be used in coating processes (due to its low penetration) and the alternating current is not used.

The welding voltage affects the mode of weld metal transfer and bead appearance. A higher voltage increases the width of the cord and reduces its convexity, but excessively high values cause porosity, spatter and bites. Very low values can also cause porosity (for loss of protection due to turbulence caused by process instability), excessive convexity and folds on the bank of cord.

The proper amount of tension for a given application depends on many factors such as the thickness and type of joint, the robot welding position, the wire diameter and composition and shielding gas composition.

2.2. Welding wire used in welding processes

One of the most important factors to be taken into consideration in welding processes MIG / MAG, into the coffers is the correct selection of welding wire. This wire in combination with the shielding gas produces the chemical deposition which determines the physical and mechanical properties of the weld.

Although there is no specification applicable to industry in general, most wires are in accordance with standard AWS (American Welding Society).

The type of wire is generally indicated based on the ratings given by the specification of standards, such as AWS A. 5.18 determining the chemical composition and solid wires for electrodes.

We have in Figure 1, the chemical composition arising from the standard AWS A5. 18. p.2 containing the requirements of composition for solid electrodes. Remember that the wire used in the studied company is the manufacturer ER70S Belgo-6 type, which are wires that are designed for simple welding or for multi-pass welding. They are suitable especially for metal in applications where you want to adopt smooth strings and structural steels. These electrodes / wires enable the use of larger current ranges with either CO2 or gas mixture.

Chemical Composition Requirements for Solid Electrodes and Rods

AWS Classification[b]		UNS[c]	Weight Percent[a]												
A5.18	A5.18M	Number	C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu[d]	Ti	Zr	Al
ER70S-2	ER48S-2	K10726	0.07	0.90 to 1.40	0.40 to 0.70	0.025	0.035	0.15	0.15	0.15	0.03	0.50	0.05 to 0.15	0.02 to 0.12	0.05 to 0.15
ER70S-3	ER48S-3	K11022	0.06 to 0.15	0.90 to 1.40	0.45 to 0.75	0.025	0.035	0.15	0.15	0.15	0.03	0.50	—	—	—
ER70S-4	ER48S-4	K11132	0.06 to 0.15	1.00 to 1.50	0.65 to 0.85	0.025	0.035	0.15	0.15	0.15	0.03	0.50	—	—	—
ER70S-6	ER48S-6	K11140	0.06 to 0.15	1.40 to 1.85	0.80 to 1.15	0.025	0.035	0.15	0.15	0.15	0.03	0.50	—	—	—
ER70S-7	ER48S-7	K11125	0.07 to 0.15	1.50 to 2.00[e]	0.50 to 0.80	0.025	0.035	0.15	0.15	0.15	0.03	0.50	—	—	—
ER70S-G	ER48S-G	—	Not Specified[f]												

Figure 1. Chemical composition requirements for solid electrodes.

Source: AWS A5. 18, 2005, p.2

2.3. Models plates used for making the safes

The robots operate in an automated manner in the manufacture of ATMs and so that they can perform the welding process should take into account the use of plates that are used in the process. For a better understanding of the entire production chain, these plates are selected and according to the project presented by Engineering, it is designating which the thickness and the necessary and corresponding steel plate model for the customer in question. After all project information is checked and assessed by the responsible sector, these metal pieces will gain an initial format for the construction and manufacturing safe.

Figure 2 suggests models of existing plates in the company for the production of safe, where we can identify the length, width and thickness of the sheets.

CODIGO	DESCRIÇÃO	AÇO	ESPEC.	DIMENSOES (mm)			AVANÇO LASER
				COMP.	LARGURA	ESPESSURA	
74.610.00017-8	Chapa aço # 11 SAE 1020 3000x1200	SAE 1020	#11	3000	1200	3,18	3500
74.610.00028-4	Chapa aço nº 11	AÇO 1070	#11	3000	1200	3,18	
74.610.00010-9	Chapa aço # 14 1200X3000 SAE 1020	SAE 1020	#14	3000	1200	1,98	4700
74.610.00011-6	Chapa aço # 16 SAE 1020 1200x3000	SAE 1020	#16	3000	1200	1,5	6000
74.610.00012-3	Chapa aço # 18 SAE 1020 1200X3000	SAE 1020	#18	3000	1200	1,25	6500
74.610.00015-4	Chapa aço # 20 SAE 1020 1200x3000	SAE 1020	#20	3000	1200	0,95	7000
74.610.00018-5	Chapa aço # 8 1200x3000 SAE 1020	SAE 1020	#8	3000	1200	4,37	2500
74.610.00006-2	Chapa gros 1"x2440x6000mm	SAE 1020	1"	6000	2540	25,4	-
74.610.00026-0	Chapa aço 1/2"x2440x6000mm	SAE 1020	1/2"	6000	2540	12,7	950
74.610.00016-1	Chapa grossa 1/4" 1500x3000 aço 1070	AÇO 1070	1/4"	3000	1500	6,35	2050
74.610.00027-7	Chapa aço 1/4"x1500x3000 aço 1020	SAE 1020	1/4"	3000	1500	6,35	
74.610.00013-0	Chapa aço 3/16" 1200x3000 SAE 1020	SAE 1020	3/16"	3000	1200	4,76	2500
74.610.00004-8	Chapa aço 3/8" SAE 1020 1200X3000	SAE 1020	3/8"	3000	1200	9,53	1300
74.610.00004-8	Chapa aço 3/8" SAE 1020 1500X3000	SAE 1020	3/8"	3000	1500	9,53	

Figure 2 - Specification sheets used in the studied company

Source: The author, 2014.

The plates knowledge process is the starting point for the start of the knitting of safes. After the correct choice of the workpiece, it passes through laser cutting or plasma procedures in which the plates are all sectioned. These are sent to the machining sector to be made all the holes, recesses, bevels, etc., where later the pieces are brought to the welding industry. To start is given the focus of this work, the performance of the robots starts from there, covering the entire production process in the realization of the union of the plates forming for the product.

2.4. Manual welding process in the manufacture of safes

In various parts of the production process of manufacturing of safes, manual welding is applied effectively, where some parts are welded the safe operators. These applications of manual welding in the vaults are of great importance and influence on the progress of activities, because it must perform four basic operations in order to have a good quality in welding, as follows:

- Proper handling of equipment (the operator must is duly authorized to perform such activity, it must have full knowledge of all the components that will be used during the process);
- Welding in correct positions (vertical downward, horizontal etc.), always analyzing the operation of the welding machine;
- After completion of the welding operator must check the cord that was made;
- Analysis of the quality of the weld bead, regardless of the piece that was welded, always aiming at the finish and visual quality of the piece.

The manual welding is usually done in smaller pieces, such as welding stops, mounting bearings and moldings on the doors of safes, the guide pin welding and others.

The manual process is also applied to the welding of supplementary parts for the manufacture of doors, such as the component parts of the media locks casters and some parts in general.

This manual welding process is also used for spot welding (tacking) External safe, and internal weld fill the box, and the internal welding, in some locations, the operator is in uncomfortable and ergonomically incorrect situations increasing their process fatigue, causing discomfort to the operator, with no guarantee of weld quality with a good degree of surface finish. Hence there is the need to transfer this process of welding stops and internal weld complement of the box to the robotic process, generating savings in time and productivity, among other factors that must be taken into consideration. Properly use the equipment in manual welding process is the responsibility of the welder, who must keep it in perfect condition and operate it so that you get the best possible performance.

2.5. Robot application in boxes of Electronics Industry

A industrial robot consists of a set of connected and articulated links, the first link linked, usually, a fixed base link and the last named terminal end, has a tool (welding torch) MARQUES et.al. (2009, p.131).

The applicability of the use of robots in ATM manufacturing process is the objective of this study in order to be demonstrated various aspects of its use, such as its features and components involved.

Below we have in Figure 3, an example of a robotic unit used in MIG / MAG welding process in the studied industry where we can see the robot running the rapprochement between the torch and the part to be welded.

Figure 3: Robot welding process used in MIG / MAG

Source: The author, 2014.

In modern robotics, there is research and development of humanoid robots or anthropomorphic entitled. However, such robots are unable to perform any kind of tasks, and only respond to external stimuli. These devices perform their activities through programming, as well as robots used for electric arc welding.

They will be presented following the welding robots particularities working at the company. Also will show their work environments, functionality, programming, types of transactions performed by them, torch cleaning process, security systems, alarm types, components involved in the operation process of the robots, and other aspects related to the welding process robots working in the company.

The welding robots that will be shown operating with seven axes, they receive specific names robot parts and closing robot. In Figure 4, the examples have two robotic units used in the study company, the first welding part of the safe and the second to make the closing of the welding safe box.

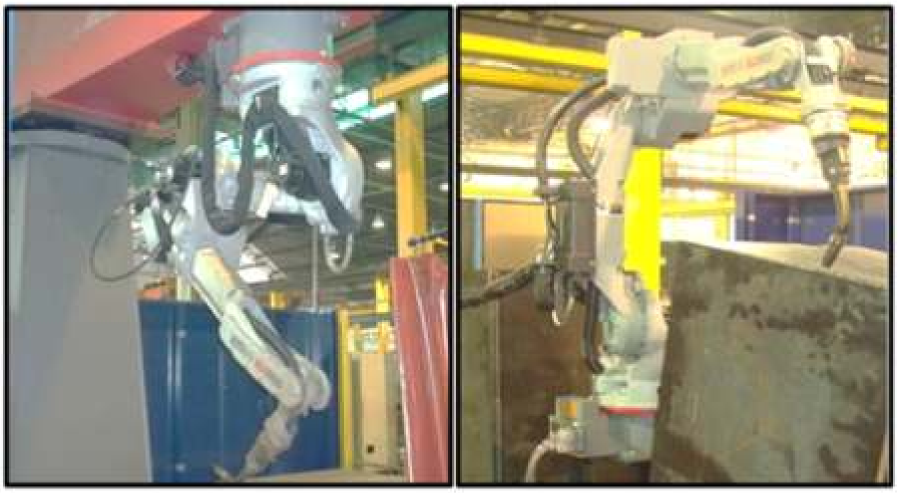

Figure 4: Welding Robot parts, and closing respectively.

Source: The author, 2014.

The robots used in welding processes using the DX 100 controller, produced by a large Japanese manufacturer is now in high levels of technology when it comes to robotics in Brazil and other countries. The robots have studied its applicability proven over all welding processes, where they play a very important role in the task automation framework because they can perform repetitive tasks with quality and execute welds in hard to reach places for manual welders, It has a range and a very effective deposition welding this weld which may change their speed and specific commands.

2.6. Desktop of Welding Robots

Robots internally called as parts of welding robot and closing robot, working in different environments, but with some interaction with each other. The parts of welding robot operates in a closed environment, free from any human contact interference, but the operator can stop the robot activities where necessary, be removed for maintenance or alarm, welding torch replacement, cleaning the area of operation, or the tables.

This robot works in the welding of the constituent parts of the vault, such as right and left sides, top, bottom, and bottom, is filling plugs holes. Performs continuous weld seams and at intervals depending on the project stipulated by the Project Engineering and according to the needs of clients in question, it can perform various activities.

Within the parts of robot work environment there is a cleaning station robot torch, which will be explained forward, and which also operates synchronously with the welding robot programming. These tables operating in the welding system in conjunction with the robot depending on the desired location, the robot performs the welding on the workpiece that is located over a table. Tables Tables are referred to as A, B, C, D and E, and each receives a different part of the safe.

The tables play important roles in parts of the welding process, each robot is connected to a hydraulic system which allows its advancement and retreat. The parts to be welded are placed in these tables where each table is responsible to receive a part of the safe.

Below is the division on which part of each table receives safe and which is welded in the respective table.

-Table A: gets the top and stop;
-Table B: get the safe of the fund;
-Table C: receives the right side and stop;
-Table D: get the left side and stop;
-Table E: get the base and stop the vaults.

In Figure 5, we have the working environment of tables operating in parts of robot, where we can check the tables waiting for the pieces to be welded. At this stage of the process, the tables have to be used are properly programmed to receive parts according to the customer's safe to be made in order that all parts have been released by Industrial Engineering so that the welding process is started by the robot.

Figure 5: Tables welding robot parts.

Source: The author, 2014.

The action of setting box closing robot is limited, however, has a safety system light beam which will be explained later, is located near the environment of the weld and welding process after the point (tack) from the box. In Figure 6, we can see the desktop of charge robot to make the closing of the boxes.

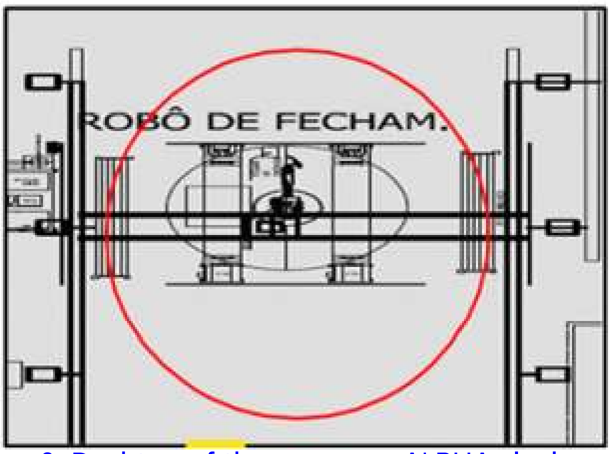

Figure 6: Desktop of the company ALPHA closing robot.

Source: Company Layout Alpha. 2014.

The closing robot work environment consists of two swivel bases which are moved through pre-programmed commands to control the robot. These bases are responsible for maintaining fixed the boxes of safes to be welded by the robot in the correct position so that the welding procedures are carried out. These bases move according to the position set at the moment is being made the programming of the welding robot, and operates in accordance with the robot movement, because a movement of the other complements.

The robot performs the welding process following exactly the path that is determined by the developer at the time of program building where it determines where the points will be applied to welding for the joining of metal parts.

The environment is also formed by an automatic cleaning station which is responsible for maintaining the welding torch robot where, as well as the robot, the operation of the cleaning station is also programmed to cut off welding wire, clean the torch tip removing the excess solder which is deposited in the cavity of the torch, and also has an activity that is the automatic application of antirespingo, leaving the welding torch involved with a protection against adhesion of particles that are released in the process welding.

2.7. Cleaning Station Torch robots

The robots Torch Cleaning Station (parts and closing) performs a very important role within the welding process, as it is in charge of doing the cleaning torch removing the particles entering the cavity of the torch. After the robot perform all programmed instructions welding, it receives a cleaning schedule. This process is included every time the robots finish the process welding or, depending on the activity, the automatic cleaning can be performed in half of the program.

In cleaning schedule the following topics are included:-

Wire cut at the end of the process and progress of a new wire;

After the end or middle of the welding process, the wire comes out warm and with a kind of sphere at the tip. The first cleaning process is the cutting edge of this wire, which after being cut, the robot takes care of the advancement of a new wire.

-Cleaning Torch through the cavity of the rotary cutter;

During the welding process several particles from the welding torch in the stick. The same is cleaned by a rotary cutter which performs three movements: one approach to increase the cavity of the torch, a rotary movement to perform cleaning, and the lowering movement to return to the initial position and await a new process at the end of the welding box or another part of the safe.

Automatic anti-splash -Application;

The anti-splash is the last process in the cleaning, the application is done automatically applied by servo motors and pumps that work directly in the process. Figure 7 shows the torch cleaning station of the robot, comprising: wire cutting, rotary cutter and application of anti-splash.

Figure 7: torch cleaning station.

Source: The author, 2014.

3. RESULTS AND DISCUSSION

With the migration of manual welding processes for the robotic, there was an improvement in the visual appearance of the weld where they identified aspects will be compared below.

In manual welding it was found that the operators use fans close to the welding stations, (so that they can cool off while performing welding) and in some cases this can interfere with ventilation weld quality. If this ventilation somehow reaches the site to be welded, there may be a failure in the shielding gas because it tends to be expelled with this occurrence ventilation and in some cases affects the visual quality of the weld that can be noticed by the Indeed the solder perform welding in the same position all day, raising their level of fatigue.

The linearity of the manual welder start your shift, is not the same at the end of the turn, your body is prone to fatigued, your joints have been subjected to a lot of effort level throughout the day, the unhealthy environment makes spaces which is held hot and uncomfortable for the operator manual welding.

These and other factors as the very light desktop causes it can not maintain the same standard of welding from start to finish, and it becomes acceptable to process because it is humans. Therefore, the migration of these points previously made by welders can easily be transferred to the stations for robots that have higher quality and higher linearity of the welding, since the robots are able to work without fatigued, fully perform their activity in environments in which humans have a lower performance, they can perform their welding functions with programmed speeds, and can operate at speeds of the lowest to the highest. Depending on the situation than the product itself needs, robots can adapt according to what is established by the Engineering and customers.

Already with robotic welding performed by robots there was a significant visual improvement in the weld quality, since the welding robots were subjected to the same parts that operators had once welded, and was proven applicability and improves the physical appearance of qualitative welding greater penetration of the piece weld metal, higher welding speed, greater range of executive positions of weld beads made in welding stations of robots.

In figure 8, we can see visual comparison between manual soldering and welding stations made by the robots in proving the efficacy of the migration process, resulting in greater productivity and higher quality.

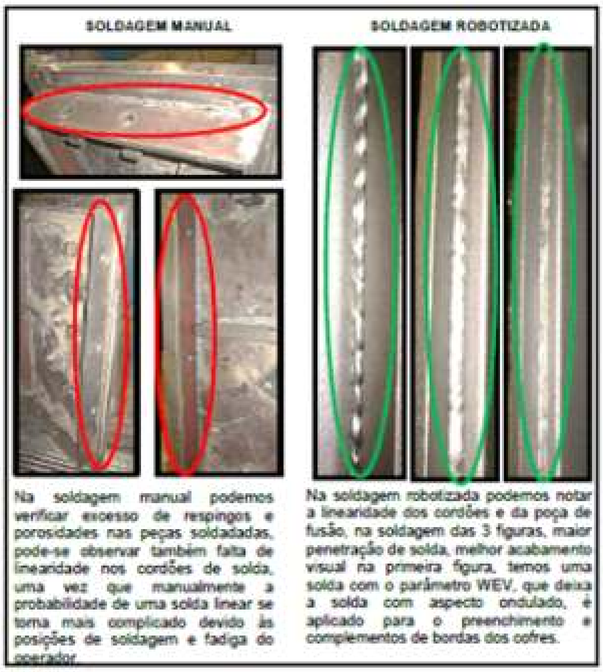

Figure 8: Comparative welding, Manual and Robotic.

Source: The author, 2014.

Figure 8 shows the comparison between manual and robotic welding, where you can check the quality that the robotic welding can keep visually with the same look and linearity. Robots show versatility in welding can run multiple weld beads at different points in alternating speeds, making the process more efficient and can receive a number of changes without affecting their quality process, thus maintaining an efficient work pattern with gain of time and productivity.

3.1. Improvement as the productivity gain in transfer processes.

By taking the time and comparative analysis between manual and robotic welding processes in relation to the process of time that each activity takes to run below the results will be presented, which aims to show the productivity gain with the welding robot used in welding stops and internal welding of the box.

Taking time was held in September 2014, in the days 01 to 04, starting from the first measurement principle: the beginning of the turn of the welders to 06h00min in the morning, and as the basis of the last measuring 15.30 hours hours end of shift of employees.

The comparative analysis also verifies that the collection-time comparison of the two processes may be observed times of sampling the first and last four days of the sample during verification. We also have a difference in productivity gains between the two activities as a means of analysis. The robotic welding provided a time gain for processes in general, those welders who performed manually internal welding box and stops were allocated for welding performance of smaller parts, requesting less human effort, best positions for the completion of welding as activities, for example, welding stations of smaller pieces that make up the assembly of the safe, which are known as welding components such as:

- Welding the bases locks of safes;
- Welding the supports of the wheels;
- Frames in general.

3.2. Presentation of the times and costs for manual welding processes vs robot

We can see in this comparison stops welding process the difference of times where the robot keeps the same starting and ending time, since the manual presents variations welding We have also described the cost in relation to the variation of time for manual welding, which is R $ 499.00 (four hundred and ninety-nine reais) year / operator. This value multiplied by the number of three operators that perform the task, has a cost R $ 1,498.00 (one thousand, four hundred ninety-eight reais) year. Once the robot can perform the activity of three operators together, it is feasible to use the robot in this process, because it can perform this activity during three consecutive turns.

Note that these values are only valid for the Client Y, because the welding time for other customers will vary.

In figure 9, taking the time and costs in the welding stops, comparing the manual and robotic processes to the customer Y.

SOLDAGEM BATENTES MANUAL vs ROBOTIZADO						
Data da coleta	Tempo Inicial		Tempo Final		Diferença em Minutos	
	Manual	Robô	Manual	Robô	Manual	Robô
01/set	5,00	2,00	6,20	2,00	1,20	0,00
02/set	5,20	2,00	6,60	2,00	1,40	0,00
03/set	5,10	2,00	6,20	2,00	1,10	0,00
04/set	5,20	2,00	7,00	2,00	1,80	0,00
Total da soma das diferenças em minutos					5,50	0,00

CUSTO HORA MÁQUINA X OPERADOR					
CUSTO EM R$ OPERADOR/HORA			CUSTO EM R$ ROBÔ/HORA		
R$		90,82	R$		181,23
valor p/minuto	R$	1,51	valor p/minuto	R$	3,02

Valores para um operador (soldagem manual)			ROBÔ	
Média de tempo dia em minutos	1,38		0,00	
Valor em R$ dia	R$	2,08	R$	-
Valor em R$ mês	R$	41,63	R$	-
Valor em R$ ano	R$	499,51	R$	-
3 operadores	R$	1.498,53	R$	

Figure 9: Comparison of time and costs for manual welding - stops.

Source: the author, 2014.

The following is the collection of data on internal welding safe box, Figure 10 shows the outlet times of welding processes for customer Y.

SOLDA INTERNA DA CAIXA MANUAL vs ROBOTIZADO						
Data da coleta	Tempo Inicial		Tempo Final		Diferença em Minutos	
	Manual	Robô	Manual	Robô	Manual	Robô
01/set	10,00	5,00	14,00	5,00	4,00	0,00
02/set	10,20	5,00	15,00	5,00	4,80	0,00
03/set	10,10	5,00	15,30	5,00	5,20	0,00
04/set	11,00	5,00	15,10	5,00	4,10	0,00
Total da soma das diferenças em minutos					18,10	0,00

CUSTO HORA MÁQUINA X OPERADOR					
CUSTO EM R$ OPERADOR/HORA			CUSTO EM R$ ROBÔ/HORA		
R$		90,82	R$		181,23
valor p/minuto	R$	1,51	valor p/minuto	R$	3,02

Valores para um operador (soldagem manual)			ROBÔ	
Média de tempo dia em minutos	4,53		0,00	
Valor em R$ dia	R$	6,85	R$	-
Valor em R$ mês	R$	136,99	R$	-
Valor em R$ ano	R$	1.643,84	R$	-
3 OPERADORES	R$	4.931,53	R$	-

Figure 10: Comparison of time and costs for manual welding - box.

Source: the author, 2014.

We can see in this comparison of the internal welding process of the box, unlike the times where the robot as well as the welding stops maintaining the same starting and ending time, since the manual welding presents variations. Has also been described, the cost relative to the time range for manual welding which is R $ 1,643.84 (one thousand, six hundred and forty-three reais and eighty-four cents) year / operator. This value multiplied by the number of three operators that perform the task, we have a cost of R $ 4,931.53 (four thousand nine hundred and thirty-one reais and fifty three cents) per year. Once the robot can perform the activity of three operators together, it is feasible to use the robot in this process, because it can perform this activity for 3 consecutive turns, keeping only their nominal cost.

It is emphasized that these values are only valid for the Y customer as the welding time for other customers will vary.

3.3. Comparative analysis of welding processes

Below the graphics that make comparison between manual and robotic welding of welding processes. In Figure 1, we have the welding process time of manually stops and robot parts of the robot.

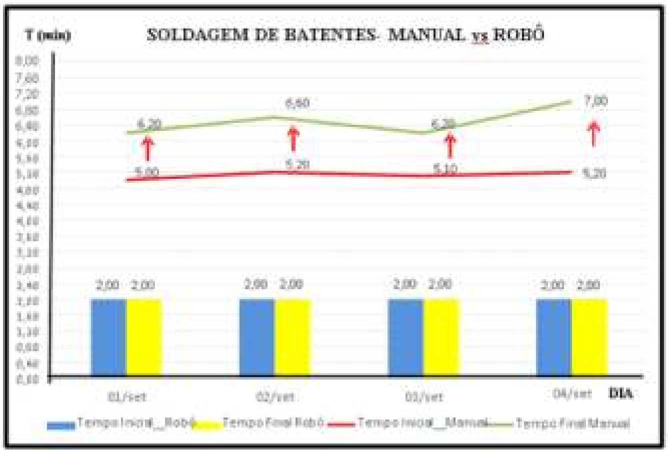

Figure 10: Comparison of time and costs for manual welding - box.

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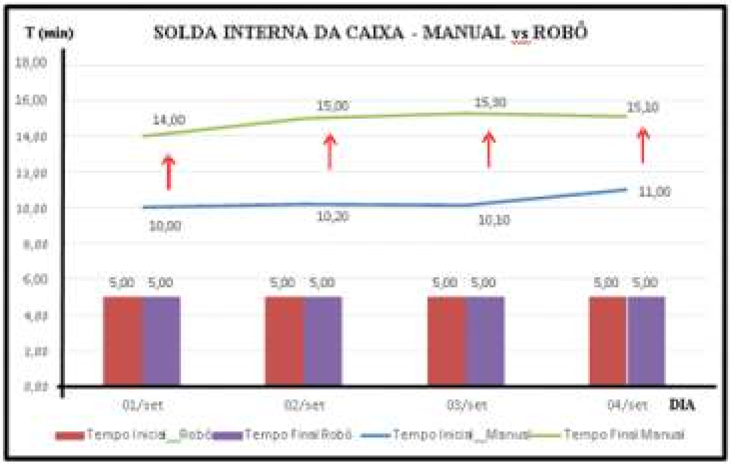

Figure 2: Comparison between welding box - manual vs robot.

Source: The author, 2014.

Welding using the robot achieved a saving of time compared to manual welding, according to data collection, the manual welding process time from inside the safe box suffers average variations of 4.53 minutes due to the factors discussed once such as unhealthy environment, excessive heat in the production sector, welding ergonomically incorrect positions, so enabling variation in the welding time. The internal welding of the box, the closing robot obtained a reduction of time compared to manual welding, where we can see that your income remains constant relative to the start time and end time, adding greater productivity to the sector, bringing higher quality of welding and can work repeatedly, also improving the finish of the final product. Operators replaced by the application of robots were transferred to the implementation of other activities such as: welding other pieces of smaller size and welding positions that offer better conditions for carrying out welding activities with greater ergonomics and devices to the aid of the processes, such as spot for supporting the welding torch and devices to hold the pieces to be welded.

In Figure 11, illustration of the improvements have, in regard to aid the operator in carrying out the welding activity. Highlighted the support for the welding gun and device for fixation of the parts. The implantation of these devices tend to improve the performance of the operator, making the manual welding process has assured quality.

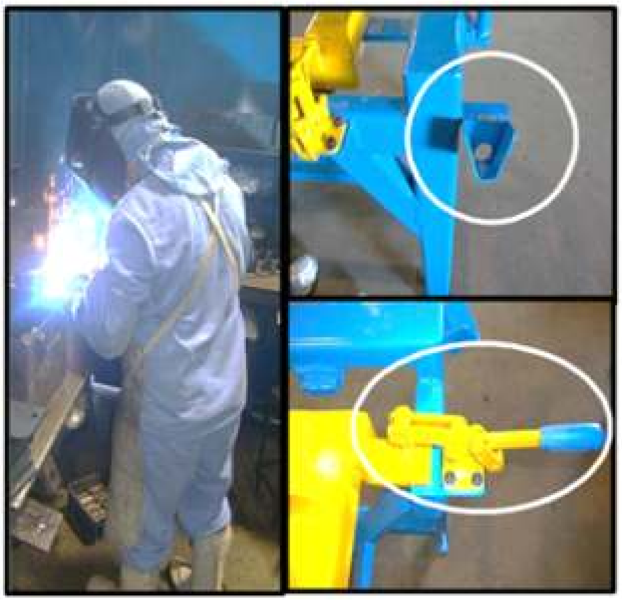

Figure 11: Enhancements for operators.

Source: The author, 2014.

These improvements are aimed at improving the quality of life of enabling operators to their level of fatigue and physical effort decreases, causing the quality of manual welding is improved, reducing also the rate of crashes and spills on parts, thereby achieving a good continuity.

4. CONCLUSIONS

The welding process MIG / MAG, using robots in the manufacture of safes as well as brought dynamism to the production, significant benefits for the supply chain, such as: reduction in time of welding the parts process, reduce operational costs and better use of operators in other activities.

The safety devices involving robotic cells brought comfort for operators, since even with all the protection and PPE (Personal Protective Equipment) used by welders, manual welding is nonetheless harmful to the health of the environment human to be an unhealthy site and in many cases may lead to health problems welders, such as gas inhalation and eye irritation among other diseases over time and also due to the exposure time can affect the performance Welder staff, reducing their productivity and quality. Thus, the migration of welding processes using automation employing the use of robots minimizes these risks to welders, also providing increased quality and productivity with less human effort, making use of robots in a productive sector has greater acceptance.

With the introduction of robotic automation in the welding process, there have been improvements over time gain in activities where you can use this enhancement to increase the welding sector's productivity capacity and can allocate this developer who once made the process so manual, to develop other activity that has less physical and mental effort in ergonomically correct positions, reducing the level of likelihood of disease and accidents. Another significant improvement with the use of robots was the excellent visual and surface finish of the weld, since the robots are able to maintain greater repeatability and reproducibility beyond the precision in their movements when performing their activities.

Thus, it can be seen that the use and utilization of robots brought the possibility of development of the industry and the industry as a whole, steadily decreasing production errors and accidents that could previously be assigned to human labor, thereby providing a increased quality for the product at the end of production of safes currently developed by the banking automation companies.

This work contributed to the enrichment of information on the knowledge of the ATMs welding industry because it is a sector still very restricted to a few companies. The demonstration of the welding process the particularities of the safes provided greater understanding of the issues involved by making known what activities are performed within the production chain, on which equipment and all the technology used to assist in the production, making the automated sector through the programming of robots and safety devices involved in robotic cells, causing the industry to develop and gain prominence in relation to production processes, making these aspects a competitive edge over competitors.

With the migration of the manual process for using robots were no significant improvements in the workplace, among which we can mention as positive aspects:

- Improved quality of the final product;
- Process time gain to be used as a parameter for the productivity increase;
- Reduction of human exposure time in unhealthy area;
- Welding with better surface finish and visual and etc.

These positive aspects show how the deployment of automation is necessary in a production chain, always aiming at improving the quality and reducing costs and risks to humans.

But like all change within an organization in relation to processes tends to have little lapses of instability resulting from the change itself of not having one hundred percent accuracy, with the use of robots, even if indirectly end up generating a social impact, as with the implementation of automated processes create some fear in the working class, since there is a tendency to believe that with the rapid advancement of industrial automation and robotics many lose their jobs, these aspects are softened from the time when operators begin to understand the need that industries have in automating its processes, thereby making machines have greater effort than men. In contrast, the industry ensures better quality of life for this operator, and allocates them in sectors that require less effort, making this useful individual in the process.

5. THANKS

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