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## DEVICE FOR WELDING

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**Abstract:** This work met the demand of a metallurgical company in the region, which needed to automate some welding processes. With this in mind, an automated device for welding was designed, with linear movements X, Y and Z. The device was installed in on top of a mobile bench where two welding equipment and two gas cylinders necessary to carry out the process are installed. The project was developed in SolidWorks and to validate the structure, static calculations were carried out in the Ansys software. In this project, all necessary ergonomics and safety standards were followed, meeting the company's requirements and improving the employee's quality of life. Great results were obtained in the project, which was able to fully meet the company's demand, at an affordable cost.

**Keywords:** Automation, welding, innovation.

## INTRODUCTION

Welding has been known to humanity for thousands of years, but only with the industrial revolution in the 19th century did this process undergo many evolutions, and its importance in industries increased. Currently, the welding process is used from the microelectronics industry to the manufacture of robust structures to withstand heavy loads (FARIA et al., 2022).

Currently, most welding processes in industries are carried out manually, requiring a high level of operator skill and intense work. In addition to offering several risks, such as inhalation of toxic gases, burns from high temperatures and high levels of radiation (FARIA et al., 2022).

There is still a major problem related to quality, as it is a manual process there is no reproducibility of parts maintaining the welding standard. This also leads to the loss of parts (scrap), welding wires and gas due to a process carried out outside the necessary standards. (PINTO; OKADA, 2022).

A study was carried out on "RCNC robot for automating MIG/MAG welding in extremely difficult positions and situations" where the automated device "TARTÍLOPE V4" was developed and manufactured, with three linear axes and another circular axis, to carry out the welding process of ducts, flat or curved walls, which is fixed using magnets on the wall to be welded and performs your process by a CNC command. The results were satisfactory, but there were problems in some axes, such as the Z axis, making correct adjustment impossible and the Y axis was very slow, not allowing weaving above 2Hz. (CARVALHO, 2009).

The work was based on the design of a bench with height adjustment and casters, for the university laboratory, thus creating a more flexible and versatile bench, adapting to all locations and always meeting ergonomic standards. The main objective of the bench is mainly aimed at people with some type of movement limitation, who end up being excluded from some activities. With this, the bench can be developed by the students themselves, making the students themselves contribute to the accessibility of their classmates. (SEIFERT, 2022).

In this context, a device was designed to meet the demand of the company ``Metalúrgica Golden Arts``, which manufactures industrial valves, to carry out linear welding processes, with the help of a jig with rotating movement that can be used to weld pieces with circular shapes. This device has a four-axis controller interface to control automated movements in the linear axes X, Y, Z, as programmed.

Therefore, for greater versatility and a wider range of applications, this welding device was installed on a bench with casters, which has a higher base to attach the device and a lower base where the welding devices were installed, whether they MIG or TIG. It also has a support for the gas cylinder, which

will be closed to protect it from heat and welding spatter, offering greater safety to the equipment.

## **THEORETICAL FRAMEWORKS**

TIG (tungsten inert gas) welding was developed in 1935, which carries out its process using an electric arc that uses a tungsten-coated electrode, the heat necessary to melt the material to be welded comes from the electric arc between the Non-consumable part and electrode, having gas protection. This process has great capacity to control the energy to be transmitted to the part and great quality in the weld, but it is an expensive and low productivity process. (SOUZA et al., 2019).

The MIG process began to be used on the market in 1948, it performs welding using an electric arc between the part and an edible wire which directly feeds the pool of material that will be melted, having protection through a mixture of gases that are active. This welding process has a more practical application and can work in all necessary positions. (PEREIRA, 2021).

The concept “robot” emerged at the beginning of the 20th century, but the term only began to become popular in 1950, generating many discussions about what the relationship between humans and machines would be. A robot is an integrated system composed of sensors, manipulators, control system, power source and software, which work together in order to carry out the movements necessary to carry out the task that was programmed through a computerized numerical control (CNC), (RODRIGUES et al., 2022).

Automated welding systems are beginning to be used in several industries, as they offer quality welding and are reproducible without the need for a very experienced operator. Therefore, reducing risks generated to the operator by exposure to radiation, gases

harmful to health and burns due to high temperature, also reducing the consumption of gas and wires, to carry out the process. (PEREIRA, 2021).

With few resources available, an automated device was designed to carry out the linear welding process of agricultural machines, as this took around 46% of the time required to manufacture the equipment. With the implementation of this, there was a great increase in productivity, considering that the welding speed increased by 83%, also generating a reduction in input costs. (LINS et al., 2023).

SolidWorks is a commercial 3D CAD software owned by the French company “Dussault Systèmes”. With it we can design, assemble parts, simulate structures and create technical drawing sheets for the parts. This software is widely used in the engineering area as it is complete software for carrying out any project (SCHIONTEK; KOIDE, 2019).

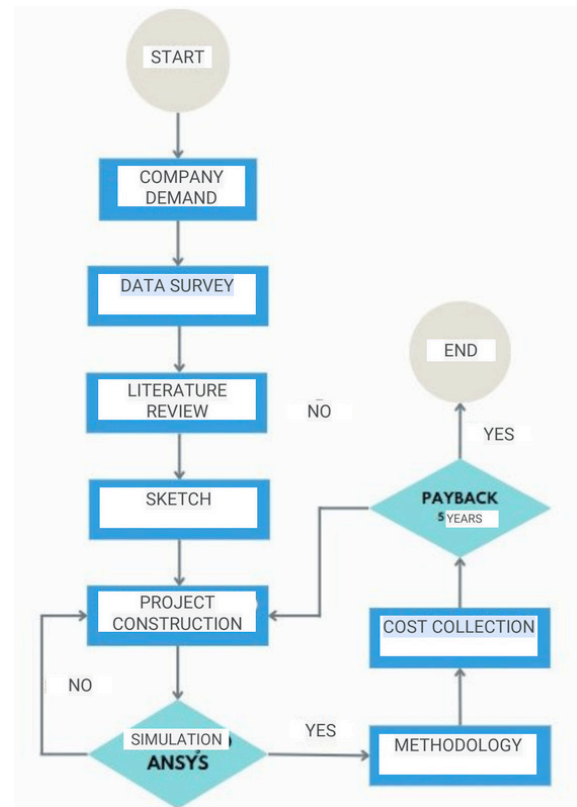
Ansys Software falls into the category of Computer Aided Engineering (CAE) programs, aiming to help the engineer make decisions in some stages of the development, sizing and validation of some projects. In general, the software reduces the cost and time needed to develop the project, due to the speed of analysis, thus having a notion very similar to reality, helping to correctly size parts and materials, reducing the consumption of raw materials and reducing expenses. to carry out the project (NETO, 2020).

## **METHODOLOGY**

In this extension discipline work, the need of “Metalúrgica Golden Arts”, a company in the region, which is a reference in the manufacture of industrial valves, was met. It found the need for automation in the welding process of some parts, as, thinking about the collaborator, always seek to improve their working conditions and consequently achieve

a high standard of quality in parts joined by welding. To meet this demand, the project of a mobile bench was developed with the capacity to carry up to two welding devices simultaneously and to have an automated welding device coupled, which has linear movements in X, Y and Z, achieving the welding standard necessary to comply with applicable standards.

The flowchart of the construction sequence of the automated welding device is presented.



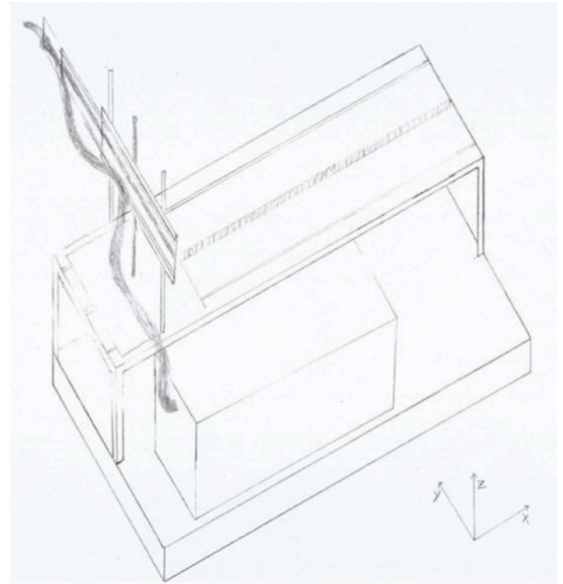
**Figure 1:** Flowchart of the construction of the automated welding device.

Source: Own elaboration

In view of the company's demand, which has the need to automate the welding process, which is currently carried out manually, keeping the operator exposed to an unhealthy place for a long time and without reproducing the same welding pattern, thus, this project was developed to automate the process, improving the operator's working environment and

achieving welding reproducibility.

Initially, all the ideas and objectives for the project were grouped, with these data defined, a sketch was created, Figure 2, to consolidate the ideas and have an initial view of the equipment.



**Figure 2:** Sketch

Source: Own elaboration.

The bench has a load capacity for two welding devices, a MIG and a TIG, and torches with 3-meter cables are required. The set of devices can have a total weight of up to 160 kg. The device works with only one welding device at a time, thus giving the operator the possibility to carry out a specific process with the other device, while the automated device is carrying out welding. The bench has a compartment for two gas cylinders with a capacity of 120 kg, one with "mixed gas" (argon + CO<sub>2</sub>) and the other with pure argon gas.

For the welding device, parts catalogs were sought from suppliers, thus choosing the most suitable ones for proper functioning. Linear guides were selected to move the X, Y and Z axes, being necessary to move the ball screw axes, which will be moved through a stepper motor with brake for the other axes. For

computer numerical control (CNC), a TMA. PC controller interface was used. DDCS4V (4 axes) which is ideal for stepper motors, being very interactive and easy for the operator to handle. For greater ease of transportation, casters with brakes were designed to support the necessary load.

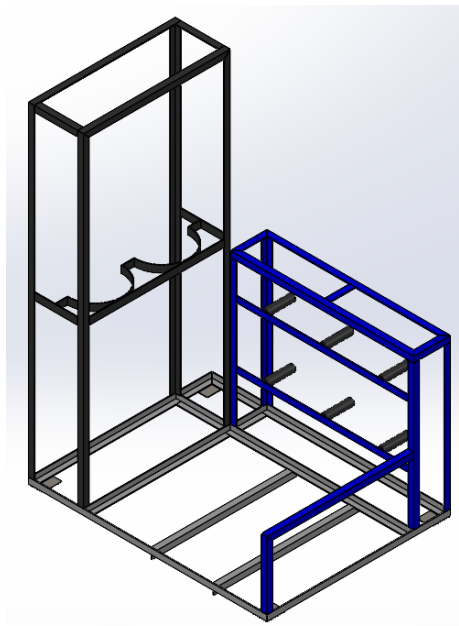
In the construction of the cart, SAE1020 structural steel was used and static calculations were carried out to dimension the bench using the Ansys software, which provided the Von-Misses deformation stress, total deformation and equivalent Von Misses stress.

After having defined the entire structural project and having carried out the simulations and structural calculations to see if the structure is well sized, the process of adapting the standards began, such as, carrying out accordion protections to cover the moving axles, installing micro-ends of strokes at the ends of the axes. The project follows standards NR12 and NR17.

A cost survey was carried out, which was analyzed and calculated in how long the device would return the investment, taking into consideration, whether it is economically viable for the company or not. Having all the data in hand, the project was delivered and presented to the company where it will internally analyze the data and make the decision whether or not to execute it.

## ANALYSIS AND DISCUSSION OF RESULTS

The structure of the mobile bench, **Figure 3** was developed in SolidWorks software, dimensioning all compartments and main structures to which welding equipment, gas cylinders, and the automated welding device were attached.

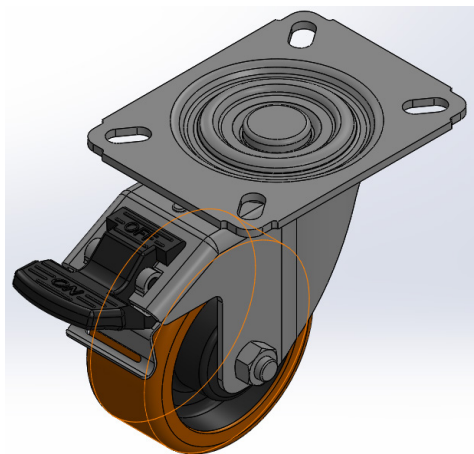


**Figure 3:** Mobile bench structure

Source: Own elaboration

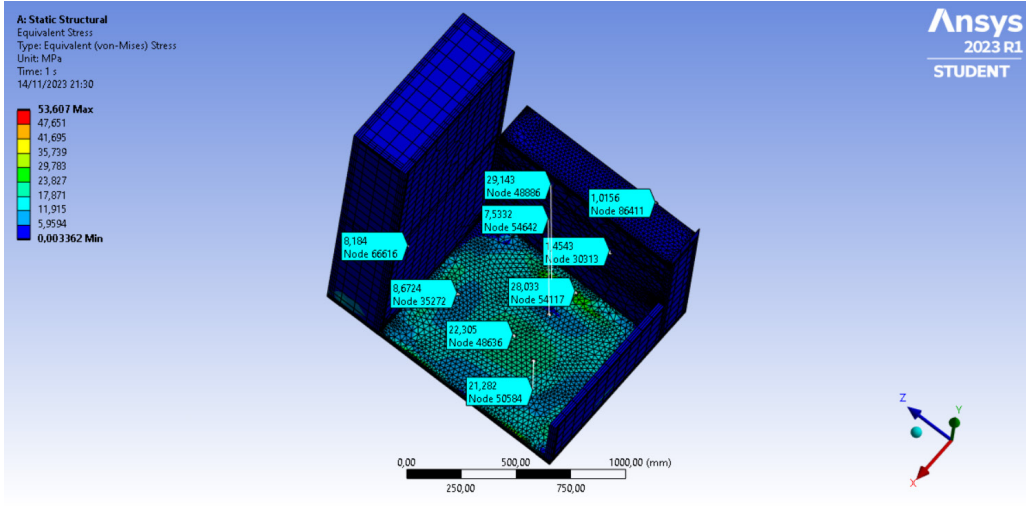
All plates and angles used are made of carbon steel, thus reducing the cost of the project and maintaining the mechanical resistance necessary to perform the function efficiently. A SCHIOPPA-GL312-PE-G caster was selected for transportation.

It is covered with a layer of polyurethane, making it difficult to attach metal residue, leaving it lighter to guarantee safety when moving the bench.

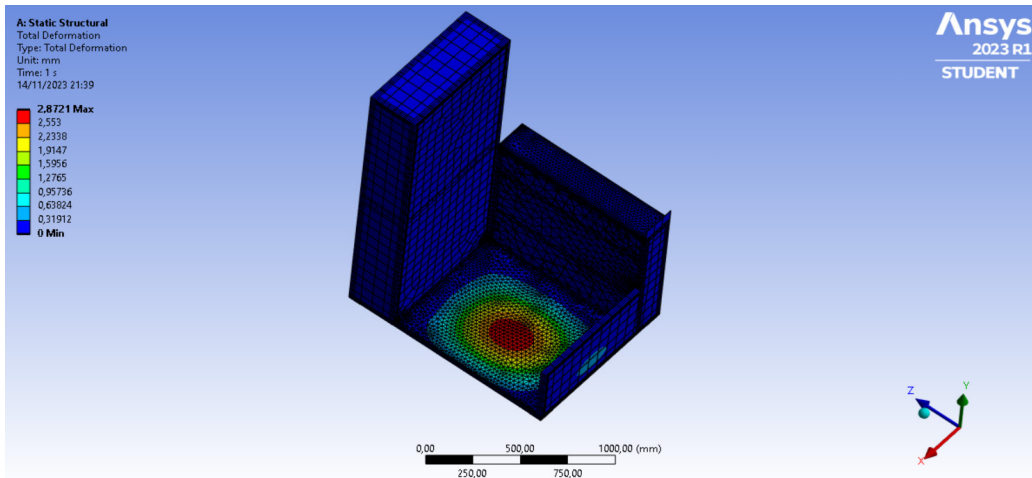


**Figure 4:** SCHIOPPA-GL312-PE-G caster

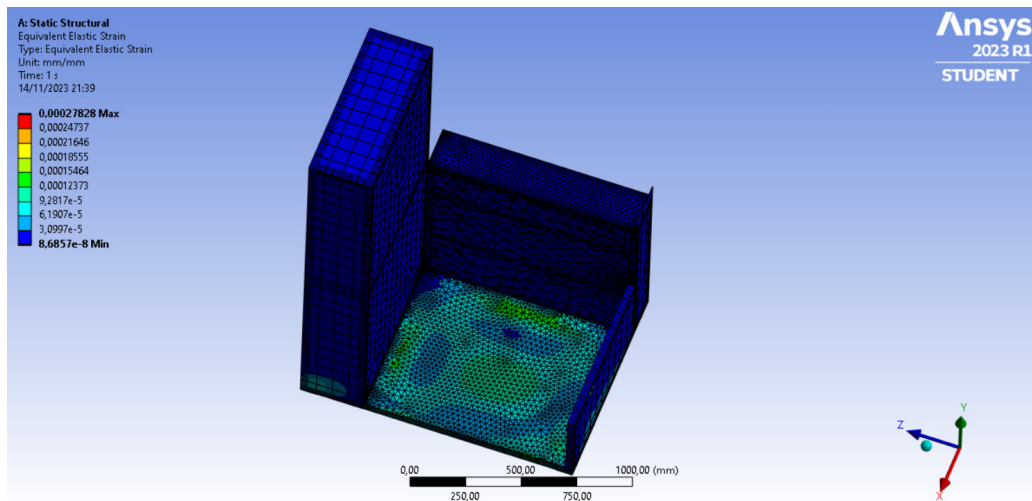
Source: Mechanic's Store.



**Figure 5:** Von-Mises Equivalent Stress of the mobile bench  
 Source: Own elaboration.



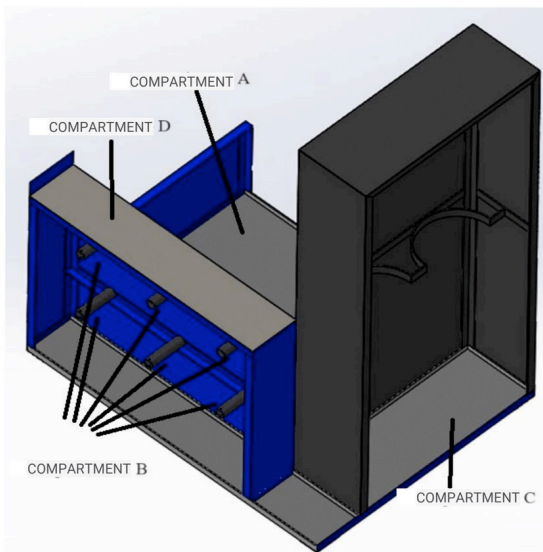
**Figure 6:** Total deformation of the mobile bench  
 Source: Own elaboration.



**Figure 7:** Elastic Von-Misses tension of the mobile bench  
 Source: Own elaboration.

With the initial structure of the mobile bench ready, structural static calculations were carried out in the software: Ansys, the Von-Misses equivalent stress Figure 5 where the points with the highest tensions were presented, which can be confirmed in the Annex 1 calculations of maximum stress and bending moment, which were calculated with the characteristics for L profiles Annex 2. The total deformation Figure 6 demonstrates which point would suffer the greatest deformation in the structure and the Von-Misses elastic stress Figure 7 which shows where the material suffers the most load.

**Figure 8**, we can visualize the bench compartments, with capacity for 6 rolls of wire (Compartment B), two welding devices (Compartment A), 2 gas cylinders (Compartment C) and the automated device (Compartment D).



**Figure 8:** Mobile bench compartments  
Source: Own elaboration.

With the simulation ready, it was seen that the cart could support 160 Kg (Compartment A) where the welding equipment was installed, 110 Kg (Compartment C) where the gas cylinders were installed, which weigh 49 Kg each, 90 Kg (Compartment B) where the spare wire rolls

were stored, which weigh approximately 15 kg each roll, and finally, 50 kg (Compartment D) where the automatic device was installed. All compartments were resistant to the proposed conditions and at no time simulation offered risks of ruptures and deformations.

To move the axes, NEMA-23 stepper motors were used, which pull the 16 mm diameter spindle and 5 mm pitch, moving the welding torch. The movement of mechanics was made using OBR A-15S skates and guides. To control the motors, a TMA.PC controller interface was used. DDCS4V 4-axis Figure 9.



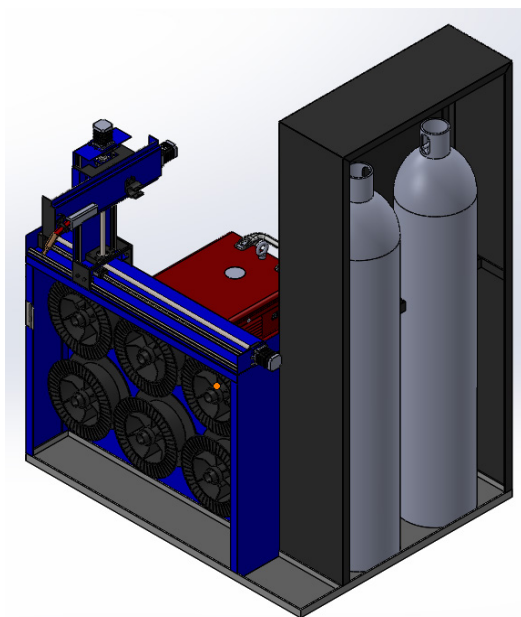
**Figure 9:** TMA.PC Controller Interface. 4-axis DDCS4V  
Source: Tecmaf.

Table 1 shows the total cost of the project, taking into consideration, all the necessary materials and labor for manufacturing and assembly.

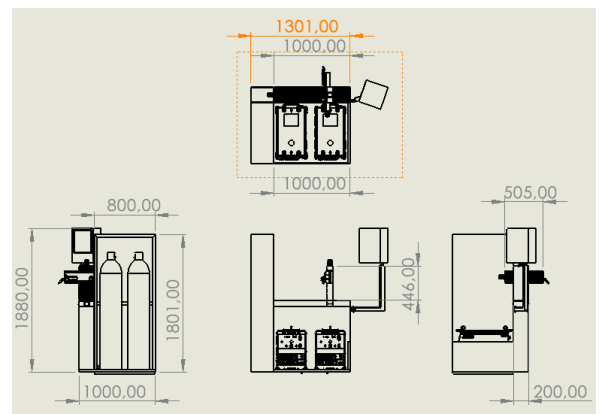
Figure 10 shows the finished device, with all equipment in their appropriate compartments and with the standard painting for the company's machines.

Supplier	Materials	Quantity	Length (cm)	Area (m <sup>2</sup> )	time (h)	Unit Value	Total
Tecmaf	Nema 23 Motor+Driver 4.2 Amp	3	-	-	-	RS 410,00	RS 1.230,00
	4-axis controller interface	1	-	-	-	RS 3.190,00	RS 3.190,00
OBR	OBR BF17 bearing	4	-	-	-	RS 254,00	RS 1.016,00
	OBR A15S Guide	6	-	-	-	RS 134,00	RS 804,00
	Nut OBR SFYR 1616 3.6	-	400	-	-	RS 1.500,00	RS 1.500,00
	Spindle OBR SFYR 1616 3.6	3	-	-	-	RS 770,00	RS 770,00
	L profile 11/4 x 3/16	-	200	-	-	RS 678,00	RS 678,00
ArcelorMittal	3-millimeter 1020 steel sheet	-	300	-	-	RS 15,00	RS 4.500,00
	1-millimeter 1020 steel sheet	-	-	1,5	-	RS 200,00	RS 300,00
Fabricação Intena	Torch clamp	-	-	5	-	RS 70,00	RS 350,00
	Torch hose clamp	1	-	-	1	RS 20,00	RS 20,00
	Welding of sheets	1	-	-	1	RS 20,00	RS 20,00
	Brown support OBR SFYR 1616 3.6	1	-	-	8	-	-
	Machining	1	-	-	2	-	-
Fusopar	Bolt and nuts	100	-	-	-	RS 250,00	RS 250,00
Reifer	Hinges	8	-	-	-	RS 20,00	RS 160,00
Inox Mais	Laser bending and cutting	-	-	-	5	RS 1.000,00	RS 1.000,00
Loja do Mecânico	Turns	4	-	-	-	RS 120,00	RS 480,00
Cobsen	Axle protection	6	-	-	-	RS 417,00	RS 2.502,00
<b>Total price of project:</b>							<b>RS 18.770,00</b>

**Table 1:** Table of prices  
Source: Own elaboration.



**Figure 10:** Finished device without protections on the axes  
Source: Own.

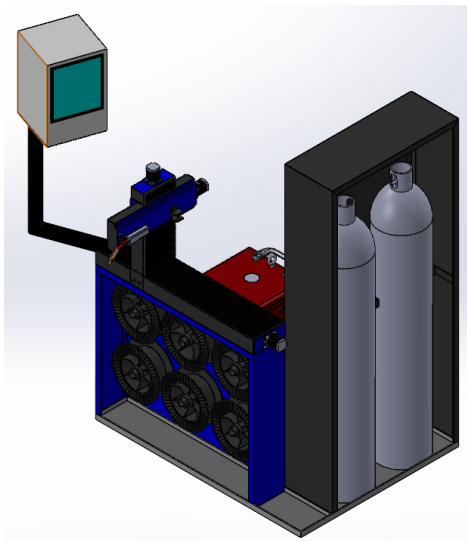


**Figure 11:** 2D drawing of the device (dimensions in mm)  
Source: Own elaboration

Figure 12 shows the result of the complete project of the automated welding device.

In Figure 11, you can see the critical dimensions and main dimensions of the finished device.





**Figure 12:** Complete design of the automated welding device

Source: Own elaboration

## FINAL CONSIDERATIONS

According to the demand of Metalúrgica Golden Arts, which required the development of an automated system for welding some flanges on industrial valves, it was possible to develop an automated device for welding, which has a mobile bench, which holds up to two welders and two cylinders of gases, having an automated device with 3 linear axes maintain a high-quality welding standard. In this project, all safety and ergonomic standards, NR12 and NR17, were met. As a suggestion for future work, a secondary bench can be developed, with just the automated welding device, which can be coupled to the device developed in this work, thus, it will be possible to use the secondary welding device automatically, improving the efficiency of the work. It is also possible to develop an automatic turning system for the torch, facilitating positioning and operation precision.

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# ATTACHMENTS

$\sum M_A = 0$   
 $A \cdot 0 - (1200 \cdot (150 \cdot 10^{-3})) + (-2000 \cdot (800 \cdot 10^{-3})) + M \cdot (800 \cdot 10^{-3}) = 0$   
 $-1780 + M \cdot (800 \cdot 10^{-3}) = 0$   
 $M = \frac{-1780}{800 \cdot 10^{-3}}$   
 $M = 2225 \text{ N/m}$

$I_{x2} = \frac{26,99 \cdot 4,76^3}{12} + (26,99 \cdot 4,76) \cdot (15,87 + 21,35)^2$   
 $I_{x2} = 42751,01 \text{ m}^4$

$I_{x1} = \frac{(31,75 \cdot (4,76)^3)}{12}$   
 $I_{x1} = 285,35 \text{ m}^4$

$I_x = I_{x1} + I_{x2}$   
 $I_x = 285,35 + 42751,01$   
 $I_x = 43036,36 \text{ m}^4$

$\sigma_{\max} = \frac{M \cdot c}{I_x}$   
 $\sigma_{\max} = \frac{2225 \cdot 22,05}{43036,36}$   
 $\sigma_{\max} = 1,1399 \text{ MPa}$

**Annex I: Maximum Stress and Bending Moment Calculations**

b		Nominal weight	Angle in inches		Area	$I_x = I_y$	$W_x = W_y$	$r_x = r_y$	$r_z \text{ min.}$	x
pol	mm		pol	mm						
5/8"	15,88	0,57		2,5						
3/4"	19,05	0,71		2,5						
1/2"	12,70	0,55	1/8"	3,18	0,70	0,10	0,11	0,37	0,25	0,43
5/8"	15,88	0,71	1/8"	3,18	0,90	0,20	0,19	0,47	0,32	0,51
3/4"	19,05	0,87	1/8"	3,18	1,11	0,36	0,27	0,57	0,38	0,59
7/8"	22,20	1,04	1/8"	3,18	1,32	0,58	0,38	0,66	0,46	0,66
1"	25,40	1,19	1/8"	3,18	1,48	0,83	0,49	0,79	0,48	0,76
		1,73	3/16"	4,76	2,19	1,25	0,66	0,76	0,48	0,81
1.1/4"	31,75	2,22	1/4"	6,35	2,84	1,66	0,98	0,76	0,48	0,86
		1,50	1/8"	3,18	1,93	1,67	0,82	0,97	0,64	0,89
		2,20	3/16"	4,76	2,77	2,50	1,15	0,97	0,61	0,97
1.1/2"	38,10	2,86	1/4"	6,35	3,62	3,33	1,47	0,94	0,61	1,02
		1,83	1/8"	3,18	2,32	3,33	1,15	1,17	0,76	1,07
		2,68	3/16"	4,76	3,42	4,58	1,64	1,17	0,74	1,12
		3,48	1/4"	6,35	4,45	5,83	2,13	1,15	0,74	1,19

**Annex 2: Characteristics of the L Profile**