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Content

VIRTUAL TOOL FOR DETERMINING REACTIONS AND DRAWING EFFORT DIAGRAMS

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ABSTRACT: This paper describes a virtual instrument that allows checking a fixed structural system consisting of two sections with different diameters, required under the action of a force applied at a point for which the position can be varied. The stress state resulting from the loads is determined based on the static balance equations recommended by the specialized literature. To perform the calculations and draw the diagram, the static balance equation was used, respectively a displacement compatibility equation.

KEYWORDS: virtual tool, axial stress, diagram, LabVIEW.

1. Introduction

Solving the problem strength of the material is a frequently imposed requirement in industrial applications. The variety of problems and the time required to solve them require finding solutions that meet the needs of engineers and students to optimize time and the results obtained. In this context, a virtual instrument was developed in the LabVIEW graphic programming environment, which allows for determining the reactions, drawing the axial stress diagram, and checking the bar for a force applied to the section of bars made of the same material.

2. Current status

The study was carried out for the structure of steel bars, requested at point C by the force P according to figure 1.

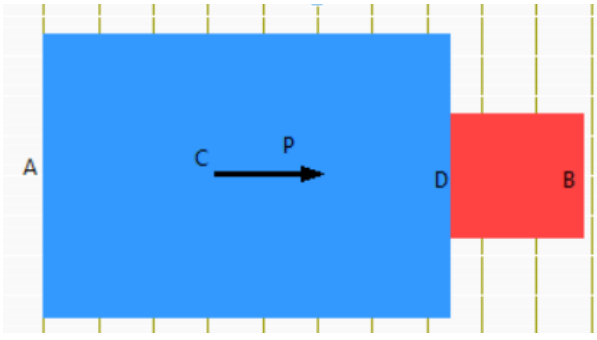

Fig. 1. Load diagram of the bar section

The bars being made of steel, the value of the admissible resistance R = 235 N/mm^2 and the modulus of elasticity E = 210, N/mm^2 were considered.

The areas of the two sections were pointed with A1 and A2, respectively, and were expressed in mm.

The state of stress is influenced by the ratio of stiffnesses to axial stress because the cross-sectional area of the bar is not constant.

Relations used in the calculations were obtained based on the static equilibrium equation and the displacement compatibility equation [1].

$$H_A + H_B = P \tag{1}$$

$$\frac{H_A * L_1}{E * A_1} = \frac{H_B * L_2}{E * A_1} + \frac{H_B * L_3}{E * A_2} \tag{2}$$

Following the solution of the system formed by the static balance equation and the compatibility equation, the HA and HB reactions resulted. Based on the determined reactions, the axial stress diagram was drawn.

Description of running the virtual instrument

The front panel of the virtual instrument is the user interface. It must be intuitive and as easy to use as possible. As a result of these features, the front panel of the application was designed.

The input data in the program are the force P, the areas of the two sections A1 and A2, the lengths of the sections L1, L2, and L3, and the admissible resistance R. To specify the values of the input data, the user has at his disposal numerical control elements.

To display numerical results, Metter indicator elements for HA and HB reactions and two Tank indicator elements for SAD and SAB stress were added to the front panel. If their values are lower than the admissible limit, the program will display a message through the LED indicator element.

Figure 2 shows the panel of the virtual instrument.

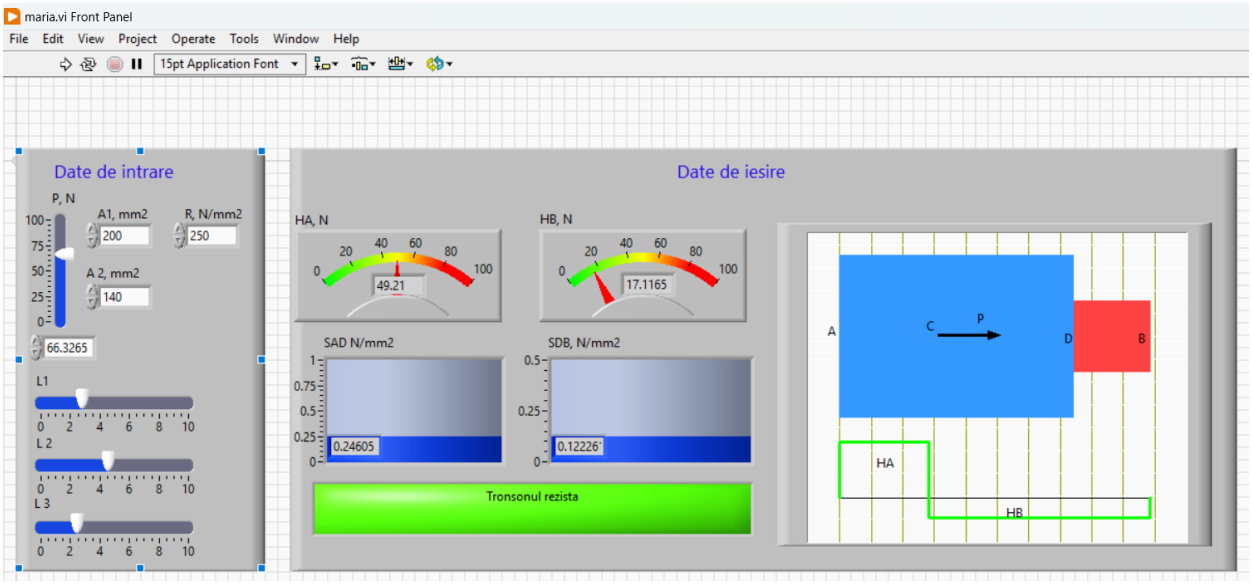

Fig. 2. Front panel

An XY Graph indicator element is also available on the virtual instrument panel where the program will show you the drawing of the bar section and the axial stress diagram.

The program allows the calculation of the results and the representation of the loading scheme, depending on the numerical values entered by the user through the control elements.

Description of the programming algorithm

The virtual instrument diagram represents the interface to the programmer. The programming algorithm was realized in the virtual instrument diagram. This was developed in two parts. In the first part, the program for calculating the results was created using the Formula Node.

In the Formula Node structure, formulas 1 and 2 were introduced, respecting the order of operations in arithmetic.

Figure 3 shows the diagram of the virtual tool for calculating the results.

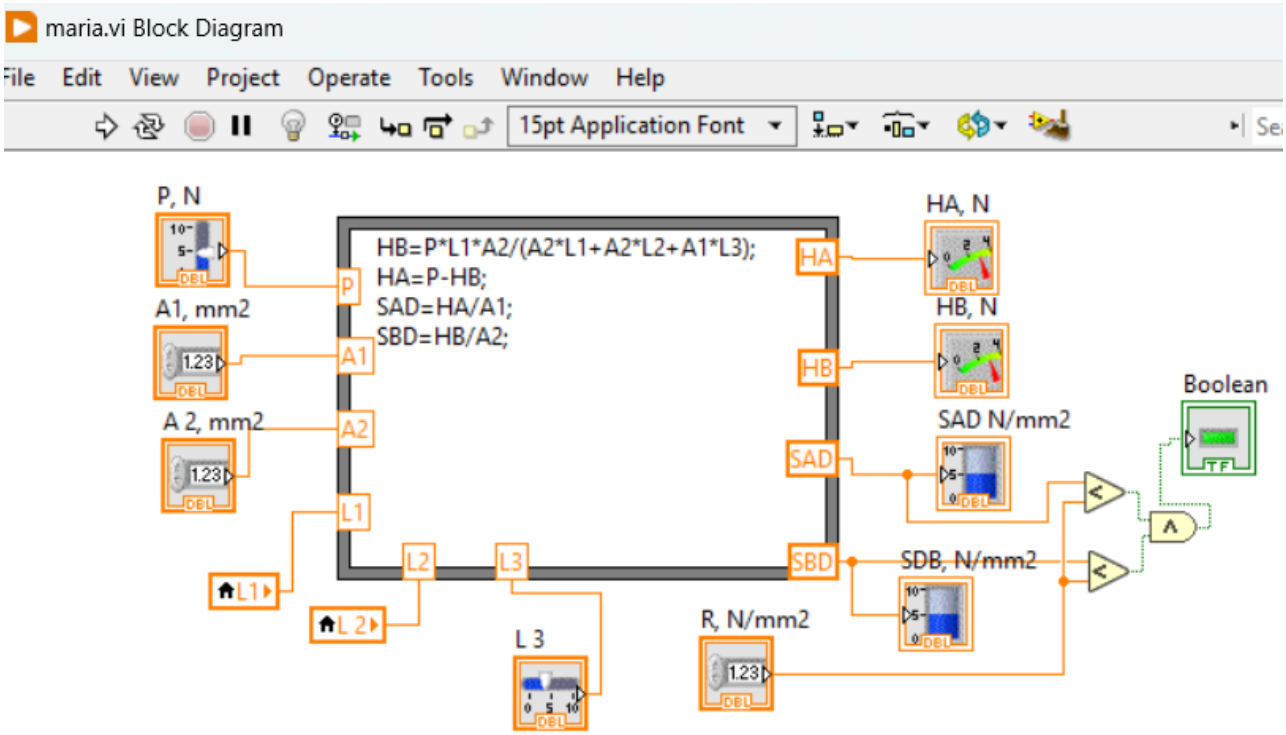

Fig. 3. Diagram of the virtual instrument for calculating the results

In the second part of the diagram, the programming algorithm was created for the representation of the bar section and the axial stress diagrams. The representation of the images was done by building several graphics that were represented simultaneously using the Build Array function.

Each graph was obtained with the Bundle function. To obtain a graph, the Build Array function was used, thus building the string of numerical values of the coordinates of the points on the graph.

Local variables for control elements and indicators have been used to simplify the diagram.

Figure 4 shows the second part of the virtual instrument.

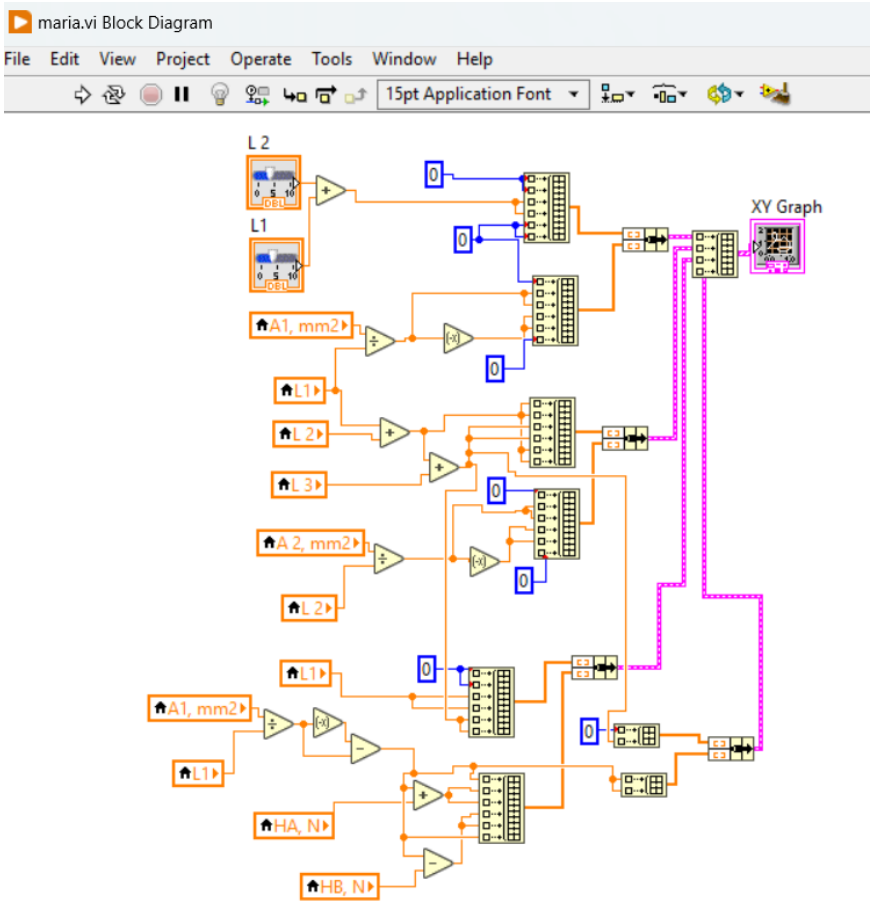

Fig. 4. Virtual instrument diagram for displaying the axial stress diagram

3. Conclusion

The current virtual instrument is recommended to solve a specific problem of stress material using the formulas from the specialized literature. It allows the calculation of reactions, allowable stresses while the user enters various input data.

As future research directions, the programmer interface will be improved using Pictures and property nodes.

The virtual tool will be developed so that it allows saving in files accessible to any user.

4. Bibliography

[1]. Jiga, G, (2014) Strength of Materials,Volume 1, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0168-2.

[2]. Savu T., Spânu P., Abaza B.(2014), Reprezentări grafice – îndrumar de laborator, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0230-6.

[3]. Spânu P, Savu T., Abaza B., (2018) Bilingual Laboratory Guide (Romanian -English) Computer Programming, Ed. Printech Bucuresti , ISBN 978-606-23-0819-3.

VIRTUAL INSTRUMENT FOR SIMULATING THE DEFORMATION OF A FIXED BAR AT ONE END UNDER THE ACTION OF THE FORCES

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ABSTRACT: This paper describes the results obtained through the design and development of a virtual instrument made in LabVIEW. The virtual instrument calculates the strength of the material for a specific application. The virtual instrument allows the calculation of the reactions for a cylindrical bar made up of two sections and fixed at one end, the checking of the bar in all bar segments, the elongations of the bar sections, and draws the axial stress diagram. The bar is subjected to the actions of the three forces at three different points.

KEYWORDS: LabVIEW, reaction, elongation, axial stress.

1. Introduction

Solving problems in the field of material resistance requires laborious and complex mathematical calculations. Sometimes, mistakes can be made in performing calculations that can lead to erroneous results. In addition, the time required for calculating the results and plotting the diagrams is quite high.

The virtual instrument allows the quick and correct calculation of the reactions for a cylindrical bar made up of two sections and fixed at one end, based on the formulas given by the specialized literature. The calculation formulas depend on the type of bar, the type of force application and the type of support of the bar.

Regardless of the values specified as input data, when the program runs, the bar loading diagram and the axial stress diagram will be drawn, depending on the values entered as input data in the problem.

2. Status

The cylindrical bar is made up of two sections and fixed at one end. The loading scheme is represented in Figure 1.

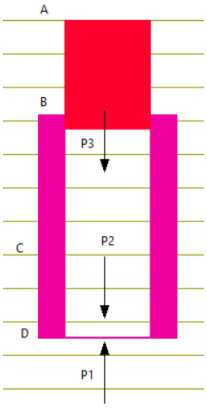

Fig. 1. Cylindrical bar with two sections

The steel bar (R = 235 N/mm^2 and E = 2.1x 10^5 N/mm2) is fixed at the end point A. It consists of two sections: AB of the circular section with diameter D_{AB} and section BD of the annular section with outer diameter $D_{BD.}$

To check the resistance condition, neglecting their weight, the calculation relationship used is given by formula 1 [1]**:**

$$\sigma = \frac{N}{A_{Ef}} \leq R \qquad (1)$$

where:

R – calculated tensile/compressive strength of the material.

A_{Ef} – the effective cross-sectional area of the axially loaded bar.

N – axial effort.

The axial load to which the bar is subjected will be strech when N > 0 and compression when the value of N < 0.

Formulas 2, 3 and 4 were used to draw the axial stress diagram starting from the free end (D) towards the embedment [1].

$$N_{CD} = -P_1 \qquad (2)$$

$$N_{BC} = -P_1 + P_2 \qquad (3)$$

$$N_{AB} = -P_1 + P_2 + P_3 \qquad (4)$$

The elongations of the bar sections were calculated using formulas 5, 6 and 7.

$$Def\ AB = \frac{N_{AB} * L_{AB}}{A_{AB} * E} \qquad (5)$$

$$Def\ BC = \frac{N_{BC} * L_{BC}}{A_{BC} * E} \qquad (6)$$

$$Def\ CD = \frac{N_{CD} * L_{CD}}{A_{CD} * E} \qquad (7)$$

3. Description of the virtual instrument running

The following controls are available on the front panel, used for specifying input data: numeric type controls named R, E, P1, P2, P3, D AB, D BD, L AB, L BC and LCD [2].

When running the program, the virtual instrument will display the calculated results in numerical indicator elements named as follows: N AB, N BC, N CD, S AB, S BC, S CD, Def AB, Def BC, Def CD.

Also, the virtual tool will display in the XY Graph indicator element, the axial stress diagram, and the bar section according to the values received from the numerical control elements.

Figure 2 shows the image of the front panel of the virtual instrument with the control elements and the indicator elements mentioned above.

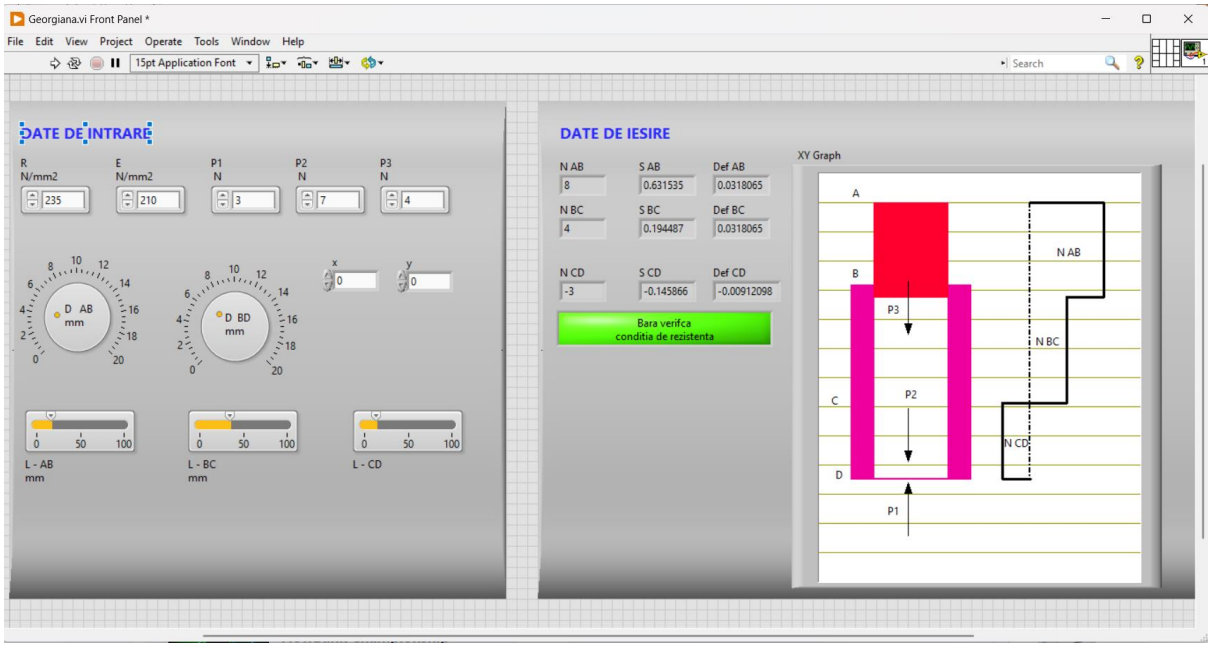

Fig. 2 Application front panel

4. Description of the virtual instrument algorithm

In the virtual instrument diagram, the Formula Node structure was used to calculate the results of the problem. In the Formula Node structure, formulas 1 - 7 were introduced, respecting the order of operations in arithmetic. Each expression was ended with a semicolon.

The tensions calculated for the three sections were compared with the admissible tension with the Less function. If all conditions are met simultaneously, the program will display the corresponding message in the LED indicator element [3].

Figure 3 shows the diagram with the programming algorithm for calculating the results.

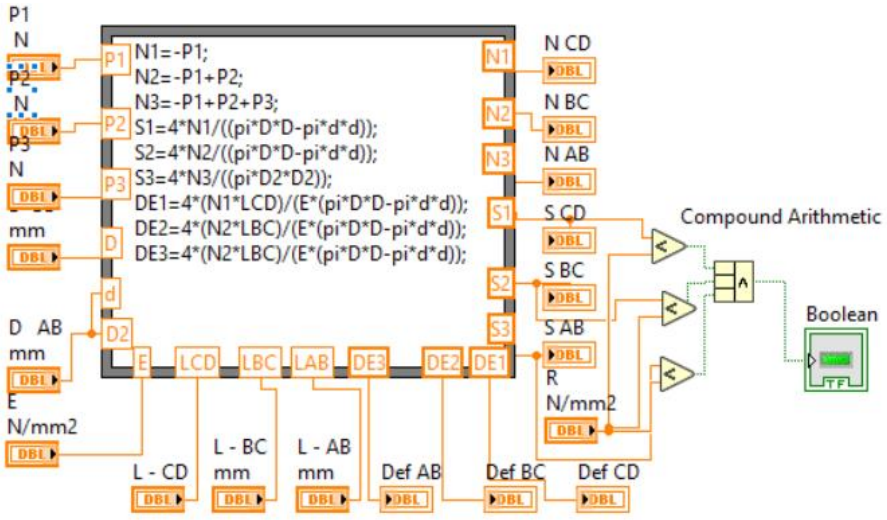

Fig. 3. Algorithm for calculating the results

The representation of the drawing was obtained by the simultaneous representation of several graphics using the Build Array function.

Each graph was obtained by a cluster constructed with the Bundle function. Each cluster contains the string of values of the numerical coordinates X and the string of values for Y.

Each array was built with the Build Array function.

To simplify the diagram, local variables were created for the control elements, respectively the indicator elements through which their numerical values were read, and which were used to calculate the coordinates of the points through which each graph was drawn.

Figure 4 shows the algorithm for the graphic representation of images.

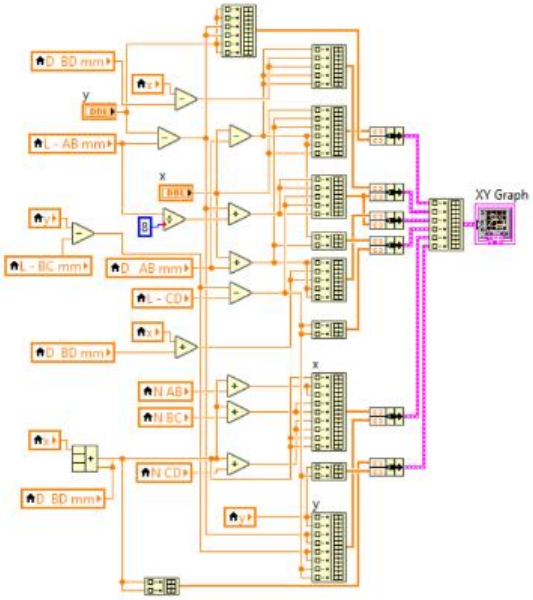

Fig. 4. Algorithm for the graphic representation of images

5. Conclusion

The created virtual instrument correctly and efficiently solves a concrete material strength problem based on the formulas from the specialized literature. It has a simple, intuitive, and easy-to-use interface for users with any programming experience.

It is recommended to improve the interface with the programmer by obtaining drawings with the help of Pictures-type functions as future research directions.

Also, the writing of calculated results and drawings in a report or files is taken into account to be accessible to any user without the need for LabVIEW software.

6. Bibliography

[1]. Jiga, G., (2014) Strength of Materials,Volume 1, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0168-2.

[2]. Savu T., Spânu P., Abaza B.(2014), Reprezentări grafice – îndrumar de laborator, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0230-6.

[3]. Spânu P, Savu T, Abaza B, (2018)Bilingual Laboratory Guide (Romanian -English) Computer Programming, Ed. Printech Bucuresti , ISBN 978-606-23-0819-3.

VIRUTAL INSTRUMENT FOR DETERMINING THE MAXIMUM DEFORMATION IN A SIMPLY SUPPORTED BEAM

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ABSTRACT: This paper describes the results obtained by designing and creating a virtual instrument made in the LabVIEW graphical programming environment, with which material resistance calculations are performed. The virtual tool allows the calculation of the maximum deflection at a point located a distance X from the left support for a bar supported by a simple support and fixed at one end when subjected to a concentrated force at the middle.

KEY WORDS: LabVIEW, deflection, concentrated force, simple support

1. Introduction

Solving problems in the field of material resistance requires laborious and complex mathematical calculations. Sometimes, mistakes can be made in performing calculations that can lead to erroneous results. In addition, the time required for calculating the results and plotting the diagrams is quite high.

The virtual tool allows the quick and correct calculation of the reactions for a bar supported by a simple support on the right side and fixed on the left side, based on the formulas given in the specialized literature. The calculation formulas are based on the length of this bar, the distance from the left support to the point where we want to find the deformation and the concentrated force applied. Regardless of the values specified as input data, when the program is run, the loading pattern of the bar, its deformation and the maximum value of the deformation at the desired point will be plotted.

2. Current Stage

Bar fixed at one end and supported by a simple support at the other end subjected to a concentrated force and its deformation for which the virtual instrument is developed is represented in figure 1.

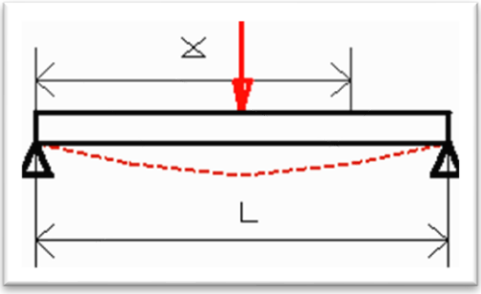

Fig. 1. Simply supported beam

The bar for which the length L = 70m is fixed at the left end and rests on a simple support at the right end. It is subjected to a concentrated force P = 55 N/mm2 in the middle.

Virtual instrument for simulating the deformation of a fixed bar at one end under the action of the forces

To calculate the maximum deformation M(x) at a point located at a distance of X = 30 m, formula 1 is used:

$$M(x) = \frac{P}{2}(L - X) \tag{1}$$

where:
M(x) – Maximum deformation at point x;
L – Length of the bar;
P – The concentrated force;
X – The distance from the left support of the bar to the point where the maximum deflection is calculated.

3. Description of how does the virtual instrument work

On the front panel visible to the user, the following control elements are available through which the input data is specified:

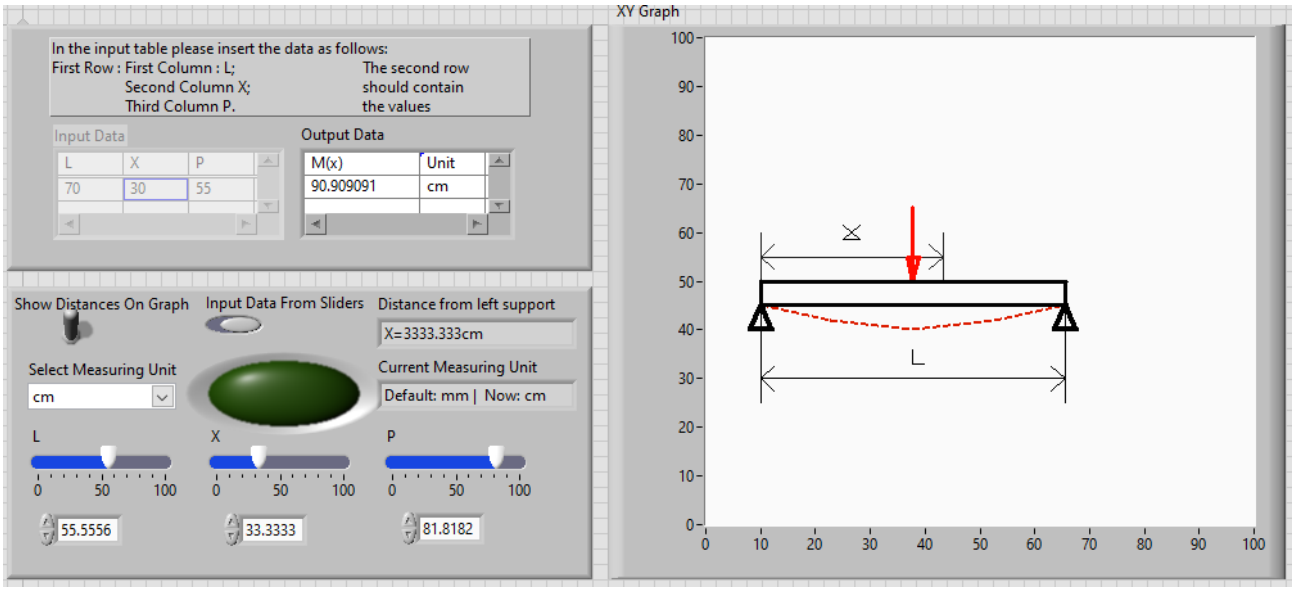

Fig. 2. User Interface

- A table for entering the length (L) of the bar, the distance from the left support to the point where the calculation of the maximum deformation (X) is desired and the concentrated force applied to the bar in the middle (P).
- A box with several options from which the user can choose the unit of measurement for length L and distance X.
- A switch to enable or disable the display of distances on the XY graph.
- A switch that allows the user to choose the way in which the data is entered: The standard way, by entering the data in the previously mentioned table or through the "Slide" type control elements to be able to follow in real time the changes made to the graphical representation of the bar chart.

When running the program, the virtual instrument will display the following in the indicator elements:

- A table showing the maximum deformation M(x) and the unit of measure used;
- The distance X entered;
- The unit of measure selected and used by the program for calculations;
- A led that indicates to the user if the distance X is greater than the length L of the bar;
- An XY Chart in which the bar chart is represented.

4. Description of the virtual instrument algorithm

In the virtual instrument diagram, the "Formula Node" structure was used to calculate the results of the problem. Formula 1 was introduced in the "Formula Node" structure, respecting the order of operations in arithmetic. The expression was terminated with a semicolon. Fig. 3.

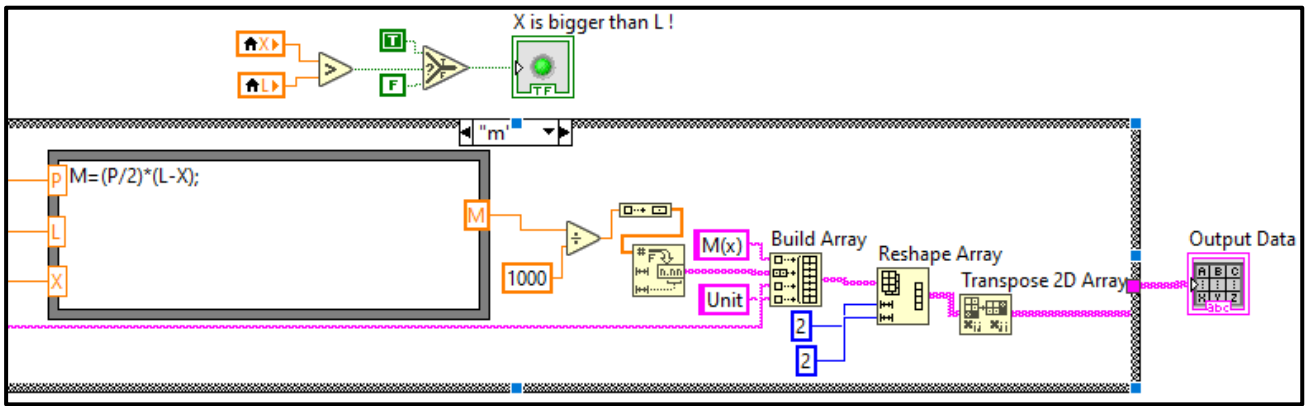

Fig. 3. Formula node in Case structure

The value calculated using the "Formula Node" structure is then divided by the corresponding value to be displayed in the unit of measurement selected by the user. Then, with the obtained value, a matrix is formed through the "Build Array" structure to which text is added using another "Build Array" structure, the matrix is then resized and transposed so that it can finally be inserted into the "Output Data" table so that the user can see the final result. Fig. 3.

To display the drawing, I used three sub-vi's joined by a "Build Array" structure to get the final graph represented by the "XY Graph" structure, which consists of three parts.

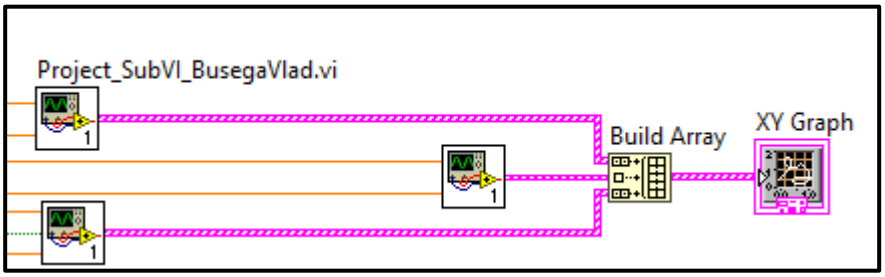

Fig. 4. The three sub-vi's

The main schema is represented by a cluster built using the "Bundle" structure. Each cluster contains the string of values of the numerical coordinates X and the string of values for Y.

Each string was built in turn using a "Build Array" structure.

The values for X and Y were obtained by processing the input data L and X entered by the user.

In Fig. 5. You can see the algorithm used for the graphic representation of the exercise.

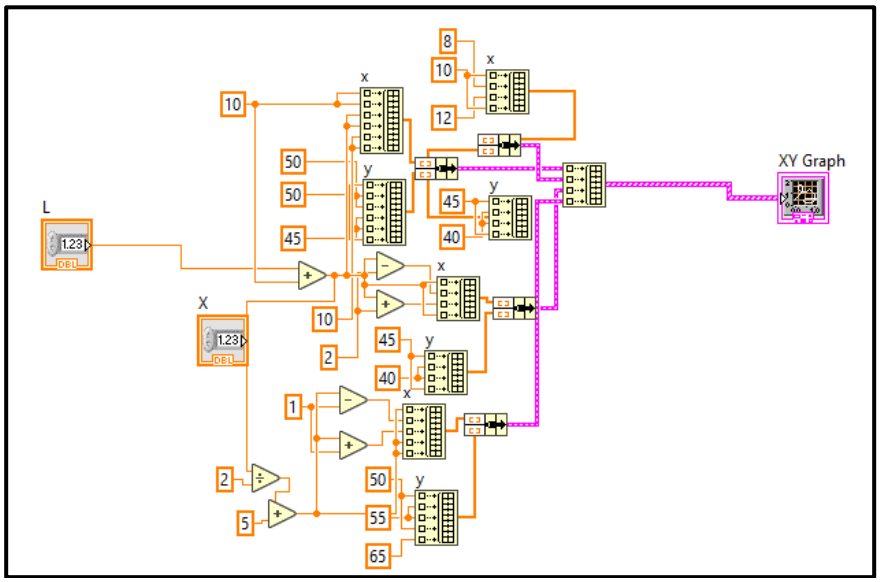

Fig. 5. Algorithm for graphical representation of the exercise

5. Conclusions

The created virtual tool correctly and efficiently solves a problem of the strength of concrete materials, based on formulas from the specialized literature. It has a simple, intuitive and easy-to-use interface for users with no programming experience.

As future research directions, it is recommended to improve the programmer interface by obtaining drawings using "Pictures" type functions.

Also, the writing of calculated results and drawings in a report or files is considered because they are accessible to any user, without the need for "LabVIEW" software.

6. References

[1]. Jiga, G., (2014) Strength of Materials,Volume 1, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0168-2.

[2]. Savu T., Spânu P., Abaza B., (2014), Reprezentări grafice – îndrumar de laborator, Ed. PRINTECH, Bucureşti, ISBN 978-606-23-0230-6.

[3]. Spânu P, Savu T., Abaza B., (2018) Bilingual Laboratory Guide (Romanian -English) Computer Programming, Ed. Printech Bucuresti , ISBN 978-606-23-0819-3.

VIRTUAL TOOL FOR CALCULATING RIVET JOINTS

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ABSTRACT: Riveting is the technological process of non-removable joining of two or more parts, using machine components called rivets. This virtual LABVIEW (VI) tool allows the riveting assembled parts to be checked, as required by external axial forces for the following three types of requests: Axial load (tension or compression), shear request, crushing request.

KEYWORDS: LABVIEW, rivets, force, demand.

1. Introduction

Riveting assembly is an operation by which two or more tables merge and become unremovable. This procedure provides safety in the operation of welded assemblies and constructions subject to dynamic loads such as bridges, aircraft, marine and river ships, etc.

Depending on the type of production, the operation can be performed mechanically or manually. Depending on the diameter of the rod, it can be performed at low or high temperatures – if it is less than 6 mm, the assembly is done cold, and at a larger diameter, hot.

The rib it is a cylindrical body fitted at one end with a cylindrical, tronconic or bulging head, and the other head is obtained by plastic deformation. Its component parts are visible in Figure 1: The starting head (a), the rod (b) and the closing head (c). Rivets are made of various materials depending on the materials of the parts to be assembled, as well as the forces to which the assembly will be requested.

The main features that materials for rivet making must meet are sufficiently high tensile strength and good plasticity.

At the joining of two plates by riveting, at each rivet, two equal forces of opposite direction are transmitted, as shown in Figure 1.

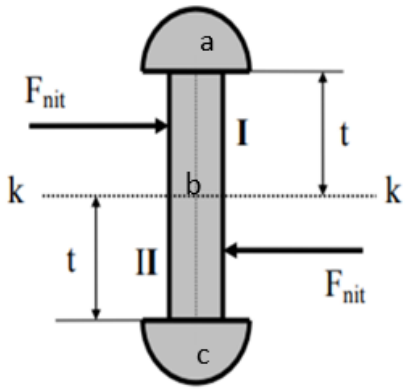

Fig 1. Ribit and applied forces

2. The current stage

If for joining are used **in rivets**, on each rivet, two equal forces of opposite direction, called forces on the nit**:**

$$F_{nit} = \frac{F}{n} \tag{1}$$

Forces on the rivet tend to scissors the rivet after the k-k separation plane of the two plates.

If the rib is required to **shear,** and has only one shear surface at the level of the separation plane between the two platbands, the calculation relationship is:

$$\tau_{max} = \frac{F_{nit}}{A_f} = \frac{F_{nit}}{\frac{\pi d^4}{4}} \tag{2}$$

Where:
maximum tangential voltage;
Af - aria suprafeței forfecate (aria de forfecare);
d - diameter of the rivet;

If the ribit is required to **crush,** the calculation relationship is:

$$\sigma_{maxs} = \frac{F_{nit}}{A_s} = \frac{F_{nit}}{t * d} \tag{3}$$

Where:
σmax - maximum normal crushing voltage;
As - area of crushed surface (crushing area);
t - the thickness of the platter;

For **axial demand**, the calculation relationship is:

$$\sigma_{max} = \frac{F}{A} = \frac{F}{(b-d) * t} \tag{4}$$

Where:
σmax - axial tension;
b - latimea platbandei;
t - the thickness of the platter;

3. Description of the functioning of the virtual instrument

Depending on the size of the rivet and plates, the program will represent the drawing of the rivet in a 2D picture indicator element.

Also, depending on the type of request, the program will calculate the voltages and compare them with the allowable values. Each variable specific to the type of request will remain visible or not with the properties in the element control panel.

The values of forces and tensions were calculated using Formula Node structures in which the necessary formulas were passed, and the drawing of the rivet was made using **the functions draw Rectangle.vi, draw Circle by radius.vi, move Pen.vi** and **draw line.vi.**

The following control elements are available on the front panel, required to specify the input data:

The force at which riveting assembly is required (**vertical pointer slide numeric** element called

"force"), the number of rivets (numerical control element called "No. Rivets'), diameter of rivets (Knob numeric element called 'rivet diameter'), thickness (**horizontal Pointer Slide numeric element referred to** as 'flatbed thickness'), width of plates (**controllable numeric element called** 'width') and the 3 permissible voltages for each request (**controllable numerical elements called** 'SS admissible' for crushing, 'S admissible' for axial and 'T admissible' for shearing

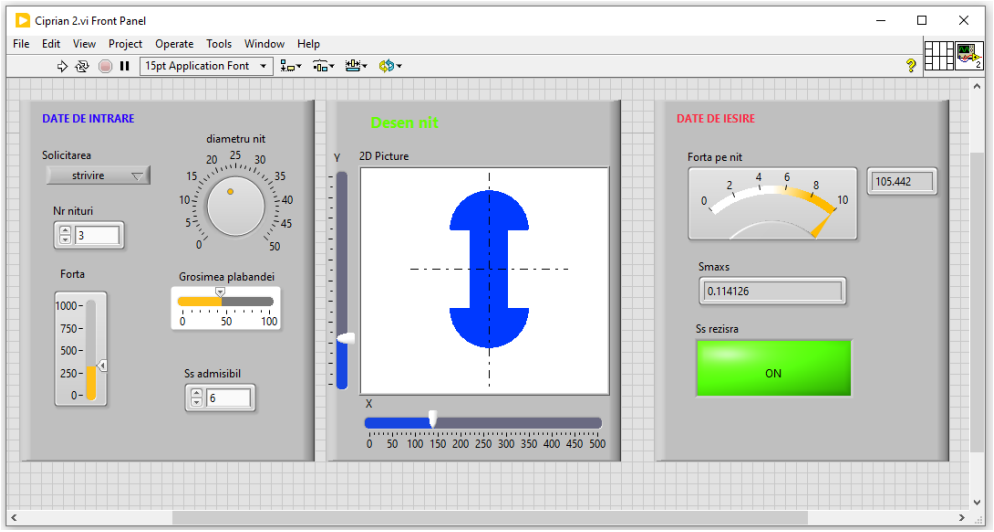

Fig 2. Application front panel

The application will also display the force applied to the rivet, calculate the maximum voltage and check if the assembly of the parts resists the maximum voltage by lighting a green bulb.

4. Description of the virtual instrument algorithm

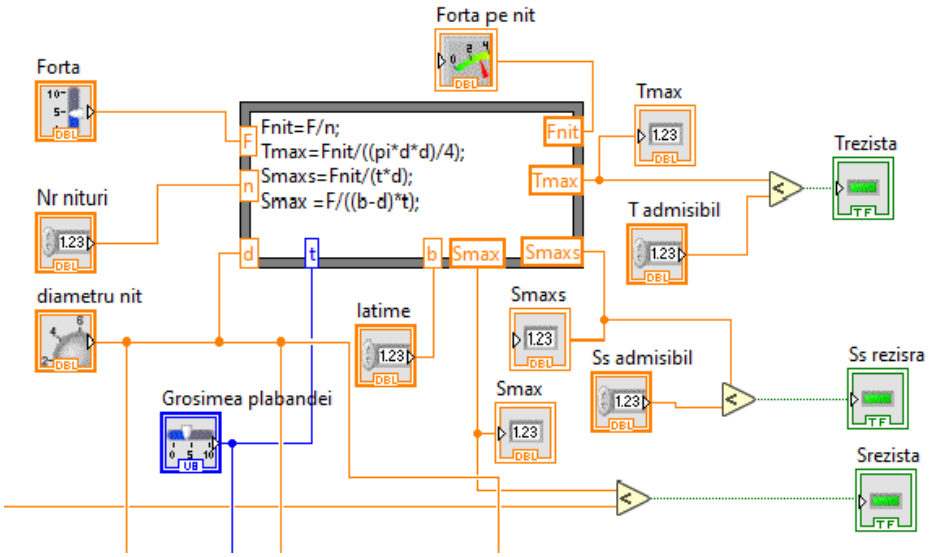

Fig. 3. Calculation of force and tension

In the diagram of the virtual instrument, the formula node structure was used for calculating the force and the voltages respectively. Formulas 1-4 were introduced in the structure, separated by enter, at the end a point and a comma were added.

The results of the voltages were compared with the allowable voltages of each request to check whether the rivet could withstand force or not. If so, each led will light up with a green color; otherwise, the led color will be red.

Figure 3 shows the diagram of formula calculations and the verification of the rivet.

The drawing was made through a 2D picture structure in which different basic functions were used that create geometric shapes and change coordinates. Each geometric shape was created and moved to make the scheme of the rivet, with different characteristics such as color, size and coordinates of each. Thus, the ribit was created from a rectangle, 2 semicircles and the 2 axes of symmetry were created.

The lengths and points where it is located have been calculated in a Formula Node structure, the results being linked to each function to draw the ribit. The coordinates of each point were created by tying an x and y into a bundle. Figure 4 shows the diagram that draws the ribit in 2D picture structure.

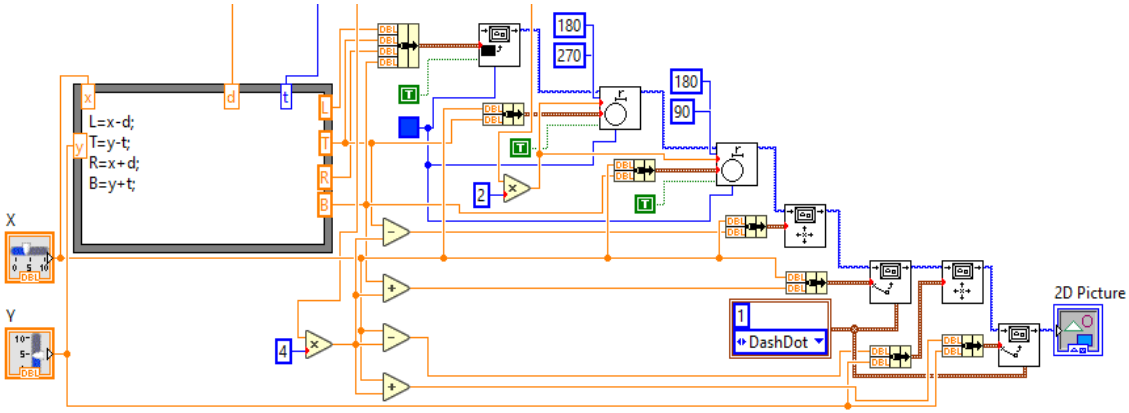

Fig. 4. Drawing the rivet in the 2D picture structure

The application at the time of selecting a request (out of the 3 existing ones) will make its items remain visible and those that do not need to disappear. This is possible by using nodes in the control panel of each item.

Each request will have visible the necessary elements linking the visible nodes to the respective request. Figure 5 shows the appearance and disappearance of the elements.

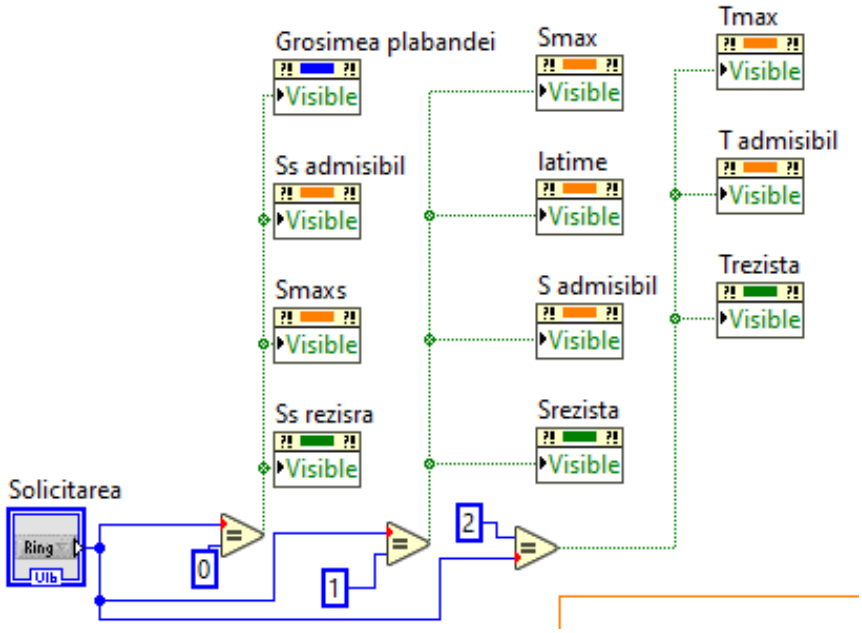

Fig. 5. Visibility of panel elements

5. Conclusions

This virtual tool correctly and efficiently solves a problem of the resistance of materials, based on formulas from the literature. The interface of the application is simple, and the algorithm is easy to use by both a specialist user and a beginner.

Making a virtual tool for calculating riveted joints through the clasps. In the case of joints riveted by means of the shins, the force is transmitted through the first group of rivets from one platter to the two shins, and then from the latter through the second group of rivets to the second platter.

It is suggested to write calculations and drawings in a file or report for safer accessibility that does not require the installation of LabVIEW software.

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PROTOTYPING AN EXPERIMENTAL MACHINE-TYPE MODEL

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ABSTRACT: Ziggi is a remote-controlled car, built using an Arduino Uno board, an L293D shield, and an HC-05 Bluetooth module, which allows wireless control of the car. Equipped with four DC motors for movement, Ziggi can be controlled through an Android app. The car features an intelligent 'return home' function, allowing it to follow the reverse route. The chassis and auxiliary mounting elements were designed, modeled, and created using a 3D printer. Additionally, the car is equipped with a GoPro camera, providing real-time visualization of the route it travels, thus facilitating control and navigation of the car in various environments.

KEYWORDS: Arduino, Ziggi, GPS, car

1. Introduction

The general aspects of the work relate to the design and construction of a remote-controlled car, called Ziggi. This project involves the use of components such as Arduino Uno, Bluetooth HC-05, DC motors and an L293D shield for motor control. Focusing on the integration and coordination of these components, the general aspects aim to create a functional and efficient vehicle that can easily be wirelessly controlled. The main objective of this work is to create an experimental machine-type model that will have functionalities such as remote control, movement in all directions, returning to the starting point through the 'return home' function, and real-time route visualization. Another important objective is the development of an Android application for the wireless control of the car. Thus, the project aims to integrate accessible technologies and efficient programming methods to build an intelligent and versatile vehicle, controlled through a dedicated application on mobile devices.

2. Current stage

In the documentation process for creating the Ziggi car, various sources and examples of similar robotic vehicles were sought. However, no exact or very close examples to the proposed concept for Ziggi were found. A project found in the specialized literature [1] was analyzed, where the author describes the creation of a GPS-controlled robotic vehicle. This robot uses a GPS module, a microcontroller, and a motor driver to move autonomously along a predetermined route. The system uses GPS coordinates to guide the vehicle to its destination and to avoid obstacles encountered along the way [1].

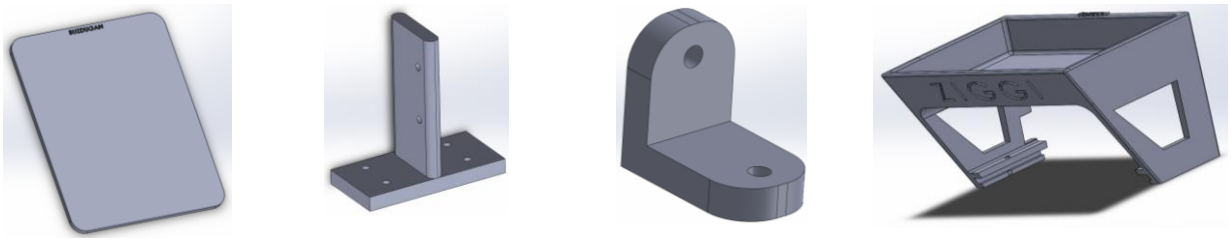
One of the main differences between Ziggi, the constructed car, and the robot presented in the article [1], is the navigation system. While Ziggi uses a route recording method based on motor control and direction of movement, the GPS robot relies on GPS coordinates to establish the route. This means that Ziggi can be used both indoors and outdoors, having the advantage of retaining the traveled route. In contrast, the GPS-controlled robot requires an open space to receive the GPS signal, thus limiting its use in enclosed areas.

3. Prototype Development

In this chapter, the main stages of creating the experimental prototype are presented, exploring in detail each aspect and how they were approached to ensure functionality, efficiency, and proper assembly of the Ziggi car.

3.1. Designing the component parts of the experimental model

All 3D-printed components were modeled and designed using specialized software.



a) b) c) d)

Fig. 1. Modeled component parts

The design stages of each component are as follows: the work plan is chosen, the sketch is drawn, and the correct dimensions are established. Then, the piece is extruded to obtain the 3D modeled components [2].

In Figure 1a the car chassis is shown. Its sketch is a rectangle with dimensions of 150x120 mm. The extrusion is 4 mm to ensure increased strength, considering that the components presented in point 3.3 will be mounted on it.

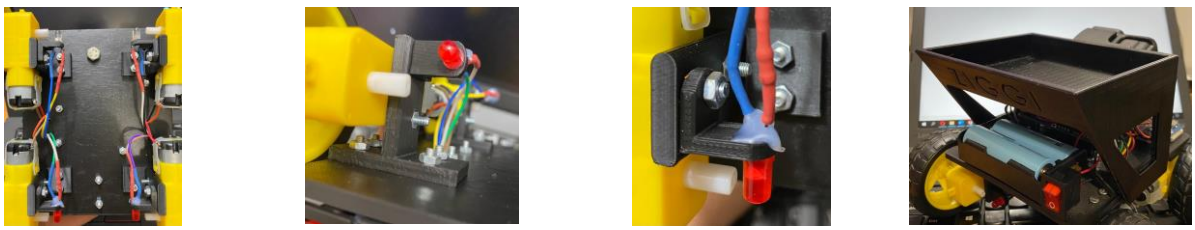
The support in Figure 1b is used for mounting the motors on the chassis with the help of M3 screws.

In Figure 1c a support for LEDs can be seen. It started from the sketch of the letter L, for which the dimensions were established, then circles with a diameter of Φ3 mm were drawn, and the corners were rounded. The thickness of the support is 3 mm.

A detachable support, shown in Figure 1d, is provided for attachment to the chassis, which can be used for transporting various objects.

3.2. 3D printing of experimental model components

After completing the modeling of the parts, the next step was to obtain the .STL files for the purpose of 3D printing them.



a) b) c) d)

Fig. 2. Printed component parts

For 3D printing, the Ultimaker Cura software [3] program was used. The material of choice is PLA (Polylactic Acid), printing was performed with a 40% infill, the print bed temperature was set at

60°C, and the nozzle temperature at 200°C. The parts shown in Figure 1b and 1c were 3D printed in four copies.

3.3. Assembling the component parts of the experimental model

After completing the printing process of the components, the assembly stage followed. In this stage a connection scheme was developed to allow for the efficient connection of the Arduino UNO board, the motor shield, motors, LEDs, the on/off button, 220Ω resistors, the HC-05 Bluetooth module, and the batteries, as shown in Figure 3.

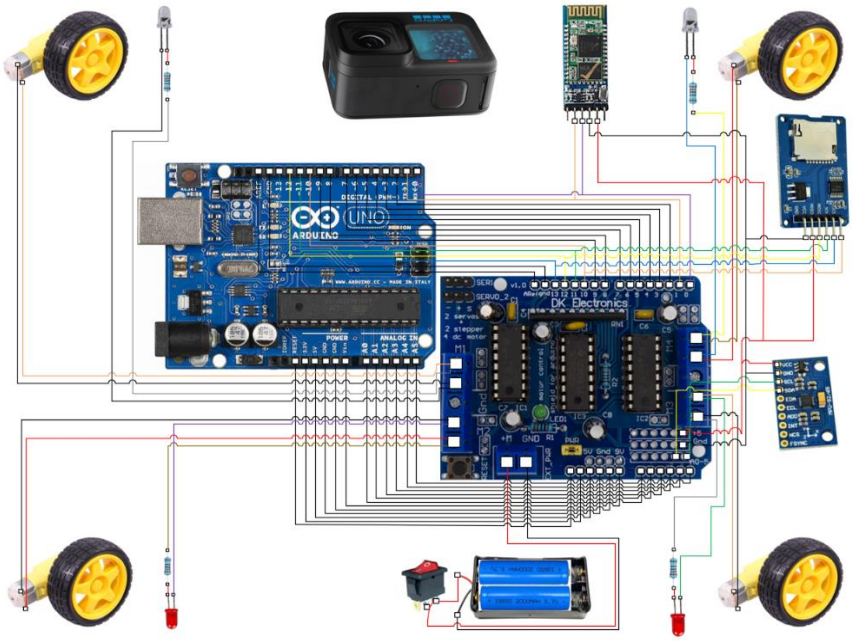


Fig. 3. Connection diagram between components

The assembly of the components was carried out in several stages, and Figure 4 shows some illustrative photos of the assembly and interconnection process of the parts.

In the first step the pins were soldered onto the L293D shield, as well as the wires needed for connecting the HC-05 Bluetooth module, specifically the RX and TX pins. The connections between the module and the Arduino UNO control board were made crosswise (RX-TX and TX-RX), as this configuration is commonly found when using this module. Additionally, the wires from the MicroSD module were soldered for the CS, SCK, MOSI, and MISO pins.

In Figure 4a the L293D shield can be seen, which allows connection to the analog pins (A0-A5) and to six +5V and GND pins, through soldered connector pins. Figure 4b shows the stage where the board was mounted on the vehicle chassis. Figure 4c highlights the soldered RX and TX wires corresponding to the TX and RX pins on the module, and Figure 4d illustrates the shield connected to the board. The next figure shows the stage of analyzing the available space on the chassis for assembling the following components.

Figure 4f highlights the mounting of the ON/OFF switch and the battery holder.

Figure 4g shows how the battery holder is attached to the vehicle chassis. The following image highlights how the GoPro camera is mounted on the vehicle chassis.

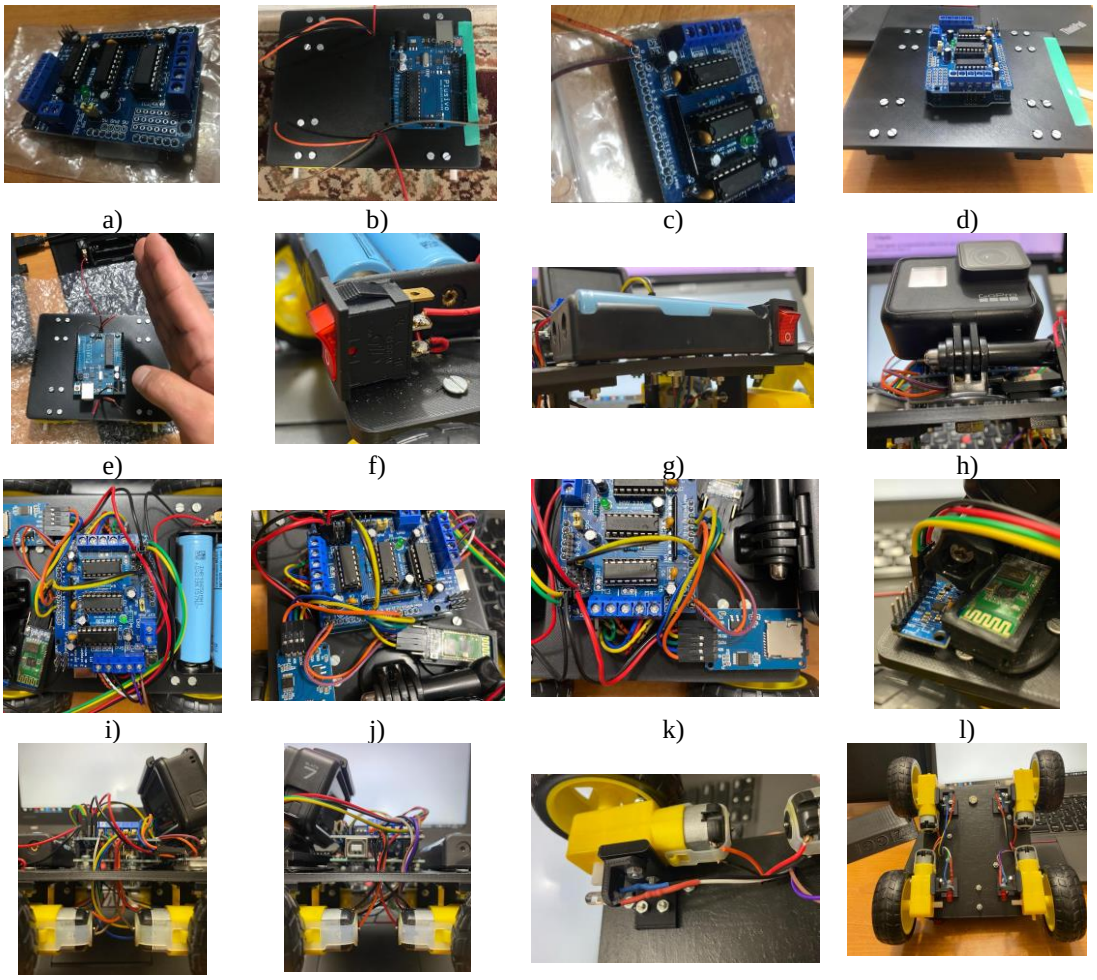
Figures 4i and j highlight all the connections on the upper side of the chassis, including the connection method of the HC-05 Bluetooth module.

The next two figures illustrate the mounting of the MPU-92/65 and MicroSD modules. These modules were mounted on the car chassis and can be used to obtain greater accuracy of the return path

within the "return home" command. The MPU-92/65 module can be used to obtain a more accurate measurement of the XYZ position coordinates, with the data being stored on the attached MicroSD card. These components can be used for further development of the experimental model.

In Figures 4m and n the side views of the chassis can be seen from both the right and left sides.

Figure 4o shows the assembly method of the 3D printed parts for fixing the DC motors and connecting the LEDs, using 220-ohm resistors. The last figure highlights all the connections on the lower side of the chassis [4].



a) b) c) d)

e) f) g) h)

i) j) k) l)

m) n) o) p)

Fig. 4. Assembly steps of the component parts

4. Description of functionality and testing of the experimental model

To implement the main control functions of the car, the code was developed and uploaded using the Arduino IDE development platform [5].

In developing this code, the AFMotor.h and LinkedList.h libraries [5] were used to simplify motor control and store the robot's coordinates in an efficient way, using the following functions listed below:

- The "controlMotors" function is important because it controls the robot's movement through the motors. It receives direction commands "F, B, L, R" and stop and clear commands "C" and "S". Through this function, the robot's direction and speed can be controlled.

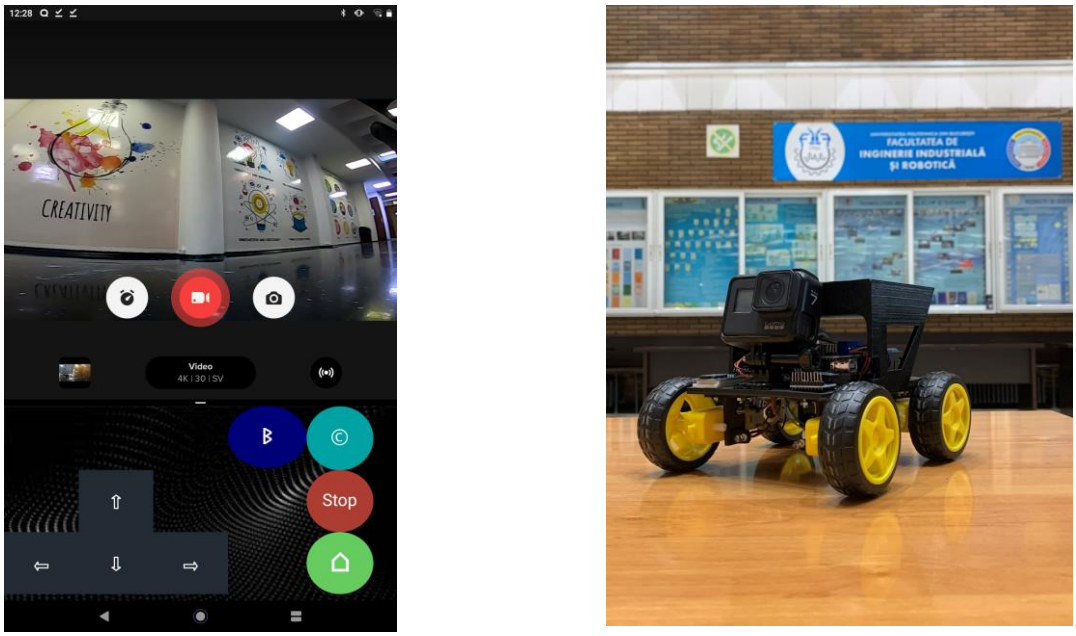
- The "updatePosition" function is important for updating the robot's coordinates and storing them in LinkedList. It receives the robot's current direction and updates the coordinates accordingly. After

updating, a "Coordinate" object with the new coordinates and the current direction is created and added to the end of the "LinkedList path".

- The "returnHome" function is essential for allowing the robot to return to the starting point, reversing the path taken by the robot. To achieve this, the motors are controlled by the "H" command to move in the opposite direction, according to the route, and wait for a specific duration to ensure the robot has stopped before moving to the next coordinate.

- Finally, the "loop" function is important for processing user commands through the serial port. It controls the robot's movement through the "controlMotors" and "updatePosition" functions and allows the user to send commands to control the robot.

In Figure 5a the user interaction interface is illustrated, which includes two components: the real-time viewing application from GoPro and the control one where customized buttons have been designed to facilitate an intuitive experience in sending instructions to the mechanical device [6], [7].



a) b)

Fig. 5. a) Real-time visualization and control application of the experimental model, b) Final model

The search and connection functions of the application to the HC-05 Bluetooth module have been implemented, and the buttons corresponding to the uppercase letters in the source code (F, B, L, R, C, S, H) have been configured as follows:

F - forward;
B - backward;
L - left;
R - right;
C - clear;
S - stop;
H - return "home".

To evaluate the functionality of the code, factors such as the friction coefficient, which depends on the material of the contact surface between the wheels and the terrain, were analyzed. We included in the code the adjustment of the rotation factor for left and right turns, allowing the optimization of the vehicle's behavior on various surfaces.

Another factor influencing the direction's accuracy is the slight curvature of the chassis obtained during 3D printing, which affects the alignment and balance of the steering system. By adjusting some

parameters in the program, these imperfections can be compensated for and the steering performance of the vehicle can be improved under various operating conditions.

5. Conclusions

The Ziggi project is a remotely controlled car, made by integrating Arduino Uno components, Bluetooth HC-05, DC motors, and an L293D shield. This versatile vehicle can be controlled through an Android application and allows movement in all directions, returning to the starting point, and real-time route visualization. The chassis and components were designed and 3D printed, and assembly and programming were detailed in subsection 3.3. As a further development, improving the return route's precision by adding the MPU-92/65 and MicroSD components can be considered.

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RESEARCH ON THE CONTROL OF PARTS WITH A CONICAL PROFILE IN PARTS IN THE AUTO INDUSTRY

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ABSTRACT: The subject of this research paper is the control of conical profile parts. In the beginning it presents the importance of the control of conical profile parts and why they should be very precisely controlled. Then the actual state presents the usage of calibers. After that it shows how the new technologies work, first the inductive probes and second the method using air gages. At the end of that are presented the advantages and disadvantages of all the methods showed before, and the new technologies are both cheaper and more precisely than the old ones. In the end it's written about the way that conical profile parts are tolerated. Finally the conclusions are about how the new technologies are more efficient then the old ones and how they should be used more often because of the fact that the conical profile parts are used in the most important parts of the car.

Keywords: pneumatic transducer, probes with inductive coupling, control, gauges
.

1. Introduction

This research paper highlights the importance of dimensional control of conical profile parts used in the automotive field. Conical assemblies are widely used in the construction of vehicles, due to their possibilities of self-connection, adjustment of clearances and sealing of the assembly.

Tolerating and sizing, as well as the control of conical parts in the automotive field is very important because they are mainly used in the construction of engines and gearboxes, prone to breakdowns by their nature and by their mode of operation.

The control of parts with a conical profile can be done by different methods such as: control with the help of a sine ruler, control with calibrated balls, rings or rollers, control with a measuring microscope, with the help of pneumatic devices, with the help of gauges or with the help of coupling inductive probes.

They are also characterized by constructive and technological simplicity, as well as by easily performing the assembly and disassembly operations of the component elements.

Conical assemblies aim to fix the relative position of two pieces, both in the radial direction and in the axial direction, creating the tightness or clearance necessary for the assembly.

2. The current stage

The existence of such a variety of control methods for parts with a conical profile has made the automotive industry focus on the most efficient methods, both in terms of the time spent to control the part, as well as the precision of the control data. Some of the most effective methods are control with gauges and control with probes with inductive coupling.

The first method is an older one, but it still has great applicability and is very efficient. The control of the internal conical surfaces with the help of gauges is carried out by the axial movement of the gauge relative to the base of the piece to be measured. For this purpose, the gauges are made with two markers, located at a distance of m, one from each other. The distance m represents the frontal distance tolerance (see figure 1).

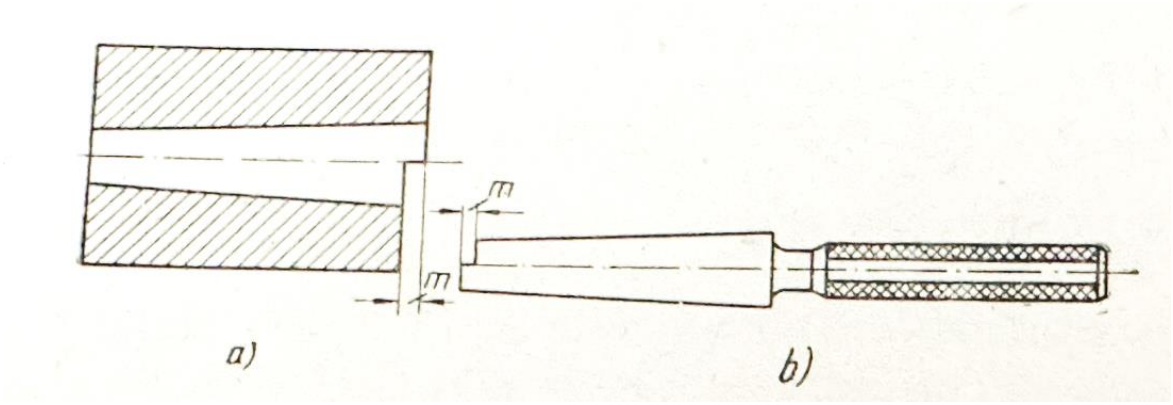

Fig. 1. The distance m [1]

Flat conical bushings are used for the external conical surfaces (see figure 2). The part to be checked rests on some pins. The verification of deviations from conicity is performed by the light slit method between the measuring surfaces of the rulers and the generators of the conical surface. The control is carried out with the help of the marks drawn by the ruler. The control of the thickness and the position of the fixing end of the cone is done with the help of two protrusions, whose surfaces must coincide with the surfaces of the ends of the conical tails of the tools.

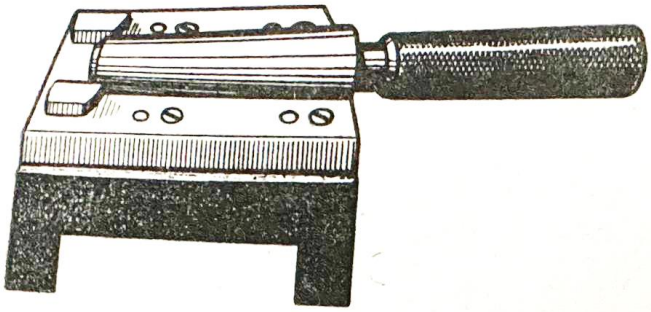

Fig. 2. Flat taper bushings

For more precise measurements and not to be influenced by the human factor as much, electric length measuring instruments were built. The most important factors that were taken into account when building this type of instrument were efficiency, precision and ease of use.

3. Digital control methodologies of conicities

The first option is the one that uses probes with inductive coupling (see figure 3 and figure 4). it can be used, however, only for the outer cones. The probes are placed in contact with the part to be measured on the cone generator. They will show the difference in absolute size between the measured values by the other 2 probes.

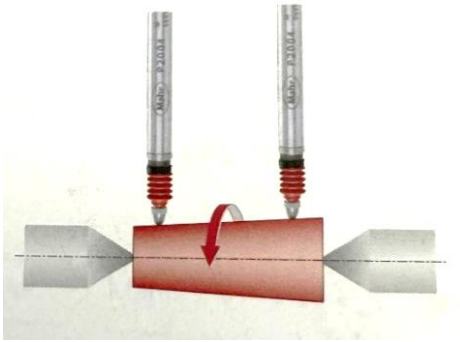

Fig.3. Probes with inductive coupling [2]

Fig.4. Solution of electrical transducers and probes with inductive coupling provided by MAHR [2]

The second version is used to control the internal conical surfaces and is based on the principle of determining the air pressure variation (see figure 5). Thus, a standard part is used, in which the air pressure does not change, and a part in which the air pressure changes. The data collected by the pneumatic transducer will be collected and processed in a graph, from which the deviations of the part will be read and it will be determined whether it is compliant or not (see fig. 7.)

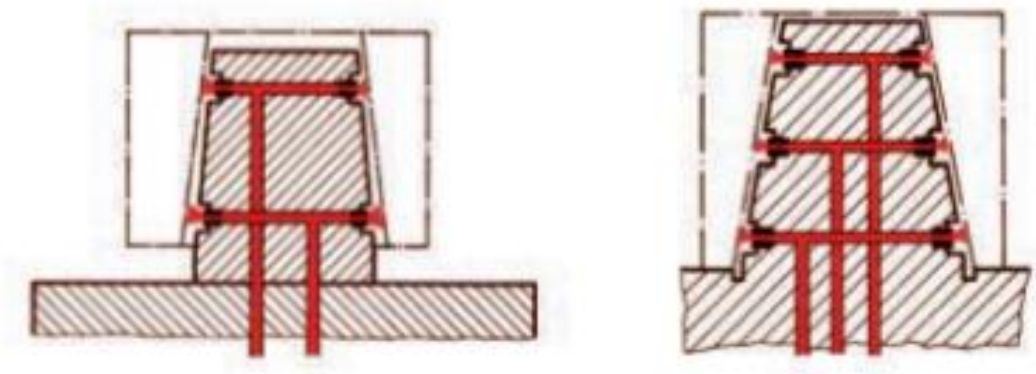

Fig.5 Mounting the pneumatic system on the inner surface of the cone [2]

3.1. Methodology of pneumatic measurement of conicities

Using the Millimar control device, it works according to the principle of determining the change in air pressure; the pressure difference between two chambers is measured. As long as there is a constant pressure in one of the two chambers, being the reference pressure, the pressure in the second chamber (measuring chamber) is determined by the distance recorded between the air jet to be measured and the part under test.

The Millimar measuring units (see fig.6) have two connection points that are directly connected to one of the two pressure chambers. Therefore, the measured values are collected directly, without any conversion through a Piezo pressure sensor and then they are digitized. Magnifications from 2500:1 to 10000:1 are achieved with interchangeable heads for air jets.

Millimar measuring instruments must be supplied with air at a constant pressure through a reduction valve. The control units that have a reduction valve can be connected to any kind of compressed air tube between 3.5 bar and 10 bar over pressure. Through which an air filter should be interconnected, because the air that helps to perform the control must be dry and free of traces of oil or other impurities.

Fig. 6. Millimar measuring unit

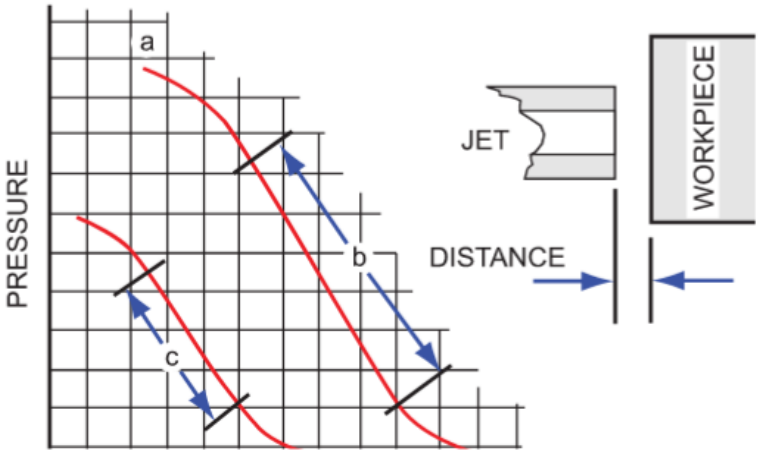

Fig.7 Graph with the pressure-distance measurements obtained from the measurements [2].

4. Advantages and disadvantages of the proposed methods

The gauge control method has the advantage of being efficient in terms of time and can be implemented by anyone, regardless of the operator's experience. One of the disadvantages is that this method is expensive, and for parts of different sizes, several gauges will be needed. These are expensive because they must be processed at least with a higher level of precision than that of the part to be controlled.

The control method with probes with inductive coupling has as advantages a very good precision, does not require a long training of the operator and can be used as any type of surface. They are resistant over time and their maintenance is not expensive. In order to be able to function the probes with coupling inductive need a translator. Mahr's translators offer both analogue and digital display as advantages. In addition, they offer a short response time and are ideal for industrial control processes. They can be connected to the computer therefore the data and parts can be evaluated by the computer automatically through various code programs.

The control method with the pneumatic transducer is a method that offers superior precision, the precision varying between 0.5 and 20 micrometers, depending on the designer's requirements. This method is not influenced by external or environmental factors. It is a non-contact method and does not affect the piece in any way. Thanks to their modularity and the ability to be mounted close to each other, they can be used as an entire control system. A final advantage is the resistance they offer over time. The collected data are displayed linearly and clearly, on a larger or longer graph, easy to read and without introducing errors in the final reading. The pneumatic transducer can also be used to control parts with a profile different from the conical one due to the ease and adaptability of the control elements. It offers a wide range of control that can increase up to 10,000 times.

5. What is the control of a part with a conical profile

Tolerating parts with a conical profile is done by several methods: tolerating the cone, specifying the conicity, tolerating the cone with the simultaneous definition of the axial position of the cone, tolerating the cone separated from the axial tolerance of the cone, tolerating the cone relative to a reference) simultaneously defining the coaxiality.

In all methods of tolerating cones, the width of the tolerance field of the conical surface is indicated, measured along the normal direction to the conical surface and noted in a tolerance frame in which the graphic symbol of the tolerance for the given shape of the surface is also passed. Any shape deviations of the conical surface must be included in this tolerance field.

With each tolerating method, the other elevations that define the conical surface are included, with the exception of the fourth method in which the axial position of the cone is also tolerated, a position determined by the Lx limit deviations (see fig.8).

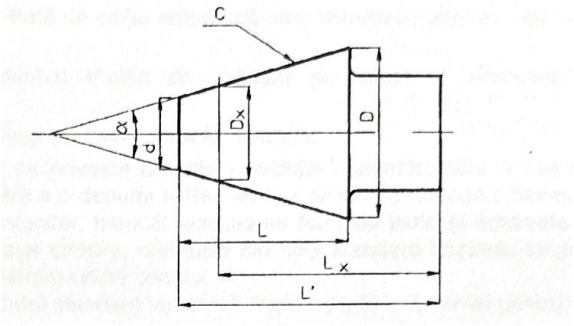

Fig.8 The representation of the Lx quota [3]

There are other methods for tolerating conical surfaces that use only dimensional tolerances, but these methods do not have an adequate indication of the shape of the surface.

Definitions regarding cones, cone sizes and cone angle tolerances are given in STAS. For the tolerances of the cone angle, 12 levels of precision are provided, marked from 1 to 12 in descending order of precision and are applied for tapers from 1:3 to 1:500 and cone lengths from 6 to 630 mm.

6. Conclusions

Since the automotive industry is largely based on series production, we will conclude that the most effective methods we can use are those presented in points 2 and 3. These offer both very good precision, requiring minimal training of the operator, being easy to be maintained, and by their nature the time required to control the part is reduced.

Another conclusion would be that in the automotive industry there is a need to control parts with a conical profile, and this should be carried out with as much precision as possible, because the parts with a conical profile are often found in the most important parts of the car, which are also subject to a high level of stress.

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MODELING OF AN OSCILLATING CAM-SLIDER MECHANISM

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ABSTRACT: This work consists of 3D modelling of a cam-piston oscillating mechanism in the computer-aided design software SolidWorks. The mechanism was taken from the book "Five Hundred and Seven Mechanical Movements" by Henry T. Brown and was adapted by us from the shown illustration.

KEYWORDS: follower, cam, oscillation, intermittent, cyclicity.

1. Introduction

The subject of the paper is the modelling and simulation of an oscillating cam-piston mechanism. The studied mechanism consists of a disc-shaped cam, a follower which traces the unique shaped groove in the disc bed, connected by a shaft and a ball bearing, a connecting rod which is set in motion by the follower and an oscillating wheel driven by this connecting rod. Modeling and simulation were performed in SolidWorks 2023, the computer-aided design (CAD) and computer-aided engineering (CAE) software for modeling solid parts, published by Dassault Systèmes.

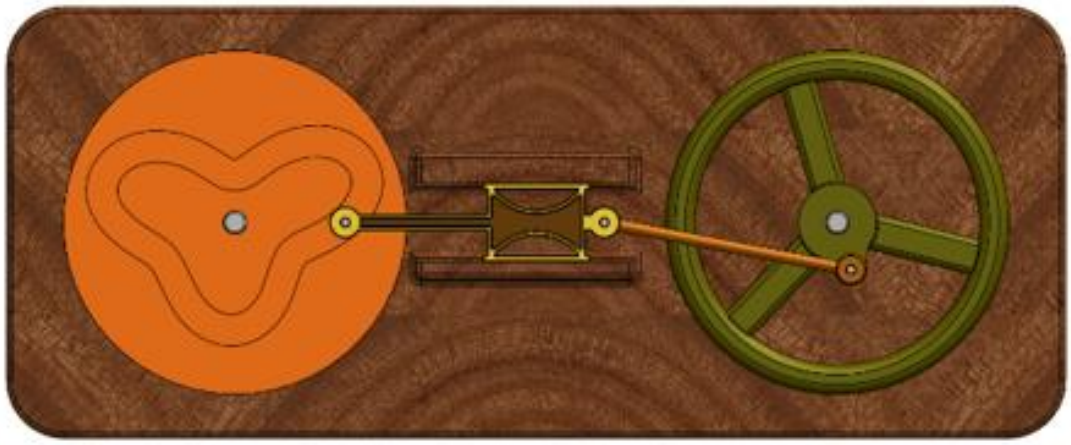

Fig. 1. Front view of the mechanism

2. Current stage

The main purpose of the chosen oscillating cam-piston mechanism is to use it as a subject of study and as a practical example. The mechanism offers students and researchers the opportunity to understand and apply physical principles and concepts of dynamics in a real-world context, which is why we decided to revive the illustration from the 1908 book [2] by 3D modelling and simulating it.

Through the oscillating cam-piston mechanism, students can gain a practical understanding of theoretical concepts such as oscillatory motion, force interaction and energy transfer in a mechanical system. It provides a concrete and tangible example, which facilitates learning and allows students to observe the effects of these principles in an interactive environment.

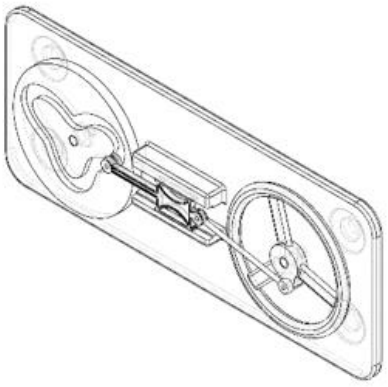

Fig. 2. Isometric view of the mechanism

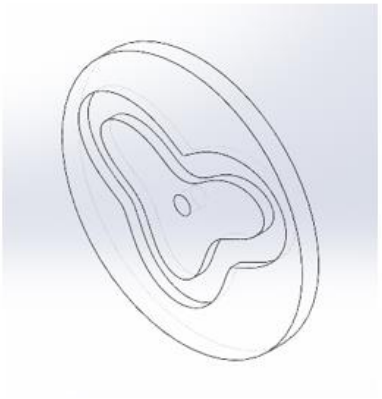

Fig. 3. Disc cam

Although a basic oscillating cam-piston mechanism can be an excellent platform to develop engineering applications, to impact research by investigating complex phenomena associated with oscillatory motion or to develop methods for control and optimization of oscillatory systems, the uniqueness of the modeled mechanism provides another perspective on the concept. The most important thing is that the student has to deal with as many examples as possible throughout their undergraduate studies, whether often encountered in the real world or not.

3. Mentions and remarks

At first glance, although a unique oscillating mechanism, once the simulation is examined, it can be associated with the mechanism present at the wheels of a steam locomotive.

The real use case for this type of mechanism in manufacturing, in the absence of CNC machines, is in the mechanical replication of parts, where the cam is the replicated profile.

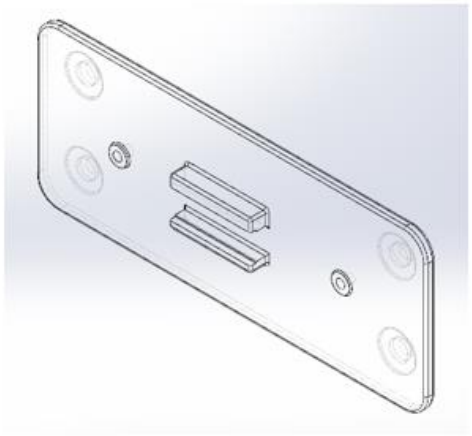

Fig. 4. Support plate

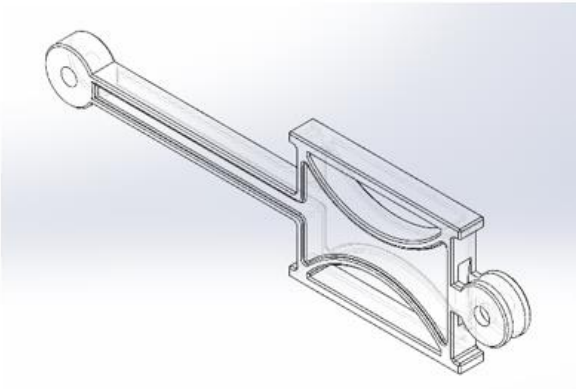

Fig. 5. Slider-Follower

4. Modeling of the oscillating cam-piston mechanism

In figures 4 to 12 is presented the modeling of the component parts of this mechanism in SolidWorks. The parts are put together and the simulation of its operation is made.

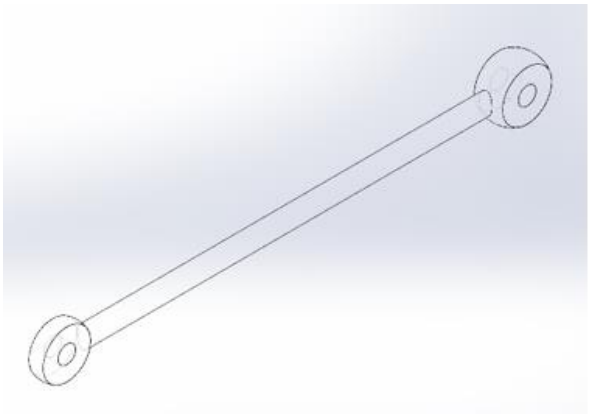

Fig. 6. Connecting Rod

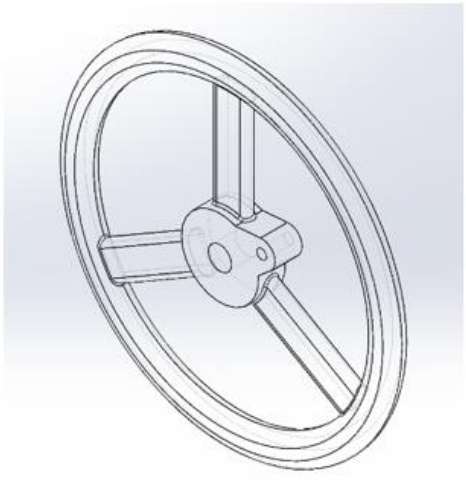

Fig. 7. Oscillating wheel

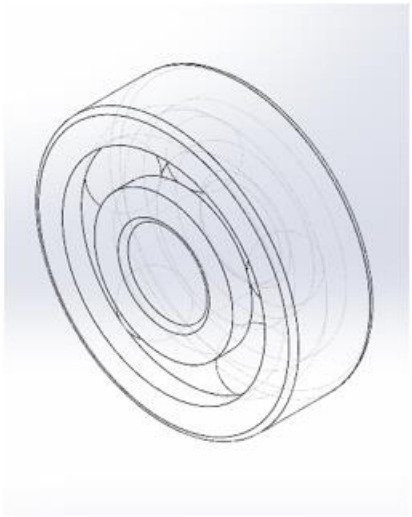

Fig. 8. Ball Bearing DIN 625 SKF

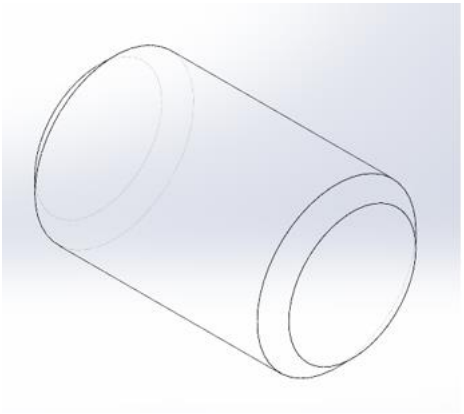

Fig. 9. Pin 5x8

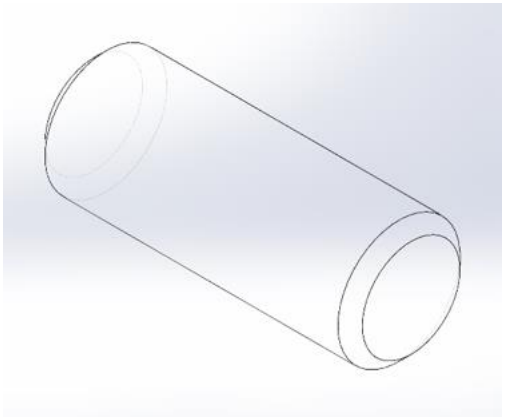

Fig. 10. Pin 5x13

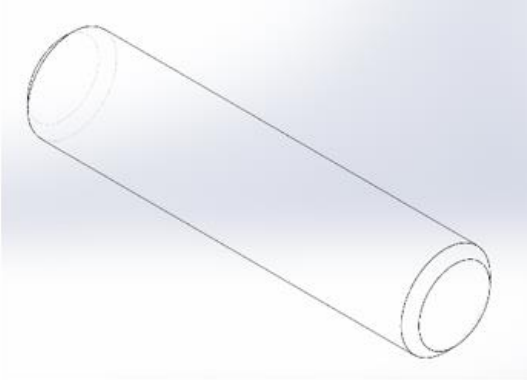

Fig. 11. Pin 5x22

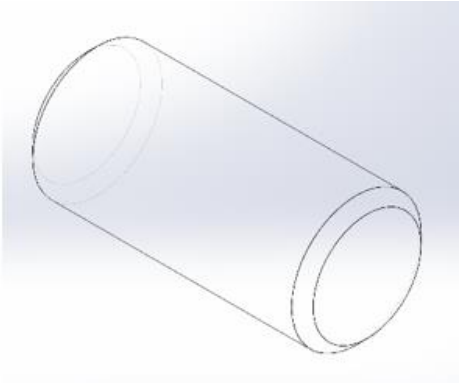

Fig. 12. Shaft 11x26

5. Materials

For a potential manufacture of the mechanism, with the exception of the basic plate for which the ideal material is wood, the rest of the parts will be made from 45 steel, even though in the CAD files we used "polished steel" for a better look.

6. Conclusions

Through the modelling and simulation process we can provide students with an example of an oscillating cam-piston mechanism in a modern manner to facilitate the learning process.

We discovered an online video [1] of an oscillating mechanism, studied it [2] and adapted and modelled it in a computer-aided design application. The mechanism consists of a cam with a unique shape, a follower that traces the "groove" in the cam bed, a connecting lever that is set in motion by the piston, and an oscillating wheel driven by mentioned connecting rod. The main objective is to model and simulate [3] this mechanism in order to use it as an subject of study. This was carried out in the computer-aided design application SolidWorks [4], published by Dassault Systèmes.

7. Reference

[1]. Stăncescu, A. (2022), https://www.youtube.com/watch?v=l2e7kPSAmg8
[2]. Brown, H.T. (1908), “Five Hundred and Seven Mechanical Movements”;
[3]. “The online edition of the classic technical reference Five Hundred and Seven Mechanical Movements by Henry T. Brown”, http://507movements.com
[4]. SolidWorks, https://en.wikipedia.org/wiki/SolidWorks

INTEGRATING A LASER FOR LASER ENGRAVING OPERATION AND FINITE ELEMENT ANALYSIS

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GIGOI Ștefan-Alexandru and MINODA Shogo-Victor
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ABSTRACT: This paper has the objective to present the integration of the FB03 laser in an engraving operation on an articulated six axis robot KR 6 R 700-2 in association with finite element analysis. For this type of process, the CAE model designed in Autodesk Fusion 360 helps us to understand better the impact of the laser on poplar plaques. Phenomenon data like heat flux, thermal gradient and the temperature are collected to improve the path, which the TCP is tracking, and to streamline the process of 3D engraving for future operations.

KEYWORDS: laser, engraving, finite element analysis, articulated robot.

1. Introduction

The engraving operation using laser is a process that vaporizes materials into fumes to engrave permanent, deep marks. This technology is typically used on a cartesian structure. The opportunity to exploit the freedom of movement of the six-axis robot allows us to expand its range of applicability. The laser used for this operation is FB03 [1], 4th class, with 10 mm minimum focal distance. For engraving in poplar wood, FB03 works without any unexpected difficulties.

Our six-axis robot used for this engraving application is a KR 6 R 700-2 [2], [3], [4]. It is the best option to improve from the first version of structure, with a high precision, about ±0.02mm, and 726 mm of workspace.

2. Overview

Initially, the laser used for this operation was installed on a cartesian structure, however this structure proved to be unsteady, and the level of vibrations was unsuitable for the purposes of engraving. Therefore, we changed the operation from the first structure to a six-axis robot, a KR 6 R700-2.

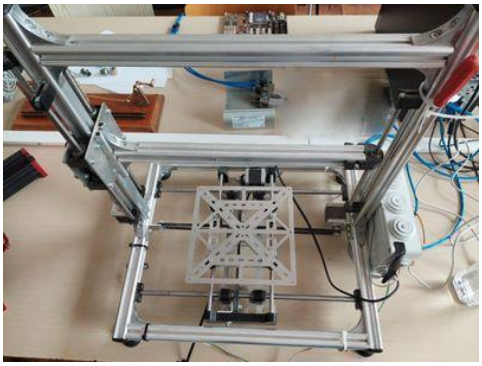

Fig. 1. Cartesian structure

Another problem we have encountered was the radiation emitted by the light which was over safe levels. To solve this issue, we used filters to prevent the light from leaking outside the workspace.

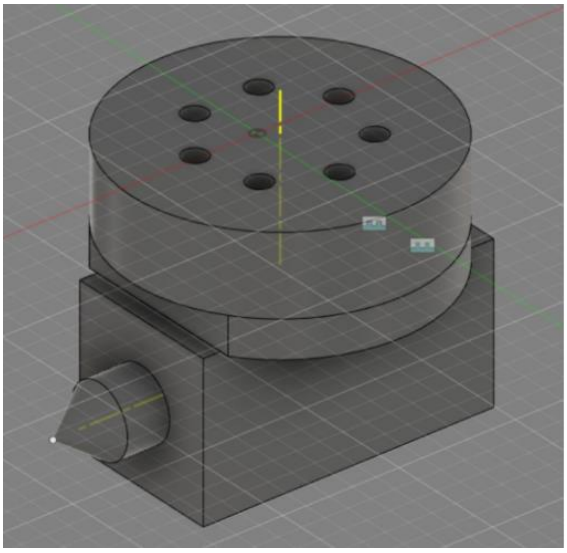

Fig. 2. Adapter flange and the laser with a model focal distance CAD

For the laser to be mounted on the robot, we designed in Autodesk Fusion 360 [5] an adaptor flange (fig. 2). Furthermore, we added the laser with a representation of the focal distance for a better TCP precision in simulations (fig. 3). With the imported CAD model (fig. 2) in KUKA sim 4.0 software, we modified the TCP to the focal point and simulated the path desired.

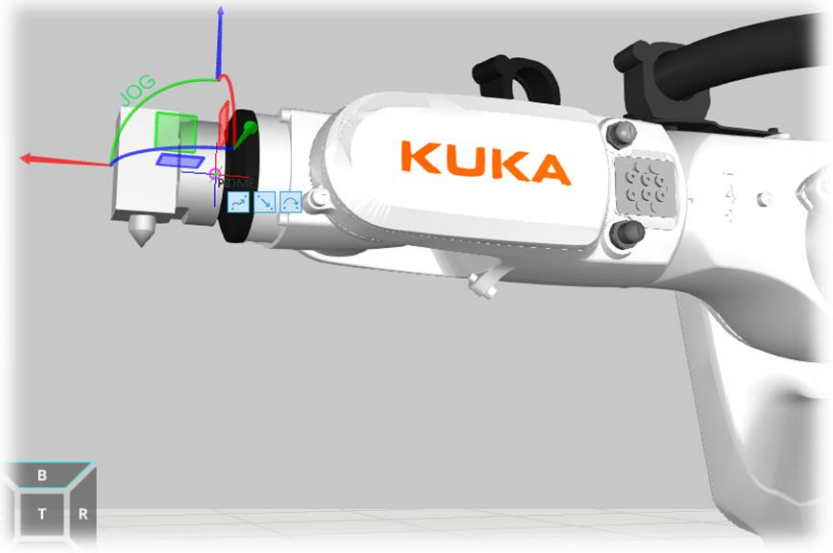

Fig. 3. Simulation of the articulated robot with the adapter flange

3. Finite element analysis

To better understand the process of engraving poplar wooden plaques and its effect, a finite element analysis [6] was required. For this, the software used was Autodesk Fusion 360 [7] which has CAE Module used for analysis. The studied phenomena for this application which interested us the most were the temperature (fig. 6), thermal gradient (fig. 5) and heat flux (fig. 4). These three would help us to better understand the reaction between the light amplified and the wooden plaque and thus signalling us if possible

damage could be done. The results show that the parameters are within the optimal range and the operation will run without any problems.

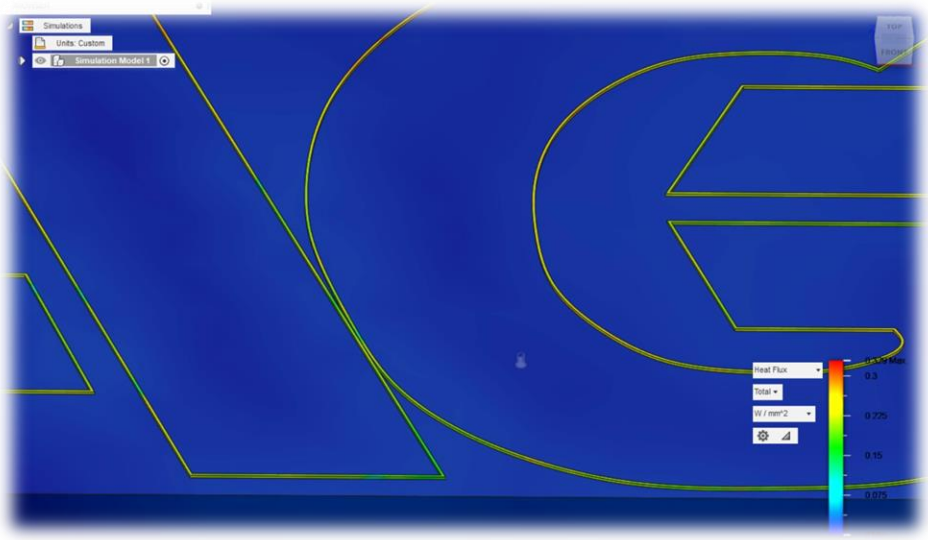

Fig. 4. Heat Flux

With a finite element analysis done, a possible optimization can be achieved by balancing heat distribution with the travel speed of the laser. The hottest parts of the trajectory must run faster to keep the same texture and to avoid hazards. In contrast, the coldest areas should run slower to avoid disruption of the contour and ruin the product.

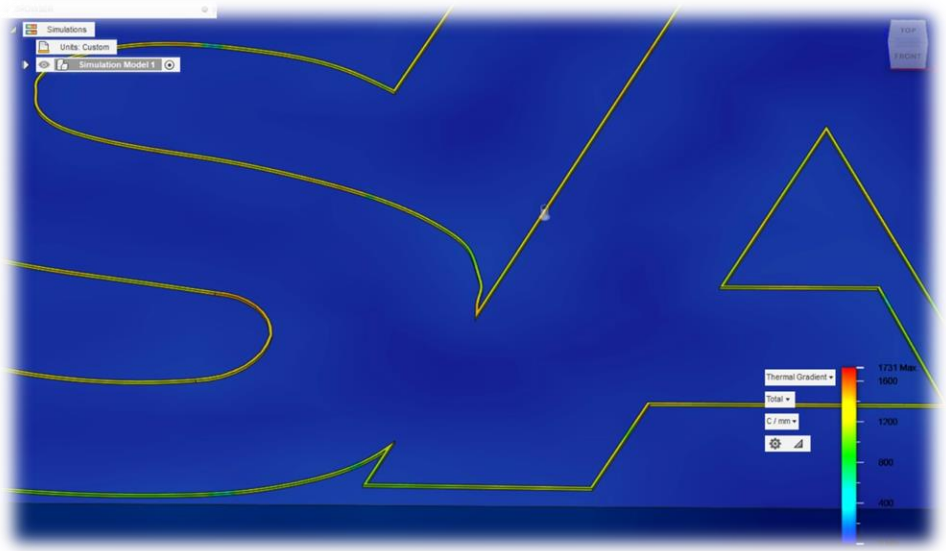

Fig. 5. Thermal Gradient

Different materials output higher or lower heat distribution, the height of the laser in relation to the surface of the etched surface affect the process, the shape of the contour can result in a deviation of the contact temperature, these are the factors that are considered while analysing, because we want the result to be done in the shortest amount of time without compromising the quality of the engraving.

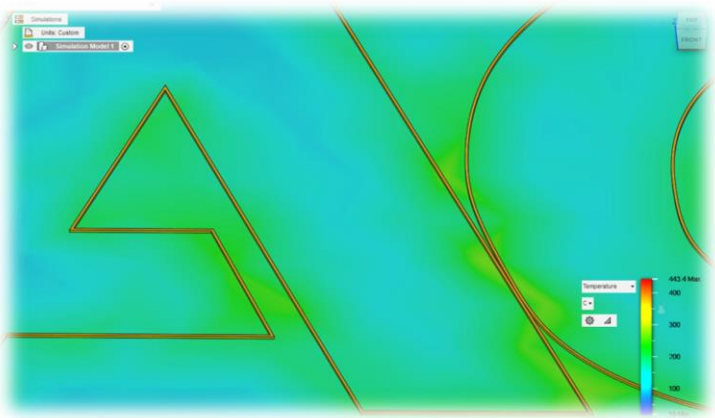

Fig. 6. Temperature

4. Conclusions and future work

Briefly, the operation of engraving with laser is by itself a very versatile application since it can be used on many materials from glass to coated metals or plastics. Adding the range of motion of an articulated robot arm, allows us to widen the possibilities of engraving on uneven surfaces, for example, a champagne glass or an engine block. We learned that the computer aided engineering assures us that the laser is used safely and efficiently, removing the need for trial-and-error tests that can take up time and resources. With this in mind, we could modify different parameters in such a way that the final product can be done multiple instances without lowering the quality or adding to the time needed.

For future endeavours, we will test the limits of this application with more irregular surfaces on different type of material and optimising the speed of which the laser is etching. Also, the size of the engraving will be tested to show the differences between smaller engravings like the serial number of an engine to larger engravings. Last but not the least, the laser will be used for other applications such as cutting, welding or even selective laser sintering.

5. Reference

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STUDY ON THE MECHATRONIC SYSTEM WITH SELF-BALANCE

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ABSTRACT: This paper aims to automate processes in MATLAB using a script that measures motor speed, issuing PWM commands to characterize the response of a 100:1 DC gearmotor, using code sections to partition scripts into smaller parts, using for loops to repeat blocks of code, using text tags and comments to organize and document matlab scripts, and creating and calling a MATLAB function.

KEYWORDS: mechatronics, matlab, component parts, equations, motorcycle.

1. Introduction

The project presents the modeling of a motorcycle that will have a two-wheeled robot that can balance and move using a rotating disc, which we will call the flywheel from now on, to compensate for the motorcycle's loss of balance. The motorcycle is controlled by an Arduino Nano 33 IoT module, an Arduino Nano Motor Carrier module, a DC motor to drive the rear wheel, a DC motor with encoder to control the flywheel, and a standard servo motor to steer the motorcycle's handlebars.

The objectives of this project are to: show how to program the motorcycle with Simulink, the control of the balance algorithm when moving in a straight line, and the improvement of the quality of the control algorithms through rapid prototyping.

2. The current stage

Building and programming a motorcycle model that balances and steers itself using a flywheel, using the knowledge gained in the courses, of physics, control algorithms and simulating the general behavior of a vehicle.

Before starting modeling and working on the project, the motorcycle must be assembled from the mechanical and electronic components. The estimated time for this operation is about 45 minutes.

For this project, the following simulation environments are used:

- *Matlab* combines a desktop environment set for analysis and iterative design processes with a programming language that directly expresses the mathematics of matrices and arrays. Includes the Live Editor for creating scripts that combine code, output, and formatted text into an executable notepad [7];
- *Simulink* is an environment for multi-domain simulation and model-based design. It supports system-level design, simulation, automatic code generation, and continuous testing and verification of embedded systems [7];
- *Simscape multibody* provides a multibody simulation environment for 3D mechanical systems such as robots. One can model multibody systems using blocks representing bodies, joints, constraints, force elements, and sensors [7];
- *Matlab support package for arduino hardware* is the package through which Matlab can communicate interactively with an Arduino board [7];
- *Simulink support package for arduino hardware* is the set of dedicated Simulink libraries to develop and simulate algorithms that run autonomously on Arduino [7].

3. Modeling the motorcycle and designing a controller for balancing

Modeling the motorcycle and designing a balancing controller aims to: model a dynamic system using knowledge of the underlying physical principles, design a feedback controller and use Simulink for rapid prototyping and controller design.

The motorcycle balancing problem can be thought of as an inverted pendulum control problem. Indeed, looking at a standing motorcycle from behind, it can look like a pendulum rod with a flywheel attached to it.

In Figure 1, the following notable points are found: A is the axis of rotation of the rotational couple between the pendulum rod and the ground. In this context of rotation, the A-axis means the axis passing through A and perpendicular to the plane of the paper. lAD is the length of the pendulum rod, i.e. the size of the motorcycle frame; B is the center of mass of the pendulum rod. We assume that the pendulum rod has a uniform density, which means that point B will be midway between A and D; C is the axis of rotation of the rotational couple between the pendulum rod and the flywheel. The flywheel is driven by a DC motor [1].

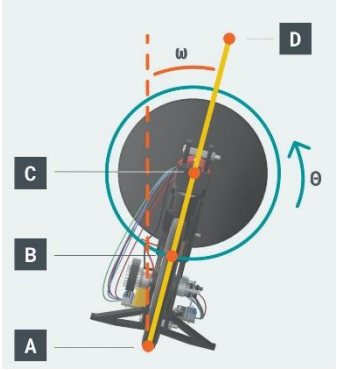

Fig. 1. The inverted pendulum

The considered system has two degrees of freedom and, therefore, the state of the system can be described by two coordinates: the angle of inclination of the pendulum rod θ, which is the angle between the rod and the vertical, so equal to 0° when the pendulum is perfectly vertical, positive when the pendulum swings clockwise and negative when the pendulum swings counterclockwise, the angular displacement of the flywheel. Since the flywheel is axially symmetric, we are not interested in the actual angular displacement but in the rotational speed (ω) and acceleration ($\dot{\omega}$) [1].

$$\text{Newton: } F = m \times a \Rightarrow \tau = I \times \ddot{\theta} \tag{1}$$

$$I = m \times r^2 \tag{2}$$

$$\text{Huygens-Steiner: } l_z = l_{cm} \times a^2$$

$$\tau = \tau_{gr} + \tau_{gw} + \tau_m$$

$$\tau_{gw} = m_w \times g \times l_{AC} \times \sin\theta$$

$$\tau_{gr} = m_r \times g \times l_{AB} \times \sin\theta$$

$$\tau_m = I_w^C \times (\dot{\omega} + \ddot{\theta}) \tag{3}$$

In addition to the torques created by gravity, the torque created by the flywheel motor must be considered. The torque applied to the flywheel and the torque applied to the pendulum rod have the same absolute value but are applied in different directions. We will define this torque as τm and assume that we have control over τ_m [2].

Now the equations for the moments of inertia of the key components are written.

The moment of inertia of the flywheel about point C. The above formula calculates the moment of inertia of a disk rotating about its center of mass [2]:

$$l_w^C = 0{,}5 \times m_w \times R^2 \tag{4}$$

The flywheel rotates about point C being driven by the DC motor, but the same flywheel also rotates about point A along with the pendulum rod. For this reason, the moment of inertia of the flywheel about point A must also be calculated, $I_W{}^A$. The previously described parallel axis theorem (Huygens-Steiner theorem) applies to the motorcycle [2]:

$$I_w^A = I_w^C + m_w \times l_{AC}^2 = 0{,}5 \times m_w \times R^2 + m_w \times l_{AC}^2 = m_w(0{,}5 \times R^2 + l_{AC}^2) \tag{5}$$

Continue by calculating the moment of inertia of the pendulum rod about its center of mass B: [2]

$$I_r^B = \frac{1}{12} \times m_r \times (3 \times r^2 + l_{AD}^2) \tag{6}$$

However, the pendulum rod rotates about point A, not its center of mass B; so the parallel axis theorem applies again [2]:

$$I_r^A = I_r^B + m_r \times l_{AB}^2 = \frac{1}{12} \times m_r \times (3 \times r^2 + l_{AD}^2) + m_r \times l_{AB}^2 \tag{7}$$

The equations of motion are written [2]:

$$\tau = I \times \ddot{\theta} \tag{8}$$

Knowing that the values of torques and moments of inertia are additive:

$$\tau_{gr} + \tau_{gw} + \tau_m = (I_w^A + I_r^A) \times \ddot{\theta} \tag{9}$$

Each term develops:

$$m_r \times \mathrm{g} \times l_{AB} \times \sin(\theta) + m_w \times \mathrm{g} \times l_{AC} \times \sin(\theta) - \tau_m =$$
$$m_w(0{,}5 \times R^2 + l_{AC}^2) + \frac{1}{12} \times m_r \times (3 \times r^2 + l_{AD}^2) + m_r \times l_{AB}^2) \times \ddot{\theta} \tag{10}$$

The rotation of the flywheel is described by the following equations of motion:

$$\tau_m = I_w^C \times (\dot{\omega} + \ddot{\theta}) \tag{11}$$

$$\tau_m = 0{,}5 \times m_w \times R^2 \times (\dot{\omega} + \ddot{\theta}) \tag{12}$$

The next step is to bring the above equations of motion into state-space format. A state vector is first defined [2]:

$$x(t) = \begin{pmatrix} \theta \\ \dot{\theta} \\ \omega \end{pmatrix} \tag{13}$$

The derivative of the state vector with respect to time has the expression:

$$\dot{x}(t) = \begin{pmatrix} \dot{\theta} \\ \ddot{\theta} \\ \dot{\omega} \end{pmatrix} = \begin{pmatrix} \dot{\theta} \\ \dfrac{g \times \sin(\theta) \times (m_r \times l_{AB} + m_w \times l_{AC}) - \tau_m}{m_w \times (0{,}5 \times R^2 + l_{AC}^2) + \frac{1}{12} \times m_r \times (3 \times r^2 + l_{AD}^2) + m_r \times l_{AB}^2} \\ {\tau_m}/{I_w^C} - \ddot{\theta} \end{pmatrix} \tag{14}$$

The next step is to implement the above equation in software, to allow the simulation of the behavior of this dynamic system and the design of a feedback controller.

These data are entered into *Matlab*, then the *Simulink* work environment is used which uses numerical approximation methods to evaluate them with finite precision. *Simulink* can use several different numerical integration methods to calculate the output of the block, each with advantages in certain applications. Using the Solver pane in the Configuration Parameters dialog box (Solver Pane) one can select the most suitable technique for a particular application.

Other block diagram elements: Multiplexing and demultiplexing blocks for efficient vector manipulation. In this case, the state vector consists of three elements, see the equation above; Purpose block for viewing signals; Constant signal sources, which represent motor torque; The labels associated with the signals represent the names given to them by the user.

Note that variables from the Matlab workspace are used to define the parameters of the Simulink model. The resulting model is presented in figure 2.

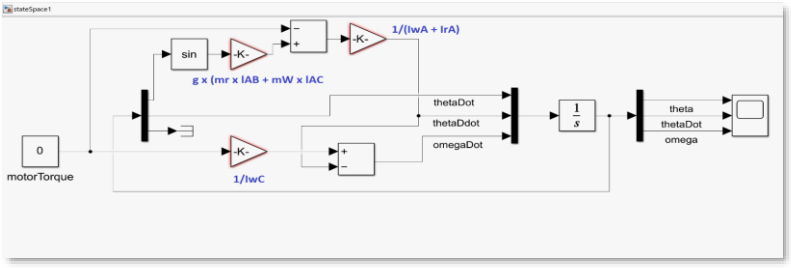

Fig. 2. Model in Simulink simulation environment

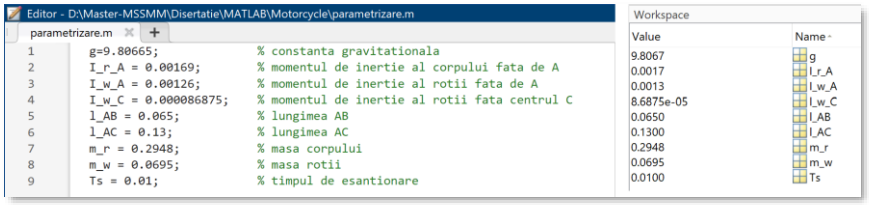

Fig. 3. Parameterization of the model

We review the key hardware components of the motorcycle, sensors and actuators, and we will create Simulink models that can interface with the sensors and actuators in order to control the motorcycle.

A sensor is a device that detects changes in the environment. Information about the environment that comes from the sensors is used to change this environment in the way that is desired. The implementation of these changes is done by means of another class of devices, known as actuators [5].

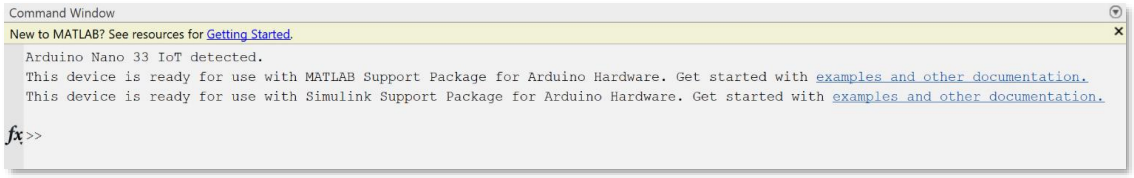

Fig. 4. Connect compatible drivers

My motorcycle has sensors and actuators. *Sensors:* accelerometer/gyroscope/magnetometer for measuring the angle of inclination of the motorcycle; rotary encoder, mounted on the flywheel motor, to measure the speed of the flywheel; rotary encoder, mounted on the rear wheel motor, for measuring the speed of the rear wheel; battery voltage sensor, which is not used for balancing, but could shut down the controller before it runs out of power.

Actuators: flywheel motor to drive the flywheel; rear wheel motor, to drive the rear wheel; servomotor for steering control [5].

Due to the inclusion of Arduino software libraries in the latest editions of Matlab, the program recognizes a wide range of Arduino boards, including shields, and connects to them via compatible drivers [6].

In Simulink we create a template that will be used to work with the ArduinoNano33IoT and test the connection:

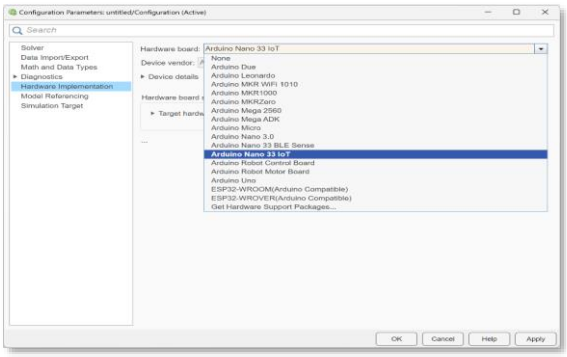

Fig. 5. ArduinoNano33IoT template

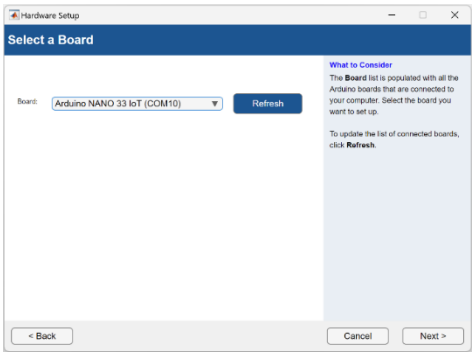

Fig. 6. Testing the connection – step 1

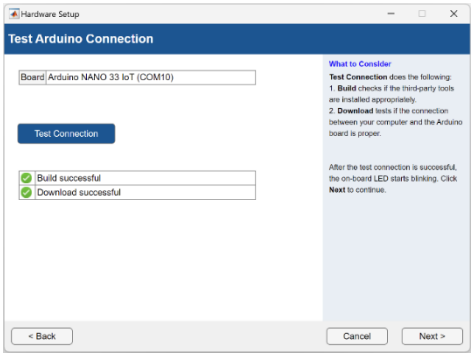

Fig. 7. Test the connection – step 2

This template will later be populated with project components.

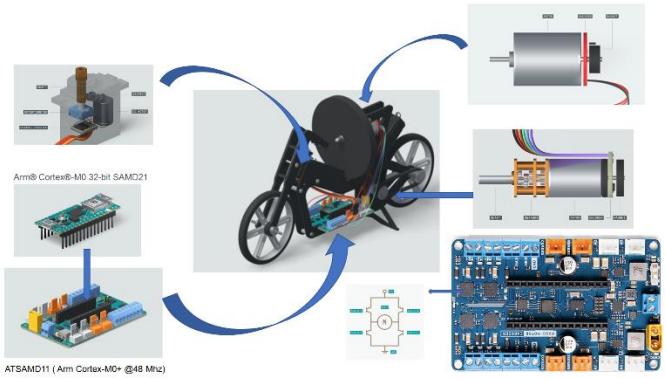

Fig. 8. The component parts of the motorcycle

In closed-loop control (stationary balance) the designed controller is combined to implement a complete balance control application that will run on the Arduino Nano 33 IoT board.

This allows to test the algorithm on the motorcycle and to adjust it, taking into account the imprecision of the model and the specific characteristics of the hardware. By the end of this exercise, you will have a motorcycle that balances on the spot.

It is followed as follows: the interfacing of hardware sensors and motors with the balance control algorithm; the implementation of safety features to ensure the operation of the motorcycle with minimal

stress on the hardware components; monitoring the physical response of the motorcycle to the control algorithm; adjusting the PD algorithm and gains so that the bike balances on the spot.

To create a high-level architecture, the model will be structured using subsystems from the beginning. It starts from a template model that was created previously: Arduino33IotNanoTemplate.slx. Open the model and add two Subsystem blocks, which will represent the motorcycle and a digital controller, respectively. Subsystem inputs and outputs are renamed to Import and Outport blocks inside each subsystem [6].

Fig. 9. Charts of both subsystems

To add hardware components (sensors and actuators) go into the motorcycle subsystem, add relevant components and test all these components separately.

To build the safety logic, following the related steps (sensor description, comparisons, reprocessing of sensor measurements, etc.), we have all the elements of the state vector: the angle of the motorcycle, the first derivative of the angle (i.e. speed) and the speed of the flywheel.

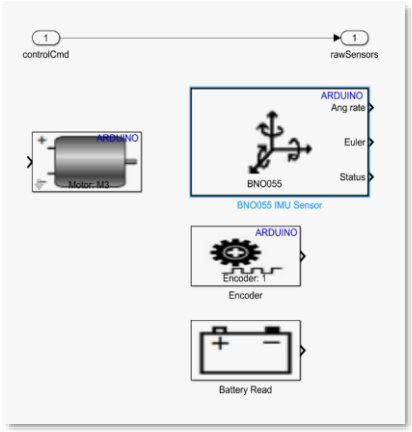

Fig. 10. Motorcycle subsystem - components needed to balance the motorcycle

In the ideal world, we'd simply reuse the controller we've already designed to balance the bike in the simulation. However, in real life, there are several considerations to take into account: IMU (Inertial Measurement Unit) calibration; battery level, loss of balance, activation of user control.

Logic control can be implemented with a dedicated Simulink > Stateflow library and adding a Chart block from the Stateflow library in the Library Browser.

The control logic implementation for handling loss of balance starts with the fact that if the motorcycle loses balance (if the lean angle is greater than a certain threshold), the controller must be disabled. One can formalize this requirement in relation to the Stateflow diagram as follows: the diagram accepts a single input, the tilt angle; chart returns a single output equal to 1 (true) when the tilt angle is within certain limits and equal to 0 (false) when the tilt angle is outside the given limits.

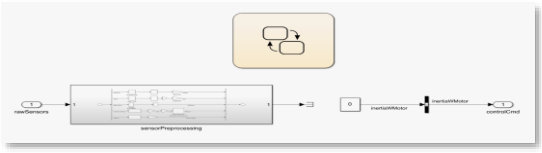

Fig. 11. Simulink dedicated library

Control logic can be implemented in various ways. We will consider the key components of the model below. The first thing you might notice are the user interface components, namely a Switch and a Lamp, both available in Simulink > Dashboard. The switch allows the user to manually disable the control when not needed. The lamp has no effect on the behavior of the model but visualizes the output of the Stateflow diagram. I also added input signals to the Stateflow diagram.

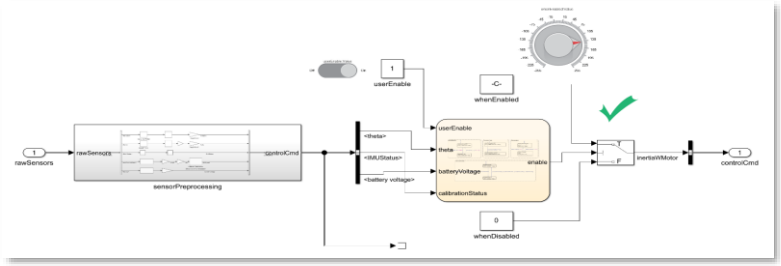

Fig. 12. Stateflow Simulink diagram

The chart itself has four parallel states, which can be identified by dashed frames:

- ✓ checkBalanced: is characterized by two states: balanced_notOK (default) and balanced_OK. The transition between the two states is made according to the theta angle: if the absolute value of the angle is less than 15°, the transition is made to the balanced_OK state. If the angle is outside this range of values, the transition is made to the balanced_notOK state.

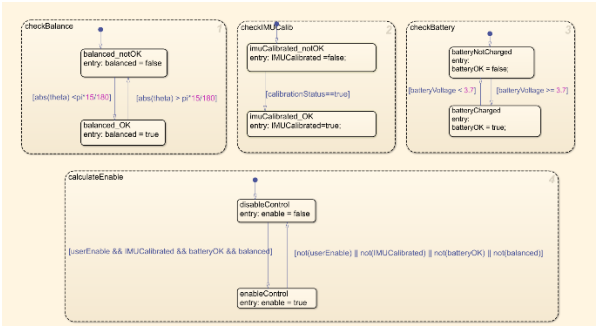

Fig. 13 Diagram with broken frames

- ✓ checkIMUCalib: The two states are: imuNotCalibrated (default) and imuCalibrated. transition to the imuCalibrated state is made when the calibrationStatus signal becomes true or 1.
- ✓ checkBaterry: Statuses indicate whether the battery is usable or discharged. The transition is made in both directions depending on the battery voltage. The switching threshold is 3.7 volts.
- ✓ calculateEnable: The activation of the control depends on the simultaneous fulfillment of the previous conditions. That is why the AND logical operator is used: userEnable && batteryOK && IMUCalibrated && balanced.

For the control to transition to the disabled state, at least one of the conditions must not be met and the logical OR operator is used: Not(userEnable) || not(batteryOK) || not (IMUCalibrated) || not (balanced).

When calculateEnable is true, the signal to the flywheel motor is enabled. The control lamp sign turns green, indicating that all the conditions in the diagram are met.

Although the parallel states run concurrently, it must be determined when to activate each during the simulation.

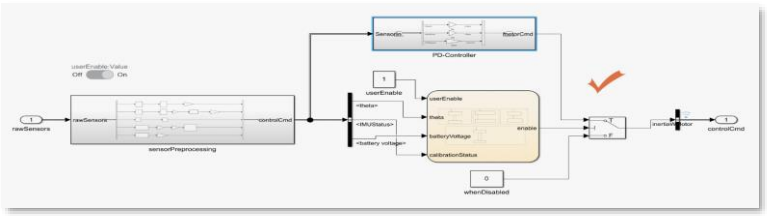

Fig. 14. PDP controller subsystem

The last step in the design workflow is to implement a feedback controller, which will calculate the control action based on the sensor measurements. The feedback control law I designed for my Simscape model consists of three components: feedback from the angle of inclination of the pendulum (motorcycle); feedback from the derivative of the pendulum tilt angle (angular velocity); feedback from the flywheel speed. Finally, the PDP controller subsystem looks like in figure 14.

Since the research work is very complex, the stages completed can only be presented in detail in the form of the final results.

4. Conclusions

In this paper, I wanted to present some of my research on self-balancing in motorcycles by which the mechatronic system balances itself, and the connection to Simulink (multi-domain simulation environment and model-based design) can be changed in real time, the parameters of SET.

"Study on the mechatronic system with self-balance" is a small part of a complex research study done by me, and this paper represents a first part of the analysis and implementation of a feedback controller and other components related to center of gravity balancing of a motorcycle and its demonstration through simulation programs such as *Matlab*, *Simulink*, *Simscape Multibody*, *Simulink Support Package for Arduino Hardware*, etc.

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[8]. *** Bosch Sensortec GmbH, fișă post, 2023.

RECONDITIONING OF HISTORIC VEHICLES

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ABSTRACT: The restoration of classical cars consists of bringing the car to its original technical and aesthetical state, as it was designed by the manufacturer.
The first part of the paper presents a particular case, the Trabant 6001 car, which was entirely restored by me as part of an ongoing project, and a Dacia 1300 which is scheduled to be reconditioned.
The second part of the paper presents the engine ensemble and the operating principles of the two cars mentioned above.

KEYWORDS: historic vehicles, engine, transmission, brakes, suspension.

1. Introduction

The reconditioning of a Trabant 601 and that of a Dacia 1300 have many similarities in terms of the process itself. First of all, both vehicless were manufactured in the same period and similar technologies were used in building them. The first step in the reconditioning process of both the Dacia 1300 and the Trabant 601 is assessing the condition of the vehicle and identifying the parts that need to be replaced or repaired. It is important to check the engine, transmission, brakes and suspensions, as these are crucial elements for the safety of the vehicle.

2. Current stage

The entire reconditioning process began in 2019 and it started with a video clip I saw on youtube. I liked the car so I started searcing for one that I could restore. Once I purchased the car (figure 1), I began working on it, putting in a lot of passion.

Fig. 1. Trabant 601

The most difficult aspect of the restoration process was to find original parts. Other than that, the mechanical and electrical repairs, the work on the mechanical and electrical issues, as well as the transmission were all done by me [1].

3. Reconditioning of Trabant 601

Trabant 601 is a very attractive car, with a distinguished design that makes it easily recognized. Additionaly, for many people this car model evokes an important period of the history of the Democratic Republic of Germany and is has a significant cultural value.

Fig. 2. Trabant 601 before reconditioning

Fig. 3. Faulty engine

After approximately one year and a half of working on it, the car came to look exactly as I wanted (fig. 4).

The Trabant 601 has an Otto engine operating as a two-stroke cycle, which means that the whole sequence of events, intake, compression, power and exhaust are completed in two strokes of the piston. The engine has two cylinders, the cylinder bore is 72 mm, the piston path is 73 mm, the stroke capacity of 594,5 $\boldsymbol{cm^3}$, compression of 7,6 and the maximum engine output of 19,1 KW (26HP) at 4200 rot/min [2].

During the intake cycle, the mixture of fuel and air is introduced into the chamber through the admission port, while the piston moves from the upper dead center to the lower dead center. In the Trabant 601 engine, the admission is enabled by means of a system of rotating slide dampers placed on the clutch, which controls the flow of fuel and air.

Fig. 4. Trabant 601 after reconditioning

In the compression and blow-out cycle, the piston moves again from the lower dead center to the upper dead center, thus compressing the mixture of fuel and air into a small compression chamber. During this process the spark generated by the ignition system ignites the mixture causing a blow-out that pushes the piston downwards. During the blow-out cycle, the mixture of burnt fuel and air burns and an exhaust gas is released. This exhaust gas is eliminated through an evacuation system which directs the exhaust gas through a rotating valve chamber and an exhaust system.

In the evacuation cycle, the exhaust gas is eliminated from the chamber through the exhaust port while the piston travels from the upper dead center to the lower dead center. In the case of the Trabant 601 engine, the evacuation is enabled by means of a rotating valve system which controls the flow of the exhaust gas. Following the evacuation cycle, the admission cycle is resumed, bringing the mixture of fuel and air into the chamber for a new compression and blow-out cycle.

Fig. 5. The interior of the car

Fig. 6. The engine

Generally, the two-stroke engine is well-known for its force and power, but also for its highly polluting emissions. It was replaced by the four-stroke engine which is more efficient in terms of fuel consumption and which has lower levels of polluting emissions. The Dacia 1300 is equipped with a four-stroke engine which is superior in terms of technical performance.

4. Reconditioning of Dacia 1300

Born and raised with a Dacia on my threshold, like any Romanian, I chose to restore a Dacia 1300 manufactured in 1974. I began the restoration process on April 25th, 2023 and hope to finish it this summer.

Fig. 7. Dacia 1300

The car was developed on the basis of a Renault 12 model and was manufactured under license by Dacia. It was a very popular car in Romania as well as in other East European countries, being known for its reliability and accessible price.

The Dacia 1300 engine is an internal combustion engine, with four in-line cylinders and an engine displacement of 1.3 liters. The operating principle of this engine is a classical one, based on the Otto cycle. The cylinder bore is 73 mm, the piston path of 77 mm, stroke capacity of 1289 $\boldsymbol{cm^3}$ and maximum engine output of 54 HP at 5250 rot/min [3].

In the *admission phase*, during the piston's first travel, the admission intake valve opens, allowing the mixture of air and fuel to enter the cylinder. This mixture is done in a carburettor which adjusts the quantity of fuel as needed. In the *compression phase* the piston moves back, compressing the mixture of air and fuel in the cylinder, while the intake valve shuts. In the *blow-up* phase, when compression reaches maximum point, a spark from the plug ignites the mixture of air and fuel, generating a controlled blow-out which pushes the piston upwards. During the *evacuation phase*, the piston moves backwards and pushes the combusted gases towards the evacuation gallery. This cycle repeats continously, generating the necessary output to make the car move.

Fig. 8. Purchase Dacia 1300

The Dacia 1300 engine is an internal combustion engine with spark ignition and therefore can produce a maximum output of 54 HP and a maximum torque of aproximately 93 Nm at a rotational speed of 3000 rotations per minute.

5. Conclusions

The most difficult process in restoring the Trabant was finding the spare parts and among these the hardest to find were the parts for the engine and for the brake system. However I eventually managed to find all the parts which were new and came from old stocks. Currently I have a stock of parts that will allow me to restore one more Trabant. What I like is go out in the car on the road and people greet me in traffice and wave at me or take photos - I feel my work is rewarded.

I intend to complete the Dacia 1300 this year and in 2024 to take part in the Sinaia elegance contest with both cars.

6. Reference

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[2]. VEB FACHBUCHVERLAG LEIPZIG RedaktionsschluB 15.11.1905 Satz und Druck: Engelhard-Reyhersehe Buchdruckerel KG, Gotha RH trabant 601, rumanisch KG 3/3/66;
[3]. Dacia 1300 technical maintenance and operation handbook UAP 1970.

NUMERICAL AND EXPERIMENTAL STUDY OF AN AL-PLA SANDWICH BEAM LOADED IN BENDING

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SUMMARY: The aim of this paper was to highlight the difference between the results obtained experimentally and those numerically obtained with FEM for sandwich beams loaded in bending. There are three types of core oriented to different angles: 30^o, 45^o, 60^o. *The beams were supported at their ends, a force being applied in the middle spam. Sandwich beams are strength components for larger structures, so it is very important to know their behavior when subjected to various loadings, in this paper being study their behavior in bending.*

KEY WORDS: Sandwich beams, experimental results, three-point bending, FEM.

1. Introduction

For this study, we chose to compare the specific deformations and force reactions for three models of bearings, which have a variation of the α angle of 30^o, 45^o, and 60^o, respectively. The angle to be modified can be seen in Fig. 1.

These cores will be noted:

- ✓ F1- Honeycombs with an inclination of the angle of 30^o
- ✓ F2- Honeycombs with an inclination of the angle of45^o
- ✓ F2- Honeycombs with an inclination of the angle of 60^o

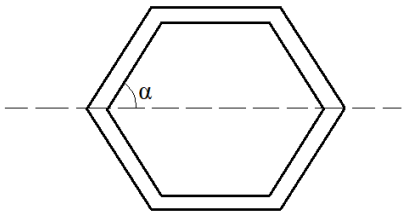

Fig. 1. Evidentierea unghiului α

2. The experimental part

3D printing is a process of forming a solid three-dimensional object of any shape. 3D printing is also distinct from traditional processing techniques, which are mainly based on the removal of materials by methods such as cutting.

The Fig.2 depicts the Vertex 3D printer that was used to print the PLA core.

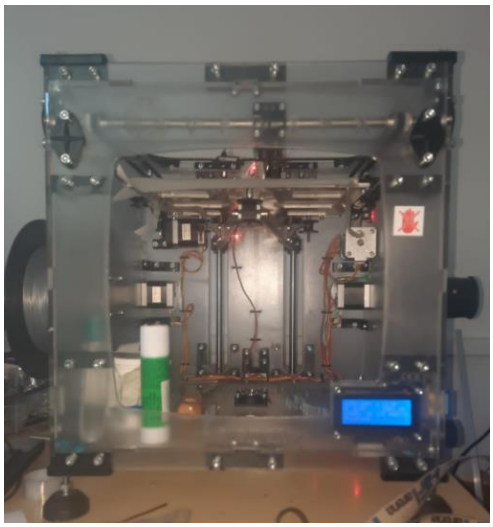

Fig. 2. Vertex 3D printer

CURA is an open-source application for 3D printers. It was created by David Braam, who was later hired by ULTIMAKER, a 3D printer company, to maintain the software. The CURA was originally released under version three of the Affero General Public License with open source, but on September 28, 2017 the license was changed to LGPLv3. This change has allowed for better integration with third-party CAD applications.

In Fig. 3 is the 3D printer that was used is marked with index one. The second index marks the two print heads of the printer. It can be seen that one head is inactive and the second one is assigned the material, PLA.

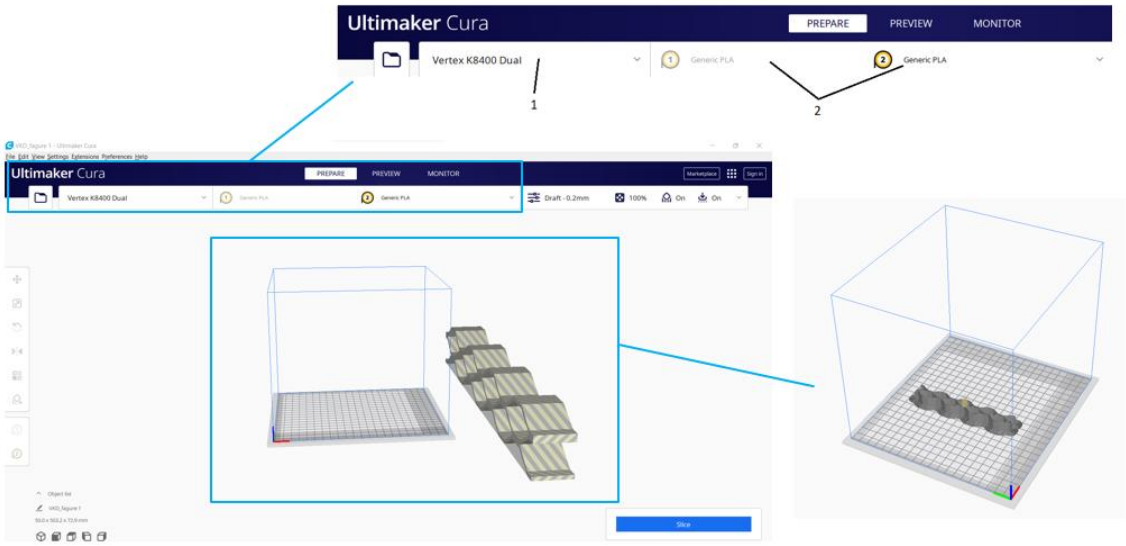

Fig. 3. Soft interface ULTIMAKER CURA

A virtual version of the 3D printer is generated on the right side of the new figure, so that the operator can estimate the maximum dimensions that he can use for a structure.

Once the structure has been dimensioned and positioned inside the virtual printer, a preview can be given to make sure everything is compliant.

This printer can use one or two printheads. If two printheads are used, the structure can have two colors. In our case it has been used a single printhead.

Fig. 5 shows the print head on the right side, the red LED indicating that the printing of the structure is in progress and on the left side you can see the roll of PLA filament that has been used.

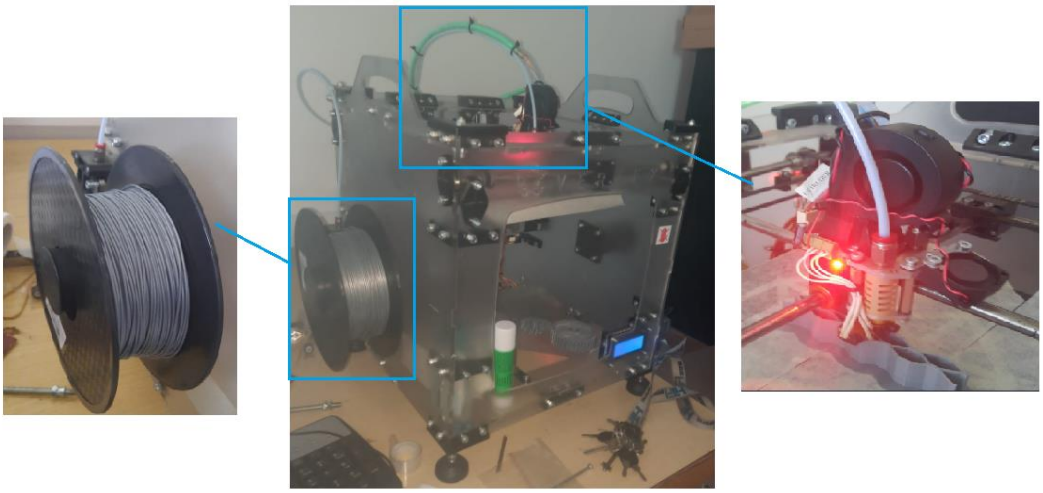

Fig. 5. 3D printer and they component

Polylactic acid (PLA) is a thermoplastic aliphatic polyester produced from renewable resources, such as corn starch (in the United States) or sugar cane in the rest of the world. It is biodegradable under certain conditions, such as the presence of oxygen, and is difficult to recycle.

The 3D printing filament is the thermoplastic raw material for 3D melt molding printers. There are many types of filaments with different properties that require different printing temperatures. The filament is commonly available in the two standard diameters of 1.75 mm and 2.85 mm.

PLA polymers range from amorphous glassy to semi-crystalline and highly crystalline polymer, with a glass transition of 60–65 ° C, a melting point of 130–180 ° C, and a Young modulus of 2.7–16 GPa. PLA is heat resistant, up to 110 ° C.

After the tiles were cut to the desired size, they were sanded at a 45° angle for better adhesion of the adhesive. They were degreased with industrial acetone and avoided touching them so as not to leave a layer of grease on them, as the adhesion of the adhesive would have been negatively affected

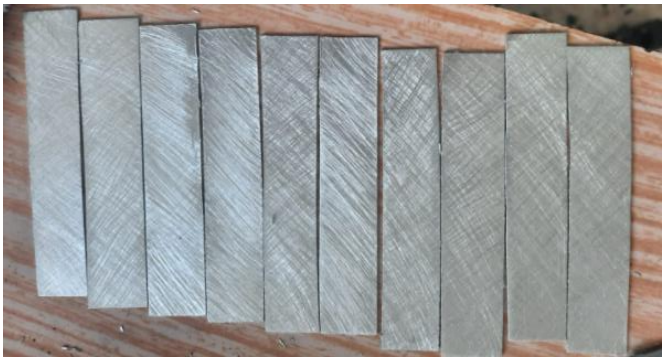

Fig. 6 Aluminum plates

Fig. 7 shows the adhesive that was used, which is a metal adhesive. It can be seen that it consists of two tubes, inside one of them being the base, and inside the second one being the hardener. I tried to put an equal amount of both in the plastic holder and mix them until a homogeneous substance was formed.

Fig. 7 Adhesive

The sandwich beam was subjected to a -point bending test as can be seen in Fig. 8. In order not to stress only the aluminum plates, the structure was supported in the area where the aluminum comes in contact with the PLA, and the displacement of was placed in the middle of the beam following the same principle. The required displacement was considered to be 1 mm/ min.

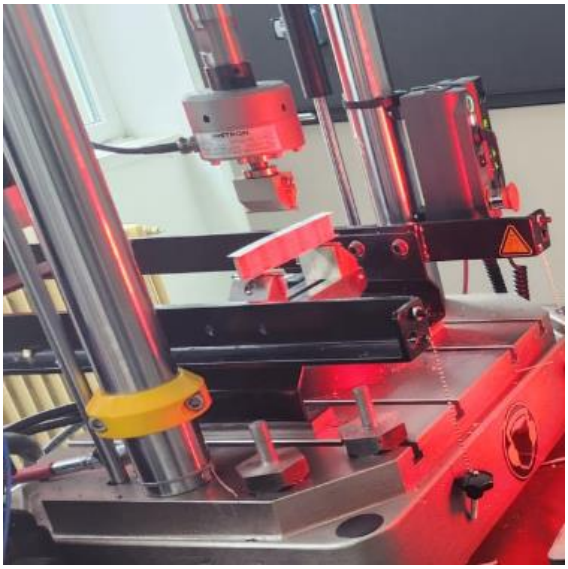

Fig. 8. Equipment used to perform three-points bending

2. Analysis of a sandwich beam in Ansys Workbench

In order to perform the analysis, the material characteristics for each surface must be defined. In figure 9 it can be seen that three different materials have been defined. The standard aluminum, the adhesive, and the PLA for which Young's modulus, Poisson's ratio, and density were selected.

Outline of Schematic B2: Engineering Data

	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
2	Material				
3	Adeziv			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
4	Aluminum Alloy			Ger	General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.
5	PLA			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material				

Fig. 9. Defined materials

Table 1. Material characteristics of the sandwich beam

No.	Material	Density [kg/m^3]	Young modulus [MPa]	Poisson's ratio
1.	Aluminum	2770	71000	0.33
2.	Adhesive	1380	3050	0,34
3.	PLA	1400	3200	0,35

Once the materials were defined, the geometry was modeled. It was performed in CATIA V5 and later imported into Ansys.

Three planes have been created in Space Claim to apply the supports and movements. These planes are highlighted with indices one, two and three.

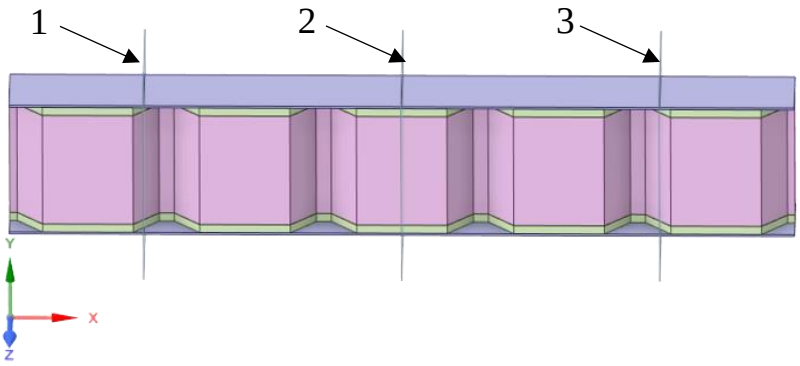

Fig. 10. Geometry and highlighting of the three planes

A controlled discretization was used so that the elements were predominantly quadrilateral and had a size of 1 mm. Due to the appearance of a single element on the thickness of the structure it has been necessary to use the function "Element Order" → "Quadratic". The use of a single element on the thickness of a structure should be avoided as this may influence the results. In Fig. 11 it has been represented the structural mesh.

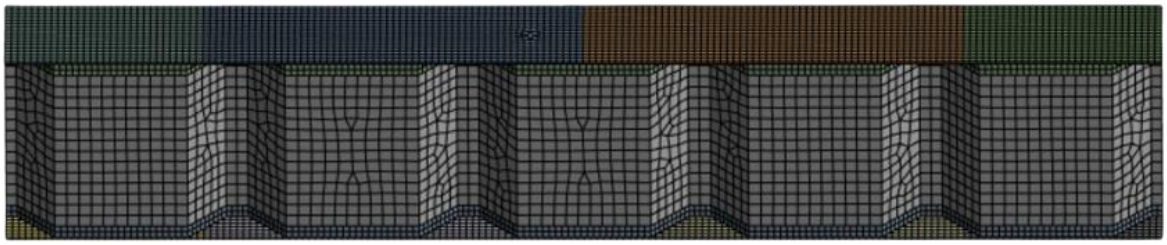

Fig. 11. Structure mesh

The boundary conditions were applied as it can be seen in Fig.12. A 1.88 mm "Displacement" was applied at the top, and a "Displacement" was also applied at the bottom so it will allow the structure to move only along the z axis.

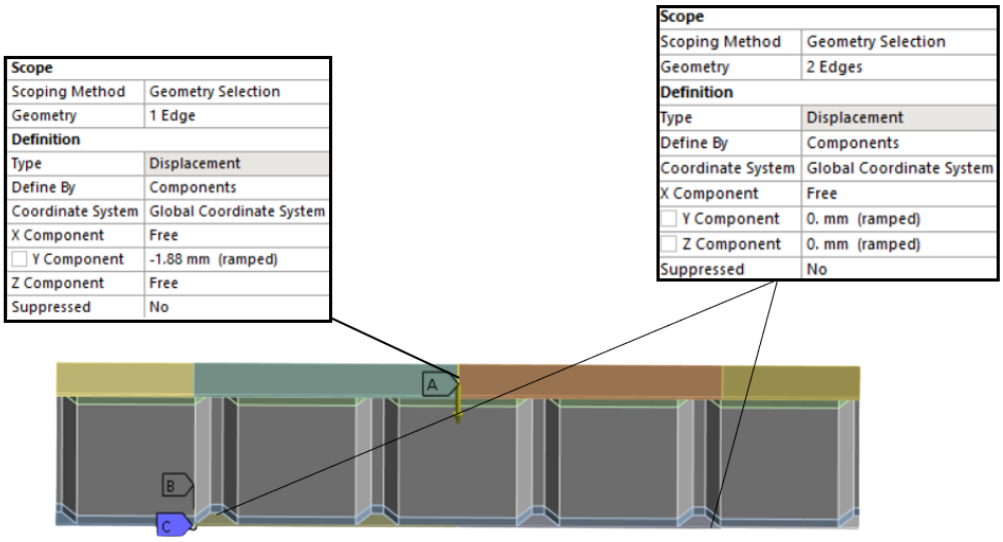

Fig. 12. The boundary conditions

3. Comparison of results

Cazul	Proba	Forța maximă [N]	Deplasarea maximă [mm]
Unghi de 30^o	MEF	3907.7	1.881
	Experimental	1171.7	1.172
Unghi de 45^o	MEF	3934.2	1.881
	Experimental	1358.5	1.561
Unghi de 60^o	MEF	4682.7	1.881
	Experimental	1342.3	1.423

4. Conclusions

In conclusion, the differences between the results obtained experimentally and FEM are due to the erroneous preparation of the adhesive. In addition to this, the aluminum surfaces were not degreased with technical acetone.

On the other hand, the PLA core has a higher weight than the standard one (the weight of the core had to be two thirds of the total weight of the structure).

Also, the honeycombs are made of PLA, this being an inhomogeneous material, while in Ansys it is considered homogeneous.

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STRUCTURAL AND FABRICATION PROCESS OPTIMIZATION FOR A ROBOT EFFECTOR

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- Coordonator științific**: Ing. Alexandru Andrei ANCUȚA**

REZUMAT: This paper aims to provide research into structural and fabrication methods for a robot effector, specialized for palletizing operations. The goal was to achieve a high-reliability, low-cost gripper, in order to be able transport cylindrical parts. The analysis performed was both of a structural type (by comparing different parameters, such as infill percentage and construction shape) and from a cost perspective. Material choice was also considered, between different types of FDM, and one SLA variant.

CUVINTE CHEIE: Structural analysis, Finite Element Analysis, Structural optimization

1. Introducere

The field of robotics has been rapidly advancing in recent years, experiencing exponential growth. In various settings, particularly those involving repetitive and demanding tasks, industrial robots are taking over the roles traditionally performed by humans. These machines are particularly valuable when human limitations hinder the optimal functioning of technological processes.

When delivered in their factory configuration, robots lack practical utility beyond serving as mere demonstrations. To be effectively incorporated into a technological environment, robots need to be equipped with a component known as an effector. This effector determines the specific functionalities and capabilities of the robot. The type of effector required varies depending on the application, such as manipulation (moving parts between multiple points), palletizing (specifically keeping the part parallel to the ground plane), arc welding, and so on.

The objective of this article is to provide a comprehensive analysis of the structural aspects related to an effector necessary for the palletizing process. In addition to considering orientation requirements, this analysis encompasses various physical and structural constraints. The purpose is to ensure that the reference load can be efficiently manipulated within the workspace, utilizing the maximum speeds permitted by the load-bearing structure. Safety considerations for both the environment and the operators in the vicinity are also taken into account.

2. Stadiul actual

A means of achieving low-cost, fast fabrication is via FDM (fused-deposition-modeling). FDM (Fused Deposition Modeling) Fabrication:

FDM is a widely used additive manufacturing technology that creates three-dimensional objects by extruding thermoplastic materials layer by layer. It has gained popularity due to its affordability, versatility, and ease of use. FDM technology supports a wide range of thermoplastic materials, including ABS, PLA,

PETG, nylon, and more. Manufacturers have developed specialized filaments with improved properties, such as enhanced strength, flexibility, heat resistance, and chemical resistance. This expanding material selection allows for diverse applications and end-use parts. A base characteristic of FDM is that most parts generated are hollow, with a parameter named “infill” determining both the percentage and shape of material used for rigidization and support of the outer shell.

Robot palletizing refers to the automated process of using robots to stack or arrange items, products, or packages onto pallets in a systematic and organized manner. It is a common application of robotics in industries such as manufacturing, warehousing, logistics, and distribution centers. The process typically involves a robot equipped with an end-effector, such as a gripper or vacuum system, that can grasp and lift objects. The robot is programmed to precisely pick up items from a conveyor belt, production line, or storage area, and place them onto pallets following a predefined pattern or configuration. Overall, robot palletizing plays a significant role in streamlining warehouse operations, optimizing logistics, improving product handling, and enhancing overall productivity in industries that involve the movement and storage of goods.

In order to analyze the structural behavior of the end-effector, a process called FEM is employed: FEM stands for Finite Element Method. It is a numerical technique used for solving engineering and mathematical problems by dividing them into smaller, simpler parts called finite elements. FEM is widely used in various fields, including structural analysis, heat transfer analysis, fluid dynamics, electromagnetics, and many others.

The steps involved in using FEM typically include:

- Discretization: The domain is divided into a finite number of elements, and the nodes and connectivity between elements are established.
- Formulation: Mathematical equations are developed to describe the behavior of each element based on the governing physical laws and properties.
- Assembly: The individual element equations are combined to create a system of equations that represents the entire problem.
- Solution: The system of equations is solved numerically using iterative or direct methods to obtain the solution.
- Post-processing: The results obtained from the solution are analyzed, visualized, and interpreted to gain insights into the problem being studied.

For the present study, the Ansys software was utilized.

3. Initial process:

In developing an end-effector for the application, the first step was to develop a 3D model: this was done following two approaches: two different versions of the effector have been suggested, each with implications for the generation of the robot's workspace. The first variant is eccentric, enabling the complete accessibility of the workspace by positioning the load along a guiding radius that runs parallel to the robot's workspace. Nonetheless, this eccentric variant has a drawback as it introduces additional loads that result in bending and shearing forces at the contact points between the chucks, screws, and mounting flanges.

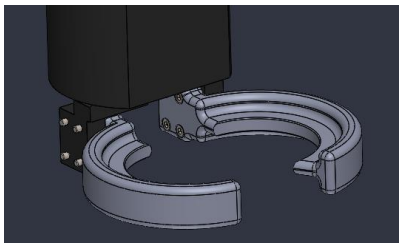


Fig. 1. Chucks in an eccentric configuration

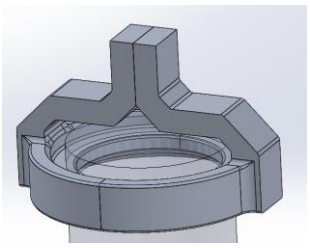
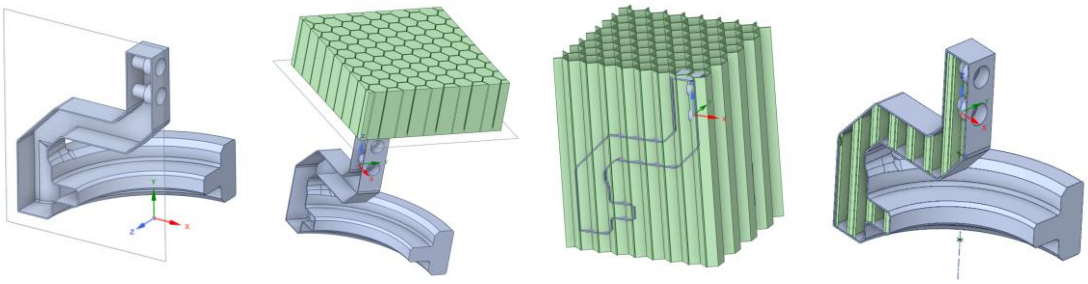


Fig. 2. Chucks in a concentric construction

An initial analysis was performed, after which the concentric variant was chosen to continue the study. Initially, an infill parameter of 100% was chosen, in order to eliminate pertaining to it. The concentric variant performed best under loads applied.

4. Generation of geometry

The geometry, with different infill configurations, was difficult to obtain from the CAD software. A workaround was devised, utilizing the Space Claim CAD software: by first generating a cube above the model, creating the desired infill, then projecting said infill downwards, it was possible to generate two bodies: the outer shell of the chucks and the inner infill. Between the two bodies, a frictionless contact was generated.



Figs. 3-6. The shape generation process

5. Material choice

Material choice is extremely important, both when designing the real product, and when performing the analysis. Material properties were obtained both from the manufacturer datasheets, and from literature. Of great importance are parameters such as Young's Modulus, the Shear Modulus, and S-N Curve, necessary for fatigue analysis. Three different plastics were considered: ABS, PLA and HIPS.

6. Configuration of the FEA model

The model must first be configured, in order to allow the analysis to be performed. Firstly, contacts have been defined. These can be broken down in 3 types: between the chucks, between the chucks and the object being palletized and between the outer shell and infill.

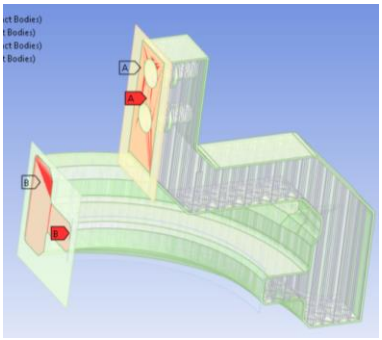


Fig. 7: Chuck contact

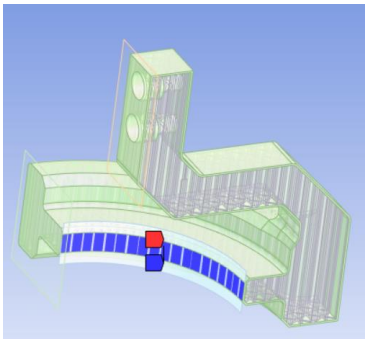


Fig. 8: Chuck and object contact

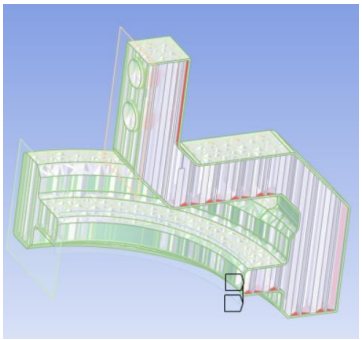


Fig. 9: Outer shell and infill contact

7. Identifying areas of interest

Discretization can be broken down into two types: generalized and fine-grained. Generalized discretization utilizes large spatial shapes, lowering computation time, but also reducing accuracy. An initial, gross discretization is done. Iterating further, in areas that present high loads additional reference systems are created. In spherical areas, radiating out of these reference systems, the discretization was refined, in order to achieve parity with a real behavior.

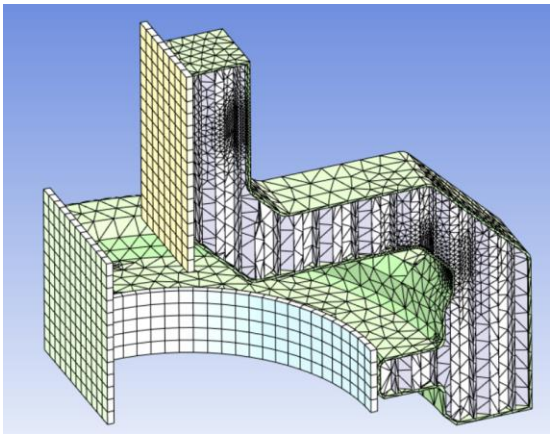


Fig. 10: Discretization

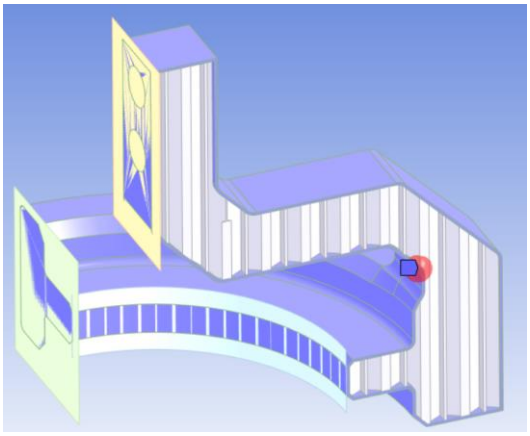


Fig. 11: Areas of interest

8. Static loads

Static loads have to be determined in order to simulate the behavior of the model: The “A” surface was considered a fixed support, the plane of contact between the closed chucks of the effector. Surface “B” represents the contact between the chuck and the flange. Surface “D” supports the weight of the load. Surface “E” is the gripping force of the effector, while “F” was considered a remote load, in order to better simulate inertial forces acting upon the chucks.

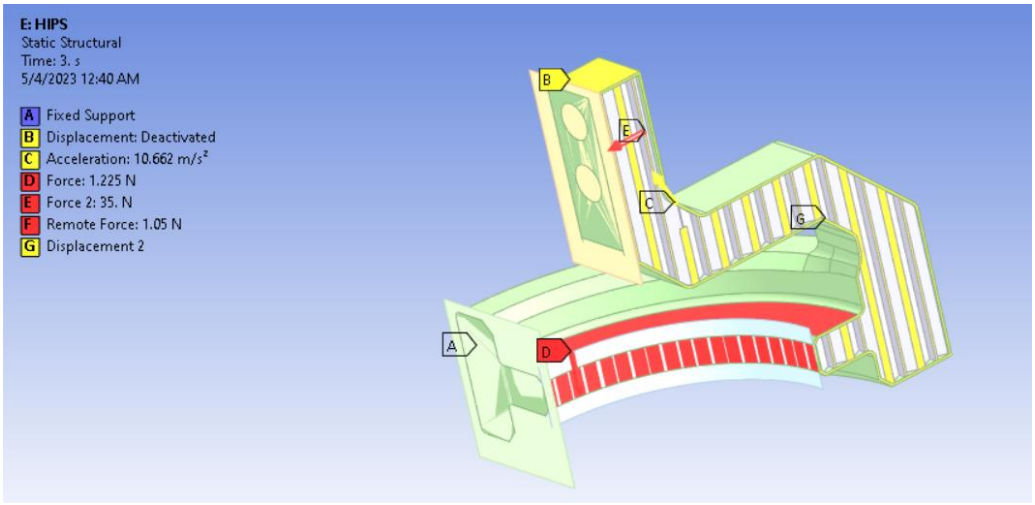


Fig. 12: Simulated loads

9. Simulation steps

During the course of a cycle, a number of distinct “steps” can be identified, during which the loads and accelerations change (as contacts become active):

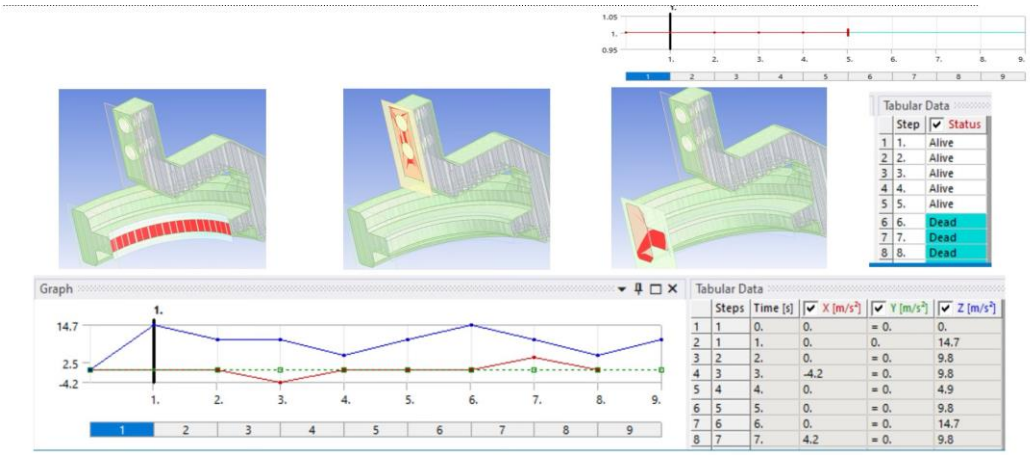


Fig. 13: Contact step control configuration

Accelerations had to be determined experimentally, as the robot datasheet provided no information about them. A measuring apparatus was created utilizing an Arduino Nano 33BLE development board, which was equipped with a 9-axis inertial sensor LSM9DS1. A setup was constructed consisting of a standard AAA battery pack connected through spot welding and supported by a plastic plate. Real-time outcomes were wirelessly transmitted using the Bluetooth Low Energy (BLE) protocol to the central computing unit for subsequent analysis and processing. The device was additionally safeguarded by a soft braid covering to absorb potential impacts, while insulation tape was applied to the plastic plate to enhance grip on the robot's chucks.

10. Analysis results – Maxmium equivalent von Mises stress

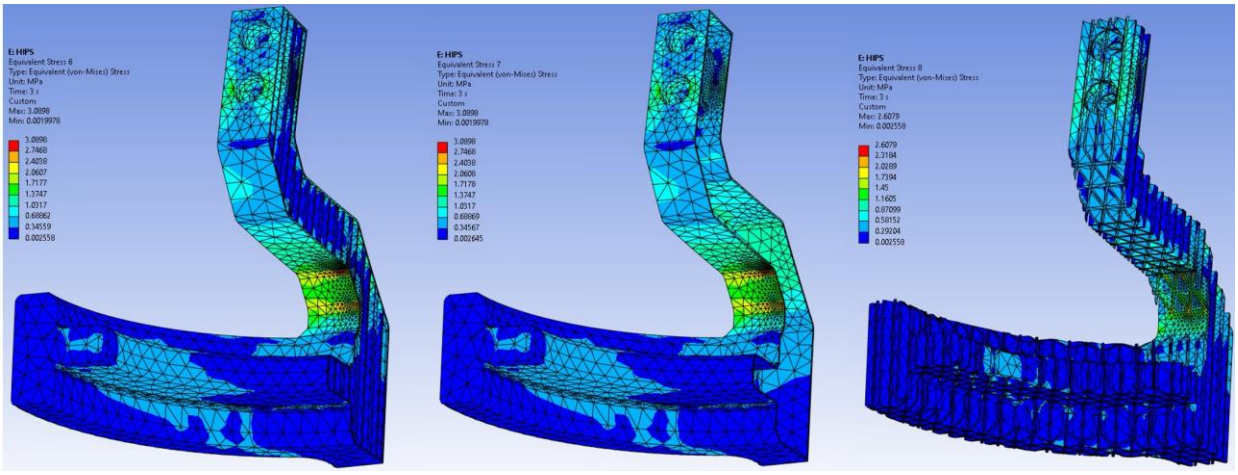


Fig. 14: Maxmium equivalent von Mises stress

Following the analysis, doubled by a fatigue study, it was determined that most infill types yield infinite lifetime for the chucks, proving the viability of the design.

11. Closing thoughts

The FEM and structural optimization analysis of the robot end-effector produced through FDM manufacturing presented intriguing findings. The comprehensive evaluation explored various parameters, leading to insightful observations and potential avenues for further exploration. The results demonstrated promise in terms of enhancing the end-effector's performance, durability, and efficiency. However, additional investigations are warranted to fully comprehend the complex interplay between the design parameters, material characteristics, and printing process. Ultimately, this study serves as a stepping stone for future research and development endeavors in the realm of FDM-produced robot end-effectors, contributing to advancements in robotic systems and their associated applications.

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CONSIDERATIONS REGARDING THE CHOICE OF THE MATERIAL AND THE PRINTING PARAMETERS FOR EFFICIENT PROTOTYPES IN THE INDUSTRY OF PLASTICS

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The paper deals with the comparison between two materials (ABS- Acrylonitrile Butadiene Styrene and PLA-Polylactic Acid) printed with different configurations of parameters (infill, and internal structure). This study is focused on the analysis of mechanical and elastic properties of five specimens for the same configuration with all the combinations of parameters. For carrying out this paper the specimens were printed using the fused filament fabrication, and they were tested using the digital image correlation and an extensometer. The results were centralized, and the most important findings were highlighted on the final part of the paper, including the maximum values for mechanical and elastic properties.

Keywords: Fused Filament Fabrication, Poisson's ratio, Digital Image Correlation, Young modulus, Additive Manufacturing

1. Introduction

Nowadays there are a lot of materials used for filament fabrication for 3D printers. These materials are often made from biodegradable sources, and they are cheap and easy to print. These factors led to a decrease in costs for the plastics industry. The paper deals with the determination of Young modulus and Poisson's ratio for different configurations of printing parameters such as infill and internal structure. The specimens were designed using CATIA V5 R21 software with size specifications according to ASTM D638 Standard. The specimens were made using a 3D printer based on Fused Filament Fabrication. For their testing the authors used a INSTRON servo-hydraulic machine and two cameras to analyze the specimen elongation, this technique being called Digital Image Correlation. To calculate the elastic equivalent modulus, it was used WolframAlpha to determine the slope of the obtained stress-strain curve.

2. The specimens preparation

The specimens were made using the dimensions according to ASTM D638 standard as shown in Figure 1. It was used CATIA V5 R21 software.

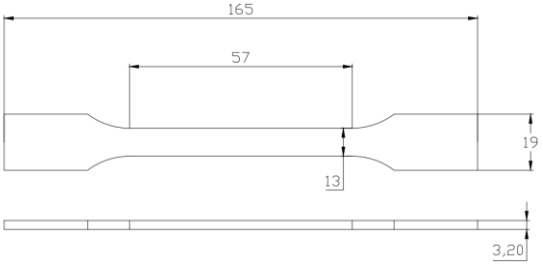

Fig. 1. Specimen dimensions

The next step was to determinate the printing parameters for the specimens. For this study there were used two materials (ABS and PLA), two types of internal structures (triangular and trihexagonal)

with two infill percentages (30% and 80%). These two types of materials were used because they are very cheap and widely used for prototypes in plastics industry. The trihexagonal structure is made of hexagons and triangles interconnected to each other, and this configuration offers a bi-directional strength (along longitudinal and transversal axis) using a minimal quantity of material. The triangle structure is made of parallel lines in three directions forming triangles all over the structure. This configuration offers good shear stress. There were used two percentages of infill to make the comparison between printing times and the quantity of materials needed to print the specimen. In general, the 30% is used to test the printer and to evaluate the quality of the printed surfaces because it requires less time, and 80% is used for prototypes with a functional role. Other important parameters for this study are the diameter of the filament used was 1.75 mm, the printer resolution was 60 μm, printing speed 60 mm/s, diameter of the printing head was 0.4 mm, the printing temperature for PLA was 210°C and 260°C for ABS and the temperature of the printing bed was 60°C for PLA and 80°C for ABS. The differences between the internal structure and infill are shown in Figure 2. [1]

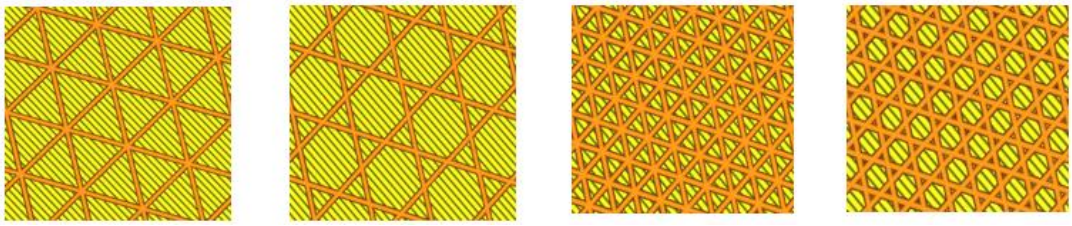

Fig. 2. Differences between the internal structure

3. Experimental analysis

For the experimental analysis it was used the INSTRON 8872 testing machine, which is a compact servo-hydraulic testing machine for a wide variety of specimens. The maximum force of this device is 25 kN. The specimens were fixed between the two grips as one can see in Figure 3.

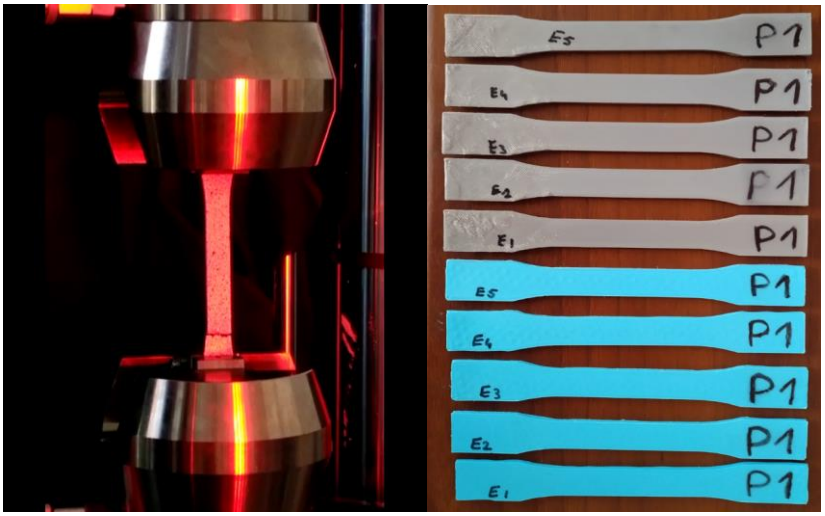

Fig. 3. The specimens in INSTRON machine and before testing

To determine Poisson's ratio for those specimens it was used the Digital Imagine Correlation. This method consists in the analysis of the dimensions and the shape of the objects through images from two cameras. The images are processed using a software which will assign a Cartesian coordinate system for each pixel from the images. Comparing these images the software can show the elongation in real time, and all the values (the force and elongation) are collected. For the software to calculate the elongation the specimens must be painted in white with black dots. The cameras must be calibrated before using the machine, as one can see in Figure 4.

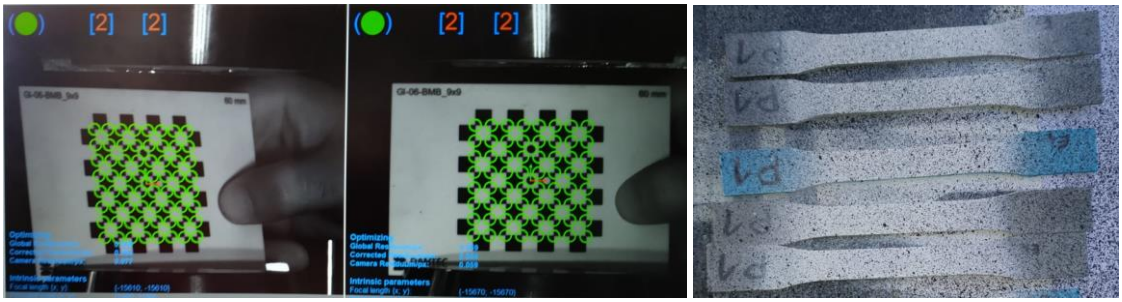

Fig. 4. The calibration procedure for the machine and the painted specimens

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4. Comparison of the results

For this study the most important features to compare at first were the material used, density (infill), the internal structure, time spent on printing, quantity of the material used and the maximum force (breaking force of the specimen). Those results can be seen in table 1.

Table 1. Preliminary comparison

Material	Infill and internal structure	Printing time	Quantity of material used	Breaking force of the specimen
ABS	30% triangles	74 min	8.2 g	882.6 N
	30% tri-hexagonal	74 min	8.2 g	848.4 N
	80% triangles	87 min	10.2 g	958.4 N
	80% tri-hexagonal	86 min	10.2 g	988.6 N
PLA	30% triangles	74 min	8.2 g	1038.2 N
	30% tri-hexagonal	74 min	8.2 g	1057 N
	80% triangles	86 min	10.2 g	1271.4 N
	80% tri-hexagonal	85 min	10.2 g	1252.6 N

As can be seen in the table, the printing time and quantity of material used was almost the same for all the specimens, so those two criteria can't show the best configuration of the specimens. The breaking forces for the PLA specimens are with around 15% higher than ABS. For this study the authors determined the conventional stress-strain curve for all the configurations, meaning that it was used the whole cross-section area for each specimen. This area doesn't have an exact value because of the internal pattern and the infill percentage. So that means the values for the elastic modulus that there were first calculated with Wolfram Alpha are not the real ones. In order to have the real values it was used a compensation formula. The values are centralized in table 2.[2]

Table 2. Second Comparison

Material	Infill and internal structure	Poisson's ration	Maximum stress [MPa]	Elastic modulus [MPa]	Elastic modulus (real) [MPa]
ABS	30% triangles	0.29	15	1089	762.3
	30% tri-hexagonal	0.31	14	1003	702.1

	80% triangles	0.22	17	1260	1008
	80% tri-hexagonal	0.34	17	1291	1032.8
PLA	30% triangles	0.31	18	1266	886.2
	30% tri-hexagonal	0.34	18	1280	896
	80% triangles	0.30	23	1767	1413.6
	80% tri-hexagonal	0.29	22	1675	1340

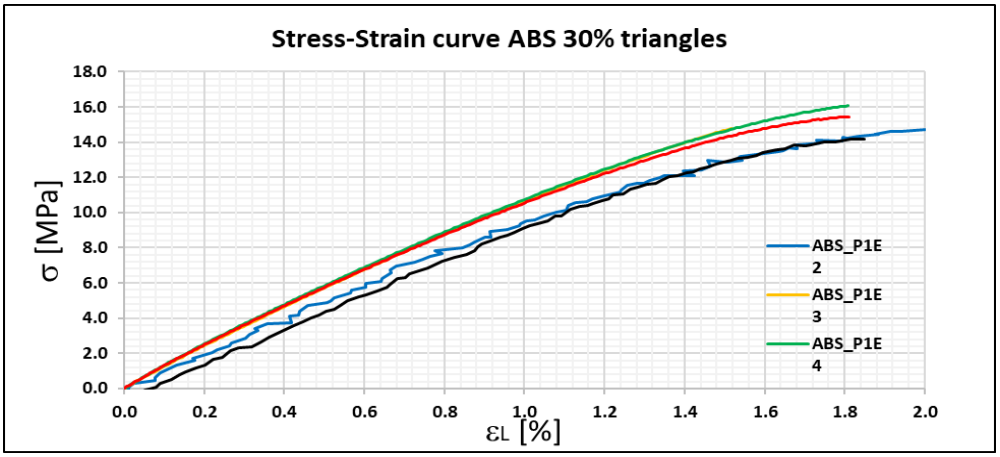

Fig. 5. Stress-strain curve for ABS 30% triangles

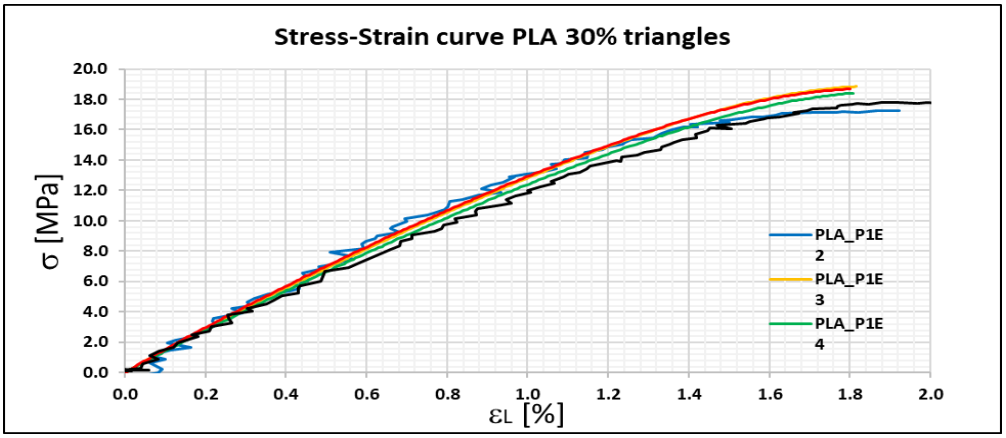

Fig. 6. Stress-strain curve for PLA 30% triangles

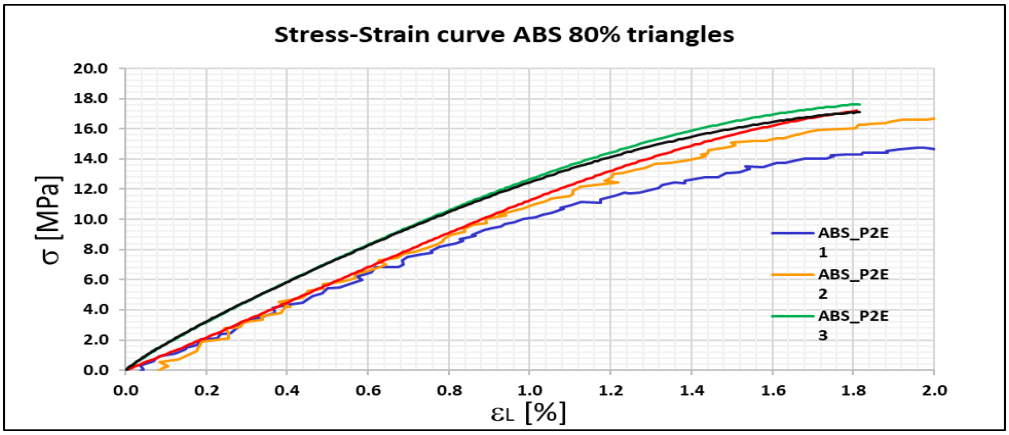

Fig. 7. Stress-strain curve for ABS 80% triangles

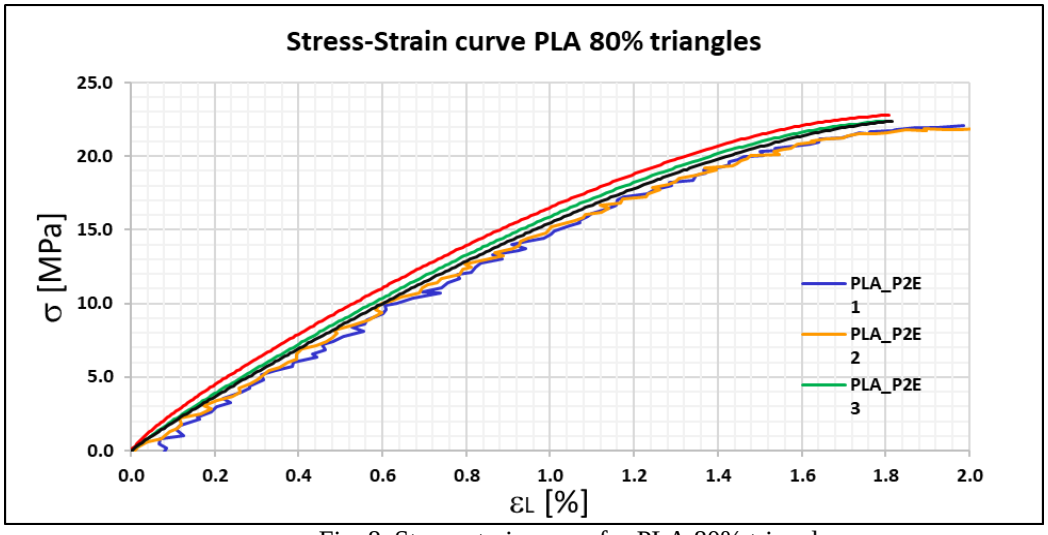

Fig. 8. Stress-strain curve for PLA 80% triangles

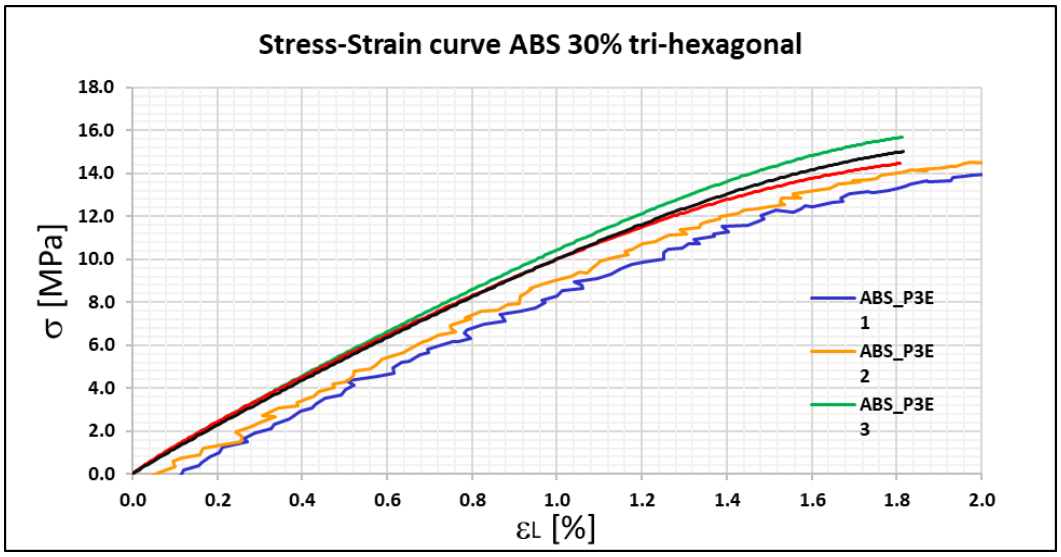

Fig. 9. Stress-strain curve for ABS 30% tri-hexagonal

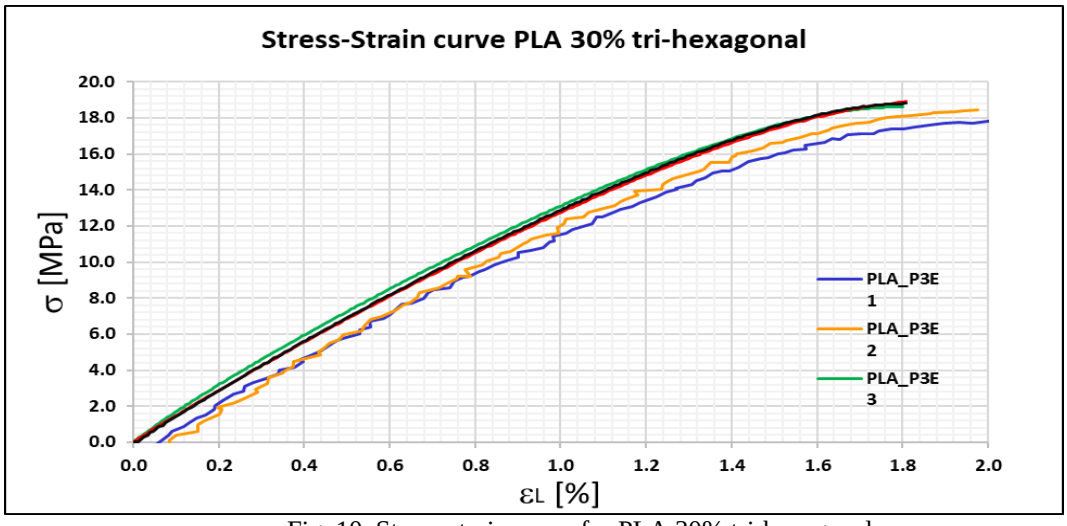

Fig. 10. Stress-strain curve for PLA 30% tri-hexagonal

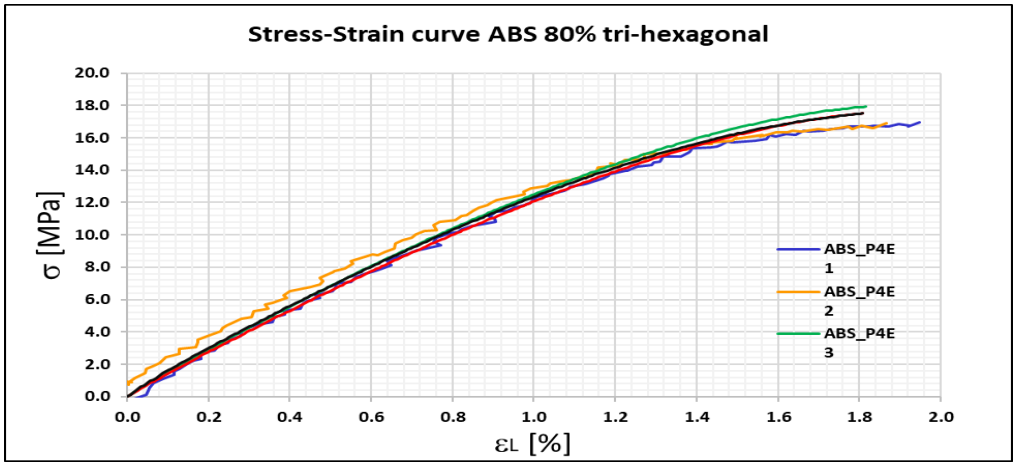

Fig. 11. Stress-strain curve for ABS 80% tri-hexagonal

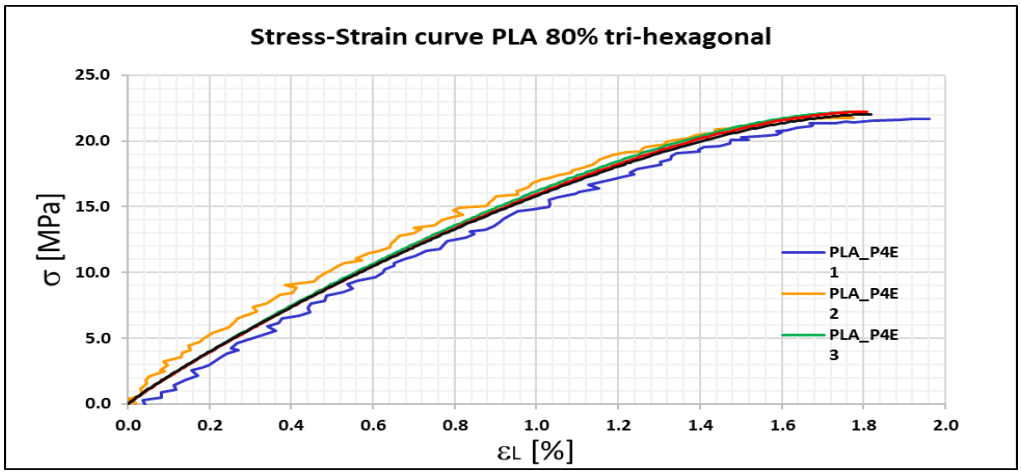

Fig. 12. Stress-strain curve for PLA 80% tri-hexagonal

5. Conclusions

The two materials, PLA and ABS, had a similar behavior during the tests, but as we can see in Table 2, PLA has a higher elasticity modulus than ABS, and all the specimens made from PLA withstand higher breaking forces than ABS, so this material is defiantly stronger. For these specimens the differences in those with the same infill and different internal structure are not very prominent both breaking at the same stress value. The maximum stress was supported by PLA specimen with 80% triangles. The same specimen with the same configuration had the highest value for the Young modulus. In conclusion, we can affirm that the best configuration from the tested specimens was 80% triangles.[3]

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LINEAR BUCKLING ANALYSIS OF STIFFENED PANELS

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This article investigates the buckling behaviour of stiffened panels commonly used in aeronautical engineering. Stiffened panels play a critical role in aircraft structures, providing structural integrity and load-bearing capabilities. The article outlines the analytical approach based on classical plate theory and a finite element method (FEM) analysis of a simply supported thin plate. This example highlights the applicability of both approaches and emphasizes the role of numerical simulations in complex structural analyses. Moving beyond the simple plate example, the article then focuses on the linear buckling analysis of a stiffened panel that resembles a real aircraft structure. The panel's geometry and boundary conditions are defined to simulate the actual operating conditions of the aircraft. Furthermore, a comparative analysis is conducted to evaluate the buckling performance of a similar panel without stiffeners. This comparison highlights the essential role of stiffeners in designing aircraft structures.

KEYWORDS: linear buckling, stiffened panels, aeronautical engineering.

1. Introduction

For any given loading condition of the aircraft the structure is stressed in tension, shear, or compression. In tension, ultimate load is usually limited by the quality of the material available. However, in case of compression, thin-walled structures are, by definition, susceptible to loss of elastic stability (buckling). In most cases, ultimate strengths of stiffened panels are primarily dependent on the stability behaviour, therefore stiffened panels are widely used, due to their high strength-to-weight ratio and ability to withstand complex loading conditions.

According to [1], the components of stiffened panel may be classified as follows:

- Longitudinal reinforcing members- stringers and spars, that can carry appreciable tensile loads and, when supported, compressive loads as well.
- Skin- tensile, compressive and shear loads can be carried, but reinforcement (lateral support) is required. The thin skin used in aircraft structures can only sustain and transmit normal pressure over short distances by bending.
- Transverse reinforcing members- ribs, that provide in-plane stiffness and strength, being incapable of carrying much lateral load.

A typical wing section is presented in Fig. 1:

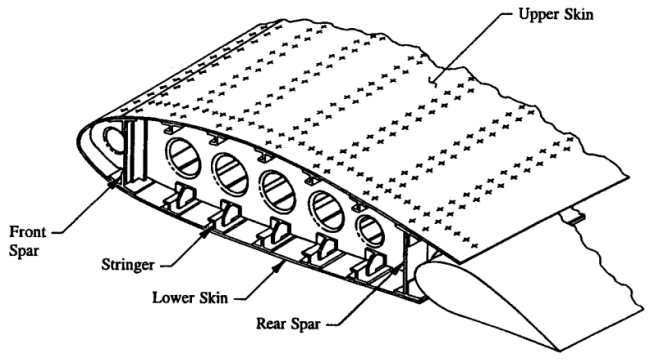

Fig. 1 Main wing components [2].

The key initial instability modes of stiffened panels are:

- Skin Local Buckling- generally involves waving of the skin between stringers in a half-wavelength comparable with the stringer pitch [5].
- Stiffener Local Buckling- out-of-plane stringer web or flange displacement in a half-wavelength comparable with the stringer depth [5].
- Inter-rivet Buckling- buckling of the skin as a short strut between rivets [5].
- Panel Global Buckling- buckling of a panel as a whole, often a catastrophic stiffness reduction that can lead to structural collapse.

After the initial knuckling, following failure can occur:

- Stiffener Column Buckling- once buckled, skin is no longer able to carry the applied loads, resulting in a column-like behaviour of stiffeners [1].
- Crippling Failure- local distortion of the cross-sectional shape, the beginning of which usually occurs at the load appreciably less than the failing load with more stable portions of the cross-section continuing to take additional load while supporting the already buckled portion until complete collapse occur [1].

A key aspect of stiffened panel stability is stringer's section. There is a multitude of different cross-section of stiffeners used in aircraft design, the typical skin-stringer configurations are shown in Fig. 2:

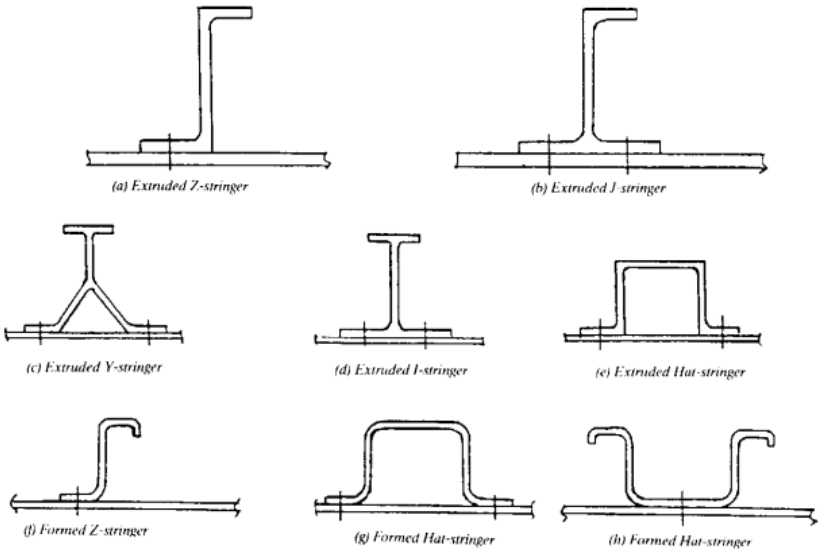

Fig. 2 Typical skin-stringer configurations [1].

Z-stiffened panels are efficient structural elements for compressive load. Other important merits of Z-stiffened panels include ease of assembly and good accessibility for inspection [6]. Although panels with closed section stiffeners, such as hat-shaped stiffeners, are slightly more efficient than Z-stiffened panels, they are more difficult to inspect.

Other than the stringer type, a skin-stringer configuration is defined by width and thickness of the stiffeners and the stiffener spacing. Following dimensions were considered for this study: frame spacing of 600 mm (rib pitch) and stiffener spacing of 250-300 mm (stringer pitch).

2. Finite Element Models

This study comprises three distinct finite element models (FEM), each designed to investigate a specific aspect of buckling analysis for thin panels. These models include:

- An analytical relation-based example of a thin rectangular plate with all edges simply supported, intended to validate the accuracy and reliability of buckling analysis techniques for thin panels.
- A FEM of a thin stiffened plate with dimensions closely resembling those of a real aircraft structure, specifically the horizontal stabilizer of a private jet.
- A FEM of a thin plate with identical dimensions to the stiffened plate. The purpose of this model is to enable a comparison of the buckling behaviour of the plate with and without stringers, highlighting the effects of stringers on the buckling behaviour of aircraft structures.

The general buckling equation for a thin rectangular plate in compression [3] (see Fig. 3) allows to determinate the critical buckling stress:

$$\sigma_{cr} = \frac{k\pi^2 E t^2}{12(1-\mu^2)b^2} \tag{1}$$

Using relation (1), the critical buckling load for a plate with following dimensions was determined: a=300 mm, b=100 mm, t=1 mm, μ=0.33, E=71000 MPa, k=4 (for all edges simply supported).

$$\sigma_{cr} = \frac{k\pi^2 E t^2}{12(1-\mu^2)b^2} = \frac{4 \cdot \pi^2 \cdot 71000 \cdot 1^2}{12(1-0.33^2)100^2} = 26.21 \text{ MPa} \tag{2}$$

A thin plate lengthened in the direction of loading, with an aspect ratio of three, will buckle into three waves, each of them being square and acting as shown in Fig. 3 (at the left):

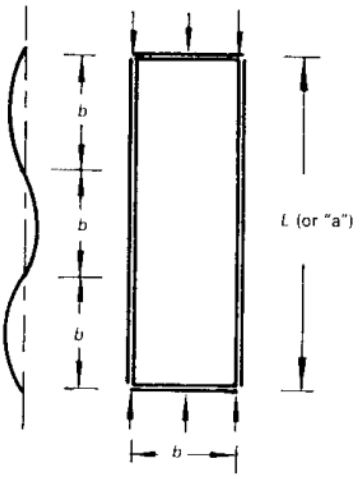

Fig. 3 A rectangular plate with all edges simply supported [1].

From the load determined with analytical relation (1) the critical buckling force was determined:

$$F_{cr} = \sigma_{cr} \cdot a \cdot t = 26.21 \cdot 100 \cdot 1 = 2621 \text{ N} \tag{3}$$

Considering given geometry, material and supporting conditions, a simple FEM was developed in ANSYS Workbench, student version (2022 R2) [4]. A schematic representation of the boundary conditions is presented in Fig. 4:

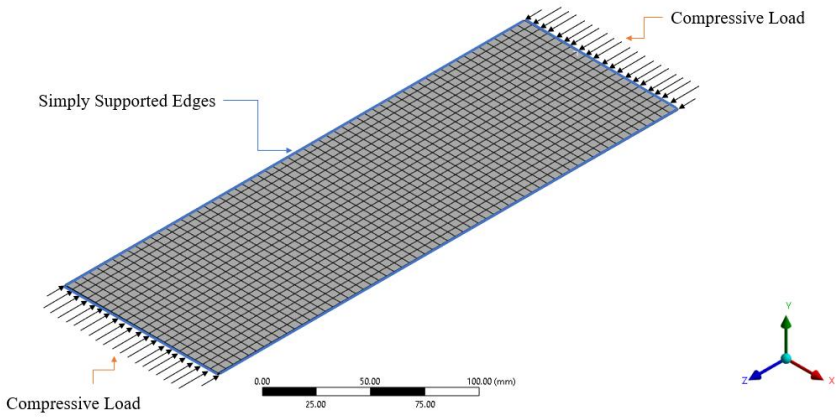

Fig. 4 FE model of a simply supported thin plate loaded in compression.

For the second part of the study, a model of a thin stiffened panel with dimensions and supports condition resembling real aircraft structure was analysed. As a reference, a private jet plane horizontal stabilizer (HS) was considered. A simplified cross section of the lower HS skin is presented in Fig. 5:

Fig. 5 Sequence of stiffeners along HS skin panel.

A part of the skin panel was modeled, consisting of a sequence of four Z-stiffeners bonded to the skin. The general dimensions are presented in Fig. 6:

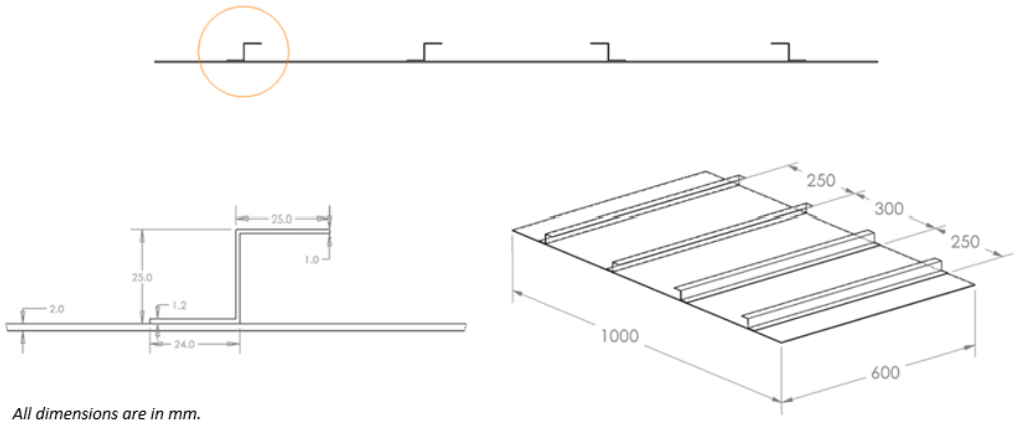

Fig. 6 Stiffened panel general dimensions. All dimensions are in mm.

Skin panels are supported in the transverse direction by ribs, providing a simply supported condition. Additionally, as only a part of the skin panel was analysed, a symmetry condition is applied to edges parallel to stringers. To determine the critical force value, a compressive load was applied, aiming for a resultant load multiplier factor close to one for the first buckling mode. The schematic representation of the boundary conditions is shown in Fig. 7. For accurate analysis, a fine mesh was generated with an element size of 10 mm. The contact region was treated as bonded and modelled using CONTA174 and TARGE170 elements.

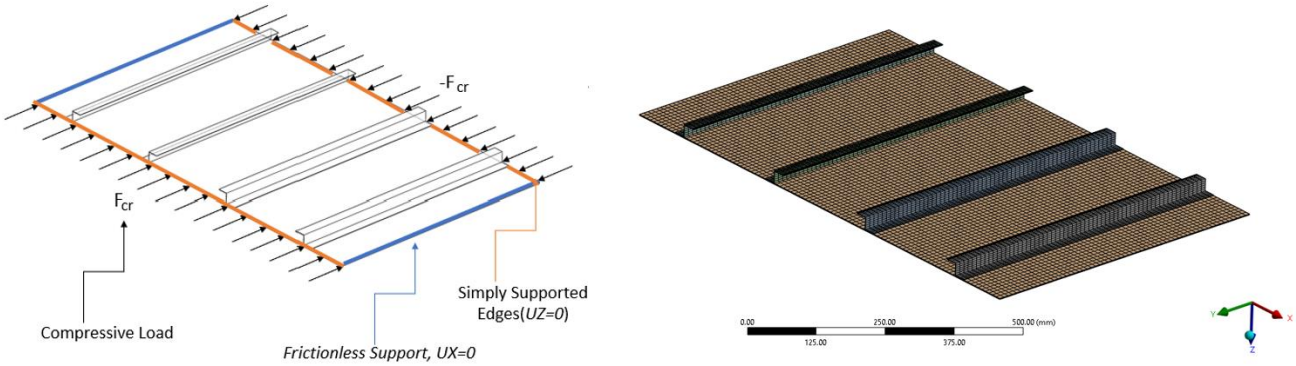

Fig. 7 Boundary conditions and the mesh of stiffened panel model.

Additionally, to enable a comparison of the buckling behaviour of the plate with and without stringers, a third FEM of a thin plate with identical to the stiffened panel dimensions and boundary conditions was analysed.

3. Results and Discussions

Using the Eigenvalue Buckling module [4], the first buckling mode of the simply supported thin plate was determined. The obtained load multiplication factor was approximately one (1.03), indicating that the applied load can be considered critical. As described in [1] the thin plate under investigation was observed to buckle into three waves, as shown in Fig. 8. This result confirms the validity of the model and demonstrates its capability to accurately capture the buckling behaviour of thin plates.

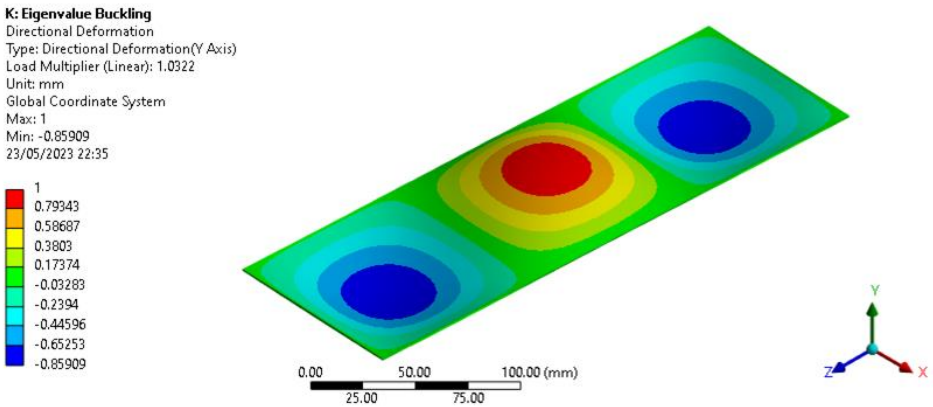

Fig. 8 The first buckling mode of the rectangular simply supported thin plate.

For the second example, the first four buckling modes corresponding to an axial compressive load of 25000 N were determined. For the first buckling mode a load multiplier factor of 1.07 was obtained. Results are presented in Fig. 9:

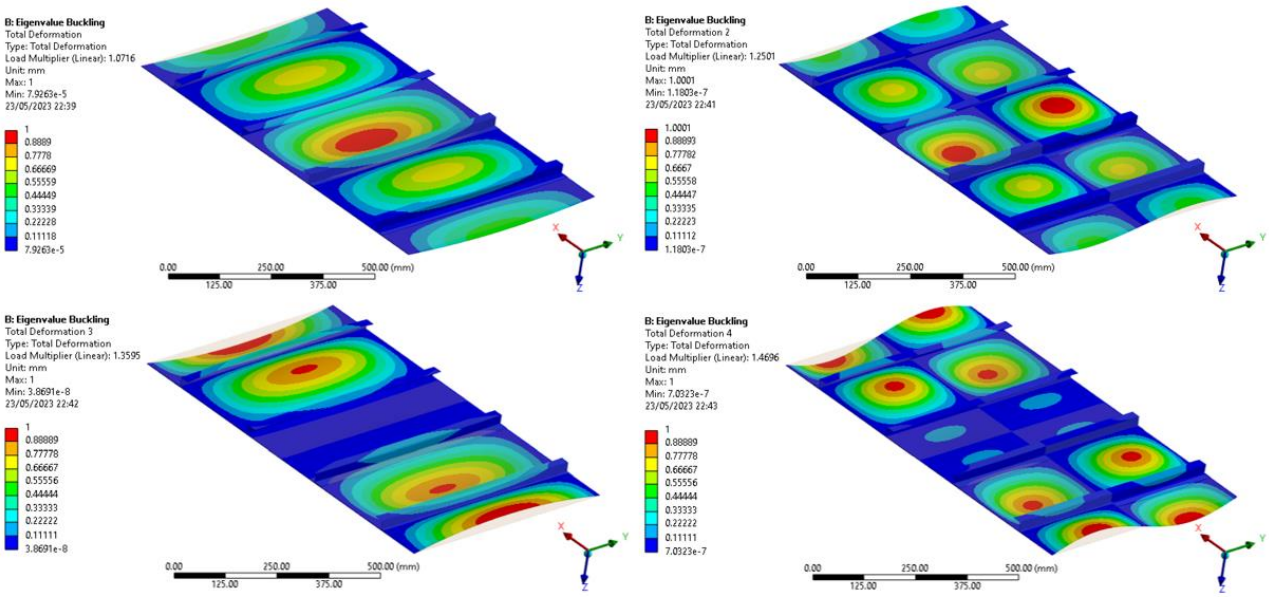

Fig. 9 The first 4 buckling modes of the stiffened panel.

The same approach of determining critical buckling force was applied for the analysis of panel without stiffeners. An axial compressive force of 1400 N was used to obtain the first four buckling modes. For the first one a load multiplier of 1.04 was obtained. Fig. 10 shows the first four buckling modes for panel without stiffeners:

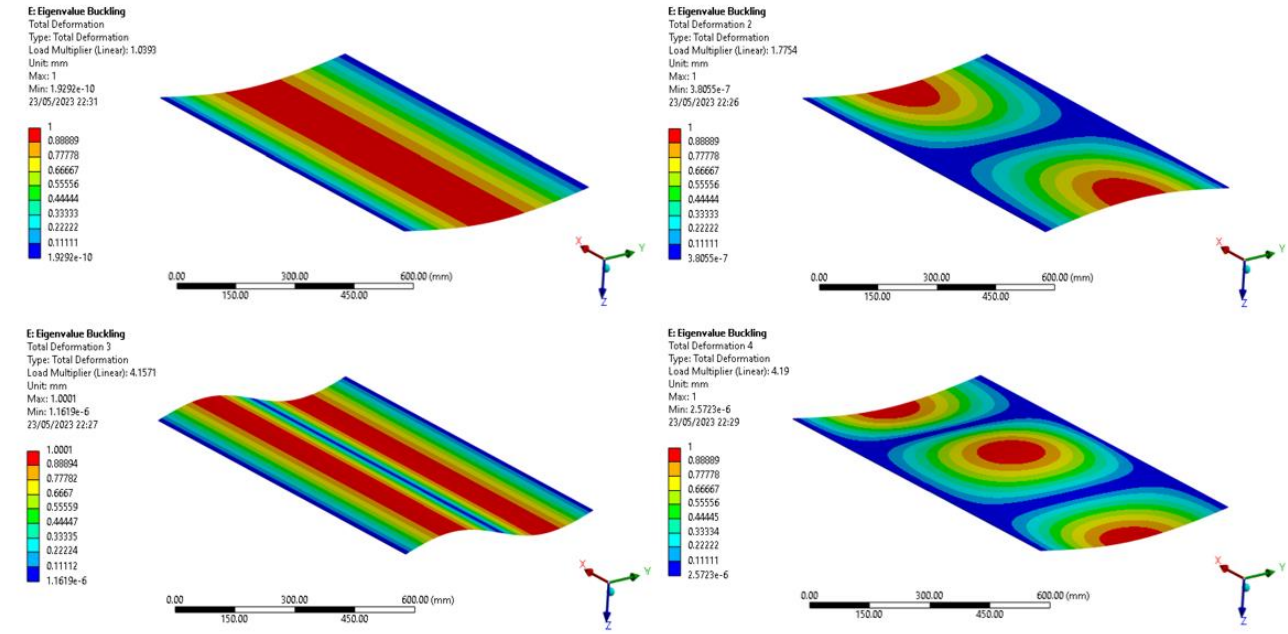

Fig. 10 The first 4 buckling modes of the panel without stiffeners.

LINEAR BUCKLING ANALYSIS OF STIFFENED PANELS

The results derived from the analysis of both stiffened and unstiffened panels provide insight into the influence of stringers on the buckling behaviour of thin plates. Table 1 presents the critical buckling load for the two plate types. The presence of stiffeners increased F_{cr} by 23600 N, resulting in a 17.85 times greater critical buckling force. Such improvement is a clear example of stiffener's high strength-to-weight ratio and ability to withstand demanding loading conditions.

Table 1 Eigenvalue Buckling Results

Results	Panel with stiffeners	Panel without stiffeners
Critical Buckling Load [N]	25000	1400
Load Multiplier [-]	1.07	1.03

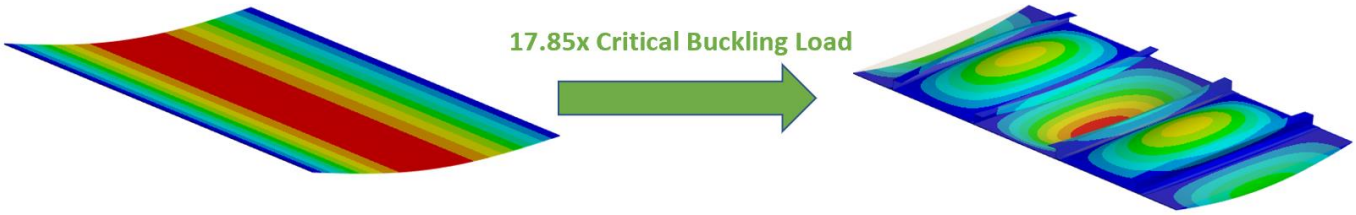

Fig. 11 Increase in critical buckling load: panel with and without stiffeners.

Moreover, the introduction of stiffeners alters the buckled shape of the plate. Fig. 9 illustrates how the skin locally buckles between stringers, enabling load redistribution within the skin-stringer configuration and creating a structure capable of carrying load even in a post-buckled state. On the other hand, for panels without stringers, the first mode of buckling resembles a column (Fig. 11). As the stability of the plate is greatly influenced by boundary conditions, a plate with 2 free edges will behave as a column once it reaches the critical buckling stress. This transition is presented in Fig. 12:

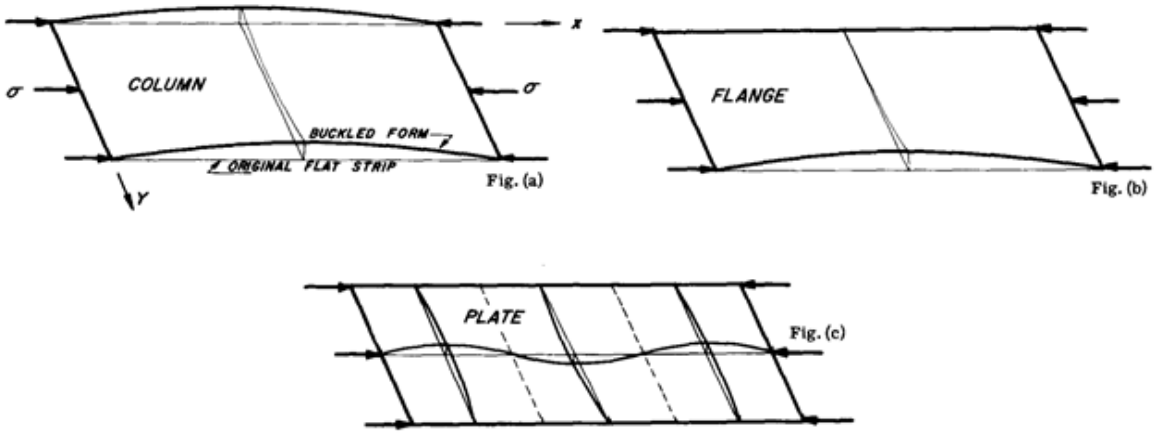

Fig. 12 Transition from column to plate as supports are added along unloaded edges [7\]

Initial buckling of a stiffened panel consists of a local buckling mode which is a mixture of skin buckling, local instability and torsional intability, the predominant type of buckling being dictated by the geometry of the particular skin-stringer configuration used [1]. Understanding the role of these factors are extremely important for designing and analyzing stiffened panels, especially in aerospace applications, where weight and structural performance are crucial.

4. Conclusions

Three distinct finite element models were built to investigate various aspects of buckling analysis for thin panels. Each model served a specific purpose and highlighted the essential role of stiffeners in designing aircraft structures.

By comparing the available analytical results with FEM results for a simple geometry, with distinct boundary conditions, the study confirmed the effectiveness of the chosen analysis techniques in predicting buckling behaviour accurately.

A side-by-side comparison of a panel with and without stiffeners revealed a significant increase in load-carrying capabilities when stiffeners were present. As in the aeronautical field weight is a crucial parameter, lightweight structures with a high strength-to-weight ratio are of great interest. By considering the specific geometry of the skin-stringer configuration, engineers can predict and address the primary mode of buckling more accurately, enabling them to create the most optim designs.

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Nomenclature

FEM: Finite Element Model
σ_{cr}: critical buckling stress
F_{cr}: critical buckling load
k: non-dimensional constants that depend upon condition of edge restraint and shape of the plate
E: Young modulus
t: thickness of the plate
b: width of the plate
a: height of the plate
μ- Poisson's ratio
HS- Horizontal Stabilizer

DESIGN, OPTIMIZATION AND VERIFICATION OF THE STRUCTURAL INTEGRITY OF THE PISTON OF A SYSTEM THAT HAS THE FUNCTIONAL ROLE OF A HEAT PUMP

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SUMMARY: This research article represents a study that aims to identify an optimal topology for a heat pump device, considering factors as lifetime, cost and thermodynamics reliability. The device in question is constructed similarly to hydraulic cylinders. Within this paper the overall design of the system, a working cycle and the initial stage of the designing, parametric optimization and validation of the first device's piston integrity are presented. The first parametric optimization is realized using Ansys direct optimization module, The second one is represented by manuals, iteratives improvements of the model based on post-processing the results obtained from the direct optimization module. The objective function of the optimizations is reducing of mass while the restrictions consisting in a minimum lifetime of 36000 cycles and a safety coefficient of stability equal or higher than four.

KEY WORDS: Ansys, parametric optimization, F.E.A., heat pump

1. Introduction

This article focuses on an early phase of optimizing the piston of a heat pump device, presenting also the general design of the device and its working cycle. The finality of this particular research is to identify the optimal piston topology regarding its mass. In order to achieve this objective, a parametric optimization and multiple manuals, iteratives improvements of the model were performed. The parametric optimization was made in Ansys [1], has an objective function of reducing mass, and two restrictions: a minimum lifetime of 36000 cycles and a safety factor of stability equal to or greater than four [2].

2. The general design of the device

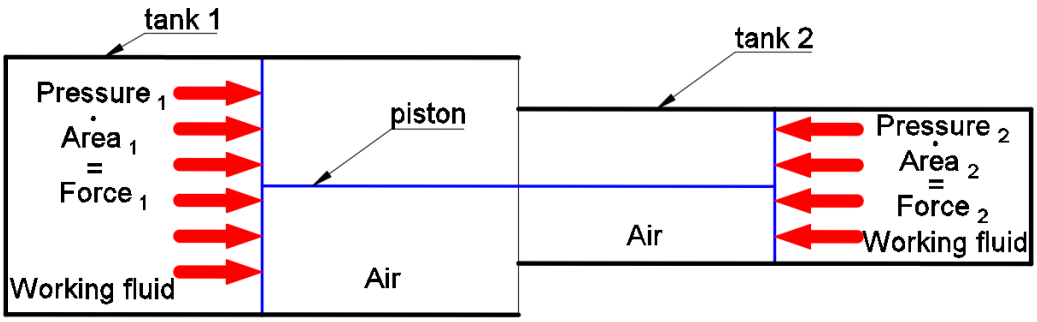

Fig. 1. Sketch of the general design of the device.

In Fig. 1. are illustrated the primary components of the device, which include two tanks of different diameters, each with a sliding lid. The two lids are rigidized one to another by a rod, forming what it will be further called as the piston of the device. The working fluid is constantly in a double state of aggregation, being on his vapor-liquid curve. For the moment, the device is designed, and the piston is

optimized to have carbon dioxide as working fluid. However, once the optimal device topology is identified, the research will continue by identifying a working fluid with superior thermodynamic properties.

3. The working cycle

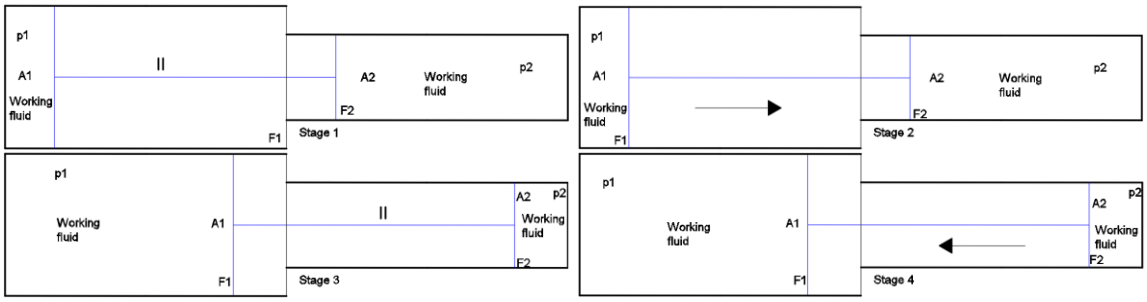

Fig. 2. Collage of four figures depicts the principal phases of the working cycle.

In Fig. 2. are illustrated the different stages of the working cycle. Each tank and lid assembly are characterized by a pressure and area, therefore a force. Initially, the piston is help in place by an external force, as the tanks are at equal pressure determined by the ambiental temperature. When the piston is released, a dynamic imbalance occurs due to the different lid areas, resulting in the movement of piston in the direction of compressing the working fluid from the smaller tank. The compression generates variation of enthalpy on the vapor-liquid curve of the carbon dioxide, leading to heat release. After a period of time the difference between the forces tends to 0 so the piston become balanced from a dynamic point of view. This represents the third stage. In the fourth stage, an external force returns the piston to its initial position, preparing it for the next cycle.

4. The device topologies that will be designed, optimized and verified to find the best option

In this series of research, to identify a suitable topology for the functional role of such a system and the loads to which is subjected, there will be designed, optimized and verified a variety of topologies.

A topology of system includes predominantly the design and the structural verification of the tank and the piston (including its lids).

Topology classification criteria:

1) By the type of the main degree of freedom:
    a. System with the main degree of freedom of the translation type;
    b. System with the main degree of freedom of the rotation type.
2) According to the perimeter shape of the piston ends (criterion valid only for systems with the main degree of freedom of translation type)
    a. System with circular perimeter of the piston ends;
    b. System with stepped shape of the piston ends.
3) By the number of stiffeners placed between the piston ends (criterion valid only for systems with the main degree of freedom of translation type)
    a. System with 16 stiffeners placed between the piston ends;
    b. System with 12 stiffeners placed between the piston ends;
    c. System with eight stiffeners placed between the piston ends;
    d. System with four stiffeners placed between the piston ends;
    e. System with one stiffener placed between the piston ends (the stiffener is present on all the circumference of the end of the piston).

4) By the presence of a stiffener plate positioned on the middle of the piston (criterion valid only for systems with the main degree of freedom of translation type)
    a. System with a stiffener plate positioned on the middle of the piston;
    b. System without a stiffener plate positioned on the middle of the piston.

In the followings, not all combinations that can result from the upper criterions will be studied. The study will start from one of the possible topologies, after this, using the initial configuration will be compared all the possibilities present at the fourth criterion. With the optimal version, will be analyzed in the same manner all possibilities from the third criterion and the procedure will repeat until it will be identified an overall optimal topology.

5. First topology – general elements

Based on the mentioned criteria, the first topology of the system is characterized as having a primary degree of freedom of the translation type, with circular perimetral ends of the piston, 16 stiffeners between the piston lids and no central stiffener plate on the rod.

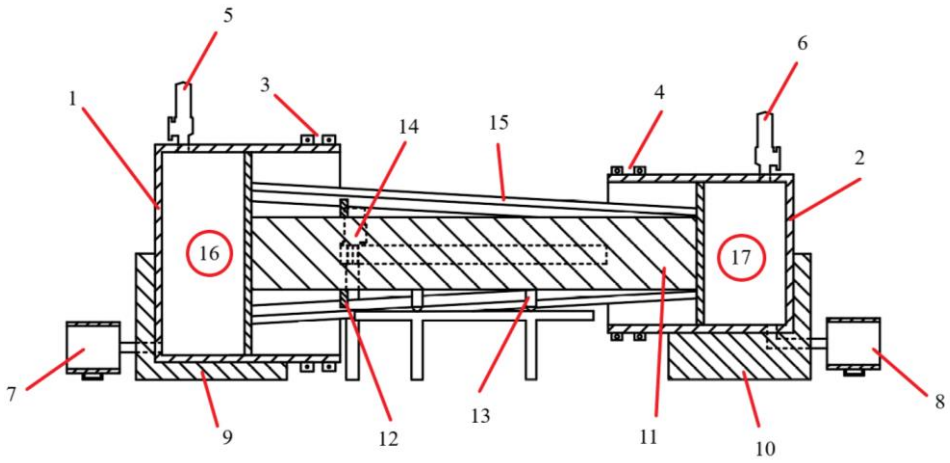

Fig. 3. Schematic drawing of the heat pump with the primary components identified.

Legend: 1, 2 – principal tanks, 3, 4 – stiffening collars of the main tanks, 5, 6 – safety valves, 7, 8 – auxiliary tanks featured with pumps and sense vales, 9, 10 – grounding system, 11 – piston, 12 – stopping element, 13 – the system of ensuring the orientation of the device, represented by guideways (roller supports), 14 – gear electromotor with rack and pinion, 15 – stiffeners of the ends of the piston, 16, 17 – working fluid (represented by carbon dioxide)

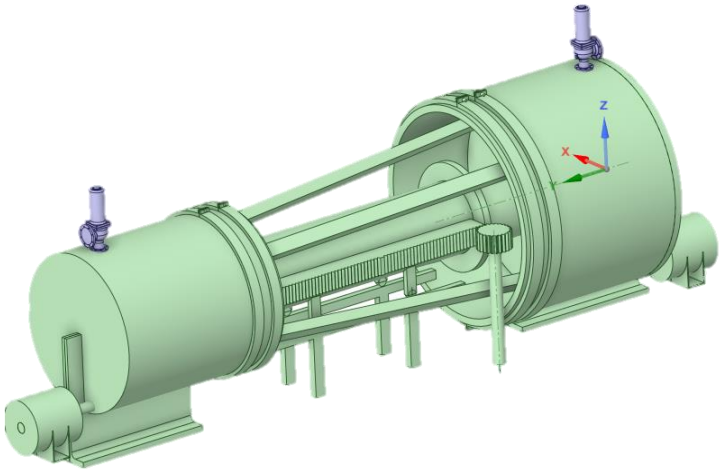

Fig. 4. The 3D representation of the first topology.

6. Parametric optimization and structural verification of the piston of the first topology

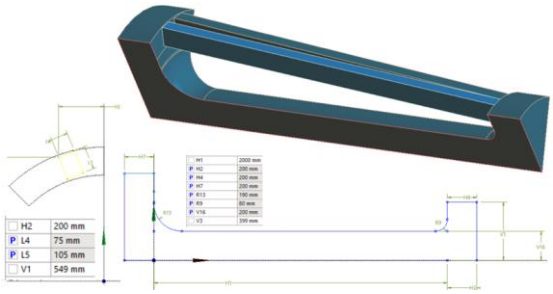

Fig. 5. Collage illustrating the geometry that was utilized to generate the finite element model.

The geometry used for to generate the finite element model was created in Design Modeler instead of Space Claim (as initially tried). Design Modeler offers advantages over Space Claim, such as clarity and ease of setting input parameters. Additionally, mathematical relations can be configured between input parameters to gain more control over the geometry. All the elements indicated with a blue "P" represents input or output parameters. For the input parameters that define the geometry manufacturable values were set before running the optimization analysis. The finite model used represents only one eight of the whole piston.

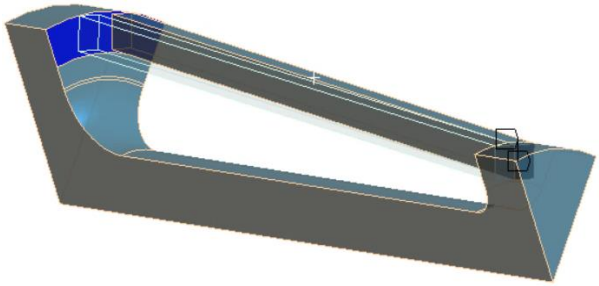

Fig. 6. One of the two contacts of "bonded" type, defined between the stiffeners and the lids of the piston.

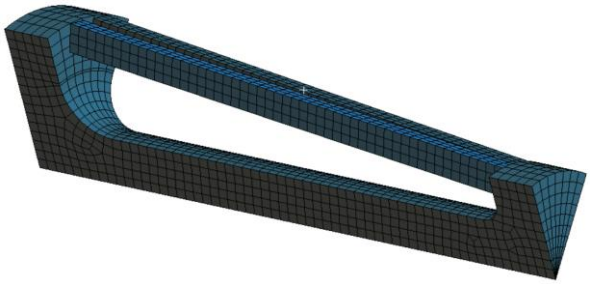

Fig. 7. The mesh of the model (controlled in local and global sizing, mesh method and element order).

The global element size is also configured as an input parameter, the reason will be covered later in this article.

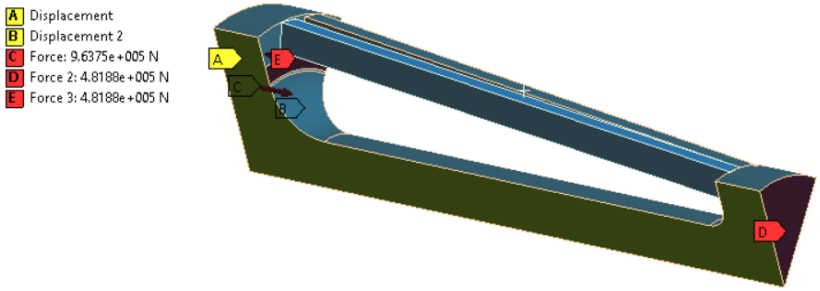

Fig. 8. The boundary conditions (including the loads acting on the structure).

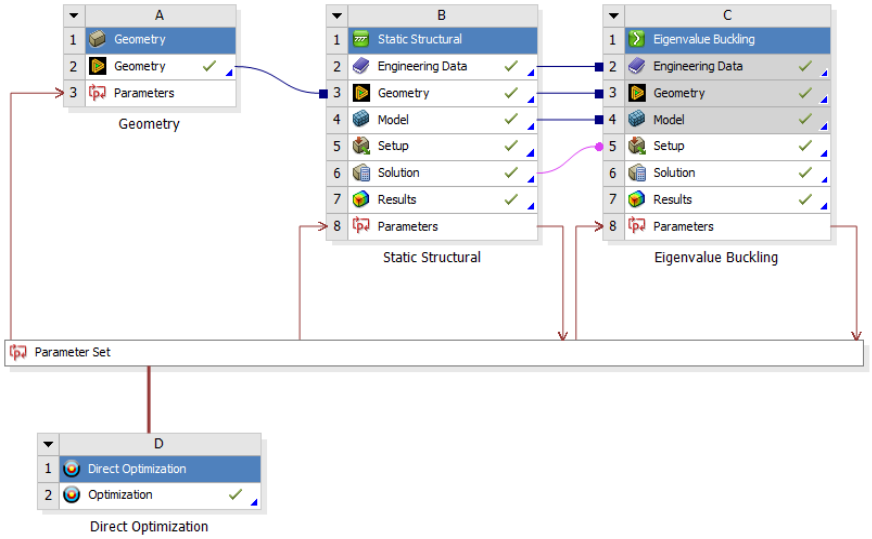

Fig. 9. The optimization project includes a static module with fatigue calculus and a stability calculus module based on eigenvalues and eigenvectors.

The objective function of the optimization was mass reduction, and it has two restrictions: a minimum lifetime of 36000 cycles and a safety factor of stability equal of higher than four [2].

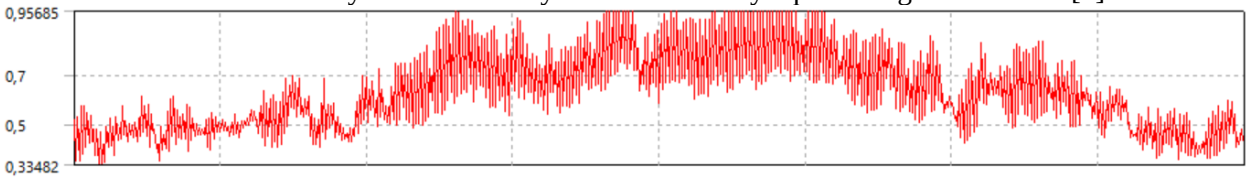

Fig. 10. The diagram illustrating the fatigue cycle.

The daily temperature fluctuations over the course of a year results in pressure changes on the piston lids. To simulate this, was implemented a fatigue block consisting of 365 daily cycles, which is shown in Fig. 10. This fatigue block depicts the fluctuation of the pressure exerted on the piston lids as a consequence of the daily temperature variation experienced throughout each day of a year. The daily temperatures were obtained by the National Meteorological Administration of Romania, using the Meteorological station located in Targul Jiu, and published in the article [3].

To obtain this fatigue block it was created a C++ program that was designed to intersect the daily minimum and maximum temperature with the pressure-temperature expression of the vapor-liquid curve for the working fluid [4] resulting corresponding pressure values for each recorded ambiental temperature.

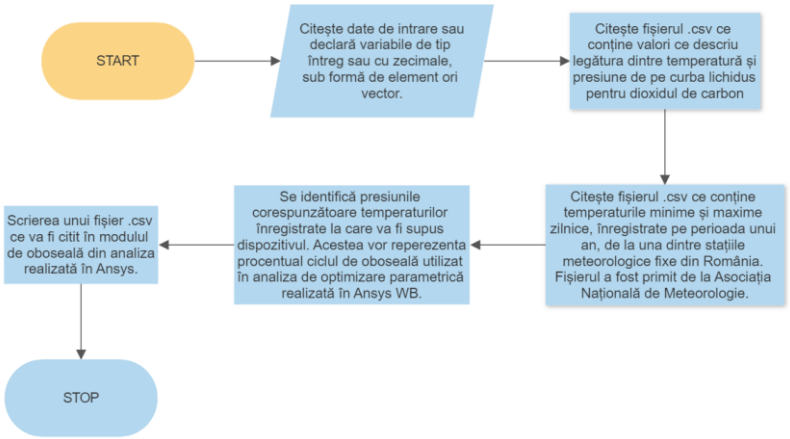

Fig. 11. The pseudocode of the program that generate the pressure fluctuation of a year.

It is indeed true the fact that the approximative working cycle is currently unknown in this stage of the research. However, this particular aspect is not considered extremely relevant in the current phase. Only a rough approximation is needed with the scope of identify an optimal topology, which will be further analyzed subjected to a more realistic work cycle.

In the study of the lifetime, the Soderberg mean stress correction theory was used. This theory, from the ones implemented in Ansys, is the most conservative and returns a zero lifetime for any zone that experiences stress above the yield stress.

The optimization method utilized in the study was the M.O.G.A. (Multi-Objective Genetic Algorithm), which successfully converged after computing 370 design points. The optimization process involved eight input parameters, resulting in a vast number of possible permutations (approximative 0.1 billion). However, this number was significantly reduced by defining the first two inequations depicted in Fig. 12. These constraints ensure that all the design point will have a geometry that can be generated. The final two inequations, which are also visible in Fig. 12, represents the control mechanism of the global sizing of the meshing elements. By controlling the global mesh element size, it had been achieved that all the design points exhibit similar accuracy in terms of stress and load multiplication coefficient, and all this advantages in the smallest computing time.

P20 <= (200[mm]-P22)+80[mm]	P20	<=	(200[mm]-P22)+80[mm]
P21 <= (200[mm]-P22)+190[mm]	P21	<=	(200[mm]-P22)+190[mm]
1	(P20*P20*(1-3.14/4)*2*3.14*(P20+P22)/2.37+P21*P21*(1-3.14/4)*2*3.14*(P21+P22)/2.37+564.2[mm]*564.2[mm]*3.14*P19+399[mm]*399[mm]*3.14*P17+2000[mm]*3.14*P22*P22)/(8*9000/4)	>=	P33*P33*P33
2	(P20*P20*(1-3.14/4)*2*3.14*(P20+P22)/2.37+P21*P21*(1-3.14/4)*2*3.14*(P21+P22)/2.37+564.2[mm]*564.2[mm]*3.14*P19+399[mm]*399[mm]*3.14*P17+2000[mm]*3.14*P22*P22)/(8*15000/4)	<=	P33*P33*P33

Fig. 12. The constraining inequations used in the optimization.

7. Manual optimization of the piston of the first topology

The results of the parametric optimization realized in Ansys optimization module were post-processed and was concluded that the model can be further enhanced. All the results can be analyzed in chapter 8. Results. Because of the fact that the model could be further enhanced the following solution and procedure in two steps was implemented. The first step had consisted in obtaining a dimensionless factor, defined for each input parameter, that signifies both the sensitivity of the of the structure's mass and its reliability. The equation that defines this parameter is Eq. (1), where *m* represents the mass and *c* the safety factor for two design points 1 and 2. These two design points differ in only one input parameter.

$$S = \frac{\sum_{i=1}^{n}\left(\frac{m_{i1}-m_{i2}}{c_{i1}-c_{i2}}\right)}{n} \tag{1}$$

This step was realized using a C++ code, which has the pseudocode presented in Fig. 13, that imported all the 370 design points (as input and output parameters) calculated in the Ansys optimization module. After this, the program identifies all sets of two design points that differs in one input parameter, and calculates the dimensionless factor presented in Eq. (1) for each input parameter. This factor is a measure of how much a parameter influences the structure both in mass and stability safety coefficient. Using the resulted sensitivities, it was clear which parameter should be decrease in order to obtain a more reliable model. After each modification, the analysis was run and the sensitivity for the changed parameter was recalculated. Then, the parameter with the greatest sensitivity was reidentified and procedure was reapplied. In only nine of these iterations, the Ansys optimized model was decreased in mass with an additional 30%. Additionally, it is no longer necessary to have predefined values for the parameters, so the last obtained model was again manually optimized.

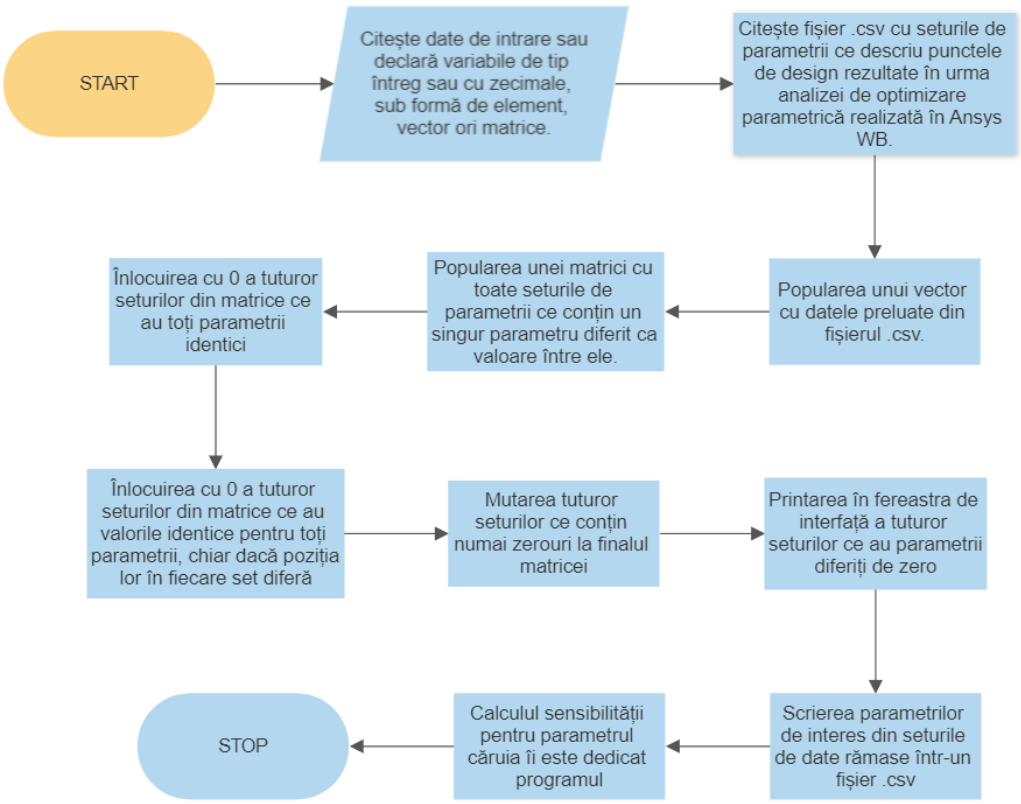

Fig. 13. The pseudocode of the program that calculates the sensitivity factor.

8. Results

The results of the optimizations are presented tabular, following this paragraph, being observed an overall mass reduction of 81.5%, percentage not necessarily relevant since I intentionally chosen a robust initial model, resulting section of the stiffeners of the piston are similar to the ones obtained analytically.

Table 1. Concatenated Results

Parameters	Initial model	Ansys optimized model	Manually obtained model (9 steps)	Manually obtained model (no predefined values)
Tank two - diameter lid thickness (H4)	200 mm	80 mm	40 mm	38 mm
Tank one - diameter lid thickness (H7)	200 mm	80 mm	40 mm	37 mm
Tank one – stiffening radius (R13)	190 mm	190 mm	140 mm	125 mm
Tank two – stiffening radius (R9)	160 mm	160 mm	140 mm	140 mm
Core radius (V16)	200 mm	80 mm	60 mm	59 mm
Stiffeners of the lids section width (L4)	75 mm	45 mm	45 mm	45 mm
Stiffeners of the lids section length (L5)	105 mm	55 mm	55 mm	48 mm
Minimum lifetime	10^6 cycles	10^6 cycles	38061 cycles	36378 cycles
Equivalent von Mises stress	24,73 MPa	98,54 MPa	202 MPa	202 MPa
Multiplying loads coefficient	57,25	5,84	4.67	4.0216
One eight of the resulting structure mass	6585.2 kg	2026.25 kg	1357 kg	1218.8 kg

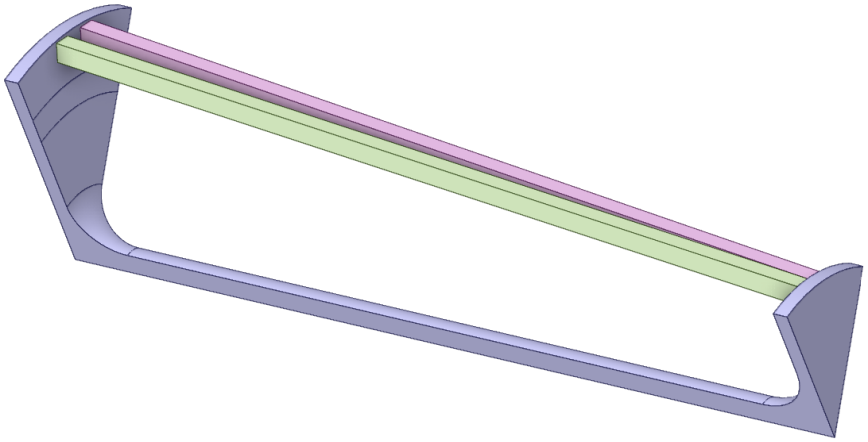

Fig. 14. The geometry of the resulted optimized model.

9. Conclusions

In this initial paper of a series, the author introduced the overall design of a device specifically developed as a heat pump, intended to utilize ambient temperature and energy for its functional purpose. The paper also presented the operational principles and the functioning of this device through the described work cycle. Additionally, an examination of various topologies was conducted to enable a future comparison and identification of the most optimal among them.

The design and initial phase of verification and optimization for the structural piston of the first technology were also introduced. The optimization process contains two optimizations, one realized in Ansys, and another one realized in a manual manner. The objective of the optimization analysis done in Ansys was to minimize the mass and had to two constraints: a minimum lifetime of 36,600 cycles and a stability safety factor of four or higher [2]. The achieved mass reduction between the initial and final models amounted to 81.5%, although the significance of this percentage is currently not substantial.

On short term, the next step is creating a Python program, using the PyMAPDL library, which will be used as an optimization module for this device. In this optimization module, with the data obtained after an initial set of design points which will be controlled by the user of the program (this represents a consistent advantage over using Ansys optimization module for example) an neural network will make prognostics about other design points (not calculated yet), for each prognostic the model will be run and compared the results with the values predicted by the artificial intelligence. This procedure will be repeated until the results and the predicted values will converge, and from that point on will be chosen the optimal model based on the predicted values that can be made on millions of design point in a very short time.

On long term the author will apply the same procedure on different tanks and, after this step, on other topologies with the scope of identification of the optimal version for these devices.

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DETERMINATION OF THE STRESS AND STRAIN STATE IN THE MOUNTING SOLUTION OF PARALLEL ACTING INDUSTRIAL ROBOT

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The present work aims to evaluate the stress and strain state in the case of the mounting plate of a parallel actuation robot. In this study, an analysis based on the finite element method will be used, more precisely a transient regime analysis. To provide the necessary input data for recreating the robot kinematics, offline simulation and programming of the industrial cell, performed for the purpose of assembling electronic components in mobile phone cases was carried out. Therefore, based on the cyclograms of movement obtained after the realization of a program necessary to obtain a work cycle, the robot can be recreated cinematically. The robot kinematics can be realized after defining all the kinematic couplings in ANSYS Code. Also, the purpose of this study, in addition to verify such a structure intended to support a DELTA-type robot, was also to design a modular structure made of aluminum profiles and stiffening elements in addition to components such as the conveyor having an active role in running an industrial application.

KEY WORDS: Paralel acting robots, Robot kinematics, Transient analysis, Industrial cell design, Offline programming

1. Introduction

In order to achieve the integration of robots with parallel actuation within an industrial cell, it is necessary to realize and design a structure for the location of the base of these robots. This topic of designing such a DELTA robot mounting solution is quite sensitive, as the stresses to which the structure is subjected must be evaluated. In the case of any mechanical structure subjected to the action of some forces (in our case inertial and overturning moments), deformations occurred can affect the positioning precision but also the accuracy with which the robot can accomplish a trajectory described in the program; consequently, the achievement of a certain type can be compromised of application. Also, one of the main aims of this study was the creation of an industrial cell dedicated to the assembly operations of various electronic components within mobile phones. All elements of the assembly cells have been selected or designed in order to obtain a variant of such a fully automated cell.

Based on the simulation and offline programming of the robotic assembly cell, the data related to the movement of the numerically controlled axes will be extracted, and these data will be further used in the transient analysis

2. Current state

The modeling of the cell as well as its simulation was completely realized in the ABB-Robot-Studio software. The motion data of the ABB-IRB-360 (DELTA) robot was obtained based on offline simulation and used in the analysis of its base mounting structure.

A parallel actuation robot made by the ABB corporation is the type of industrial robot that is included in the automation cell used for the assembly process of electronic components. This robot is the

fastest in its class, and from the standpoint of carrying capacity and the range of motion that determines the working area, it can carry out all the tasks necessary for the suggested application.

In Figure 1, the main objective of the work can be observed, namely the exploitation of robots with parallel acting to increase the degree of automation of the production of smart phones.

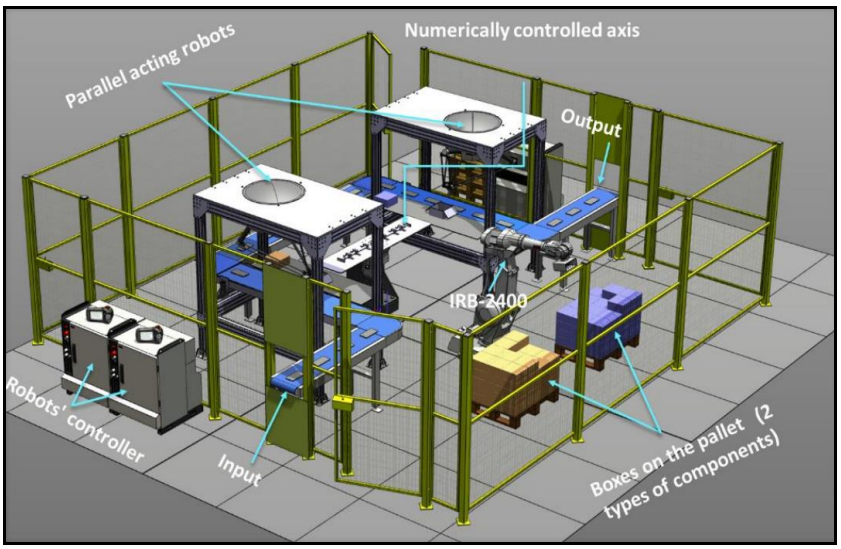

Figure 1. Design of the industrial cell

3. Design of structural elements

For the suspension of the DELTA robots, a structure made of aluminum profiles of different sizes was designed, with stiffening elements. At the structure level, additionally a conveyor serving the transportation parts for the DELTA robots has been added.

The design of the assembly dedicated to the location of the IRB-360 robot is also based on the possibility of calibrating the robot. Thus, the distance between the aluminum profiles is a concern to allow the movement of the robot segments to the points dedicated to its calibration. Within the structure of the location of the robot base, there are also elements with an active role, such as the belt conveyor for transporting objects, a camera for detecting the position and orientation of objects, etc.

In Figure 2, one can observe the virtual prototype of the support structure, but also the method of fixing the robot.

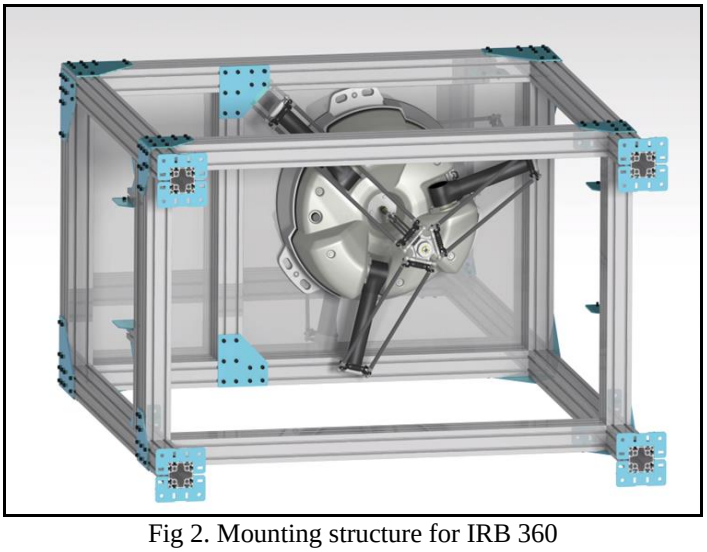

Fig 2. Mounting structure for IRB 360

The technical drawings of the structure taking into account the gauge dimensions and other dimensions of interest were obtained based on the 3D structure modeled in CATIA V5.

In Figure 3, one can observe the 2D technical drawings that have the role of facilitating the assembly part of the designed structure.

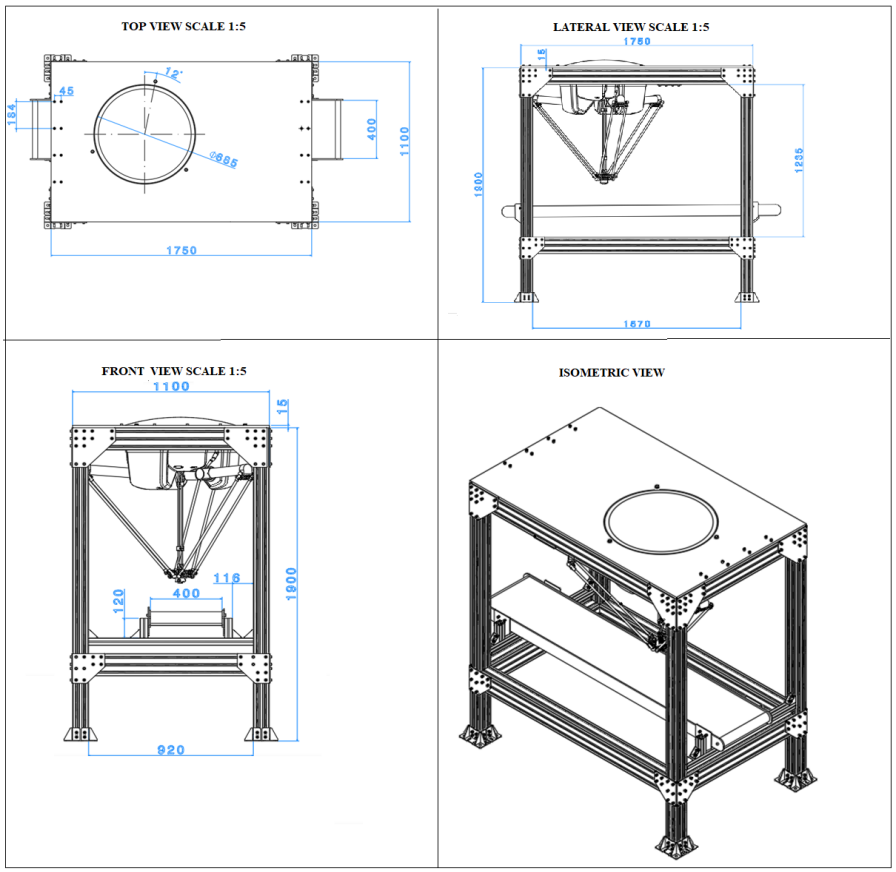

Fig 3. Technical drawings of mounting structure for DELTA type robot

3. Offline programming

In accordance with the assembly process, the robots integrated in the automation cell were programmed to achieve the duty cycles associated with the assembly of the electronic components. As a way of programming industrial robots, offline programming and simulation is used through the programming language dedicated to ABB robots called RAPID [1], [2].

Thus, the articulated arm type robot with 6 degrees of freedom has the role of facilitating the transfer of boxes with electronic components to workstations equipped with ABB IRB-360 parallel drive robots. DELTA ABB IRB-360 robots carry out the assembly process of the two types of electronic components, namely batteries and speakers.

One of the essential elements of the offline programming was obtaining the movement characteristics of the robot because these signals will be used in the finite element analysis which aims to evaluate the von Mises stresses and the deformations appearing in such a structure.

In Figure 4 one can observe the movement signals of the robot with parallel actuation, extracted from the robot controller (IRC5 Single Cabinet). These motion signals will be found as motion data on the kinematic couples recreated in ANSYS.

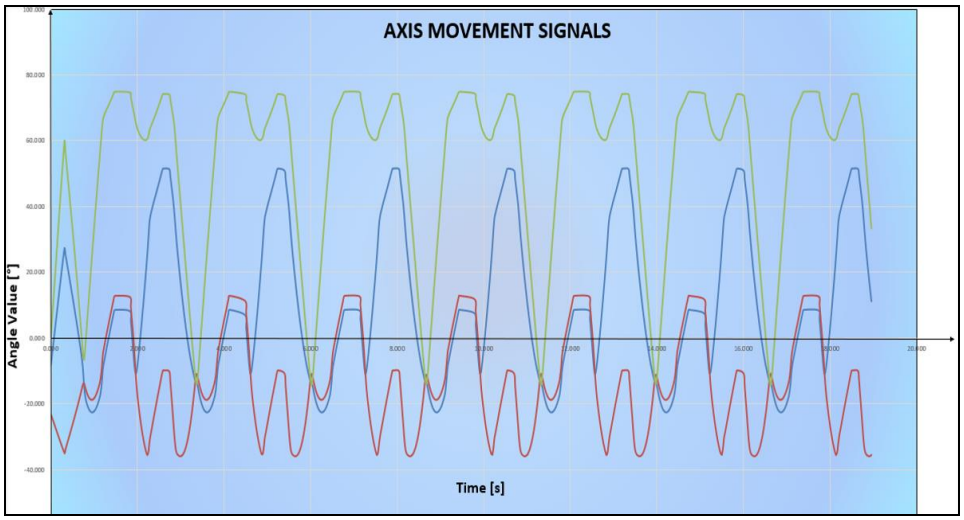

Fig 4. Axis movement signals

4. Structural analysis of modular structure for mounting the DELTA type robot

To assess the behavior of the structure that one of the robots is installed on, the authors of this study performed a transient analysis. A fundamental three-dimensional model is utilized in every FEM investigation. Since some components of the original model have a negative impact on the analysis, this fundamental model has been streamlined. In this study, a file import from CATIA V5 is the first step in the FEM analysis, which is then followed by a structure simplification based on the basic model (Figure 5).

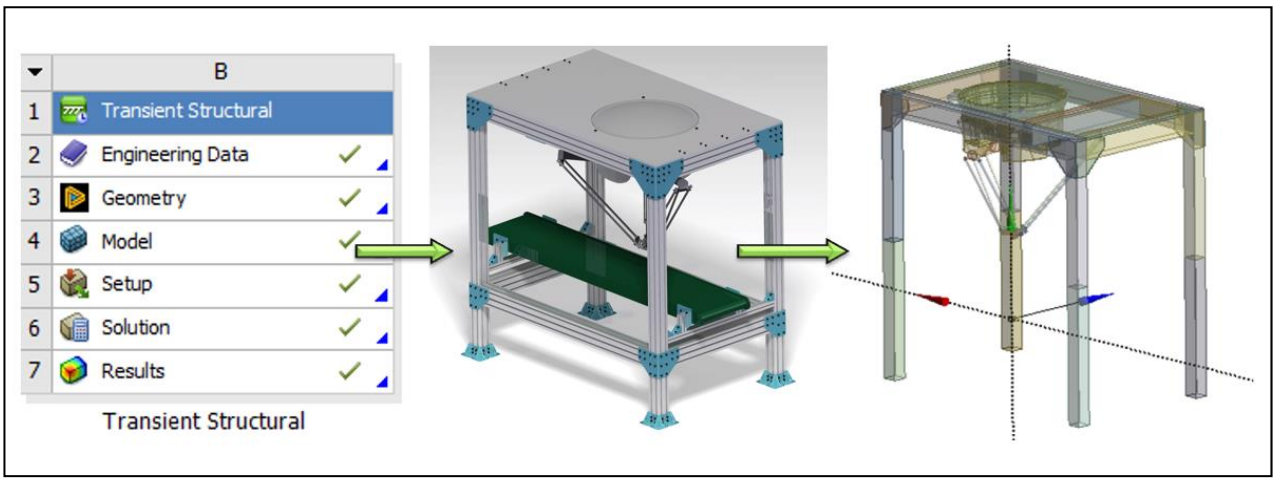

Fig 4. Simplified geometry

The next stage for performing the transient analysis is defined by recreating the kinematic couplings and simulating the robot's working cycle based on the data extracted from the offline programming and simulation software provided by ABB (Robot Studio).

In the case of the parallel actuation robot, these are three cylindrical joints (from the three segments of the RI), four spherical joints for the articulated quadrilaterals to connect the robot segments to the actuated movable element, plus six more spherical joints from the actuated movable element [3].

The definition of kinematic couples is depicted in Figure 5.

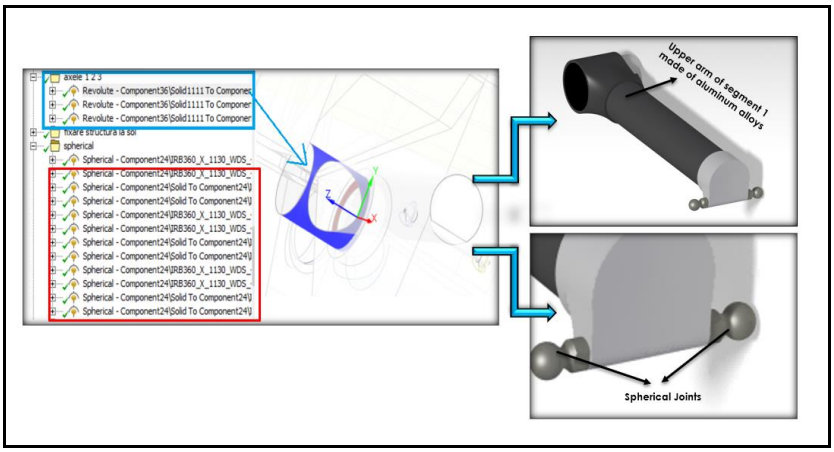

Fig 5. Joints definition

The definition of materials is very important in finite element analysis because the actual study is performed according to the data presented in the robot data sheet. In this sense, the sum of all the volumes for the partial assemblies (robot base, robot segments, actuated mobile element) must be exactly as in the data sheet. Therefore, by using the "measure inertia" function in CATIA V5, the volume of these subassemblies is calculated and, in accordance with the technical sheet, a specific density is assigned to the material from which the robot components are made. After simplifying the geometry and defining the kinematic joints, it was necessary to define and to allocate the specific materials to each element of the robot structure. In Figure 6, a. one can observe the materials that are used in the transient analysis.

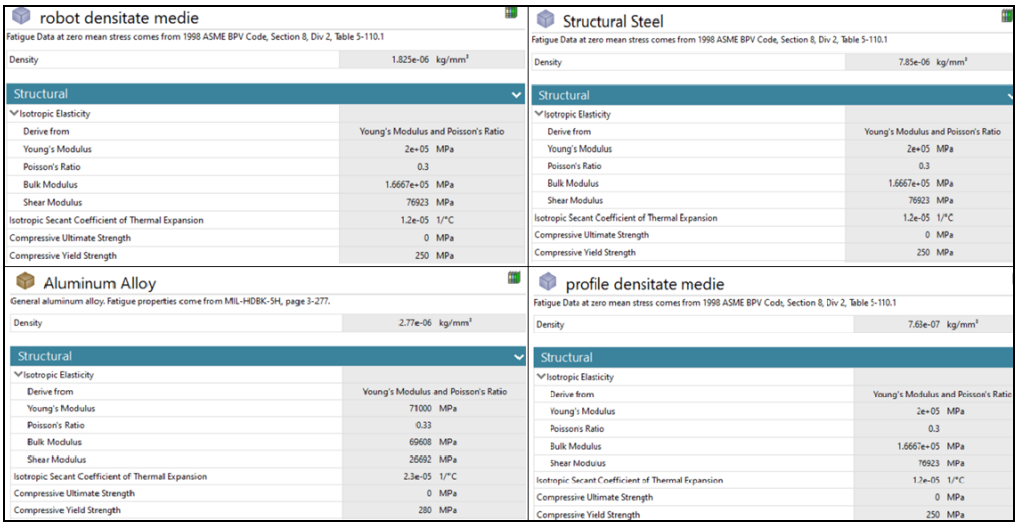

Fig 6. Materials properties

Structural steel was selected for the top plate whereas the aluminum for the robot arms. The materials chosen for the robot segments are those presented in the product manual, where it is specified that the segments of the three-robot axis must generate small moments of inertia. The meshing was controlled at a global level, as a local level. Globally, the meshing type elements have been set to be of second order, with a size of 40 mm. At a local level, the authors imposed a size of 20 mm for the meshing elements, the discretization being refined around the robot fixing holes. At the same time, it was used the sweep method with two elements, these settings having the role to ensure correct results in the shortest time [4]. The structure meshing is shown in Figure 7.

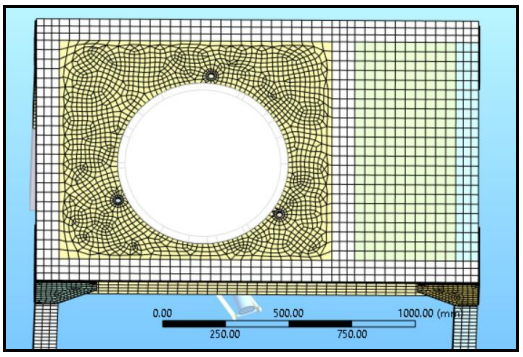

Fig 7. Controlled mesh

5. Results interpretation

Although the structure is safely to use, the integrator will take into account the calculation of the structural fatigue stress because a robot frequently repeats the same work cycle. Equivalent stress distribution is shown in Figures 8.a and 8.b, with a maximum value of 24,739 [MPa].

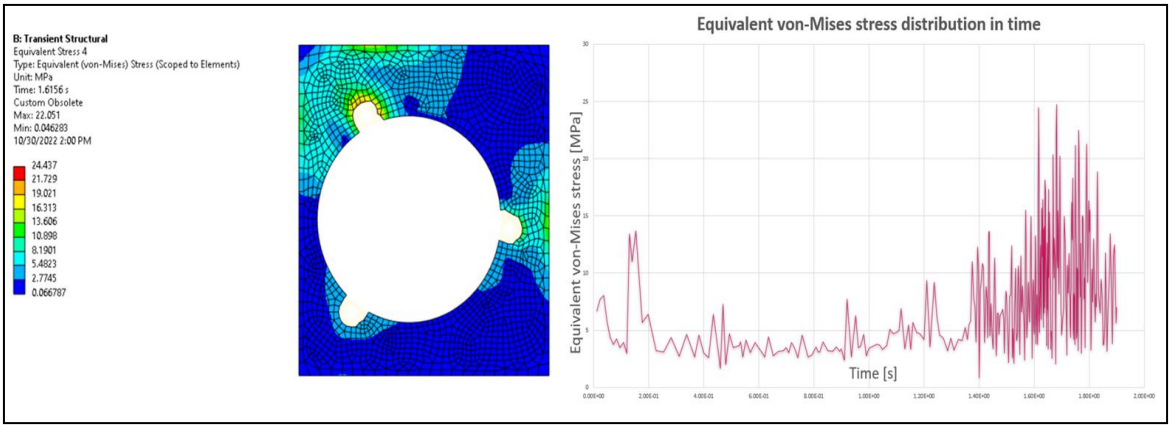

Fig 7. von Mises stress distribution

Also through this transient analysis, the value of the deformations in the steel plate on which the base of the robot is mounted, a value of 0.165 [mm] was obtained. This deformation value affects the positioning accuracy by a percentage of 32.5% if we refer to the robot specifications, and in the case of the proposed industrial application we consider that the operation of the robot is not compromised due to its mounting structure

5. References

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FINITE ELEMENT ANALYSIS OF MECHANICAL AGRICULTURAL PARTS

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ABSTRACT: This paper aims to provide valuable information about stresses in the tillage domain, one of the most known sectors in agriculture. A finite element analysis regarding the parts of this equipment is done using a dedicated software, Ansys Workbench, and analytical calculations have been estimated for corelating with the FEA results. Finally, critical sections are observed, and conclusions are drawn.

KEYWORDS: tillage, agriculture, spring, cultivator, finite element analysis.

1. Introducere

The purpose of this research is to do a Finite Element Analysis (FEA) on common tillage equipment used in agricultural applications. Tillage tools are subjected to a variety of loads in operation, therefore maintaining structural integrity is vital to extending their lifespan and improving their performance.

A FEA study helps us to predict how the tillage equipment will respond under different loading conditions and identify potential failure or deformation zones. The findings of the investigation might provide valuable ideas for improving the development and manufacture of tillage equipment, which would assist farmers and the agricultural industry by increasing output and decreasing costs. Finite element modelling (FEM) is used to examine complicated physical systems or structures. It involves dividing a bigger structure into smaller, finite parts, each with their own set of features and characteristics. These pieces are then joined at discrete places – nodes, to form a mesh that can be studied under different loading conditions providing a good visualization of the structure.

In our country, agriculture plays a significant role because people depend on it. Being the primary source of food, it is also an important economic contributor worldwide, this sector providing employment opportunities, which I also look forward to.

Throughout the mid-twentieth century, there was a considerable shift toward conservation tillage, which attempted to limit soil disturbance and conserve soil quality. This resulted in the invention of new tillage instruments, such as chisel plows and field cultivators, which were designed to work the soil at shallower depths and leave crop residue on the surface. Tillage tools are still evolving in response to technological and technical improvements. Many current tillage tools, for example, are built using computer-aided design (CAD) software and made with high-strength materials such as steel alloys. Furthermore, some tillage instruments now have modern features like as GPS navigation systems and hydraulic depth control.

Under the impact of the forces that give content and personality to the revolution in knowledge, society will undergo essential mutations, qualitatively superior, mutations that, as time progresses, will be on an increasingly upward slope. The increasing intensity of this process is guaranteed by the progressive power of the great scientific discoveries that emerged from the 2nd half of the last century [1].

Objectives of finite element analysis in this paper include the following: strength calculation, results interpretation, results comparison, and discussion.

2. Model understanding and analysis

The following model represents an agricultural cultivator. The CAD model (Fig. 1) is imported from Grabcad [2] and then adjusted and simplified in Design Modeller from Ansys to obtain a better model for the following finite element analysis.

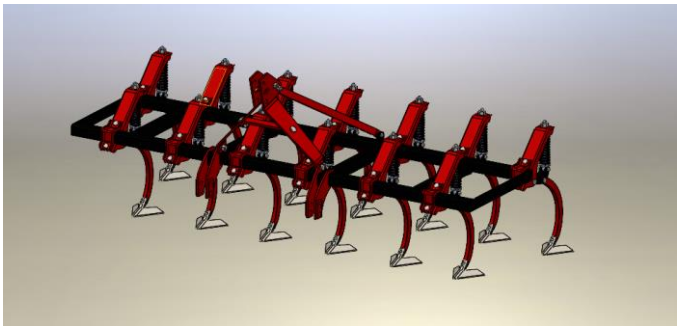


Fig. 1. Cultivator model imported into SolidWorks.

In order not to be distracted by the complexities of the entire machine, only a section (unit) of the cultivator was first analysed to gain deeper understanding of the mechanics and workings of that unit. This way, critical zones will be observed properly, and improvements may be suggested. The analysed unit is composed of several parts, each with its own function (see Fig. 2).

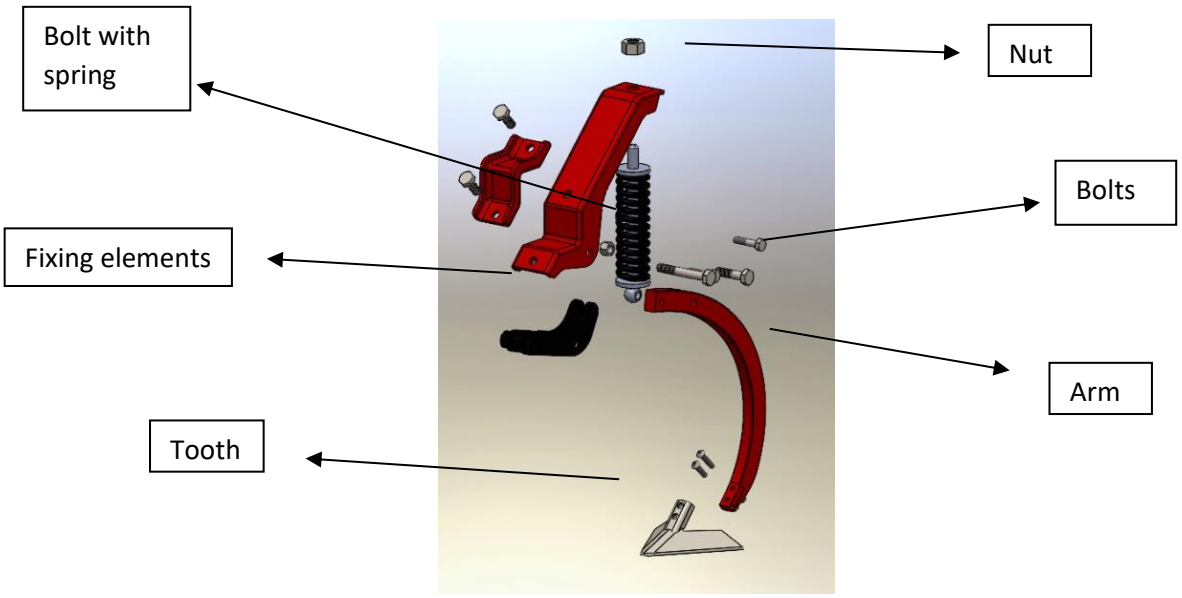


Fig. 2. The analysed unit in Ansys - exploded view.

The tooth is in V-shape to better penetrate and to minimize soil disturbance, improving the efficiency of the operation. The arm has a curvature radius of 280 mm reducing stress concentration and better distributing the load along its length. Fixing elements, including bolts and nuts, create a strong and reliable assembly which is then attached to the main frame.

The most important part is the bolt and spring part, which takes over a big part of the transmitted load. The design is made so that the arm moves backwords when the tooth section meets strange objects (rocks, tree roots etc.) and the length of spring will shrink. Because it represents a critical part in the model, the analysis shall first be focused on the spring. The figure 3 contains measures done on the bolt and spring assembly, measures that are needed for the analytic calculation.

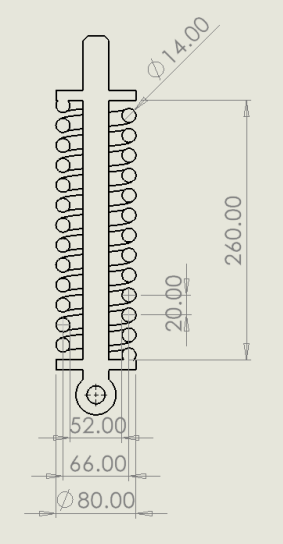


Fig. 3. Bolt and spring dimensions.

The spring model consists of a round-wire helical spring which is compressed by an axial force *F* while the downwards position, in the bolt that attaches the model with the rest of the components, is fixed. Using an engineering handbook [3] the maximum shear stress is calculated:

$$\tau = K_B \frac{8F \cdot D}{\pi d^3}. \tag{1}$$

The equation above is quite general and applies for both dynamic and static loads. K_B represents the Bergsträsser factor, which corrects both for curvature and direct shear, and is given by the measure of the coil curvature, the spring index *C*, defined as

$$C = \frac{D}{d}, \tag{2}$$

and then

$$K_B = \frac{4C+2}{4C-3}. \tag{3}$$

In our case, *C* has a value of 4.7, but for most common springs it is recommend to range between 6 and 12. Furthermore, the spring deflection *y* is computed using [3]

$$y = \frac{8F \cdot D \cdot N}{d^3 \cdot G}, \tag{4}$$

where *N* is the number of active coils and *G* is the shear modulus for steel. The total strain energy *U* is characterised by two components, shear and torsion:

$$U = \frac{T^2 \cdot l}{2GJ} + \frac{F^2 l}{2AG} \tag{5}$$

Knowing that [3]:

$$T = \frac{FD}{2}; \qquad l = \pi DN; \qquad J = \frac{\pi d^4}{32}; \qquad A = \frac{\pi d^2}{4}, \tag{6}$$

it results:

$$U = \frac{4F^2D^3N}{d^4G} + \frac{2F^2DN}{d^2G}\,. \tag{7}$$

Finally, the spring rate *k* is computed:

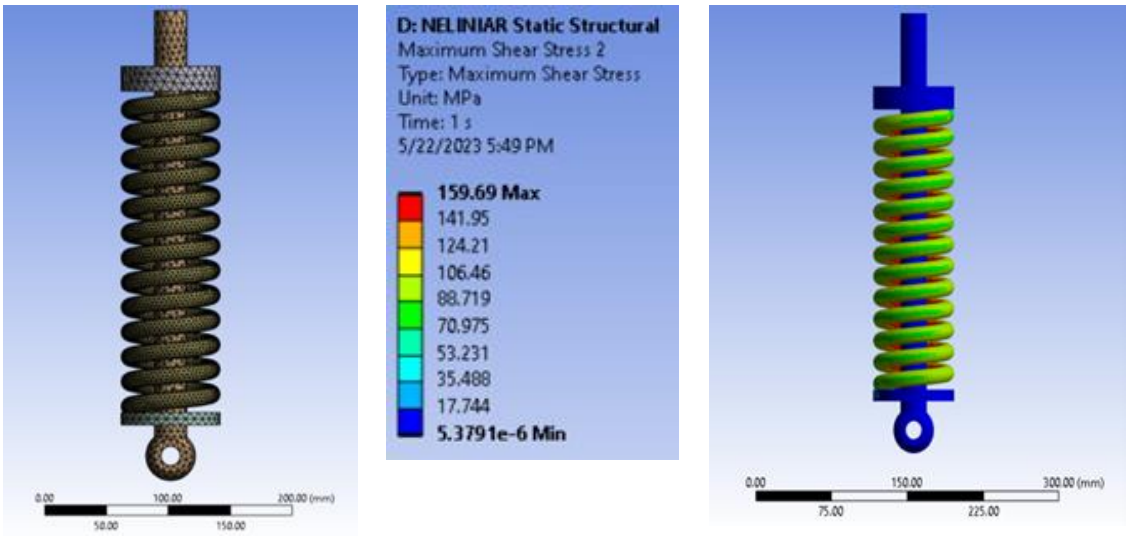
$$k = \frac{F}{y}; \qquad k = \frac{d^4G}{8D^3N}\,. \tag{8}$$

Results of the calculations may be affected by the spring index *C* and the different correction factors (K_B, K_W, K_S or K_C) used in literature [3]. A higher value is recommended for *C*, at least 8, and other correction factors directly influence the shear force results [3]. In Table 1, a comparison between the correction factors and maximum shear stress is presented for nominal force in the spring.

TABLE 1. Maximum shear stress in spring coil for different correction factors

Spring						Correction factor				SHEAR STRESS			
Force	Mean coil diameter	Wire diameter	Active coils	Shear modulus	Spring index	Bergsträsser	Wahl						
F[N]	D[m]	d[m]	N[-]	G[Gpa]	C[-]	Kb[-]	Kw[-]	Ks[-]	Kc[-]	τ [MPa]			
1890	0.066	0.014	13	79.3	4.7	1.315	1.332	1.106	1.189	152.262	154.237	128.039	137.662

The geometric complexity of the spring suggested a tetrahedron meshing type, with quadratic elements (10 nodes per element), this way the model is better discretizated without sacrificing the element quality.The FEM for bolt and spring (Fig. 4,a) includes a number of 99712 nodes and a total of 58905 nodes. Results may be affected by the total amount of finite elements (meshing density), so a finer discretization with a higher number of elements would provide better results. In this case a comfortable limit of 100,000 nodes is considered.



(a) Spring and bolt mesh (b) Maximum shear stress distribution

Fig. 4. Bolt and spring meshing and stress results.

Applying a force F_{tooth} on the tine (tooth) of the cultivator, a moment is created (see Fig. 5). Following the distances *B* (576.8 mm) and *b* (238.5 mm) with the respect to the point (*O*) a counterforce F_{spring} is computed (Fig. 5). This may be proven by the use of the following equation:

$$\sum M_O = 0 \qquad \Leftrightarrow \qquad F_{spring} \cdot b = F_{tooth} \cdot B\,. \tag{9}$$

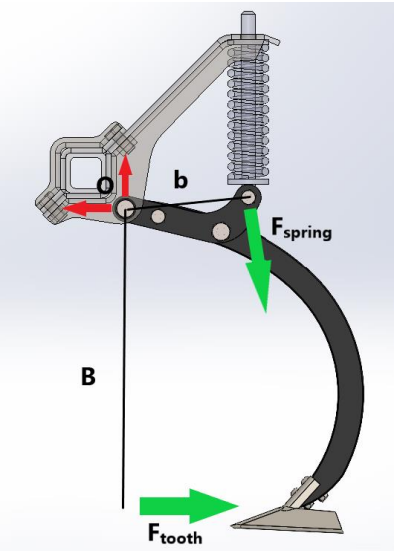
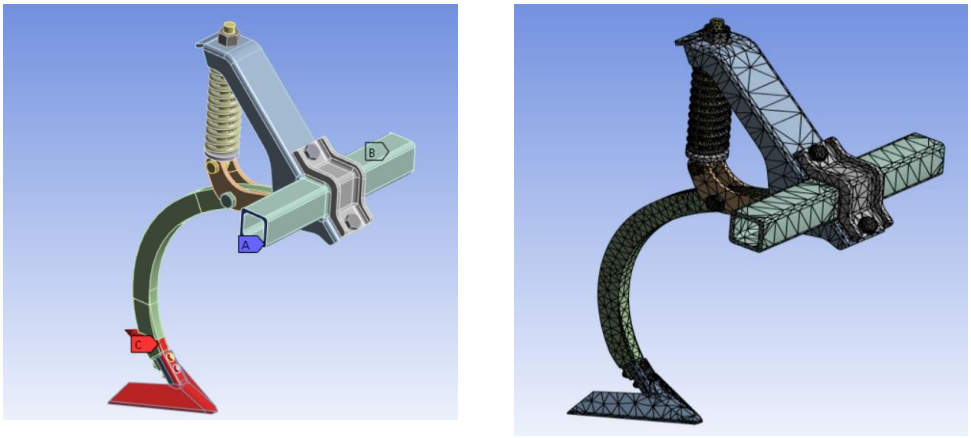


Fig. 5. Free body diagram for arm.

For the loading conditions, a force F_{tooth} of 1000 N is applied on the tine region (see point C in Fig. 6,a) and fixed supports are inserted at the frame cuts in A and B (Fig. 6,a). Tetrahedral elements were used to mesh the model, with smaller elements of same size applied in contact zones to ensure accurate modelling of contacts between parts.

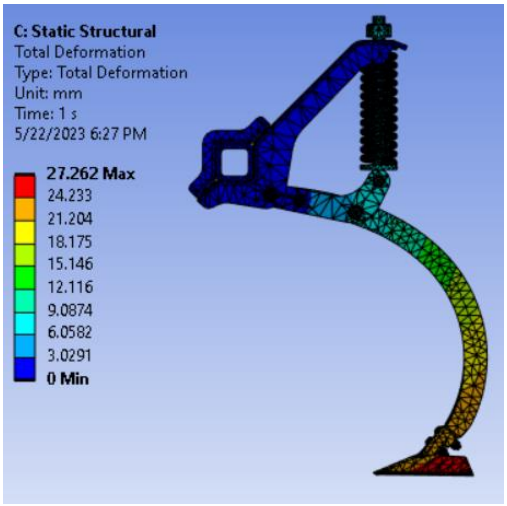


(a) Supports and applied force (b) Assembly meshing

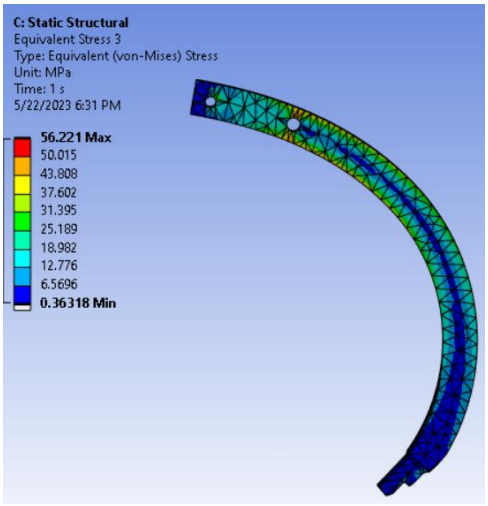
Fig. 6. Boundary conditions and mesh setup in the unit finite element model.

Different type of contacts are used. For bolt and nut regions it is assumed that the parts are perfectly connected and can transfer loads without any relative motion between them, so the “Bonded” option is set, while in contact regions between fixing elements and bolt, “No separation” options is set because there is no separation between the parts. After the contact regions are set, the simulation is performed.

Some representative results, total elastic displacement of the repetitive analysed unit finite element model and the von Mises stress distribution in the arm are presented in Fig. 7.



(a) Total deformation of the unit FEM



(b) von Mises stress distribution in the Arm

Fig.7. FEA results.

3. Conclusions

After examining the cultivator subassembly in Ansys Workbench and performing the finite element analysis, stress distribution zones are observed and assumptions about critical zones are drawn. As predicted, the arm take over a big part of the stress which is then distributed to the bolt and spring section. Being a safety mechanism, the spring compresses and further failures in the rest of the cultivator are minimized.

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A COMPARATIVE NUMERICAL STUDY OF DENTAL IMPLANTS

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ABSTRACT: In the present study, the goal was to create a finite element model of two different dental implants by using 3D Scanning to accurately reproduce the geometrical features of the implants. These models were created to obtain preliminary results on the stress distributions in the two implants to identify the maximum stress zones by applying an axial force with a value taken from the literature. The main drive to do this initial study is to prepare a more complex model of the dental implant system which will take into consideration the mechanical properties of the edentulous and dentate bone with its different zones (cortical and trabecular).

KEYWORDS: dental implants, finite element, 3D Scanning, NASTRAN, FEMAP

1. Introduction

The present study has the main goal to model two dental implants, starting from 3D scanning, by using a finite element method (FEM) preprocessor and to determine the stress distribution into implants by means of a static structural analysis with an axial load on the implant, emulating the occlusal load.

The stages applied for achieving the CAD (computer Aided Design) models of the implants for subsequent FEM evaluation consist of 1- acquiring the dental implants, 2- reconstruct their virtual geometry by 3D scanning means, 3- prepare the geometry using Computer Aided Manufacturing (CAM) software (Autodesk ReCap Pro and Autodesk Fusion 360) and 4-then import the geometry file in a FEM preprocessor to model it. The software used for the FEM pre- and post- processing was FEMAP v12.0.1 and the solver used for generating the results was NASTRAN 2019 FP1.

To create a trustable finite element model, adapted to clinical reality, a literature study was done regarding the medical terms, the phenomenological aspects in the implant region and other FEM studies. In this respect, the main papers that were reviewed were published in medical and biomechanical journals.

The last goal was to prepare a more complex model plan to continue this study by modelling the implant system using bone regions and computer tomographic images (CT) to reduce the errors given by the approximations used in this study. This last goal was achieved by studying different publications regarding the mechanical properties of edentulous and dentate human bone structures with or without an implant system present. This plan refers also to using non-conventional modelling of the affected areas by using element types specific to NASTRAN.

2. The dental implant

A dental implant is a treatment solution for replacing missing teeth (this pathology being named edentulism). The dental implant is a prosthetic structure made of alloplastic materials (materials which are biocompatible but are not naturally present in the human body). It will be implanted in the oral tissue beneath the mucosa and periosteum, through the bone for retention and support of the crown or prosthesis.

The common implant prosthesis has three main components: the implant (the screw which will be implanted in the oral tissue), the abutment and the dental crown, as it is presented in figure 1.

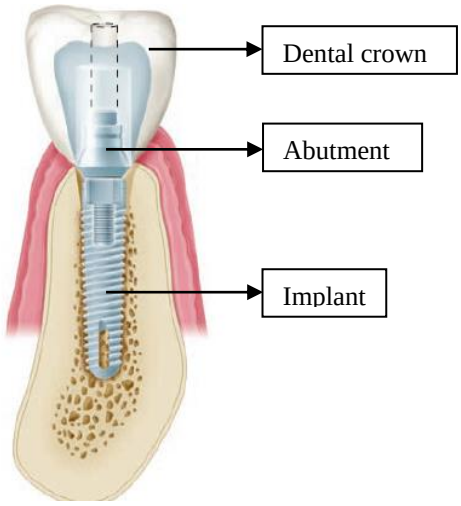

Fig. 1 **Implant assembly components**

The most common biocompatible materials used in nowadays dentistry are Titanium alloys, hydroxyapatite, zirconium, and sapphire bio ceramics. Zirconium is commonly used for the dental crowns, for the abutments, titanium alloys, while the implants are mostly made of titanium alloy.

For each of the three parts constituting the implant assembly (figure 1), there are lots of variations in shape. In the following, a classification taken from paper [1] is presented. The four main implant types are presented in Figure 2. Implant type A is a screw implant made of titanium alloy with no surface treatment, Implant type B is a titanium alloy screw implant plasma coated, type C is a cylinder implant coated with hydroxyapatite and the last type of implant (D) is a cylindrical titanium alloy implant plasma coated.

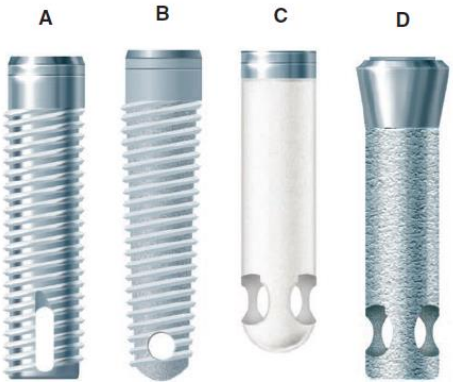

Fig. 1**. Implant classification**

There are also several types of abutments. These different abutments, as the different types of implants are used for different pathologies for the edentulous patient. These pathologies can be given by topological reasons (the part of the maxilla/mandible bone in which the implant will be inserted) or by different diseases regarding the bones or gums.

According to [1] the different types of abutments are presented in Figure 3, as follows: A is a standard abutment used for a simple screwed dental crown (the connection of the crown to the implant is made by a screw, which will ensure the necessary mechanical and functional support), B is a fixed abutment which will be used for attaching a cemented crown (a crown mounted on an implant by means of an adhesive – dental cement), C is a angled abutment, which can be used for both of the dental crown

configurations spoken about above, D is a conical abutment used for the screwed dental crowns and E is a nonsegmental or direct abutment used for screw retained dental crowns.

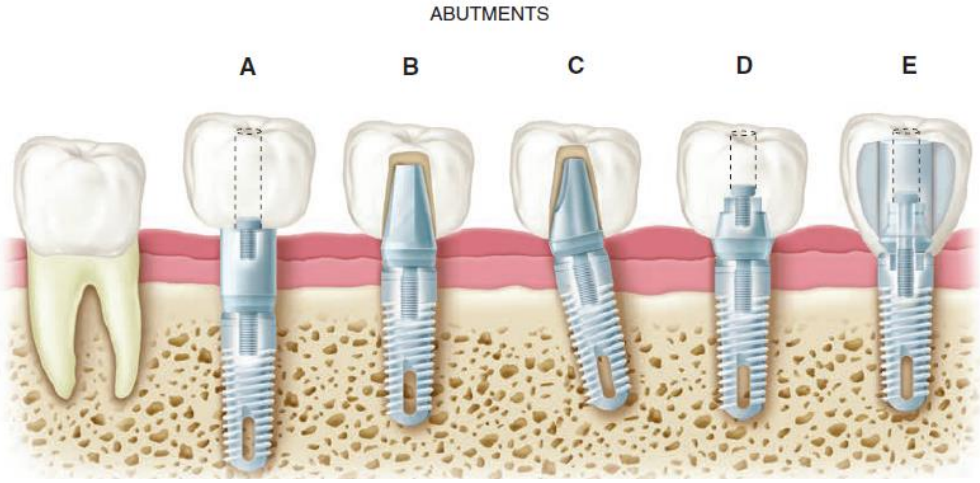

Fig. 3. **Abutment types**

Figure 4 presents a visual explanation of the two types of dental crowns. The screw retained dental crown is mounted onto the abutment by means of a screw, while the cemented dental crown is mounted onto the abutment by means of an adhesive substance and the abutments are screwed into the implant.

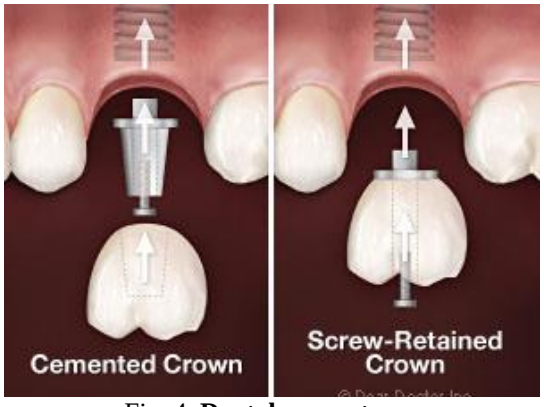

Fig. 4. **Dental crown types**

3. FEM studies for the dental implants

The start of the study was to find a paper regarding the subject to be able to see the methodology of modelling the implant and to compare the information regarding the physiology of the dental occlusion (the way a human closes the mouth and the forces which appear in the process of mastication). The most relevant study found was paper [2]. In this study, the main goal was to determine the influence of deformation and stress between the bone and implant assembly from various bite forces using numerical simulation analysis. The first step the authors made was to take a part of an edentulous mandible (corresponding to the first molar, given the fact that this region is mostly loaded during mastication) from a CBCT (cone-beam computed tomography) scan and model it as a homogenous part with the density and mechanical properties of a cancellous bone. In Table 1 the values of the mechanical properties used in paper [2] are given. The next step was to model the assembly between the whole implant system and the bone, and this was done using a CAD program.

The loading of the system was made at more angles (0, 90, 30, 45 and 90 degrees) and the forces varied in the interval 100-500 N. They successfully managed to obtain stress and displacement distributions under considerable simplifications of the model (the bone was modeled as homogenous, and linear bonded contact between the parts of the assembly was applied).

Tabel 1. Material properties of the implant system [2]

Component/material	Crown/Zirconia	Abutment/Titanium	Implant/Titanium	Spongy bone
Young modulus [GPa]	200	96	96	1.37
Pisson's ratio	0.3			

In the study presented here, the first step was to perform a static linear analysis of the implant without the bone using the same values for the loading as in study [2] to identify the critical area of the implant, from the strength perspective.

3. The numerical models

The implants used in this study are RESISTA implants with different configurations. Given the fact that the CAD files of the implants were not provided, to ensure that the geometrical properties of the implants were kept, the implants were 3D scanned by means of a intrabuccal 3D scanner used in dental practice. These scanners are not very precise regarding the fillet of the implants, but for a preliminary numerical study, the results obtained were good enough.

After the scanning, AUTODESK ReCap Pro (Student license) was used to clean the mesh obtained and then the obtained mesh was imported in FEMAP for the FEM preprocessing.

In the Figure 5, the implant configurations are presented (only the External Hex Connection and the Uni Q MUA configurations were analyzed), while in Figure 6 are presented the scanning device and the resulting virtual geometries of the scanned implants.

Fig. 5 **Implant configurations analyzed within this paper**

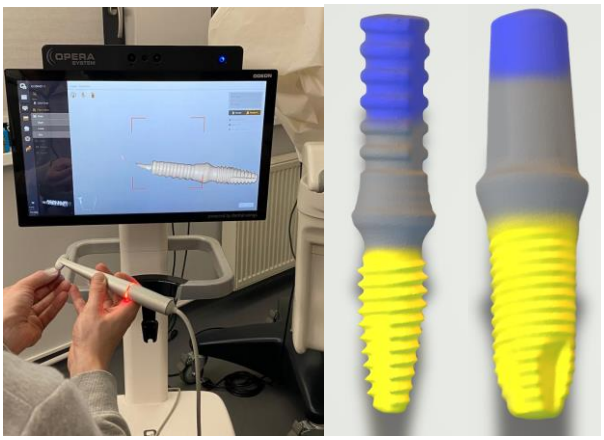

Fig. 6 **3D Scanning using an intrabuccal scanner and the resulting implant CAD models**

For the FEM modelling the material properties used for the implant are taken from [2].

The boundary conditions applied in this study consist of blocking the translations on the screw part of the implant and applying a 1000N force on the implant head (maximal statistic force of mastication in the first molar zone). In Figure 7 there are highlighted with yellow the regions were translations were blocked and with blue the application regions of the force, for the External Hex Implant (left) and the UNI Q MUA Implant (right). The yellow zone is the one considered to be inserted into the bone while the blue zone represents the zone on which the abutment-crown system presses.

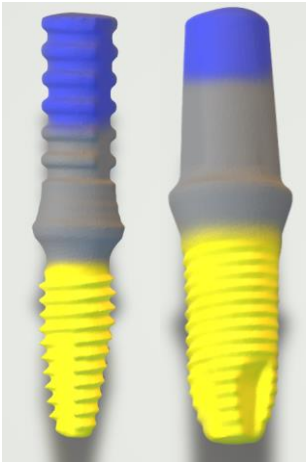

Fig. 7. **The boundary conditions applied on the two analyzed implants: restraints in al translations (yellow regions) and mastication forces (blue regions)**

4. Results

Using NASTRAN, the results were obtained and visualized with FEMAP. As expected, the stresses resulted are high because the analysis performed is a static linear analysis and there is no bone structure to dampen the load. The constraints are rigid. In Figures 8 and 9, the von Mises stresses (left) and the total displacements (right) are plotted for the two implants respectively.

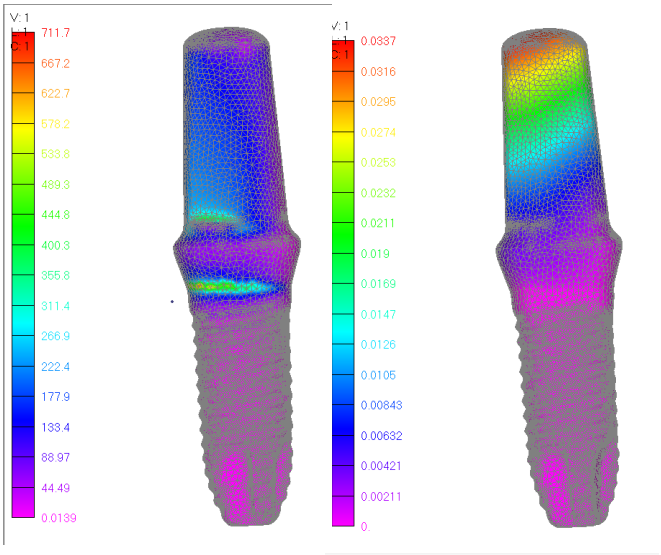

Fig. 8. **von Mises stresses (left) and total displacements (right) in the Extrenal Hex Implant (Units: MPa and mm)**

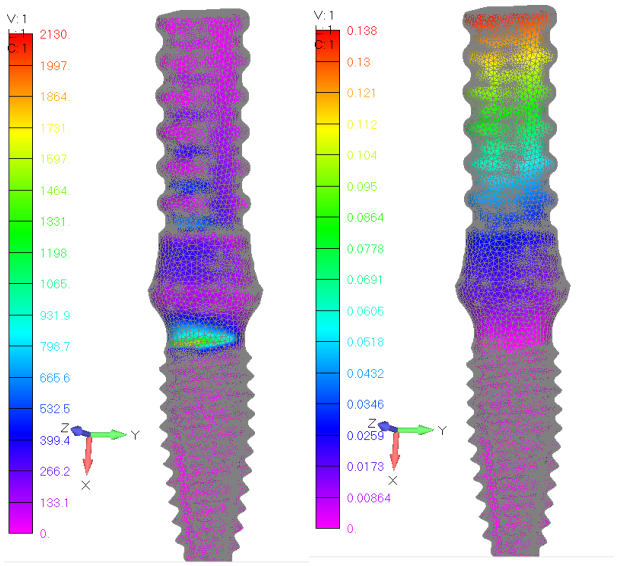

Fig. 9. **von Mises stresses (left) and total displacements (right) in the UNI Q MUA Implant (Units: MPa and mm)**

5. Conclusions

It can be concluded that the maximum loaded zone of the two implants is the flange zone at the interface between the implant and the bone.

The 3D scanning helped preserving the geometry and is a viable tool to be used when dealing with a complex geometry in analysis.

The further research focuses on modelling the bone and the hole into the implant head to obtain more realistic values of stresses and displacements for the implants and make physical tests to be able to check if the assumptions made in the FEM model are close to the reality.

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RESEARCH REGARDING THE IMPLEMENTATION OF QUALITY MANAGEMENT PRINCIPLES IN THE STUDENT LIFE

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Abstract: *This paper presents an analytical study carried out with the aim of implementing the principles of quality management in the lives of students. One of the principles that are the basis of the ISO 9001:2015 standard is stakeholder relationship mangaement, thus the study aims at the orientation of the UPB organization (FIIR) towards customers. Following the stakeholder analysis the customer chosen for the study is the student. In order to check the current stage of the implementation of this principle, a survey was drawn up and collected, thse including different topics of interest to students.*

KEYWORDS: student, client, organization, stakeholders, questionnaire, results

1. Introduction

The ISO 9001 quality management system is one of the most important international standards that contains requirements to help companies or organizations be more efficient and effective in increasing customer satisfaction. Organizations must meet the requirements contained in ISO 9001, implement them and maintain the applied system so that these requirements can be continuously met.[1] The rigorous structure of the standard helps organizations to organize processes and to sustain improvement in a wide variety of contexts, including students' lives.

The purpose of this research paper is to analyze how the UPB organization (FIIR) manages the realtionship with the students, as the main customer.

To achieve the goal, the analysis of the interested parties was used to identify the main topic, completed by the creation of a survey that includes various topics of interest for the chosen sample of students.

2. Stakeholder analysis

In the analysis of the interested parties, their needs and satisfactions in relation to the UPB organization (FIIR) were identified in Table 1

Table 1 Stakeholder analysis

Needs	Interested parties	Satisfaction
Customers		

- education; - social environment; - decent accommodation conditions; - practice possibilities; - scholarships;	Student	- career success; - development of technical skills; - the variety of jobs in both the public and private sectors; - graduation in a continuously developing field; - ensuring a clean and safe working environment;
- education; - social environment; - decent accommodation conditions; - practice possibilities; - scholarships; - validation of safe education environment.	Parents	- ensuring a clean and safe working environment;
- engineers with a development perspective; - variety of specializations - quick adaptability to the work environment	Employers	- graduates with practice proposals dedicated to future engineers to complete their training; - extensive offer of bachelor's and master's programs in the engineering field - interest of involvement in development projects
Needs	Interested parties	Satisfaction
Employees:		
- professional development opportunities - optimal work conditions - job stability - the benefits of the job (health insurance)	Professors	- salary package + benefits - maximum use of professional skills - professional experience - the organization's interest in occupational health and safety
	Administrative and auxiliary staff	
Sponsors:		
- workforce - wide variety of institutions for budget allocation	State	- workforce

- marketing support - obtaining new employees - improving students' skills	Companies	- the performance of study programs from previous promotions - marketing satisfaction - the organization together with the supplier develops the technical equipment within the laboratories
Community:		
- the need for profit - the need for space near the faculty	Supermarket	- large number of students from study programs from all over the country - the allocation of commercial spaces and green spaces
	Real estate developers	
- providing delivery services	Delivery services	- allowing delivery to the campus and student complex
- the permanent need for travelers	Public transport	- the organization meets the needs of public transport through the large number of students in the province

3. Analysis and interpretation of the survey

Following the analysis of the interested parties, the student was extracted as its main subject. In order to verify the efficiency and effectiveness of the UPB organization (FIIR) in the management of the relationship with the interested parties, a survey was created that includes topics of great interest for the targeted sample. Students from the first year to the last year in the bachelor study programmes have been targeted.

The results of each theme of the survey and their interpretation are presenetd, as follows:

Personal information of the sample:

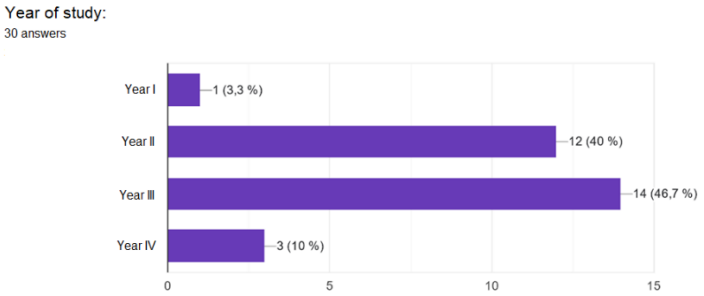


Fig.1 Graphic year of study [2]

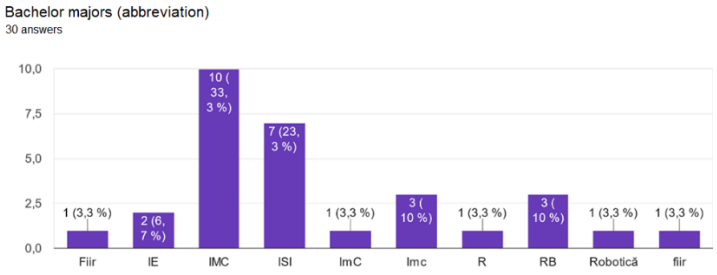


Fig.2 Bachelor majors graph [2]

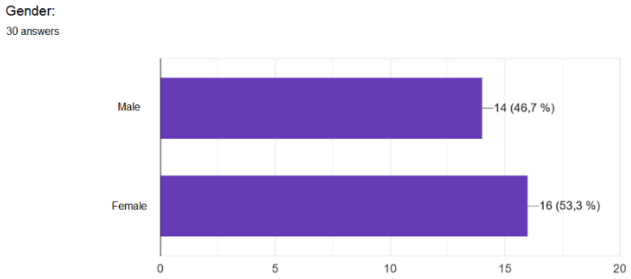


Fig.3 Gender graph [2]

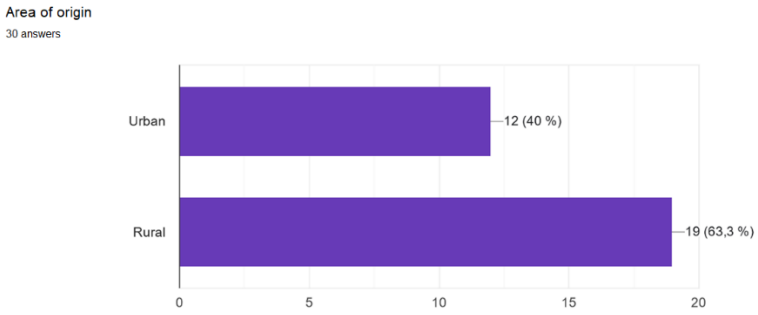


Fig.4 Grafic zonă de proveniență [2]

The graphs above show that the most interested people in this study are females, from the 2nd and 3rd years of the IMC specialization

Topic 1: Admission

The results of the topic related to *Admission* show that the choice of the faculty presents a medium to low difficulty for the people participating in the survey. The respondents to the

questions considered a high level of importance for information regarding the choice of faculty. The study contract was the least difficulty encountered by the subjects of the survey

The most relevant answers to the open question "What improvements would you make to the faculty selection process? Were:

- „More visits to the faculties and maybe even participation in didactic activities. "
- „I recommend conselors offerd by the university to students who want to come to the Polytenic University. Thus, after conseling, it will be easier for the student to choose his favorite faculty under the umbrella of the university"
- „Several workshops on choosing a profession both from the University and from the high school of origin"
- „The open doors day in whitch will be explained to the future students „whith what is eatten" at the faculty and also to show them practical things"
- „Career guidance courses at high school"

Topic 2: Impact of life as a student

The results of the topic related to the *Impact of life as a student* show that dormitory life has a generally high to medium impact, but among the people who consider this impact to be almost non-existent are also students who do not live in the dormitory. Students considered that the process of accomodation and getting to know new colleagues is short-lived. Regarding participation in the student association, the sample of students considered it unnecessary. The events organized by UPB (FIIR) show for respondents a high participation in their social, cultural and academic development

The most relevant answers to the open question "What personal preferences could UPB fulfill to improve students life?" were:

- „More self-knowledge activities"
- „Settelment for metrorex subscriptions"
- „Organizing events involving several categories of students from different years of study"
- „More frequent organization of pest control in student dormitories, more careful selection of products used to prepare food in student canteens"
- „Renovation of dormitories"

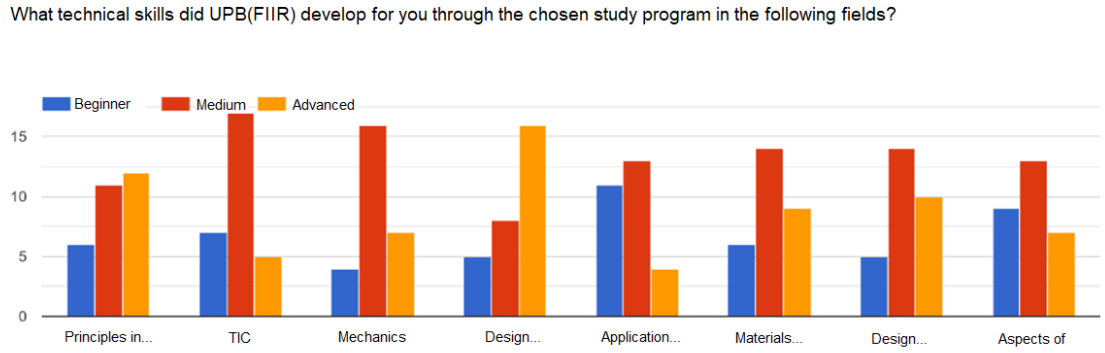
Topic 3: Social competences

The results of the Social Competences theme show that teamwork is of major importance for students. In critical moments, a limited number of students turned to educational counsealing. The teacher-student relationship was considered to be of medium to low difficulty by the respondents. Teacher behavior is a key factor in student performance.

The most relevant answers to the open question „Did UPB's reaction following reported unpleasant experiences meet your expctations?"

- „ No, the management of UPB did not have an objective attitude following the interactions I had throughout the academic year"
- „ I had higher expectations"
- „ Everything OK"

Topic 4: Technical competences



The results of the subject Technical competences indicate the student's confidence in the competences acquired or developed to date.

4. Conclusions

- In the analysis related to admission, a difficulty was noted in answering some questions related to the choice of faculty.
- In the topic of the impact of student life, the respondents claimed that the process of accommodation in the dormitory was difficult for them.
- In the topic of social skills, respondents claimed that teamwork is of major importance. Educational counseling was a topic they avoided. Also, the behavior of the teachers is an additional motivation for the students.

5. Lessons learned

- ✓ The subject of teachers' conduct could be developed, letting the students express their opinion.
- ✓ For the skills question, we could have given students the opportunity to mention the areas in which they feel they have developed.
- ✓ The perception of the students when taking their opinion into consideration appaers less favorable to the management of UPB (FIIR).

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MANAGEMENT OF NONCONFORMITIES IN THE INDUSTRIAL FIELD

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REZUMAT: The work is based on a study that quantifies the costs of a production batch of a gas safety valve product. It will be studied if it is worth putting a quality loop in order to make the product. The control of non-conforming safety valve products is an important process to ensure the reliable and normal operation of safety valves. Safety valves are used to protect systems and equipment from overpressure or other hazardous conditions, so it is important to ensure that they are operating properly within specifications. The main non-conformities are analyzed with the help of a quality inspection method, which appear after the FMEA in order to establish improvement methods for them. The marketing part of the product will also be created to emphasize the important features of the safety valve.

KEYWORDS: nonconformity, AMDEC, crack, improvement, inspection

1. Introduction

The paper focuses on the management of nonconformities in industrial engineering. Using the AMDEC method, the main benchmark with the highest score that could cause the failure of the Gas safety valve product is studied. The costs will be established if a 100% compliant inspection process is carried out on the landmark and if a non-compliance is determined, and the costs of repairs. The SR ISO/TR 10014:2015 Guidelines for the management of the economic aspects of quality will be used for the evaluation. Improvement methods will be established on the benchmark to prevent future non-conformities.

2. Case Study

The gas safety valve is a product that is designed to automatically open and release gas in a controlled manner if the pressure in the gas system exceeds a certain limit. The landmarks that make up the overall assembly are made of different steels. As the main part that makes up the general assembly Body gas safety valve is made of brass, it may be subject to non-conformities that would make it difficult for the product to function in the operating environment. The objectives of the work are to establish a global cost of evaluating a quality block (a quality control on the flow) and if a nonconformity occurs, the repair cost for it.

3. AMDEC analysis

Failure Modes and Effects Analysis (AMDF or FMEA) is a systematic method of analyzing the ways in which a product or system can fail, identifying their causes and effects. This method is mainly applied in industrial and manufacturing fields, but can be used in a variety of other fields.

AMDEC analysis is an inductive method that allows a qualitative analysis of the reliability or operational safety of a system, from a lower functional level to the highest level of the system.

In order to analyze AMDEC, the product "Gas safety valve" presented in figure 1 will be considered.

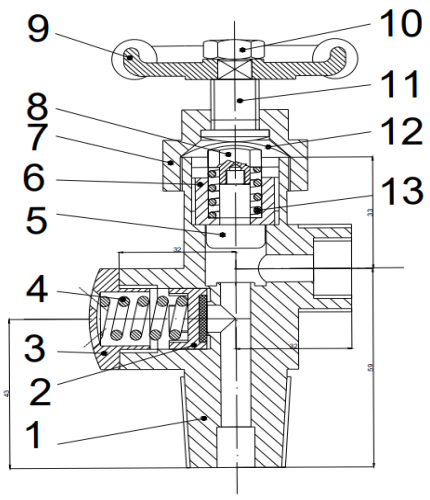

Fig. 1. Gas Safety Valve product for AMDEC analysis

The improvement of the product's performance is based on a detailed design analysis, which aims to identify all non-conformities and take improvement measures, where the situation requires it. In order to improve the product, a research topic will be drawn up.

In what follows, I will analyze from the point of view of failure modes using the AMDEC method, the criticality of each milestone to determine which of them affect the functionality of the product. I use this method to prevent and fix future non-conformances that may occur in the benchmark with the highest score.

Following the AMDEC analysis studied in the table below, we can see that the highest value of the risk coefficient is represented by the gas safety valve body and cover 1. These are the main points that can cause the malfunction of the general gas safety valve assembly.

In the following, the main non-conformities that may appear in the main points of the general assembly and may cause its non-functionality are presented.

The landmark "Gas safety valve body" is a part obtained by the technological casting process. The finished semi-finished part is obtained through mechanical processing: milling, turning, drilling and reaming.

The following table shows the main types of non-conformities according to the technology of obtaining the finished semi-finished product.

To control nonconforming products, organizations must develop and evaluate nonconforming products - after nonconforming products have been identified, organizations must evaluate them to determine the degree of nonconformity and the impact on implement quality control procedures that include the following steps :

- Identification of non-conforming products - it is important that organizations can quickly and accurately identify products or services that do not meet quality standards or specific customer requirements.

- Taking corrective action - organizations must take corrective action to remedy the non-conformity and prevent similar issues from occurring in the future. These measures may include repairs, replacement of non-conforming products or services, or modification of production processes to avoid future errors.

- Verifying the effectiveness of corrective actions - after corrective actions have been taken, organizations must verify that they have been effective in eliminating the problem and preventing its recurrence.

Table 1. Nonconformities according to the technology of obtaining the semi-finished product

Process name	Name non-conformity	Cause of non-conformity
Casting	Cracks	The melting temperature of the material
	Goals	Insufficient amount of material
	Sulfide	The presence of air or gases in the cast material
	Incomplete form filling	The melting temperature of the material Mold design
Mechanical processing	Dimensional and shape deviations	Non-compliance with work technology
	Surface appearance	Incomplete documentation
	Material scratch	Wrong part grip

Table 2. Selective AMDEC analysis

ANALYSIS OF FAILURE MODES FOR THE "SAFETY VALVE" PRODUCT							
Landmark name	Function accomplished	Failure mode	The causes of the defect	The probability of failure	The criticality of the defect	The difficulty of detecting the defect	Risk coefficient
				A	B	C	R=A·B·C
Safety valve body	Role of protection and assembly of landmarks as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	5	5	100
Chair	Spring support roll Ø12;	Deformation;	Wrong assembly as a whole;	2	3	2	12
Threaded Cap 1	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	4	5	80
Helical Spring Ø12	Damping of shocks and vibrations;	Deformation;	Strong vibrations; Strong shocks;	2	2	2	8
Pushing	Fixing role of landmarks 6 and 8;	Deformation;	Wrong assembly as a whole;	2	3	4	24
Threaded bushing	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	3	3	36
Threaded Cap 2	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	5	3	60

4. Quantifying the costs of quality assessment

To quantify the quality costs, three scenarios will be evaluated for which it will be determined whether introducing a quality loop would optimize the quality costs or not. This loop has a cost to the product but can determine and prevent non-conformities that can be repaired. The non-conformity is considered to be cracks detected by the non-destructive inspection method with penetrant liquids, which can be repaired. These products will have different labels printed on them to identify whether or not the product has been inspected.

In the following, the aspects of calculating quality costs are presented.

The following table shows the variables for the quality loop calculation process represented by quality control.

Table 3. Process variables (estimated values)

Process variables (estimated values)	100% inspection and repair scenario			Scenario without quality cost		
	1	2	3	1	2	3
N_p	2400	2500	2500	2400	2500	2500
P_d	2%	2%	1%	2%	2%	1%
C_i	0,1	0,2	0,2	0	0	0
C_e	-	-	-	960	1000	500
C_r	2	2	2	-	-	-
C_o	15	15	15	-	-	-
R	80%	80%	80%	-	-	-
C_s	-2	-2	-2	-	-	-

Where,

C_e= represents the cost of failure

N_p= number of units manufactured in the process

C_n=unit cost of moving defective units to the next process

P_d=proportion of defective units after the process

C_i = cost of inspection and control

C_r=unit cost of repair

C_o=unit cost of not delivering units

R=proportion of repairable defective units

C_s=unit cost of waste

In order to achieve the quality costs with 100% inspection and repair, the following calculation formulas present in the following table will be used.

Table 4. Calculation formulas for establishing quality costs

Nr. Crt	Name cost	Calculation formula
1	The cost of inspecting the number of units manufactured in the process C_{np}	$C_{np} = N_p \cdot C_i$ (1)
2	Number of defective units (after manufacture) N_{df}	$N_{df} = N_d \cdot P_d$ (2)
3	Number of repairable units (defects) N_r	$N_r = N_{df} \cdot R$ (3)
4	Repair cost (of repairable defective units) C_{re}	$C_{re} = N_r \cdot C_r$ (4)
5	The number of unrepairable units N_n	$N_n = N_{df} \cdot (1 - R)$ (5)
6	Cost of delivery of defective units C_{nu}	$C_{nu} = N_n \cdot C_o$ (6)
8	Waste cost for unrepairable units C_{dn}	$C_{dn} = N_n \cdot C_s$ (7)
9	Internal failure E_i	$E_i = C_{re} + C_{nu} + C_{dn}$ (8)

The results of the calculations are presented in the following table where the quality costs are determined.

Table 4. Quality costs

Costs	100% inspection and repair scenario			Scenario without quality cost		
	1	2	3	1	2	3
The cost of inspecting the number of units manufactured in the process C_{np}	240	500	500	-	-	-
Prevention costs	-	-	-	0	0	250
Number of defective units (after manufacture) N_{df}	48	50	25	-	-	-
Number of repairable units (defects) N_r	38	40	20	-	-	-
Repair cost (of repairable defective units) C_{re}	76.8	80.0	40.0	-	-	-

The number of unrepairable units N_n	10	10	5	-	-	-
Cost of delivery of defective units C_{nu}	144	150	75	-	-	-
Waste cost for unrepairable units C_{dn}	-19	-20	-10	-	-	-
Cost of delivery of defective units C_{nu}	240	500	500	-	-	-
Internal failure E_i	202	210	105	0	0	0
External failure E_e	0	0	0	960	1000	500
Total cost of quality	**442**	**710**	**605**	**960**	**1000**	**750**
Total quality/unit cost	0.18	0.28	0.24	0,4	0,4	0,3
Proportion of defective units (after quality control) sent to waste	0.4%	0.4%	0.2%	2%	1%	1%

After the analysis carried out in the three scenarios for the two situations, the following important aspects on the cost of quality were concluded:

1. If there is no quality control loop on the manufacturing flow to detect possible non-conformities in the product, it is considered that it is sent to the customer without the product undergoing changes to the quality cost. Two scenarios can be determined in this situation.

i. a first scenario is when the product is sent to the customer and it performs its functional role in the operating environment without the appearance of a non-conformity in the product. In this case it is considered that no quality control loop is performed, the quality cost being very low and the profit per product being maximum.

ii. a second scenario is when the manufacturer cannot do anything to improve the situation and the customer reacts against the manufacturer.

2. If a quality control loop appears on the product manufacturing flow to detect nonconformities that could disrupt functionality in its operating environment, the cost of quality would increase and the rate of occurrence of nonconformities would decrease. In this scenario, it is considered that the product sent to the customer is according to the specifications and it performs its functional role. It can be considered that the product has a non-conformity (the rate of non-conformities in this situation being very low) that would negatively influence the functional role of the product, the customer returns to the manufacturer and the cost of the repair varies depending on the non-conformity. The total cost of quality increases and the profit per product would decrease drastically.

5. Conclusions

Following the analysis for whether or not to introduce a quality loop on the manufacturing flow, some important aspects are concluded.

1. We have managed to establish any occurrence on the manufacturing flow of the product that appears in the quality loop. We optimized the quality calculation and reduced the number of non-conformities that can appear in the benchmark.

2. The AMDEC analysis carried out for the Gas Safety Valve product prevents future scenarios in which various non-conformities may appear in the benchmark with the highest criticality according to table 2, but not only that, it also establishes the main non-conformities that appear as a result of the way the product was obtained.

3. A product that has an inspection during the manufacturing flow may be cheaper than a product that does not benefit from such an inspection. This is because inspection during manufacturing helps to identify problems and errors earlier in the production process. By identifying and correcting problems in the early stages, the high costs of recalls or subsequent repairs are avoided.

4. By improving manufacturing processes through periodic inspections, the number of defects can also be reduced, which can reduce overall production costs.

5. Inspection during the manufacturing flow can help improve product quality and reduce overall manufacturing costs, although specific costs may vary depending on the manufacturing process and final product.

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SELF-ASSESSMENT OF THE INTEGRATED MANAGEMENT SYSTEM IN AN EDUCATIONAL SERVICE PROVIDER ORGANIZATION

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SUMMARY:

The quality improvement plan is part of the operational plans but is also based on the internal quality assessment strategy. The main goal of self-assessment is to improve quality. It should be accompanied by planning for improvement, strengthen strengths' areas and implement other necessary changes identified in the self-assessment process.

The EFQM Excellence model, used in this research for the self-evaluation of the integrated management system in an educational services organization, aims to identify strengths and areas of improvement. Using EFQM criteria and applying Deming's cycle, we were able to identify areas that need to be prioritized in the future so that the organization can improve its results.

KEYWORDS: Education, planning, improvement, results, excellence

1. Introduction

This research aims to self-evaluate the integrated management system in an educational service provider organization, using the EFQM Excellence model of excellence, which involves achieving excellence, regardless of the field of activity. The main objective of self-assessment is to improve quality. An effective self-assessment, using the criteria of the EFQM Excellence model, allows the school unit to identify its strengths and areas of improvement, compare its performance with that of other schools, and develop an improvement plan. The monitoring, analysis and evaluation carried out during the self-evaluation process directly contributes to ensuring the quality of the educational offer. Self-assessment is not an end in itself, but a means for continuous improvement. It is accompanied by planning for improvement to address weaknesses, strengthen strengths and implement other necessary changes identified in the self-assessment process. The evaluation according to the EFQM Excellence model is cumulative, based on strengths, while identifying areas for further development of the organization.

2. Study – assessment of factors

2.1. EFQM Excellence Model criteria

LEADERSHIP

1d) Leaders reinforce a culture of Excellence with the organization's people

Strengths

The management of the Primary School Theodor Pallady communicates at the beginning of each school year within the teaching council the mission, vision, values, policies and strategies, plans, goals and targets he has set. They are visible both on the school's website and on the educational platform used by the employees, so that they can be consulted all times.

School's leaders are always accessible, actively listening and responding to employees' problems or proposals, both in individual meetings, teacher boards or meetings with the

coordinators of the curricular areas. Through their conduct and professionalism, they inspire and unite the team.

School management helps employees to achieve their plans, goals, and targets by supporting them by partially or totally financing individual continuing education courses or by bringing in trainers to school that responds to the learning and improvement needs of the teachers. It also motivates through awards and bonuses employees who are actively involved in continuous training and development.

Leaders promptly acknowledge the efforts of individuals and teams in carrying out educational projects at the level of classes and schools, expressing their gratitude for the active, continuous and professional involvement of the staff and for the outstanding results achieved.

School management promotes and encourages equal opportunities and diversity, teaching staff being made up of employees of various nationalities and religious denominations. Recognizes and takes into account the different cultural contexts of origin, promoting social and cultural activities, by organizing international festivals and fairs. It respects the right to free speech and creates opportunities to manifest one's own aspirations and beliefs.

Areas of improvement

Although the objectives of the school are presented at the beginning of the school year and are visible on the educational platforms provided to the teaching staff, their achievement is not monitored and verified continuously, there is a risk that some of them will be only partially fulfilled. There is no permanent monitoring of their operationalization and staff are not guided in finding solutions to achieve the desired performance level. Also, the presentation of the objectives does not specify the benefit achieved, the progress achieved by achieving them.

School management does not give equal opportunities to employees to participate in various activities (educational fairs, conferences, trainings, etc.) by not informing them and choosing on criteria lacking transparency of certain persons.

Another area of improvement is related to effective communication within the team, with those who actually contribute to the achievement of the proposed objectives. Often, these decisions are only communicated to the responsible for the curricular areas to be passed on to the team, without taking into account their material and temporal resources. Also, there are situations when the extracurricular projects are in very large numbers over a short period of time, diminishing the quality of the educational process.

Evidence

- The school website
- Google classroom
- Virtual Catalogue, field dedicated to professional training.
- Images from fairs, exhibitions, projects with intercultural themes presented on the school's media channels (Instagram, YouTube, Facebook)
- The Character Education program that is being implemented

POLICY AND STRATEGY

2a) Policy and strategy are based on the present and future needs and expectations of stakeholders.

Strengths

The organization identifies, understands, and anticipates the needs and expectations of current and future stakeholders, including customers, employees, partners, society. At the beginning, end and throughout the school year, students, parents, employees' complete questionnaires aimed at measuring the degree of satisfaction, as well as identifying areas for improvement. The results of these questionnaires are centralized and communicated to

stakeholders in teacher councils and parent meetings. Also, regular meetings with parents and parents' representatives are organized, and monthly meetings with students, through the representatives of the student Council, and with teachers, within the teaching Council. Weekly meetings are held on each curricular area and with curricular area managers. The purpose of these meetings is to identify the satisfaction of stakeholders and identify areas for improvement. Also, meetings are organized with representatives of the city hall and school inspectorates and regular ARACIP inspections are scheduled.

Within the organization, information is collected to define the markets and market segments in which the organization operates and will be able to operate in the future, including possible competing activities. Identifying, understanding and anticipating market developments will lead to an increase in the number of students, attracting qualified staff, increasing the trust of the organization in the market, attracting partners, all aiming to increase the satisfaction of all stakeholders.

Areas of improvement

Although the organization is constantly concerned with identifying the needs and expectations of the stakeholders, the centralized results did not attract improvement and development measures but remained at the statistics stage. The school management did not create strategies that would improve the process, leading to a decrease in the number of clients in certain sectors.

Evidence

- Questionnaires
- Meetings with students, parents, employees

PEOPLE

3d) People and the organisation have a dialogue

Strengths

School management develops communication policies, strategies and plans based on communication needs, using horizontal communication channels, by weekly organizing meetings on each curriculum area, and vertically from top to bottom and bottom to top, in the teaching councils and meetings with the heads of the curricular areas. It also uses virtual means of immediate communication, using social media platforms and email.

Areas of improvement

Within the organization, communication needs from the bottom up are not encouraged. The climate of the organization does not allow subordinates to formulate messages without fear of penalty or without attracting future repercussions. School management also does not identify and provide opportunities to provide good practices and knowledge acquired by some employees in training courses, conferences or other training and professional development activities.

Evidence

- Verbal reports
- Social platforms

PARTNERSHIPS AND RESOURCES

4d) Technology is managed.

Strengths

The organization has created a technology management strategy that supports the organization's policies, strategy, instructive-educational process, effective communication, innovation and development. It also manages the portfolio of technologies (educational platforms, computers, video projectors, copiers) by identifying and replacing the old ones, as well as the acquisition of the modern ones (smart tables, graphics tablets). School management encourages energy and resource conservation, minimization of waste production and encourages recycling and reuse through educational projects that lead to awareness of the need to save resources and stop waste: Placing selective recycling containers on the school halls, Using technology instead of paper-printed worksheets, teamwork, practical activities using recyclable materials, encouraging outdoor activities, using ICT to support and improve the effective operation of the organization, virtual catalog, using technology to support improvement activities, etc. The organization has also supported the training of teaching staff in the use of technology, through courses for the use of different educational platforms, and purchased subscriptions at the institution level for educational platforms used by the school staff.

Areas of improvement

School management should create strategies to monitor consumption and raise awareness of staff and students about the need for resource saving and selective recycling. It is also recommended to find ways to measure the degree to which purchased educational platforms are used and replace old methods of paper printing. A comparative analysis of resource consumption with and without the use of technology is required.

Evidence

- The virtual catalog
- Digital competence certificates of employees
- Subscriptions for different educational platforms
- Educational projects
- Contracts with recycling companies

PROCESSES

5e) Customer relationships are managed and enhanced

Strengths

The organization, through the didactic, non-didactic and auxiliary staff, identifies and meets the requirements of the students through active listening, both during the classes and at meetings with school counsellors or school management, during the meetings of the student Council. It also manages feedback from daily contacts, including complaints, and engages pro-actively to discuss and meet their needs, expectations, and fears. Through the use of regular surveys and other forms of structured data collection during daily contacts with students (drawings, teaching games, debates, meetings, personal development hours), the school employees determine and raise the level of satisfaction of the students regarding the teaching activity, the means and working methods used, teachers' work, understanding of information. Through the educational programs used, the organization maintains creativity and innovation in the instructional-educational process and the active involvement of students in its own training. Students are constantly advised on how to behave both during class hours and during breaks or during activities outside school.

Areas of improvement

It is recommended that the organization use the results of questionnaires filled in by the students in order to improve the activity of the teachers and the educational process. It is also

necessary that the activity is centered on the student and meets his immediate needs and expectations. In an educational organization, the client is the student, and the chosen strategies should take into account the satisfaction of his needs, as the main beneficiary of the educational act.

Evidence

- Questionnaires
- Verbal reports
- The work of students

CUSTOMER RESULTS

6b) Performance Indicators

Strengths

Theodor Pallady Primary School was founded in 2004 in Bucharest, enjoying a material basis according to European standards and an educational environment specific to the age. The school applies the European norms of education, being at the same time a school with a Romanian profile, based on the National Curriculum. In the school year 2008-2009, Theodor Pallady primary School was accredited. During the evaluation was found the high-level compliance with accreditation standards, by areas and managerial functions: Curriculum, human resources, material resources, class management, projects and programs, partnerships, image. Theodor Pallady primary School was present at countless educational fairs and was appreciated for the educational values promoted. The constant number of pupils and the constant demand on the market indicate the trust of the parents, as well as a high professionalism of the teaching staff. Also, the congratulations and thanks of the parents displayed on social networks, the articles published in the press that praise the perforations of the students, strengthen the conviction that the school's mission is fulfilled and successfully responds to the needs and expectations of students and parents. The loyalty of parents, their recommendations that attract more and more students, year after year, the low number of complaints, the high degree of customer maintenance, are the performance indicators of the quality of the school, which permanently help the organization to prosper.

Areas of improvement

Although the organization enjoys a very good image on the market, the annual increase in the tuition fee, without a transparent justification, could lead to a decrease in the number of students. Also, the lack of certification could lead to a decrease in customer confidence in the quality of the services offered.

Evidence

- The school website
- The school magazine
- Social media pages of the school

PEOPLE RESULTS

7a) Perception Measures

Strengths

The measurement of employee perception is obtained through questionnaires, interviews, meetings at the level of curricular areas and collective meetings within the teaching council.

Motivating employees is achieved through an open communication, in which they can express their needs for personal and professional development, by encouraging and material support of professional training, by delegating responsibilities and power, according to the aspirations of the employees, by actively involving them in projects and activities carried out at school level, through team-building and recreational activities organized by the school management. At the institution level, learning opportunities are created, by organizing training and development programs adapted to the improvement needs of the employees and the merits are recognized by awarding prizes and bonuses. The leadership style creates equal opportunities for training and development, and through the values, mission, vision, policies and strategies of the institution, the qualities and performance of the employees are put to the test.

The administration of the organization manages to maintain a high degree of employee satisfaction by creating optimal working conditions, a favorable climate, a work environment based on trust and collegiality, by providing the staff with the means and material resources necessary for the proper functioning of the activity. Security at work is ensured through the security firm and the surveillance cameras existing throughout the institution. Motivating salary and benefits, job security, stability of the organization in the community and society are the reasons that lead to an increase in employee satisfaction and well-being in the workplace.

Areas of improvement

It is necessary for the organization to provide equal opportunities to occupy management positions by informing employees and organizing competitions. It is also necessary to create facilities and services for employees, such as health and life insurance, first aid courses, the possibility of promotion and employment of management positions, according to professional training. It is recommended that recognition of employee merits is a moment in itself within the teaching boards, which motivates and stimulates the performance of others.

Evidence

- Questionnaires
- Prime
- Prizes awarded
- Distinctions
- Training courses
- Team-buldings
- Recreational activities and spending time with the team

SOCIETY RESULTS

8b) Performance Indicators

Strengths

The staff of Theodor Pallady Primary School is qualified, and the age in the institution is up to 14 years. All teachers for primary education are holders, which shows the employees' trust in the organization, and hold the second and first degree in a proportion of 95%. Although more than half of the teachers are holders through national competition, they prefer this organization to the detriment of state schools, precisely because the institution manages to meet their needs.

The school organizes competitions at the municipal and national level, through wich it promotes performance, free expression through art and sports.

Areas of improvement

Although the institution involves students and parents in educational projects, they take place at the institution level and less at the community level, which is why the merits of the school are not recognized locally and are not rewarded with awards or diplomas in this regard. The institution should organize exchanges of good practices related to "social responsibility", pedagogical circles at the level of the sector or Bucharest Municipality, partnerships with cultural and educational institutions.

Evidence

- Certificates for obtaining teaching degrees
- The social media channels of the school

KEY PERFORMANCE RESULTS

9a) Key Performance Outcomes

Strengths

Through the chosen strategies in the financial field, the organization managed to fit into the established budget and the results of the audits of the accounts (revenues, grants, expenses) showed a good management of financial resources and an attraction of new funds through the educational projects carried out (The Mărțișor Fair, The Romanian Cousin Fair, The International Festival, Book Fairs, etc.). Investments in materials needed to carry out projects were amortized following the sale of products.

In its nearly 20 years of market presence, Theodor Pallady Primary School has shown that vision and mission have led to a rate of ever-increasing success, the school already has two offices in Bucharest and a third in the process of opening. The results of inspections and controls demonstrated compliance with the legislation, employee professionalism, good administration, good practices, process performance, the grades obtained are always very good and the accreditation is renewed every time. The teaching staff obtained maximum scores following the specialized inspections, demonstrating professionalism and good didactic training.

Areas of improvement

Management at the highest level should give greater importance to innovation and learning, which, based on results, contributes to the optimization of „processes" and „premises" leading, in turn, to a new improvement of results. It is recommended that key performance start from the results obtained – both those concerning members of the organization or customers (their satisfaction occupying a very important place), as well as the results obtained at the level of the whole society, and to take into account the interests and aspirations of all stakeholders.

2.2. Evaluation results

Tabel 1 The Deming Cycle (PDCA)

Criterion part of the EFQM Excellence model	PLAN (P) [%]	DO (D) [%]	CHECK (C) [%]	ACT (A) [%]	GLOBAL SCORE [%]
1d	85	80	50	60	**68**
2a	80	75	85	65	**76**
3d	75	50	50	25	**50**
4a	85	75	50	50	**65**
5c	90	75	90	75	**83**
6b	85	75	70	80	**78**
7a	75	50	25	25	**44**
8b	75	75	50	50	**63**
9a	85	90	75	50	**75**

The overall score was calculated as the arithmetic mean of the four categories (PDCA), in order to identify areas for improvement.

Tabel 2. Total Points

Criterion	Overall score	Factor	Points Awarded
1.Leadership	68	x1.0	68
2.Policy and Strategy	76	x0.8	60.8
3.People	50	x0.9	45
4.Partnership and Resources	65	x0.9	58.5
5 Processes	83	1.4	116.2
6.Customer Results	78	2.0	156
7.People Results	44	0.9	39.6
8.Society Results	63	0.6	37.8
9.Key Performance Results	75	1.5	112.5
Total Points			**725**

3. Conclusions

From this evaluation the people results and the society results are found to be improved.

Making this research it has been discovered that the EFQM Excellence model is very well structured and applying it has been noticed that the organization plans and implements many activities but, in essence, focuses less on verification and improvement, with an imbalance between the components that treat the factors.

This experience helped to make a detailed analysis of the integrated management system at school level and to highlight the strengths and areas for improvement.

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SELF-EVALUATION OF THE INTEGRATED MANAGEMENT SYSTEM IN A FINANCIAL SERVICES PROVIDING ORGANIZATION

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Summary:
La Stejar Romania is a company providing services in business information, debt management, and online services. The EFQM self-assessment is an important tool for the organization to identify areas for improvement and develop an action plan. The EFQM methodology involves criteria and sub-criteria that cover all important aspects of an organization's activities. La Stejar Romania underwent an evaluation based on objective evidence and systematic implementation, identifying areas for improvement. Lessons learned include involving people from all departments, prioritizing areas with the greatest impact, and the need for active involvement of top-level management. The self-evaluation process is a continuous one that needs periodic review and updates.

Key words: EFQM self-assessment, performance evaluation, risk management, improvement opportunities.

1. Introduction

The EFQM (European Foundation for Quality Management) self-assessment methodology is a method of evaluating organizational performance based on criteria that cover all important aspects of an organization's activities. It was developed by EFQM, a non-profit organization in Europe, and is based on a holistic approach to quality management.

EFQM self-assessment is a structured process that involves evaluating and analyzing the assessment criteria of the EFQM model. The process begins with setting objectives and planning the self-assessment. Then, data is collected and the organization's performance is evaluated based on the fundamental criteria and the results criteria. These criteria cover areas such as organizational leadership, strategy and planning, resource management, key processes, customer satisfaction, employee satisfaction, societal impact, and organizational results.

The assessment is carried out in two stages: internal assessment and external assessment. The internal assessment refers to the self-assessment of the organization and the identification of strengths and weaknesses. The external assessment refers to the evaluation of the organization by an external evaluator, who can be a consultant or an auditor specialized in assessing according to the EFQM model.

During the self-assessment process, the organization's performance is evaluated based on the assessment criteria of the EFQM model. Each criterion is evaluated based on several sub-criteria, and points

are awarded for each evaluated sub-criterion. The total score obtained represents the organization's score in the EFQM self-assessment.

EFQM self-assessment is a rigorous process that requires time, effort, and dedication from the organization. The goal is to identify the strengths and weaknesses of the organization and develop an action plan to improve organizational performance and the quality of services and products offered by it.

La Stejar Romania is a company that provides services and solutions in the field of business information, debt management, and online services. Founded in 1987, the organization was one of the founders of the Association of Commercial Credit Management (AMCC), which represents the most important players in the commercial debt collection market.

The EFQM self-assessment is important because it provides the organization with an overview of its overall performance, identifying areas that need improvement and developing an action plan to address them. Additionally, self-assessment can help increase the efficiency and effectiveness of processes, improve customer satisfaction, and develop a better work environment for employees. Therefore, the EFQM self-assessment can be a valuable tool for the La Stejar Romania organization in its efforts to remain competitive and achieve its strategic objectives.

2. EFQM Methodology

The EFQM (European Foundation for Quality Management) model is an assessment and improvement framework for organizational performance, developed by the European Foundation for Quality Management. It is based on 9 fundamental criteria that cover all key aspects of an organization and provide a comprehensive framework for self-assessment and continuous development.

The EFQM evaluation methodology consists of a set of criteria and sub-criteria that cover all important aspects of an organization's activities, divided into two categories: determining criteria and results criteria.

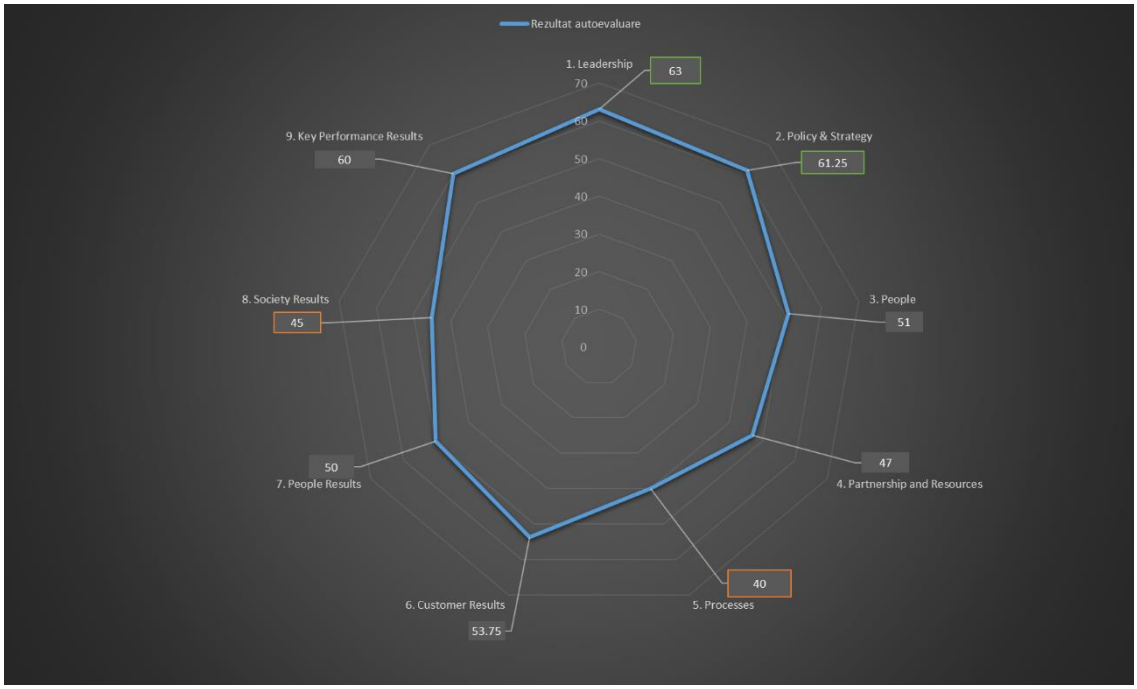
The EFQM self-assessment involves going through these criteria and sub-criteria and assigning a score based on the degree of compliance with them. The final score reflects the level of performance of the organization in the various analyzed areas.

After conducting a preliminary assessment, the next step in implementing the EFQM model would be developing an action plan. This should be based on identifying the strengths and weaknesses of the organization, based on the assessment and feedback obtained. The action plan should establish specific objectives, measures, and deadlines for improving organizational

performance. The implementation and monitoring of the action plan should be done continuously to ensure sustainable development and continuous improvement of organizational performance.

In the case of La Stejar Romania's evaluation, the self-assessment process began with criterion 1 and continued in order up to criterion 9, along with all the relevant sub-criteria. The evaluation was based on the verification of objective evidence and the consistency and systematic implementation, and based on this information, corresponding scores were awarded.

The final evaluation reflected the level of performance of the organization in the various analyzed areas, thus identifying areas for improvement.



Criterion 1 - Leadership (score 63): The high score for this criterion suggests that the organization has strong and committed leadership that creates a clear vision, sets ambitious goals, and promotes the organization's values.

Criterion 2 - Policies and Strategy (score 61): The high score for this criterion suggests that the organization has well-defined policies and strategies that are integrated into all its activities to support the vision and goals.

Criterion 3 - People (score 51): The average score for this criterion suggests that the organization still has room for improvement in managing human resources, including recruitment, development, and employee engagement.

Criterion 4 - Partnerships and Resources (score 47): The low score for this criterion suggests that the organization may need to improve its relationships with suppliers and consider better resource management.

Criterion 5 - Processes (score 40): The low score for this criterion suggests that the organization may need to improve its internal processes to ensure the efficiency and effectiveness of its activities.

Criterion 6 - Results in relation to the organization's customers (score 53): The high score for this criterion suggests that the organization is focused on its customers' needs and strives to continuously improve its products and services.

Criterion 7 - Results in relation to employees (score 50): This assessment indicates that the organization has decent performance regarding its employees, but there is still room for improvement. Regarding employee engagement, increased attention to communication and ensuring their needs are met may be necessary to keep them motivated and satisfied. Additionally, developing an employee training and development program may be necessary to enable them to fulfill their roles and responsibilities efficiently.

Criterion 8 - Results in relation to society (score 45): This assessment indicates that the organization has decent performance in terms of engagement and collaboration with society, but it can still be improved. Potential improvement actions could include developing corporate social responsibility programs as well as involvement in community or environmental projects.

Criterion 9 - Key Performance Results (score 60): This assessment indicates that the organization has a solid performance in achieving key performance results, but there is still room for improvement. This may involve identifying and implementing new strategies to improve the organization's performance, evaluating and enhancing processes, and utilizing data and analytics for better-informed decision-making and maintaining a high level of performance.

3. Conclusions

Based on the analysis of the EFQM 2010 self-assessment results, the organization needs to take action to improve its performance, particularly in relation to Criterion 5 - "People." With a score of only 40%, the organization should focus on developing its capacity to attract, develop, and retain qualified and engaged personnel, and create a positive and supportive work environment.

Regarding the enablers criteria, the organization has the highest scores in Criteria 1 and 2, but does not fully meet Criteria 3 and 5. Improvement is needed in processes, suppliers and partners, as well as in resources and organizational culture.

In terms of results criteria, the organization has a moderate to high level of performance in Criteria 6, 7, and 9, but should pay greater attention to improving performance in Criterion 8 - "Societal Impact." This criterion refers to how the organization fulfills its social responsibility and its impact on the community and the environment.

Overall, the analysis indicates that the organization needs to take measures to improve its performance in support and results criteria, with a particular focus on developing its capacity to attract, develop, and retain qualified and engaged personnel. An appropriate action plan can be developed based on these findings, with clear and measurable objectives for improving the organization's performance.

4. Action plan

Criterion 5

Objective 1: Increase the score for sub-criterion 5e from 45 to 60 by improving risk management capacity. Measure: Develop and implement a risk management system in accordance with ISO 31000 standards. Develop a risk management plan, implement risk monitoring and reporting procedures, and train employees in risk management.

Objective 2: Increase the overall score for Criterion 5 and sub-criterion 4d. Measures could include: Updating and optimizing existing processes for data archiving and storage systems:

- Reducing redundancy and better structuring information
- Implementing data verification and validation procedures to prevent errors and invalid information.

Criterion 8

Increase the score for sub-criterion 8a from 45 to 60 by improving the performance of activities that lead to resource conservation. Measures could include:

- Periodic analysis of the quantity of recyclable waste collected and processed to monitor and improve recycling program efficiency.
- Evaluating energy consumption and identifying opportunities to reduce energy consumption and encourage the use of renewable energy.

- Implementing energy reduction and renewable energy use programs, including installing solar panels.

5. Lessons Learned

It is important to involve people from all departments of the organization in the self-evaluation process to obtain a more complete perspective on the organization's performance.

The self-evaluation showed that, despite some strengths, there are still opportunities for improving the organization's performance. It is important not to be complacent about the strengths, but to constantly focus on improvement and development.

Communication is essential for gaining commitment and support from all departments and the management team. The self-evaluation showed that we need to work harder to ensure that everyone has the same understanding of objectives and that all information is communicated clearly and effectively.

The correlation between results and determinants: Another important thing we learned is that there is a strong correlation between the results achieved and the determinants of the organization. Therefore, to achieve good results in a particular area, it is necessary to focus on the factors that influence those results and improve them.

Discovering improvement opportunities Another important aspect we learned is that the self-evaluation process can bring to light more areas for improvement than we initially expect. Through self-evaluation, we can identify problems and shortcomings in the organization and take measures to improve them. We learned that it is important to focus on areas with the greatest impact and prioritize activities according to their importance. This allows us to focus our resources and efforts where they are most needed, thus achieving significant results.

The need for involvement of top-level management : We learned that, to achieve significant results through the EFQM model, there is a need for active and continuous involvement of top-level management. They must be the leaders who set the tone and commit to bringing about real changes in the organization.

Self-evaluation is a continuous process that needs to be periodically reviewed and updated according to the organization's and the surrounding environment's evolution.

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DEVELOPMENT OF PERFORMANCE INDICATORS IN A COMPANY FROM THE AUTOMOBILE INDUSTRY

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Summary: In this document is presented the development of the performance indicators based on the EFQM evaluation of Renault Technologie Roumanie company, an organization operating in the field of the automotive industry. This company is actually a regional center that deals with engineering activities and technical consulting (CAEN 7112) for the Renault Group. Following this self-assessment, one of the most important fields, which have to be improved is the performance indicators which will also help to develop the concept of people.

1. Introduction

This work aims to improve the performance indicators for the company Renault Technologie Roumanie, following an action plan. Renault Technologie Roumanie (RTR) is a regional engineering center of the Renault Group. The main responsibility of this company, is the global development of the Dacia range but also a small part of the Renault range, especially an adaptation of projects targeting vehicles and mechanical manufacturing in the Eastern Europe and the Mediterranean region [1].

This company have design offices in Bucharest, where engineers try to fulfill market requirements in terms of automobiles. The vehicles designed in those offices are tested and approved on the Titu Technical Center. After an authority give the approval, the vehicles are mass-produced in the Mioveni factory [1].

2. Current stage

The EFQM's principles of excellence are chosen to cover all the concepts of this evaluation, to have a whole picture of this company [12].

- Achieving Balanced Results [2]
- Taking Responsibility for a Sustainable Future [2]

By covering all the concepts of this model, a much clearer overview of this organization can be achieved at the end of this evaluation. Both the concepts that have a positive impact on the organization and those that can be improved can be determined. These improvements can be implemented through an action plan [12].

Table. 1. EFQM principles and concepts [3]

	1					2				3					4					5					6		7		9	
	Leadership					Strategy				People					Partnerships & Resources					Processes Products and services					Customer Results		People Results		Key Results	
	A	B	C	D	E	A	B	C	D	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	A	B	A	B
Achieving Balanced Results																														
Taking Responsibility for a Sustenable Future																														

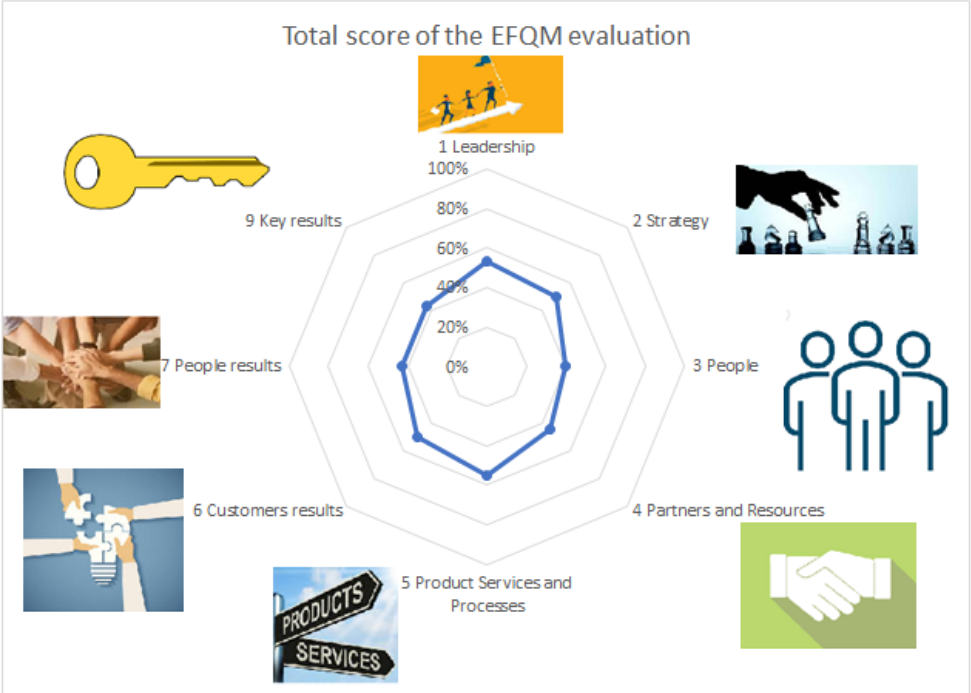


Fig. 1. Total score of the EFQM evaluation [4],[5],[6],[7],[8],[9],[10],[11]

The strengths of this company which are identified after going through all the concepts and principles of the EFQM, are on the side of products and services, exactly on point 5C of this assessment scorebook (Products and services are designed and developed based on customer needs and expectations), where this company scored a total of 55 points out of the total of 100 points and on the leadership side, exactly on point 1C (Leaders interact with customers, partners and representatives of society), where this company scored a total of 60 points out of the total of 100 points. On this last point (1C), even if it has the highest score from all the concepts, on the systematic deployment part there where the approach must be deployed in a structured way with the method used for deployment being planned and executed soundly, this company scored 35 points out of the total of 100 points. This systematic deployment is directly linked to the people and their results [12].

The main problem in this organization, according to the scoring mentioned before, is not that the people don't get good results in general, but they do not get good results compared to the goals that are set by the organization. These things can explain areas for improvement that are identified after going through all the concepts of the EFQM. Those points are on the people side, exactly on the point 3D (People and the organization have a dialogue) where this company scored 35 points out of the total of 100 points, on the people results (7B Performance Indicators) and key results (9A Key Performance Outcomes) where this company scored 40 points out of the total of 100 [12].

Table. 2. EFQM results [3]

	1					2				3					4					5					6		7		9	
	Leadership					Strategy				People					Partnerships & Resources					Processes Products and services					Customer Results		People Results		Key Results	
	A	B	C	D	E	A	B	C	D	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	A	B	A	B
Achieving Balanced Results						50%			45%							35%			55%						55%	45%	45%	40%	40%	45%
		50%	60%					55%																						
Taking Responsibility for a Sustenable Future	55%				45%								35%	45%			45%					55%								
Total	53%					50%				40%					45%					55%					50%		43%		43%	

Action Plan

The objectives and the indicators that are followed for the development of the performance indicators of this organization are described below:

For the performance indicators to be configured in a such way that people's results will be closer to the target, the fixed objective is to balance the tasks at the level of the departments and to introduce a bonus system for key solutions that can bring time/cost reduction within the projects through innovation.

To pursue this objective, the following indicators will be established:

• Measuring the variation over time of the number of tasks at the level of each employee compared to the average time

• The duration of a project from the prototype phase to the final product phase

• The cost savings that each department can bring through innovation

These indicators will be tracked following the actions:

• Reanalyzing the volume of the work at each level, to balance the number of tasks at the level of employees.

• Optimizing the time in which a project goes from the prototype phase to the final product phase to highlight and unblock the stages that receive more work requests than they can process at their maximum flow capacity (bottleneck)

• Introducing a bonus system for finding new and innovative solutions for each element of the vehicle. Through this action, the organization aims to reward any employee who will find an economical and innovative solution for vehicle parts.

The following targets will be set for these indicators:

• The target set for the first indicator is to balance the workload equally for each employee (by managing the ETI involvement time estimation factor).

• The target set for the second indicator is to shorten the development time of a new vehicle by 10%,

• Cost reduction for the final product by 1% without affecting their quality

1`st objective: Measuring the variation over time of the number of tasks at the level of each employee compared to the average

The estimation of the involvement time of each employee for each activity refers to his activity rate considered proportionally to the average activity rate. [15]

For a certain period, the activity rate (RA) is the ratio between the average working time on a certain perimeter of the employee and the average working time of the reference on each perimeter.

Calculation method:

1) The equivalent of the involvement time of each employee will be calculated for each activity that is carried out

2) Summing of all of the factors described in point 1)

Example:

Estimated involvement time of each employee (ETI) is the summation of the activity rate for all of the perimeters (RA) [15]

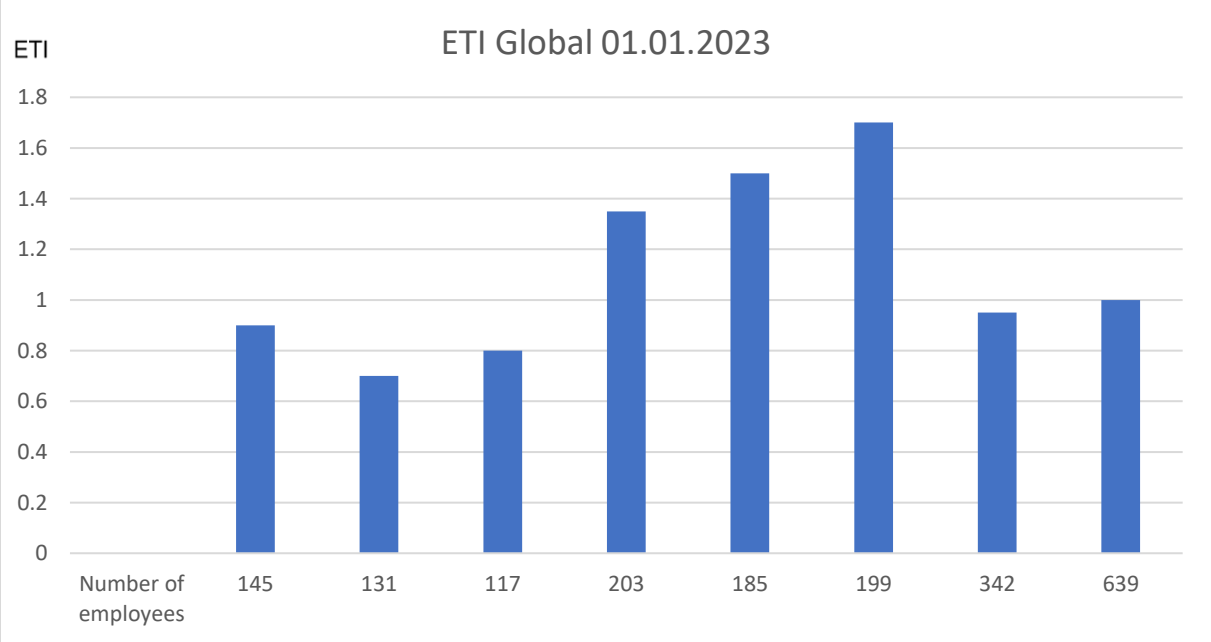
$$ETI = RAx + RAy + RAz \quad (1)$$

The target set for this ETI factor, will be 1 (100%), or in other words, the estimate of an employee's involvement time related to the activity rate for all perimeters should not exceed or be less than the average activity rate.

The time set for reaching this target will be 6 months.

The data will be collected both by management and by the self-assessment of each employee.

Table. 3. ETI global [14],[15]



To be easier to process, an average will be made of the data collected of the employees who exceed ETI 1, of those who are below the threshold of 1 and they will be related to the employees with the average activity rate as in the graph below.

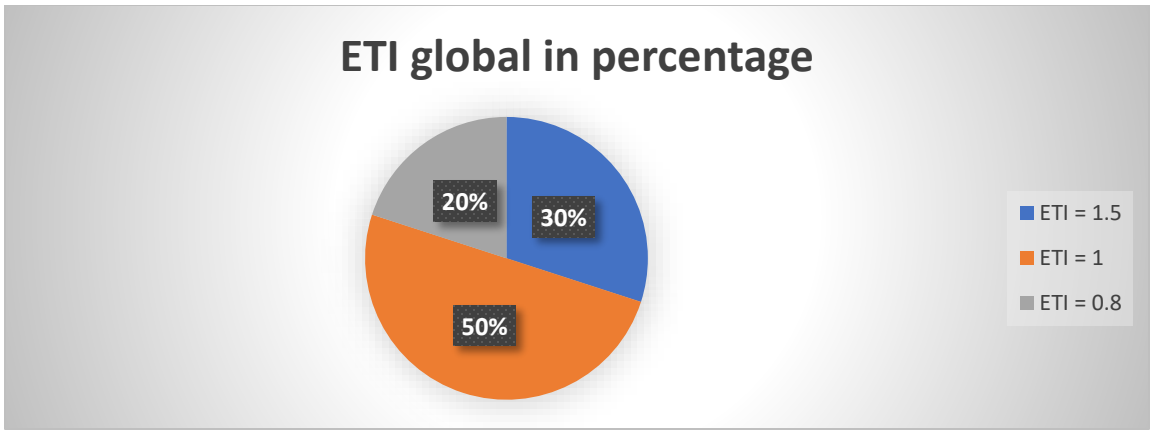


Fig. 2. ETI global in percentage [14],[15]

To optimize the workload and to reach the proposed target, the following formula will be used:

$$Optimized\ ETI = \frac{ETI1 + ETI2 + ETI3}{3} \quad (2)$$

$$Optimized\ ETI = \frac{1{,}5 + 1 + 0{,}8}{3} \quad (3)$$

$$Optimized\ ETI = 1{,}1 \quad (4)$$

2`nd objective: The duration of a project from the prototype phase to the final product phase

From the design phase, it must be considered what it can be borrowed from the old platforms so that the production costs will be as low as possible. Any new solution is difficult to implement because it implies changing the machines and processes on the assembly line. To make this transition from one model to another as easy as possible, for each thing that will be borrowed from one vehicle to another, analysis will be made in terms of feasibility, reliability and quality. After the design phase of those new vehicles, several prototypes will be created in order to be sent for testing [15].

For a vehicle to be competitive in the marketplace, it must meet customer expectations, have the best price and comply with all the regulations in force for the commercial areas where they want to be sold.

For the development of a vehicle from the prototype phase to the final product phase, the duration is 12 months on average. Shortening the development duration by 10% would mean a gain of 5 weeks for each product.

To make this process of vehicle testing and homologation more efficient, the action plan is to divide the types of activities into entities according to the development centers and the capacity of the assembly lines for 12 months.

Since the level of pollution has increased in the last 20 years, the regulations are much tougher from year to year, and the manufacturers had to decide to create 3 types of vehicles:

• Thermal vehicles with engines adapted to combat pollution

• Hybrid vehicles, which use an electric motor to reduce pollution in urban traffic jams

• Electric vehicles with 0 CO2 footprint after manufacturing

Thus, this separation by entities will be established mainly according to this factor. Because in Romania there is the engine factory and the assembly plant in Mioveni, the Titu Technical Center and the design offices in Bucharest, Renault Technologie Roumanie will completely take over the thermal part, partially the hybrid part and will help with the design and engineering of electric vehicles.

In this way, the transport of prototypes, their redesign and validation can be optimized. The current process takes around 50 weeks, but this optimization can save 3 weeks for transport, minimum 1 week for redesign and minimum 1 week for validation.

3`rd objective: Cost savings that each department can bring through innovation.

A 1% cost reduction for each product means a profit of 150 euros for each vehicle. At a volume of 1,000,000 vehicles sold, this will mean a profit of 150,000,000 euros.

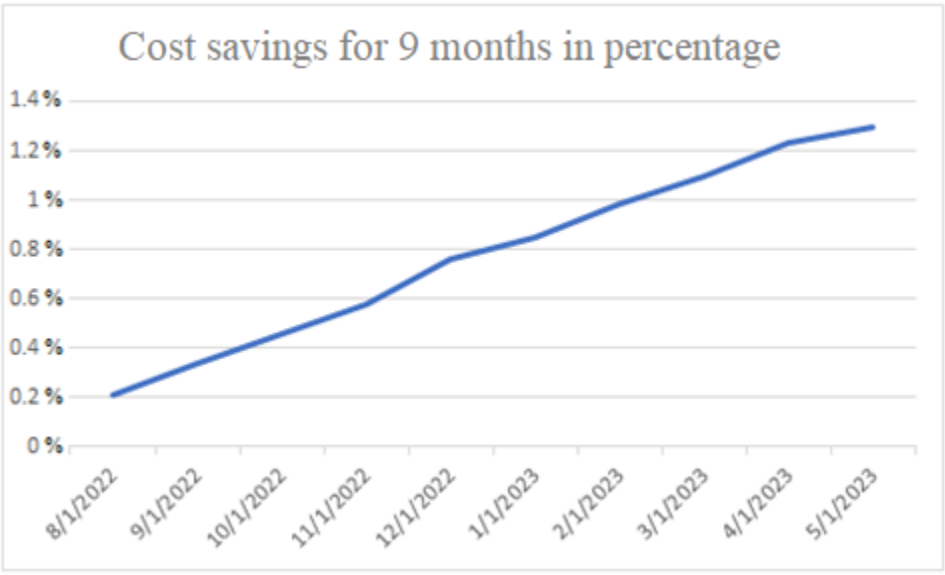
To improve efficiency and increase the finding of this engineering solution, a bonus system has been proposed for each employee. Global cost reductions for vehicles as well as customer complaints resulting from these savings will be monitored for 12 months. Cost savings without customer impact can be achieved with cheaper parts or solutions that completely replace a more complicated solution.

Example:

The use of the ABS computer to determine the pressure in the tires to the detriment of the use of pressure sensors. Basically, instead of 4 physical parts (one pressure sensor for each wheel), a calculation formula will be used. This calculation formula will determine if one of the wheels spins slower than the other 3. This means that the pressure in that tire has changed. Through this solution, cost saving was achieved in the past without impacting the client. Monthly bonuses were granted to the "employee of the month" or the employee who brought the greatest cost savings for a vehicle model in that month. The action plan was implemented since August 2022.

Table. 4. Cost savings [14],[15]

Table. 5. Cost savings for 9 months in percentage [14],[15]



The percentage in the table above was calculated from the average sales value of a vehicle (15,000 euros). No customer complaints were reported following these economic solutions found.

Conclusions

For the first objective: Measuring the variation over time of the number of tasks at the level of each employee compared to the average:

- The established target cannot be reached with current resources.
- For each employee to have an optimized volume of work, new hires will have to be made or some processes will have to be outsourced.
- By optimizing the workload, employees can give a higher yield, some mistakes caused by the workload can be avoided and people's results, along with performance indicators, will improve.

For the second objective: The duration of a project from the prototype phase to the final product phase

- The established target can be reached and can bring an advantage of at least 5 weeks.
- With the help of a clear distribution of projects under development, dead times will be eliminated, and people's results will increase.
- Competitiveness on the market increases since new products can be launched faster.

For the third objective: The cost savings that each department can bring through innovation.

- The established target was reached and even exceeded after the first 9 months.
- Employee satisfaction is increasing following this bonus system.
- The ratio between the premiums granted and the economy brought by these solutions is in the company's favor.
- Savings on final products have no impact on customers.
- This action plan has a positive impact on people's results as well as performance indicators.

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MANAGEMENT SYSTEM SELF-ASSESSMENT OF A DISTRIBUTION COMPANY OF MEDICAL DEVICES

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SUMMARY: The paper presents the self-evaluation of an organization that imports and distributes medical devices for over 25 years on the Romanian market; the self-evaluation was carried out according to the EFQM Excellence Model. The evaluation of the integrated management system implemented at the organization represents an important step in the development/aspiration towards excellence. The sub-criteria were analysed in correspondence with two fundamental concepts, identifying strengths and areas for improvement, with the aim of evaluating the degree of maturity of the integrated management system, as well as identifying priority improvement areas with relevant and motivating potential for the organization.

KEYWORDS: self-assessment, management system, medical devices, EFQM excellence model.

1. Introduction

The EFQM model is a globally recognized management framework that supports organizations in managing change and improving performance [1]. Since the organization SOFMED is concerned with the continuous improvement of performance, its evaluation according to the EFQM Excellence Model represents the way in which the improvement areas available at the level of the organization's processes are identified, but also the degree of maturity of the management system implemented in the organization is evaluated. The objectives of the assessment were to identify areas that require actions to maximize the company's efficiency and performance.

To achieve the proposed objectives, the organization was analysed according to the corresponding sub-criteria of two fundamental concepts of the Excellence Model: Management through processes and Adding value for customers. Following the identification of strengths and improvement areas for each analysed sub-criteria, marks were awarded, which were used in the assessment of the organization according to the Model of Excellence.

The abbreviation "EFQM" comes from "European Foundation for Quality Management". The foundation not only gave the concept a name, but also developed it. In general, the EFQM model is considered a comprehensive quality management model. The latest version is based on eight fundamental concepts (taking responsibility for a sustainable future, building partnerships, nurturing creativity & innovation, succeeding through people, managing by processes, leading with vision, inspiration & integrity, adding value for customers, achieving balanced results), which are analysed through the lens of enablers and results, to help understand and analyse the behaviour, thinking and culture of an organization. The instrument used for diagnosing the organization’s current strengths and opportunities for improvement is RADAR logic (acronym for Results, Approaches, Deploy, Assess and Define). The goal is always to improve operational performance in all areas and at all levels.

The model provides a holistic view of the organization, identifies areas for improvement, and provides techniques and tools for measuring improvement over time. The determining factor here is the relationship between cause and effect. Companies should analyse what they have done, the results they have achieved and the gaps that still exist. In short, the EFQM model is a quality-focused management

framework that shows where an organization is on the "path to excellence" or what steps need to be taken for improvement [1].

2. Presentation of the organization

The organization SOFMED is a company operating in Europe that provides innovative medical technologies for patients in the fields of minimally invasive surgery, robotics, cardiovascular, intensive care, endoscopy and pneumology.

They make life-saving technologies available to patients in the most remote regions of Europe by empowering healthcare professionals with the most trusted innovation and learning ecosystem.

SOFMED was established in Bucharest in 1994 with the aim of opening new paths and creating opportunities in the Romanian medical system by providing life-saving medical technologies.

During its 29 years of existence, the company has developed in more than 5 countries in Europe, out of the desire to provide innovative medical technologies to as many patients as possible. Since the beginning of the establishment of the company, great attention has been paid to the management system, and currently the company holds three certifications according to ISO 9001:2015, ISO 13485:2016, ISO 14001:2015 standards [2].

Some of the company's major achievements in the last 20 years comprise of the first introduction of automatic peritoneal dialysis therapy in Romania (1997), the initiation of the first "Artificial Heart" program in the South East Europe (2001 – Romania), the first video-endoscopy capsule in the South East Europe (2003 – Romania), the first private dialysis treatment in Romania (2005), the first assisted robotic surgery in the South East Europe (2006 – Romania), the first minimally invasive magnetically guided procedure (2015 – Romania) are.

The self-assessment of the organization according to the Model of Excellence is a point of analysis and evaluation that highlights and provides new opportunities for improvement to maximize the efficiency and performance of the company.

3. Fundamental concepts of excellence analysed

In the self-assessment carried out, two of the eight fundamental concepts of excellence were analysed: managing through processes and adding value for customers.

In the organization SOFMED, all activities are driven through processes. The processes and interactions between them are defined in the Quality Manual. Each process has a designated process manager, who, together with the compliance department personnel, implements, monitors, updates and ensures compliance with the procedures and the use of the documents associated with them.

Each process has clear objectives established, with performance indicators, cascading down to the performance indicators of each employee. The desired results are defined both in individual KPIs (key performance indicators) and in the organization's Development/Strategic Plans. Any non-conformity is dealt/treated with by corrective actions and corrections, being considered an opportunity to improve the process and existing procedures, which allows for continuous improvement.

The efficiency and effectiveness of the integrated management system is analysed in the periodic analysis meetings of Management Review. During these meetings, but also as a result of the observed non-conformities and complaints, new risks and opportunities are identified and integrated into the management system. An annual customer satisfaction is carried out annually, through a questionnaire, for collecting customers perception about the organization. In addition, any direct or indirect feedback is recorded in the Feedback Registry and taken into account in Continuous Improvement meetings and beyond.

The organization knows its customer base and adapts its products and services according to their needs and expectations. Through the interactions of clinical support staff, relationships between the organization and clients are built and maintained, based on values such as transparency and integrity. Top-level management is always aware of the latest technologies in the medical field, with the aim of analysing their potential and offering customers the most innovative products and services.

The added value for the customer comes from providing products and services that comply with the applicable legislation in force (compliance for which many actions are taken), along with clinical support and professional development opportunities for the health care professionals. Clinical support personnel not only perform the activities of selling products and services, but also hands-on clinical support, such as in the operating room/treatment, by supporting the health care professionals who operate the products and technologies offered. The personnel have the necessary skills, information and tools to provide clinical support. Any feedback from stakeholders and especially from customers is recorded and considered for continuous evaluation and improvement of the organization. Any complaint about the product or service provided is recorded and its possible cause is identified, with the customer being informed and actions implemented to prevent the recurrence of the complaint.

4. Enablers and results

The EFQM excellence model represented in Fig. 1 is a non-prescriptive framework based on nine criteria out of which five of these are 'Enablers' and four are 'Results'. 'Enablers' criteria cover what an organization does. The 'Results' criteria cover what an organization achieves and how it does it. 'Results' are caused by 'Enablers' and 'Enablers' are improved using feedback from 'Results'.

The arrows emphasize the dynamic nature of the Model, showing innovation and learning contributing to improved enablers that in turn lead to improved results [3].

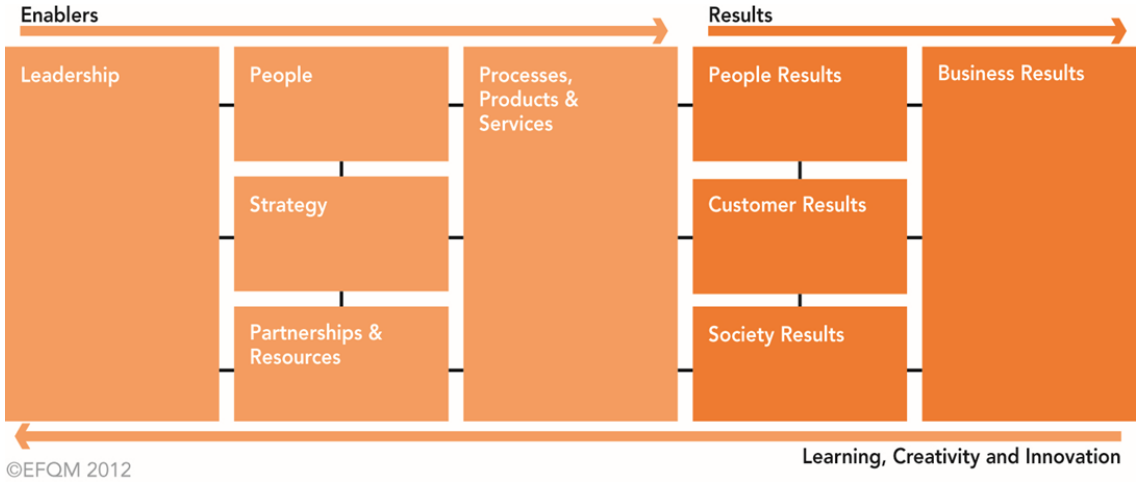

Fig. 1 Enablers and results [3]

Next, the strengths, objective evidence and areas for improvement identified for each enabler and result will be explained.

Leadership enabler

Strengths

• The commitment of the Top-level Management - the vision, the mission established for the company and towards the integrated management system → manifested in the meetings at the beginning of the year

• Process results - monitored and analysed in periodic management meetings

• Stakeholder analysis - identifies needs and expectations → periodically reviewed and improved

Areas for improvement

• Correlating the commitment of Top-level Management with process performance, by identifying tangible elements that will maintain leaders' interest in Integrated Management System

• The introduction of performance indicators to evaluate the commitment of the Top-level Management

• Strengthening the relationship with patient associations

Part of the *objective evidence* that supports the identified strengths includes the periodic implementation of the Stakeholder Analysis and its updating, obtaining, and maintaining the ISO 14001 certificate, establishing quality objectives, establishing and monitoring performance indicators, making reports corresponding to management meetings, completing the Dashboard monthly, drawing up the organization's policy and distributing/promoting it within the company.

Strategy enabler

Strengths

• The quality policy and the commitment of the Top-level Management - publicly displayed. Policy - communicated to personnel via internal newsletter 2 times per year.

• Stakeholder analysis is carried out and continuously improved. Annual assessments of partners and suppliers.

• Top-level management performs the quarterly analysis of performance indicators

Areas for improvement

• Evaluation of awareness of the quality policy and strategy, by introducing performance indicators for all levels of the organization

• Personnel awareness of their role in achieving quality objectives and the impact of each individual's activity on service compliance

• Carrying out an evaluation of the performance of competitors in the medical industry, benchmarking.

Part of the *objective evidence* supporting the identified strengths includes drawing up the organization's policy and distributing/promoting it within the company, setting quality objectives and achieving and monitoring action plans to achieve the objectives, conducting periodic review/management meetings, and producing appropriate meeting reports.

People enabler

Strengths

• Personnel is encouraged to use their skills and knowledge for the benefit of the organisation

• Each employee knows the processes in which they participate and their personal and process performance indicators

• Personnel from different departments collaborate in case of an unexpected/unprecedented situation

Areas for improvement

• Encouraging commitment and completion of an activity, coordinating an action from start to finish

• Periodic reminder of the mission, vision, and strategic objectives, through internal communications/meetings with management

• Awareness of the importance of each employee in achieving the organization's objectives

Part of the *objective evidence* supporting the identified strengths includes organization-wide recognition of employees whose performance is noted by peers, as well as regular training and retraining of staff.

Partnerships and resources enabler

Strengths

• Budgets are established for each department, budget allocation plans; every possible expenditure must be approved before its realization.

• The analysis of risks and opportunities is carried out periodically, with the identification, analysis, and estimation of risks, to treat, monitor and reassess the risk.

• The analysis of partners and suppliers is carried out annually.

• Specialized sources of amendments to the legislation in force, official sources of publication of public tenders are consulted daily, in order to participate; Monthly internal newsletters are prepared with the most relevant news in the medical field, with new devices approved in the EU.

Areas for improvement

• Realization of finance courses for non-finance personnel to understand the basic financial indicators

• Digitization of the evaluation process of partners and suppliers

Part of the *objective evidence* that supports the identified strengths includes the completion of the risk registry and its updating, the preparation of the monthly internal Newsletter with the newest products and innovative technologies in the medical field, the completion and continuous updating of the Tender Registry, the preparation and implementation of a Policy of decision-making, as well as the preparation of the annual evaluations of the partners.

Processes, products, and services Enabler

Strengths

• All processes - the basis of an integrated management system, certified according to ISO 9001:2015, ISO 13485:2016 and ISO 14001:2015 standards.

• Processes are periodically improved, through corrective actions and through the analysis and implementation of employee suggestions/proposals for improvement

• Before introducing a new technology/business group - assessing the impact of the change

• The business model - defined in the Quality Manual, with the mention of key capabilities, processes, partners, and value propositions.

• All products are checked to ensure that the organization supplies only compliant products.

Areas for improvement

• Carrying out market studies, customer questionnaires to anticipate and identify market needs.

• Comparing the performance of the organization's products and services with competitors.

• Identifying the company's market position and using it as a competitive advantage in promoting the products and services offered

• Increasing awareness of quality as a company's competitive advantage and maximizing its promotion

Part of the *objective evidence* that supports the identified strengths includes obtaining and maintaining ISO 9001, 13485 and 14001 certificates, drawing up and updating the Quality Manual, completing, and updating the Register of non-conformities, as well as carrying out Impact change assessments.

Clients Result

Strengths

• Customer perception - assessed in the satisfaction rating questionnaire (Net promoter score - NPS). Based on the answer to a first question, customers fall into one of the following categories: promoters, detractors, or passives.

• All interactions between health care professionals and clinical support specialists are documented through meeting reports, with any spontaneous feedback recorded.

• Following each complaint regarding the products or services provided, letters are sent to customers identifying the causes of the defect/complaint, together with actions that aim to prevent the recurrence of these situations.

Areas for improvement

• Introducing a satisfaction evaluation questionnaire following the purchase of products and services.

• Conducting Focus Group meetings (customers, partners, invited suppliers) to have free discussions/ Q&A/ different discussion topics.

• Making an annual comparison of the organization against other companies with similar activities, comparison at the level – size/object of activity/financial data/customer satisfaction, in order to be able to analyse the place of the organization in the Romanian market.

• Measuring customer retention by analysing existing partnerships.

Part of the *objective evidence* supporting the identified strengths includes submitting the customer satisfaction survey and achieving the NPS score, completing the Feedback Registry, requesting, and receiving root cause analysis letters, and completing the Complaints and Non-conformities Registry.

People Result

Strengths

• Each employee - individual performance indicators derived from process performance indicators, as a measure of meeting process objectives. Annually - evaluate individual performance indicators.

• Every employee should take at least one annual development course, after which they share what they have learned with the relevant people.

• All initiatives and improvement proposals communicated by the employee are mentioned in the annual evaluation.

• At the organization level, every quarter and annually, the Employee of the quarter/year is chosen following the proposal of the people by the management and their voting by all the employees of the company.

Areas for improvement

• Personnel involvement in decision-making and their commitment to the management system - number of improvement proposals, active participation in meetings, number of observations/corrective actions.

• Introduction of performance indicators to evaluate the fulfilment of the obligation to share with interested persons the information/new knowledge acquired following the development courses.

• Awareness of improvement initiatives/proposals and their promotion.

• Creation of Career path to motivate personnel to exceed.

Part of the *objective evidence* that supports the identified strengths is the annual evaluation of the employees by the direct manager, the recognition in front of the whole organization of the employees, evidence of the necessary skills of the personnel, as well as surveys conducted at the personnel level.

Key performance indicators Result

Strengths

• The organization annually establishes the desired financial results, based on the needs and expectations of the stakeholders, considering the analysis of the performances and results obtained in the past and anticipating them for the next year.

• Each process has established process performance indicators, consistent with the company's mission, vision, and strategy, which cascade down to individual performance indicators.

• All process performance indicators are monitored and analysed quarterly, to take actions to achieve the proposed targets. The analysis of the indicators was carried out in the last 3 years, with the fulfilment of the targets for more than ¾ of the indicators.

Areas for improvement

• Identifying and protecting intellectual property

• Risk assessment in the field of information security, followed by the planning and implementation of vulnerability control measures

Part of the *objective evidence* supporting the identified strengths includes completing and monitoring the Dashboard, establishing annual financial objectives, conducting partner and supplier evaluations, establishing and monitoring process and individual performance indicators, as well as conducting an analysis of previous years' results.

5. Outcomes

Following the analysis of the below mentioned sub-criteria of enablers and the results (first line of Fig. 2), scores were given in accordance with the RADAR logic of the EFQM model, the outcomes obtained being shown in Fig. 2.

Enabler	1B	1C	2B	2D	3C	4B	4E	5A	5B	5C	5D	5E	6A	6B	7B	9B
Score	72	58	53	60	48	63	45	83	60	56	73	63	44	58	39	66

Fig. 2 The score obtained for each enabler/result analysed

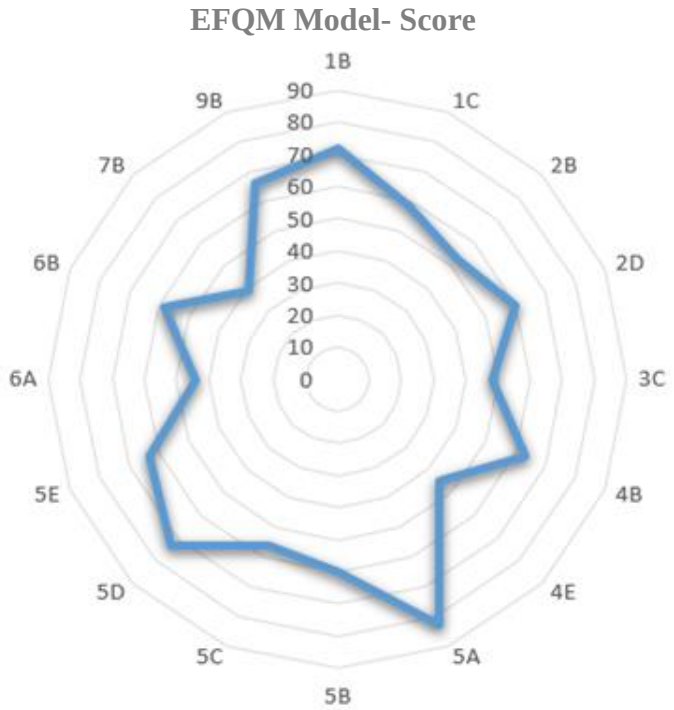

Fig. 3 Chart of scores to identify areas for improvement

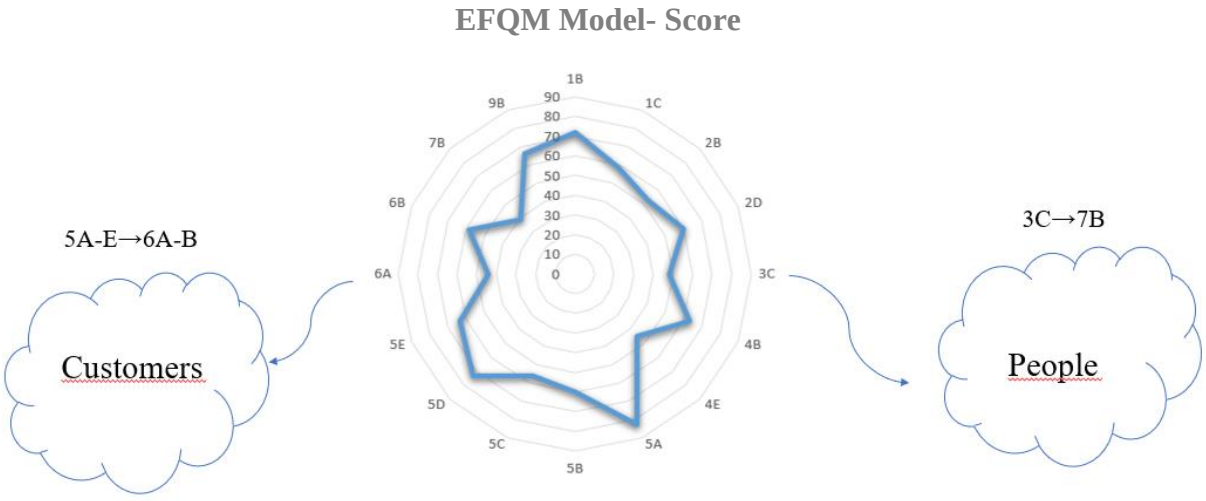

Fig. 4 Graph of scores obtained along with identification of areas for improvement.

The self-assessment of the integrated management system according to the EFQM excellence model allowed the identification of two improvement areas, according to the scores obtained on the enablers and results for people and customers.

Improvement strategies may start with the following:

• Awareness of the importance of each employee in achieving the organization's objectives
• Personnel involvement in decision-making and their commitment to the management system
• Introducing a satisfaction evaluation questionnaire following the purchase of products and services
• Carrying out an annual comparison of the organization against other companies with similar activities, comparison at the level – size/object of activity/financial data/customer satisfaction
• Increasing awareness of quality as a company's competitive advantage and maximizing its promotion

6. Conclusions

The self-evaluation of the integrated management system implemented at the organization SOFMED according to the EFQM Excellence Model highlighted the following aspects:

✓ It was identified a model that helps the organization to correlate the company's results with the enablers that determine these results, highlighting the correspondence between enablers and results;

✓ It was identified a structured way of analysis that allows the correlation of objective evidence with the strong points of the organization's efforts and areas for improvement were easily identified;

✓ Two fundamental concepts of the Excellence Model were analysed, which led to the identification and argumentation/substantiation of the improvement projects that the company can develop. At the same time, the identified strengths can be exploited even more in order to be used as a competitive advantage over other organizations with similar activities on the market.

Improvement projects target two broad groups of enablers and results, people (personnel) and customers. The areas of improvement identified will be developed and applied in this regard in the next project to improve the integrated management system.

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MONITORING THE LEVEL OF POLLUTION IN THE HENRI COANDĂ INTERNATIONAL AIRPORT AREA

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ABSTRACT: The aviation industry is a large global industry and has a significant impact on the environment. In all phases of air travel, many types of pollutants are released. For this reason, air travel contributes to anthropogenic global climate change. Pollutants emitted by jet engines include both criteria air pollutants, defined as common pollutants considered harmful to public health and the environment, as well as greenhouse gases. Both types of pollutants are known to have serious health effects and a significant impact on the environment.

As a research subject, we have chosen the area around Henri Coandă International Airport. The purpose of this research is to understand and estimate the pollution indices in this area, to develop a research algorithm to determine the level of pollution in the airport area, and to develop problem-solving skills. The proposed research project includes both theoretical content and practical content presented in the tables on the following pages.

KEYWORDS: airplanes, pollution, airport, carbon dioxide

1. Introduction

The aviation industry is constantly growing, so the impact of these emissions is becoming increasingly concerning. However, new strategies are being developed to reduce the impact of the growing market worldwide. In Romania, approximately 15 million passengers land and take off annually at Henri Coandă International Airport.

The National Airports Company Bucharest recorded, in 2021, at Henri Coandă International Airport and Aurel Vlaicu Băneasa International Airport, an air traffic of 7 million passengers (an increase of 55% compared to 2020) and 93,000 landings and takeoffs, an increase of 37% compared to the previous year. Compared to 2019, the year with the highest traffic, specifically 15 million passengers, the data indicates a decrease of 53%. Otopeni Airport had in 2022 an air traffic of over 12 million passengers, an increase of 82% compared to 2021, but 85% compared to 2019, the reference year before the Covid-19 pandemic. Henri Coandă Bucharest International Airport currently operates 45 airlines, which transport passengers to 128 destinations.

The first part of the study describes the current situation with the definition and objective of the main characteristic parameters: landing time, takeoff time, number of landing airplanes, number of takeoff airplanes. The study model for the current situation is then described, and proposed solutions for improving the air quality in the area are presented. The results were recorded in tables and the data sets were treated with statistical tools.

2. Methods used in air pollution assessment in the Otopeni airport area.

For this research, we used the mobile application "Flightradar24", which allows real-time tracking of airplanes in flight. To be able to view an airplane on this application, it needs to have an ADS-B transponder, which works together with GPS and transmits a signal that contains speed, route, weather, wind direction, altitude, angular coordinates, latitude (north and south) and longitude (east and west). In addition to this application, we also used the official website of the airport to see all flights and their landing and takeoff times.

According to sources, an airplane takes about eight minutes to take off, from the moment it leaves the platform until it reaches approximately 9842 feet (3000 meters), and four minutes to land, from the moment the pilot positions on the runway trajectory. From our analysis of flights, airlines operating flights at Henri Coandă Airport use airplanes from manufacturers such as Airbus, Boeing, and ATR. For example, Ryanair only has Boeing 737 in its fleet, Tarom has eight Boeing 737, 13 ATR airplanes, and four Airbus planes, while Wizz Air has a young fleet, consisting of a single type of aircraft, Airbus. In addition to passenger flights, there are also cargo flights at Otopeni Airport, with DHL and Cargoair operating regularly. These companies have Boeing 757F and 737F aircraft in their fleets.

If we analyze from a distance/consumption perspective, the most fuel is consumed until reaching cruising altitude. In these stages, aircraft engines operate at maximum power. For passenger aircraft, fuel burn has been allocated between passenger and cargo transport using the following three equations:

Equation 1:

$$Fuel\ used\ per\ passengers[kg] = \frac{Total\ weight\ of\ passengers[kg]}{Total\ weight[kg]} \times Total\ used\ fuel[kg]$$

Equation 2:

$$Total\ weight\ of\ passengers[kg] = number\ of\ seats \times 50\ kg + number\ of\ passengers \times 100\ kg$$

Equation 3:

$$Total\ weight\ [kg] = Total\ weight\ of\ passengers[kg] + Total\ weight\ of\ the\ plane\ [kg]$$

Therefore, the total fuel/passenger consumption is proportional to the payload mass after taking into account the furniture and service equipment required for passenger operations. Equivalently, once the total fuel consumption is known, it is multiplied by 3.16, which is a constant, and the result represents the number of tons of CO2 produced by burning one ton of aviation fuel (according to the ICAO and IATA Carbon Emissions Calculator Methodology). This provides the total carbon emissions.

CO2 emissions from commercial aviation averaged 150 grams of CO2 per passenger per mile in March 2022.

According to estimates, on average, a Boeing 737 aircraft uses approximately 700 kg/min of fuel during takeoff, with a typical weight of 70,000 kg, of which only the aircraft weighs 42,000 kg, and 300 kg/min during landing. This fuel consumption rate can vary depending on factors such as runway length, aircraft weight, temperature, and air humidity. For example, if the runway is shorter or the aircraft is heavier, more fuel may be needed for takeoff. An Airbus A320 aircraft uses approximately 600 kg/min of fuel during takeoff and 250 kg/min during landing, while an ATR 72 aircraft uses approximately 455 kg/min of fuel during takeoff and 227 kg/min during landing.

3. Results and discussion

According to our calculations, the amount of fuel consumed by a Boeing aircraft during the takeoff phase, which lasts about eight minutes, is 5600 kg, and during the landing phase, which lasts four minutes, it is 1200 kg. As for the Airbus aircraft, it consumes approximately 4800 kg of fuel during takeoff and 1000 kg during landing. At the same time, the ATR consumes 3640 kg of fuel during takeoff and 908 kg during landing (see Figure 3).During the takeoff process, the amount of carbon emissions produced by a Boeing aircraft is approximately 17,696 kg, while during landing, it is reduced to approximately 3,792 kg. An Airbus aircraft produces around 15,168 kg of carbon emissions during takeoff and 3,160 kg during landing, while an ATR emits approximately 11,502 kg of carbon emissions during takeoff and 2,869 kg during landing. On average, an aircraft produces 14,789 kg of carbon dioxide during takeoff and 3,274 kg during landing (see Figure 3).

Most flights took place on Thursday, with 197 landings and 196 takeoffs (see Figure 1). On this day, the highest amount of CO2 was recorded throughout the period we monitored the flights, namely 3,555,051 kg (see Figure 5). The graph also shows a sudden increase in takeoffs and landings, as well as in carbon dioxide, during the time intervals of 06:00-07:00; 15:00-16:00 and 20:00-21:00, which are the busiest hours both in the airspace and at the airport (see Graph 1). Taking into account an average of CO2 emissions produced by gasoline and diesel vehicles, we can estimate that 3,555,051 kg of carbon dioxide, produced by airplanes in a single day, mostly during those time intervals, could be emitted by 29,625,425 km traveled by vehicles. The total amount of pollutant emitted on Thursday represents the equivalent of the pollutant amount for the entire car fleet in the capital city, in a day, assuming that a vehicle travels 20 km/day, an average route from home to work and back. Currently, there are 1,500,000 cars in the capital city.

In a week, airplanes produced 22,875,328 kg of CO2, equivalent to 190,628,567 km traveled by vehicles (see Figure 3). Aviation emissions are increasing because the number of flights and passengers is constantly growing.

Ora/Zi	Sambata				Duminica				Luni				Marti				Miercuri				Joi				Vineri			
	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2	Aterizari	Decolari	A+D	CO2
00:00 - 01:00	11	1	12	165.951	11	3	14	172.498	8	4	12	131.405	11	1	12	165.951	12	5	17	193.834	12	1	13	180.739	10	5	15	164.257
01:00 - 02:00	11	0	11	162.677	12	0	12	177.466	9	0	9	133.099	8	0	8	118.310	9	1	10	136.373	9	1	10	136.373	10	0	10	147.888
02:00 - 03:00	4	1	5	62.429	1	0	1	14.789	3	0	3	44.366	2	0	2	29.578	2	0	2	29.578	3	2	5	50.914	1	0	1	14.789
03:00 - 04:00	2	0	2	29.578	1	1	2	18.063	3	0	3	44.366	2	0	2	29.578	1	0	1	14.789	3	0	3	44.366	5	0	5	73.944
04:00 - 05:00	1	0	1	14.789	0	0	0	0	1	2	3	21.336	1	2	3	21.336	2	0	2	29.578	1	0	1	14.789	1	0	1	14.789
05:00 - 06:00	0	5	5	16.369	0	4	4	13.095	1	3	4	24.610	0	3	3	9.821	0	0	0	0	0	5	5	16.369	0	4	4	13.095
06:00 - 07:00	16	17	33	292.275	13	16	29	244.635	16	15	31	285.727	10	13	23	190.447	14	4	18	220.138	14	16	30	259.423	17	17	34	307.064
07:00 - 08:00	1	11	12	50.800	1	8	9	40.979	3	18	21	103.294	2	17	19	85.232	5	16	21	126.324	2	15	17	78.684	4	18	22	118.083
08:00 - 09:00	2	12	14	68.863	2	13	15	72.136	3	15	18	93.473	4	15	19	108.262	4	15	19	108.262	4	17	21	114.809	4	15	19	108.262
09:00 - 10:00	2	3	5	39.399	2	3	5	39.399	10	6	16	167.531	6	4	10	101.828	8	18	26	177.238	13	5	18	208.623	10	6	16	167.531
10:00 - 11:00	2	2	4	36.125	3	7	10	67.283	10	6	16	167.531	11	4	15	175.772	12	5	17	193.834	7	6	13	123.164	8	5	13	134.679
11:00 - 12:00	7	5	12	119.890	12	4	16	190.561	14	7	21	229.960	11	3	14	172.498	14	8	22	233.233	14	6	20	226.686	7	9	16	132.985
12:00 - 13:00	8	10	18	151.048	8	10	18	151.048	9	7	16	156.016	12	12	24	216.751	11	6	17	182.319	13	9	22	221.718	14	9	23	236.507
13:00 - 14:00	7	8	15	129.712	11	11	22	198.688	12	13	25	220.024	7	12	19	142.807	9	9	18	162.563	5	9	14	103.408	10	15	25	196.994
14:00 - 15:00	10	6	16	167.531	10	10	20	180.626	12	9	21	206.929	9	4	13	146.194	10	8	18	174.078	11	8	19	188.867	11	5	16	179.046
15:00 - 16:00	22	9	31	354.817	21	11	32	346.576	16	12	28	275.906	20	8	28	321.966	15	9	24	251.296	18	8	26	292.388	18	10	28	298.936
16:00 - 17:00	1	9	10	44.253	5	11	16	109.955	10	10	20	180.626	5	9	14	103.408	9	9	18	162.563	9	11	20	169.111	8	8	16	144.500
17:00 - 18:00	10	9	19	177.552	7	16	23	155.902	11	13	24	205.236	9	15	24	182.206	10	8	18	174.078	4	13	17	101.714	7	12	19	142.807
18:00 - 19:00	2	16	18	81.958	6	16	22	141.113	3	22	25	116.389	4	20	24	124.630	6	13	19	131.292	8	16	24	170.691	6	22	28	160.756
19:00 - 20:00	5	3	8	83.765	10	5	15	164.257	11	6	17	182.319	6	5	11	105.102	8	23	31	193.607	9	14	23	178.932	7	7	14	126.438
20:00 - 21:00	14	5	19	223.412	14	11	25	243.055	13	9	22	221.718	11	4	15	175.772	8	7	15	141.227	18	7	25	289.115	14	7	21	229.960
21:00 - 22:00	3	10	13	77.104	8	7	15	141.227	6	8	14	114.923	6	5	11	105.102	10	6	16	167.531	5	11	16	109.955	8	9	17	147.774
22:00 - 23:00	4	8	12	85.345	4	14	18	104.988	6	7	13	111.649	3	12	15	83.652	3	8	11	70.556	6	16	22	141.113	4	12	16	98.440
23:00 - 00:00	9	1	10	136.373	10	0	10	147.888	5	0	5	73.944	6	0	6	88.733	8	12	20	157.596	9	0	9	133.099	7	0	7	103.522
Total/Zi	154	151	305	2.721.813	172	181	353	3.136.224	195	192	387	3.512.378	166	168	334	3.004.932	190	190	380	3.431.886	197	196	393	3.555.051	191	195	386	3.463.044

Fig. 1 Landings, Takeoffs and CO2 Total / Every hour

	Combustibil consumat la decolare [kg]	Combustibil consumat la aterizare [kg]	CO2 produs la decolare [kg]	CO2 produs la aterizare [kg]
Boeing	5600	1200	17.696	3.792
Airbus	4800	1000	15.168	3.160
ATR	3640	908	11.502	2.869
Medie Consum	4680	1036	14.789	3.274

Fig. 2 Fuel Used

Ora/Zi	Total/Interval Orar				Medie CO2/Interval orar [Kg]
	Aterizari	Decolari	A+D	CO2	
00:00 - 01:00	75	20	95	1.174.635	167.805
01:00 - 02:00	68	2	70	1.012.186	144.598
02:00 - 03:00	16	3	19	246.442	35.206
03:00 - 04:00	17	1	18	254.683	36.383
04:00 - 05:00	7	4	11	116.617	16.660
05:00 - 06:00	1	24	25	93.359	13.337
06:00 - 07:00	100	98	198	1.799.708	257.101
07:00 - 08:00	18	103	121	603.396	86.199
08:00 - 09:00	23	102	125	674.066	96.295
09:00 - 10:00	51	45	96	901.548	128.793
10:00 - 11:00	53	35	88	898.388	128.341
11:00 - 12:00	79	42	121	1.305.813	186.545
12:00 - 13:00	75	63	138	1.315.407	187.915
13:00 - 14:00	61	77	138	1.154.196	164.885
14:00 - 15:00	73	50	123	1.243.270	177.610
15:00 - 16:00	130	67	197	2.141.886	305.984
16:00 - 17:00	47	67	114	914.416	130.631
17:00 - 18:00	58	86	144	1.139.294	162.756
18:00 - 19:00	35	125	160	926.828	132.404
19:00 - 20:00	56	63	119	1.034.420	147.774
20:00 - 21:00	92	50	142	1.524.258	217.751
21:00 - 22:00	46	56	102	863.615	123.374
22:00 - 23:00	30	77	107	695.744	99.392
23:00 - 00:00	54	13	67	841.154	120.165
Total/Zi	22.875.328				

Fig. 3 Total of every Landing, Takeoff and CO2 per hour

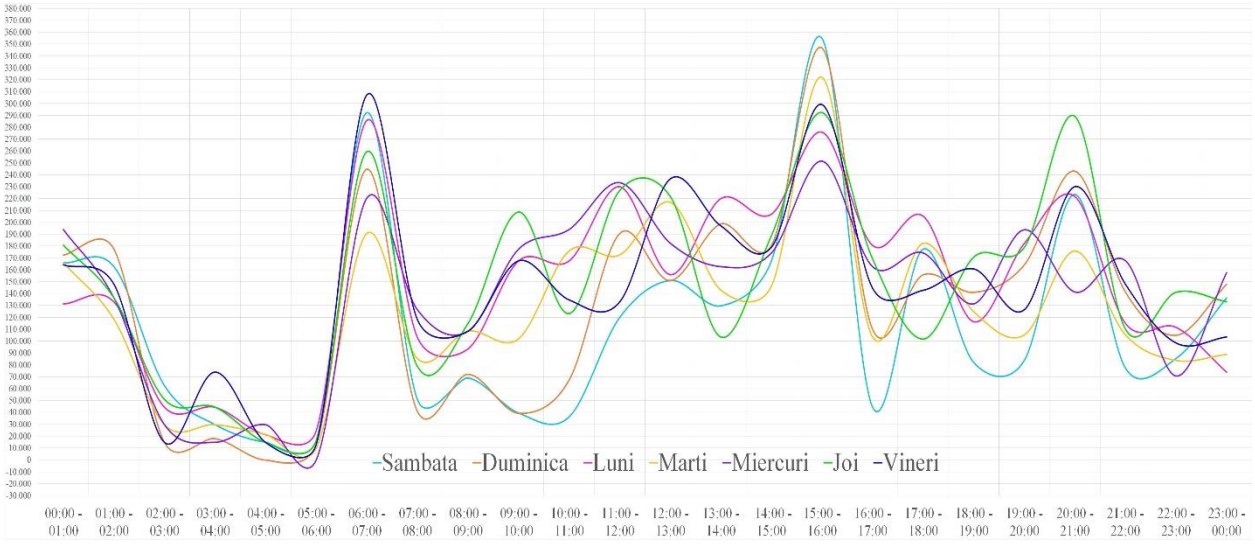

Fig. 4 The amount of carbon dioxide, by hourly intervals, for one week

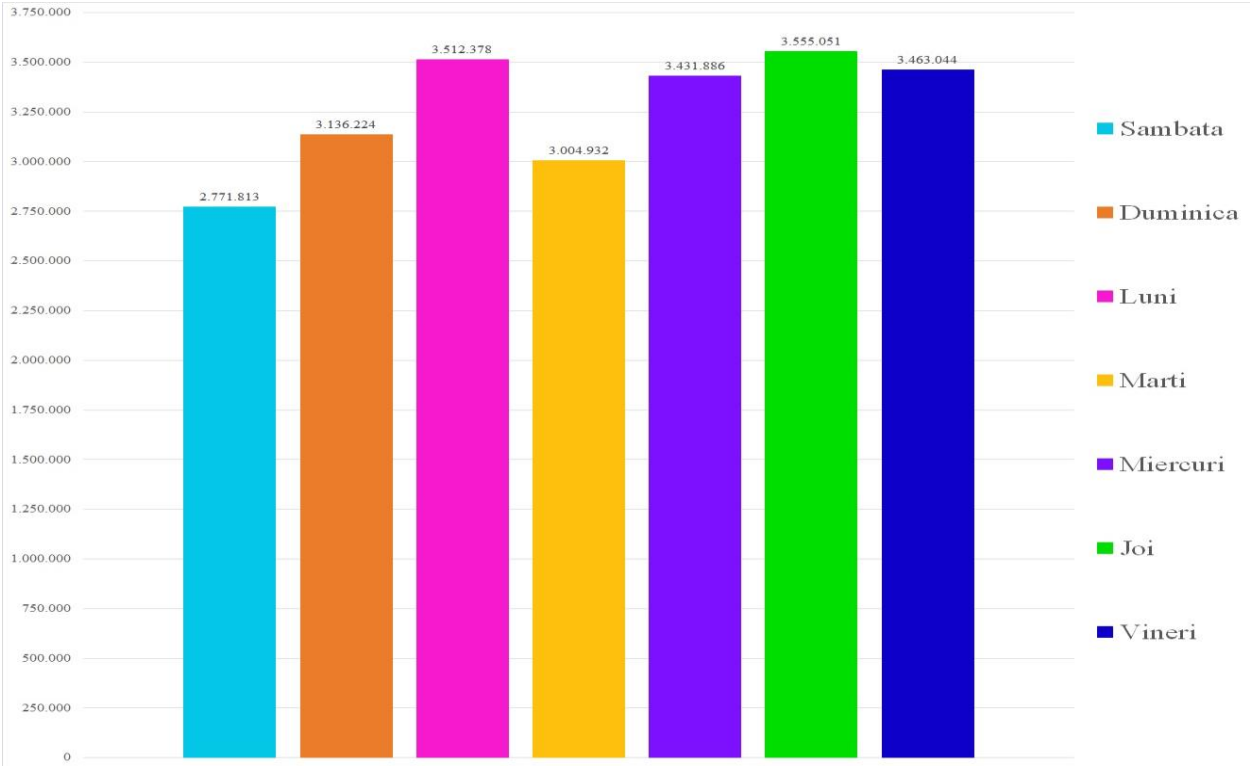

Fig. 5 CO2 Total / Day

4. Conclusion

Pollution around the "Henri Coanda" airport is a significant problem for the environment and the health of people living in those areas. Airplanes produce a wide range of atmospheric pollutants, including fine particles, nitrogen oxides, hydrocarbons, and excessive noise. These pollutants can have negative effects on air quality and contribute to the development of respiratory and cardiovascular diseases. Also, pollution can affect the fauna and flora in the surrounding areas. A study conducted in 2009 by the MIT, a research institute specializing in climate research, concluded that airport areas have much higher pollution levels (covering an area of approximately 20 km, exactly the size of Bucharest) and the emissions from altitude destroy the ozone layer and enhance the greenhouse effect. An airplane taking off produces as many toxic emissions as a car traveling 40,000 km.

There are several technologies and modifications to airplanes that can be implemented to reduce the pollution impact on the environment:

1) Using more fuel-efficient aircraft: Aircraft manufacturers are developing new engines and aircraft models that consume less fuel and emit fewer greenhouse gases. Airlines should upgrade their fleets with these newer and more efficient aircraft to reduce global emissions.

2) Using sustainable aviation fuels (SAF): SAF is a category of biofuels that are produced from renewable sources, such as plants, used oils, or algae. When used in airplanes, SAF can significantly reduce CO2 emissions compared to traditional aviation fuel. Some airlines are testing and using SAF (Alaska Airlines, Delta Air Lines, KLM, Lufthansa) to reduce their carbon footprint.

3) Improving operational efficiency: Airlines are implementing operational improvements that can help reduce fuel consumption and emissions, such as optimizing flight routes, reducing aircraft weight by using a higher percentage of composite materials, and improving ground operations.

4) Generally, buying airline tickets during less busy periods can contribute to reducing the environmental impact. Reducing baggage weight can contribute to reducing fuel consumption and greenhouse gas emissions during the flight. If each passenger reduces the weight of their luggage by a few kilograms, fuel consumption and greenhouse gas emissions could be significantly reduced. For this reason, airlines charge high prices for luggage requests that are much heavier than what is provided in the ticket.

Finally, as the manager of Henri Coanda airport, I would like to disperse the amount of pollutants by trying to eliminate pollution peaks, increasing the hourly time interval of flights. As observed in the chart, the time intervals of 06:00-07:00; 15:00-16:00; 20:00-21:00 are the busiest, and I propose to be moved to time intervals close to those where pollution is very low. For example, some flights that are in the first hourly interval can be moved between 04:00-06:00, where the records are minimal. Some flights from the next hourly interval could be moved between 14:00-15:00, or between 16:00-17:00. In the last interval, flights can be interspersed between 19:00-20:00 and 21:00-00:00.

I would try to suggest, at the time of ticket purchase by the consumer, days or hourly intervals when pollution is lower, by displaying a banner on the website where ticket reservations are made.

These measures can be taken together or separately, depending on the specific needs of each airport and the communities in the surrounding area.

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6. Notes

The following symbols are used in the paper:
ADS-B=Automatic Dependent Surveillance Broadcast
ICAO= International Civil Aviation Organisation
IATA=International Air Transport Association
MIT= Massachusetts Institute of Technology
SAF=Sustainable Aviation Fuel

FIRST AID AT THE WORKPLACE – NEED OR OBLIGATION

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SYNOPSIS: In the work, a presentation is made about the need to provide first aid, as well as other general elements regarding the records and statistics carried out through opinion polls. Definitions, graphs, statistics and suggestive images regarding the need to provide first aid are presented. The authors of the paper believe that first aid must be accessible to everyone and be an integral part of a more extensive development method.

KEY WORDS: first aid, work accident, victim, airway obstruction, cardiopulmonary resuscitation

1. Introduction

Prevention is much better and simpler than treatment. Most of the time, the first person who can provide first aid is family, friends or colleagues because an injury, wound or illness can occur at any time and in any environment. So, each of us should have a minimum of essential knowledge to be able to provide first aid. Moreover, we can all be victims of unforeseen events, such as a storm, flood, earthquake or accident, be it on the road or at work, and first aid knowledge and the speed to intervene can sometimes be vital.

Basic first aid, as defined in Law 95/2006, art. 92, lit. G represents - the performance of life-saving actions to people who have suffered an injury or acute illness, by people without medical training, without the use of specific equipment for this purpose. Basic first aid is given by any person trained in this regard or by persons without training, on the indications of the personnel in the emergency dispatches. [2]

Therefore, any adult person can be trained in basic pre-medical first aid, regardless of education level, income, background.

Regarding first aid at work, it is recommended that every employee has a minimum knowledge of first aid, even if they are not assigned to provide first aid on a regular basis, to be able to intervene if a colleague has a condition of discomfort caused by an illness or is injured as a result of an unforeseen situation. That's why every home, every office and every car should have a minimum first aid kit. Fig. 1.

Fig. 1. The composition of a first aid kit

2. International first aid

At international level, Directive 89/391/EEC of 12 June 1989 on the implementation of measures to promote the improvement of the occupational health and safety, as amended by Directive 2007/30/EC, aims to ensure a high level of worker protection by implementing preventive measures to protect them against work accidents and occupational diseases through information, consultation and training of workers and their representatives. [3]

At European level, the legislation that provides training in the field of first aid varies from one country to another, depending on the internal regulations of each country. In most EU countries, first aid courses are supported by non-governmental organizations specialized in first aid, such as the Red Cross, companies specialized in the training and education of adults or medical institutions. [4]

In EU countries, first aid courses are regulated by law, regarding the number of hours and the standardized curriculum that must include prevention concepts, as well as cardio-pulmonary resuscitation techniques, the use of the defibrillator (automatic or semi-automatic), airway clearance maneuvers and stopping bleeding in case of hemorrhages and wounds. To obtain certification, each participant must complete the curriculum, which includes theoretical and practical parts, and must take a final test. [4]

In France, Article R.241-39 of the Labor Code mentions the details regarding the number of employees in the workshops, who must enter first aid. [4]

"In every workshop where dangerous work is carried out, in every site employing at least 20 persons for more than fifteen days, where dangerous work is carried out, a member of the staff must have received the necessary instructions for rendering first aid in case of expedite. The employees trained in this way cannot be considered as taking the place of the medical assistants provided for in article R.241-35." [4]

Also by Decree no. 2018-1186 of December 19, 2018, automatic external defibrillators must be installed in most units open to the public. Automated external defibrillators include automated and semi-automated defibrillators (AEDs and DSAs). [5]

The defibrillator is a very important device in case of heart disease, easy to use and safe for the victim or the person providing help. [5]

From early 2022, the defibrillator was required for some Category 5 units:

- reception structures for the elderly;
- facilities for disabled people;
- health units;
- railway stations;
- mountain hotels and restaurants;
- mountain cabins;
- closed and covered sports facilities as well as multipurpose sports halls. [5]

3. Local first aid legislation

In Romania, the legislation on first aid at work is based on Law no. 319/2006 on occupational health and safety. According to this law, employers have the obligation to ensure that employees are trained in first aid at the workplace.

According to the Occupational Health and Safety Law, no. 319 / 2006:

"WORK ACCIDENT represents violent injury to the body, as well as acute professional intoxication, which occur during the work process or in the performance of work duties and which cause temporary incapacity for work for at least three calendar days, disability or death". [1]

"FIRST AID consists of all the actions taken immediately after the occurrence of an accident, including work, until the moment of the intervention of specialized medical personnel, with the aim of preventing the jeopardy of the patient's healing, either by the appearance of complications that can make the subsequent therapeutic act more difficult to perform, or by an unfavorable evolution followed by the installation of definitive infirmities or death". [2]

According to art. 94, paragraph 1 of law 95/2006, also called the "Good Samaritan Law", "Persons without medical training who provide basic first aid voluntarily, based on the indications provided by a medical dispatcher or knowledge in the field of first aid by basis, acting in good faith and with the intention of saving a person's life or health, are not criminally or civilly liable." [2]. This paragraph encourages any person certified to complete a basic first aid course to intervene when a victim, whether an acquaintance or a stranger, is injured or requires pre-medical assistance.

4. First aid in school

Some EU Member States have introduced specific requirements for first aid training in schools (even from primary grades) and high schools. The course curriculum is age-appropriate, students are trained in first aid techniques, and successful completion of such a program can be recognized as a first aid qualification. [3]

In Romania, in 2017, 15 senators submitted a legislative initiative to include the subject "First Aid Courses" as a compulsory study subject. The statistics mentioned in the statement of reasons claim that approximately 70,000 Romanians die annually because they are not resuscitated in time and that less than 1% of the nearly two million secondary and high school students have first aid knowledge. The initiative received favorable opinions from the Legislative Council and the Health Committee of the Senate, but the Commission for Equal Opportunities and the Economic and Social Council sent negative opinions. The motivation of the latter was that the introduction of such a course is not justified because the issue is already included as an optional subject. Ultimately, the initiative was rejected. [10]

The only first aid demonstrations that are supported in schools are through the national program "Different School", where students are presented with the importance of knowing the concept of first aid and the essential maneuvers, in order to recognize a serious situation and be able to intervene safely for providing first aid to victims. Fig. 2 and Fig. 3.

Fig. 2. Presentation of first aid course in schools

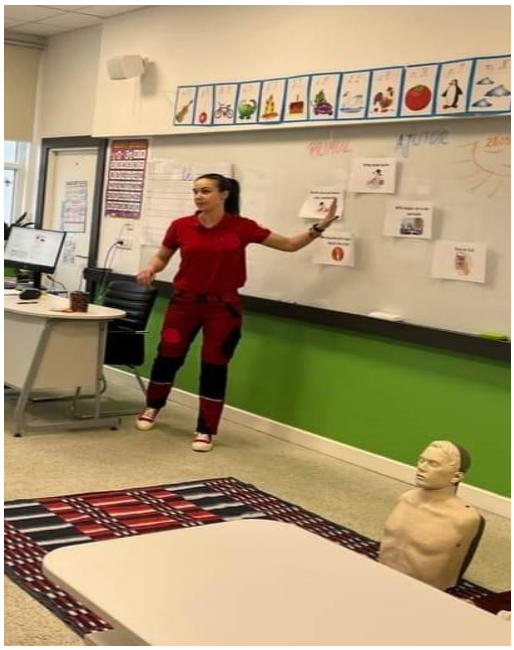

Fig. 3. Presentation of first aid course in schools

5. First aid training

To provide first aid, it is important to know the 4 essential steps:

1. Securing the area and the safety of the rescuer - before intervening, in any situation it is necessary to take measures to prevent injury, infection or even illness to us, the rescuers, because if we decide to put ourselves in a dangerous situation we risk becoming victims. The preferable situation is to have one victim and one rescuer, not 2 victims and no rescuer.
2. Primary assessment of the victim – after we have assessed the situation and we have determined that it is safe for us to intervene, the next step is to assess the victim's condition (if he/she is conscious, is breathing or has other life-threatening injuries).
3. Calling the emergency services (112) – after we have assessed the victim, we will have to call the emergency services to request their specialized help (qualified services). It is important to give the dispatcher clear information about the location where we are in order to locate as quickly as possible, the number of victims and their condition (conscious, unconscious, in cardio-respiratory arrest, with bleeding or severe burns). The dispatcher will determine the severity of the situation and communicate with all departments to send qualified first aid crew (ambulance), fire brigade or police if necessary.

4. Providing the actual first aid – this is the stage in which we provide first aid, based on the knowledge we have or under the guidance of the dispatcher (112 call).

6. Case study

On Wednesday, 26.04.2023, a 14-year-old student choked with a jelly, at Geaca Secondary School, in Cluj county. In a short time, due to the obstructed airway, the girl lost consciousness and the teaching staff called 112. When the SMURD (Mobile Emergency, Resuscitation and Discharge Service) crew arrived, basic resuscitation maneuvers were applied to the girl by the family doctor from the village medical office and the nurse medical from the Secondary School. SMURD and SAJ (County Ambulance Service) medical teams resuscitated the teenager and cleared her airways with the help of special equipment. Shortly after, the girl's vital signs returned. The student was picked up by a SMURD helicopter and was urgently transported to the UPU (Urgent Reception Unit) of the Children's Hospital in Cluj-Napoca. [7].

Doctor Corina Dumitru from the Gherla Ambulance declared: "It was blocked (the jelly) at the entrance to the trachea, it practically stuck to it. It could only be visualized with the laryngoscope. It was a white and green apple-flavored jelly. They are quite large jellies, available in supermarkets, they are very dangerous. Unfortunately, it took time for us to get to Geaca, precious time during which the girl's brain was without oxygen. That's why we encourage everyone to learn first aid measures. The Heimlich maneuver, performed correctly, could have been lifesaving". [8]

In this example, a few simple but effective maneuvers, applied even by the teaching staff, could have prevented this serious situation. Airway obstruction can be partial (incomplete) or severe (complete). In the case of incomplete obstruction (when the victim moves his hands to the throat but can still breathe and speak), as first aid measures we encourage the victim to cough and reassess him periodically because the foreign object can migrate and completely block the airway leading to a complete airway obstruction, with conscious victim.

In the situation where we have a victim with complete, severe airway obstruction (when the victim has his hands positioned in the neck area and cannot cough or breathe) but is conscious, as first aid measures we place the victim in a slightly bent position and apply 5 inter scapular blows (between the shoulder blades) Fig 4, then we alternate with 5 abdominal compressions (Heimlich maneuver - one of the hands is positioned with a closed fist between the navel and the sternum of the victim and the second hand is placed over the first and suddenly pulled from the bottom, upward and from front, towards the back). Fig. 5 și Fig. 6.

Fig. 4. Interscapular strikes

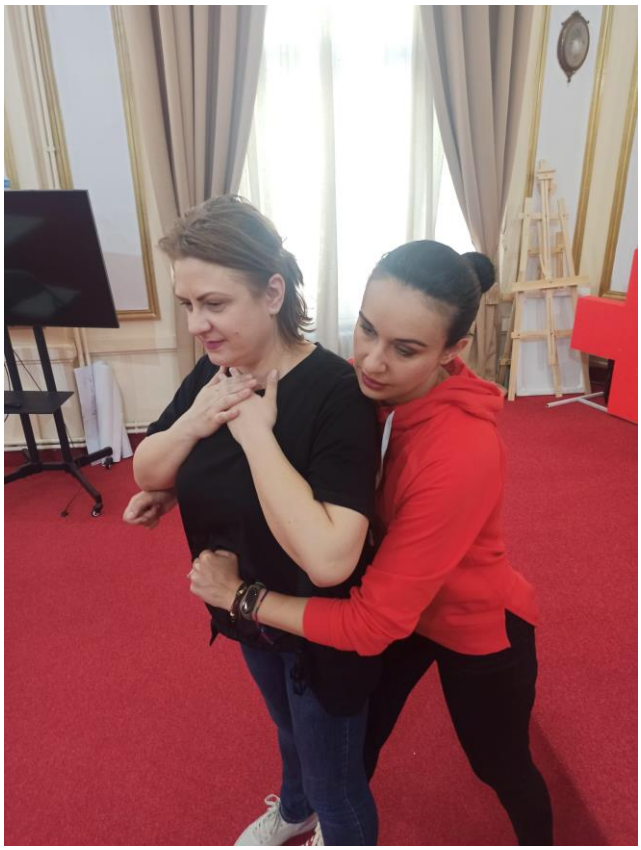

Fig. 5. Abdominal compressions, the Heimlich maneuver, positioning the fist between the navel and sternum

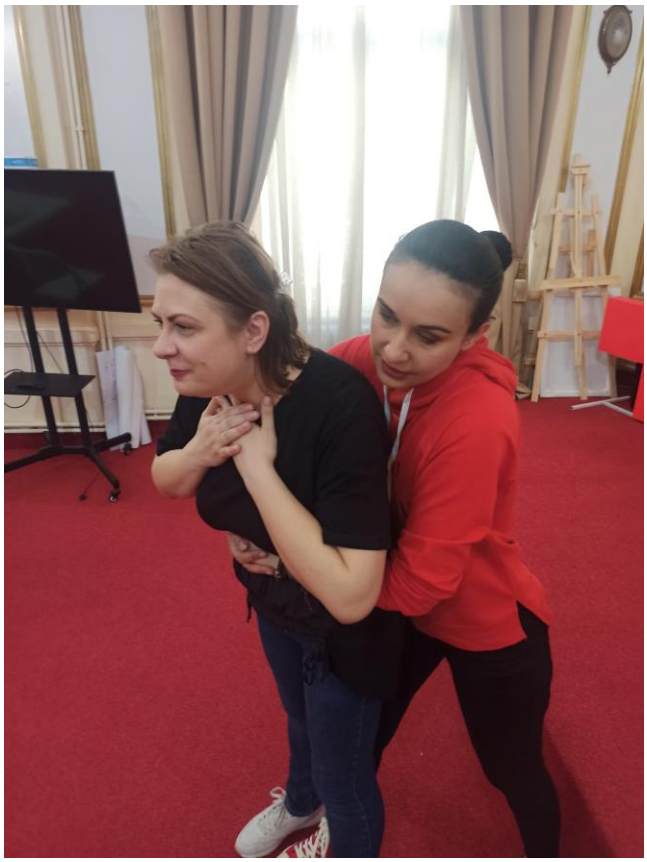

Fig. 6. Abdominal compressions, Heimlich maneuver, the second hand is placed over the first and suddenly pulled from the bottom up and from the front to the back

If the victim loses consciousness, we will start the cardio-pulmonary resuscitation maneuvers – we kneel next to the victim and position the palm of one hand on the victim's chest, in the middle of the inter-nipple line. We position the second palm, over the first, with the fingers interlaced, keeping the arms straight. We apply 30 chest compressions, at a third of the depth of the trunk (5-6 cm in the case of an adult), with a rate of 100-120 compressions/minute, Fig. 7, then we apply 2 rescue breaths (mouth-to-mouth breaths), Fig. 8.

As a particularity, in the case the victim is a children younger than 8 years old, we will start with 5 rescue breaths and the we will make the chest compressions with one hand, and in the case of babies (newborn-12 months), we will start with 5 rescue breaths and the we will make the chest compressions with 2 fingers.

Fig. 7. Applying chest compressions to a victim in cardio-respiratory arrest

Fig. 8. Applying ventilations to a victim in cardio-respiratory arrest

If resuscitation is started in the first minutes after the cardiorespiratory arrest is established and if it is maintained until the arrival of the ambulance, the chances of the patient's survival and recovery increase by more than 75%. [9]

7. Conclusions

The purpose of this paper on the need to acquire first aid knowledge is to form an overview of the basic pre-medical aid provided until the ambulance arrives. [3]

In the case study presented above, if the teachers at the school had known how to intervene quickly, a tragedy could have been avoided. So, whatever field of activity we work in (construction, agriculture, education, HoReCa, etc.) sometimes basic first aid knowledge can make the difference between life and death.

Following an opinion poll carried out on a sample of 35 people, with ages between 16 and 65, consisting of students, employees and pensioners, 100% of the people interviewed answered "yes" to the question of whether they had heard of the first aid, Fig. 9. When asked if they participated in first aid trainings, only 11 respondents said "yes" (31%) and 24 said "no" (69%), Fig. 10, and to the question of whether it is necessary to introduce first aid in schools or at the workplace, 89% of the people interviewed answered "yes" and 11% answered "I don't know". Fig. 11.

Row Labels	IF HE HEARD OF F.A
YES	35
Grand Total	**35**

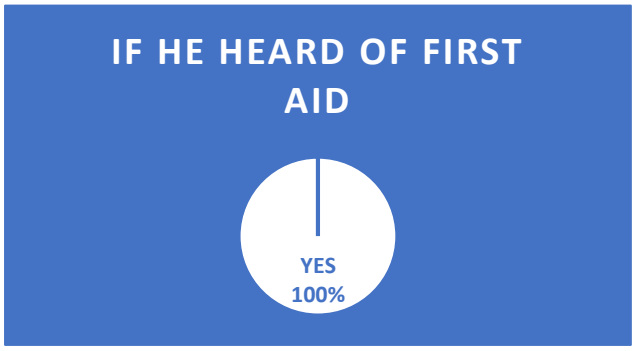

Fig. 9. Chart on the survey of people who have heard of "first aid"

Row Labels	HAVE YOU ATTENDED FIRST AID COURSES?
YES	11
NOT	24
Grand Total	**35**

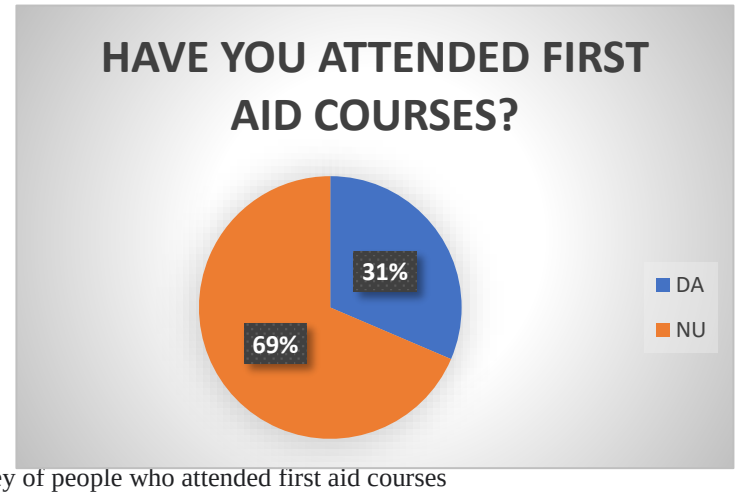

Fig. 10. Chart on the survey of people who attended first aid courses

Row Labels	IF IT IS NECESSARY TO INTRODUCE FIRST AID INTO SCHOOLS/WORK
YES	31
I DO NOT KNOW	4
Grand Total	**35**

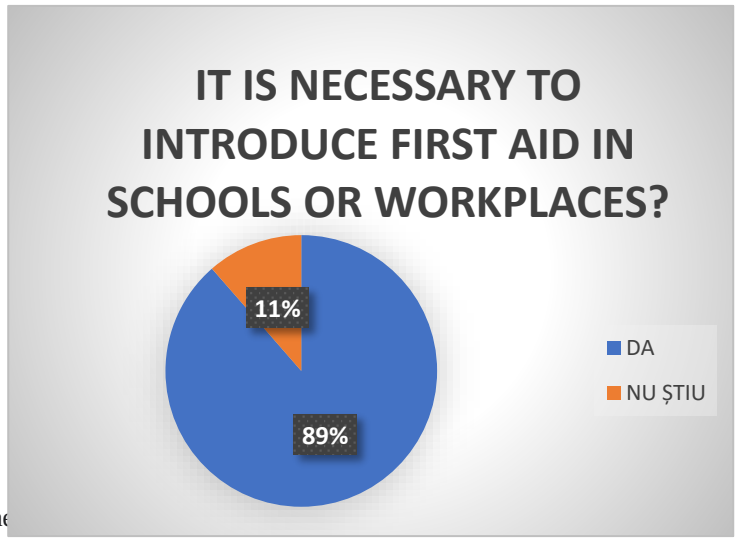

Fig. 11. Graphic regarding the

We believe that participation in first aid courses should not be conditional on obtaining a certificate required at the workplace. First aid courses are vital for personal protection, but also for helping others in special situations. A first aid training is not only useful in the workplace, but also in everyday life. Unforeseen situations arise at any moment, in which our loved ones need support. First aid dexterity is extremely important when we don't have quick access to specialized medical help. [11]

We also believe that first aid is not a substitute for emergency services, it is a vital first step in providing a quick and effective intervention that helps reduce serious trauma and improve the chances of survival. [6]

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THE EVALUATION ON THE EFFECTIVENESS OF PROTECTIVE MASKS AGAINST RESPIRATORY INFECTIONS

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ABSTRACT: This study aimed to evaluate the effectiveness of protective masks against respiratory infections, with a specific focus on the COVID-19 pandemic. A survey was conducted among a sample of individuals to collect their perceptions and attitudes towards wearing protective masks, including the frequency of use, type of mask used, and reasons for use or non-use. The survey also explored the impact of wearing masks on daily life, as well as sources of information and trustworthiness of such information. The study identified several factors that affect mask usage, including age, gender, and occupation. These findings have important implications for public health policies and education programs aimed at promoting the use of protective masks.

KEYWORDS: protective masks, respiratory infections, efficacy, evaluation, physical distancing, COVID-19.

1. Introduction

The paper on "*Evaluation of the effectiveness of protective masks against respiratory infections*" focuses on assessing the effectiveness of different types of protective masks, including N95 masks, surgical masks and masks made of cotton or other materials, in preventing the spread of respiratory infections, especially in the case of the COVID-19 pandemic.

This study aims to assess how effective protective masks are in preventing respiratory infections. It proposes to us to determine whether the use of protective masks can reduce the spread of respiratory infections and to offer recommendations for improving their use in order to prevent respiratory infections.

The study was conducted in the context of the COVID-19 pandemic, which began at the end of 2019 and was declared a pandemic by the World Health Organization in March 2020. The pandemic has generated a global health crisis and put pressure on the health system and suppliers of protective equipment, including protective masks. Since the SARS-CoV-2 virus spreads through respiratory droplets, including the expiration, coughing and sneezing of infected people, the use of appropriate protective masks can help prevent the spread of infection. In this context, assessing the effectiveness of protective masks against respiratory infections, including COVID-19, is a topic of great importance for public health and for the protection of vulnerable people. [3]

Linking this theme is motivated by the special importance of protective masks in the prevention and control of respiratory infections, especially in the context of the COVID-19 pandemic.

Firstly, the COVID-19 pandemic has highlighted the importance of using protective masks against respiratory infections and highlighted the need to assess their effectiveness. Therefore, it is important to understand how different types of protective masks work, how effective they are and to what extent they can help prevent the spread of respiratory infections. [1]

Secondly, this study can contribute to the development and improvement of techniques for the prevention of respiratory infections and to improve safety in areas such as the medical system and the food industry. [1]

The objectives of this research are:

- To identify the frequency and type of protective masks used by participants.
- To evaluate the perceptions and attitudes of participants towards wearing a protective mask, including the reasons why they wear it or not wear it.
- To look at the impact of wearing a protective mask on the daily lives of participants.
- To provide recommendations and suggestions for the development of public health policies and education programs to promote the effective use of protective masks in the prevention of respiratory infections. [2]

The study's hypotheses are:

- Surgical protective masks are more effective in preventing respiratory infections than protective masks made of cotton or other textiles.
- The use of protective masks reduces the spread of respiratory infections in communities or crowded environments.
- People who wear protective masks are less likely to contract respiratory infections than those who do not wear masks.
- Protective masks may be more effective in preventing respiratory infections in certain situations (in environments with polluted or crowded air) than in others.

2. Current status

In recent years, respiratory infections have become a major public health problem worldwide, and the COVID-19 pandemic has highlighted the importance of measures to prevent and control these infections. There are some studies that suggest that protective masks are effective in preventing the spread of respiratory infections, including COVID-19, but their effectiveness is controversial.

Respiratory infections are caused by various pathogens - viruses, bacteria and fungi, which infect the airways of the body. They can affect the nose, throat, sinuses, ears, trachea, bronchi and lungs. The most common symptoms are cough, nasal discharge, pain, fever, headache and fatigue. [8]

Protective masks are one of the most important means of preventing and limiting the spread of the COVID-19 virus. This virus is transmitted through contact with viral particles expelled from the nose and mouth when an infected person speaks, coughs or sneezes. Protective masks help limit the spread of these particles by filtering the air you breathe. Protective masks used in connection with COVID-19 include N95 masks, surgical masks and textile masks. It is important to note that protective masks are not completely effective and should be used in conjunction with other precautions - physical distancing, hand hygiene and avoiding crowding. [7]

This study consists of evaluating the N95 masks, the surgical masks, the cotton masks and other materials. We will present the characteristics regarding these types of masks used against respiratory infections:

N95 masks are respiratory protective masks that have the ability to filter at least 95% of non-oily aerial particles, including very fine particles - those from viruses and bacteria. These masks are also called N95 particle filter masks. [4]

They are considered of high quality and are commonly used by medical workers and those who work in environments with dust and other particles. N95 masks are subject to strict standards and regulations to ensure they provide adequate protection against respiratory infections. [4]

These masks are created with an external layer of non-oily material, which protects against larger particles - those made of dust and pollen, as well as with an internal electrostatic filtration layer, which captures finer particles - those from viruses and bacteria. They are designed to fit tightly on the face so that particles can’t enter the body through the edges of the mask. [4]

N95 masks are also available with a valve, which facilitates breathing. However, the use of these masks with a valve is limited in certain environments - medical ones, since the valve can allow particles to be expelled into the environment, which can pose a risk to other people. [4]

Surgical masks are medical devices that are designed to protect patients and doctors from bacterial and viral contamination. They are used especially in health facilities, but they can also be worn by people who want to prevent respiratory infections - flu or colds. [5]

Surgical masks are made of non-woven materials - polypropylene, which are able to filter out particles of small size. They are usually white or blue and are available in different sizes and shapes, to suit different faces. [5]

Surgical masks are classified according to their particle filtration efficiency. There are three main types of surgical masks: type I, type II and type IIR. Type I surgical masks are the least effective and can filter at most 95% of particles of small size - those of bacteria. Type II surgical masks are more effective, being able to filter at least 98% of small particles. IIR surgical masks are the most effective, being able to filter at least 98% of small particles and are resistant to liquid splashes. [5]

Surgical masks are designed to be worn only once and then discarded. They must be used carefully to prevent contamination, and people who use them must strictly follow the instructions for use and disposal. [5]

Masks made of cotton or other textiles are generally used in order to reduce the risk of spreading respiratory infections. They are often used in non-medical environments, such as in communities or where high protection against particles or bacteria is not required. Masks made of cotton or other textiles are made of multiple layers of fabric and can be equipped with filters. They are reusable and can be washed, which makes them more affordable and environmentally friendly than other types of masks. [6]

However, cotton or other textile masks do not offer the same protection as N95 or surgical masks. They cannot be considered an alternative to them in environments at high risk of exposure to particles or bacteria. Also, if they are not manufactured and used correctly, these masks can increase the risk of infection. It is important to follow the guidelines and recommendations of health authorities on the proper use and cleaning of masks made of cotton or other textiles. [6]

The correct use of protective masks is essential to reduce the spread of respiratory infections, including COVID-19. It is important to understand the differences between the types of masks and to use the appropriate masks for each situation. In general, surgical masks are recommended to prevent the spread of viruses and bacteria, while N95 masks are recommended for personal protection from very fine particles - those from combustion fumes or toxic materials. It is important to follow the guidelines and instructions of public health authorities on the use, disinfection and disposal of protective masks to prevent the spread of infections. It is also important to understand that the use of protective masks is not sufficient in itself to prevent the spread of respiratory infections, and that a combination of personal hygiene measures is required - regular hand washing and physical distancing.[9]

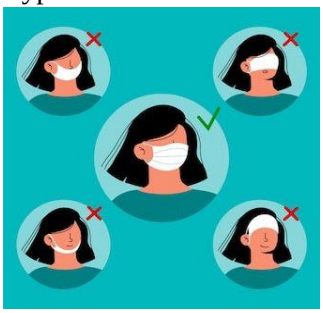

Fig. 1 Correct use of protective masks

3. Research methodology

To investigate the effectiveness of protective masks against respiratory infections in the context of the COVID-19 pandemic, we will use the following methodology:

- Selection of the sample:

Probabilistic sampling is used to ensure the representativeness and validity of the data. The sample consists of 100 randomly chosen people of different ages, targeting people who wear protective masks in

various situations - medical employees, employees in industries, people who use public transportation, pupils / students, both in urban and rural areas. An appropriate sample size shall be determined in order to obtain significant and representative results.

- Data collection:

As a research method, we used a survey method that is based on a questionnaire. The questionnaire was submitted online and included questions about the habits of wearing masks and experiences regarding their use in different situations.

Link to questionnaire: https://forms.gle/YTX4Dq4WZ79BATLz9

- Data analysis:

The data collected was analyzed using appropriate statistical methods, including univariate and bivariate analysis. Statistical inference tests have been used to determine if there are any significant differences between groups of people for the relevant variables.

- Interpretation and presentation of the results:

The results include an analysis of the similarities and differences between the groups of people and the goals of the study. The implications of these findings in the context of respiratory infections in the context of the COVID-19 pandemic are discussed. Recommendations are being made for future public policy actions and the respiratory infections we face.

3. Results

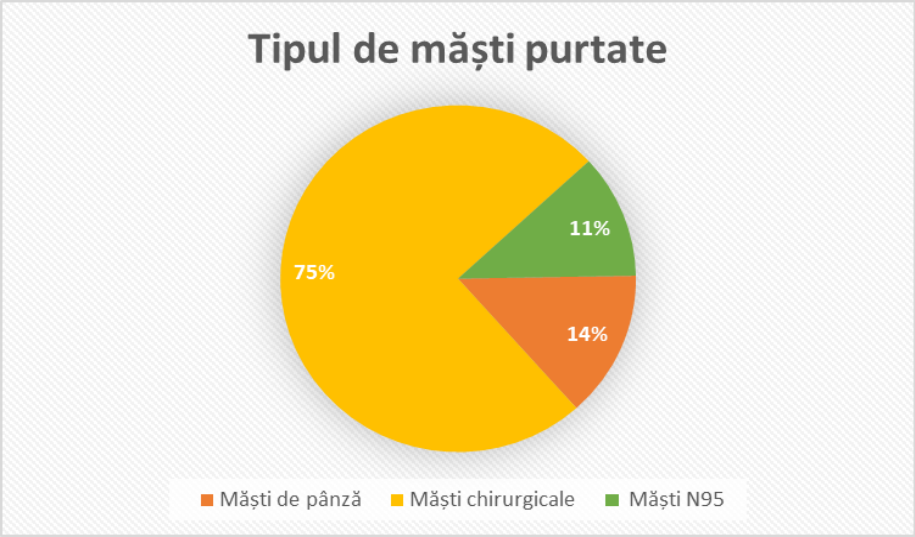

Fig.2 Type of masks used by participants againstCOVID-19 Infection

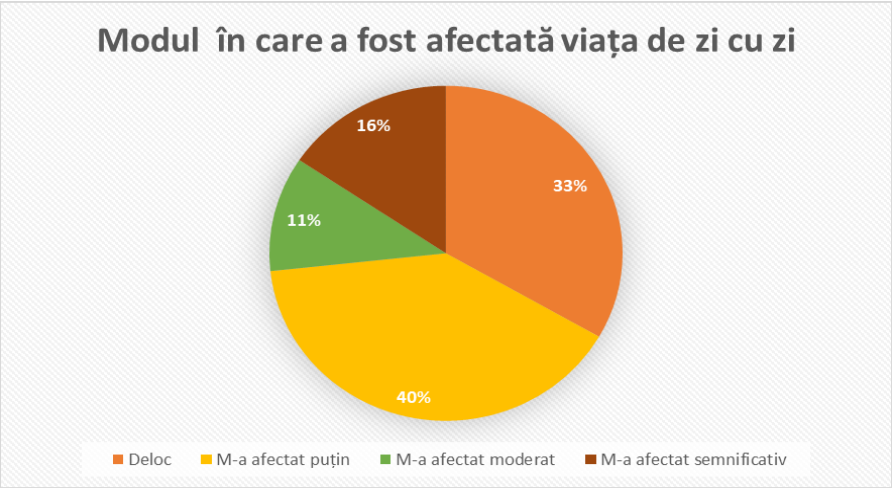

Fig.3 How it affected the daily lives of the participants regarding the wearing of protective masks

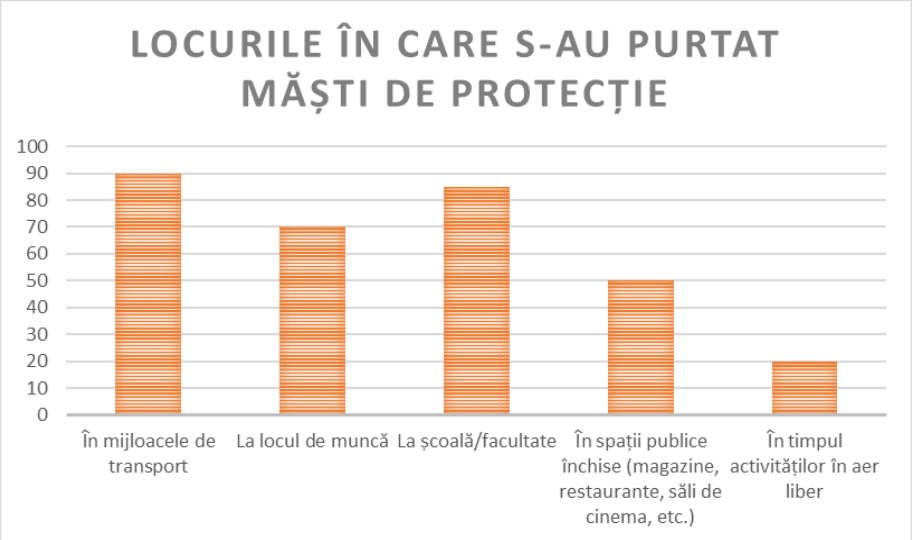

Fig.4 The most common places where participants wore protective masks

Our study showed that surgical masks were the most used (Fig.2), and people reported that wearing them did not significantly affect everyday life (Fig.3). However, wearing masks can be uncomfortable or disturbing for some people - those with respiratory problems or those who wear glasses. There are also concerns about the social and emotional impact of wearing masks - the difficulty of nonverbal communicating and the feeling of isolation. Generally, people are willing and wear masks to protect their own health and those around them. Masks have been worn in several places, especially in closed spaces, crowded or at high risk of infection. These include public transport, schools, workplaces, shopping centers, cinemas, and other public places where it is difficult to maintain physical distance (Fig.4).

4. Conclusions and recommendations

From the results of our study, we can conclude that N95 masks are the most effective in preventing respiratory infections, followed by surgical masks. Cotton or other textile tiles are less effective, but they can be useful as additional protective measures in certain situations. It is important to pay adequate attention to training and education on the correct use of protective masks, as well as to consider other preventive measures - social distancing and proper hand hygiene. These conclusions have significant implications for public policies and for the management of respiratory infections in the context of the COVID-19 pandemic.

Recommendations:

- It is important to use quality protective masks that cover the nose and mouth and are comfortable to wear in order to avoid frequent adjustments;
- Change masks regularly and wash them after each use, especially those made of textiles;
- In addition to wearing protective masks, it is important to observe the other hygiene measures - regular washing of hands and maintaining social distance;
- To avoid the risk of infection, it is recommended to avoid close contact with people who have symptoms of respiratory infection or who have been exposed to the virus;
- In case you show symptoms of respiratory infection, it is important to stay at home and seek immediate medical attention;
- In general, protective masks should be used as an additional protective measure, and the decision to use them must be taken in the specific context of the situation and in accordance with the recommendations of local health authorities.

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IMPROVING THE HOUSING STRUCTURE

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SUMMARY: The need for consolidation works of the existing constructions takes a very large scale with the passage of the years, mobilizing human and material resources comparable to those used for new investments. The consolidation of the structures must be carried out on the basis of clearly and coherently expressed principles, leading to the achievement of safe constructions with a predictable seismic vulnerability to the incidence of an earthquake of maximum probable intensity. The objective of the work is to establish the causes that lead to the degradation of the constructions, the elimination of these causes and the proposal of consolidation measures, of the degraded structural elements, following the qualitative evaluation as well as after the verification of their bearing capacity in accordance with the standards and norms in force. The present study aims to analyze the behavior of some constructions subject to seismic action.

KEYWORDS: construction degradations, consolidation solutions, elastic linear analysis, nonlinear elastic analysis, composite materials with carbon fiber.

1. Introduction

Examination of an existing building and design of the interventions required for its safety in relation to the action of future earthquakes must be taken into account the following points:

- Ensuring a favourable overall design, allowing for a response in advantageous conditions for seismic actions. It should be pointed out that in this respect, in buildings existing, and especially in the older ones, there are often problems in terms of taking over the gravitational loads in good condition, in the sense that the expertise could pull out in evidence of important malfunctions, weakening of some load-bearing elements due to deficiencies execution or due to corrosion, etc.
- Verification by calculation of the strength structure, which must include the checks strength (determination of load-bearing capacity), stiffness checks (limitation of lateral deformations under the action of seismic horizontal forces), ductility checks (the ability to develop post-elastic deformations without reaching the state of collapse).
- The composition of the structural elements and the links between them.

2. State of play

The global trend is to increase the level of safety of the construction, architectural conformation, urban dimensions, importance to the owner, or for society, this increase being made mainly by taking into account a upper level, of the current hazard level at seismic design action.

Romania is a country with important seismic activity, being on the 24th place of the the 80 states that recorded casualties from earthquakes between 1900 and 2000.

For this reason, it is necessary to structurally rehabilitate all buildings designed and made before 1977, the year that due to the devastating earthquake forced the Romanian state to impose superior requirements in the design of constructions. Design rules older had not included anti-seismic measures or had specified low levels of

seismic activity.

The need for works to consolidate existing constructions is on a very large scale sea with the passage of years, mobilizing human and material resources comparable to those used for new investments. The occurrence in time of degradations as a result of aging materials, fatigue phenomena, slow flow, but also the effects of some actions extraordinary (the action of the earthquake, the action of fire or explosions), as well as the aggressiveness the environment has led to numerous cases of damage in construction, material damage and many or even human.

Consolidations of structural elements can keep the same structural scheme, increasing the sections of the elements by the addition of concrete and reinforcement, metal bars or composite materials or can be executed by introducing new elements that partially discharge the initial structure.

3. Case study

Palace Hotel in Govora Băi

Baile Govora spa resort is located in the area of the Getic Subcarpathians of Vâlcii (Fig. 1), 18 km. away from Râmnicu Vâlcea.

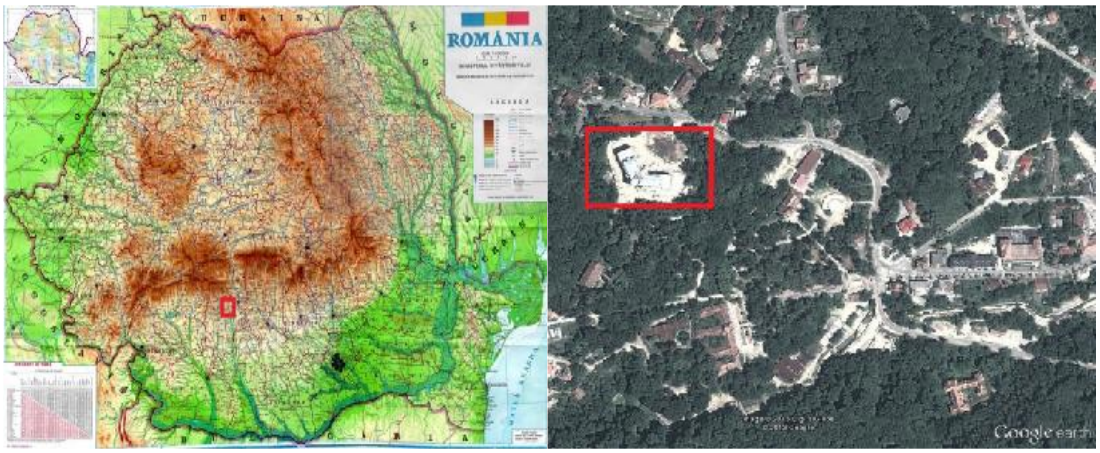

Fig. 1 Geographical positioning of the building

Historical monument, emblem of the resort, built between 1911–1914, HOTEL "PALACE" (Fig. 2) was the first hotel with a treatment base in Romania, built after the plans of the French architect Eduard Doneaud, the works being coordinated by the Romanian engineer Bratescu and the Italian engineer Pukliky. The architecture of the building is eclectic with art influences nouveau and elements of neo-Romanian architecture. For the weight of the construction to be cat smaller, the dividing walls were made of cork. The building has 365 voids (doors, windows, etc.), the figure symbolizing the number of days in a year. Luxury hotel at that time, the Palace was built in the middle of the resort park arranged by the French landscape architect E.Pinard. The furniture of the Palace Hotel was made of linden wood, bronze chandeliers and crystal mirrors. Medical equipment was brought to the treatment base from Germany, part of which is still preserved today. Initially, the hotel had no heating system, the activity being seasonal from May 15 to September 15.

Fig. 2 Hotel "Palace" (main façade and secondary façade)

Visual inspection of the construction is an important activity that helps us to we observe the possible irregularities in both the structural and non-structural elements. In following the visual inspection, the building shows a degree of wear due to age and lack of major and uniform interventions to maintain the building. In many areas (especially bathrooms) concrete from floors and beams shows segregations and lack of covering concrete, with reinforcement appearances, corroded, exterior and interior finishes are partially degraded, floors and the carpentry is partially degraded.

The strength structure of the building is made of load-bearing brick masonry with wall thickness of max 100 cm and min 70 cm in the basement. In the superstructure the load-bearing walls of bricks have a maximum thickness of 75cm and a minimum of 45cm. Also, the pillars and The beams of the structure have rigid reinforcement (metal profiles embedded in the concrete).

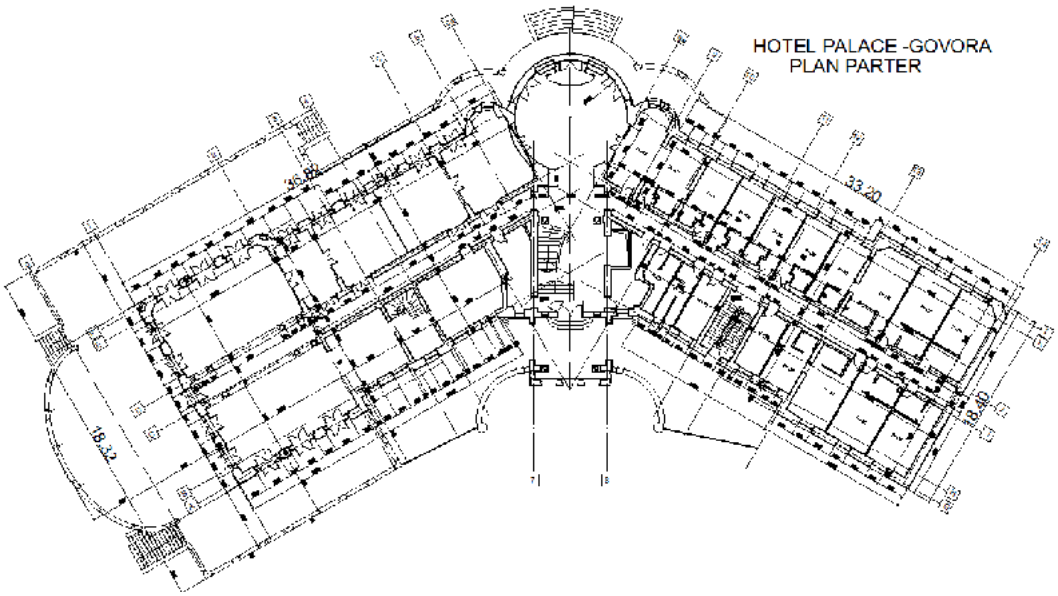

Fig. 3. Ground floor plan Palace Hotel

4. Proposed consolidation measures

The consolidation works will include:

- strengthening of brick screeds with carbon fiber;
- arrangement of closed reinforced concrete frames throughout the height of the building;
- consolidation of the floors in the basement, by cleaning with the sandblasting method or with jet of
  air, replacement of corroded or broken reinforcement by welding, restoration of the concrete layer by plastering and restoration of plasters;
- consolidation of the metal beams of the floor (in the basement) affected by corrosion, with metal platband welded to the bottom after cleaning them or the use of carbon fiber chips;
- consolidation of the floors on the balconies, by cleaning by sandblasting or jet of air, replacing the corroded or broken reinforcement by welding, restoring the concrete layer and restoring the plasters;
- restoration of the layers from the exterior terraces;
- strengthening the framing by replacing the damaged elements of the resistance structure;

Fig. 4. Reinforcement of the consolidation framework

Fig. 5. Strengthening masonry screeds with carbon fibers

5. Execution technology

1. Preparation of the support by mechanical means and removal of dust. It is recommended that all living edges beveled and rounded.
2. A layer of epoxy adhesive is applied to the area of consolidation.
3. Apply the carbon strip, pressing it on the adhesive using a plastic roller, so that the adhesive passes through the carbon fibers and the fabric is embedded in the adhesive.
4. The adhesive layer is finished with the gleter or trowel.

6. Assessment of the risks of injury and occupational disease – unskilled construction worker – work at a height

Table 1 – Risk factors

RISK FACTORS SPECIFIC TO THE CONTRACTOR
Improper assembly of fasteners for handling and transporting masses;
Fall from a height by stepping into the void, sliding, unbalanced;
Work in electrical installations without qualification and authorization;
Travel, parking in dangerous areas – under the load of lifting means, on the roads
Non-use of the personal protective equipment, non-verification of its integrity, degree of wear, non-replacement of it;
Non-verification of the technical condition of hand tools;
Non-synchronization of teamwork, when transporting or handling heavy materials;
Inappropriate primary relationships (unprincipled relationships between colleagues, tense states, verbal or physical aggressions, deficiencies in the communication system);
Failure to observe discipline at work by presenting to work tired or intoxicated, drinking alcohol during the program.
RISK FACTORS SPECIFIC TOTHE TASK
Non-marking or non-marking of dangerous workplaces;
Dynamic handling effort, transport, bulky load storage.;
Forced or vicious working positions producing disorders of the osteo-musculoskeletal system;
Manual handling of masses weighing more than 25 kg, without help
RISK FACTORS SPECIFIC TO THE MEANS OF PRODUCTION
Hitting by means of transport when moving the pedestrian or during the loading/unloading operation;
Use of improper hand tools;
Free fall, overturning, free leakage under the effect of gravity of objects, materials, tools located at a height;
Use of non-standard ladders and/or scaffolding that is not standardised or without bulwarks;
Not enclosing the work platforms and access stairs located at a height;
Dangerous surfaces or contours, pungent, abrasive, sharp (hand tools, etc.);
Electrocution by direct and indirect touch (defective sockets, cables with damaged insulation, uncarried equipment, etc.);
RISK FACTORS SPECIFIC TO THE WORK ENVIRONMENT
Air currents due to outdoor work;
The high air temperature during the hot period and low in the cold season;
Working at a height in adverse weather conditions;
Natural disasters (earthquakes, etc.);
Pneumoconiogenic powders (powders, dust, etc.);

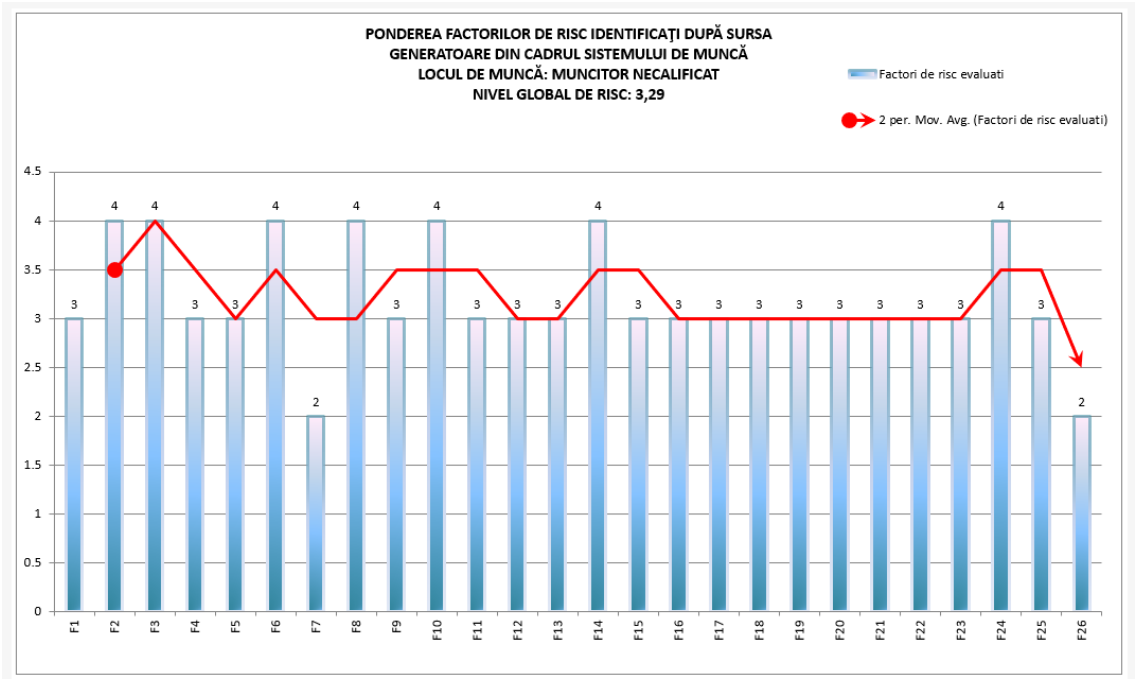

Fig. 6. Share of identified risk factors

7. Conclusions

Following the analysis of the risk factors and the evaluation carried out, the overall risk level (Ng) calculated according to the approved method has the value of 3,29 being below the acceptability limit (3,5), in the category of low risks.

A number of 26 risk factors have been identified, of which: 7 factors have partial risk level above the acceptability limit of 3.5 and 19 factors have partial levels of risk below the acceptability limit (Chart no.1). The factors for which rigorous measures must be taken to eliminate or mitigate their effects are (risk level > 4).

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THEORETICAL MODEL FOR ESTIMATING ATMOSPHERIC POLLUTION BASED ON CAR TRAFFIC OBSERVATION AND MONITORING STATION

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ABSTRACT: In the context of increasing concerns about air pollution and its impact on public health and the environment, this research article proposes a theoretical model to estimate air pollution based on vehicle traffic observation and air quality monitoring station records. The study took place over five days at a chosen location near a monitoring station, and data on car traffic and vehicle emissions were collected and analysed. Using the numerical simulation program MATLAB, based on the data from the specialized literature, the empirical formula was developed to estimate the atmospheric pollution at time t0, taking into account the previous pollution, in 10 minutes increments, in the last 60 minutes before the moment of calculating its value. The results of the theoretical model are compared with the values recorded by the air quality monitoring station, and the subsequent analysis and discussion, based on appropriate statistical tools, address the performance of the model and the factors that may influence its accuracy. The conclusions drawn from this study provide valuable information about the effectiveness of the theoretical model in the estimation of atmospheric pollution and the possibility of its application in the management and monitoring of atmospheric pollution in the urban environment. Prospects and directions for further research are related to the possibility of using in the future, instead of the very expensive monitoring station, a car traffic surveillance camera together with a suitable software that would allow the estimation of air pollution in many more points in the inhabited areas and/or with heavy car traffic.

Keywords: air pollution, air pollution monitoring, Matlab numerical interpolation

1. INTRODUCTION

Air pollution is a global problem with a significant impact on human health, quality of life and the environment [1], [2]. The phenomenon has been associated with a number of conditions, such as cardiovascular, respiratory and even cancer [3], [2].

In this context, air pollution monitoring is essential to understand the origin and distribution of pollutants, to assess the impact on human health and the environment, and to develop pollution reduction policies and strategies [4], [5].

The current study aims to develop a theoretical model for air pollution estimation based on the observation of car traffic and air quality monitoring station records, addressing the need for effective tools for monitoring and managing air pollution in the urban environment [6], [7]. The main goal is to evaluate the performance of the proposed theoretical model in the estimation of atmospheric pollution and to explore the possibility of its application in the management and monitoring of atmospheric pollution in inhabited areas and/or with intense car transit [8], [9].

Also, this study aims to strengthen and expand the existing knowledge in the field of air pollution monitoring [10], [11] and provide new perspectives for the development of effective monitoring solutions, such as the use of traffic surveillance cameras and software specialized for the estimation of air pollution at several points in inhabited areas and/or with intense car transit [12], [13].

2. MATERIALS AND METHODS

The study methodology involved the completion of the following stages:

- The choice of the study location: the area near an air quality monitoring station, which has heavy traffic and where it is possible to clearly observe moving vehicles, was selected as an observation point, namely the Drumul Taberei neighborhood, on Brașov street, on both sides direction of travel, towards Lujerului Street and Ghencea Boulevard, and the air monitoring station where the reference values were taken was B5.

- Observation period: a time period of one hour (between 7 and 8 AM) was selected, as this represents a period of intense traffic, associated with the daily commute, during a week (between 04.04.2023 and 11.04. 2023).

- Allocation of observers: Human observers were placed on each direction of travel of the vehicles. This enabled effective traffic monitoring and identification of the vehicle type and associated pollution rate.

- Registration of vehicle type and pollution standard: observers recorded each vehicle that passed by, identifying its type (car, bus, truck, etc.) and classifying it in an European Union pollution standard (Euro 1, Euro 2 , Euro 3, etc.), based on the year of manufacture and the type of engine (petrol or diesel). A predefined list of pollution norms or a mobile application can be used to facilitate this process.

- Data collection and recording: performed at 10-minute intervals. The observers marked the number of vehicles in order to subsequently sum up the emissions for each type of emission (CO, NOx, HC, PM, SOx, etc.), for all vehicles that traveled in the monitored area. The recording of these data was done tabularly.

- Data analysis and interpretation: at the end of the observation period, the collected data were analyzed and the total emissions for one hour were made, using a calculation formula obtained with the Matlab numerical simulation program, based on information from the specialized literature [12]. The results were compared with those recorded by the air quality monitoring station to assess the compliance of the proposed calculation model.

During this research approach, several problems had to be solved related to the formulated working hypothesis - the estimation of urban pollution at time t0 based on the study of car traffic in the last hour:

- the first of these referred to the way in which some numerical data with different emission reports could be correlated: the technical norms of passenger cars provide for emissions expressed in [g/km] and the values recorded by the monitoring stations presented at time t0 in [g]. The correlation of these values was made considering that the values that arrive at the station are those in its immediate vicinity, i.e. the value given by the manufacturer per kilometer, divided by one thousand.

- the second problem that had to be analyzed was that of the different weight that each car passing through the registration area has when estimating the pollution at time t0, read at the monitoring station. Data from the specialized literature were taken into account and by numerical interpolation of the graph drawn based on them, the numerical weighting coefficients of the emission values every 10 minutes were identified. For confirmation, a study on the evolution of emissions can be carried out at exactly the same monitoring station in Romania, Bucharest, Cartierul Drumul Taberei, str. Brașov, station B5, by representing the emission values for one hour, after car traffic has been restricted in the area. The real curve of the evolution of emissions over time can thus be obtained, through its numerical treatment (symmetrization) and graphic interpolation, thus being able to calculate the real coefficients of importance for each moment of time taken into account by the present study.

The formula for calculating the pollution estimate of vehicle emissions, which circulated for one hour in the area of the monitoring station, is:

$$E_P = 0.0859X_1 \quad 0.0900X_2 \quad 0.1006\,X_3 \quad 0.1196\,X_4 \quad 0.5270X_5 \quad 0.0769X_6 \tag{1}$$

where:

- X_i represent values for emissions recorded at time points 7:10, 7:20, 7:30, 7:40, 7:50,8:00;
- the coefficients of the polynomial function were calculated using the Matlab numerical simulation program based on experimental data extracted from the specialized literature (see figure 1).

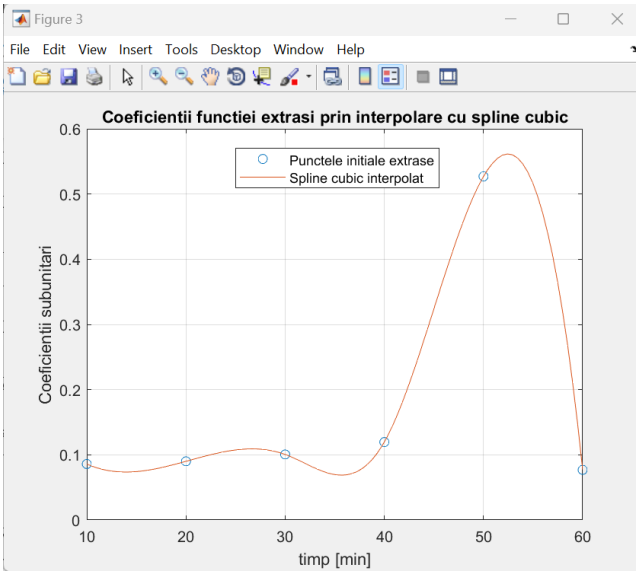

Fig. 1. Determining the coefficients of the polynomial function by numerical interpolation in Matlab

In order to be able to extract significant information about the data strings regarding the analyzed emissions, different statistics were made for their characterization (mean square deviation, median, coefficient of variation):

The standard deviation calculates the degree of dispersion of the values in a data set relative to the arithmetic mean. A large standard deviation indicates that the values are widely dispersed, while a small standard deviation suggests that the values are closer to the arithmetic mean:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{2}$$

The median of a data series gives an indication of the concentration of the data set around the mean value. A large difference between the mean and the median may suggest that there are outliers in the data set that significantly affect the mean value. These extreme values may be higher or lower than the majority of values in the data set and may be significant deviations from the general trend of the data. A large difference may also indicate a skewed distribution, where most values are concentrated in one area of the data set and extreme values are present in another area. On the other hand, a small difference between the mean and the median suggests that the data set is relatively symmetrical and that there are no significant outliers affecting the mean. This may indicate a relatively even distribution of values or a relative concentration of them around a central .

$$Me = \begin{cases} the\ middle\ value\ of\ the\ string, if\ n\ is\ odd \\ the\ sum\ of\ the\ values\ in\ the\ middle/2, if\ n\ is\ even \end{cases} \quad (3)$$

The coefficient of variation shows the degree of variation of the data in relation to the arithmetic mean/median taken as a percentage. A large coefficient of variation suggests that the data are highly variable relative to the arithmetic mean, while a small coefficient of variation indicates that the data are relatively constant relative to the arithmetic mean.

$$Cv = \frac{\sigma}{\underline{x}} 100\ [\%] \quad (4)$$

- The Pearson correlation coefficient was calculated between the experimental data and those measured by the monitoring station:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (5)$$

where:

r - is the Pearson correlation coefficient,

n - is the number of pairs of values in the data series,

x_i, y_i - are the individual values in the two data series,

$\bar{x}$, $\bar{y}$ - are the arithmetic means of the x and y data series.

When the correlation coefficient is close to 1 or -1, this indicates a strong linear relationship between the two measurement methods, meaning that both methods provide consistent results and can be used interchangeably. A high correlation coefficient (close to 1) indicates that the two measurement methods can detect emission values in a similar way, which helps to confirm the accuracy and reliability of the experimental data. When the correlation coefficient is close to 0, this may indicate major differences between the two measurement methods and may suggest the need for further analysis to determine their causes, which may include measurement errors, incorrect calibration of measuring instruments or the influence of external factors.

3. Results and Discussion

The mean square deviation for the estimated and read emissions at the monitoring station in the reference interval are presented in table no. 1, on meaning 1:

Table 1. Mean square deviation on mean 1

Chemical elements	Estimated CO	CO read	Estimated HC+Nox	HC+Nox read	Estimated PM	PM read
Sigma	0.024129	0.073824	2.946806	7.923606	0.334557	3.991927

The mean square deviation for the estimated and read emissions at the monitoring station in the reference interval are presented in table no. 2, on meaning 2:

Table 2. Mean square deviation on mean 2

Chemical elements	Estimated CO	CO read	Estimated HC+Nox	HC+Nox read	Estimated PM	PM read
Sigma	0.012771	0.073824	3.057685	7.923606	0.378609	3.991927

It is observed that the mean square deviation for carbon monoxide estimated at 8.00 am is lower than the one calculated based on the reading from the monitoring station, respectively the values 0.0241 and 0.07382. It follows that the estimated daily values are closer to the mean than the read ones, so the data string most likely does not contain outliers caused by recording errors.

The absolute values of the arithmetic mean of the read and estimated values of pollution on the 5 days of monitoring are 0.2629 and 0.72, respectively. A difference of 0.45 g is observed, a result that may come from the pollution estimation methodology used in the calculations.

Regarding the HC and NOx emissions, a rather large difference is observed between the values of the average deviations of the two data sets, 2.9468 estimated and 7.9236 monitored. The higher value in the case of the monitoring station may come from the fact that these emissions are much more sensitive to the weather conditions of the day, wind, fog, cloud cover, etc.

For suspended dust the estimated average value is 0.0045 while the read one is 25.586, therefore it follows that practically suspended dust has other causes than the emissions from internal combustion engines and their source must be looked for in another direction.

Raporting results:

Through random measurements, it was found that the emissions of a motor vehicle remain in the monitoring area defined as a circle with a diameter of 250m, during peak traffic hours, for around 5 minutes. The measurements assumed the summation of the number of cars according to the criteria of years, the value obtained being multiplied by the emissions for each pollution standard.

The first range of the CO correlation coefficient, on the 1st sense, has a weight of -0.67, and on the 2nd sense of -0.81. The 2nd interval of the HC+Nox correlation coefficient, on direction 1, has a weight of -0.58, and on direction 2 of -0.06. On the last interval of the PM correlation coefficient, on the 1st direction, it has a weight of - 0.14, and on the 2nd one of 0.18.

4. Conclusions

The values resulting from the calculation were compared with those measured by the monitoring station over a period of 5 days. From the measurements, the recorded values are higher than the read values, most of the Pearson correlation coefficients are negative, resulting in large differences between the values. So, following this study, it was found that the visual assessment could not cope with the hundreds of cars with the specific characteristics of each brand. That is why it is recommended to mount a camera and create a software for automatic measurement of traffic and noxes in real time, which can be positioned in several locations, being a flexible, practical and cheap alternative to the actual pollution station, which comes to almost 10 thousand dollars per station, excluding the installation and its maintenance.

The mean square deviation in the two directions evolves sinusoidally, for the estimated and read chemical element CO, the values being approximately similar. In the case of estimated and read HC+Nox chemical elements, respectively estimated and read PM, the values differ significantly.

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3D PRINTING TECHNOLOGY AND BUILDING THE 3D PRINTER

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ABSTRACT: *3D printing technology is a method of forming three-dimensional objects of arbitrary shape, created through an additive process that creates layers on top of each other. The technology is in constant development although it is capable of creating complex shapes avoiding most human errors . In the last decade 3D printing has become accessible to all consumers. Creating such a machine is not difficult and can be done with an average level of difficulty by anyone who can invest a relatively small amount of money. One can thus see the importance of this technology in the fields of construction, engineering and even medicine.*

KEY WORDS: 3D printer, Manufacturing methods

1.Introduction

3D printing technology is an additive process by which complex shapes are created by superimposing several layers on top of each other. The technology appeared in 1976 when the first ink printer appeared, which in 1984 had several adaptations until it reached printing with various materials created by Charles Hull. 3D printers went through a series of developments until 2009 when kits for creating such printers began to be introduced on the market**[4].**

The technology has come to be used in the field of construction, noting in an article dated December 22, 2019, an office building from the Arab Emirates in Dubai created by Apis Cor, this being built only by means of 3D printing technology[3]. This technology has also revolutionized medicine, for example, in early 2019 a team at ETH, led by PhD student Nicholas Cohrs, made what they say is the first artificial heart created from soft materials using a 3D printer[6]. Thus, the pumping mechanism works, thanks to silicone ventricles, which pump exactly like those of a real heart.. This technology is accessible at a minimum cost of 1000 lei for anyone who wants to enter this field with an average level of knowledge. The objective of this studio is to present the 3D printing technology and its capabilities for the industrial and medicinal revolution, but also to analyze and present the realization capabilities.

2. Current research

Nowadays the technology has become so accessible that they can be created and used at home by a relatively large number of people as a hobby. Printers have come to range from the smallest and most compact ones that can be carried in a small box to printers large enough to print entire buildings[2]. Templates for printed articles can be created independently or downloaded from the Internet.

When it comes to the printing process, we can easily say that a 3D object is created by building several layers of material, retains the desired shape after curing and has the typical properties of the material used. It is either filament or resin. 3D printers differ from each other in the printing process, as the following example method illustrates[5] :

- FDM (Fused Deposition Modeling) or FFF (Fused Filament Manufacturing): A type of polymer fused deposition modeling. Heat the filament to melt and extrude it. Based on the information in the print file, the head moves with the X and Y coordinates to reproduce the modeled object. In this

case, the platform it is built on is also mobile, moving in the Z direction and building layer by layer. The advantage of this technique is that it is efficient and fast, but it runs from the bottom up and is not suitable for models with too prominent parts.

- SLA (Stereolithography): Stereolithography is a fairly old system that uses a photosensitive liquid resin that hardens with a laser. The layers are then piled up to form a finished product. It has the same limitations as FDM, but creates objects with very smooth surfaces and lots of detail.- DLP (Digital Light Processing) – Digital Light Processing is a type of 3D printing similar to SLA, but with a light-curable liquid photopolymer. The result is a very high resolution and a robust object.

- SLS (Selective Laser Sintering): Selective laser sintering is similar to DLP and SLA, but uses powder instead of liquid. Used for printers with nylon, aluminum and other such materials. The laser attaches dust particles to form objects. Casting and extrusion can create parts that are difficult to manufacture.

-Support: Although the most popular printers are compatible with Windows, macOS and GNU / Linux, you should pay special attention if there are drivers for your system.

-Extra: Some printers include other features that can be interesting, such as LCD screens with process information, WiFi connectivity to connect them to a network, built-in cameras to be able to film the printing process, etc.

- Assembly and Disassembly: Many printers can be used out of the box (for beginners), but if you're into DIY, you can find inexpensive models that you can assemble piece by piece using kits.

There are many types of 3D printers, but not all of them are intended for use by consumers. When it comes to building a printer you need to consider your intended use, budget and desired features. It requires an investment to be able to make it but also some knowledge to be able to make an efficient printer.

2.1. ANET A8 3D printer, the difficulty of creating and examples of 3D printers

An ANET A8 3D printer was created for the demonstration. The printer has a printing capacity on a surface of 220 x 220 x 240mm.

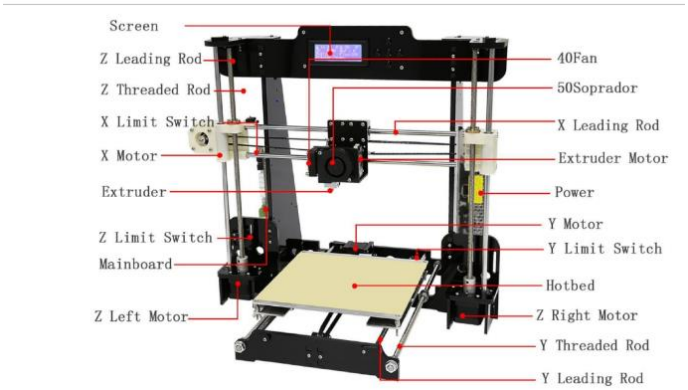

Fig. 1. ANET A8 3D printer

The printer provides the ability to learn printing technology. The printer can use filaments of the following types: PLA, WOOD, PVA, ABS, PP. Even if the kit is enough to create this model, an additional investment is required to optimize, ensure its integrity and functionality. Most printer upgrade components can be printed [8].

This printer is a good start for a person who wants to learn. New prototypes can be made from this. An example of a model that was created from the principle of the ANET A8 3D printer but with the idea of small size and transport capacity is the Positron V3, which is a compact printer that prints in contrast to the classic ones in reverse.

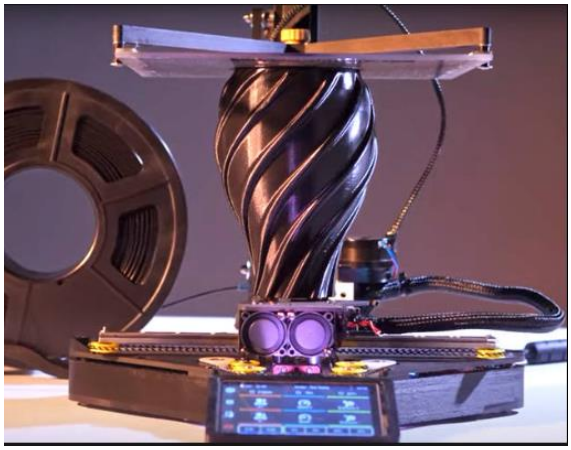

Fig.2. Positron V3

This model is proof of the innovative capacity of 3D printing, which can make parts in a short time wherever you need them.

The A8 printer uses various filaments but the most common is PLA, a biodegradable thermoplastic that is derived from renewable resources and has the ability to degrade into lactic acid. This material is easy to work with, so it works well for beginners. In addition, it is less prone to deformation and is available in translucent colors that glow in the dark. ABS filament provides a very strong and durable product at a low cost, as well as being light and semi-flexible. It can be used to design objects that need to withstand high temperatures, such as moving parts, electronic housings and toys.

An 3D printer is built in two steps. In the first stage, the basic building blocks are organized into functional assemblies and subassemblies. In a second step, the latter are assembled and interconnected on a 3D printer. Most parts are ordered due to lack of resources to make them by hand. The base frame is the "foundation" assembly of the 3D printer, which in addition to housing the structural elements of the frame at the bottom of the 3D printer, also contains a fully functional Y-axis along with the print table. The frame must be solid and the axles must have as little resistance as possible to ensure the printing speed. The axles are made of aluminum bars that have a motor in the ends on which is placed a band that drives the axle.

On the X-axis is the printhead that heats the filament and layers it on top of each other. It is operated with the help of a belt and a motor that makes it move on the axis. The X-axis is held on either side by the Z-axis which gives it vertical mobility.

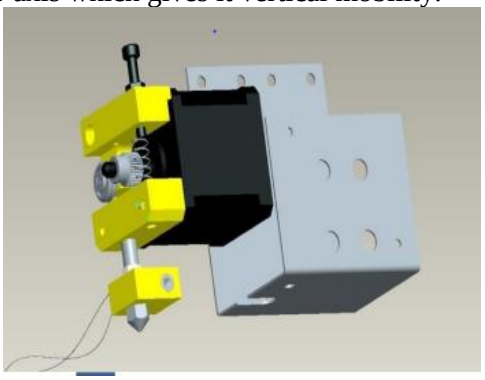

Fig. 3. Printer head.

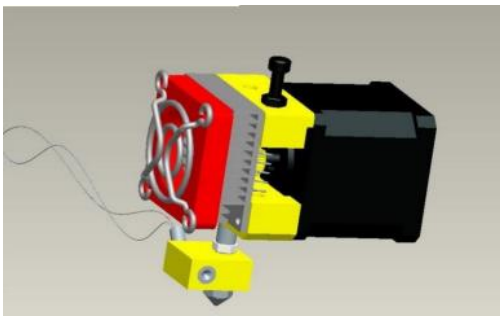

Fig.4. Printer head fan.

The print head contains a fan that provides effective cooling to slow down its overheating.
This whole assembly is controlled by a control board that controls the speed of the motors, the temperature of the print head and allows the user to insert an SD card with 3D models to be printed .

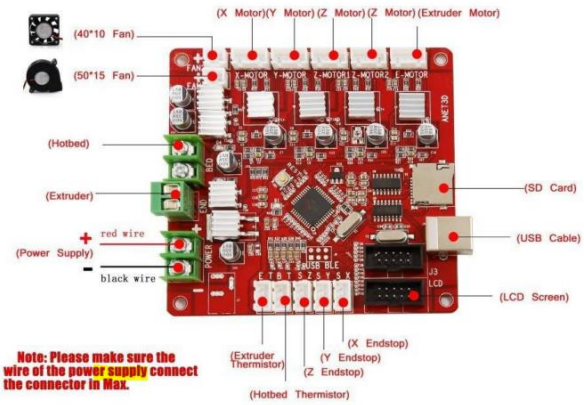

Fig. 5. MotherBoard.

The printer screen allows the selection of temperatures, the calibration of the axes and the printing surface, and the choice of the desired object to be printed.

For a beginner who wants to understand the structure of a 3D printer but doesn't want to invest a huge amount of money, it's a good start, but some upgrades are needed to ensure user safety. Due to the low price, the printer has little frame stability and lacks some of the fuses of a normal printer.

Normally a printer needs minor user intervention but due to the lack of fuses and normal optimizations it needs to be monitored much more than a classic printer. These things can be fixed by creating supports that will strengthen the frame that can be achieved with the help of the printer, investing in sensors that analyze the temperature of the print head and stop the entire printer when it reaches a critical temperature.

3. Conclusions

3D printers can be built from readily available and affordable components and materials. The assembly process is simple and requires some knowledge, attention and a little skill. Once built, the 3D printer is both a means of production for various objects and a stimulus for research and innovation, in order to diversify its functionalities and increase its performance or create new models, but also the ability to innovate the field of construction but also of medicine.

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GLIDER WING MODEL MADE OF COMPOSITE POLYMERIC MATERIAL

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Summary:

This project was made to experiment with a construction method for the glider wing. In this paper, we will explain the principles of building a glider wing and all the phenomena necessary to understand this process. As part of the work, an experimental model of a glider wing was created at a scale of 1:450, made by 3D printing from UV resin and covered with glass fiber. In the physical model, you can see the structure of the wing and the materials used.

In the introduction, we will explain the principle of flight of an aircraft to better understand the importance of the materials used in the aeronautical field and the shapes chosen for the wing geometry. The experiment looks at the strength of such a wing in flight, tested in specialized programs, as well as the ease of its design, also analyzed in programs such as SolidWorks and XFLR5. Next, we will explain the physical construction process and the steps taken to obtain the final object.

1. Introduction

The glider is a heavier-than-air flying device, not equipped with a propulsion unit and which, by launching at a certain height, will fly with a continuous downward slope. There are four main forces that act on a glider and help it move along its path and stay in the air. First, the weight of the glider pulls it toward Earth with the help of gravity and gives it a natural tendency to descend. This force must be countered by other forces to allow it to fly. Thus, the concept of lift force comes into play. In the direction of travel, we encounter two other forces: the resistance to the forward movement and the traction force.

Flight is based on the lift force created by the wings of the airplane. The wings are designed to produce a low-pressure zone above them and a high-pressure zone below them, creating a lift force that keeps the airplane in the air. This effect is produced by the flow of air streams along the wings.

As the airplane moves through the air, the air streams that flow over the wings are directed towards the back of the wings, where they expand and slow down. This leads to a decrease in the air pressure above the wings, while the air pressure below the wings remains constant. This phenomenon is based on Bernoulli's principle, which states that air pressure decreases as speed increases. Thus, air streams that move faster over the wings create a low-pressure zone, while air streams that move slower below the wings create a high-pressure zone.

2. The geometry of the wing

Following a section through the wing we will be able to define the following elements:
- the leading edge is the front part of the wing that hits the airfoils during flight.
- the trailing edge is the rear part of the wing.
- the chord of the profile is the straight line that joins the leading edge with the trailing edge.

- the maximum thickness is the maximum distance between the upper surface and the lower surface
- the maximum curve is the maximum distance between the chord of the profile and the median line.

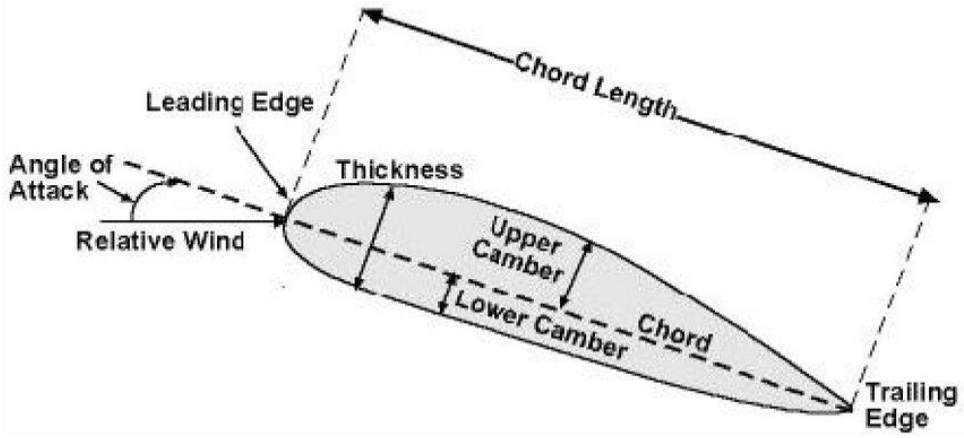

Fig. 1 – Elements of the wing

3. Choosing the airfoil for the wing design – NACA 23012

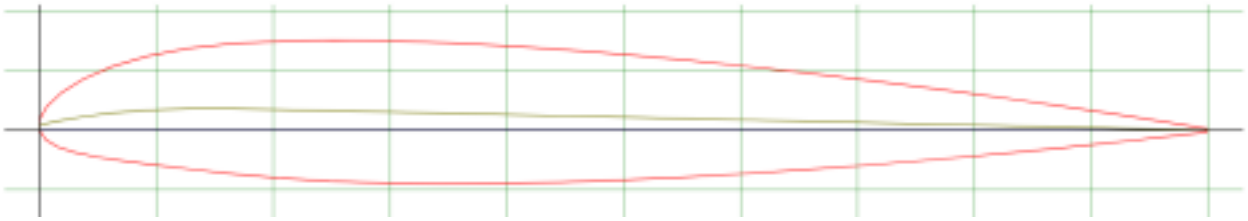

Fig. 2 – NACA 23012 airfoil

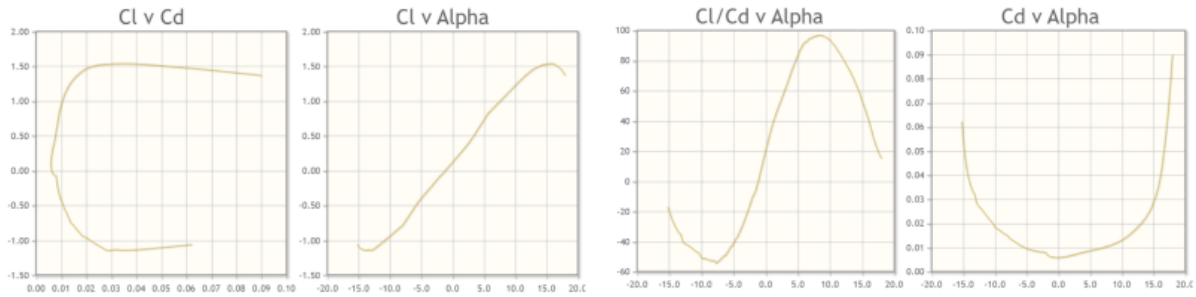

Fig. 3 – Graphs with the rapports between lift and drag coefficient and the angle of attack for NACA 23012 profile

Where:
Cl = lift coefficient
Cd = drag coefficient
Alpha = angle of attack
Cl/Cd = aerodynamic finesse

To calculate the Reynolds number for a glider wing with a wingspan of 18 meters, we can use the following formula:

$$R_e = \frac{\rho v l}{\mu} = \frac{v l}{\vartheta} \quad (1)$$

Where:

Re = Reynolds number

v = Characteristic velocity of the fluid (in meters per second)

l = Characteristic dimension of the wing (in meters)

ρ = Air density (in kilograms per cubic meter)

θ = Air viscosity (in kilograms per meter per second)

We consider a glider speed of 100 km/h. To convert it to meters per second, we will divide the value by 3.6. Therefore:

v = 100 km/h / 3.6 = 27.8 m/s

For standard air at sea level, the density is about 1.225 kg/m^3 and the dynamic viscosity is about 1.8 x 10^-5 kg/(m*s).

ρ = 1.225 kg/m^3

θ = 1.8 x 10^-5 kg/(m*s)

The trapezoidal wing has a span of 18 m and a chord of 1.5 m. For a trapezoidal wing, the characteristic dimension L is taken as half the span and the chord, so:

L = (18 m + 1.5 m) / 2 = 9.75 m

Thus, we can substitute the values in the Reynolds number formula:

Re = (27.8 m/s * 9.75 m * 1.2 kg/m^3) / (1.8 x 10^-5 kg/(m*s))

The result is about 1.85 x 10^7, which suggests that the airflow is flowing from laminar to turbulent on the glider wing, which can have a significant impact on the glider's performance. It is important to note that this is a rough estimate, and that the actual Reynolds number of the glider depends on several factors and can only be accurately calculated by knowing the exact geometric details of the wing and the air properties.

4. Materials used

Before presenting the materials used in the construction of gliders, we must see what they are for efforts are subjected to the parts that make up a glider. The requests to which they are subject the pieces are:

- traction or stretching (triggers, control cables, wing covers, etc.).
- bending (wing spars)
- shear occurs in flight during passage through a separation surface between a stream ascendant and one descendant. This phenomenon happens especially when flying in clouds of vertical formation.
- torsion - the wings during flight are subjected to tension efforts around the spar.

The plywood used in aviation must meet the following conditions:

- Tensile strength along the grain = 700 kgf/cm^2
- Tensile strength perpendicular to the grain = 450 kgf/cm^2
- Shear strength along the grain = 100 kgf/cm^2
- Shear strength perpendicular to the grain = 750 kgf/cm^2
- Shear strength at 45◦ = 150 kgf/cm^2

For the wing presented in this document, the following materials and dimensions were used. The inner part (the wing's core) was made of 10mm of resin to which three layers of 0.3mm fiberglass were added.

4.1. Fiber glass

The technological process of obtaining glass fibers includes two main phases: obtaining the glass and spinning the fiber. The raw material for the manufacture of glass fibers is fusible inorganic products, based on silicates, extracted from siliceous sands.

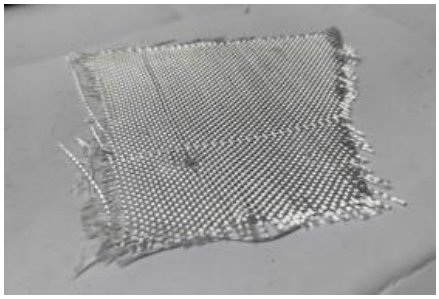

Fig. 4 – Sheet of fiberglass

The properties of the fiber glass are the following:

- good resistance to radiation;
- Silica fibers, unlike type E, have a better electrical and thermal insulation capacity.
- are resistant to chemical agents (except hydrofluoric acid)
- they are not toxic, and fungi and bacteria do not degrade them
- glass fiber is resistant to acids and alkalis. It is distinguished by an increased chemical inertness since it consists entirely of quartz sand.

4.2. Resin

Composites are a combination of reinforcing fibers in a resin matrix. The resin matrix holds all the bonded material and transfers the mechanical loads through the reinforcing fibers to the rest of the structure. In addition, the resin protects the composite from impact, abrasion, corrosion, environmental factors, and careless handling. Resin types come from a variety of chemical families, each type is designed to offer different advantages such as economic, structural, and strength performance.

UV resin is different from the others in that it consists of a single component. This type of resin requires exposure to UV light to trigger the chemical reaction that allows the resin to harden. You can use a UV lamp, specially designed for quick hardening of jewelry and miniatures. 3D resin is a type of material used in 3D printing that polymerizes under the action of UV (ultraviolet) light. This can be used in 3D printing with technologies such as stereolithography (SLA) or projection lithography (DLP).

5. Designing the wing and testing its characteristics

Work steps in SolidWorks:

1. The NACA 23012 airfoil was sketched using the sketch function and after using the smart dimensions function it was brought to the required dimensions.
2. A parallel plane was created at 8000 mm from the first plane on which sketch 1 was created. Here again a NACA 23012 airfoil was sketched again using the sketch function and the chord size was 1000 mm.
3. To create the contour of the wing, the Surface Loft function was used, thus joining the contours of the 2 sketches.
4. The Thicken function was used to create the thickness of the wing skins.
5. I created an Assembly in which I put the Part with the Wing created earlier.
6. I created a new part inside the Assembly to copy the wing through the offset surface function.
7. After making the offset surface on the outer surface, I used the thicken function and gave the desired size. This function helps us create the fiberglass layer we used.
8. I created another offset surface on the wing, only on the inner part. I used the thicken function again and created the resin layer that is in the wing construction.

Work steps in XFLR5:

1. Added NACA 23012 profile to XFLR5 application using the following options Module > Direct Foil Design > Foil > Naca Foils.

2. Airfoil performance was analyzed using the following options Module > Xfoil Direct Analysis > Analysis > Define an Analysis. A window appeared on the screen where the values obtained from the calculations were added and the OK button was pressed. In the upper right corner, the values of the angles at which the wing was tested to the flight horizontal were set and the Analyze button was pressed.

3. After checking the tables obtained from the polar analysis, the design of the wing was carried out, where the following steps were followed. Modules > Wing and Plane Design > Define a new plane.

4. After a new plane was defined and all components except the wing were removed the following were used under the Plane > Current Plane > Edit Wing menus.

5. After the wing was edited and the previously calculated values were added, a new analysis was performed on its performance.

6. The practical realization of the model

- Printing the glider wing on a reduced scale using the printer in the picture below
- Cleaning the piece of residues was carried out in a special device as in the image below
- The wing was sanded using 2 types of sandpaper with 1200 and 2000 grit
- Fiberglass was soaked in resin
- Fiberglass was applied to the wing surface, stretched, and smoothed
- Finally, a base was designed in Solidworks and printed with a 3d printer that uses PETG

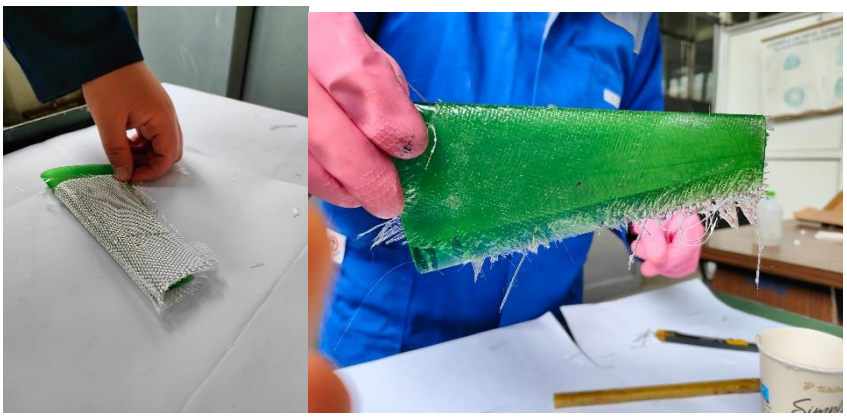

Fig. 5 – the physical figure before and after glueing the fiberglass

7. Conclusions

After testing and calculations, it is observed that the NACA 23012 airfoil fiberglass covered resin wing model is extremely easy to design, print, manufacture and complete. Related to its strength, with the help of a professional printer and a high-performance resin, and with the help of a special chamber and furnace, where glass fiber can be applied, a high-performance wing can be made.

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THREE-DIMENSIONAL ASTROID WITH VARIABLE ROUGHNESS

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Summary: This paper discusses the technological process of casting molten metal, in this case an alloy of tin and lead commercialized under the name of "fludor", in temporary forms. An analysis of the differences in the processes for the two created pieces will also be presented, based on the roughness obtained and the casting defects observed. This text follows details such as the composition of the materials, up to the different paths taken in creating the parts and what were the final consequences of said paths. The conclusion states which process suits rough parts better, and which process suits the casting of finer parts, based on the observations.

KEYWORDS: casting, tin alloy, roughness

1. Introduction

The paper talks about the casting of two parts of tin and lead alloy in temporary forms and goes into detail: both about the technological process in general and about the particularities discovered during the experiment. Afterwards, a discussion is started on the defects of the parts, which evolves towards a comparison between their different roughness.

2. Current research

At the moment, the two pieces are cast. The first piece was cleaned of the casting material, but could not be sanded to a much lower roughness, and the second piece was sanded until it was smooth enough, so that its finer defects could be observed.

Henceforth, we will talk about the technological process that took place when casting these pieces, as well as their defects and roughness.

Fig. 1. First part

Fig. 2 . Second part

3. The first casting and its roughness

This paper will discuss briefly beforehand the technological process of casting in temporary or non-reusable forms. This particular experiment overlooked sand casting. In sand casting, molten metal is poured into a sand cavity, which will later on be destroyed in the process of taking out the said metal, after it has solidified. It is one of the most used processes under the wide array of metal castings, accounting for a relatively high amount of the total cast in weight. During this process, the metal is heated to a previously known temperature, which can also be treated chemically in order to assure a certain outcome. Since it allows the user to create a great range of parts, both economically and geometrically, it accounts for just over 70% of the total metal castings. As we will see in this chapter, it unfortunately has low dimensional accuracy and poor surface finish, but if used correctly, it can be very efficient for mass production of rougher parts. Going forth, we will discuss the experiment.

In advance, we purchased a quantity of 1kg of alloy of 40% tin and 60% lead for casting the first part.

The process consisted of 6 main steps: creating the wooden frame for the semi-temporary casting form, preparing the casting mixture and placing it in the previously created form, carving the casting cavity and preparing it, melting the metal and casting it, and finally, removing it from shape and allowing it to cool and solidify.

Fig. 3. The cavity for the first part

Firstly, we took 4 wooden planks that we cut in order to build a frame of 0.8m by 0.8m, which we later joined to create the initial shape. In the next step, we prepared the mixture for the casting cavity. We combined construction sand with water to give it a certain solidity and to be able to sculpt it in the shape of

the desired model. We poured the respective mixture into the form of wood and smoothed it by successive additions of mixture and pressing it with another wooden plank.

After we made sure that the sand was solid enough, we started to sculpt the desired shape of the astroid with the help of some measuring tools and a modeling knife. For the preparation of the mold, we also sprinkled a small amount of calcium carbonate in the form of powder, so that the molten metal would not have other defects and would come out easily from within the mold.

Next, we moved on to the steps regarding the melting of the metal. We untied the alloy wires and placed them in a thermally resistant metal container. To make sure that the molten metal would not stick to the container, we put an unguent paste on the walls of the vessel. We kept the heat source at a temperature of 200 degrees Celsius, above the melting point of the alloy of 183 degrees Celsius, to ensure a slow melting and a homogeneous mixture at the end. After several checks, we reached a point where the metal was fluid and had enough liquid flow and could be cast without problems.

We took the container from the heat source and took it to the temporary mold. We poured the molten metal to below the upper edge of the cavity. We let it cool down for a short period of time, so that no cooling defects would appear, after which we removed the piece from the sand with the help of thermally resistant tools. After it cooled down, we removed the grains of sand embedded in certain points, after which we sanded the piece for the final look.

We came to the conclusion that due to the using of the construction sand that had a significant grain, we obtained a piece with such a high roughness, unlike the second piece that will be presented in the next chapter, where the technological process had some differences, hence the fineness, respectively the accuracy, of the piece. That is why this process could be used for rough parts. Nevertheless, these final product differences were the most important parts of the work, being the ones that led us to the scientific conclusions regarding the casting process.

Also, the casting mold was destroyed at the end of the process, as we needed to remove the piece from the sand, hence the name temporary casting mold.

4. The second casting and its defects

In this part of the article, we will discuss the process of paper casting, how it differs from the first process and in the final we will discuss about the advantages and disadvantages and point out some possible applications in industry. Paper casting is used on a smaller scale than sand casting, and at the present moment it is used for manufacturing small pieces of civil equipment like fishing tools or even spare parts for the furniture. It can easily be used by most of the people for obtaining simple parts used in the daily life, respecting some elementary protection measures. It is not a dangerous or complicated process, and it doesn't require special facilitates. We chose this method of casting to highlight its simplicity and efficiency in obtaining small pieces of tools.

Firstly, we chose for the form an origami model that we learned about during the research time period. The choice of the origami model as a casting mold was justified by the possibility of creating complex shapes out of simple pieces of paper, which made the process cheaper and less time consuming than any other choice. A small disadvantage of the paper as material is represented by its bending property, which makes it difficult to resist during the action of pressure forces. To mitigate the risk of paper bending during the metal casting, we stabilized the paper mold inside a box filled with sand.

For the choice of the material that was used to create the piece, we considered solder to be the best option, because of its properties. Solder is an alloy mainly composed of lead and tin. The presence of lead into the alloy is raising the melting point of the alloy just enough to be melt with a simple gas cooker, but also maintaining a resistant structure. After putting 350 grams of solder inside a pot on the gas cooker, we waited for approximately ten minutes for it to melt.

Once the metal was completely melt, we poured it into the mold, and then we waited for it to cool. After the metal was completely hardened, we opened the mold, and we extracted the piece. The extraction was an easy process, as the paper is a soft material and it was easily ripped away. The finishing process

was needed because, the piece was covered with burnt material, that made the observation of the details and imperfections difficult. For this process we used a simple file.

After the finishing was complete, imperfections could easily be observed. The imperfections we identified are cracks on the surface of the piece, voids and incomplete filling of the part.

The cracks on the surface are usually caused by the high pouring speed, the lack of flexibility of the mold and big thermic or contraction tensions. The voids are represented by empty holes at the surface or inside of the body. They look like a dent on the surface of the body and they form under the influence of the contraction during the solidification process. The main cause of this defect is represented by the high contraction of the material during the solidification process or by the high temperature of the liquid metal. The main causes of the voids are the low fluidity of the liquid metal, the insufficient quantity of material inside the melting pot.

5. Conclusions

With this article we are aiming to detail and compare two different processes of casting: sand casting and paper casting. As we have seen in the previous part, both have undeniable advantages, but they also have some decisive disadvantages making them suitable for specific purposes. The pieces obtained with sand casting are heavier and they present a high degree of roughness with less dimensional precession. Due to its roughness, imperfections are more difficult to track. The sand casting is widely used in industry and offers the possibility to make a large number of pieces.

On the other hand, the paper casting creates parts with a smaller degree of roughness and a better dimensional precision. It can be used to make tools useful in the daily life, being a cheap and easy process. One big advantage of the process is the possibility of recycling paper by using it as a mold.

All of these characteristics are to be found in the attached Table 5.1

Table 5.1.Advantages and Disadvantages of the parts

First part	Second part
Harder	Finer
Higher roughness	Lower roughness
Hardly noticeable defects due to high roughness	Defects easy to follow: patches, cracks, incomplete filling
Average shape accuracy due to the process	High accuracy
Process suitable for mass-produced parts	Process suitable for finer parts

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THEORETICAL AND EXPERIMENTAL CONSIDERATIONS REGARDING THE REALIZATION OF A HEAT TREATMENT FURNACE

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ABSTRACT: The structure of this article details the elements of design, execution and operation of a heat treatment furnace (TT). It features a gas-based cylinder heat source supercharged by a blower that brings extra air to the centrally arranged burner area in the upper furnace panel. The walls of the furnace enclosure are lined with refractory brick, the housing consists of steel sheet S235JR and is placed on 4 feet that allow to adjust the vertical position of the furnace by means of screw assemblies. The oven temperature is adjusted by means of onehour taps that offer the possibility of varying the flow rate of the fuel mixture and the additional air flow brought by the blower. The indoor temperature is monitored using a thermocouple. The furnace also features a metal door lined refractory. The performance of the furnace in operation can be assessed based on the temperature reached, the heating speed, the controlled cooling speed (in air flow, possibly), based on the types of TT that can be achieved on this furnace.

KEYWORDS: heat treatment furnace, fuel gas, manual welding,

1. Introduction

Heat treatments are widely used processes in industrial engineering and metalworking, used to alter the physical and mechanical properties of metal materials [1]. These treatments involve controlled heating and cooling of materials in specialized furnaces to obtain desired characteristics such as: hardness, ductility, machinability, wear resistance, corrosion resistance, etc. [2]. In addition, heat treatments can improve the performance of parts during operation and extend their service life [3].

The purpose of this heat treatment furnace is to allow the realization of heat treatments for relatively small parts in the research laboratory of the Department of Quality Engineering and Industrial Technologies (ICTI). The main objectives of the project include the development of an efficient and versatile furnace that can perform different types of heat treatments, such as annealing, normalization, quenching and tempering [4].

The furnace will be designed to achieve high temperatures and to allow precise control of the heating and cooling speed in order to ensure an even distribution of heat inside the furnace. Another important objective of the furnace is to be economical and environmentally friendly, using a gas-based heat source of a cylinder supercharged with additional air brought by a blower [5]. The furnace must also be easy to use and maintain so that it can be used effectively in the research laboratory.

2. Design of the heat treatment furnace

The designed heat treatment furnace will have the overall dimensions of 450 x 400 x 250 mm, being designed to fit into the workspace of the research laboratory of the ICTI department and to meet the heat treatment requirements of the relatively small parts. These dimensions were established following a rigorous analysis of functional requirements and space limitations.

The inside of the furnace will include a central area for heating parts, as well as spaces for the gas supply system, burner and auxiliary components.

The furnace housing and the access door were made of S235JR steel sheet, with a thickness of 4 mm. Steel S235JR is a material with physical, mechanical, technological and chemical properties suitable for the construction of the heat treatment furnace [6].

This type of steel has a moderate tensile strength, good ductility and excellent weldability, being suitable for use in metal construction applications in general [7].

The S235JR steel has a thermal conductivity of around 60 W/m·K, which means that it allows a good transfer of heat through conductivity and in what means the evacuation of heat through radiation it has a moderate thermal radiation. The flow limit of the S235JR steel is about 235 MPa (N/mm^2), which gives it good resistance to plastic deformation and the ductility is good, that is, it can be relatively easily bent and deformed without breaking.

Steel S235JR has a moderate corrosion resistance and needs to be protected by a layer of paint or other coating to prevent oxidation.

In terms of weldability, S235JR steel has a very good weldability, which makes it suitable for welding with different processes, such as manual welding with coated electrodes (SMEI), MIG/MAG welding, TIG welding and others [8].

Also, steel S235JR can be easily processed by plastic deformation, such as lamination, forging and extrusion.

The joints between the steel sheet plates were made by hand welding with coated electrodes, thus providingthe furnace's carcas with rigidity, mechanical strength and adequate protection for the heat treatment furnace.

The inner walls of the furnace were lined with refractory brick, a material known for its thermal insulation properties and resistance to high temperatures [9]. The use of refractory brick will help maintain a stable temperature inside the furnace and minimize heat loss to the outside, while ensuring effective protection of the outer structure of the furnace [10].

The furnace will be supported on height-adjustable legs, made of steel rods with a diameter of 10 mm, which will allow to adjust the height and level the furnace according to the working conditions.

The heat source for the heat treatment furnace will be based on cylinder gas, which allows for greater flexibility in operation and high thermal efficiency compared to other heat sources such as electricity [11].

The gas supply system will include a gas cylinder, a network of pipelines and gas flow control valves to ensure a constant and safe supply of gas to the burner [12].

In order to maintain high efficiency and reduce greenhouse gas emissions, the furnace will be equipped with a gas supercharger system, which allows an additional air flow to be brought to the burner area [13]. This will contribute to a complete combustion of gas and improve heat transfer inside the furnace.

The burner will be centrally placed in the upper panel of the furnace to ensure an even distribution of heat inside the furnace enclosure [14]. This will be a burner with stable flame and with a thermal power sufficient to reach the temperatures necessary for the desired heat treatments (annealing, normalization, return and hardening).

The air supercharger system comprises a blower that will supply air to the burner area to improve combustion efficiency and reduce greenhouse gas emissions [15]. The additional air flow rate is regulated according to the needs of the heat treatment process and the performance requirements of the furnace. The supercharger system is made of pipe with a diameter of 80 mm l, and the holes for distributing the combustible gas mixture are located on its periphery, at equal distances, being in the number of 10. The temperature control system will include an air tap that comes from the blower and that regulates the supercharging of the burner, as well as a combustible gas valve coming from the cylinder [16]. This configuration allows for effective temperature control inside the furnace, ensuring optimal conditions for heat treatments [17].

The air supply system is designed in such a way as to allow a fine adjustment of the ratio of air to gas, in order to achieve optimum combustion and effective control of the temperature inside the furnace. The adjustment of the additional air flow is carried out by means of a blower control device, which allows the adjustment of the air flow according to the needs of the heat treatment process [18].

In addition, the burner and the additional air supply system have been designed in a modular manner so as to ensure easy maintenance and replacement of the components in case of wear or defects [19]. This aspect is very important for a continuous and efficient operation of the furnace.

3. Materials and methods used in the execution of the heat treatment furnace

For the realization of the heat treatment furnace housing, the steel S235JR with a thickness of 4 [mm] was used. The chemical composition and mechanical properties of steel S235JR, in accordance with standard EN ISO EN 10025-2-2004 [20], are presented in Table 1 and Table 2 respectively.

Table 1. Chemical composition and properties of steel S235JR [20]

C [%]	Mn [%]	P [%]	S [%]	N [%]	With [%]
Max 0.2	Max 1.4	Max 0.04	Max 0.04	Max 0.012	Max 0.55

Table 2. Mechanical properties of steel S235JR [20]

R_m [MPa]	R_{eH} [MPa]	A [%]
360-510	Min. 235	24

Ptechnological vignettes of steel S235JR:

- ✓ *Weldability*: good due to its low carbon content; does not require prior heat treatment or post-welding in most cases;
- ✓ *Machinability*: good, it can be processed by chipping, forging, hot and cold rolling, bending and cutting.

To make the casing in welded construction used:

- *the type of joint*: - butt joint (for the joints of the oven frame) with the simple V-joint with an opening of about 60 degrees, which means 30 degrees for each part of the joint. This angle ensures a good penetration of the welding material and a quality joint, while avoiding excessive penetration;

- corner joint in T (for adjacent elements).

- *the addition material*: it was chosen the e lectrod of rutile type E6013, which ensures a quality welded joint and a good compatibility with the base material. This is a rutil-based sheathed electrode designed for welding low-carbon steels. The rutile coating contains mainly in its composition titanium oxide (TiO_2). It is used for the manufacture of electrodes to improve arc stability, reduce diffusible hydrogen levels and improve the appearance and quality of weld seams.

The average chemical composition of the seam made when welding with this electrode provides mechanical properties that allow the seam to withstand mechanical stress in operation without deforming, cracking or breaking.

In addition, the E6013 electrode has a low susceptibility to cold and hot cracking due to its low hydrogen content and balanced chemical composition. This makes the welded seam more resistant to the formation of cracks in conditions of rapid temperature changes (thermal cycles).

The E6013 electrode is a superfluous electrode and belongs to the category of electrodes for welding carbon steels. According to the AWS (American Welding Society) classification, the E6013 breaks down into the "E" for the electrode, "60" indicating the minimum tensile strength of 60 psi (about 410 MPa), "1" for the welding position all positions (horizontal, vertical, flat surface) and "3" indicating the type of coating.

The chemical composition and mechanical properties of electrode steel E6013, in accordance with AWS SFA 5.1 [21], are presented in Table 3 and Table 4 respectively.

Table 1. Chemical composition and properties of steel S235JR [20]

C [%]	Mn [%]	Yes [%]	P [%]	S [%]	Mo [%]	Nor [%]	Cr [%]
Max 0.2	max 1. 2	1,00	max 0.025	max 0.025	0.3	0.3	0.20

Table 2. Mechanical properties of steel S235JR [20]

R_m [MPa]	R_{eH} [MPa]	A [%]
410	Min. 330	17

The E6013 electrode is recommended for welding carbon steels in the field of their construction, shipbuilding industry, manufacture of vehicles and agricultural equipment, etc.

- electrode diameter: a diameter of 3.2 [mm] has been chosen , according to the manufacturer's specifications, for the E6013 electrode that provides the average chemical composition necessary for welding the basic material used;

- *welding current*: can have values between 100 and 140 A. Value used was 120 A, value that ensures the realization of a quality welded joint, both in terms of geometric characteristics and mechanical owners.

- *arc voltage*: it can have values between 19 and 25 V. The chosen value was 20 V has ensured the proper shape of the seam as well as the correct filling of the joint.

- *Welding angle*: can have values between 40^0 and 45^0. The value of 30 0 was chosen , a value that ensures an adequate penetration of the material and a proper filling of the joint.

- *Welding speed*: varies depending on the current and voltage of the welding, so as to ensure adequate penetration and optimal weld quality. The welding speed used was 10 cm/min.

- *pendulum of the electrode*: the optimal movement for the electrode head in this situation would be a pendulum movement combined with a rectilinear advance. This type of movement can help to achieve better penetration, uniform heat distribution and proper filling. It can be welded with good performance and directly rectilinear, without pendulum, this being the variant chosen for the execution of the case.

- *the number of passes*: depending on the width of the joint and the thickness of the material, 1-2 passes may be needed to ensure a complete weld. The one-pass welding option was chosen.

Type of equipment used for welding: an electric arc welding machine and transformer type Fronius TransPocket 150 (Fronius International GmbH, Wels, Austria) was used.

Stress relief of the welded joint: after welding, hammering was applied to the weld seam to reduce tensions and prevent cracks.

Removal of the collar: at the end the slag was removed with a metal brush to ensure a clean surface of the joint.

Control of the welded joint: the welded joints were examined optically visually and with penetrating liquids in order to identify possible imperfections occurred during the welding process.

4. Results

The heat treatment furnace was made in welded construction, with the purpose of its use in ICTI laboratories.

Following the optical-visual examination and with penetrating liquids of the welded joints, no imperfections or defects were detected that would require additional technological operations.

The heat treatment furnace carried out in welded construction is shown in Figure 1.

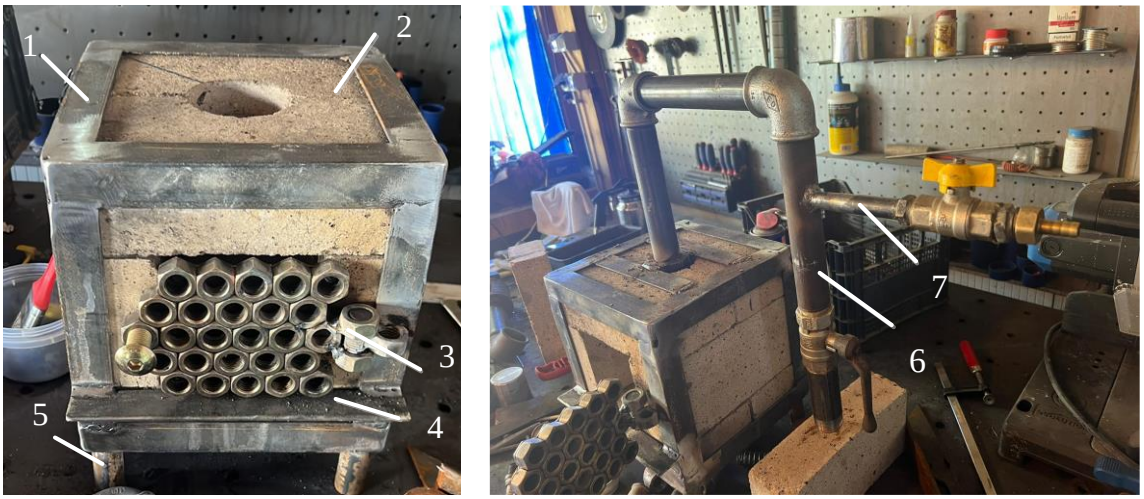

Fig. 1 Heat treatment furnace in the execution phase: 1 – metal frame, 2- refractory brick, 3- door supply parts, 4 – helper element, 5 – adjustable foot, 6 – supercharger blower, 7- gas supply route.

4. Conclusions

Following the design and construction of the heat treatment furnace, the following results and personal contributions were obtained:

- development of an efficient and versatile heat treatment furnace, able to carry out various heat treatments, such as annealing, normalization, ironing and return, for small parts in the research laboratory of the ICTI department;
- the design of a furnace that reaches the temperatures necessary for heat treatment processes and allows precise control of the speed of heating and cooling, ensuring a relatively uniform distribution of heat inside the furnace;
- the creation of an economical and environmentally friendly furnace, using a heat source based on cylinder gas supercharged with additional air brought by a blower, thereby reducing greenhouse gas emissions;
- realization of an easy-to-use and maintainable furnace, adapted for effective use in the research laboratory.

Further research directions and improvementaspects of the heat treatment furnace:

- the introduction of a system for automatic regulation of the temperature and the speed of heating and cooling, allowing a more precise control of the heat treatment process and reducing the risk of human error;
- the addition of a real-time temperature monitoring system and other relevant parameters inside the furnace, allowing users to easily supervise the heat treatment process and make adjustments as needed;
- optimisation of the gas supply and supercharger system in order to improve energy efficiency and reduce greenhouse gas emissions;
- exploring the use of other materials and technologies of thermal insulation, to further reduce heat loss and improve furnace efficiency.

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