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RESEARCH ON ESTABLISHING THE DIMENSIONS OF THE SEMI-FINISHED PRODUCT AND THE OPTIMISATION OF STAMPING PATTERNS

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ABSTRACT: The paper aims to design an algorithm and a computer application that will determine the dimensions of the flat surface of the semi-finished product in order to obtain an optimal cut. The dimensions of the flat surface of the semi-finished product will be determined, through the application, by means of specific calculation operations according to the dimensions of the product taken from its 2D execution drawing. The computer application will optimize the stamping scheme according to the need expressed on the number of workpieces of the user and according to the standard calculations required when cutting strips or sheets.

KEY WORDS: semi-finished product, cutting, stamping, algorithm, LabView

1. Introduction

Stamping is a cold deformation process, without cutting, of objects of the same shape, from tables, strips, discs, or wires. This operation is performed by cutting with the help of stamps.

Cold deformation is one of the oldest methods of transforming metal into useful objects. Currently, most metal parts processed by deformation are utilised within the body elements of several types of vehicles, in a percentage of 60-70% [3].

Treating/ Cutting/ Tailoring the boards and strips represents the distribution on the surface of the product with well -defined forms, in order to cut them in such a way that the amount of unused material is minimal, contributing considerably to reducing the production cost of the representations manufactured en masse [4].

2. The current stage

Currently, there is a very small number of such applications in the industry, most of which have a complexity that does not fully meet the requirements associated with the research topic. The first example of a complex application, which has several advantages, is Metalix; an application that deals with the simulation of processing procedures. This application is easy to use, but does not focus on obtaining a single piece with a stamp/ mould with simultaneous suction, but several marks are processed which are suitable for a combined cut using as a main semi-finished product, a metal sheet. Two other examples of applications that are suitable in this domain are Deepnest and Mynesting, two applications that largely deal with the arrangement of parts on the sheet for numerical control machines. In conclusion, there is no application at this time in the industry that focuses on the finished piece and its processing on stamps and moulds with successive actions [5].

At this time, because there are no applications that will treat the optimization of the crossing using a tape semi -finished product, the classic method for calculation and optimization is still used. The succession of the calculation stages, defined in the specialised literature, include:

- Calculations for unfolded bent parts [1, 2]:
  - r = 0

$$l = \sum_{i=1}^{i=k} l_i + k * g * (n-1) \quad (1)$$

l- the length of the unfolded part; G - the thickness of the material; Li - the length of the rectilinear portions; N - the number of rectilinear portions; K - coefficient that takes into account the radius.

- $r \neq 0$

$$L = \sum_{i=1}^{i=k} l_i + \sum_{i=1}^{i=k-1} l_{\varphi i} \quad (2)$$

L - the length of the unfolded part; Li - the length of the rectilinear portions; K - the number of rectilinear portions; lφi - the length of the neutral layer of the bent portion

$$l_{\varphi i} = \frac{n * \varphi_i}{180} * (r_i + x * g) \quad (3)$$

φi - the angle of bending; ri - the inferior bending ray; X-coefficient that takes into account the movement of the non-layer and whose values are given in a specific table.

- Tailoring analysis. In order to have an optimal tailoring, you need to make calculations for the most correct placement of the part on the metal sheet. The decks necessary for the cut are A, B, C and the step p. following the establishment of these values, the efficiency of the tailoring is calculated [1, 2].
  - Decks A and B are calculated as per the following formulas:

$$A=k_1*k_2*k_3*a1 \quad (4)$$

$$B=k_1*k_2*k_3*b_1 \quad (5)$$

- k_1, k_2, k_3, a_1, b_1 are values that differ depending on the material category and the thickness of the metal sheet and can be found in the specific tables in the specialized literature..
  - Deck c differs depending on the thickness of the metal sheet and is found in a specific table in the specialized literature.
  - Step P, is calculated by gathering the length of the piece with deck A..
  - Tailoring efficiency is calculated using the formula:

$$k_c = \frac{n * A}{p * l_s} * 100\ [\%] \quad (6)$$

n - the number of tailoring rows; A - the area of the piece determined by the outer contour; P - the tailoring step; Ls - calculated width of the tape.

3. Developing the methodology of the desing algorithm

The algorithm aims to establish the dimensions of the semi-finished product by the calculation of the finished part considering a minimum interaction with the user. Following the calculation, the dimensions will be displayed on both the X axis and on the Y axis of the flat surface. This data is subsequently used to optimize the stamping tailoring according to the desired material category and the desired number of results. User input is necessary in choosing the values necessary for the calculations so that they are as close as possible to a correct and accurate optimisation. Finally, the user will be able to

view the necessary dimensions for the metal sheet or band to be processed, the quantity of the remaining material and a drawing that represents in a minimalist way the distribution of the finished products on the surface of the semi-finished product. Figure 1 represents the overall running process of the application

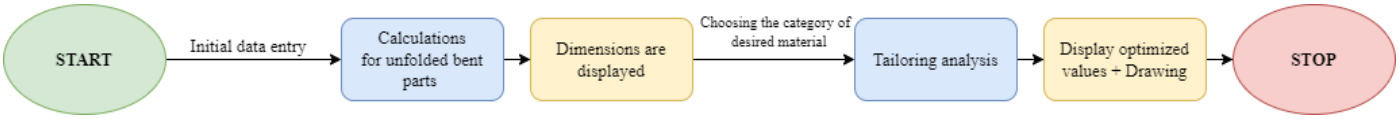

Fig. 1 – The overall running process

4. Developing the application

The proframic environment used to create the application is LabView, an accessible and efficient working tool in relation to the purpose imposed by the research theme. The whole program is integrated into a While Loop, and in the following you can see the components in the described order and in the main diagram.

Figure 2 shows the interface for the calculation of the piece. This contains both the data that the user will have to enter and some helpful information in in relation to it.

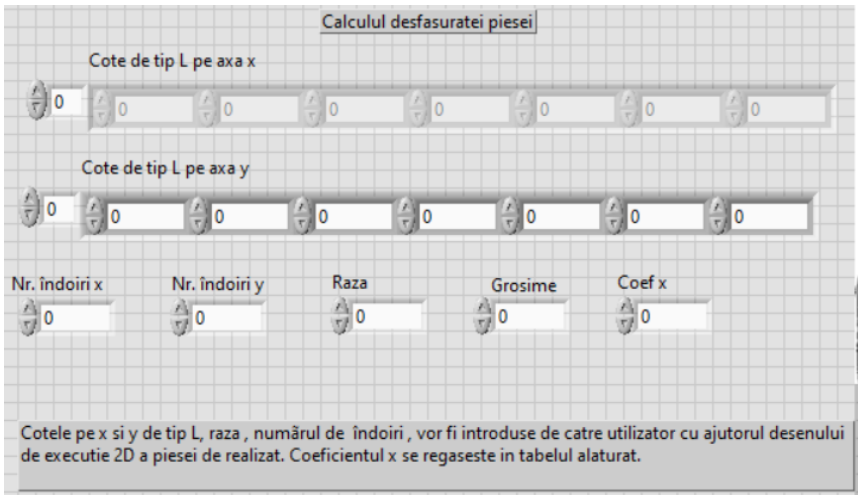

Fig. 2. Calculation of the unfolded piece (Front Panel)

Figure 3 presents the structure of the program with the operations necessary for the calculation necessary for the part. Each function used has a label to help the user easily follow the structure of the elaborate algorithm.

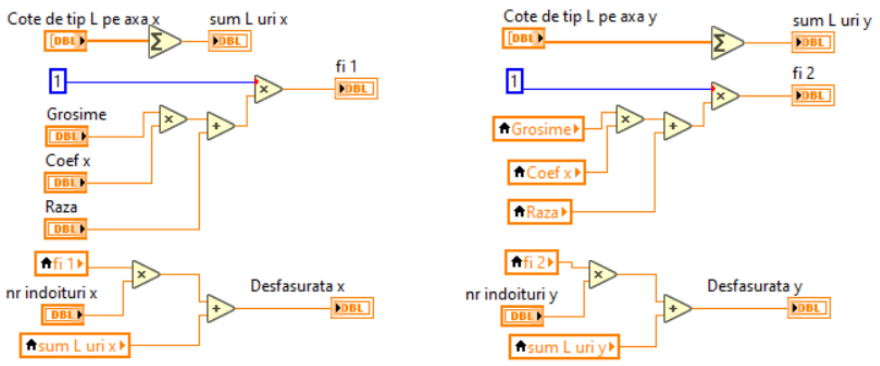

Fig. 3. Calculation of the unfolded piece (Block Panel)

Figure 4 presents the interface of the program for analysing the semi -finished product. In this section of the program, the user will be able to enter the necessary data and will be able to choose the desired material category for an optimal tailoring.

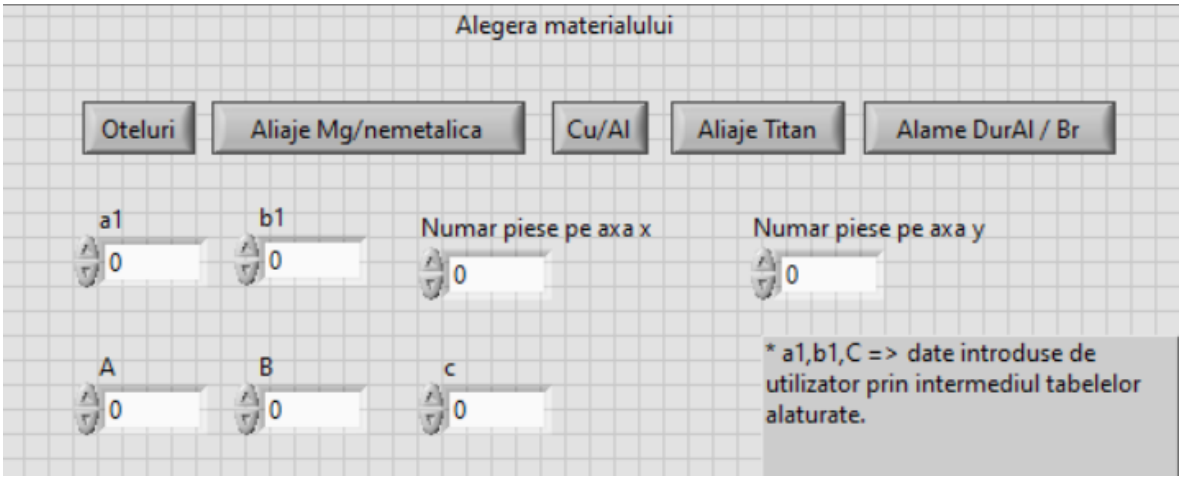

Fig.4 - Tailoring (Front Panel)

Figure 5 presents the structure of the algorithm used for the calculation of the cut and the algorithm necessary for the drawing that contains the exemplification of the method of cutting and the arrangement of the semi -finished product.

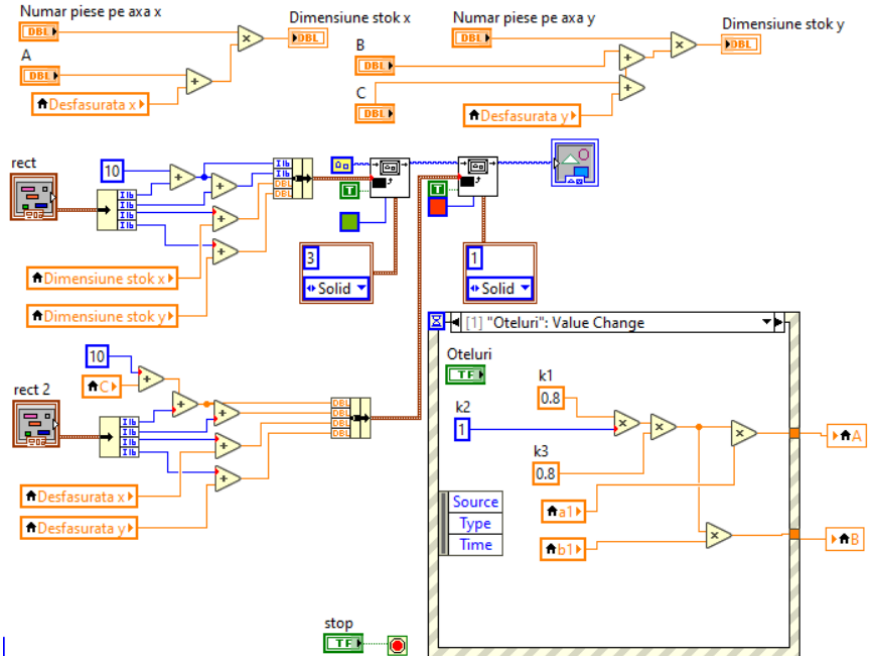

Fig.5 - Tailoring (Block Panel)

Figure 6 represents the model drawing to exemplify the method of cutting and the arrangement of the semi -finished product.

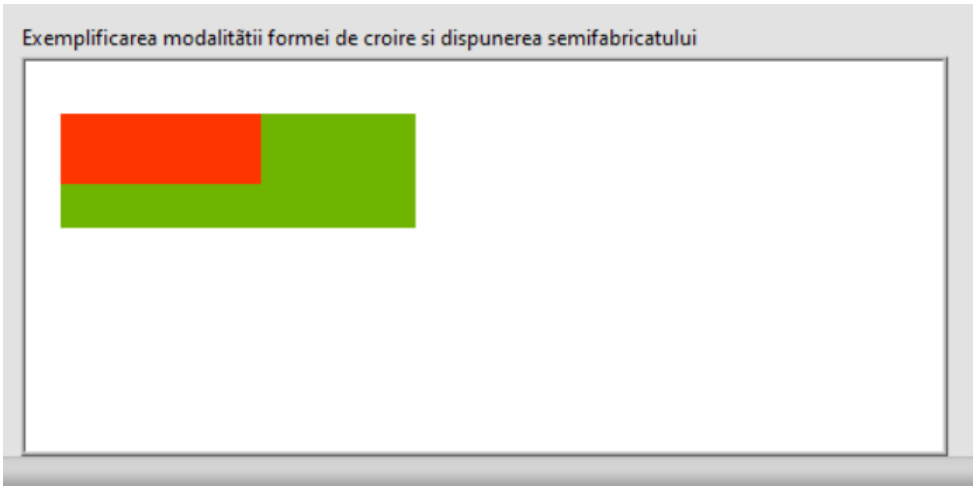

Fig.6 - Exemplification of the way of cutting and the arrangement of the semi-finished product

Figure 7 shows other elements from the program interface. These items are necessary for an easier use of the program and in order to help the user in understanding the way in which it works.

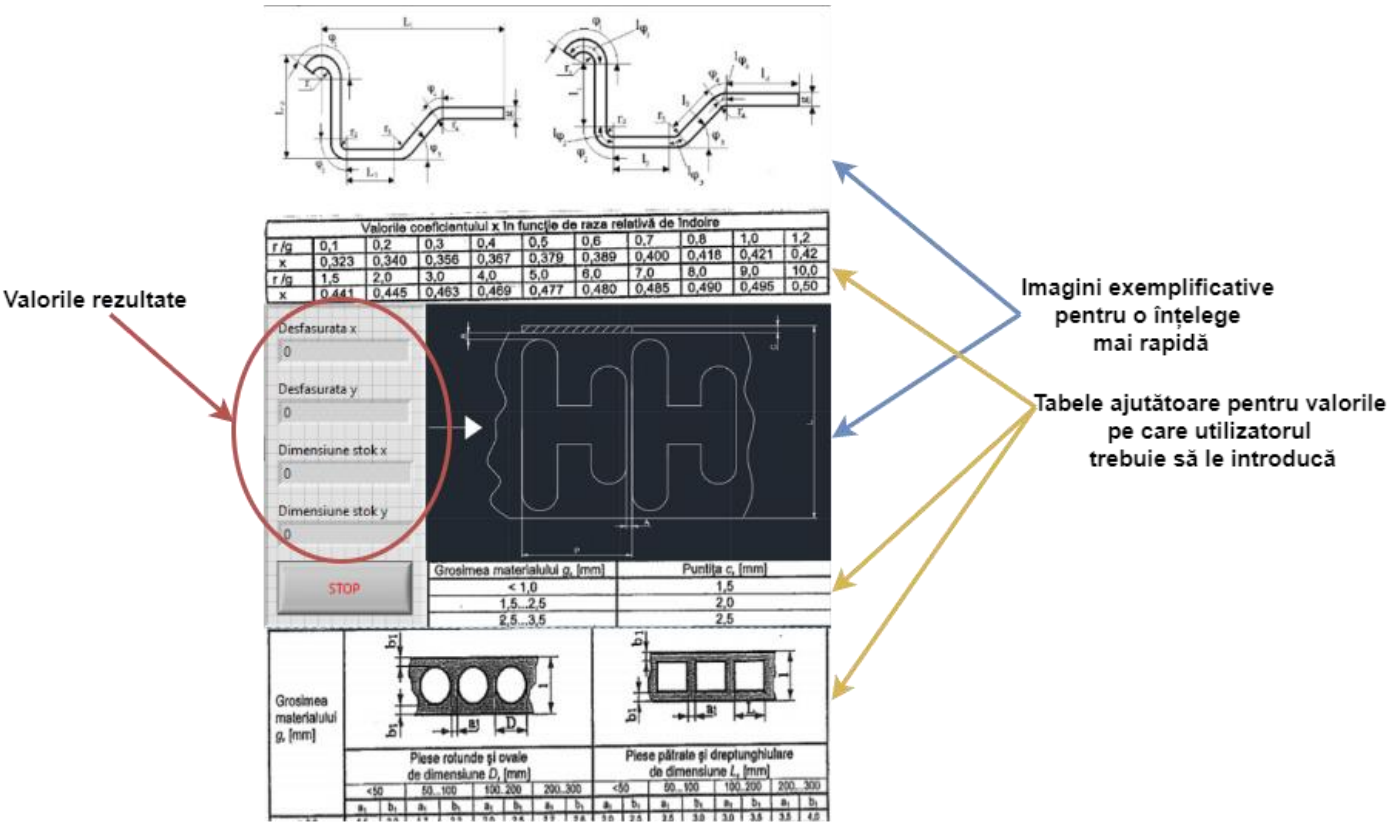

Fig.7 - Elements in the program interface

5. Conclusions

The developed application aims to create an accessible, easy -to -use program, that helps the desiging engineer in the design stage of cold deformation equipment, which implies the analysis and efficiency of the semi -finished products. The application contributes to the elimination of possible calculation errors that can occur during the use of the classical method, considerably reducing the time allocated to perform the calculations.

Subsequent developments of the application will also include calculations regarding the efficiency of the flat and bent parts, thus becoming a useful working tool in developing an optimal technological process, which aims to minimize the production cost associated with a landmark obtained by cold deformation.

6. Bibliography

[1]. Sindilă, Gh. (2016), „Tehnologii de Prelucrare prin Deformare Plastică la Rece" VOL I, BREN, București.
[2]. Sindilă, Gh. (2016), „Tehnologii de Prelucrare prin Deformare Plastică la Rece" VOL II, BREN, București.
[3]. Teodorescu, M. (1987) „Prelucrări prin deformare plastică la rece", E.T. , Bucureşti.
[4]. Zgură, Gh., Drăgănescu F., Trandafir., Sindilă,Gh. (1975), „Stanţarea şi matriţarea la rece-Îndrumar de proiectare", I.P.B., Bucureşti.
[5]. Dobrescu, I., Popescu, P. (2002), „Prelucrări prin deformare la rece a tablelor", Piteşti

DESIGN OF AN ALGORITHM FOR GENERATING THE GRAPH OF A TECHNOLOGICAL PROCESS

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ABSTRACT: In computer science, a graph is an abstract data type that is meant to implement the undirected graph and directed graph concepts from the field of graph theory within mathematics. A graph data structure consists of a finite (and possibly mutable) set of vertices (also called nodes or points), together with a set of unordered pairs of these vertices for an undirected graph or a set of ordered pairs for a directed graph. These pairs are known as edges (also called links or lines), and for a directed graph are also known as edges but also sometimes arrows or arcs. The vertices may be part of the graph structure, or may be external entities represented by integer indices or references. A graph data structure may also associate to each edge some edge value, such as a symbolic label or a numeric attribute (cost, capacity, length, etc.).

KEY WORDS: graph theory, graph data structures, directed graphs, abastract data types

1. Introduction

The technological process of machining a part can be designed in a very large number of variants, each of them ensuring that all the technical conditions imposed on the part are met [1]. Of all the possible machining variants, only one ensures the lowest cost.

A method that can be used to determine the optimal variant of a technological process is based on the use of graph theory, a theory that allows through the procedural model and the logical scheme associated with the problem, can simultaneously consider all the real possibilities of machining a part, indicating the most economical and fastest variant [4].

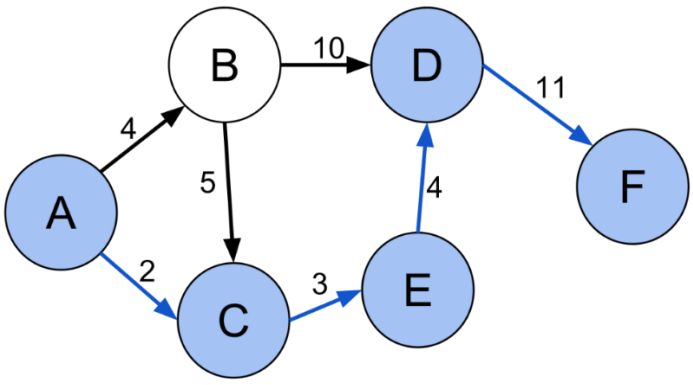

Fig. 1. Graphical example of a directed graph showing the shortest path [2]

In figure 1, the path in a graph consists of the sequence of arcs that allows one to pass from one vertex to another in the direction of their orientation, so that the final orientation of one arc coincides with the initial extremity of the next arc. In object-oriented programming, the hierarchy of objects (classes) in a program can be represented by a graph in which each node represents a class [3].

2. Current status

The development environment used to build the algorithm is MATLAB, a development environment for numerical computation and statistical analysis containing the programming language of the same name, created by MathWorks. MATLAB allows manipulation of matrices, visualisation of functions, implementation of algorithms, creation of interfaces and can interact with other applications. With its help, a directed graph can be generated in which the most efficient path is highlighted. For web-based communication with the program, the LabVIEW development environment was used, a graphical programming language that allows the development of applications using icons. Unlike textual programming languages, where instructions determine the execution of the program, LabVIEW uses instead data flow highlighted by an appropriate graphical presentation. [5]

The scheme of the principle of operation of the application is shown in Figure 2.

Fig. 2. Schematic diagram of the algorithm

Sending data from LabVIEW to MATLAB will be done using the OPAL-RT package. Depending on the execution drawing (Figure 3) and the machining required to make the desired part (Figure 4), the user will choose one by one all the specific details using a web interface provided by LabVIEW and the Web Services development package, until all the operations have been registered, as shown in Figure 4. It is important to keep in mind that the grouping of surfaces and operations within the program is done after the landmark is attached to the tool machine.

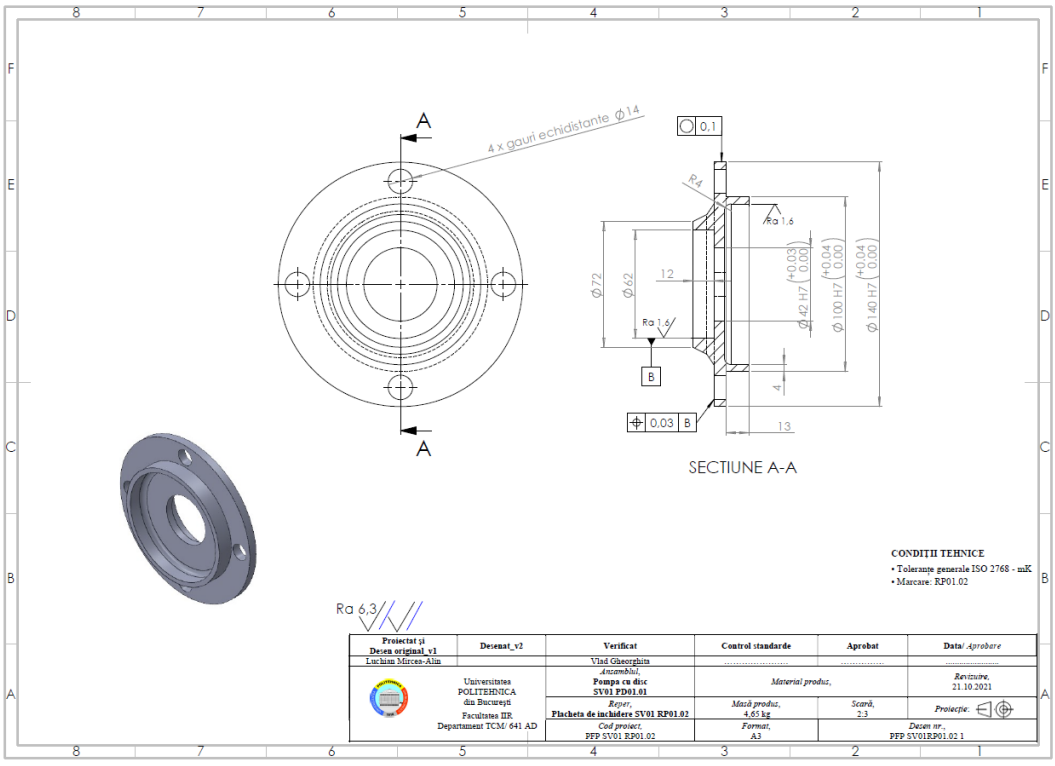

Fig. 3. Example of execution drawing

Operations saved so far:

S_k	Accuracy class	Roughness (μm)	Surface	Step	Type
S1	IT10	6,3	Outer cylindrical/conical surface	Turning	Rough turning
S2	IT10	6,3	Outer cylindrical/conical surface	Drilling	Rough drilling
S2'	IT10	6,3	Outer cylindrical/conical surface	Drilling	Rough drilling
S2''	IT10	6,3	Outer cylindrical/conical surface	Drilling	Rough drilling
S2'''	IT10	6,3	Outer cylindrical/conical surface	Drilling	Rough drilling
S3	IT6	1,6	Interior cylindrical surface	Turning	Rough turning
S3'	IT7	6,3	Interior cylindrical surface	Turning	Finishing turning
S4	IT7	6,3	Interior cylindrical surface	Widening	Roughing widening
S4'	IT6	1,6	Interior cylindrical surface	Widening	Finishing widening

Generate oriented graph

Download the table

Add surface

Add another step

Reset table

Fig. 4. Current web interface with a table populated with user-made entries

Depending on the need, the user can generate the oriented graph with the choices that have been registered or download them as a table. Downloading the table will save a .csv file which can be read by Microsoft Excel. Pressing the "Reset table" button will delete all entries in the table.

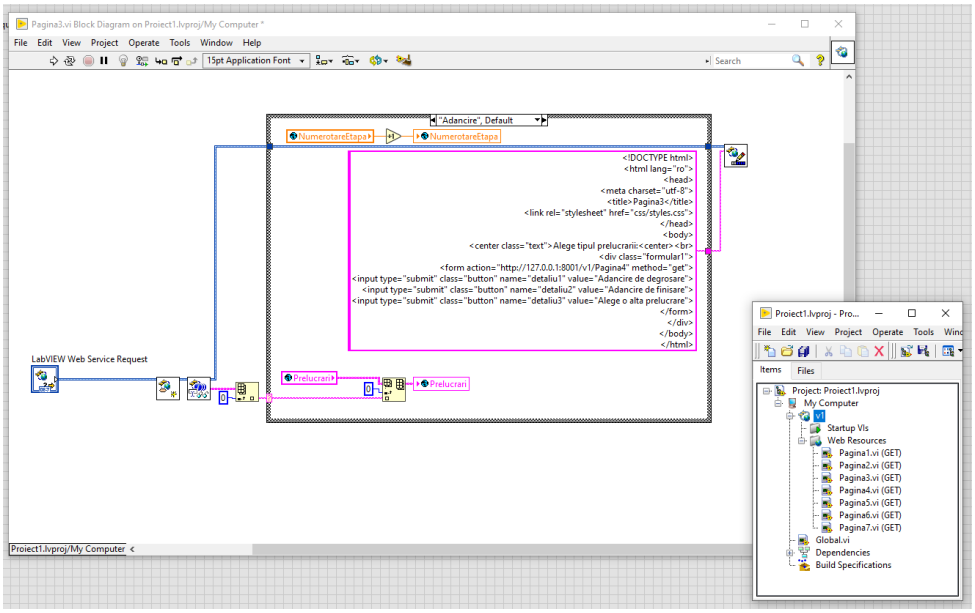

Fig. 5. LabVIEW project and one of the sub-programs that adds new web page entries to the global variable

The global variable is used for storing records within the program and using the Web Services package a processed text is sent in the form of a HTML editing language (Figure 6) to be read and interpreted by a browser.

The functions in this package exchange data with the programs in the project over a local network, sending a response to HTTP requests from clients.

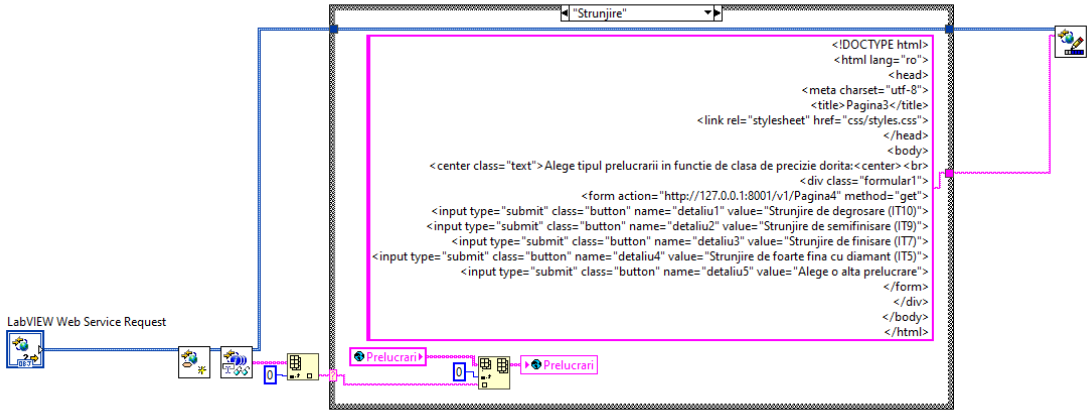

Fig. 6. Example of one of the diagrams of a VI (Virtual Instrument) sub-program for displaying a web page

The incoming data is entered into a script using the OPAL-RT package (figure 7) where the entries in this structure will be replaced by the stored entries in the global variable. The references will receive nodes and edges by 2 vectors (one of sources and one of targets) used to make the directed graph after assigning a length to the edges and naming the nodes. The oriented graph is called using the *digraph* command and is displayed (figure 8) using the *plot* function with a layout layout that makes the edges as easy to read as possible.

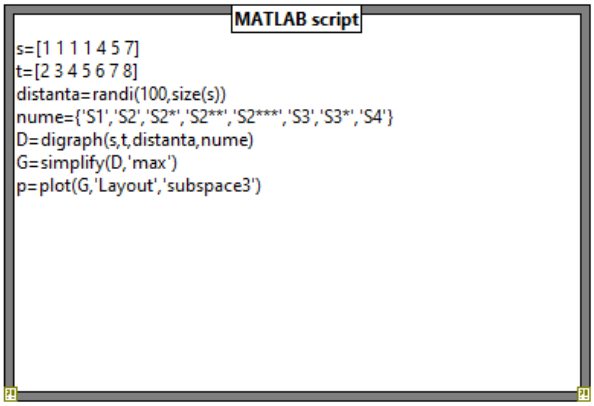

Fig. 7. Sample script from MATLAB in LabVIEW

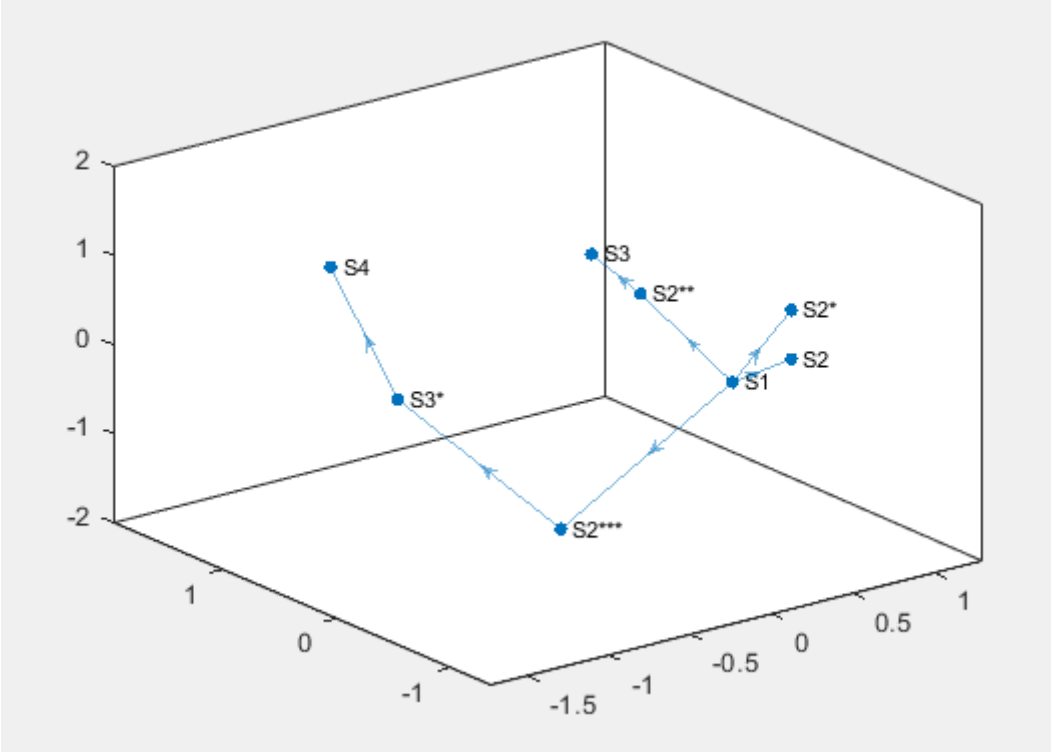

Fig. 8. Oriented graph generated at the end

3. Conclusions

Displaying and generating a directed graph can be done in MATLAB and displayed in a web service using LabVIEW. The resulting application is a tool that helps the user when it comes to assisting the planning of activities in a technological process. The role of the application is to provide and generate a graph with the chosen processes in a correct order. This leads to optimisation, standardisation of activities and increased efficiency.

Improvements are needed in the algorithm so that each operation has a value that corresponds correctly to the real manufacturing process, to respect the machining constraints (the graph will take into account the order of the machining, e.g. widening or deepening only after drilling; finishing after roughing and semi-finishing; threading after drilling) and the web page (the page should be user-friendly, to be able to display the oriented graph correctly and save it in a . png or .jpeg, be able to save the operation table in a .csv format). The application will use functions such as *shortestpath* and *highlight* that determine the shortest path, highlight it by thickening the edges, and color it in a desired color.

4. Bibliography

[1]. https://en.wikipedia.org/wiki/Graph_(abstract_data_type), date of access 07/05/2022
[2]. https://en.wikipedia.org/wiki/Shortest_path_problem, date of access 07/05/2022
[3]. https://ro.wikipedia.org/wiki/Teoria_grafurilor, date of access 07/05/2022
[4]. Jungnickel D. (2005), Graphs, Networks and Algorithms, 2nd edition, publisher Springer-Verlag Berlin Heidelberg, ISBN 3540219056
[5]. Travis J., Kring J. (2006), LabVIEW for Everyone: Graphical Programming Made Easy and Fun, 3rd edition, publisher Prentice Hall, ISBN 013185672

DESIGN OF AN ALGORITHM OF A COMPUTER APPLICATION FOR REMOTE MONITORING

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ABSTRACT: Industrialization represents the period were people try to change economy of society using more machines instead of workers. First country has adopted this process of industrialization was the Regat of Great Britain in XVII century during the industrial revolution. Nowadays the biggest country with an industrial power is China, manufacturing a lot of products and parts for every domain. The most known invention is steam machine developed by James Watt and that transform thermic energy in mechanical work. Subsequent that was used in componence of a train engine.

KEYWORDS: IoT, LabVIEW, Fluid mechanics

1. Introduction

Dosing assemblies are one of the most important parts of an automated liquid dosing process. Assemblies of this type are a combination of various specific devices, and the dosing system may comprise several components. The automation of such a process represents an increase in the manufacturer's production and a reduction in the risks to which operators are exposed in the case of chemical liquid dosing assemblies.

"THE DESIGN OF AN ALGORITHM AND THE REALIZATION OF SOME COMPONENTS OF A COMPUTER APPLICATION FOR REMOTE MONITORING OF A MECHANICAL FLUID DOSING INSTALLATION" is the title of the topic I chose to develop for the diploma project, but also to try to operate such a system from the distance.

As the technology evolves faster and faster, more and more, this kind of assembly, due to IoT, can be followed and operated from the distance. IoT is at the core of the development of the Industrialization 4.0. For the development of this system we needed knowledge of fluid mechanics to calculate and create the dosing route and the experimental stand, programming in LabVIEW to develop the graphical interface with which the operator has first contact, but also to automate the process using electronic components such as frequency converter , process computer, but also a relay, WEB development knowledge in order to be able to make the platform on which the operator will have access to view the status of the process, but also to control it.

2. The current stage

The current state of this application is at the level of testing, verification and optimization for its use and fictionalization. As we are talking about an industrial process, it has a hardware component, a software component, but also an experimental stand. All this being interconnected with each other and depending on each other for a good functionality of the whole dosing process. In the following we find an extensive completion of the components, the explanation of the dosing procedure, the logic of automation but also the use of the web platform.

a) Software component:

- Web platform
- Automation

b) Hardware component:

- Process calculator
- Frequency converter
- USB card

c) Experimental stand component:

- Dosing pump
- Solenoid valve
- Measuring units

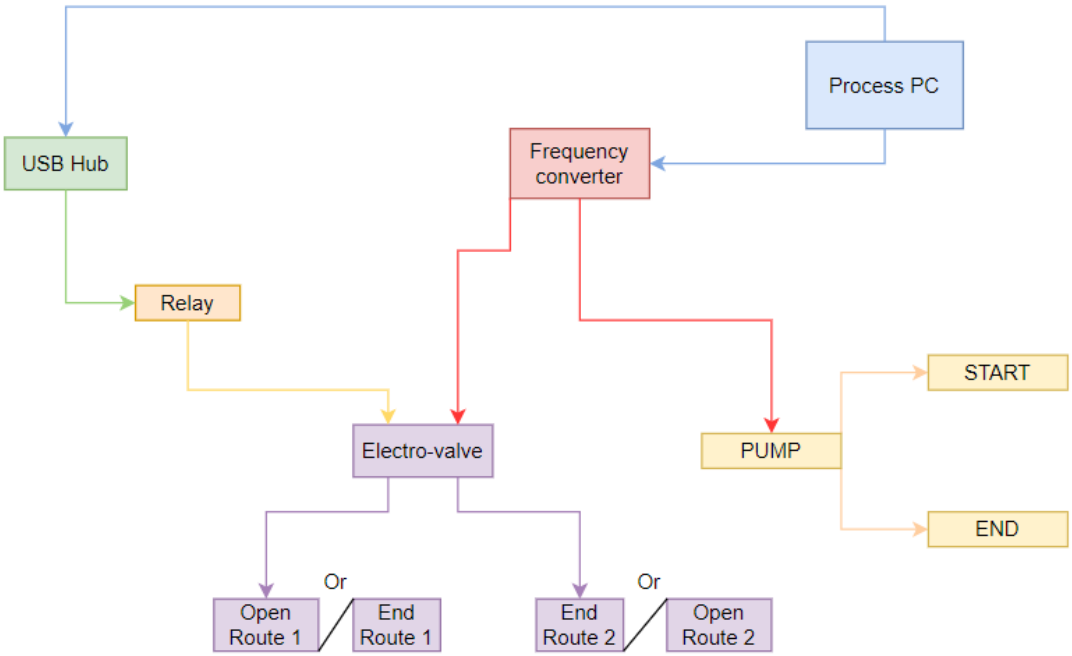

Fig. 1. The logical scheme of the ensemble

In the figure represented above we find the operating logic of the Hardware components and those of the experimental stand, working in tandem. All automation is controlled by a process computer on which the software created in LabVIEW is uploaded. As shown in the diagram above, the computer is connected to both the frequency converter and the USB card that will switch, in turn, on which route to open and close the solenoid valve. Since we used a liquid material dosing pump, they will be stored in two mixers, one for each type of liquid transported in the system.

The mixers have sensors attached so that they can monitor their filling level. If errors occur during the process, they will be displayed in the interface to be able to locate exactly which route the problem is on and to find a timely solution, in extreme cases the process is stopped for maintenance.

From the process computer the parameters are sent to the converter that will activate the solenoid valves that will open the path indicated in the program after the frequency converter activates the pumps that will start extracting the liquid from the magazine.

For the correct operation of all the components listed above, the scheme represented in Fig. 1 has been carefully elaborated. 2 representing the routes, but also the electrical connections between them.

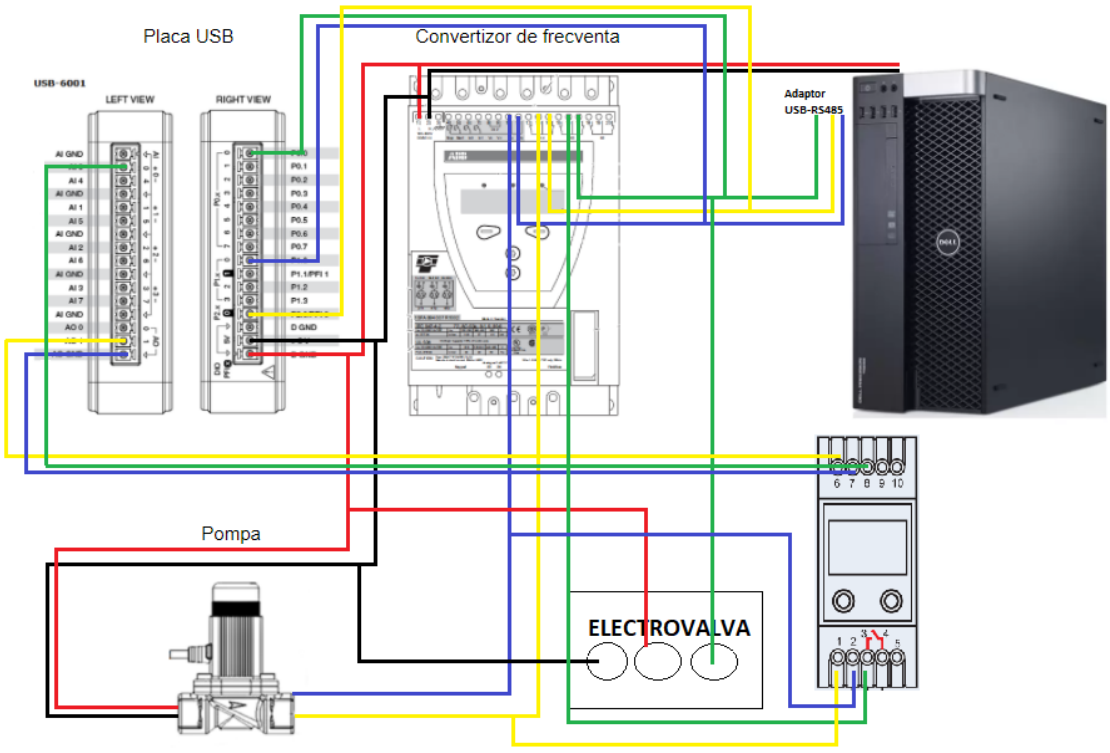

Fig. 2. Electric schema

- Connection legend Eclectic diagram

--------- Power supply +
--------- Power supply –
--------- Signal transfer / frequency Route 1 / Route 2
--------- Power supply to the computer
--------- START / STOP signal transfer

Once these components are connected, the system verification step begins, running the automation program. In the image below we find the graphical interface of the process that the operator can view and access the web platform created especially for it. To connect it to the platform, you need to enter a user account (Fig. 4.), a threshold made to increase the security of the platform.

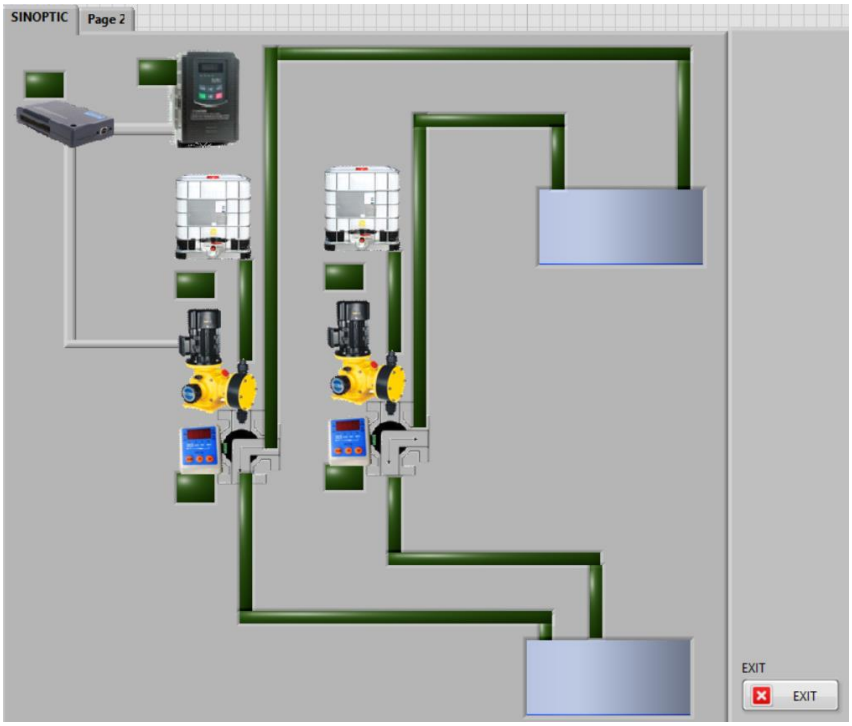

Fig. 3. Process graphical interface

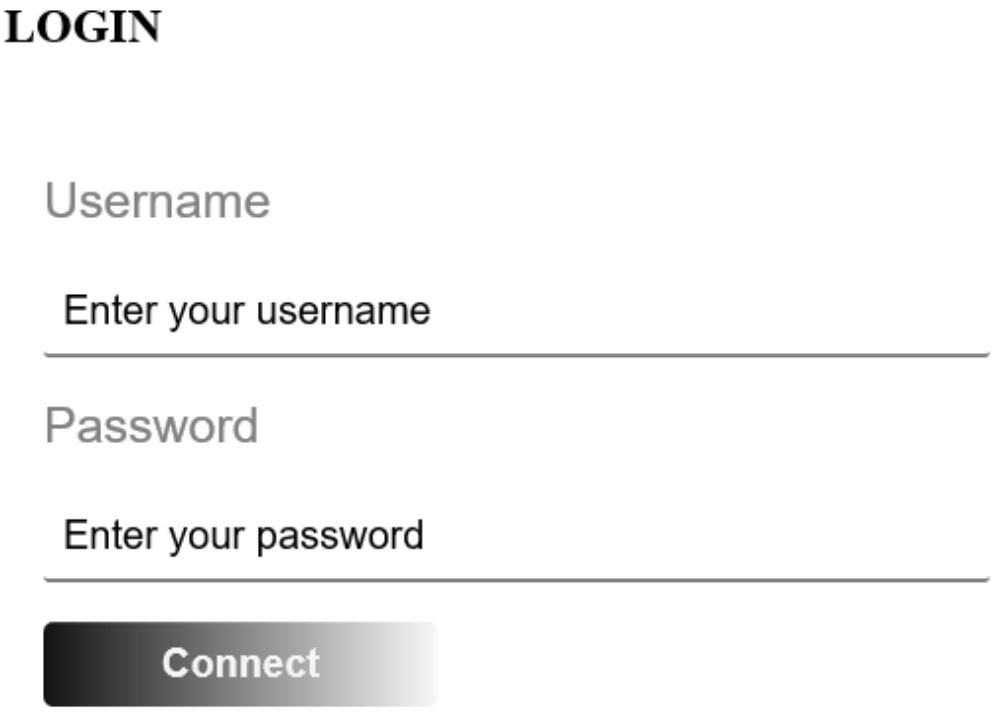

Fig. 4. Platform Login Portal

3. Experimental stand

Since I had the equipment listed above, I was able to perform in physical format part of the experimental stand developed. In the image below we find the hardware components electrically connected to the components of the experimental stand.

Fig. 5. Experimental stand in physical format

4. Conclusions

Although dosing processes have been automated since the beginning of industrialization as the level of manufacturing of liquid component products has increased, the set developed above is trying to mold itself to Industrialization 4.0, which is current and in continuous development. Its level of operation is low as it uses modern technologies and methods with which both operators and people are already accustomed to using them at work or for their own purpose.

5. Bibliography

[1]. Balaban, A, “Sisteme de automatizare”, suport curs
[2]. https://math.fandom.com/ro/wiki/Mecanica_fluidelor#Generalit.C4.83.C5.A3i
[3]. https://ro.wikipedia.org/wiki/Mecanica_fluidelor
[4]. https://ro.wikipedia.org/wiki/Internetul_obiectelor
[5]. https://www.scritub.com/stiinta/fizica/Mecanica-fluidelor65689.php
[6]. https://ro.wikipedia.org/wiki/Internet#Web_3.0
[7]. Andrei, V, “Mecanica fluidelor”, vol. I, II, III, Editura Fundatia universitare „Dunarea de jos”, Galați, 2005.

STUDIES ON THE IMPLEMENTATION AND DEVELOPMENT OF AN AUTOMATED PROTOTYPE OF AN IRRIGATION SYSTEM

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ABSTRACT: The paper is based on the in-depth study of the automation methods of the classical drip irrigation system. As a way of working, we will use the LabView program with which we will be able to measure environmental factors such as temperature, soil moisture and light intensity. Depending on the values of these factors, different orders will go to a water pump, which will meet the need for soil moisture. This paper involves the need for tools such as sensors and water pumps. These will be connected to an Arduino Mega2560 board and then to the computer to run the project program. The recorded data will be displayed in a text file, where the date and time will also be specified.

KEY WORDS: sensors, LabView, automation.

1. Introduction

The automation of irrigation systems is achieved by equipping them with machines that partially or totally take over some activities performed by the operating personnel, such as the functions of measurement, memory, decision, command and control.

The irrigation system appeared as a need to save water and also for extreme situations such as drought. For the good development of crops from small to large, this system is ideal. Expert studies show that irrigation is mainly used in areas where long periods of drought are expected or irregular rainfall is known.

The objectives of the thesis are to offer new perspectives on the needs of farmers in terms of irrigation of cultivated areas. In order to give the users of this system a clearer overview of the main functionalities, an experimental stand was created consisting of: humidity, temperature and light intensity sensors, Arduino Mega2560 board, water pump, 12V power supply, driver, hoses, wires, Lenovo laptop, plastic box and 12 kg of earth.

2. The current stage

Irrigation systems are in a continuous process of performance evolution, with reflection on the quality of watering application, labor productivity and easier adaptation to natural conditions. All this is done in order to achieve a high degree of automation and, of course, increased agricultural production. Rehabilitation, automation or modernization of irrigation systems will bring major benefits to the agricultural sector.

Among the irrigation systems to be mentioned are those that have a high degree of use and are noted for their low and well-controlled water consumption even in the event of major climate change.

Irrigation systems are in full development, with a focus on renewable energy sources or even water recycling. For the purpose of understanding these types of systems, in Figure 1- block diagram of the pumping system, there is a diagram of an algorithm that uses solar energy as a power supply.

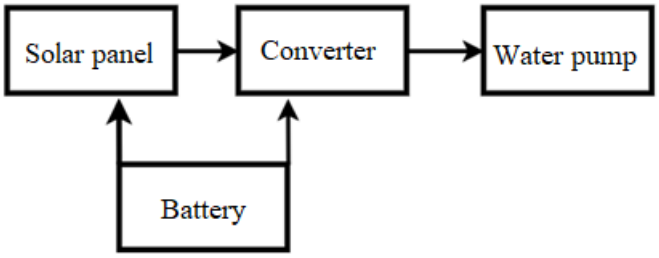

Fig. 1. Block diagram of the pumping system

3. Own contribution

For a better understanding of the operation of the experimental stand, the following mechanical diagram was made:

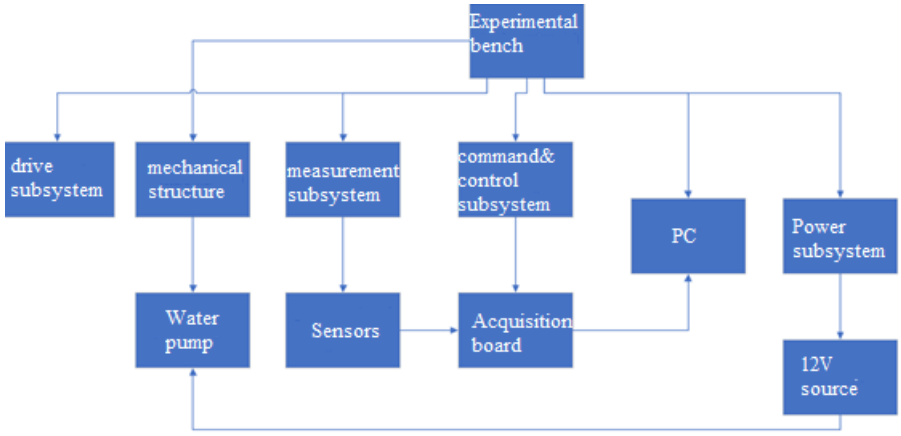

Fig.2. Mechanical scheme of the experimental stand.

The application was made using the LabView program. The values of the 3 factors of major interest were constantly monitored: soil moisture, outside temperature and light intensity. The operating conditions are:

1. If the temperature is below 25 degrees Celsius and the soil moisture is below 60%, then the system can start.
2. If the humidity is below 60%, but the temperature above 25 degrees Celsius the system will not start.
3. Another factor to consider is light intensity. If the temperature is higher than 25 degrees, but the light intensity is in the range of 20,000 - 30,000 Lushes, then the system can start.

Ascan be seen in figures 2 and 3 - The program of the experimental stand, the Ardunio board is connected to the laptop, then the board port is selected and the sensors are connected to the board.

The signal transmitted by them is read with the help of analog and digital read functions, creating constants for each occupied port. The pump is represented by a boolean indicating its position, in the case shown, whether wet or not. A local variable has been created for the boolean that represents the pump to be connected to the various conditions in the application. The program was created using a while loop because it records the values continuously.

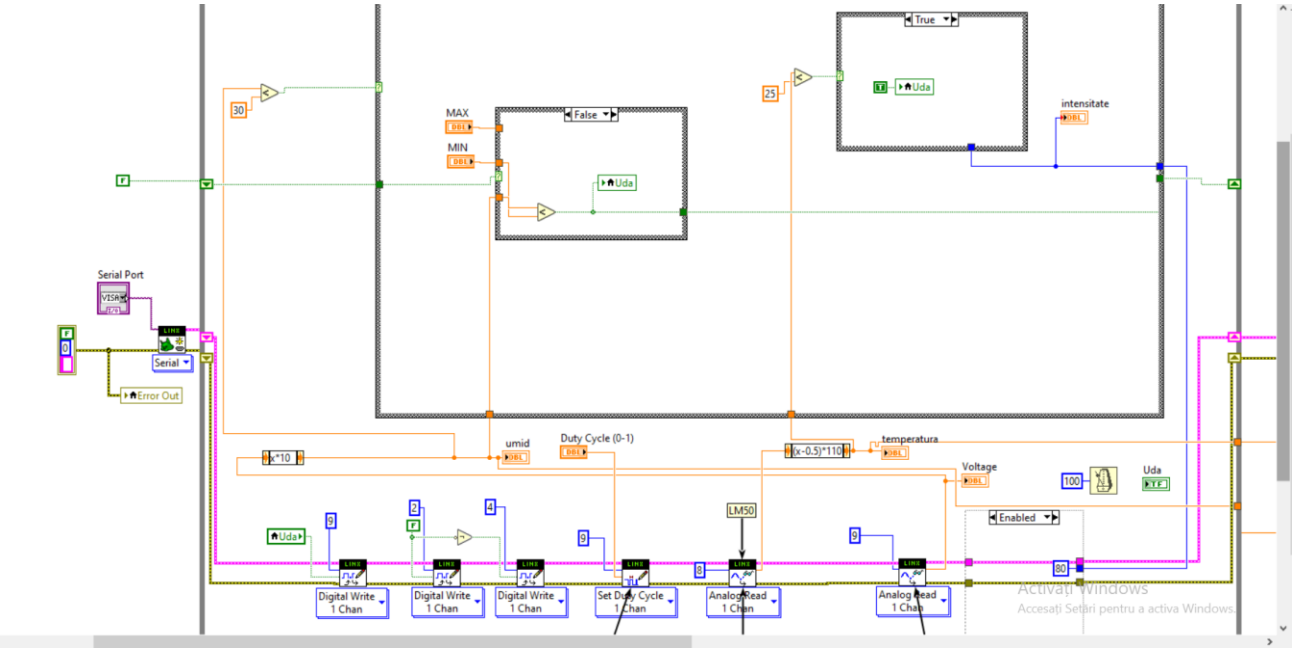

Fig.3.Program of the experimental stand

The program interface in Labview is shown in Figure 4 - The front panel of the program. There are two indicator type boxes that constantly show the values recorded by the sensors. The error box helps us to identify the errors that may occur, and the box entitled "Duty Cycle" helps us to control the speed of the water pump.

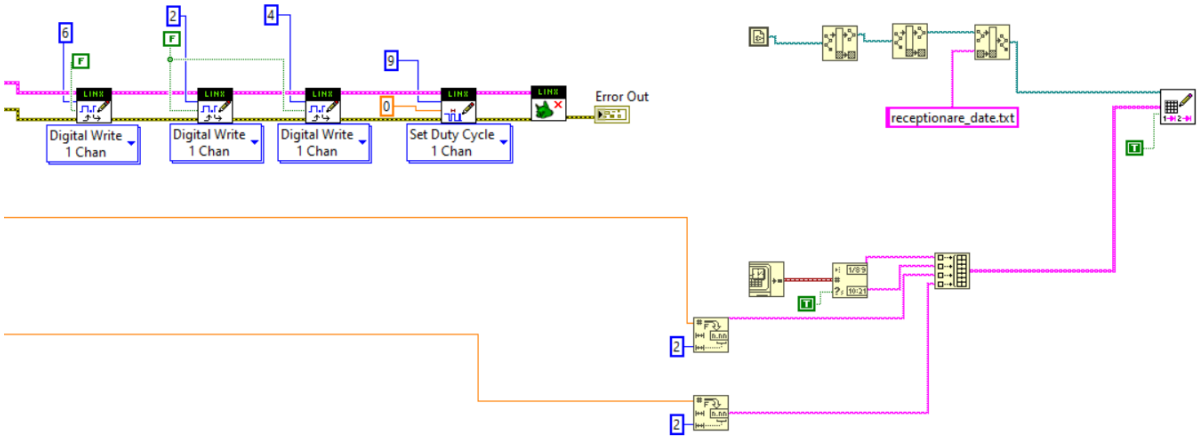

Fig.4.Program of the experimental stand

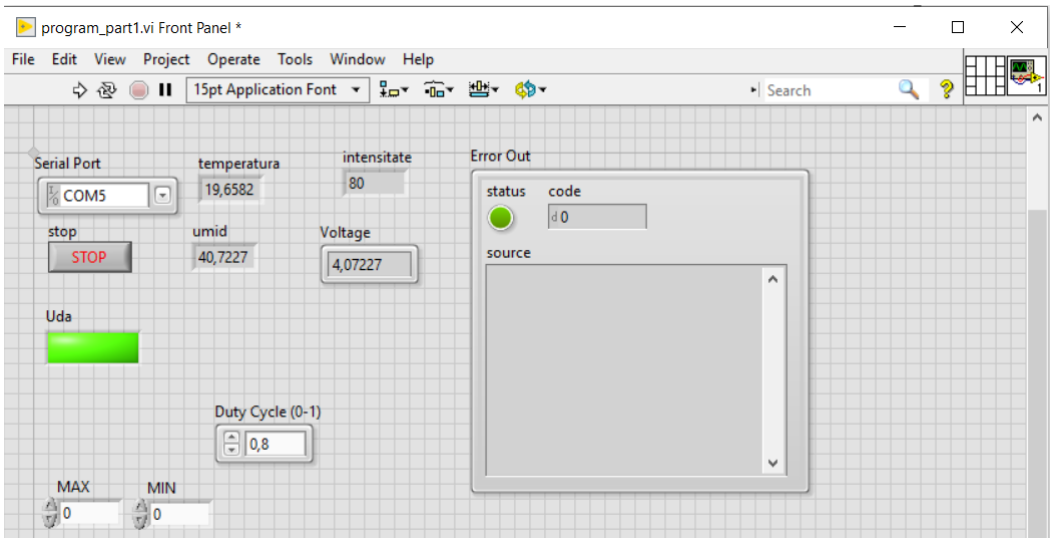

Fig.5. The front panel of the program

Figure 6, called the received data file, shows that the measured data is stored in a text file.

receptionare_date.txt - Notepad

Fișier Editare Format Vizualizare Ajutor

12.05.2022	14:13:44	-55,00	0,00
12.05.2022	14:14:48	24,49	41,11
12.05.2022	14:17:17	20,73	41,06
12.05.2022	14:22:28	-55,00	0,00
12.05.2022	14:23:53	23,96	41,02
12.05.2022	14:24:24	20,20	41,06
12.05.2022	14:47:55	-55,00	0,00
12.05.2022	14:49:40	19,66	40,92
12.05.2022	14:52:07	19,66	40,72

Fig.6.File with received data

Components of the experimental stand

- Arduino Mega 2560 board - this type of development board connects the sensors mentioned above, the stand's power supply and the water pump [1].
- LM50 temperature sensor - this sensor measures temperature, which is the main influencing factor in the watering process. It delivers 5V voltage and has 3 input / output pins. [2]
- Shield for VNH 5019 engine driver - helps to make the connections between the acquisition board and the rest of the components. It provides the necessary voltage and current for the water pump. [3]
- Light intensity sensor - with this we can start the system if the temperature can exceed 25 degrees Celsius, but the intensity does not exceed 30,000 Lukes. [4]
- Soil Moisture Sensor - This sensor tracks minimum and maximum soil moisture. [5]
- 12 V power supply. [6]

The elements listed above were assembled according to Figure 3 - The experimental stand of the irrigation system.

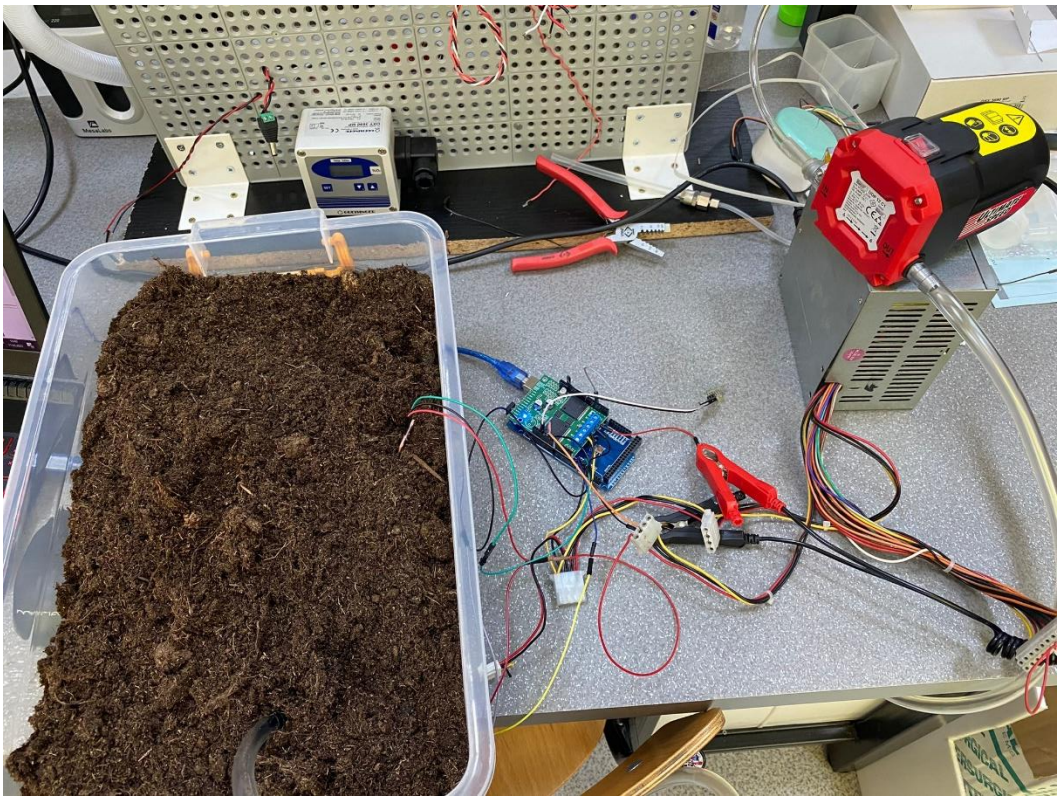

Fig.6. Experimental stand of the irrigation system

4. Conclusions and directions of development

This paper aims to increase the productivity of farmers and beyond. The implementation of such a system can allow the monitoring of the essential parameters in the development of crops. The system can be improved by adding hole hoses for efficient plant irrigation. A web service will be created that will contain two control buttons that will allow the system to switch from automatic mode to manual mode and pump control at any time.

5. Bibliography

[1] Arduino Mega 2560 Rev 3.https://store.arduino.cc/products/arduino-mega-2560-rev3
[2] Temperature sensor LM 50.https://www.tme.eu/en/details/rbfn-sen-vrm-05/environmental-sensors/robofun/rbfn-eu-sen-vrm-05/
[3] Pololu Dual VNH5019 Motor Driver Shield.https://www.pololu.com/docs/0J49/3.c
[4] Light intensity sensorhttps://ardushop.ro/ro/home/88-modul-senzor-lumina-intensitate-luminoasa.html
[5] Soil moisture sensor.https://www.robofun.ro/senzor-umiditatea-solului.html?gclid=CjwKCAjwve2TBhByEiwAaktM1A1hBOeGz8ktfuPv-gUtXUxWyahSJ9Sk3xDxHRtfu142LK3ghQxBRD
[6] 12 V power supply.https://eldepo.ro/sursa-alimentare-metalica-12V-20A?language=ro-ro¤cy=ROU&gclid=CjwKCAjwve2TBhByEiwAaktM1C5E1nShQly53e-FyEQGmutUDQ8ao-JSPfxWaWVW

RESEARCH ON THE DESIGN OF AN ALGORITHM AND THE DEVELOPMENT OF AN ONLINE COMPUTER APPLICATION FOR ASSISTED TRACKING OF MANUFACTURING BATCHES

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ABSTRACT: The paper involves the creation of an online computer application built using the C # programming language. This application facilitates the online tracking of production batches, offering the possibility to report daily the status of the various departments where the parts are distributed. The head of reporting provides information at the end of the day, and the batch tracker views the aggregated data from all departments in a concise manner, being able to make real-time decisions if the batches do not meet the requirements.

KEY WORDS: C #, batch tracking, SQL Server

1. Introduction

Tracking production batches requires an increased degree of complexity due to the multitude of batches that can be performed simultaneously in different production lines (departments). Thus, the application facilitates the distribution of landmarks to the corresponding production lines and the centralization of all reports in one place. It is important that the batch tracker has real-time information to determine landmark compliance.

The application was developed in the C # programming language, and the open-source Blazor framework, which allows developers to create web applications. Blazor is developed by Microsoft. The database was designed in SQL Server, a database server that is also provided by Microsoft.

The application allows 2 types of users:

- The user responsible for tracking batches
- The user responsible for batch reporting

From the user's point of view, who is responsible for batch tracking, the flow is as follows: It enters a command into the system that contains several landmarks. At this point, all parts are assigned lots and start and end dates of the manufacturing batches and the department in which they will be made. Subsequently, orders can be tracked throughout them, graphically viewing the status of manufacturing batches and their progress. Notifications of a specific order sent by the reporting user may also be read, and notifications may be sent to the departments responsible for certain batches.

The user responsible for reporting could send at the end of the day the number of points made, if he encountered problems that day, any suggestions to avoid problems and can read the communications sent by the user responsible for tracking batches.

2. The current stage

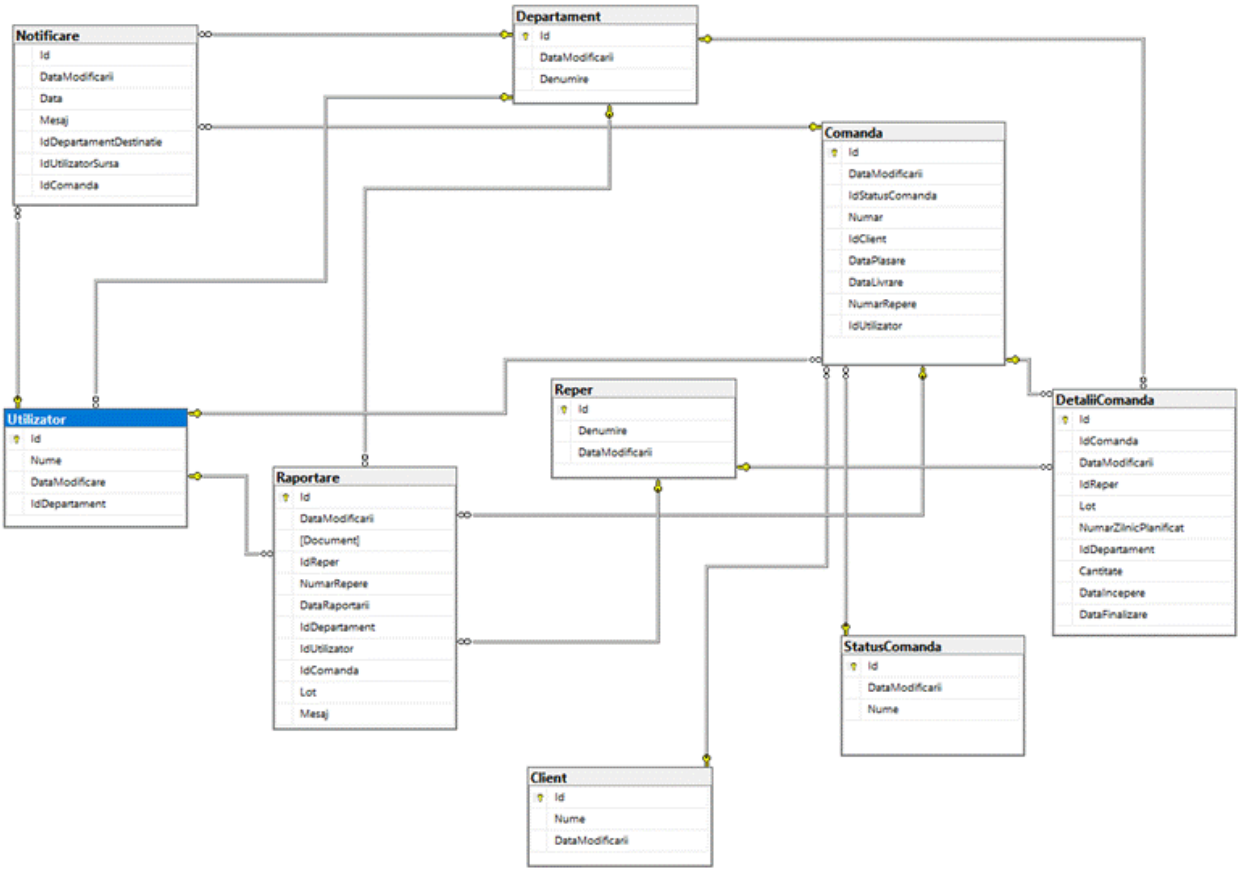

Figure. 2.1. Databasis diagram

The image above shows the databases diagram. All tables contain the Id and Date of Change columns. Id is the primary key to all tables. The primary key is a field that uniquely identifies the records in a table. The Date Modification column is automatically filled in with the current date and time insert operation at the time of insertion and has been entered to make it easier to track the order of databasis operations.

The tables were linked together using foreign keys. A foreign key is a column or group of columns in a relational database table that provides a link between data in two tables. It acts as a cross-reference between tables, as it refers to the primary key of another table, thus establishing a link between them. For example, the link between the User and Department tables is a one-to-many link, and is made using a foreign key. The Department Id column of the User table contains a foreign key to the primary key of the Department table (Id column). Thus, a department can have multiple users.

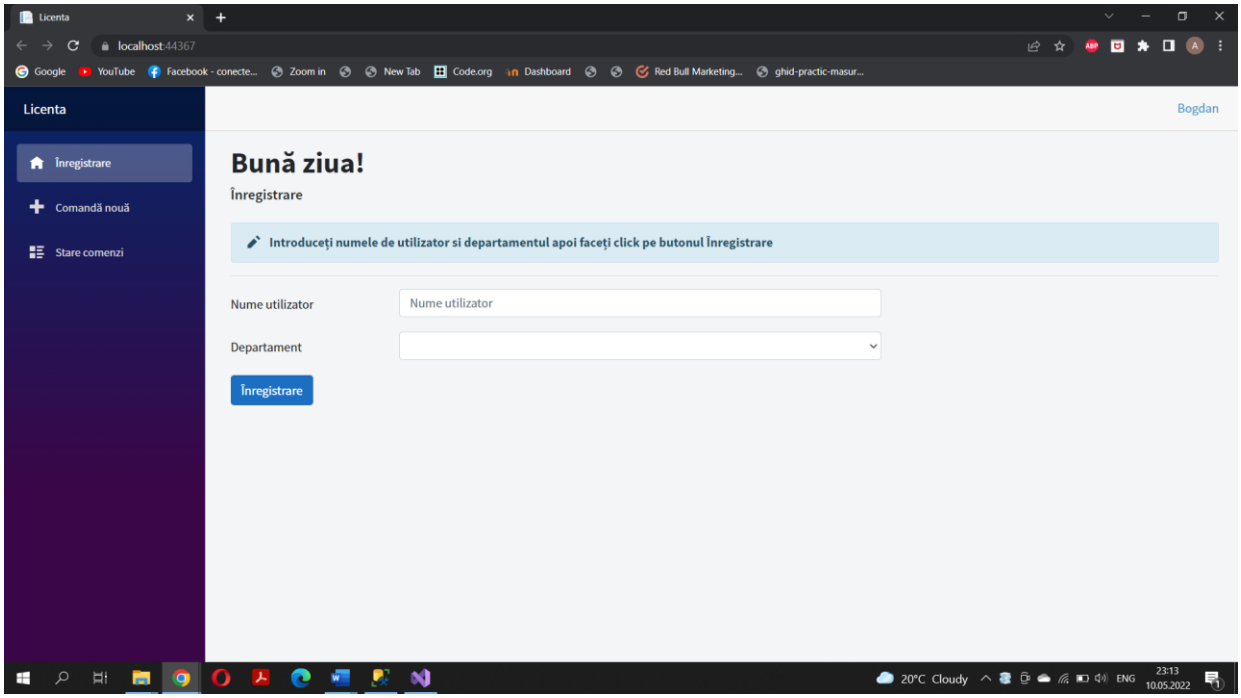

Figure. 2.2. Application login page

The login page of the application, where you enter the username and choose the department to which it belongs. The list of departments is loaded when you start the application, selecting them from the databasis.

```
<h1>Bună ziua!</h1>

<EditForm Model="@Utilizator" OnSubmit="@HandleSubmit">
    <DataAnnotationsValidator />
    <h4>Înregistrare</h4>
    <Prompt Title="Introduceți numele de utilizator si departamentul apoi faceți click pe butonul Înregistrare" />
    <hr />
    <div class="form-group row">
        <label for="firstName" class="col-sm-2 col-form-label">
            Nume utilizator
        </label>
        <div class="col-sm-6">
            <InputText id="firstName" class="form-control" placeholder="Nume utilizator" @bind-Value="Utilizator.Nume" />
            <ValidationMessage For="@(() => Utilizator.Nume)" />
        </div>
    </div>
    <div class="form-group row">
        <label for="department" class="col-sm-2 col-form-label">
            Departament
        </label>
        <div class="col-sm-6">
            <InputSelect id="department" @bind-Value="SelectedDepartmentId" class="form-control">
                @foreach (var dept in Departments)
                {
                    <option value="@dept.Id">@dept.Denumire</option>
                }
            </InputSelect>
        </div>
    </div>
    <button class="btn btn-primary" type="submit">Înregistrare</button>
</EditForm>
```

Figure. 2.3. Application algorithm

```
3 references
public Task<List<Departament>> GetDepartments()
{
    var connectionString = @"Server=localhost\SQLEXPRESS;Database=licenta;Trusted_Connection=True;";
    var queryString = "SELECT * from departament";
    using (var connection = new SqlConnection(connectionString))
    {
        var command = new SqlCommand(queryString, connection);
        var departamente = new List<Departament>();
        try
        {
            connection.Open();
            var reader = command.ExecuteReader();
            while (reader.Read())
            {
                var dept = new Departament
                {
                    Id = (long)reader["Id"],
                    Denumire = reader["Denumire"].ToString()?.Trim()
                };
                departamente.Add(dept);
            }
            reader.Close();
        }
        catch (Exception ex)
        {
            throw ex;
        }
        return Task.FromResult(departamente);
    }
}
```

Figure. 2.4. Application algorithm

3. Languages used

Blazor is a new framework from Microsoft designed to compete with industry-leading platforms such as React. Except that instead of using JavaScript, it runs on the .NET runtime and allows developers to create interactive web applications with C # and HTML. [1]

HTML (Hypertext Markup Language) is a text-based approach to describing how content in an HTML file is structured. This bookmark tells a web browser how to display text, images, and other forms of multimedia on a webpage. [3]

C# is an object-oriented programming language developed by Microsoft in the late 1990's. It was designed as a competitor to the Java language. Like this, C# is a derivative of the C++ programming language.

C# greatly simplifies writing programs for Windows, iOS, Android, etc. It is a cross-platform programming language. [2]

4. Defining the pursuit

Manufacturing monitoring involves the activity of supervising the way in which the production is carried out, more precisely the reverse cycle through which the execution of those provided in the planning and programming phases is verified.

The follow-up of the production is a continuous management activity consisting of the daily uninterrupted supervision of the production. [5]

Tracking process:

- It is performed daily by supervising all operations
made by workers and machines;
- Supervise the production activity;

- It has a more passive character, of analysis of the way of accomplishment of operations and finding of deviations;
- It is made by a section of the production department. [5]

Production tracking can be made in three ways:

- Program-based tracking. As I mentioned before, in the programming activity certain graphics and worksheets are made that have the role to specify the time and place where each operation will be performed. Based on these graphs the people responsible for tracking production can ascertain whether these operations have been carried out;
- Documentation tracking. This method is based on documentation performed during the launching activity in manufacturing;
- Inventory tracking. After analyzing material stocks and finished products stocks, we can deduce how to carry out the production process. [5]

Batch production is a method of manufacturing in which products are made in specified groups or quantities over a period of time. A batch can go through a series of steps in an extensive manufacturing process to achieve the desired final product. Batch production is used for many types of production that may require smaller quantities of production at a time to ensure specific quality standards or process changes. [4]

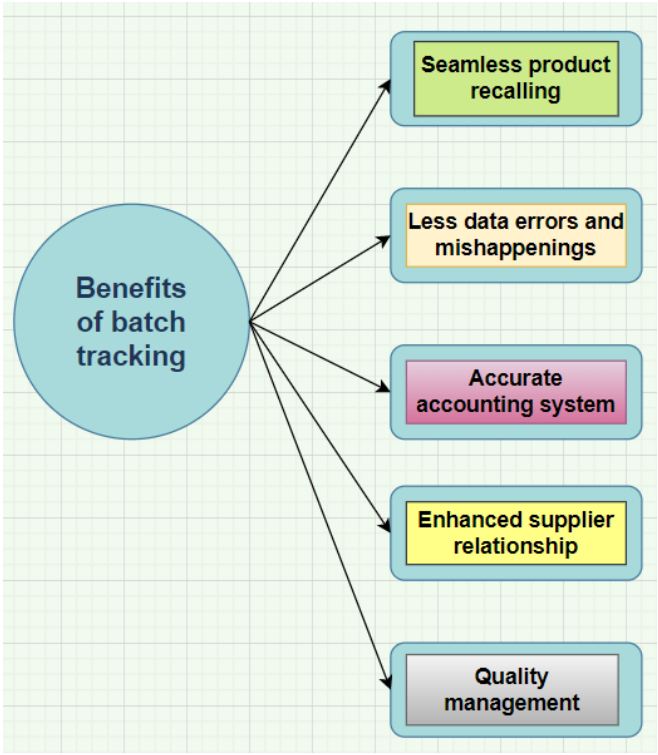

Figure. 4.1. Benefits of batch tracking

- In the final version, the application will work according to the flow in the diagram below.

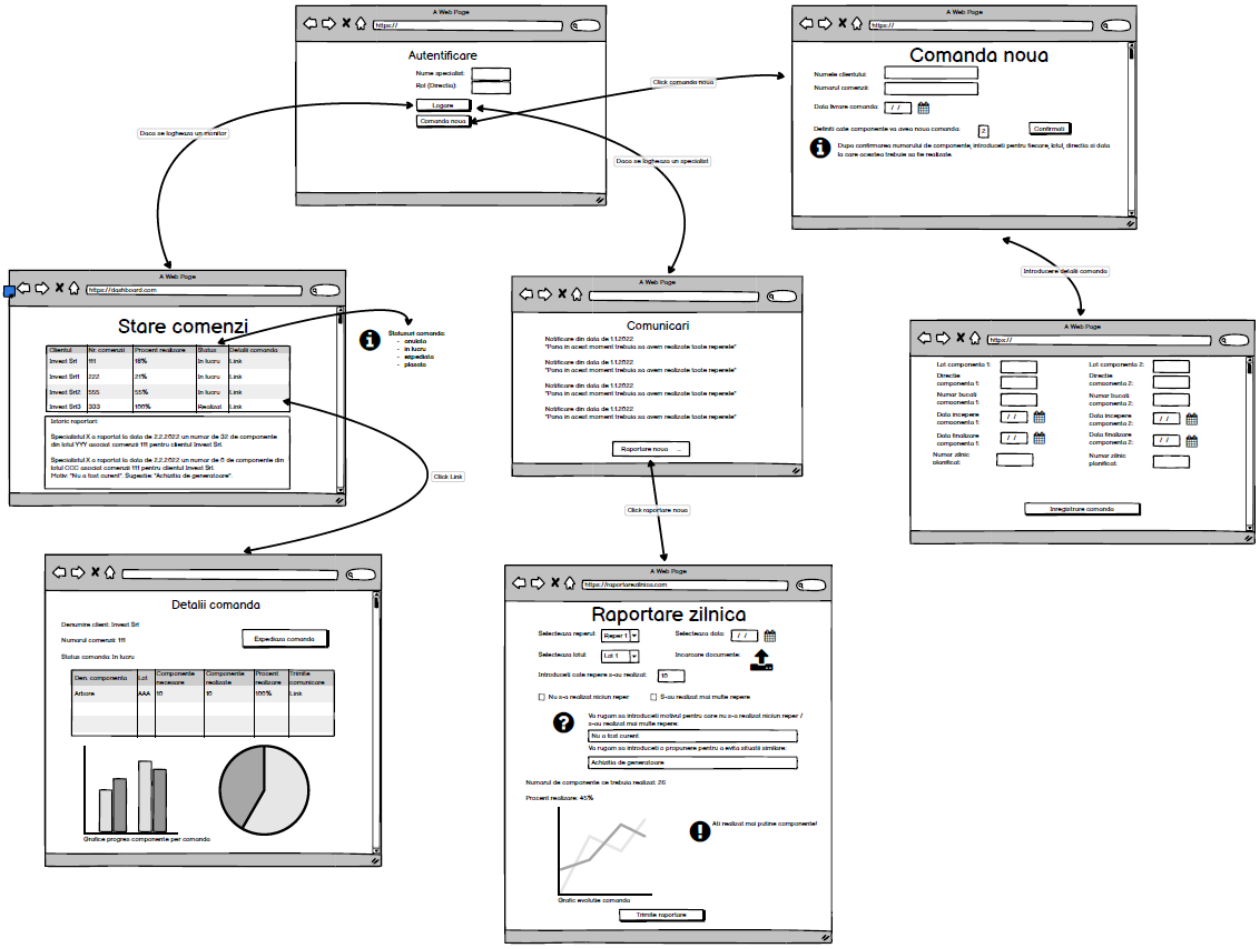

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Figure.4.2. Sketch screens

5. Conclusions

In conclusion, a computer system for tracking manufacturing batches contributes to the realization of batches in an optimal time, offers the possibility of placing an order in a detailed way, thus ensuring the quantity of each batch and whose department corresponds to the realization of the product. It also provides an overview of the processes performed in all departments and provides useful cumulative statistics to determine work capacity.

6. Bibliography

[1]. ***What is Microsoft's Blazor Web Framework, and Should You Use It?, Howtogeek.
https://www.howtogeek.com/devops/what-is-microsofts-blazor-web-framework-and-should-you-use-it/
[2]. ***C sharp, Wikipedia.
https://ro.m.wikipedia.org/wiki/C_sharp
[3]. ***HTML(Hypertext Markup Language), Theserverside.
https://www.theserverside.com/definition/HTML-Hypertext-Markup-Language
[4]. ***Producție in loturi, Wikipedia.
https://en.wikipedia.org/wiki/Batch_production
[5]. ***Managementul Operational al Productiei, Scribd.
https://www.scribd.com/document/142028831/Managementul-Operational-Al-Productiei

RESEARCH ON THE CONSTRUCTION AND DEVELOPMENT OF AN AUTOMATION PROTOTYPE FOR A CATTLE FARM

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SUMMARY: With the evolution of technology, more and more farmers use automated systems for their business, because they are much more efficient in terms of time and resources, thus considerably increasing production capacity.
The paper aims to make a functional prototype of a cattle farm on a much smaller scale, using components for hobby projects. In this paper I wanted to highlight the operation of three of the important systems in a farm, these being: ventilation, evacuation of manure from the alley, and watering.

KEY WORDS: farm, cattle, ventilation, watering, evacuation

1. Introduction

This research aimed to make a prototype of an automated cattle farm because more and more farmers want to automate their farms due to a lack of labor and to increase their production capacity.

For starters, the proposed prototype will have 3 automated systems: ventilation, manure evacuation, and watering.

In the animal shelters, the animals emit heat, humidity, carbon dioxide, and from manure and bedding, they emit ammonia, hydrogen sulfide, and strong odors, to which is added the dust from the handling of fodder or bedding. If all these noxious substances are not eliminated, concentrations of harmful, foul-smelling gases appear in the shelters, which, exceeding a certain limit, result in reduced growth spurts, decreased animal production, and even animal disease.

The environment must be dry, free of drafts, and well ventilated inside the shelter. At temperatures above about + 25 ° C, cattle reduce their feed consumption as well as milk production and/or weight gain. The most unfavorable conditions result when there is a combination of high temperatures, a high level of humidity (> 80%), and low air exchange. To avoid heat stress, it is necessary to pay special attention to the animals when the temperature exceeds + 20 ° C.

Thus for this prototype, we monitored the temperature in the room, and when the temperature exceeds the value of + 20 ° C the natural ventilation takes place by opening the shutter, but if the temperature rises above the value of + 25 ° C the fan will start while the shutter is opened to reduce the temperature below + 20 ° C.

At the same time, to encourage cattle to go to the feed area on very hot days, we will use a spray cooling system, because the best quick cooling solution is obtained by combining water sprayers with fans. Thus, when it is detected present in the feed area, water will be sprayed through the nozzles located in the upper part.

The next system is the manure cleaner, which is made with a scraper plug located in the back of the speakers, and it cleans the alley once every 2 minutes.

The last system proposed for this prototype is the one to be adapted.

Daily water requirements for cattle are influenced by air temperature, feed content, and milk production. Dairy cattle usually consume 30-100 liters in 24 hours. The watering rate for dairy cattle is 10 to 20 liters per minute if the water surface is free. They prefer water with a temperature of 15 - 20 ° C, which positively influences milk production.

Therefore for this prototype, we will use a tank fed from an external source in which the water temperature will be measured and will be brought to a value of 17 ° C, and then it will be distributed to the special drinkers whenever they have the level of water below 5 cm.

2. The current stage

For some time now, we have been witnessing a real revolution of robots in agriculture worldwide, and Romania taking quite big steps in this direction. The first steps in the field of agricultural robots in Romania, which ended with visible results, with the appearance of the robot "Banat", were made by a team of students from the University of Agricultural Sciences and Veterinary Medicine of Banat in Timisoara and the Polytechnic University of Timișoara. And the estimates are quite optimistic: in about five decades, every rural household will be supported by agricultural robots.

In Timiş County, the first dairy cattle farm in the west of the country has been operating since 2020, where robots do almost everything, from milking to cleaning and pushing feed. In addition to the construction of the new stable, with a manure tank located under the traffic alleys in the animal shelter, was also purchased an automated milking system Lely Astronaut, a 3,000-liter milk cooling tank, a feeding system with robot automatic feed pushing, automatic robot manure cleaning system, a Lely Luna cattle brush, a tractor and a front loader, as well as a vacuum.

However, the largest project of this type, in our country, is the one in Hunedoara County. A cattle farm with a population of 3,680 heads, daily production of 55,000 liters of milk, and a milking plant unique in the country by its size. At the Locator Agrar farm in Vadei village, Hunedoara county, the cattle are milked at a rotating installation with 72 seats (Fig.1).

Fig. 1. Rotary milking machine

3. System’s structure

The preliminary general structure of the stand is highlighted in Figure 2. It shows the 3 types of connections between the main components, mechanical, electrical, and data connections.

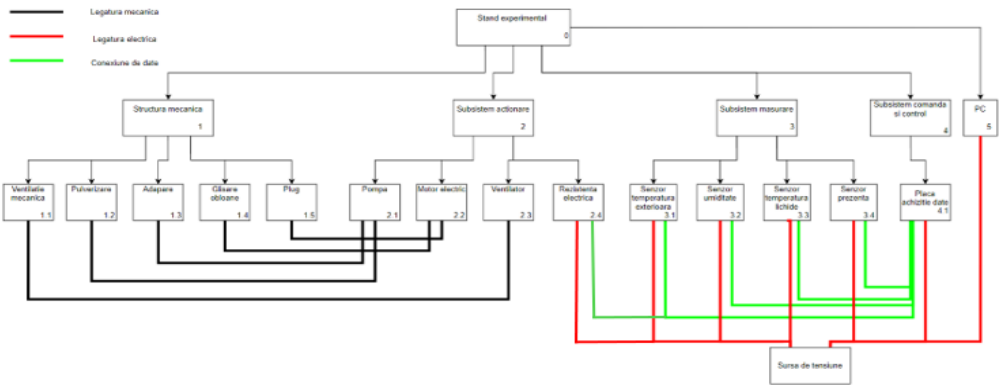

Fig. 2. General stand structure

For this prototype, we used a 12V and 10A source (fig. 3) to supply the components that needed this voltage. At the same time, with this source and with a lowering voltage module (fig. 4), we also supplied all the sensors with a voltage of 5V through a breadboard.

Fig. 3. 12V 10A Switching Voltage Source (120W)

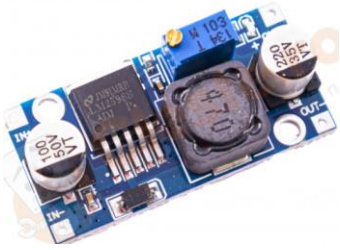

Fig. 4. LM2596 voltage drop mode

The data is collected with the help of two data acquisition boards compatible with Arduino UNO (fig. 5), and the orders are also given through this board.

Fig. 5. Arduino compatible UNO R3 development board

The programs used to read the sensors and control the motors are: Arduino and Labview MakerHub.

For the ventilation system we used a temperature and humidity sensor (fig.6) with which we took the data from the room and decided whether to start the ventilation or not.

Mechanical ventilation is performed by means of a fan (fig. 7) which is supplied with 12V, and with the help of a relay commands can be transmitted from the board to the fan.

Fig. 6. DHT22 temperature and humidity sensor

Fig. 7. PC fan, LHR Super fan, 80X80X25mm

Natural ventilation is achieved by opening the shutter, and for this, a servo motor was used that can rotate 360º (fig. 8), and can be controlled directly from the plate. And to have control over the shutter and to be sure that it is completely open or closed, I used 2 microswitches (fig.9).

Fig. 8. Motor Servo 360 12kg

Fig. 9. Mini switch (microswitch)

The values transmitted by the temperature sensor are read, using the second plate in the series, to be able to decide whether ventilation is needed or not. Also, it is checked if the window is open or closed at the beginning. Thus, if the temperature rises above 20 ºC, the shutter will open, sending the pulse value 1750 to the Servo motor, as long as the switch at the top is not pressed, and when it is actuated it means that the shutter is fully open and the motor must stop, thus receiving the value 1500. When the temperature drops below 20 ºC, the motor will rotate in the opposite direction, receiving the value 1300 until the switch at the bottom will operate. At the same time, if the temperature does not drop and is higher than 25 ºC, the fan will start at the same time.

For spray cooling, we used an ultrasonic presence sensor (fig. 10) to be able to spray water only when it detects the presence in that area. The water in this installation is distributed directly from the tank using a pump of the type shown in figure 11, also controlled from the plate, using a relay. And it is sprayed through a nozzle (fig. 12).

Fig. 10. HC-SR04 ultrasonic sensor

Fig. 11. 12V water pump

Fig. 12. Spray nozzle

Figure 13 shows the subprogram implemented in Labview for ventilation.

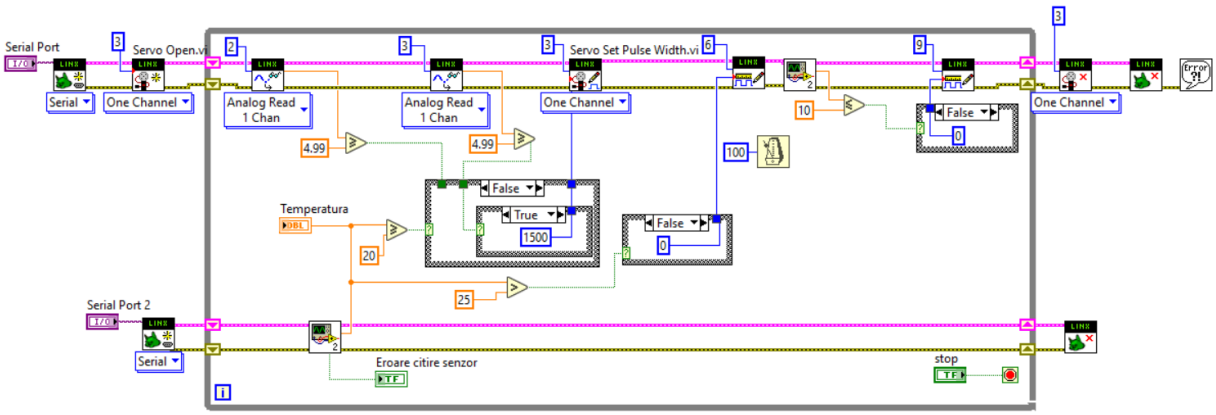

Fig. 13. Ventilation subprogram

The evacuation of manure on the main alley behind the pits was also done with the help of a servo motor, identical to the previous one, which drives a chain and 2 microswitches for the end of the stroke. The subroutine for this system is shown in Figure 14. This checks where the original plow is, and if it is not at the starting point, it is brought to that position. Furthermore, the plow is operated by pressing a Play button, to have control over it, and in case of a problem, it can be stopped quickly by pressing a button. Once the start button is pressed, the plow will perform a forward and backward movement every 2 minutes. Thus, it starts from point A, reaches point B, waits for a second, returns to point A, waits 2 minutes, and resumes the cycle.

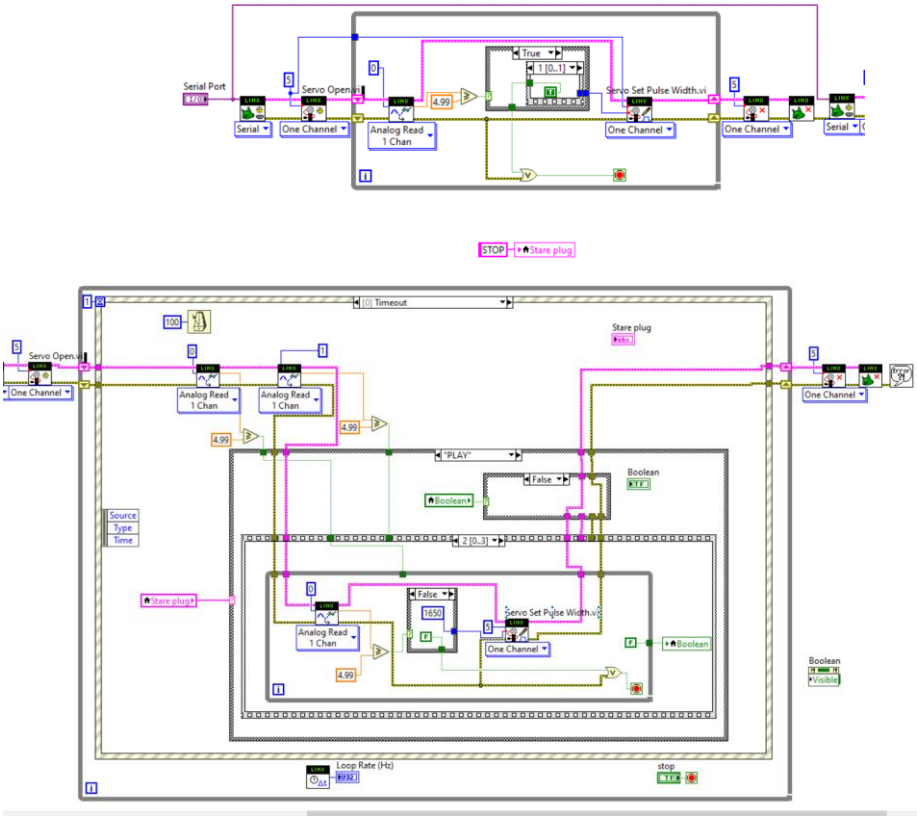

Fig. 14. Manure evacuation subprogram

The watering system consists of a tank, which is based on the 2 pumps for spraying and watering, in which there is a temperature sensor (fig. 15) and a heater (fig. 16). Thus, the water temperature is checked, and if it is below the value of 17 ºC, with the help of the plate and a relay, the heater is ordered and the water is brought to the desired temperature. After the water temperature reaches the preset value, the water is distributed in the installation using a pump identical to the one above. There is a water level sensor in the adapter (fig. 17) that constantly monitors how much water is in it. Therefore, as much water as needed is distributed in that waterer.

Fig. 15. DS18B20 temperature sensor

Fig. 16. Lansenfish LS-100W aquarium heater

Fig. 17. Water level sensor

The subprogram for this system is shown in Figure 18.

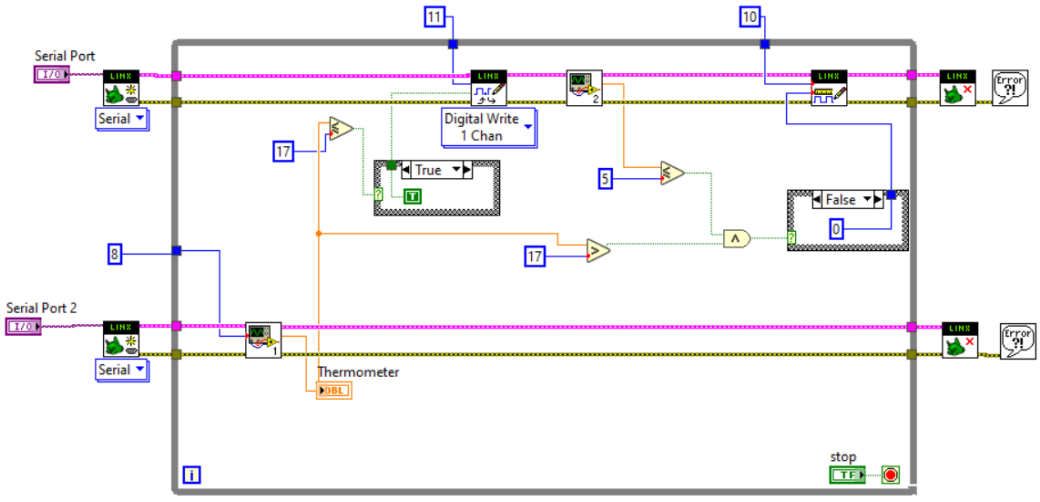

Fig. 18. Watering subprogram

4. Conclusion

In this paper, a functional automation prototype was made for a farm using much smaller scale components and various other common components to exemplify how it works.

In the future, other automated systems can be added to increase productivity as much as possible, and at the same time, an application with which to constantly monitor important parameters on the farm to have much more control over unforeseen events that may occur would be very effective.

5. Bibliography

[1]. https://www.revista-ferma.ro/articole/zootehnie/ferma-de-vaci-robotizata
[2]. https://www.revista-ferma.ro/articole/zootehnie/veri-racoroase-in-adapost-cu-sistemele-delaval
[3].https://portal.afir.info/Uploads/GHIDUL%20Solicitantului/PNDR2020/Standarde_de_ferma/Vaci%20vol%201_by%20EC_WEB.pdf
[4]. https://www.revista-ferma.ro/articole/masini-agricole/sisteme-de-climatizare-si-de-ventilare-in-ferme

CALCULATION OF CUTTING FORCES FOR THE HOLE DRILL MANUFACTURING PROCESS

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ABSTRACT: Technological processes are constantly evolving due to the efforts of engineers who analyze, optimize and improve on a well-established computational algorithm. These efforts, supported by a theoretical basis and multiple experimental trials, can give rise to new, much more efficient algorithms, which can bring a considerable advance to the industry.

KEY WORDS: drill, algorithm, technological process, machining

1. Introduction

In any technological process we find different manufacturing processes. These have the role of modifying the properties of the material or semi-finished product. However, throughout history, the efforts and calculations of mathematicians and engineers have made it possible, by supporting technological advancement, the leap from the rudimentary abrasive stone to the automatic lathes and machine tools that we know today.

The cutting process is a processing process that consists in the action of a cutting tool on a semi-finished product, removing from its surface, in the form of chips, the excess material in order to obtain the designed shape and size. [1] Drilling (or drilling) is the cutting process by which holes (bores) in solid material are obtained, and the process can be performed on boring machines or lathes. This is the only method of full bore processing.

This paper focuses on the design of a computer application that helps to automate the calculation of cutting forces in the process of processing through drills, trying to optimize them on the principle of economic processing. In general, the choice of a machine tool suitable for drilling is done by analyzing the possibilities of the machine compared to the needs of the part. The main factors influencing this decision are:

- device's weight and size and part weight and size;
- the diameters and the depth of the holes (in the case of drilling , the initial diameter of the hole will always be zero, because the processing is creating a bore in a solid material);
- the required machining accuracy;
- the number of holes machined in a single clamp;
- the number of tools used for each hole;
- machine power;
- axial force, required speeds and advances, depending on the hole. [2]

These aspects are determined in advance according to the technical specifications of the chosen machine tool and are entered manually in the computer applications. To develop the algorithm and the application we need to understand the parameters involved in the cutting regime. In the process of machining a hole, the cutting edge of the tool must undergo a (main) rotational movement during the formation of the chips and a rectilinear (advance) movement to ensure the detachment of new layers of material. [3]

The speed of the main movement is determined as such:

$$v_p = \frac{\pi D n}{1000} \text{ [m/min]} \quad (1)$$

where:
D – drill diameter [mm]; n – drill RPM [rot/min]. [3]

The speed of the forward movement is calculated as follows:

$$v_a = n \times s \text{ [mm/min]} \quad (2)$$

where:
n - drill RPM [rot/min]; s – advance [mm/rot]. [3]

Another important parameter is the advance of the drill, which can be calculated using the formula:

$$s = C_s \times D^{0,7} \quad (3)$$

where:
Cs – coefficient that takes into account the processed material; D – drill diameter [mm]. [3]

Cs values are canonical tabulated values, which will be entered manually in the computer application. Another important parameter is the depth of cut. It's formula can be found below:

$$T = \frac{D-d}{2} \quad (4)$$

where:
D – final hole diameter [mm]; d – initial hole diameter [mm]. [3]

In the case studied, namely considering the optimization in economic regime, the cutting speed for drills has the following formula:

$$v = \frac{C_v \times D^{Z_v} \times k_{v_p}}{T^m \times t^{x_v} \times s^{y_v}} \quad (5)$$

where:
Cv – speed coefficient ; D – drill diameter [mm]; zv – diameter exponent ; Kvp – speed correction coefficient; T – tool durability [minute]; m – durability exponent; s – advance [mm/rot];
xv – advance exponent; t –depth of cut [mm]; yv – depth of cut exponent. [3]

The values of durability, coefficients and exponents will be entered manually in the computer application depending on the parameters. In the drilling process, the cutting force is perpendicular to the surface of the material. Therefore, axial force on drills has the following formula:

$$F = C_F \times D^{x_F} \times f^{y_F} \times K_F \text{ [N]} \quad (6)$$

in which the constants, exponents and correction coefficients are determined experimentally, for specific cutting cases. [4]

2. Current stage

In the initial phase, a LabView application (Laboratory Virtual Instrument Engineering Workbench) [5] was developed to test the cutting force measurement algorithm. The application displays, as a percentage, and locally measures the compressive force exerted by a compactor (with the role of simulating the cutting force at the drill) on a force cell type sensor. In order to allow the reading and processing of data, the use of an Arduino Mega type acquisition board was chosen, and for making connections within the application, the LINX MakerHub module was used [6]. The force cell, assembled in the experimental stand on two designed support plates, is connected to its pins.

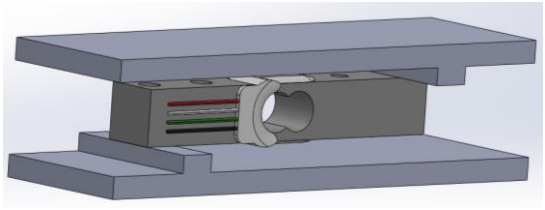

Fig. 1. Power cell mounting assembly

The Microsoft Office suite, more precisely Microsoft Excel, a spreadsheet program, was used to test the calculation algorithm. [7] This test medium was chosen because of the ability of the program to automatically calculate certain values based on certain parameters entered individually. In a spreadsheet, the formulas of the parameters of the cutting regime were introduced and adapted, the application displaying, depending on the specifications of the machine tool and the material introduced by the human operator, the minimum theoretical values necessary for the drilling process.

3. Simulation and testing

An experimental stand consisting of the following components was made to test the operation and correctness of the force measurement application:

- power source;
- drive motor BTS7960;
- strain gauge TAL220B;
- Arduino Mega pcb;
- 12 V motor;
- compactor (simulates drill forces);
- laptop.

These connected components form a test system, and the connections between them are illustrated in the principle diagram of the stand in Figure 2.

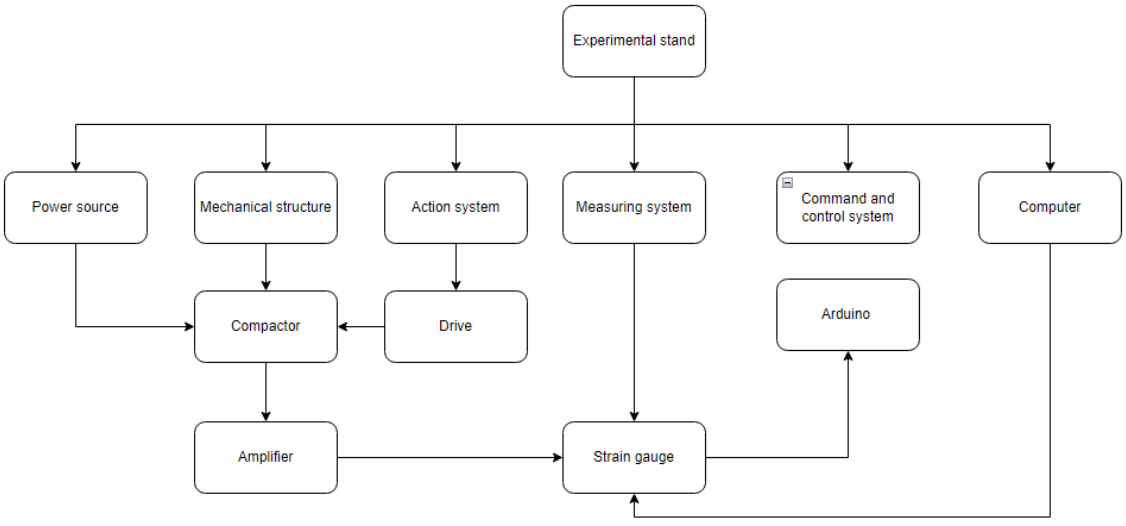

Fig. 2. Schematic diagram of the experimental stand

In the LabView power measurement application, the measurement process is initialized through the LINX Open function, which establishes the connection between the application and the Arduino board through the COM3 port of the laptop. The LINX Analog Read function is used to read the signal, and the LINX Digital Write function is called for speed control. Thus, by linking the value read by the sensor [8],

multiplied by 20 to find out the percentage, at a Vertical Progress Bar, we can display the percentage of pressure of the sensor. Subsequently, it is connected to 2 LED indicators that indicate at what stage of the process we are: pressing / compacting, respectively returning to the initial position. In case of sensor overload, the application automatically changes the direction of the motor, which switches the compactor to return to the initial position. A Switch button can be pressed in the front panel of the application to initiate the compaction process. The engine speed is also manually entered into this panel, just before the start button is pressed. The application also has a stop button, which once pressed stops the application operation and engine operation.

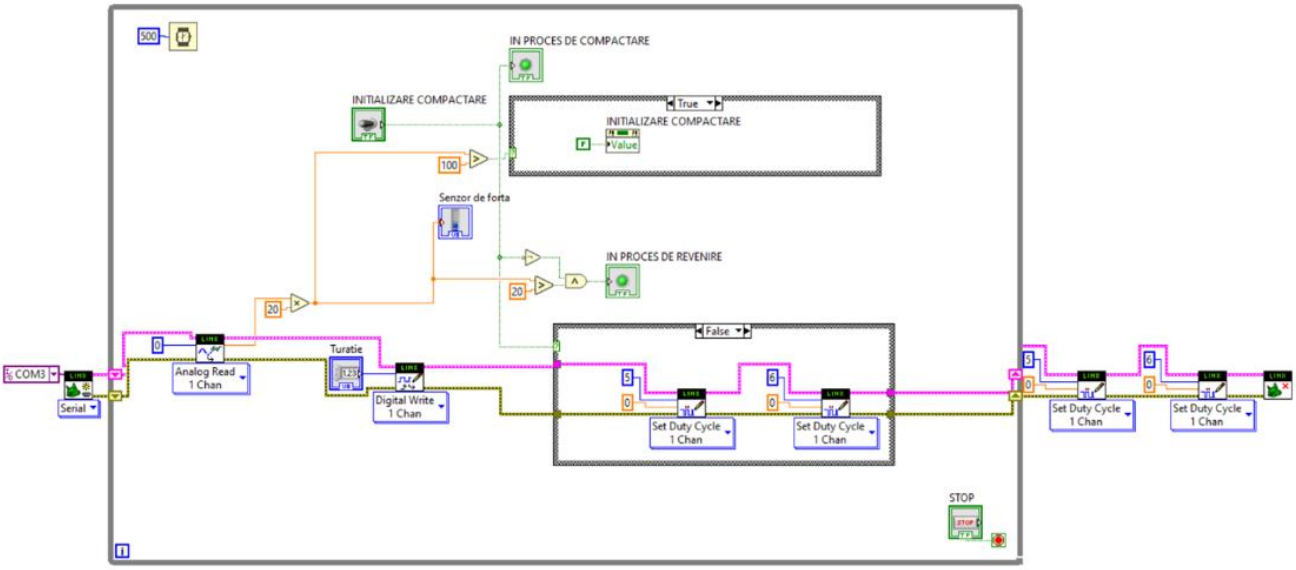

Fig. 3. Program's block diagram

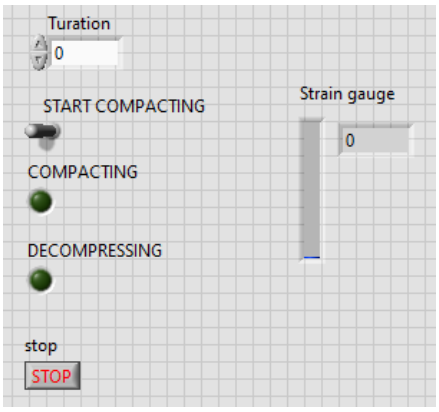

Fig. 4. Program's front panel

The Excel spreadsheet has introduced and adapted the calculation parameters of the cutting parameters. [9] The operator will enter the drill speed and diameter, and then select the hole size and material from the predefined list. The program automatically takes the tabular data of the coefficients specific to the entered parameters and calculates the theoretical values of the main parameters of the drilling process.

Parameters	Values	
Material specific Brinell hardness (HB)	160	
Cs coefficient	0.085	
Drill diameter	8	
Drill turation	20	
Hole diameter	8	
Material	Steel	
Cutting speed	0.5024	[m/min]
Depth of cut	4	
Advance	0.36	
Advance speed	7.29	[mm/min]
Axial force during drilling	3.097144111	[kgf]

Fig. 5. Calculation of parameters

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=(P10*((C4)^P12)*P8)/((R3)^P11)*((C10)^P13)*((C12)^P14)
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Fig. 6. Model for adapting the formula for calculating the axial force to drills

4. Conclusions and further developments

The applications have been developed as test environments for the future computer application that will include both components: measurement and calculation. Their operation is an important step towards solving the proposed problem, namely to optimize the parameters of the drilling process.

The theoretical calculation process presents a basis for the development of an optimization algorithm according to a certain principle, such as: minimum energy consumption; of the minimum cutting force (which ensures the avoidance of excessive deformations); of optimizing the drill path on the part (if more holes are made) and others.

This will be done by adjusting the parameters and adapting the canonical formulas so as to arrive at a set of optimal parameters for the machine tool used in the case of processing a specific blank. The algorithm can be tested at the University, but the application can be developed to be used on a larger scale. This makes it easier to take into account the technical specifications of the various machine tools available in a factory by comparing the calculated data with their catalogs, resulting in an increase in productivity without increasing the cost of production.

In the following period, we will look for a way to integrate the two applications, but also to adjust the algorithm in order to more efficiently calculate the minimum axial force required for drilling certain semi-finished products, as the ultimate goal to reach a more efficient processing process..

5. Bibliography

[1].http://softeducationalmecanica.blogspot.com/2012/01/importanta-prelucrarilot-prin-aschiere.html

[2]. Ing. Dragoş Simionescu şi Ing. Ion Munteanu (1961), „Dispozitive pentru maşini unelte”, Editura Tehnică , Bucureşti;

[3]. Teodor,V. (2008), „Bazele proceselor de prelucrare prin aşchiere”,Universitatea „Dunărea de Jos”,Galaţi;

[4]. Croitoru C. , Mihailde M. (2000) . „Îndrumar practic pentru calculul teoretic al forțelor de așchiere”, Universitatea Tehnică “Gheorghe Asachi”,Iaşi;

[5]. https://en.wikipedia.org/wiki/LabVIEW

[6]. https://www.labviewmakerhub.com/doku.php?id=libraries:linx:start

[7]. https://en.wikipedia.org/wiki/Microsoft_Excel

[8].https://www.sites.google.com/view/masurareculabview/4-senzori/4-4-m%C4%83surarea-deforma%C8%9Biilor-cu-m%C4%83rci-tensometrice

[9].https://support.microsoft.com/en-us/office/overview-of-formulas-in-excel-ecfdc708-9162-49e8-b993-c311f47ca173

RESEARCH ON THE DESIGN AND IMPLEMENTATION OF AN EXPERIMENTAL MODEL OF A MOBILE SYSTEM FOR ACOUSTIC SCANNING OF AN ENCLOSURE

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ABSTRACT: This paper aims to familiarize the reader with mobile robots, namely line follower robots (the principle of operation and their control part), as well as the acoustic measurement part (the norm that imposes the rules for measurement and the theoretical part behind unit / method of measurement used).

KEYWORDS: line follower,PWM,noise level;

1. Introduction

The basic idea is that on a mobile system we have attached a device with which we will determine the acoustic power of a landmark positioned in a predetermined area.

In our case, the mobile system is represented by a mobile robot, and the device for acoustic measurement will be a sound sensor with a high sensitivity.

"Mobile robots are robots that are capable to navigate in their environment with the help of sensors and software. To do this, mobile robots must have energy and information autonomy. Informational autonomy refers to the robot's ability to perform the task for which it was programmed, being able to make decisions in extreme situations. The easiest way to navigate a mobile robot is to follow the line (line follower robots)". [1]

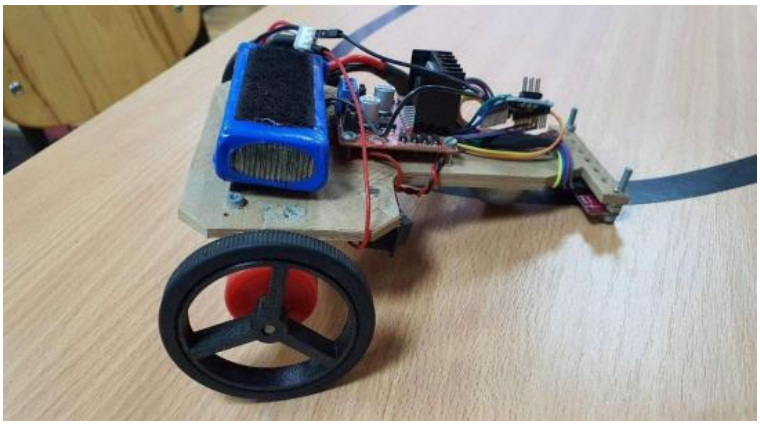


Fig 1 Line follower type robot [1]

Principle of operation of the line follower robot:

"Infrared sensors are used to position and hold the robot on the line, which are based on the property of dark materials to absorb more infrared light than light ones.

The sensor has an infrared light emitter that generates a light wave to the tread. The wave hits the surface on which the robot moves and depending on the material and color encountered, the wave is absorbed more or less.

Then where it is reflected by the work surface and returns to the receiver the sensor that measures the degree of absorption of the wave. If the degree of absorption is low it means that the wave has encountered a light-colored surface and if the degree of absorption is high it means that the generated wave encountered a dark surface. Based on this principle, the sensor can send a signal to the microcontroller which interprets whether the robot is above the tracking line or not.

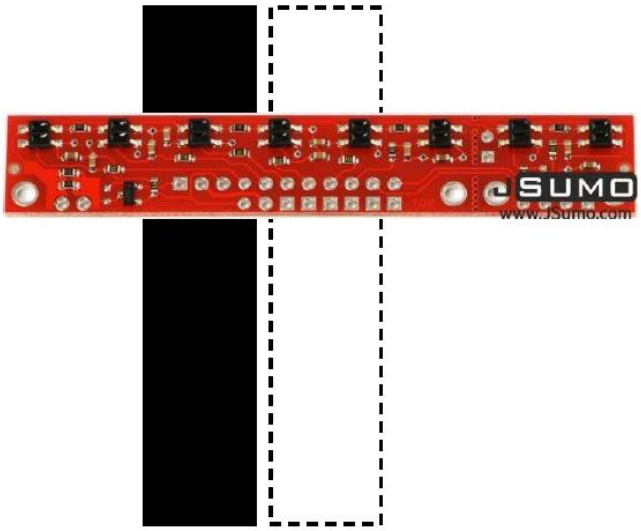


Fig 2 Reading the sensors and interpreting the position of the robot[1]

After reading the sensors, the program continues with the calculation of the correction on the robot's position,so that if the line moves left or right, the robot will vary the speed on one of the motors to return the robot to the center position.

Varying the motor supply voltage can change the shaft speed and the speed of the robot. The ability to change the speed of each crankshaft is required for the mobile robot to make turns.

For example, a lower speed on one of the wheels will cause the robot to turn in that direction.

Fig 3 Trail of line follower robot [1]

The method of varying the average supplied voltage of a DC motor is via a PWM (Pulse Width Modulation) signal. This is a rectangular, constant frequency signal at which the filling factor can vary. Specifically, it changes the time the signal has a maximum value (if the range is 0-5V then the maximum value is 5V) over a period of time, depending on the frequency of the signal.

This type of signal is often used for command and control applications and is easily generated by microcontrollers. ” [1]

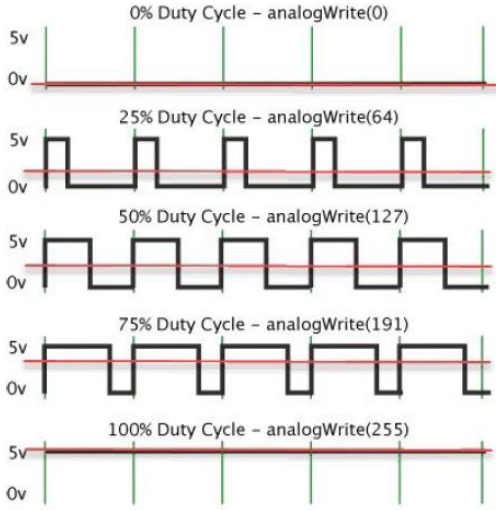


Fig 4 Voltage variation depending on the fill factor of a PWM signal [1]

For the acoustic scanning part we will use a high sensitivity sound sensor to measure the acoustic power level (in decibels).

"The original definition of the decibel is based on the power ratio

$$L_P = 10 \lg \frac{P}{P_{ref}} (\text{dB}) \qquad (1)$$

$P_{ref} = 10^{-12}$ w is the reference power and P is the acoustic power of the source.

The acoustic power of a source is obtained by integrating the acoustic intensity on any closed surface S around the source

$$P = \int_S I_n \cdot dS \qquad (2)$$

The intensity of normal component must be measured in a direction perpendicular to the dS area element.

If a spherical surface is chosen, then the acoustic power of an omnidirectional monopoly source ($I_n = I = ct$) becomes

$$P_m = 4\pi r^2 I \; ; \; P_m = \frac{p_{rms}^2}{\rho c} 4\pi r^2 \qquad (3)$$

The last relation is transcribed to

$$P_m = \frac{p_{rms}^2}{Q\rho c} 4\pi r^2 \qquad (4)$$

in which the directivity factor was noted with Q. This factor takes the values 1,2,4,8 as the source is placed in the air, on a rigid floor, on the edge between two rigid surfaces, respectively in the corner of a room, at the intersection of three walls. " [2]

The response given by the sensor is transmitted to the microcontroller, this being a voltage analog response, and for displaying the results in decibels we will use the formula provided by the manufacturer in the technical data sheet of the sensor.

The role of this experiment is to observe if the measured benchmarks correspond to the current standards and if the values given by the manufacturers are true.

2.The current stage

"NOISE LEVEL - In the context of this standard, abbreviated name for "ACOUSTIC PRESSURE LEVEL", Lp, expressed in dB, dB (A) or Cz curve number.

- dB is a unit of measurement for characterizing noise physically. Its spectrum is used to define a noise; values - in 1/1 or 1/3 octave frequency bands - are given in dB.
- dB (A) is a unit of measurement for the characterization of noise from a physiological point of view (weighting on the weighting curve A takes into account the perception of the human ear). In specific cases, weighted levels in frequency bands are useful.
- The number of the Cz curve is the value in dB at 1000 Hz of the sound pressure level curve that cannot be exceeded at any point in the spectrum.

In the case of expression of the noise level in dB (A), the measurement is made using an electro-acoustic system that weights the components on noise frequencies, similar to the response of the human ear. The A-weighting curve, originally set for noise levels below 55 dB, is generally accepted today for measurements in the context of noise protection. "[3]

"Measuring sound pressure levels:

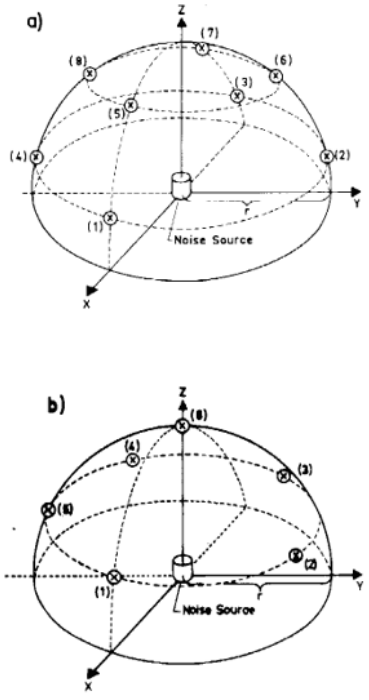
- a parallelepiped reference surface is defined; the dimensions of the reference parallelepiped shall be calculated as the minimum parallelepiped containing the apparatus being tested; constructive elements of the device which are not significant acoustic emitters but which will be mentioned in the test report may be neglected; calculate the characteristic size of the source d0 according to the dimensions of the reference parallelepiped and the location of the device (in the center of the horizontal plane, near a wall or at the corner);

- the shape of the measuring surface (on which the microphones will be placed) and the number and positions of the microphone placement points are established, taking into account the shape of the measuring surface and the location of the device; measuring surface that can be used are:

-parallelipipedic; recommended for normally mounted sources and / or to be measured in unfavorable acoustic rooms or spaces (eg many reflective objects and high background noise levels), at which the measuring distance must be small; the distance between the parallelepiped reference surface and the measuring surface is recommended to be 1m, but not less than 0.25m (possible values: 0.25, 0.5, 1, 2, 4 or 8m);

-hemispherical; it is recommended for sources usually mounted and / or to be measured in large open spaces, with favorable acoustic conditions, at which the measuring distance is recommended to be large; the radius of the hemispherical surface must be equal to or greater than twice the characteristic distance of the source but not less than 1m (possible values: 1, 2, 4, 8, 10, 12, 14 or 16m);

- the area of the measuring surface is calculated;



Micr. Pos	X	Y	Z
(1)	0.97r	0	0.25r
(2)	0	0.97r	0.25r
(3)	-0.97r	0	0.25r
(4)	0	-0.97r	0.25r
(5)	0.63r	0	0.78r
(6)	0	0.63r	0.78r
(7)	-0.63r	0	0.78r
(8)	0	-0.63r	0.78r

r= Radius of Hemisphere

⊗ = Microphone Positions

Micr. Pos.	X	Y	Z
(1)	0.89r	0	0.45r
(2)	0.28r	0.85r	0.45r
(3)	-0.72r	0.53r	0.45r
(4)	-0.72r	-0.53r	0.45r
(5)	0.28	-0.85r	0.45r
(6)	0	0	r

Fig 5 Distribution of measuring points on a hemisphere

No.	x	y	z
1	a	0	$0{,}5c$
2	0	b	$0{,}5c$
3	$-a$	0	$0{,}5c$
4	0	$-b$	$0{,}5c$
5	a	b	c
6	$-a$	b	c
7	$-a$	$-b$	c
8	a	$-b$	c
9	0	0	c

$$S = 2(2bc + 2ac + 2ab)$$

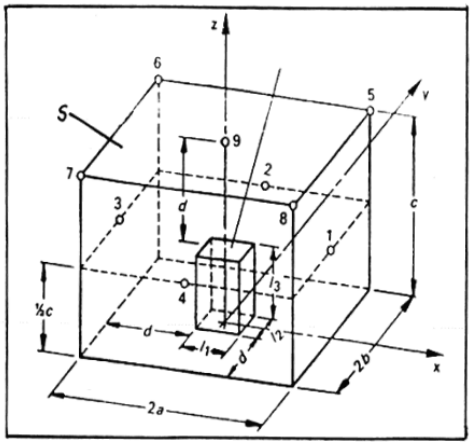


Figure 6 Distribution of sound pressure level measurement points on a parallelepiped surface (9 points) **[2]**

- before each series of measurements, the device for stabilizing the operating conditions is put into operation;

-the appliance will be tested in normal operation; if in operation it goes through several operating cycles, the testing for all cycles will be done and all these values will be noted; in practice, testing at multiple regimes will be avoided, applying only if the cyclic operation is the

basis for the equipment to perform the tasks for which it is designed; priority must be given to simple regimes that ensure satisfactory repeatability and reproducibility of measurements;

- the sound pressure level is measured for each position of the microphone locations at a time-mediated level over the typical period of operation of the source, both in octave or one-third octave bands and as an A-weighted global level (if there are a number of microphones available equal to the number of measuring points, simultaneous measurement at all points is recommended, and if the number of available microphones is less than the number of measuring points, it is acceptable to move the microphone (s) to the points where no measurements and resumption of testing have been performed, the number of measurements must be kept to a minimum, as large errors may occur in determining the acoustic emission for non-stationary emission devices over time);"[4]

3. Conclusions

Since the way to determine the noise level is in a large proportion identical to the one used in the field, our contribution with this project is to significantly reduce cost because for acoustic determination we use a single measuring device and the orientation in the positions of measurement is performed by the mobile robot on a predetermined route, the input of human personnel will decrease.

Another benefit of this system its flexibility. To measure different landmarks it's enough to change the default route and a small adjustment of the code.

And last but not least, the system is easy to purchase. Being a modular system, the parts for it are easy to change with others from other manufacturers or with those available in the respective geographical area.

It does not have a high acquisition cost, and its assembly does not require expensive equipment.

4. Bibliography

[1]. Emil Ionut Nita (2021), Suport laborator SM

[2]. Constantin-Daniel Comeaga (2021), Suport curs CVAZ

[3]. Ministrul dezvoltării regionale şi turismului (2012), " Normativ privind acustica în construcţii şi zone urbane. Indicativ C 125–2012";

[4]. Constantin-Daniel Comeaga (2006), ,PROCEDURA PENTRU DETERMINAREA PUTERII ACUSTICE A SURSELOR DE ZGOMOT. METODĂ TEHNICĂ CU MĂSURAREA ÎN PUNCTE A PRESIUNII ACUSTICE*";*

RESEARCH ON THE CONSTRUCTION AND DEVELOPMENT OF A PICK AND PLACE ROBOT

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ABSTRACT: The introduction of automation into the industry can provide operational efficiencies and low costs in many areas of it but navigating the path form concept demonstration to successful expansion can be a complex task and can be challenging. The paper presented is the result of research conducted in order to develop an efficient and innovative palletizing system.

KEY WORDS: robotic arm, Arduino, Labview, palletizing, industry.

1. Introduction

The aim is to develop an experimental model of a pick and place robotic arm for handling and placing products. The system consists of an articulated robotic arm, a conveyor for transporting the products, a support for the products to be taken over by the effector and a storage shelf for the handled products.

The purpose of the entire system is to streamline the palletizing process.

2. The current stage

By definition, a robotic arm means a type of mechanical arm, usually programmable, that has functions similar to those of a human arm. Such an arm can stand on its own or be a part of a larger robot.

The connections for this type of mechanism are made through the joints, thus allowing the rotational movement (for the articulated robotic arms), or they move linearly, allowing the translational movement. It can be said that these arm connections form a kinematic chain. At the end of the manipulator is a final effector that is analogous to a human hand.

Pick and place robots are usually mounted on stable supports, positioned so that they reach different designated areas for work. They have integrated advanced vision systems to recognize, capture and move objects to different locations.

To make this paper, test and simulations were performed using the LabVIEW programming environment.

3. System’s structure

The main component of the test is the *NI 9237* module [1], which was used to calibrate a force cell. The module can be used in a wide range of applications at industrial level, such as applications for measurement, control and communications. This input module works using *NI-DAQmx* 8.1 or later software.

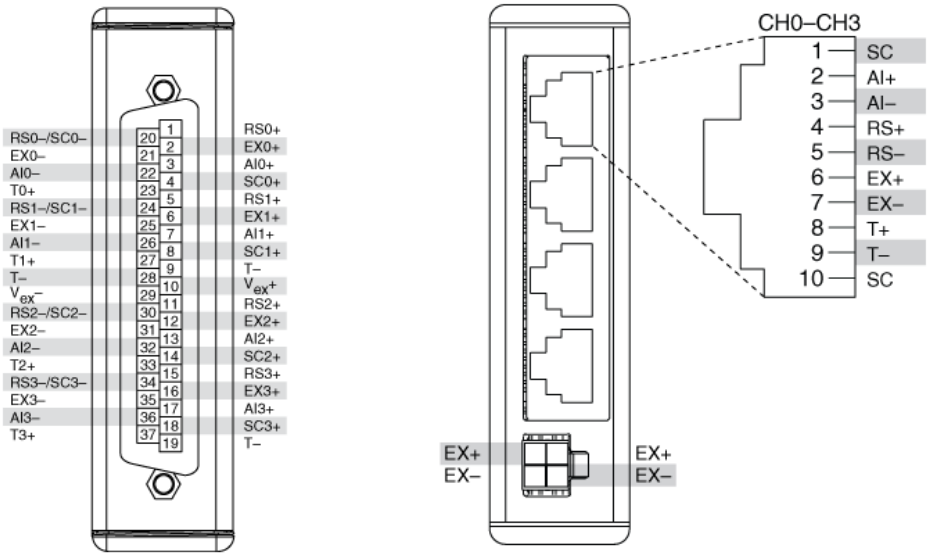

Fig. 1. NI 9237 module

Tehnical specifications:

- Resolution: 24 bit
- Connectivity: D-Sub or RJ-50
- Channels: 4
- Sample rate: 50kS/s
- Frequency: 12.8 MHz

Another component with which the movement was made is the *NEMA 23* stepper motor [2]. It is a hybrid bipolar stepper motor that is generally used in CNC machines, 3D printers, pick and place machines or linear actuators. This motor can be controlled by two H bridges, but it is recommended to use a stepper motor driver.

The first coil is formed with black and green wires, and the second coil is formed with red and blue wires.

Tehnical specifications:

- Voltage rating: 3.2V
- Current rating: 2.8A
- Step angle: 1.8°
- Steps per revolution: 200
- No. of phases: 2
- Holding torque: 19kg-cm
- Width: 56.4mm
- Length: 56.4mm
- Height: 76mm
- Shaft diameter: 3.8mm
- No. of leads: 4

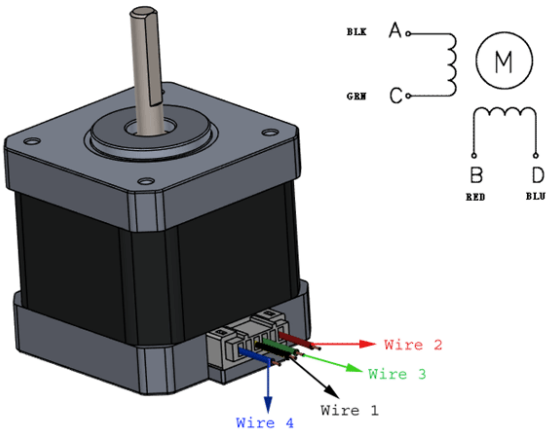

Fig.2. NEMA 23 stepper motor

Calibration was performed using a force cell [3]. This is basically a transducer that turns the force into a measurable electrical output.

A weight sensor works by converting mechanical force into digital values that the user can read and record.

The internal operation of such a sensor differs depending on its type. There are hydraulic, pneumatic or extensometer weight sensors. The ones with the extensometer are among the most used, and the extensometer inside such a sensor transmits voltage irregularities when under load.

Tehnical specifications:

- Maximum load: 1kg
- Excitation voltage: 5V (max 10V DC)
- Output signal: 1 ± 0.15mV/V
- Mounting holes: 4 x M4
- Weight: 27g
- Dimensions: 12.7mm x 12.7mm x 75mm
- Connectivity:
    - Excitation voltage + : red
    - Excitation voltage - : black
    - Signal + : green
    - Signal - : white

Fig.3 Force cell

For the data acquisition we used the Arduino Mega development board, based on the Atmega 2560 microcontroller. It has 54 digital input / output pins, 15 of which can be used as PWM outputs, 16

analog inputs, 4 UARTs (hardware serial ports), USB connection, 16 MHz crystal oscillator, power plug, header ICSP and reset button.

Fig. 4. Arduino Mega

Tehnical specifications:

- Operating voltage: 5V
- Input voltage: 7 – 9V
- DC current per I/O pin: 40mA
- DC current for 3.3V pin: 50mA
- Flash memory: 256KB
- Frequency: 16MHz

4. Development of the testing program

The purpose of this program is to start / stop the stepper motor depending on the mass applied to the force cell.

The first step in developing the program was to calibrate the force sensor using the *NI MAX* module of the LabVIEW program, by adding values of some masses.

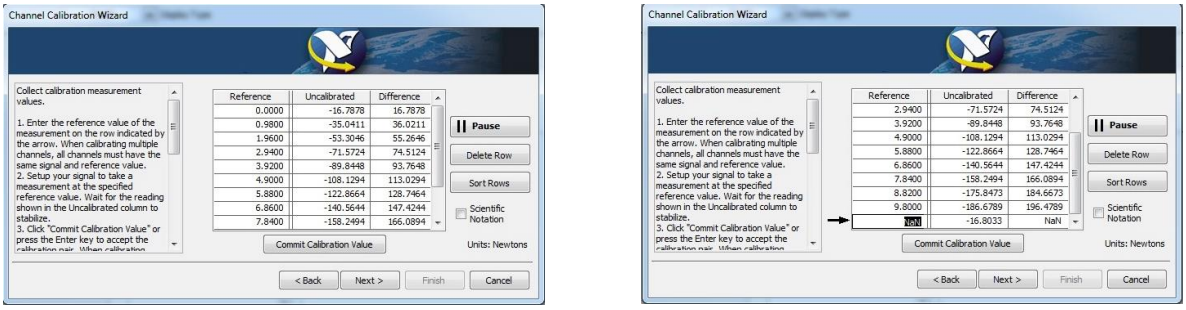

Fig. 5. Force sensor calibration

After this step, the actual programming is made in the LabVIEW software.

Reading and displaying of the mass applied to the force sensor is done through the functions in the *DAQmx* module.

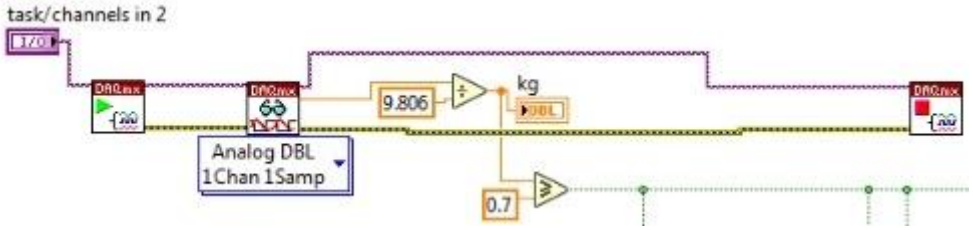

Fig. 6. Reading and displaying the mass

To manage the starting and stopping of the engine according to the mass applied to the sensor, we used the functions in the *Linx* module.

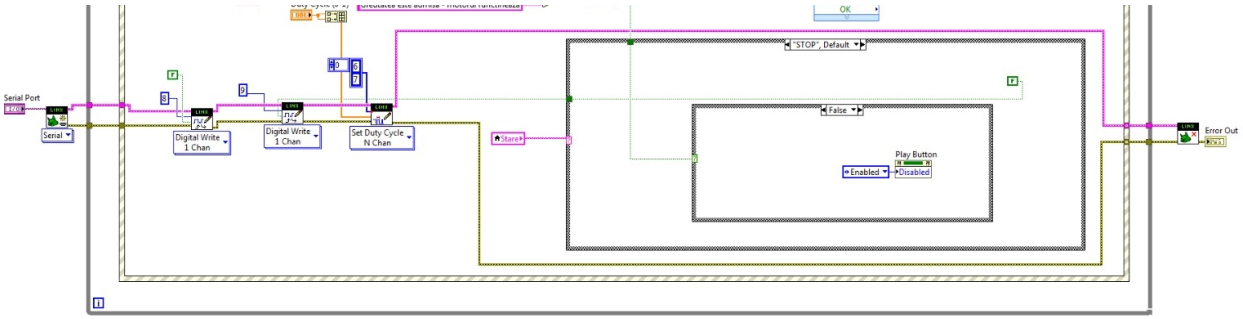

Fig. 7. Starting / stopping the motor

The motor has been connected to the Arduino Mega development board, and above you can see the pins on which the operting directions of the motor and the output of the PWM signal are given.

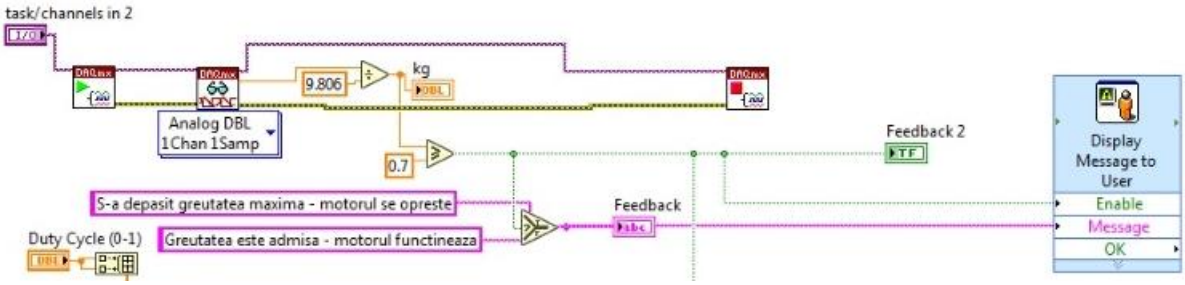

Fig. 8. Setting the start / stop condition

By setting the condition show in the figure above and the *Case structures* used, the engine starts if the mass is <=0.7kg and stops if it exceeds 0.7kg.

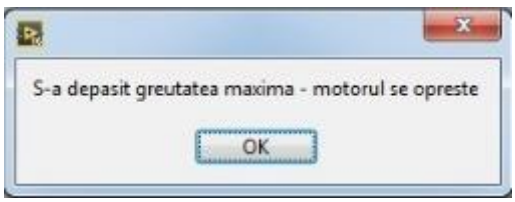

Fig. 9. Warning message

If the weight is not allowed, a warning message will also be displayed when the engine will stop. The full program is shown in the picture below:

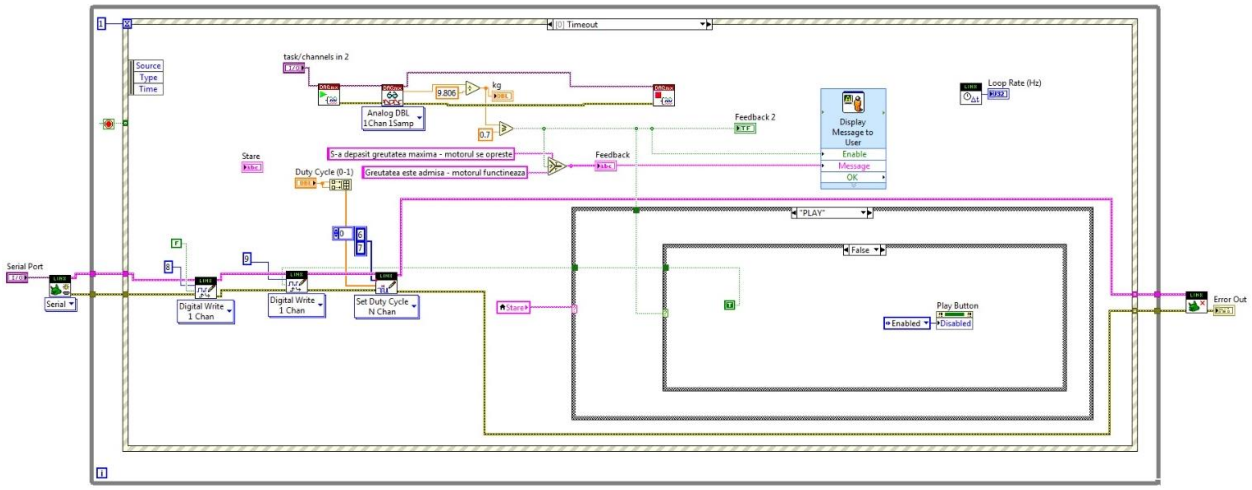

Fig. 10. Testing program

5. Conclusion

Through the research carried out on the basis of the sources specified in the paper, of the selected components and by carrying out the program necessary for the tests, we obtained a part of the system that will contribute to the automation of a pick and place robotic arm.

For future developments we have taken into account the simulation of the movement of the axes necessary for the palletizing process and the introduction of other sensors for a better accuracy of the movements.

6. Bibliography

[1]. https://www.ni.com/ro-ro/support/model.ni-9237.html
[2]. https://components101.com/motors/nema-23-stepper-motor-datasheet-specs
[3].https://ardushop.ro/ro/electronica/247-senzor-greutate-1kg.html?gclid=Cj0KCQjwl7qSBhD-ARIsACvV1X1kekDjmGI3aYiR8CLYktPIp99BEX54rbiZdGv_SoR2tBS75QUEoXwaAq9hEALw_wcB
[4]. http://store.arduino.cc/products/arduino-mega-2560-rev3
[5].https://6river.com/what-is-a-pick-and-place-robot/#:~:text=Pick%20and%20place%20automation%20speeds,focus%20on%20more%20complex%20work.
[6]. https://robotics.kawasaki.com/ja1/xyz/en/1804-03/
[7]. Savu, T., (2022), Course notes, PUB.

DESIGN OF ALGORITHMS AND DEVELOPMENT OF A COMPUTER APPLICATION FOR THE EVALUATION OF TRAVEL STRATEGIES FOR A MOBILE CRAWLING ROBOT

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ABSTRACT:

KEY WORDS:

1. Introduction

The aim of the paper is the theoretical as well as the physical realization of a robot that moves with crawling motion, similar to the movement of a snake or a worm, this being useful for rough terrain or small and closed spaces, where a typical robot could not move normally. The objectives pursued were to achieve the movement by crawling, to achieve a sufficiently strong skeleton to shocks and other geo-climatic factors. The 3d model of the robot was made using Solidworks 3D CAD. The initial tests were performed using an Arduino Unor R3 board, an SG90 servo motor and an HC-SR04 ultrasonic sensor, and the algorithm was created using Labview for component control. The servomotors are used for movement, the microcontroller for robot control, and the ultrasonic sensor for detecting the distance of obstacles.

2. The current stage

We made a final 3d model of the robot, which was made and improved after 2 previous versions. I made an elaborate documentation related to the realization of the movement by crawling, models and prototypes made by other companies and universities, from which I learned how I could improve the robot and what it needs. I found several libraries for Arduino and ESP32, which will help me to realize the navigation algorithm. Currently, I have several components, as I mentioned before, on which I will perform several tests. We performed torque calculations so that I could choose the servomotors correctly and to know that they will be able to operate the modules from which the robot is made.

3. Equations

To realise the crawling movement I will use MG996R servo motors, which have a locking torque of 13kg-cm. The mass of each module was calculated using Soldiworks software, based on the material chosen and the weight specified in the technical detail of each component in the system.

$$F = mg = 13kg * 9{,}80665m/s^2$$
$$F = 13kg * 9{,}80665m/s^2$$
$$F = 127{,}48N$$

$$\tau = 1{,}27Nm$$

Torque calculation for a module at a 45° angle:

$$\tau = rF$$
$$F = 0{,}292kg * 9{,}80665m/s^2$$
$$F = 2{,}86N$$
$$\tau = (9{,}35cm * \cos(45°)) * (2{,}86N)$$
$$\tau = (0{,}0935m * \cos(45°)) * (2{,}86N)$$
$$\tau = 0.06611 * (2{,}86N)$$
$$\tau = 0{,}189N\text{m}$$

Torque calculation for a module parallel to the ground:

$$F = 0{,}292kg * 9{,}80665m/s^2$$
$$F = 2{,}86N$$
$$\tau = (9{,}35cm) * (2{,}86N)$$
$$\tau = (0{,}0935m *) * (2{,}86N)$$
$$\tau = 0{,}267Nm$$

From the equations used, it follows that servo motors are powerful enough to drive these torques.

4. Tables

Table 1. Material Data Sheet: Z-ABS

Physical Properties	Metric
Density	1.04 g/cm^3
Linear Mold Shrinkage	0.0055 cm/cm
Melt Flow	3.9 g/10 min
Mechanical Properties	
Hardness, Rockwell R	108
Tensile Strength, Yield	30.3 MPa
Elongation at Yield	1.8 %
Tensile Modulus	1.86 GPa
Izod Impact, Notched	1.33 J/cm
Charpy Impact, Unnotched	NB
Charpy Impact, Notched	0.700 J/cm^2 1.600 J/cm^2
Thermal Properties	
Vicat Softening Point	104°C
Flame Class Rating	HB
CTE, linear, Parallel to Flow	74.0 µm/m-°C
Deflection Temperature at 1.8MPa (264 psi)	98.9°C

The moduless will be realized using additive manufacturing technology

5. The figures

Figure 1 Final version of the robot

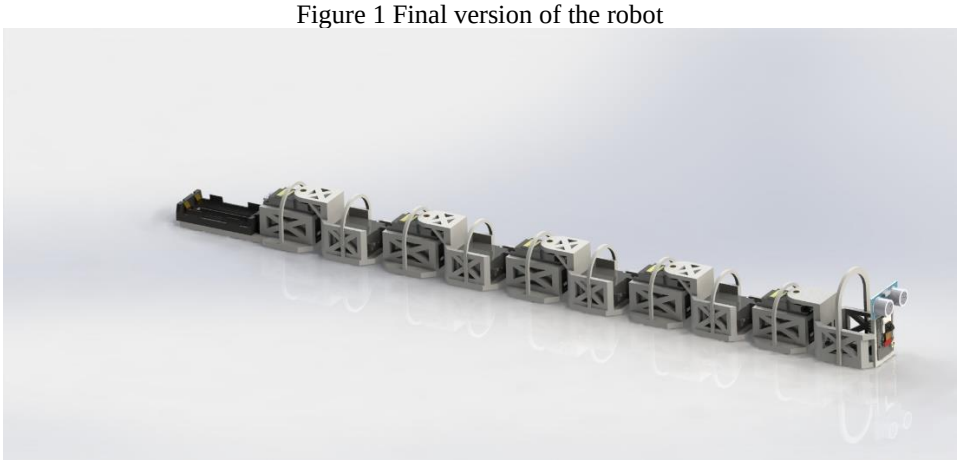

Figure 2 Previous Version

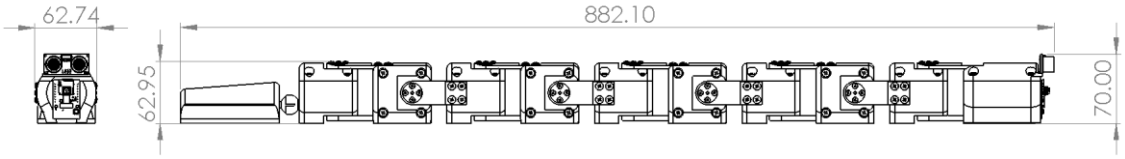

Figure 3 Overall dimensions

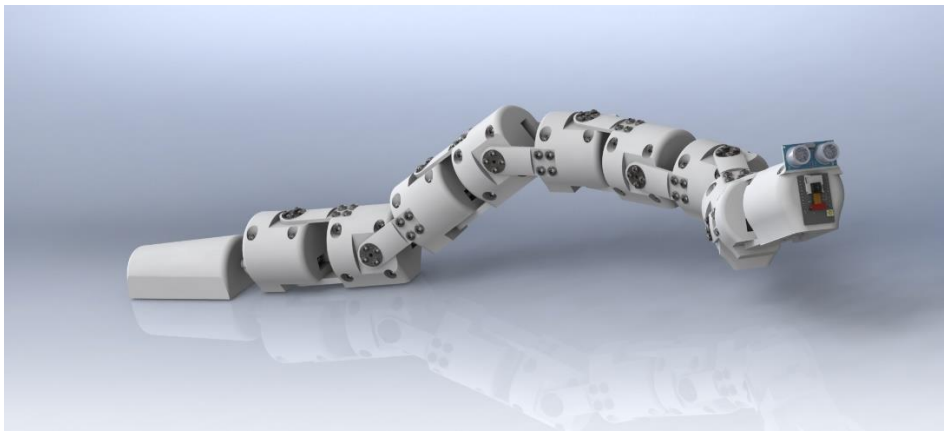

Figure 4 Movement by crawling

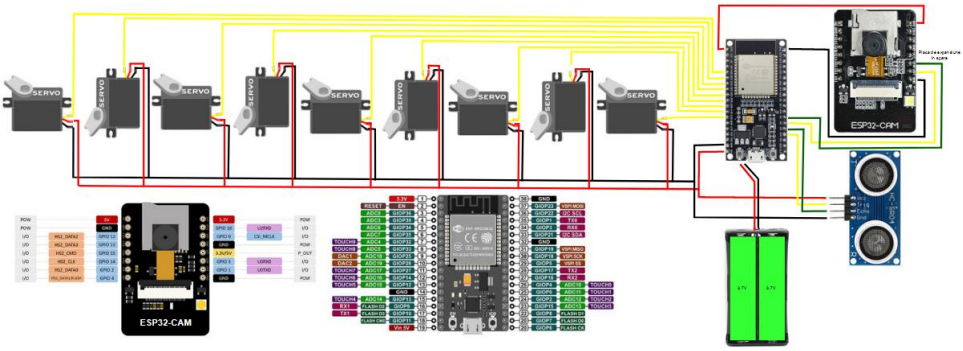

Figure 5 Wiring diagram

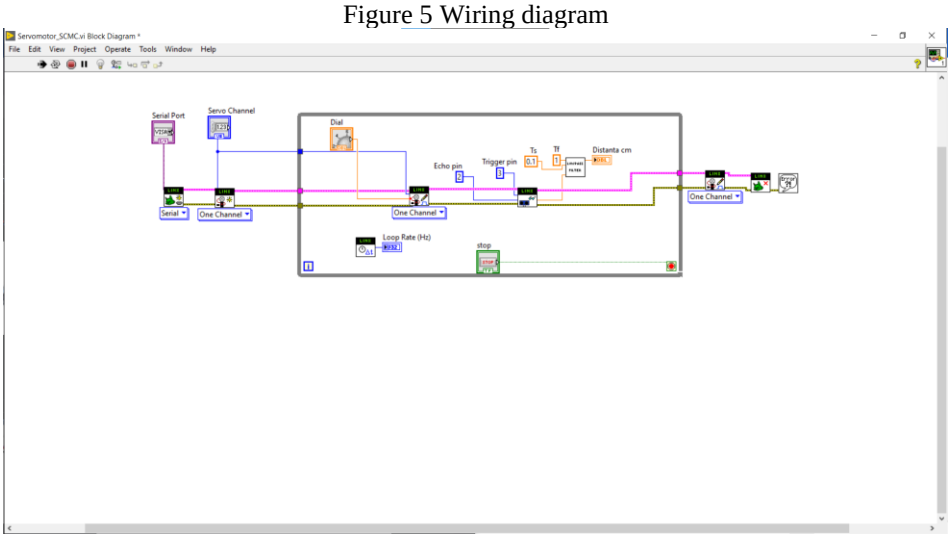

Figure 6 Block Diagram

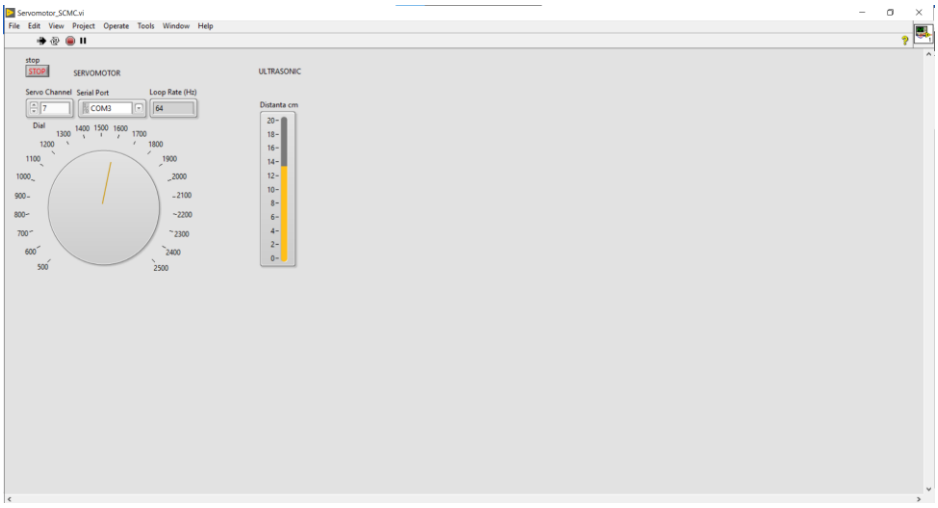

Figure 7 Front Panel

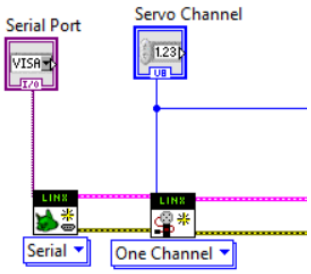

Figure 8 Labview

COM3 serial port opening for servomotor and ultrasonic. It connects to the Servo Open Channel to set the channel to which the servomotor is connected.

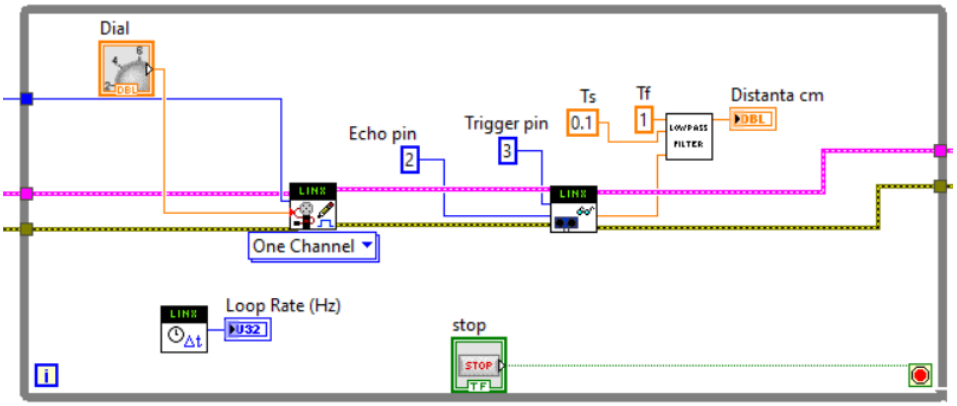

Figure 9 Labview

A While Loop is created, in which the Set Pulse Width One Channel function will be used to open the specific channel for the servomotor. Also, the Ultrasonic Read function will be used, in order to be able to read the Ultrasonic sensor, two constants called Echo Pin have been created to produce a pulse when receiving the signal, and respectively Trigger pin for initiating the pulse. Connected to the Ultrasonic Read function is also connected a LowPass filter function, to filter the noise received by the ultrasonic sensor

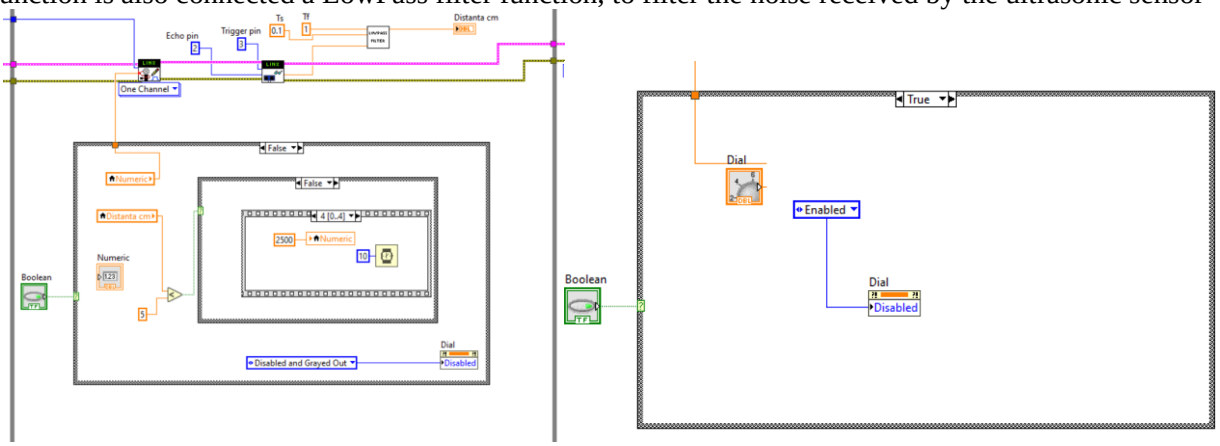

Figure 10 Labview

A Structure Case has been created inside the Loop, when the value is true, the servomotors operate normally, when it is false, the servomotors stop in the neutral position at 90 degrees (1500uS, the servomotor can rotate between 500 and 2500uS) when the servomotor detects a distance of less than 5cm to avoid contact.

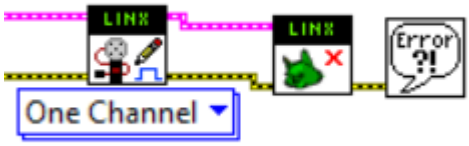

Figure 11 Labview

The final function is connected, outside the While Loop, to the Servo Pulse Width One Channel output and then to the Close function to close the serial communication.
MakerHub - Linx functions were used to realise the Vi

6. Conclusions

The original contribution made in the paper is the 3d model, which was created with the intention of protecting the robot's components as much as possible and not to get stuck on the ground on which it moves. I am going to further research the crawling movement in robots, it is a necessary field, but with an incipient development.

7. Bibliography

https://wyss.harvard.edu/news/snake-inspired-robot-uses-kirigami-to-move/

https://github.com/Obijuan/ArduSnake

http://www.iearobotics.com/wiki/index.php?title=ArduSnake:_Arduino_Modular_Snake_Robots_Library

https://www.youtube.com/watch?v=oEkTYmGqIWo

https://www.instructables.com/Snake-Robot/

https://www.instructables.com/Snake-Robot-1/

https://github.com/mvipin/slitherbot

https://www.youtube.com/watch?v=Q69HzF_Xq_s

https://www.youtube.com/watch?v=vef4ZbVga4I

https://www.youtube.com/watch?v=GM_56lLf_7o

https://www.youtube.com/watch?v=iC0-s4q5DUY

https://grabcad.com/library/oppas-open-source-parametric-snake-robot-1

https://www.youtube.com/watch?v=qCtXsTaEscM

https://www.youtube.com/watch?v=UC-CfQxdCn8

https://www.youtube.com/watch?v=K_IJisZce44

https://www.youtube.com/watch?v=8VLjDjXzTiU

RESEARCH ON THE DEVELOPMENT OF AN AIR PURIFICATION DEVICE WITH UV-C TYPE LAMPS

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ABSTRACT: The purpose of this research is to develop an air purifier with UV-C lamps. For this, several concepts were developed, regarding the components, their positions and the design of the product. An analysis of the competition and one of the concepts was also performed, the best ones being chosen for the product. Finally, a simulation of the purification process was performed using the NetLogo program and a few advantages and disadvantages were highlighted. Based on the information obtained, some conclusions were drawn regarding the product and future research directions.

KEY WORDS: purification, UV-C lamps, concept.

1. Introduction

In recent years, there have been more and more respiratory infections, which can be caused by viruses, dust, pollen, animal hair or dust mites. Thus, purifiers can reduce these causes of a certain infection in the human body. They have different filtering options, which help to remove fine dust, germs, pollen and other particles from the air that are not visible to the naked eye.

UV-C radiation is a disinfectant known for air, surfaces, objects and water, which can help reduce the risk of infection, and has been used extensively for over 40 years [1]. All bacteria and viruses tested so far respond to UV-C disinfection [3].

The aim of this research is to develop concepts of air purifiers with UV-C lamps that ensure the capture and destruction of pollutants and the release of purified air in a room.

2. The current stage

To develop a particular product, we need to identify the needs of its users and what are the conceptual solutions that meet these needs. An analysis of the market to be launched is also needed.

Needs are certain conditions which, if not satisfied, both the existence and the progress of man and society are not possible [2].

This air purifier will allow you to breathe clean air, eliminate all types of viruses and bacteria from the room and facilitate the protection of the health of the respiratory tract.

3. Competitors analysis

In order to identify the necessary specifications for the product to be developed and to carry out an analysis of the competitors, were extracted information about similar products existing on the market. Examples of products with similar specifications are shown in Table 1.

Table 1. Similar competing products

Nr. crt.	Name	Picture	Specifications
1	Dyson Purifier Cool ™ TP07 [4]		Captures dust, allergens and bacteria; 360 ° watertight filtration system; Automatically detects and captures pollutants; Dimensions: 22 x 20.4 x 105.4 cm (L x W x H); Maximum airflow settings: 290 l/s. Weight: 4.65 kg; Price: 3000 LEI.
2	Philips 4000i Series Air Purifier [5]		Removes nano particles up to 3 nm in size: viruses, mites, allergens; Automatic mode and 4 manual speed levels; It purifies the air, from a room of 20 m², in 5 minutes; The colored ring provides real-time feedback on indoor air quality: Red - low quality Purple - medium quality Blue - good quality Price: 3250.99 LEI.
3	San: 90W active air [6]		Targeted disinfection of the air through the active circulation of air in the room and the conduction of air next to a UV lamp. Fully enclosed case in matt anodized aluminum profile with integrated wiring and electronic ballast. 1 integrated UV lamp with long life, high disinfection performance and low energy consumption. Degree of continuous air disinfection in the room: 80% approximately 550 m³ room volume Approximately 88% of the room volume is 75 m³ Air circulation speed 36 m³/h Housing L x W x H 1000 x 105 x 105 mm Weight about 6 kg Lifetime UV lamp 10,000 h Number of UV lamps 1 Max. 40 ° C IP class 54 protection class Price: 1067 EURO approximately 5335 LEI

Nr. crt.	Name	Picture	Specifications
4	UV-C AIR GUARD 50W Ultraviolet Disinfection Lamp with Mobile Frame Mount [7]		AIR GUARD 50W device lamp, with mobile frame mounting, for air disinfection and purification. The device can be used for disinfection and purification of an air volume of 30 m^3/h. Time of efficient operation of biocidal tubes until reduction of UV-C light by 15%: 9,000 hours; Disinfected air flow: 30 m^3/h; Equipped with filter; Power supply: 220V / 50Hz, grounded socket; Power cord length: 3 m (or according to customer requirements); Frame support leg diameter: 41 cm; The frame is provided with four rollers, of which an antistatic roller and with brake; Price: 2481 LEI
5	Professional air purifier and sterilizer AlecoAir S1000 WALL [8]		S1000 Wall is a device designed to sterilize the air through UV-C technology, without risk to people in the room. UV-C lamps are located inside the unit. The air is sucked out of the room and passed through the filters of the device to capture microparticles and then passed through a UV-C tunnel to sterilize it. Dimensions: 1000 × 380 × 160; Air flow: 1000 m^3/h; Noise level: ≤ 55dB; UV-C energy released: ≥10000 μw/cm^2; Recommended for spaces up to 100 sqm - 120 sqm; Power: 250 W; Price: 5599.99 LEI
6	UV radiation disinfectant, MidasAnAir 3040T [9]		Device for disinfecting air with concentrated flow of UV radiation Supply voltage: 230V Power consumption: 45W Disinfected air flow: 90mc / h Noise level: 22dB Lifespan of UV-C generators: 7000 hours UV-C wavelength: 253.7nm Weight: ~ 5.5 Kg Dimensions: 71.5 x 23.5 x 12 cm Metallic case Operating mode: remote control, programmable Installation: horizontal wall mounting Applications Medical industry: Hospitals, Medical offices, Dental offices; Pharmaceutical industry: Laboratories, Drug factories; Food industry: Food processing and packaging factories; Cosmetics and Spa: Beauty salon, SPA; Public spaces: Schools and kindergartens, waiting rooms, commercial offices; Price: 2397.85 LEI

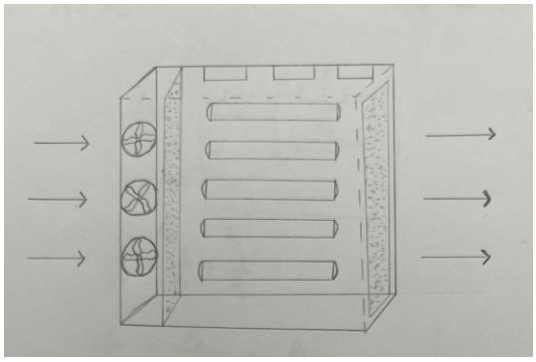
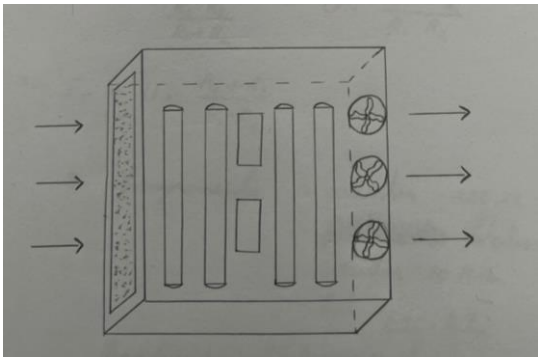
Following this analysis, there is a shortage of UV-C lamp purifiers in homes, with most manufacturers allocating these products to industrial premises. Thus began the development of such a product for relatively small spaces.

4. Concepts

In order to choose a concept, several design variants were analyzed, both in terms of the components used and their location, and in terms of product design. Subsequently, depending on the results obtained, two proposed concepts were chosen for the placement of the components and four design concepts that we are going to use to make the product and to select the optimal variant.

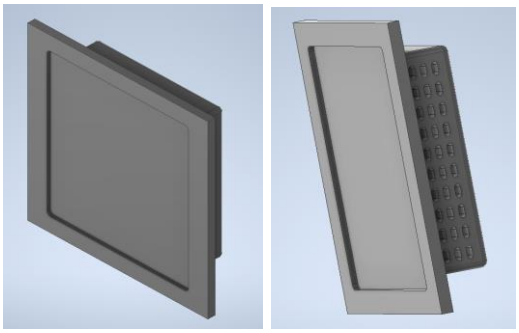
The concepts related to the components used and their location are presented in Table 2, and those related to the design of the product can be found in Table 3.

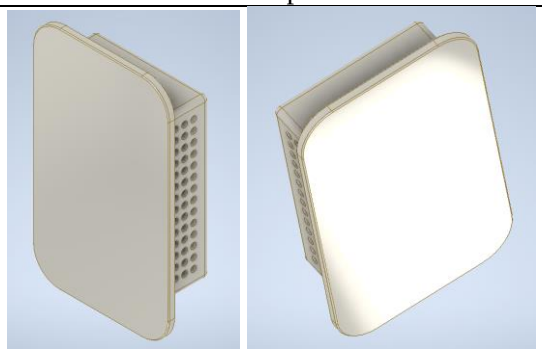
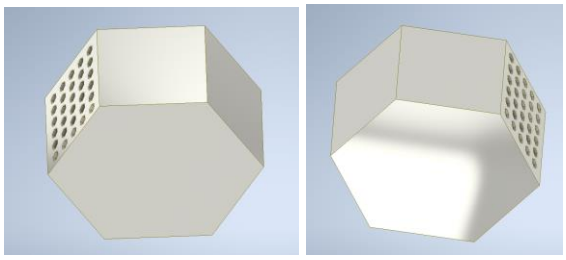
Table 2. Interior concepts

Concept 1	Concept 2
	

Both concepts use UV-C lamps with a power of 25 W, several starters equivalent to half the number of lamps because one starters is used for the operation of two lamps. It is also observed the use of three fans and an air filter, for concept 2, respectively two filters for concept 1. For the development of the product was chosen concept 2, this being the optimal one because with the help of fans that have a higher power absorption, the air is much more circulated and purified to the greatest extent possible.

Table 3. Product design concepts

Concept 1	Concept 2
	

Concept 3	Concept 4
	

For the developed product, 4 concepts related to the product design were developed: clock, picture, mirror and hexagonal object, but all contain a space for the purification system. Following an analysis of the customers, it was found that the object that can be customized for each buyer is the one related to the picture frame. It was chosen to be studied and carried out in future research.

5. Purification simulation program

In order to be able to exemplify the phenomenon of air purification with the help of UV-C type lamps, we made it with the help of a multi-agent program, namely NetLogo.

A box was considered to be the place inside which the lamps are found and the process and circular elements that signify the dust particles take place. The red ones are the particles that contain dust or other bacteria and the blue ones are the purified particles that are obtained from the process. An image of the program interface is shown in Figure 1.

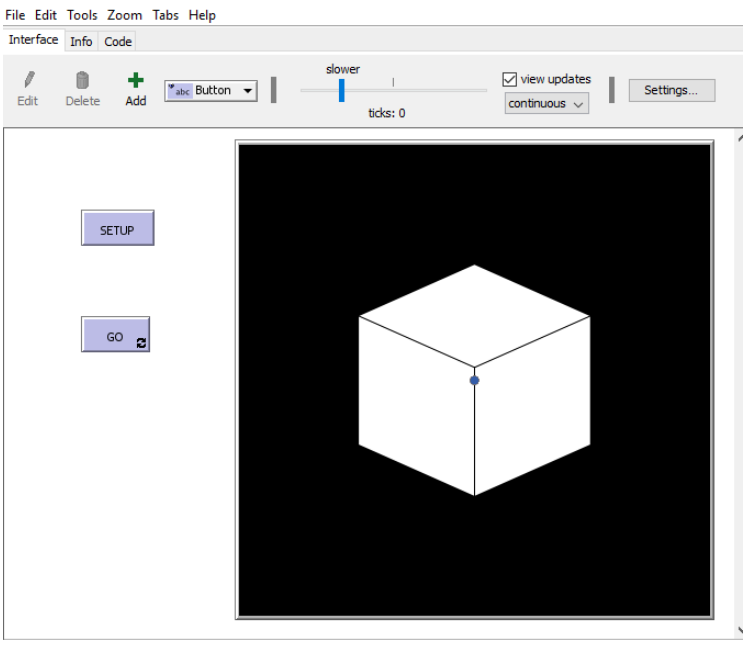


Fig. 1 Program interface

The following code has been created for its operation:

```
to setup
clear-all
reset-ticks
create-turtles 1
[set shape "box"
set size 18
set color white]
create-turtles 35
[set shape "circle"
set size 0.6]
end

to go
move-turtles
Tickle
end

to move-turtles
ask turtles [
if shape = "box"
[setxy 0 0]
if shape = "circle"
[setxy random-xcor 0
fd 1

if shape = "circle"
[setxy random-xcor 0
        fd 1
If (pxcor <0)
[red color set]
If (pxcor> 0)
[set color blue]
fd]]
end
```

The operation of this system consists in the penetration of a number of particles with dust and bacteria in the box where the UV-C type lamps are found and the exit of purified particles from it. An example of the program is shown in Figure 2.

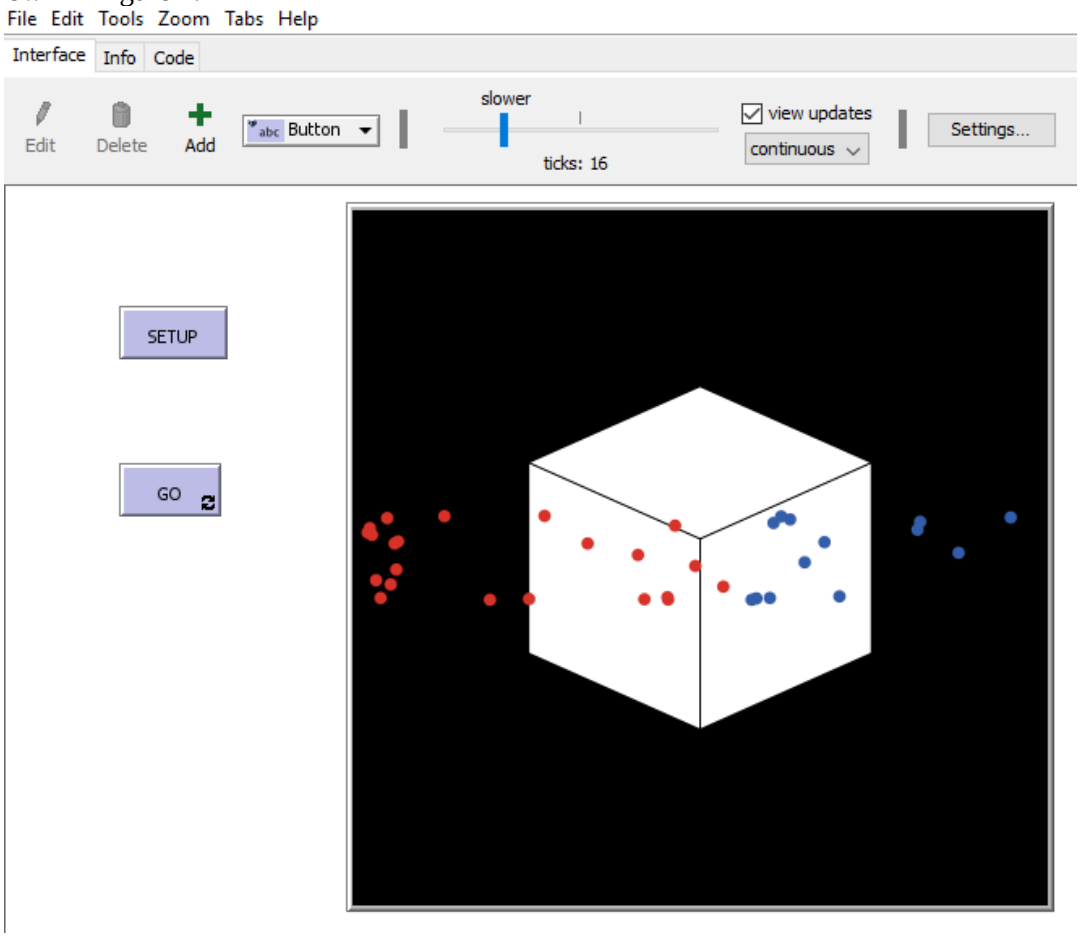


Fig. 2 Exemplify the program

6. Advantages and disadvantages

In order to develop a product that is as useful as possible, a number of advantages and disadvantages have been considered in the use of the product. Benefits include:

• Visual-protected UV-C radiation source, which allows continuous operation, even if there are people in the room;

• Low energy consumption and minimal maintenance costs;

• The product does not use chemicals in the disinfection process;

• Eliminate unpleasant organic odors, including tobacco odor;

• 99% of the room air is disinfected.

Also, in terms of disadvantages, only one was found so far, namely a high selling price of the product.

7. Conclusions

In conclusion, following the development of the concepts, both those that refer to the components used and their location, as well as those related to the design of the product, the best ones were chosen, which can lead to a functional product. In future research, it is intended to create a functional prototype that reflects as much as possible the final product.

Thus, the air purifier with UV-C lamps to be developed is intended to provide air disinfection as quickly and efficiently as possible, which is environmentally friendly and does not endanger human health.

8. Bibliography

[1]. *** EPA Report, Building Retrofits for Increased Protection Against Airborne Chemical and Biological Releases, available at: https://nepis.epa.gov/Exe/ZyNET.exe/P1005UD2.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=& & QFieldMonth = & QFieldDay = & IntQFieldOp = 0 & ExtQFieldOp = 0 & XmlQuery = & File = D% 3A% 5Czyfiles% 5CIndex% 20Data% 5C06thru10% 5CTxt% 5C00000012% 5CP1005UD2.txt & User = ANONY & Sort = ANONY & Sort Image x150y150g16 / i425 & Display = hpfr & DefSeekPage = x & SearchBack = ZyActionL & Back = ZyActionS & BackDesc = Results% 20page & MaximumPages = 1 & ZyEntry = 1 & SeekPage = x & ZyPURL, accessed on: 7.04.2022

[2]. ***, DigitalReader, "What are needs and goods? Economic activity", available at: https://www.digitalreader.ro/nevoi-bunuri/, accessed on: 7.04.2022

[3]. Adel Haji Malayeri, Madjid Mohseni, Bill Cairns and James R. Bolton, Fluence (UV Dose) Required to Achieve Incremental Log Inactivation of Bacteria, Protozoa, Viruses and Algae, available at: https://uvsolutionsmag.com/stories/pdf/archives/180301_UVSensitivityReview_full.pdf, accessed on: 7.04.2022

[4]. ***, Dyson Purifier Cool ™ TP07, available at: https://www.dyson.com.ro/produse/tratarea-aerului/dyson-purifier-cool/prezentare-generala, accessed on: 7.04.2022.

[5]. ***, Philips 4000i series air purifier, available at: https://www.philips.ro/cm-ho/purificatoare-si-umidificatoare-de-air?gclid=EAIaIQobChMIqpq2tLSE9wIVjo1oCR0DIgLsEAAYAyAAEgKCVPc_Bdata, accessed on: 7.04.2022.

[6]. ***, San: 90W active air, SanAer manufacturer catalog, accessed on: 15.04.2022.

[7]. *** UV-C AIR GUARD 50W Ultraviolet Disinfection Lamp with Mobile Frame Mount, available at:https://biocomp.ro/dispozitiv/purificator-air-guard-50w-stativ-biocomp-

nou/?gclid=Cj0KCQjwyMiTBhDKARIsAAJ-9Vs7Mbw6P11X4hVd-7V-RXe_ndCsrORG3prCYZMVwwW, accessed on: 15.04.2022.
[8]. ***, AlecoAir S1000 WALL professional air purifier and sterilizer, available at:https://altex.ro/purificator-si-sterilizator-profesional-de-aer-alecoair-s1000-wall-8-lampi-uv-c-prefiltru-filtru-carbon-1000mc-h/cpd/PURS1000WALL/?cq_src=google_ads&cq_cmp=14642104510&cq_con=128469527218&cq_term=&cq_med=&cq_plac=&cq_net=u&cq_plt=gp&gclid=Cj0KCQjwyMiTBhDKARIsAAJ-9Vv7cdbeTM_yf-PARmnZZGBoc7aMWomXgVt2YgBeP0_lrt4c4QMNJ-caArEjEALw_wcB#additional, accessed on: 15.04.2022.
[9]. ***, Device for disinfecting the air with UV radiation, MidasAnAir 3040T, available at: https://alexa-medical.ro/midasanair-dispozitiv-dezinfectie-a-aerului.html?gclid=Cj0KCQjwyMiTBhDKARIsAAJ-9VtCxKxio92CwhesEV7mo8HLd2Iu_9aDQqd3PkTQI_1kO7COCavZKnkaAqBUEALw_wcB, accessed on: 15.04.2022.
[10] https://ccl.northwestern.edu/netlogo/

RESEARCH ON THE DEVELOPMENT OF A MULTI-DEVICE TYPE DEVICE FOR PEOPLE WITH SPECIAL NEEDS

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ABSTRACT: The theme of the project "Research on the development of a multi-device type device for people with special needs" involves an intelligent haptic system that helps the blind, able to simulate the Braille alphabet and transmit user commands to an electronic device. The product resulting from this process is useful for people with special needs. Following the study carried out in this paper, a series of constructive-functional variants were analyzed for this type of product, from which the only variant was chosen, as the optimal variant. This analysis also included products competing with our device, and thus resulted in a product that has twelve components made physically with the help of additive manufacturing technology. With the help of 3D printing, we managed to have a product design model and continue its development, making it functional. The appearance of the automatic typing system is like a cropped box or a kind of miniature 3D printer, to make room for rods that help coordinate movements. The functionality of the product requires of electronic elements, but also a software that allows the recognition of the Braille alphabet.

KEYWORDS: multi-device, Braille alphabet, additive manufacturing technology.

1. Introduction

This chapter presents a history of the development of keyboard devices from the appearance of the first electromechanical product for Braille text display to the most advanced 32-cell Braille display system. Braille technology is an assistive technology, created by Louis Braille in 1825, which has been continuously developed to this day, allowing blind and partially sighted people to perform common tasks such as typing, surfing the Internet, typing in Braille, and printing. in text, chatting, downloading files, music, using e-mail, recording music, and reading documents[1].

The letters are made up of dots that can be felt with your fingers. All letters of the alphabet have corresponding signs in the Braille alphabet.

A Braille product (Braille terminal) is an electro-mechanical device for displaying text in the Braille alphabet, usually by means of rounded-pointed pins raised through holes in a flat surface. Visually impaired people who want to use a computer but can't distinguish the characters on the monitor can use a Braille display to read the displayed text. Screen readers are also frequently used for the same purpose, and a blind user can switch between the two systems or use both at the same time, depending on the circumstances. The Braille display can also be used by deafblind users [3].

Fig. 1.1The example of the Braille alphabet [2]

The advances in Braille technology are significant and there are some examples of software and hardware components currently in use, as follows:

1.1. Software component

- **Duxbury DBT** is a program that interprets the lines of a fingerprint and converts them into Braille (and vice versa) for over 100 languages;
- **JAWS** is a program that reads text on a screen and allows you to browse directories, documents, and programs under the Microsoft Windows operating system, or send text to a Braille display;

- **Kurzweil** is a device that scans texts on the computer and tells them;
- **Nvda** is an open source screen reading software with Braille supportlle.

1.2. Hardware component

Table 1.2.1 Components

 Fig. 1.2. Brailliant device Bl 32 [4]	**a) Braille keyboard** – used only with Braille typewriters. There is currently a generation of Brailliant Bl screens that incorporate state-of-the-art Braille cell technologies, clear and realistic points. The ergonomic screen fits in front of your laptop or keyboard and can be used with mobile devices.
 Fig. 1.3. The Braille printer[6]	**b) The Braille printer** renders text as touch cells. Using Braille translation software, a document can be highlighted with relative ease
 Fig. 1.4. Electronic books in Braille[7]	**c) Electronic books in Braille,** which use electroactive polymers. [5]

The first objective of the study is to create a typing system using the Braille alphabet, which helps people with special needs to communicate and navigate on a variety of devices.

Currently the 3D model of the keyboard system is almost complete, because we noticed the need for other components. This system was designed in Solidworks design software. The components have been established according to the fulfillment of the objective proposed by us.

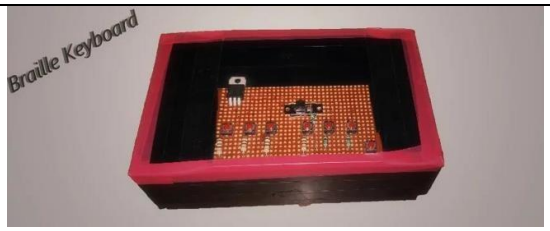
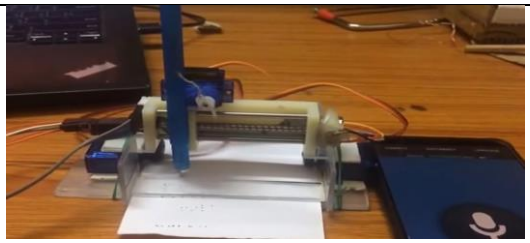
The next step is to research and demonstrate the effectiveness of the product and its commissioning. At present, only the operating principles of the components and their integrity in the system have been analyzed.

2. 3D printed variants

At present, all kinds of additive-manufactured equipment have been developed, which have the role of integrating the Braille language. These equipments are composed of both components made by additive manufacturing and components made by other means.

Table 2.3.1 3D Printed systems

 Fig. 2.1. Connecting components for the device [9]	**Option 1: Braille enabled mobile phone for the visually impaired** The project proposal is about a mobile phone design that will act as an essential device for the visually impaired, which can be used for efficient reading of SMS. [8]

 Fig. 2.2. Braille alphabet system keyboard [11]	**Option 2: Braille keyboard with voice output** This type of keyboard helps people with special needs to enter data on laptops, using Braille, and at the same time be able to hear what they are typing. With the help of the open source software "Cool Term", the typed text can also be converted into a Word document or a text document. [10]
 Fig. 2.3. Braille typewriter [13]	**Option 3: Braille writing mechanism** This type of mechanism is a paper typewriter in the Braille alphabet, connecting to a device and being voice activated.[12]

3. Functional analysis of the product Multi-device typing device

In this stage, an analysis of the product "Multi-device typing device" will be performed, in order to establish the main functions and their evaluation in fulfillment of the final purpose.

Please note that the proposed product must allow the simulation of the Braille alphabet by transmitting the commands given by the user and converting these commands to the device.[14] The functional tree for the product "Multi-device typing device" is as follows:

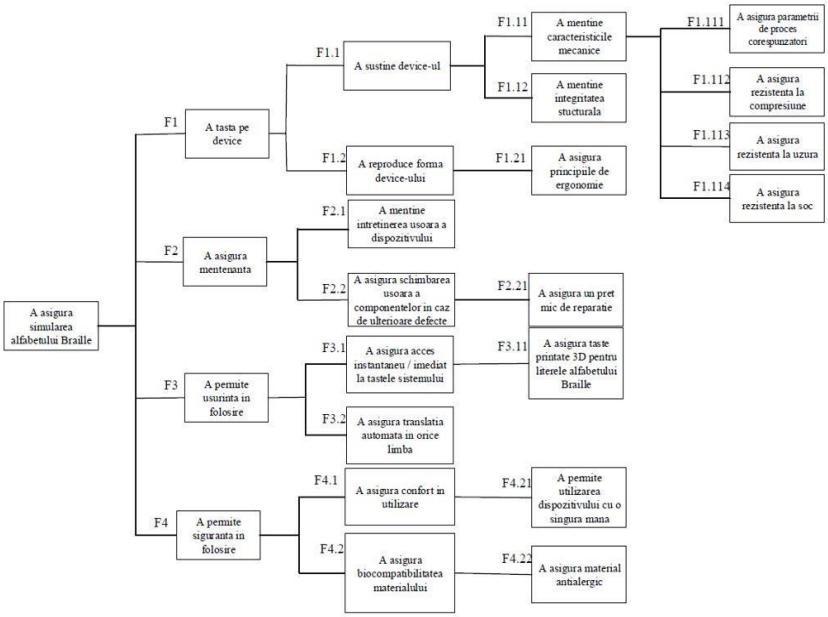


Fig. 3.1. Functional Tree for Multi-Device Keyboard Product

3.1. Hierarchy of functions and evaluation matrix

This ranking involves the determination of a final evaluation that highlights the most important functions of the product.

The evaluation will be based on the first functions of the device - F1, F2, F3 and F4. The number 1 will be placed diagonally in the evaluation matrix, following the notation of the other functions. When evaluating the functions, 2 tables will be drawn up, following to make an average of the obtained results, in order to be able to achieve the final ranking matrix.[15]

Table 3.1. Product function ranking matrix (Option 1)

Functions	F1	F2	F3	F4
F1	1	0	0	0
F2	1	1	1	1
F3	1	0	1	1
F4	1	0	0	1
Level of importance ni	4	1	2	3

Table 3.2. Product function ranking matrix (Option 2)

Functions	F1	F2	F3	F4
F1	1	0	0	1
F2	1	1	1	1
F3	1	0	1	1
F4	0	0	0	1
Level of importance ni	3	1	2	4

The final matrix of the hierarchy of functions is presented in table 3.3. This matrix highlights the final average of the importance level of the previous matrices.

Table 3.3. The final hierarchy of functions for the product

Functions	F1	F2	F3	F4
F1	1	0	0	0.5
F2	1	1	1	1
F3	1	0	1	1
F4	0.5	0	0	1
Level of importance ni	3.5	1	2	3.5

The functions weighting matrix for the multi-device typing device is shown in table 3.4. The formulas that make up the values in this table are as follows:

The importance coefficient is calculated with the relation:

$$C_i = ni/\Sigma ni ; \quad (1)$$

The weight of a product's function is determined using the relationship :

$$P_i[\%] = (ni/ \Sigma ni)*100. \quad (2)$$

Table 3.4. Matrix of general evaluation of product functions

Function	F1	F2	F3	F4	Total (Σni)
Calculated weight	3.5	1	2	3.5	10
Global impact factor	0.35	0.1	0.2	0.35%	1
Global weight	35%	10%	20%	35%	100%

By comparing the functions, it was concluded that the F1 and F4 functions obtained the same 35% score, so the support of the device, respecting the ergonomic principles are as important as the safe use of the device.

The value of the product is equal to the sum of the calculated hierarchical values, ie 10. After weighting the functions, the following percentage values result:

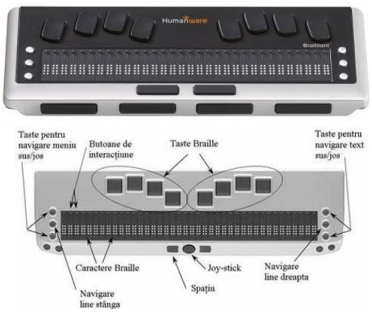
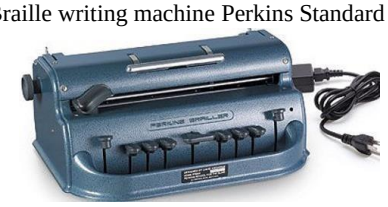
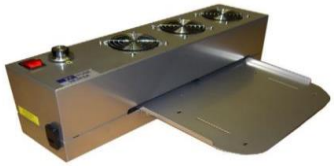
XF1 = 35%; XF2 = 10%; XF3 = 20%; XF4 = 35%.

5. Market analysis

This chapter covers the market analysis of products that fall into the category of devices that help the visually impaired. The products use the Braille alphabet.

An analysis of the existing products on the market and of the product proposed by our team will be made, highlighting the competitive advantage. 4 competing products and their specifications will be presented in Table 5.1.

Table 5.1. Competition table

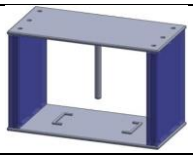
Competitive products	Product specifications
 Braille display with keyboard Competitive advantage: Low cost, low maneuverability [16].	The purpose of the Braille display is to render in Braille the descriptive and textual information that the user needs in order to interact with the applications. Technical specifications: – Keyboard with 32 Braille cells; – 4 keys for the thumb; – 6 control keys; – Extended Braille keyboard (8 keys); Total weight: 524g; Product size: 26 x 8.7 x 1.8 cm; Product price: 16,560.00 RON.
Braille writing machine Perkins Standard  Competitive advantage: High writing speed, low cost [17].	The Perkins Standard Braille Typewriter is a mechanical Braille typewriter that allows you to write the Braille alphabet on special paper, on Braille-type plastic wrap, and with a special adapter on Dymo tape. Technical specifications: – Allows you to write up to 42 characters at a time; – The text can be read while writing; – Made of metal; Dimensions: 22.5 x 15 x 39 cm; Total weight: 5,022 kg; Product price: 4849 RON.
ZY – Tactile diagram  Competitive advantage: Made of PLA, low cost [18].	The ZY- Fuse device is the simplest and fastest way to le images. al Technic pecifications: – Working rate: 4 pages / minute; – Dimensions: 150 x 520 x 500 mm; – Total weight: 7.2 kg; Voltage: 220 – V; – Price: 1048 RON.
Everest-D V5 Braille Printer  Competitive advantage: The product is not bulky or heavy, low cost. [19]	Everest-D V5 is a powerful Braille printer that offers a wide variety of solutions for the blind. The unique individual sheet feeder allows embossing of documents. Technical specifications: – Print speed: 120 characters / second; – Graphic resolution: 50 dpi; – Connectivity: USB, WIFI; – Control panel: Braille tags; – Paper sheet size: 25 x 30 cm; – Paper package weight: 15 kg; – Price: 26,548.90 RON.

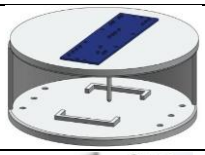
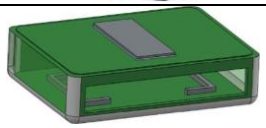
Conclusion: after analyzing the specifications of each product, we noticed that our product has the right advantages to continue its development.

5.1. Presentation of integral concepts

After analyzing the proposed problem, we had to choose from 4 concepts (constructive variants) of the product. These are presented in table 5.1. and will be accompanied by a sketch, together with a detailed description of the process performed.

Table 5.1. Presentation of the complete concepts of the product

Concepts	Sketch with description	
C1		This type of product looks like a 3D printer and has the role of typing on different devices, instead of the person who can not do it on their own. The product has a typing device, having a length and shape suitable for contact between the device and the typing instrument. The keyboard tool has a rubberized tip that helps in direct contact with the device screen.

Concepts	Sketch with description	
C2		This type of product is shaped like a sphere and is easy to integrate in different spaces, it is not difficult and it is easy to handle. The use of the product is very easy, with all the access ways at the user's fingertips. The Braille keyboard is positioned above the device and connects, using electronic components, to the component that performs typing on the device.
C3		Typing on a specific device will be done automatically, with the help of the program that will make possible the interaction between man and device. The movement of the device will be achieved by the action of 7 components that support the typing tool on the device. The system consists of 3 retaining walls, oriented on either side of it, the component that supports the Arduino control board, the top board and the base board of the system.
C4		The typing is performed with the help of a rubber dot that is positioned on top of the main test instrument, and is attached to the upper support plate. For fixing the devices, the system is provided with a portion that holds the device in place, without detaching from the table of the typewriter. The user has quick access to where the devices are placed.

The selected concept is the C3 concept, because this concept best fulfills the functions we want achievable and usable by us, those who develop the product, but also by the people who will use it, in order to make their lives easier.

6. 3D modeling and assembly of the product Multi-device typing device

The mechanical parts covered by this chapter are: device base, retaining walls (3 in number), rod and wall support component, construction rods, assembly support components, device support top, device framing component in the work environment and the supporting component of the Arduino board. At the moment, we have adapted the 3D model in such a way that the proposed study can be carried out. The 3D model was extracted from the Grabcad platform, which is an open-source platform without copyright [20].

The characteristics of the parts will be presented in table 6.1.

Table 6.1. The characteristics of the parts that make up the product

No. part	Part name	Manufacturing technology	No. pieces
1	The basis of the device	Additive Manufacturing	1
2	Retaining wall	Additive Manufacturing	3
3	Component for supporting rods and walls	Additive Manufacturing	6
4	Component that supports the device	Additive Manufacturing	1
5	Construction rod	Additive Manufacturing	6
6	Component to support the assembly in 2 holes	Additive Manufacturing	12
7	Component to support the assembly in 3 holes	Additive Manufacturing	5
8	Component to support the assembly in 4 holes	Additive Manufacturing	1
9	Top support of the device	Additive Manufacturing	1
10	Component that provides typing on the device	Additive Manufacturing	2
11	Component that supports the Arduino board	Additive Manufacturing	1
12	Support component	Additive Manufacturing	6
-	The final ensemble	Additive Manufacturing	-

The product assembly multi-device keyboard consists of the 12 parts described in Table 6.1. Connection conditions between the system components were required for the assembly. The connection conditions between the components represent the geometric position between the elements that make up the product. Next, we applied the additive manufacturing technology to make the final layout of the product.

7. Additive manufacturing of the product Multi-device typing device

This chapter includes the steps followed to carry out the additive manufacturing process, following the completion of the production process and the assembly of the designed parts.
The Z-SUITE 3D printing software was used to complete the process and the Zortrax M300 Plus printer was chosen. The material used was Z-HIPS (white).

Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF) is an additive manufacturing process that belongs to the material extrusion family. In FDM, an object is constructed by the selective deposition of molten material in a predetermined path, layer by layer. The materials used are thermoplastic polymers.
FDM is the most widely used 3D printing technology: it is the largest installed base of 3D printers globally and is often the first technology to which people are exposed. [21]
The features of the Zortrax M300 Plus 3D printing software are shown in Table 7.1..

Tabele 7.1. Features of the 3D printing software, Zortrax M300 Plus

3D printer	Description	The software used
	Zortrax M300 Plus Technology: LDP (Layer Plastic Deposition) Layer resolution: 90-290 microns Construction volume: 300 x 300 x 300 mm Minimum wall thickness: 400 microns Material diameter: 1.75 mm Nozzle diameter: 0.4 mm Materials: Z-ULTRAT, Z-PETG, Z-GLASS, ZHIPS, Z-ASA, Pro, Z-PLA Pro, Z-ESD. [22]	Z-SUITE[23]

In order to perform the part printing operation, they were converted to STL files and added one by one to the Z-SUITE printing software. 2, 3D printers were used in the printing process.

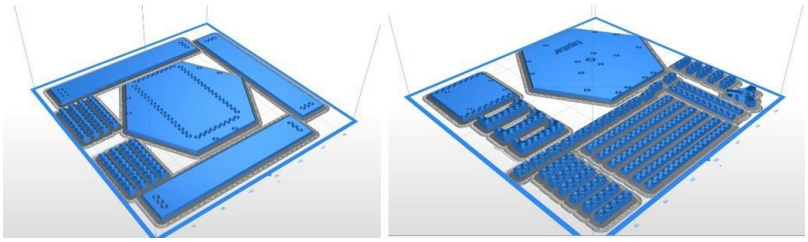


Fig. 7.1. Printer 1 (see left), Printer 2 (see right)

The following parameters have been set for making parts on printer 1:

- The material used is Z-HIPS.
- The settings for setting the media have been set to be editable.
- The nozzle diameter is 0.4 mm.
- The thickness of the print layer is 0.29 mm.
- Print quality is normal.
- The print time was set to normal and model 0, with a fill density of 50%.
- The print point starts randomly.
- Filling the thin walls is set to a maximum thickness of 2.63 mm.
- The size of the area underlying a single support pillar is set to be editable with a 7 pcs layer.
- First Layer Gab sets a gap between the cork and the first layer of a model and has been set to 0.42 mm.

After choosing the printing parameters, we decided that we do not need support structures, because the parts do not have complex shapes.
Depending on the chosen parameters, the printing time was established (17 hours and 23 minutes) and 269 grams of material were used. Printer 2 had the same printing parameters, but the resulting time was 17 hours and 53 minutes, 225 g of media were used.

Fig. 7.2. Estimated printing time

8. Conclusions

At the moment, we have assembled the 3D printed parts and noticed the need for other parts to be designed and added as a whole. Next is the purchase of control components: servo motors, controller, etc. The final product will have a control software, which will make possible the interaction between the person using the device and typing on the device.

Subsequently, tests will be made on the functionality of the parts, but also on the system that will be put into operation, and thus other improvement decisions will be made.

9. Bibliography

[1]. ***, Braille alphabet (2020), available: https://ro.wikipedia.org/wiki/Alfabetul_Braille [accessed 09.03.2021].
[2]. ***, Braille writting machine (2021), available: https://ro.abcdef.wiki/wiki/Braille#%20Braille_writing_machine [accessed 09.03.2021].
[3]. ***, Braille display (2020), available: https://beindependent.ro/produse/produse-pentru-nevazatori/computer-software-programe-pentru-nevazatori/ecrane-braille-display-braille [accessed 09.032021].
[4]. ***, Brailliant Bl 32 (2020), available: https://beindependent.ro/produs/produse-pentru-nevazatori/computer-software-programe-pentru-nevazatori/ecrane-braille-display-braille/brailliant-bi-32 [accessed 09.03.2021].
[5]. ***, Braille technology (2021), available: https://ro.abcdef.wiki/wiki/Braille_technology [accessed 09.03.2021]
[6]. ***, Braille embosser, available: https://ro.abcdef.wiki/wiki/Braille_embosser [accessed 09.03.2021].
[7]. ***, Braille e-book (2020), available: https://ro.abcdef.wiki/wiki/Braille_e-book [accessed 09.03.2021].
[8]. ***, Braille language cell phone (2021), available: https://www.instructables.com/Brail-language-cell-phone-for-visually-impaired-pe/ [accessed 09.03.2021].
[9]. ***, Braille language (2021), available: https://www.instructables.com/Brail-language-cell-phone-for-visually-impaired-pe/ [accessed 09.03.2021].
[10]. ***, Braille keyboard (2021), available: https://www.instructables.com/Braille-Keyboard-With-Voice-Output/ [accessed 09.03.2021].
[11]. ***, Braille (2021), available: https://www.instructables.com/Braille-Keyboard-With-Voice-Output/
[12]. ***, Simple Braille Writer (2021), available: https://www.instructables.com/Simple-Braille-Writer-Speech-to-Braille/ [accessed 09.03.2021].
[13]. ***, Simple Braille (2021), available: https://www.instructables.com/Simple-Braille-Writer-Speech-to-Braille/ [accessed 09.03.2021].
[14],[15]. Lupeanu M.E., (October 2009-October 2012), Research on the application of technical functional analysis to the development of new products made by unconventional additive manufacturing technologies, PhD thesis,
[16].BAUM Engineering și ICI, Tehnologii Asistive (2019), available: https://www.baum.ro/accesegov/index.php?language=ro&pagina=tehnologii_asistive [accessed 16.03.2021.
[17]. ***, Braille typewriter (2009), available: http://www.anjo.ro/masini-de-scris-braille/masina-de-scris-braille-perkins-standard-disponibila-la-comanda.html [access 22.03.2021].
[18]. ***, ZY-Fuse (2009), available: https://www.baum.ro/index.php?language=ro&pagina=produse&subpag=zyfuse [access 22.03.2021].
[19]. ***, Everest-D V5 printer (2021), available: https://qmart.ro/imprimanta-braille-everest-d-v5 [accessed 22.03.2021].
[20]. ***, Tapster (2021), available https://www.thingiverse.com/thing:123420 [accessed 09.03.2021].
[21]. ***, FDM (2021), available https://www.blog.3ddot.ro/introducere-in-fdm/ [accessed 11.04.2021].
[22]. ***, ZORTRAX (2022), available https://zortrax.com/3d-printers/m300-plus/ [accessed 12.05.2022].
[23]. ***, Z-SUITE [online image], available at https://www.makershop.fr/logiciel-imprimante-3d/2380-z-suite.html3d/2380-z-suite.html [accessed 12.05.2022].

STUDY ON STRATEGIC MARKETING AND SPECIFICATION SETTING FOR AN ERGONOMIC WHEELCHAIR FOR PEOPLE WITH LOCOMOTOR DISABILITIES

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ABSTRACT: This scientific paper addresses the possibilities of developing an ergonomic wheelchair for people with locomotor disabilities - SPD. The needs of potential customers and market opportunities were studied, and some technical specifications were established based on them.

KEYWORDS: people with disabilities, ergonomic wheels, mobility, autonomy.

1. Introduction

1.1 Brief history of the development of the wheelchair for people with locomotor disabilities

Wheelchairs have evolved very little over the last 1000 years. Most of the design changes have come about in the last few decades. The first wheelchair is known to have been designed to provide mobility and was called an 'invalid chair' (Fig. 1.1.a).

It was invented in 1595 specifically for King Philip II of Spain. The chair had small wheels attached to the end of the legs of a normal chair and included a platform for the legs and an adjustable backrest. However, it could not be self-propelled, requiring the assistance of another person to move it. In 1655, Stephen Farfler, a paraplegic watchmaker, built a self-propelled chair on a three-wheeled chassis [1].

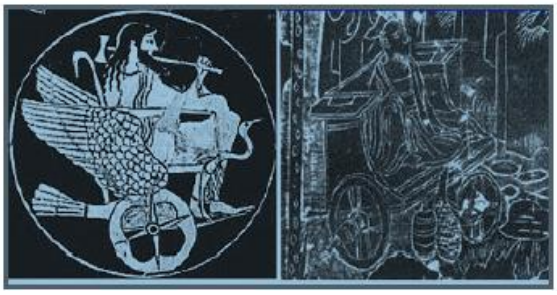


Fig. 1.1.a. The first recorded wheelchairs [1]

Fig. 1.1.b. Chair for King Philip II [1]

1.2. Presenting customer needs

For users in this category, mobility is an impediment to their daily activities. Their main need is to move from one place to another easily and independently. SPD enables mobility for people who can no longer walk on their feet permanently or temporarily due to physical limitations, thus a product will be created to meet the most demanding needs and tastes. The SPD folds up easily and can be placed in the boot of a car for transport.

At the same time, constant wheelchair use puts a lot of stress on muscles that are not really designed to be used in this way, leading to everything from repetitive stress injuries and pain to joint degeneration and carpal tunnel syndrome [2].

Therefore, user need can be addressed by transferring loads and demands typically placed on weaker shoulder and arm muscles to more capable muscles in the upper back to reduce the chance of injury and provide the user with an overall increase in strength and autonomy [2].

2. State of the art

2.1. Existing products on the market and possibilities for development

On the market there are a multitude of construction variants which often do not address the possibility of quick folding/unfolding for movement by placing the seat inside a boot. It can also be noted that competing products do not offer the user autonomy by design and that the effort required to move the seat places a heavy strain on the muscles of the upper limbs. Figure 2.1 shows three models on the international market. [3], [4].

a. Steel wheelchair Donis [3]

b. Dr. Happy manually operated wheelchair [3]

c. Ultra-light, folding wheelchair with folding handles [3]

Fig.2. 1. Construction variants of seats on the international market

As can be seen, the seat in fig.2.1.a. is manually operated, its frame is foldable, the maximum weight supported is 100 kg. It is made of a steel frame and the wheels are made of rubber. Obstacles are overcome by lifting the front wheels and driving them over obstacles [3].

Another existing model of chair is Dr. Happy - fig.2.1.b, it is designed with manual drive, it is made on chromed steel frame, foldable; solid rear wheels with plastic spokes, diameter 58 cm provided with brake, and the front wheels are PU filled and the seat and backrest are made of washable synthetic material [3].

The chair has been conceived with a modern design, this chair is manually operated, made on double painted (hardened) steel frame, features rear pocket for carrying papers, folding PU armrest. The seat and backrest are made of soft black washable synthetic material. Footrest is removable, with antero-posterior rotation movement, adjustable in length, with foot pedal and strap for fixing the heels [3].

For the SPD product, the inclusion of the following components will be considered for market access:

- Rowheel system, which allows the pulling motion to be converted into the forward motion of a wheelchair;
- the use of smart materials (the backrest is covered with mesh);
- a molded foam cushion for correct sitting position and reduction of the shock of movement;
- shock-absorbing suspensions for overcoming obstacles and bumps.
- have long wheel bases to reduce the likelihood of tipping forward.

In addition to incorporating all these components, the aim is to design the product to be easy to dismantle/fold, of relatively low weight (max. 15kg).

2.2. Main patents underlying product design

2.2.1. Comfortable wheelchair toilet

A wheelchair commode is provided that includes a portion of the seat, a base with at least one wheel and a lifting mechanism adapted for at least one of the lifting and lowering portions of the seat relative to the base. [5]

The seat portion includes a toilet seat and a backrest, and in which the lifting mechanism is arranged to provide a space under the toilet seat to allow the toilet seat to be positioned over a toilet with the backrest of the seat adjacent to the toilet. The lifting mechanism includes two arrangements of rails, each located on opposite sides of the wheelchair commode. Each of the two arrangement of rails includes two rail elements adapted to expand and retract in a scissor-type movement. [5]

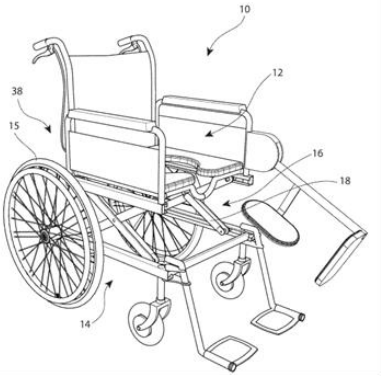


Fig.2.2.1 Comfortable wheelchair toilet [5]

2.2.2. High height wheelchair

The power-operated wheelchair (510) includes a frame (14), a lifting mechanism supported by the frame (18), a seat (22) supported by the lifting mechanism (18) configured to move the seat from a lowered position to an elevated position, a pair of drive wheels (32), at least one drive unit coupled to the frame and configured to apply torque to at least one wheel of the driving wheel pair, an arm assembly (38) including a pivotable arm element (542) coupled to the frame, a front wheel rotating coupled to the arm element and an arm limiting assembly (560) coupled to the frame (14) and configured to move from a first configuration whereby the arm element (542) is capable of pivoting relative to the frame by a first rotational range that is uninhibited by the boom limiter assembly (560), in a second configuration whereby the arm element (542) is capable of pivoting relative to the frame by a second rotational interval which is inhibited by the arm limiting assembly when the arm element (542) is the arm limiter (38), in which the arm limiter (38) is configured to compress in response to the upward movement of the arm element (542), so that the second rotation interval is less than the first rotation interval [5].

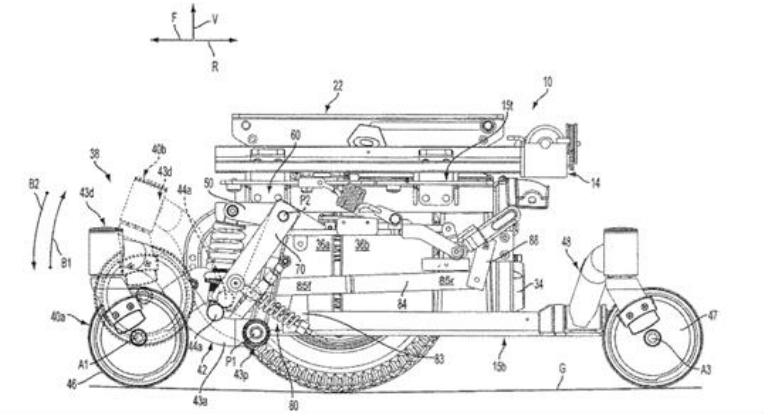


Fig.2.2.2 High height wheelchair [5]

2.2.3. Folding wheelchair

A wheelchair comprises: an armrest holder (6), a seat holder, a support of backrest (3) and a turning mechanism (64), in which the spin mechanism (64) is configured to make the armrest bracket (6) and the seat. the backrest rotates synchronously in relation to the backrest holder (3) [5].

Fig.2.2. 3 Folding wheelchair [5]

3. Strategic product marketing

3.1. Stages of development of the ergonomic wheeled chair for people with locomotor disabilities

3.1.1. Identifying market opportunities

Following the market analysis, it was found that there is a possibility of introducing SPD, following conclusions [4]:

- the non-existence on the Romanian market, according to the current knowledge of the team, of a wheelchair that has ergonomic wheels in its composition;
- the non-existence on the Romanian market, according to the current knowledge of the team, of a wheelchair to transfer the stresses placed on the weaker muscles of the shoulders and arms on the muscles of the upper back;
- the non-existence on the world market, to the current knowledge of the team, of a wheelchair that presents a modeled foam cushion in order to adopt the correct seating position and to reduce the shocks felt after the movement.

3.1.2. Mission formulation

The product description can be achieved using the following assumptions [4]:

- The wheelchair is removable/foldable weighing between 5-10 kg;
- Easy to use and efficiency in storage, taking up very little space;
- Manually operated, allows a movement of pulling back the frame of the seat e for forward movement;
- Reliable and robust.

3.1.3. Selection of potential customers

The selection of potential customers was done using the selection matrix as follows in Table 1 [1],[2],[6],[7].

Table 1. The matrix of selecting potential customers

	Top users	Users	Retailers	Service Center
Clinics for people with disabilities (occasional use)	1	6	2	2
Organizations for people with disabilities (frequent use)	3	9	1	
People with disabilities (heavy use)	1	2	2	

The product is addressed to a market consisting of:

- the user (the person concerned, the relatives of the persons);
- retailers;
- store networks;
- sales centers;
- production department;
- organizations to help people with disabilities.

To identify the requirements of potential customers, the interview was used. The interview guide used in the collection of raw data is presented in Table 2, where the answers given most frequently were selected and completed [1, 4].

Table 2. Model interview used

Product attributes	Responses	Requirement interpreted
Features of use:		
1.The medium of use of the product.	Yes	SPD is used in any atmospheric conditions
2.Provides mobility to all people with disabilities.	Yes	SPD is useful for people with disabilities.
3.It is a comfortable product.	Yes	SPD is comfortable for both the seat and the back.
4. It has additional accessories.	Yes	SPD offers various additional accessories.
Pleasant aspects of the product:		
5. Easy use	Yes	SPD allows mounting and disassembly of seat elements easily and quickly.
6. Provides safety in operation	Yes	SPD ensures the safety of the person using it.
7. Stability	Yes	SPD is light and stable on the go.
8. Documents of use	Yes	SPD is accompanied by the user manual
Unpleasant aspects of the product:		
9. High gauge	Right away	SPD can be quite compact compared to other seats in terms of gauge.
10. Low strength	Right away	SPD withstands accidental shocks
Proposals for improvement:		
11.Product maintenance is easy.	Yes	The SDP has easy maintenance according to the instructions.
12. Pleasant design	Yes	SPD has a pleasant design.

Based on the requirements identified among the users will develop the SPD product that needs to be to live up to the expectations of future customers.

4. Establishment of specifications

4.1.1. Sizes and characteristics of competing products existing on the Romanian market

An important stage in the process of developing a product is the establishment of objective specifications of the product, those values of the characteristic sizes of the requirements, for which the market success of the product is possible [5]. These values are set according to the specifications of competing products [1, 2, 6, 7].

Five competing products were used for one comparison. The characterization of competing products will be based on the following elements: overviews, developed functions and main technical characteristics [1, 2, 6, 7]. Table 3 shows important sizes and characteristics of the four competing products presented in the current study:

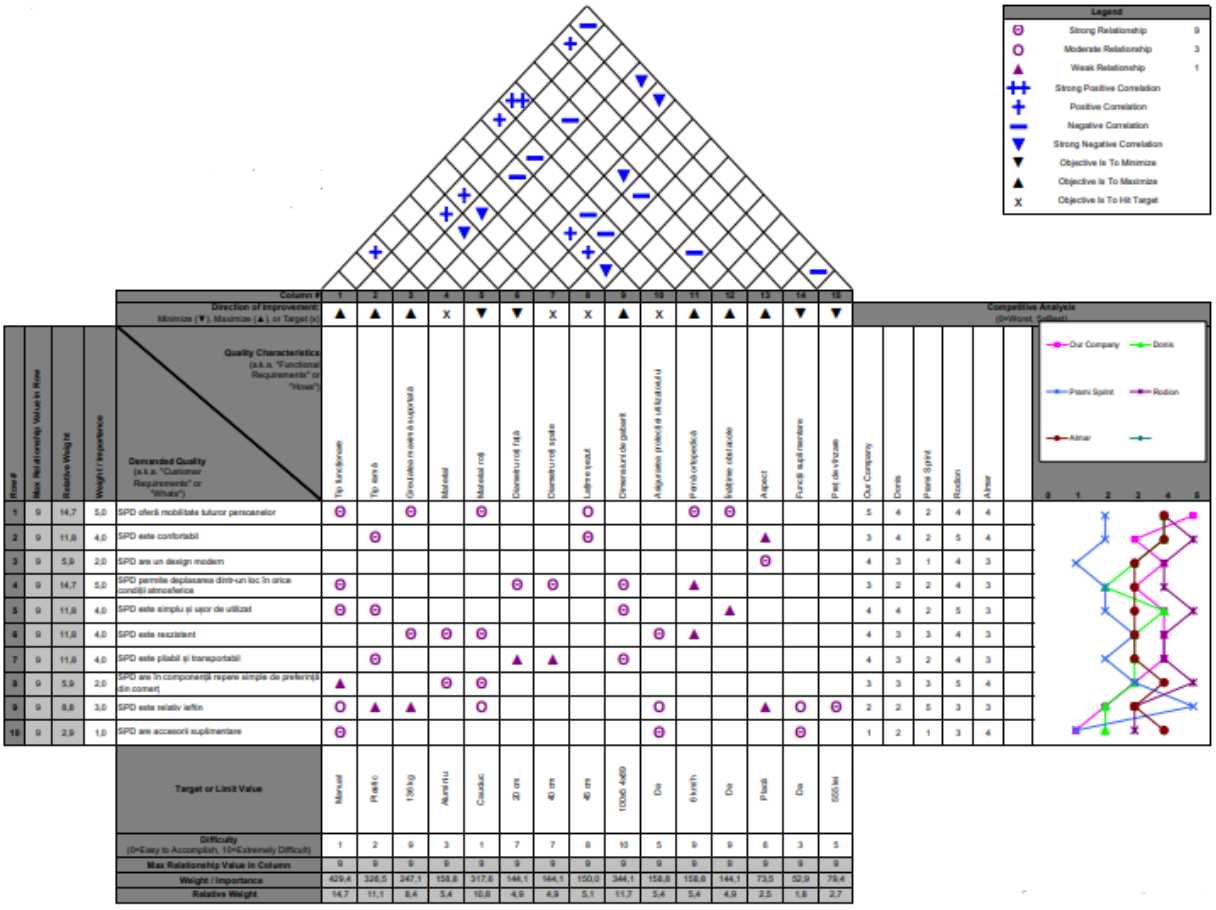
Table 3. Important sizes and characteristics

No.	Size / character.	Unity	Competitive products				
			DONIS wheelchair	PRAMI SPRINT wheelchair	RODION wheelchair	Wheelchair ALMAR	SPD
1	Operation type:	Any kind	Manual	Manual	Manual	Manual	Manual
2	Frame type	Any kind	Pliable	Pliable	Pliable	Pliable	Pliable
3	Maximum mass supported	medical history	110	110	136	115	120
4	Material	Any kind	Steel	Steel& Aluminum	Aluminum	Steel& Aluminum	Aluminum
5	Wheel material	Any kind	Rubber	PU	Metal	Rubber	Rubber
6	Front wheel diameter	cm	17	20	19	19	20
7	Back wheel diameter	cm	58	30.5	40.6	19	28
8	Sitting width	cm	46	46	43	42.5	47.5
9	Overall dimensions	cm	102x67x90	102x63x93	100.5x67x96	100x51x89	108x62.3x91.5
10	Maintenance and installation manual	Yes/No	No	Yes	Yes	Yes	Yes
11	Orthopedic pillow	Yes/No	No	No	No	No	Yes
12	Provides user protection	Yes/No	No	Yes	Yes	Yes	Yes
13	Obstacle height and curbs	cm	-	5	4	35	40
14	Appearance	Subjective	pleasant	unpleasant	pleasant	pleasant	pleasant
15	Additional functions	Yes/No	No	No	No	No	No
16	Selling price	euro	555	600	700	590	850

4.1.2. The house of quality

The first step in completing the quality house is to identify customer requirements and give importance to each requirement. The importance is usually complemented by grades from 1 to 9. The technical characteristics are defined below by translating customer formulations into physical phenomena. The roof of the quality house shows what kind of connection there is between the technical characteristics. Table 4 shows the quality house as follows. [1, 2, 6, 7, 8].

Table 4. House of quality



The Competitiveness Assessment matrix describes how other companies meet customer requirements and have been graded: 1; 3; 5; 7; 9; and for the "Sales coefficient in the future" different marks were given: 1; 1.1; 1.2; 1,4 presented in table 9 [1, 2, 6, 7, 8].

Table 9. Significance of grades

NOTE 1 not important
NOTE 3 unimportant
NOTE 5 important
NOTE 7 very important
NOTE 9 particularly important
Coef. 1 stationary sales
Coef. 1.1 slight increase
Coef. 1.2 significant increase
Coef. 1.4 major increase

An analysis is needed in order to be able to compare the new product requested by customers with existing similar products and to identify those additional features that will ensure competitiveness on the Romanian market.

In order to complete the matrix of the technical characteristics, the connection is made between the requirements of the clients and each technical characteristic granting the grades 1; 3; 5; 7; 9 grades given by multiplying by score standardized [1, 2, 6, 7, 8].

Following these, the evolution of the characteristics will be completed with symbols and finally the roof of the quality house, which is made up of the correlation of the technical characteristics. The evolution of the characteristics is as follows: Increases ↑; Expires ↓; Const ≡; Indif ×.

The signs adopted in correlating the characteristics with the customer requirements are shown in Table 10.

Table 10. Characteristics correlation indicators

Strongly positive	circle with +
Positive	the sign +
Negative	the sign -
Strongly negative	circle with -

At the bottom of the quality house are listed the target values for the technical characteristics. Current priorities, competition and future goals have been set.

5. Conclusions

Given the existing products on our market with their shortcomings / disadvantages, the research undertaken clearly indicates that the new product is needed. On the marketing side, the market opportunities in Romania were identified with the potential clients.

The QFD method was applied to determine the importance of specifications and features.

Based on the presentation of this paper, the following stages of product development will be followed, such as: project management, conceptual design, detailed design, prototype manufacturing and testing, and economic analysis.

6. Bibliography

[1]. Historic wheelchair, https://ro.eferrit.com/istoria-scaunului-cu-rotile/, accessed on April 15, 2022,

[2]. Aulive – inspired products, , https://www.moreinspiration.com/article/6294/ergonomic-wheelchair-wheels?t=healthcare, accessed on April 18, 2022;

[3]. emag.ro, https://www.emag.ro/search/scaun+cu+rotile/sort, accessed on May 7, 2022,

[4]. Ionescu N., (2017), Product Development - Course Notes, POLITEHNICA University of Bucharest;

[5]. Google Patents, https://worldwide.espacenet.com/patent/search/family/067155322/publication/CN209091918U?q=Wheelchair, accessed on March 11, 2022;

[6]. Doicin, C., (2009), Economic analysis in engineering, Bren Publishing House, Bucharest;

[7]. Doicin C., (2009), Analysis of investment projects in economics, Bren Publishing House, Bucharest;

[8]. Ghiculescu, D., (2007), Strategic Management, Printech Publishing House, Bucharest

RESEARCH ON THE DEVELOPMENT OF A DISPENSER FOR TABLETS

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ABSTRACT: This case study is based on the innovation of a product used for medical purposes based on a business strategy that has helped to identify the needs of potential customers and competing products. Also, market segmentation and target profile were an important factor in performing the functional analysis. Thus, the conceived concepts support the users by streamlining the way of administering the drug treatment.

KEYWORDS: dispenser, medicines, product development, innovative products.

1. Introduction

Medication consumption is an indicator that reflects both the health of a country's population and the efficiency of its health system and services. The data shows that Romania is a country with a low consumption of medicines, at least if we compare it with other countries in the region and the European average. According to Eurostat data from 2014, the percentage of medicines consumed in Romania is almost half of the European average. This conclusion is maintained for both prescription and over-the-counter medicines. (self-medication)[1].

The main objective underlining the development of this product was to base the research carried out within the master's program in Engineering and Management of Complex Projects on the development of an innovative product that integrates three main subsystems - mechanical, electrical / electronic and software. Also a factor that influenced the choice of this product "SMART-Pillbox Watch" was the support it can provide to the elderly.

The aim of this development was to innovate and create a medication device that is accessible for the use of people in need and to help monitor their self-medication behavior by caregivers and pharmacists.

2. Business strategy

2.1. Need analysis

For this analysis, the main needs that the device must meet have been identified. At the same time, a questionnaire was developed to identify the needs of potential users of the device. The questionnaire was distributed to a sample of 300 people, of whom 182 responded.

The characterization of the expressed needs / requirements is presented in table 2.1, as follows.

Table 2.1. Need Analysis

Expressed need	Parameter	Associated value
Be affordable	Price	< 300 RON
To provide me with the treatment for the necessary period	Storage space	14-30 compartments
Be easy	Mass/material	Max. 500g
Autonomy of 48 hours	Battery capacity	3300mAh
To be able to schedule my dose of medications Not to forget to take the medicines	Digital alarm clock No drawers	1 unit Min 3 alarms
Cannot be used by children	Locking system	1 unit
Not to recharge it very often	Recharge time	after 2 days
To alert me when I need to take the medicine	Sonorous Vibration	70 dB 120 Hz
Display the time	Digital screen	1 unit
Not to damage the drugs	Comprising	Appropriate hygiene rules
Not to mix up the drugs Taking the right medications	Automatic opening system	-
Connectivity	Association	Bluetooth connection

2.2. Functional analysis

Functional analysis is a method of researching the functions of a product and consists of identifying / determining, characterizing, ordering, ranking and evaluating functions. It can be used as an independent method in solving logical problems or as a method associated with Value Analysis in the design of a product [2].

The environmental elements and the connection of these elements with the product proposed for development are presented in Table 2.2.

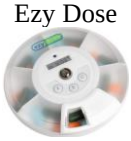
Table 2.2. Functional analysis

Environmental elements	**Actions of the environmental element**	**Main functions/ constraint**
User	Helps to achieve the main function	FC1- Make it easy to use FP1-Provides protection of medicines
Watch storage place	Ensures storage of the watch	FC2- Ensures efficient compartmentalization FP2- Dosage of drugs according to an appointment
Charger	Ensures battery charging	FC3- To be ergonomic
Stored medications	Helps to achieve the main function	FC4- To be airtight
Eye	Helps identify the design	FC5- Keep your medications safe
Water/dust	Helps identify materials and protect them	FC6- To have a durable material
Medicines in compartments	Helps identify external material	FC7- Allows charging the battery
UV light	Helps identify external material	FC8- To have a pleasant design

2.3. Competing products

Following the research and documentation phase, 4 competing products out of the 30 analyzed both from the Romanian market and other states were among the most relevant products comparable to the present idea, as shown in table 2.3. [8].

Table 2.3. Competing products

Product	Features	Advantages	Disadvantages
E-pill 4 	Dimension: 14.6 x 11.4 x 7.6 cm Material: plastic Number of compartments 4	The lids tightened on each pill box ensure that your pills do not drop when you are on the move. The set alarms will be repeated automatically every day.	Small pill organizer The duration of the alarm is 15 seconds. The material does not withstand stress Short battery life
Ezy Dose 	Size :14.5 x 14.5 x 4.2 cm Material: plastic Number of compartments 7 Bluetooth	Setup is simple, but requires some technical knowledge. The alarm is loud enough to wake you up.	The lid is not easy to close securely. The rotation does not lock, it can rotate freely. Very small compartments
MedQ Daily Pill Box 	Material: plastic Number of compartments 14	Provides treatment for 14 days Visual warning to indicate	It has no compartment locking system One to two alarms can be scheduled per day price
Live Fine Bluetooth Pill Dispenser 	Material: plastic Bluetooth Dimensions: 23.5 x 23.5 x 7.6 cm	It can be set up for up to 4 weeks The digital interface is very clear, and the lock cover prevents unauthorized access to the pills	Works with batteries It allows the transfer of several pills from one slot to another, allowing a patient to overdose on a drug.

Following this analysis, it was found that none of the identified products offer the safety system with which the dispenser proposed by the authors will be equipped/innovated with.

2.4. Market segmentation

Market segmentation is a marketing term that refers to the division of customers into groups or segments with common needs. Dividing into smaller parts allows potential producers to target different categories of consumers who perceive the value of certain products or services differently. Segmentation is, in fact, a supplement to market research that seeks to identify target groups in order to design a product and its brand in the most attractive way possible for the group [2].

Therefore, analyzing the culture of major countries, it was observed that there are no different habits in the use of the product for the administration of pills, and that regardless of race or religion, customers who buy the dispenser pursue the same way of using these products. Thus, it was concluded that there is no need to segment the market geographically for the proposed product.

2.5. Target customer profile

According to statistics, both females and males have the same degree of interest in purchasing a pill box watch because they feel the need to maintain a healthy lifestyle. In conclusion, the most favorable market segment for the sale of our product is made up of potential customers in the category of people older than 55 years, because they have a much higher degree of interest than the other categories, having a much higher need for themselves as well as for those close to them.

In addition, revenue is an important element in terms of its acquisition. Also, other potential buyers are nursing homes and hospitals, this product helping to distribute medicines în an easier manner for their patients, thus streamlining the internal distribution of medicines.

3. Development of technical solutions

The selection of the concept is often done in two stages, as a way of handling the complex process of evaluating dozens of product concepts. Sorting concepts consists of a rough and quick assessment of some viable alternatives. Conceptual evaluation is a more accurate evaluation of a few proposed concepts in order to choose a single concept, with the maximum probability of leading to a successful process [3].

In an attempt to identify the concepts, all team members developed their own concept, these are shown in Figure 3.1.

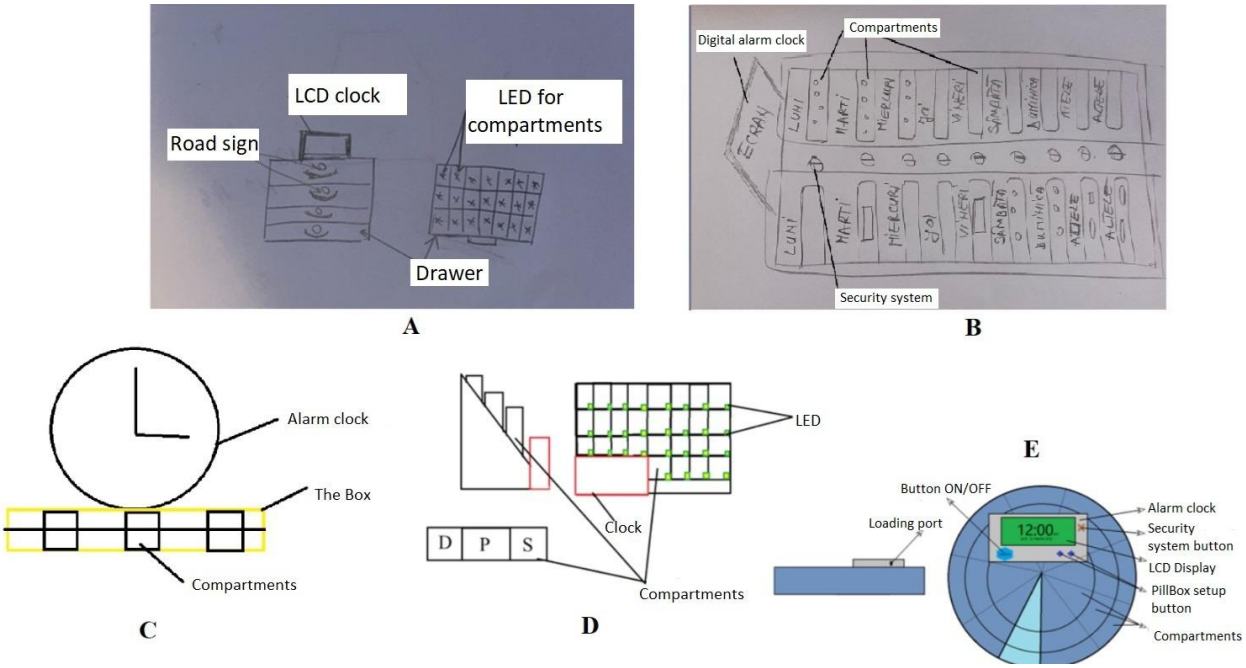


Fig.3.1. Concepts

In order to choose the concept for developement, a hierarchy of concepts was made based on certain criteria, namely:

Criterion 1 - Component production costs

Criterion 2 - Drug safety system

Criterion 3 - Type of drive

Criterion 4 - Product design

Criterion 5 - Use of software

After ranking the criteria and concepts, their comparison was made, as presented in table 3.1.

Table 3.1. Comparison of technically possible concepts

Criterion	%	Concept A		Concept B		Concept C		Concept D		Concept E	
1	**33.3**	5	166.5	5	166.5	5	166.5	2	66.6	3	99.9
2	**33.3**	4	133.2	4	133.2	2	66.6	3	99.9	4	133.2
3	**13.32**	4	53.28	5	66.6	3	39.96	4	53.28	5	66.6
4	**6.66**	3	19.98	4	26.64	1	6.66	5	33.3	3	19.98
5	**13.32**	4	53.28	5	66.6	1	13.32	3	39.96	2	26.64
Ranking		20	**426.24**	23	**459.54**	12	**293.04**	17	**293.04**	17	**346.32**

Following the analysis of the concepts and their comparison, the number two concept was chosen for further development, taking into account the most expressed needs of consumers. It offers generous partitioning, and is also designed to meet the primary need, with a mechanical-electronic drive, equipped with an LCD screen. In addition, an automatic safety system is desired, so the compartments are opened by the integrated system.

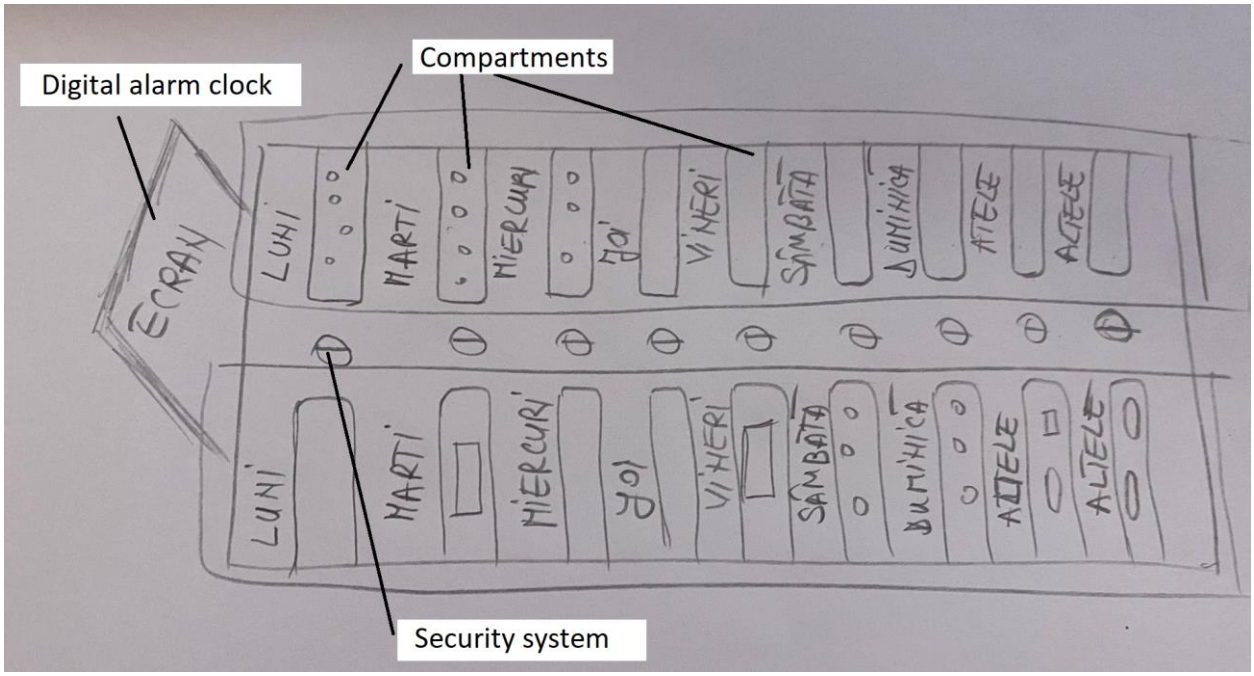


Fig.3.2. Concept B

4. Design of the chosen concept

The product "Smart Dispenser" consists of the appropriate box, medicine compartments, and each space contains an LED to indicate the drug to be administered, a clock-style screen that is equipped with a software system for setting alarms, and the system implemented to secure the compartments, to prevent them from being easily opened by children.

A first iteration of the technical solution design is shown in Figure 4.1. The compartments are operated by a mechanical system, so the user can administer their medication by pressing the lock button that will allow it to open.

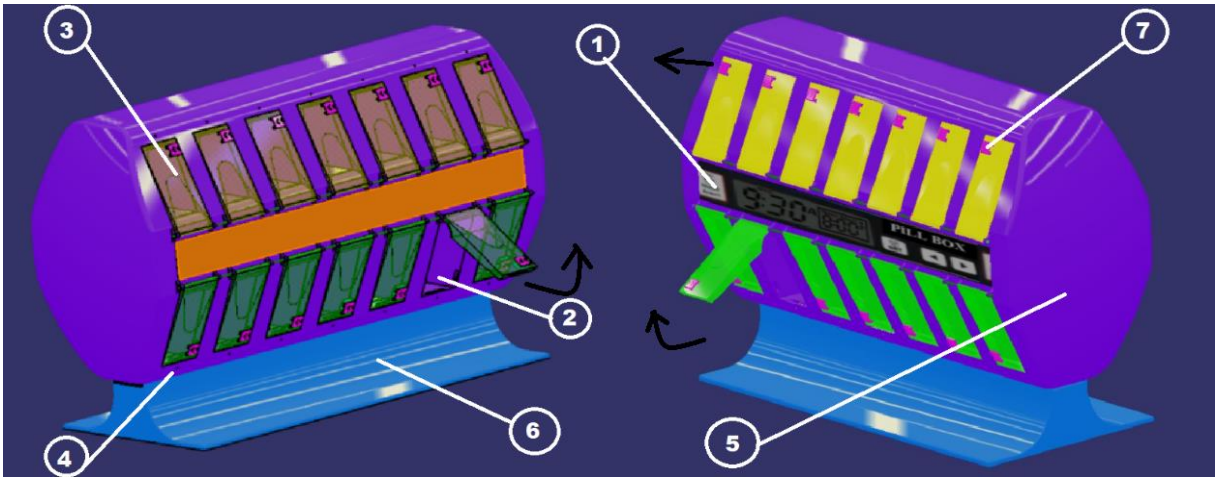


Fig.4. 1. Concept B- the first iteration

The components of the concept are shown in Table 4. 1:

Table 4.1 Components of the concept

Item No.	Components	Component description
1	Digital clock	Component to be integrated as a whole
2	Compartments	It is made of a material that protects the medicines from moisture, so as not to degrade. Its main function is to keep the drugs safe.
3	Transparent covers	It ensures the sealing of the compartments, having a not very hard polymer material.
4	LED	Indicates the subdivision of the drug to be administered according to the scheduled alarm
5	Housing	It is made of a solid material, which has the primary role of protecting the dispenser components.
6	Support	It is made of a hard material, which has a supporting role so that the housing does not degrade. Its main function is to keep the housing safe.
7	Compartment locking system	Functions automatically
8	Microcontroller	It is designed to be programmed to control dispenser operating modes (ESP32 D1 Mini)

It was also identified another technical solution by which the dispenser can dispense the medicines in a more efficient way, namely: the compartments at the top are provided for storage, and with the help of a magnet-operated pallet will allow the passage of a single tablet to the bottom. The main components of this device are shown in Table 4.2.

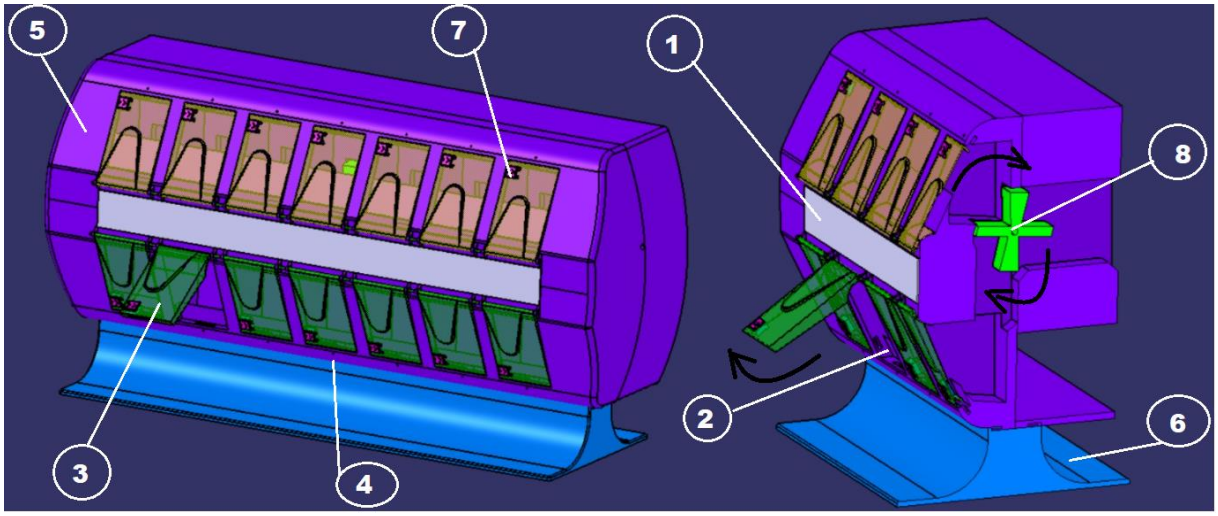


Fig.4.3. Concept B- second iteration

Table 4.2. Components of the concept

Item No.	Components	Component description
1	Digital clock	Component that we want to purchase and adapt to our system.
2	Compartments	It is made of a material that protects the medicines from moisture, so as not to degrade. Its main function is to keep the drugs safe.
3	Caps transparent	It ensures the sealing of the compartments, having a not very hard polymer material.
4	LED	Indicates the subdivision of the drug to be administered according to the scheduled alarm
5	Housing	It is made of a solid material, which has the primary role of protecting the dispenser components.
6	Support	It is made of a hard material, which has a supporting role so that the housing does not degrade. Its main function is to keep the housing safe.
7	Compartment locking system	It works automatically
8	Palette	Helps with the dosage of drugs
9	Microcontroller	It is designed to be programmed to control dispenser operating modes (ESP32 D1 Mini)

Finally, the two technically feasible conceptual solutions presented above should be able to be supplied with (compressed) drugs, be scheduled, release a dose of drugs according to a schedule, give certain notifications during operation and operate in optimal parameters.

5. Conclusions and perspectives

The project is based on the development of a smart dispenser product to support people undergoing medical treatment.

In the first part of the paper, the identification of needs and the choice of a product idea through a criterion analysis was made. Following the needs analysis on the chosen product, these

needs were identified and conceptualized based on answers to the questionnaire by its potential users.

Following the analysis resulting from the segmentation of the market and the choice of the target segment, it was proposed to achieve the profile of the target customer, according to well-established criteria. Also, there are no competitors on the Romanian market for this type of product, finding the US market as a competitor, this fact emerging from the analysis of the competition.

Putting into practice the previously obtained data, we developed five concepts to meet the needs for this product, and following the ranking of criteria and concepts, as well as their comparison, a concept was chosen for further development in CAD type software.

The concept chosen in the current stage is integrated in the development of the technical solution. The design and development of the electronic subsystems and the definition of the working modes to be programmed are to be completed. Next year we will try to experiment and test the functionality of the main subsystems and also prepare a prototype that best reproduces the proposed functions and services.

Finally, an optimized technical solution will be developed through several iterations in which we develop, design, dimension, test and prototype, to respond to every requirement we set out to fulfill.

In conclusion, the main target of the research was to obtain a product in line with current technological requirements, a device that will come to the aid of numerous people both in Romania and Europe.

6. References

[1]. *** Eurostat- Self-reported use of non-prescribed medicines by sex, age and degree of urbanization

[2]. Stanciu C.,"Development of Innovative Products and Services 1", Course Notes, UPB 2021-22.

[3]. Dijmărescu M R," Development Project 1", Course Notes , UPB 2021-22

[4] . ***, Catia V5 Program, University POLITEHNICA of Bucharest, Faculty of Industrial Engineering and Robotics. 2022.

[5]. Abaza B.,"Project Management 1", Course Notes, UPB 2021-22

[6]. Gheprghe M. .,"Manufacture of products", Course notes , UPB 202 0-21

[7] Brown, M., Bussell J. (2011) Medication Adherence: WHO cares? Mayo Clinic Proceedings.86(4), 304-314.

[8] *** , https://www.amazon.com/

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STUDIES ON STRATEGIC MARKETING AND ESTABLISHMENT OF TRUNK SPECIFICATIONS FOR DESIGNER CLOTHING AND SHOES WITH INTEGRATED SECURITY SYSTEM

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ABSTRACT: The main objective of this project is to research the new market requirements in order to create a trunk for designer clothes and shoes with integrated safety system. A market study will be carried out where the existing products on the market will be analysed and the potentials customers for the new product will be determined. The scientific importance of the topic is given by the three research directions of the realization and implementation of the new product: a) strategic product marketing – where the market study will be performed, the comparative analysis of the existing products and the determination of the target group; b) conceptual design – where the sketches of the new products and the detailed architecture will be made; c) detailed design – where the 3D model will be made, based on the ergonomics and anthropometry aspects.

KEY WORDS: designer trunk, market requirements, analysis, concepts, 3D design.

1. Introduction

This work aims to research the new market requirements in order to create a multifunctional trunk for designer clothes and shoes, where the needs of the target group will be analysed in detail. These analyses will help us to determine the new functions that the product must comply with so as to satisfy the needs of each customer. At the same time, the work aims to study the main methods of promoting the trunk for designer clothes and shoes as well as market strategies. The buyers of these products, such as the trunk, are the people with a considerable income, financially independent people, who have a vast potential to buy. Usually, these products are also targeted by people who promote elegance, luxury products.

Also, people who do not buy this type of product, may be those who still have the necessary money, but they prefer a lower product in terms of quality, just because it has a lower price. Given that they are most often used by people with a substantial income, we can say that people who choose this type of product, buy them not only for their usefulness, but also for their quality, design, colour, or prestige.

The materials used in the manufacture of these products are of high quality and have a high strength, as well as when it comes to being transported.

However, some common problems with this type of product already on the market are: poor safety methods, heavy weight due to the materials used which make it difficult to transport and low-quality materials.

So, the aim of this work is to create a practical, roomy product for all products needed by the user, light in weight, with an integrated safety system. The most important thing is that the product ensures the user the best quality, but also the safety of the stored products.

However, there are very few such products, as there are no small but spacious trunks that provide a minimum of security against product degradation or theft.

2. Strategic product marketing

2.1 Identifying market opportunities

Our product is a trunk for clothes and shoes for designers. It is used to facilitate the transport of expensive clothing items (from blouses, dresses, jackets) as well as shoes.

Due to the large storage capacity, the materials that will be used to make the product and the integrated safety system, it will stand out much more in addition to a suitcase or troller. The trunk for designer clothes and shoes must stand out through elements that have not been used in the past or similar products from other companies, this will make it stand out forming an image on the market.

2.2 State of the art

There are trunk models for shoes or designer clothes, but none of them are a combination, to store both clothes and designer shoes. They also do not have an integrated safety system to provide optimal safety to the products, as they are only equipped with simple metal locks or leather buckles.

2.3 Selecting potential customers

Potential customers who might be interested in our product, more precisely the target group is largely represented by designers, fashion designers or artists, who use our product for events (shootings, fashion shows, tours, concerts, holidays) as well as for the actual display in certain clothing stores as a standard for clothing products.

2.4 Data collected from potential customers

We used the interview to identify customer requirements. The interview used in the collection of raw data aims to obtain concrete answers regarding the new requirements of the product concerned. Questions were asked for the areas: typical uses, pleasant aspects of current products, unpleasant aspects of current products and suggestions for improvement. This resulted in the following requirements:

- The product can be used to transport clothing items;
- The product can be used for storing clothing;
- The product ensures the safety of clothing products against degradation;
- The product provides a suitable storage space for all products;
- The product has a nice design;
- The product is ergonomic;
- The product is easy to maintain;
- The product is durable;
- The product allows sale in several compartments;
- The product is relatively easy to transport;
- The product has an efficient safety system;

2.5 Data on competing products

From the point of view of competing products, we will present the products of two famous fashion houses that offer for sale similar products:

- Gucci Guccissima Leather Handcrafted Shoe Trunk

We are talking about the Italian company GUCCI, which offers the product "Gucci Guccissima Leather Handcrafted Shoe Trunk", it is strictly intended for footwear. It is made of brown leather with the golden Gucci logo, with refined handles, metal corners and metal applications of the target type on the edges. This product is priced at $ 49,300 and is pre-order only.

Fig. 1 Gucci Guccissima Leather Handcrafted Shoe Trunk [1]

- Louis Vuitton – sneaker trunk

The second competitive product is also a shoe trunk and is created by a French company under the name LOUIS VUITTON. For this company, it is a tradition to create "lifestyle trunks" for passionate collectors.

Specifications: Monogram Eclipse cloth, black cowhide handles, locking clasp, micro fibber lining, ruthenium brass metal parts, 2 mirrors, 7 drawers and double handle.

Fig. 2 Louis Vuitton – sneaker trunk [2]

3. Conceptual design

3.1 Internal research for new conceptual solutions

Following the market research and the existing models, a series of concept sketches were made for the trunk for designer clothes and shoes. Thus made the sketches I chose concept 2 due to the more organized arrangement.

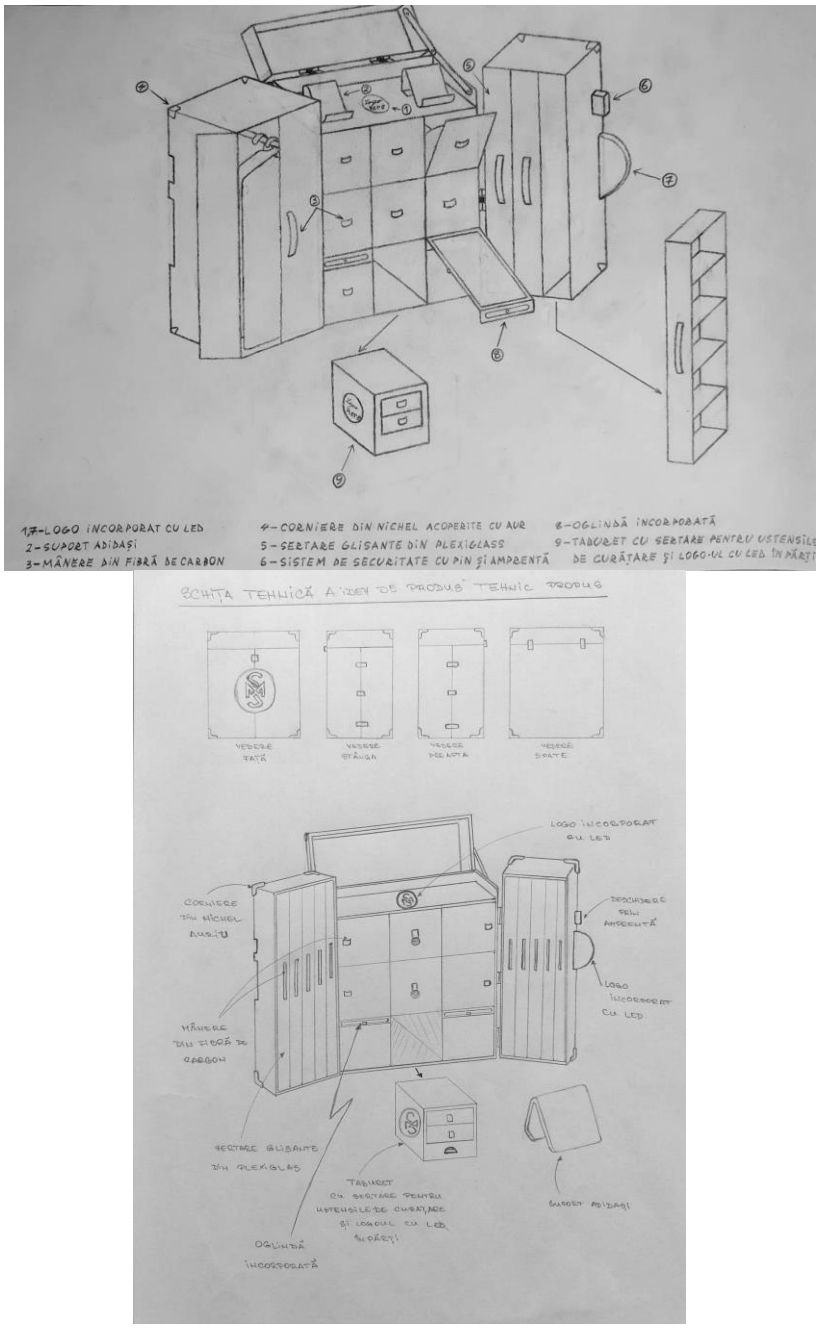

Fig. 3a Concept sketches 1 [3]

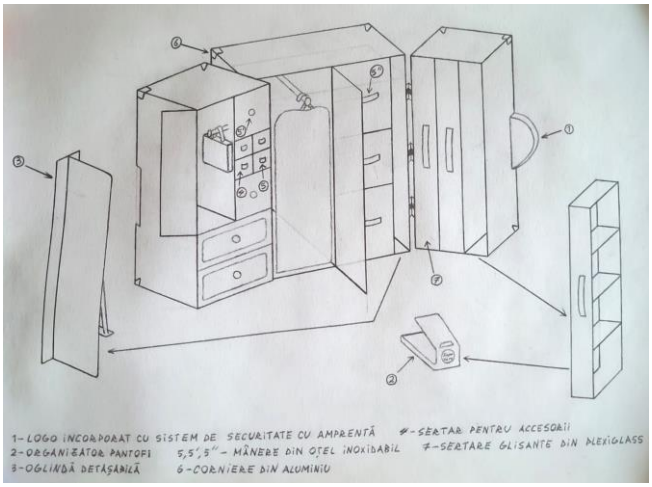

Fig. 3b Concept sketch 3 [3]

4. Detailed design

4.1 Proportion, shapes, sizes, and tolerances

- Proportions

The overall dimensions of the trunk are: 150x80 cm to facilitate its transport from one location to another.

- Shapes

The shapes used to make the trunk are quite common, namely: circles, rectangles but also arched shapes for certain elements.

- Tolerances

The tolerances shall be applied in particular to drawers so that they can be easily used, the tolerance being ± 0,3 mm.

4.2 Determination of ergonomic and anthropometric conditions

- Ergonomics

Ergonomics has an important role in the design of the trunk for the user to benefit from optimal conditions of use.

The product has been designed to be ergonomic, a design made correctly due to the shapes used to prevent illness or injury from repeated use, which can later develop long-term suffering, illness, or disability. [1]

- Anthropometry

An extremely important aspect to consider is that not only the user will come in contact with the product but also the people involved in its realization. The dimensions of the final product must be in accordance with the anthropometry of the people who will use it. In order for the shoes to be easily identified, transparent drawers have been made for when the trunk is opened and they are visible through drawers, so that the user does not have to sit bent for a long time. [2]

In order to easily identify the clothes, the compartmentalized drawers were made on types of clothes with a horizontal opening.

4.3 Defining design elements

The main design elements used are the following:

- Brand logo placed on multiple parts of the product;
- Mirrors for viewing shoes during use inside the trunk;
- Display holders for the most expensive pair of shoes;
- Metal elements in the corners of the trunk to prevent hitting;
- The stool with mini drawers on which the user can sit but in which he can also store the products for cleaning clothes and shoes.

4.4 Establishment of materials and treatments

- Cedar wood

Cedar is more weather resistant than other common wood varieties, making it ideal for the skeleton of certain products. Cedar is also rot-resistant and, as it is naturally water-resistant, does not require any pre-use treatment and is easy to process. Cedar wood can be easily processed to obtain plywood. Cedar plywood will be used to make the trunk skeleton.

Fig. 4 Cedar plywood [4]

- Plexiglass

Plexiglass is a very commonly used material due to its advantages. PMMA plexiglass weighs half as much as glass and is much more transparent (it can be colourless-transparent, coloured, translucent, or opaque). The main features of plexiglass are: durability, reliability, affordability, diversity and quality. [3]

The side drawers for the individual pairs of shoes will be made of plexiglass.

Fig. 5 Plexiglass [5]

- Carbon fibber

What is commonly called carbon fibber is a material made up of very thin filaments of carbon atoms.

These are filaments in thin filaments which are then converted to carbon fibber in four stages:

1. stabilization (oxidation);
2. carbonization;
3. graphitization;
4. surface treatment; [4]

This material will be used to dress the trunk, to give it a modern accent.

Fig. 6 Carbon fibber [6]

- Velvet

Velvet is actually a combination of fabrics (usually 2 fabrics) and yarns, which are woven together in layers, one basic and the other on the surface, so that it is evenly distributed to give it a fine, soft feel at touch. This material can be made of silk, cotton, viscose, linen, mohair, or wool. This material will be used for subtle accents inside the trunk.

Fig. 7 Velvet [7]

4.5. 3D modelling, overall design, and execution

Due to the overall dimensions, the 3D model for the trunk of designer clothes and shoes was made to scale:

Fig. 8. 3D Models – renderings 1,2 [8]

5. Conclusions

Carrying out this scientific research work aims to create a product called trunk for designer clothes and shoes. This is an innovative and also very current product.

Our product comes with a lot of new elements, which offers more confidence and a much greater impact among designers, but also people with a considerable income. Many problems can arise when making this product, regardless of its nature and type. Problems can be of different types and can occur for a variety of reasons. Examples of this are: the material, the weight of the product which may make transport difficult, etc.

Therefore, for our product, the chosen material, carbon fibber, design, weight, and advanced safety methods are some of the aspects that potential customers could benefit from.

Also, as we know, this type of product already exists on the market, the one from the Italian company Gucci and the one from the French company, Louis Vuitton, which are competing products with our product, but there are some aspects that disadvantage them, such as size and lack of an integrated safety system.

The main objective of this project is to research the new requirements on the market, in order to create a trunk for designer clothes and shoes.

The aim was to analyse the requirements in detail and determine the factors that influenced the design of the new product. At present, much better-quality materials are used, which are getting better and better, the models are much more complex and sophisticated, and our product benefits from these aspects, and in addition to all this, a plus is that it brings the complete safety system, which has fingerprint and pin.

Even if this type of product already exists on the market, from several companies, it comes with a much more beneficial and up-to-date innovation, from which our customers can benefit. The aim of this project is to create a challenging and interesting product, and our product meets all the conditions.

The original contributions of the work are primarily the design, the materials used to make the product and the integrated safety system to protect the products against burglary.

6. Bibliography

[1] Donald A. Norman (2002), *The Design of Everyday Things*. Basic Books, ISBN 978-0465067107, California;
[2] Bill Moggridge (2007), *Designing Interactions*. The MIT Press, ISBN 978-0262134743, New York;
[3] Bruce W. Gonser, *Modern Materials*. Academic Press, ISBN 978-0323150507, California;
[4] https://ro.eferrit.com/ce-este-fibra-de-carbon-2/, accessed la 23.04.2022

FIGURES

[1] https://www.bragmybag.com/gucci-guccissima-leather-handcrafted-shoe-trunk/, accessed 07.05.2022
[2] https://eu.louisvuitton.com/eng-e1/products/sneaker-trunk-monogram-eclipse-nvprod2050001v/M20146, accessed 07.05.2022
[3] Own images
[4] https://cswoodsolutions.ro/product/placaj-cedru-2500x1220mm/, accessed 29.04.2022
[5] https://publicitate.geplast.ro/productie-publicitara/placi-pmma-plexiglas/, accessed 06.05.2022
[6] https://ro.eferrit.com/ce-este-fibra-de-carbon-2/, accessed 06.05.2022
[7] https://www.nikodo.ro/catifea-imprimata-704.html, accessed 06.05.2022
[8] Own images

PING-PONG BALL THROWER FOR TRAINING

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ABSTRACT: Our work called Ping-pong ball thrower for training includes the following chapters: Introduction, current status, mission formulation, specification setting, conceptual design and detailed design. We started by identifying customer needs portfolio, and then finding opportunities to put them into practice on our device. In the next chapter on specifications we folded them according to the needs portfolio. Then, based on these, several design ideas were analyzed, of which the most reliable was preserved. With this, further consideration was given to the characteristics and technical specifications of the basic components for the device that we designed with the help of the specific software.

KEYWORDS: Ping-pong, thrower, concept, design.

1. Introduction

The presented product will be a ping pong ball thrower for training, the objectives are to make improvements by differentiating from the other competing products currently on the market and the way of developing the product is that of research, analysis and comparison with other similar products.

2. Current status

2.1. Strategic marketing of the product

2.1.1. Identifying market opportunities

A.1 Portfolio of customer needs
N1: The need to acquire reflexes during a ping pong game;
N2: The need to increase the punching accuracy of the ping pong ball;
N3: The need to play ping pong by yourself without the need for a teammate;
N4: The need to learn to hit the ping pong ball better and better;
N5: The need to improve your technique;
N6: The need to be able to monitor game statistics directly from your mobile phone using an application.

A.2 Opportunities / Products / Customers

a) Market opportunities (reasons for the need):

For the N1 need:
There is no equipment on the market that helps you improve your reflections.
For the N2 need:
There is no equipment on the market that helps you improve the punching accuracy of the ping pong ball;
For the N3 need:
There is no equipment on the market that helps you play ping pong by yourself;
For the N4 need:

There is no equipment on the market that heps you hit ping pong balls efficiently,
For the N5 need:
There is no equipment on the market that helps you to quickly improve your game technique.
For the N6 need:
There is no device on the market that can quickly connect to an app directly from your mobile phone that will help you monitor the statics of each ping pong match.

b) Products that meet specified needs:

For the N1, N2, N3 needs:

For the three needs listed above, a device will be created (device that helps you to play table tennis without needing an opponent).

c) Potential clients:
For product P1:
* *athletes who are passionate about ping pong*;*
college students;*
students;*
children with minimum age of 7 years;*
sports clubs;*
fitness centers;*

2.2 Restrictions on the production of the product prototype

R 1: To have a simple constructive form;
R 2: Have high execution speed;
R 3: To be able to process large parts;
R 4: To be able to process parts with heavy weights;
R 5: Contain items made of cheap and easily procured materials;
R 6: To have a large potential market;
R 7: Have the lowest possible cost.

2.3. Mission formulation

Our mission is to build the best pitcher that is aimed at beginners and children at a low price, that will give you in time special abilities of hitting, positioning on the ping pong table, agility and very high reflections. We thought about implementing some special features that will make this robot aim at one ball or more balls at a time frame selected by the user so that we can adjust the throw speed of each ball and we also thought about programming it in such a way that to be able to connect to the internet through a proprietary application that will allow you to set these functions directly from your phone and besides this we also thought to put a lighting system in front of him so that we can play ping pong and during the time night. [1]

2.4. Collected data from potential customers:

What do you think of the ping pong ball throwing machine?
Do you think it is necessary to implement an application in order to be able to monitor the statistics of each game and to be able to control the device remotely?
What will this device do to give up various opponents during the entire ping pong match?
What would you expect from this device?

Potential competitors on the market:

Fig.1. Shotmaker [3]

Fig.2. Donic Newgy Robopong [4]

Fig.3.SUZ Table Tennis [5]

3. Specifications settings

Based on the primary needs we have established the measurable sizes corresponding to each need, taking into account the indications on translating customer needs into measurable sizes and the specifications of the competing products analyzed.

An important step in the development of the product is to establish the objective specifications of the product, those values of the characteristic sizes of needs, for which the success in the market of the product is possible. According to these sizes, the conceptual design of the product, as well as its architecture, is carried out.

Matrix requirements – quality characteristics;

In order to determine the specifications objectively, we must find a correspondence between each primary need and the measurable size that characterizes it. The following recommendations shall be taken into account in relation to the composition of the list of sizes:

- The sizes must be dependent and not independent;
- The sizes must be practical;
- Subjective quantities shall be deleted where possible;
- Sizes should include popular comparison criteria.

In the following table is presented the matrix needs - quality features:

Table 1. Specifications settings

Needs	Quality characteristics				
	Information processing	Ball positioning speed	Launch speed	Positioning accuracy	
				Positioning accuracy	The tilt angle of the device
Productivity	*	*	*	*	*
Precission	*	*		*	*
Ergonomic form		*	*	*	*
Design	*	*	*		

Performance of competing products;

“Robo pong 2055, Newgy Donic”, “Table tennis robot” and “professional table tennis robot” are products that offer the operator an activity where he can train at fun and professional level.

The basic model for the first steps in working with a robot. Affordable solution for hobby players, beginners as well as professionals. With a low ball frequency, as well as a low spin/speed for learning basic movements.

The major disadvantage of these devices is the volume and the purchase price of these, being devices of beginner and professional level practice. These devices are intended for any age group depending on the level of training they want to reach.

Table 2. Competing products

Device name	Robo Pong 2055, Newgy Donic	Table tennis robot	Professional table tennis robot
Pictures	 Fig.4. Robo Pong 2055, Newgy Donic [6]	 Fig.5. Table tennis robot [7]	 Fig.6. Proffesional table tennis robot [8]
Price	5800 lei	310 lei	2600 lei
Procedure Type	Mechanical launch	Mechanical launch	Mechanical launch
Material	PVC	PVC	ABS
Number of balls	120	30	80
Competitional level	Intermediar	Beginner	Professional
Ball speed	2 - 44 m/s	2 – 5 m/s	4 – 40 m/s
Dimensions	152x79x46cm	35x24x27cm	41x36x32cm
Weight	8 kg	2 kg	4,5 kg

Objective and limit values – acceptable for quality characteristics.
Characterization: To establish the ideal objective values and acceptable limit, for each size, an ideal target (the best result the team can hope for) and an acceptable limit target (the value that allows the product to be commercially viable) is chosen. The following table shows the limit values and ideal values.

- Without looking for a real opponent,
- Speed adjustable according to the desired rhythm,
- The ability of the ball introduced,
- Battery/needle power type,
- Functions for different ball launch angles,

In this chapter were identified the necessary sizes for the realization of the conceptual and detailed design of the product, as well as their ideal values. [2]

4. Conceptual design

4.1. General function and component functions

The general function of this device is to launch ping-pong balls at a repetitive pace, creating a mechanism that allows the ball to be launched in different ways, allowing the auxiliary functions to be controlled manually by the user via the control panel.

4.2. Breaking down the general function into constitutive sub-functions.

Following the breakdown of the general function into the sub-functions, the functional shaft of the product will be formed. Primary and secondary functions will result. The main functions are qualities of the product that determine the general function, and secondary functions result from the interaction of the

main functions with each other and from the interaction between the main functions and the environment in which they develop.

Table 3. Breaking down the general function into constitutive sub-functions

SYMBOL FUNCTION	DEFINING THE FUNCTION (verb + noun)	CONSTITUTIVE SUB-FUNCTIONS	Components that participate
A	IT ABSORBS WEIGHT	a. Withstand the weight	Resistance structure
		b. Uniform distribution	Resistance structure
B	PROVIDE MECHANICAL ENERGY	a. It provides energy	Power cable
		b. It converts electric energy into mechanical energy.	Electric motor
		c. Provides power supply	Power cable
C	PROVIDES COMFORT	a. Provides contact (actuation)	The support of the tool
		b. It provides ergonomics	The housing of the device
D	LOCK POSITION	a. Inability to move	The housing of the device
		b. Change position	Position step (angle)
E	IT ALLOWS MAINTENANCE	a. Resists dirt	Storage box
F	IT HAS A LOOK	a. It gives satisfaction	Form
G	IT USES ENERGY	a. Provides power source	Electric motor
		b. Ensures the wheel is engaged	The silicone wheel
H	IT CONTROLS SPEED	a. Allows to change speed	Control panel
I	IT ALLOWS ANSAMBLING	a. Allows mounting of components	The housing of the device
		b. Allows mounting for attachment	Assembly components
J	LONG USE RESSISTANT	a. Resists actuation requests	Material
		b. He can stand the weight	Assembly
		c. Allows maintenance	Material
		d. It resists wear	Material

4.3. External research to identify known constructive solutions (interviews, patents, literature, data banks on competing products, synthesis).

In the paper “specification setting and conceptual design of a ping-pong ball pitcher for training”, conceptual solutions for the development of main functions were collected by accessing the Espacenet website from which several known patents for the development of main functions were extracted.

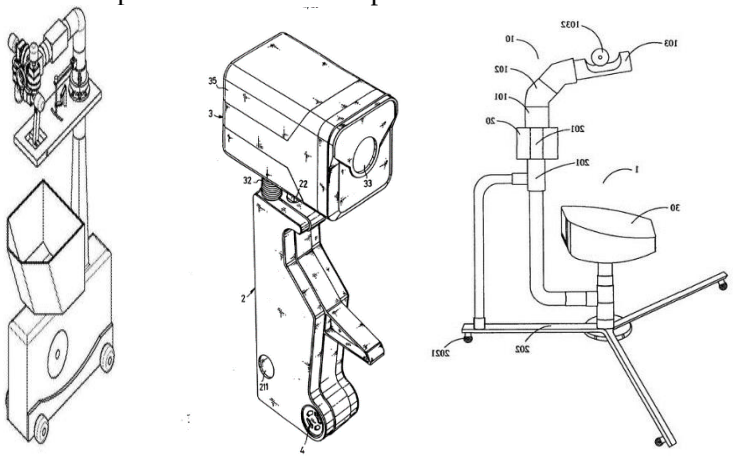


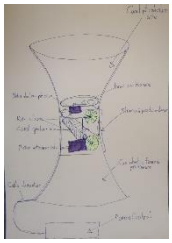
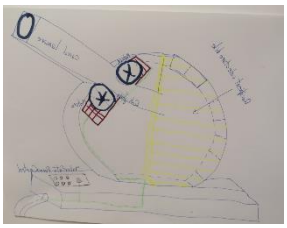
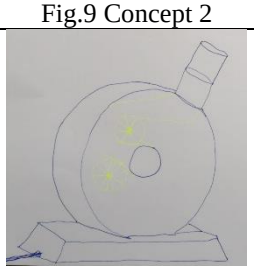
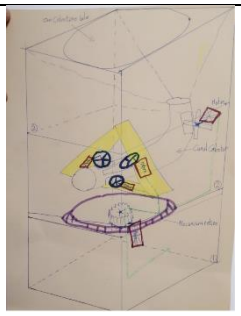
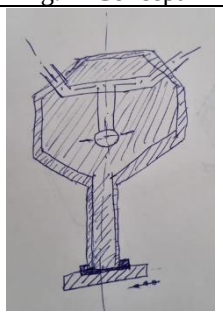
Fig.7 Extracted patent models

4.4 The triage of concepts

In this step of selecting the optimal concept, the concepts resulting from the previous stage were taken. Following the concept generation stage, a number of 6 integral product concepts developed by the team that is entitled to.

4.5. Table of integral concepts

Table 4. Integral concepts

 Fig.8 Concept 1	Concept 1	 Fig.9 Concept 2
	Concept 2	
 Fig.10 Concept 3	Concept 3	 Fig.11 Concept 4
	Concept 4	
 Fig.12 Concept 5	Concept 5	 Fig.13 Concept 6
	Concept 6	

4.6 Making the Triage matrix

Table 5. Triage matrix

Characteristic	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
Design	+	+	+	+	+	**0**
Type	-	-	-	-	+	**0**
Pos. Fab.	+	-	+	-	+	**0**
Technology	-	-	-	-	+	**0**
Cost	+	-	+	-	+	**0**
TOTAL	**3**	**1**	**3**	**1**	**5**	**0**

Following the triage of concepts, 3 integral concepts of the product were selected. Concept 1, 3 and 5. As a reference concept, I chose concept 5 (fig.12) because this concept is an obvious solution to the design problem. It is a simple solution that involves relatively low costs. [1]

5. Detailed design

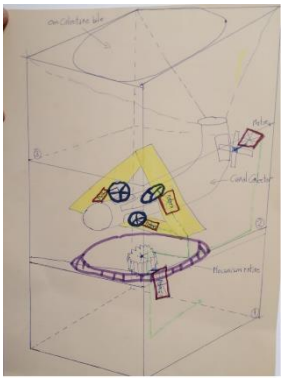


Fig.14. Concept 5

As we have presented in the previous chapters, a number of product concepts have been developed, resulting from the combination of existing technical solutions and concepts studied by the team, considering also the possibility of realization.

This will allow the following concept to be used, which will have minor design changes along the way:

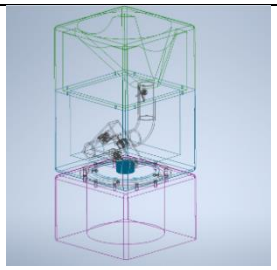
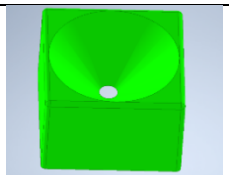
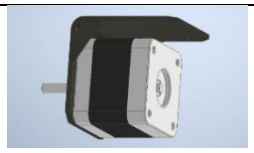
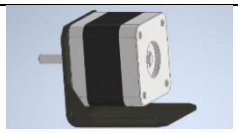
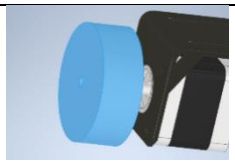
Determination of the materials used.

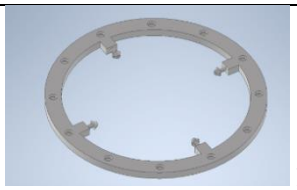
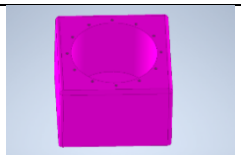
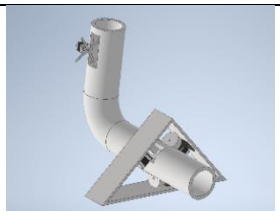
Following a study by the team on the potential materials that could be used for manufacturing, the materials used in the production of the developed product were chosen based on a market study. The aim was to identify the requirements for the materials used in the manufacture of this type of product.

The structure of the device will be made of lightweight plastic alloys to provide both strength and vibration reduction, while maintaining a light weight. All additional fixing parts will be made of metal, although attempts will be made to reduce their number as much as possible.

Accessories and parts that can be made by 3D printing will be made of plastics. [2]

Table 6. Data sheet

No.	Part name	Part Sketch	Functional role
1	Assembly of the part	 Fig.15	Launch ping-pong balls to the client for training.
1	Cone for collecting balls	 Fig.16	Provides sufficient volume to release a large number of balls
2	The electric motor that drives the disc	 Fig.17	Generates rotation motion
3	Exterior plastic structure	 Fig.18	Fixates the inner components
4	Wheel drive motor	 Fig.19	Generates rotation motion
5	Silicon wheels	 Fig.20	Launches the balls according to the controls set in the control panel

No.	Part name	Part Sketch	Functional role
7	Swing band part	 Fig.21	Rotate the top of the pitcher according to the data received from a sensor
9	Plastic cone for fixing and positioning	 Fig.22	Provides a correct launch angle and provides stability
10	Ball-throw design system	 Fig.23	Provides top-spin slide-spin and bottom-spin effects

6. Bibliography

[1].Prof.dr.ing. Cristian DOICIN, Curs Dezvoltarea produselor 1.
[2].Prof.dr.ing. Nicolae IONESCU, Curs Dezvoltarea produselor 2.
[3].https://www.dksportbot.com/ce-certificate-table-tennis-training-machine-shooting-equipment.html
[4].https://www.aliexpress.com/item/1005001895184623.html?spm=a2g0o.productlist.0.0.4a3d1e69FKo9mv&algo_pvid=05ae41ea-4378-426b-971a-829a0ea7c4f2&algo_exp_id=05ae41ea-4378-426b-971a-829a0ea7c4f2-2&pdp_ext_f=%7B%22sku_id%22%3A%2212000018041477798%22%7D&pdp_npi=2%40dis%21RON%21%21132.5%21%21%21%21%21%402101e9ce16522940165525378e64db%2112000018041477798%21sea
[5].https://www.aliexpress.com/item/4000043997504.html?spm=a2g0o.productlist.0.0.38871e69srPSvV&algo_pvid=fc4b28b5-1eb1-465a-9092-f6e8d6b34509&algo_exp_id=fc4b28b5-1eb1-465a-9092-f6e8d6b34509-5&pdp_ext_f=%7B%22sku_id%22%3A%2212000018759703804%22%7D&pdp_npi=2%40dis%21RON%21%211162.51%21%21%21%21%21%400b0a556c16522937886634827e1abe%2112000018759703804%21sea
[6].https://www.donic.com/donic/en/robots/3455/donic-newgy-robo-pong-2055-inkl.-72-donic-coach-p40-baelle
[7].https://www.emag.ro/robot-tenis-de-masa-15-mingi-de-pingpong-pvc-1591/pd/D9XQTVMBM/?X-Search-Id=cdf3e413585f8e0da426&X-Product-Id=93846011&X-Search-Page=2&X-Search-Position=15&X-Section=search&X-MB=0&X-Search-Action=view
[8].https://www.mesetenis.ro/85_Robot-Donic-Newgy-Robopong-545-cu-plasa-VERSA_12982_detalii.html?gclid=CjwKCAjw9-KTBhBcEiwAr19ig-0TP1tp4-_-MfAh4fvm8p7El7lKGajOBHgMMWHHuaygg471wBeDChoCAQAQAvD_BwE
[9].https://worldwide.espacenet.com/patent/search/family/063429292/publication/CN108514732A?q=serve%20machine%20ping%20pong
https://worldwide.espacenet.com/patent/search/family/026231619/publication/FR2728173A3?q=machine%20ping%20pong
https://worldwide.espacenet.com/patent/search/family/040126458/publication/CN201150776Y?q=serve%20machine%20ping%20pong

RESEARCH ON SMART PROSTHESIS PRODUCT DEVELOPMENT

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ABSTRACT: Finger and hand amputation are one of the most common amputations in the world, in this project it will be presented a solution for this problem.

KEYWORDS: prosthesis, design, sensor

1. Introduction

The history of amputation and prosthetics probably begins with the first instance in which a human being lost a limb and sought a replacement. Worldwide, the recorded history of amputation and prosthetics begins with Herodotus' account of a Persian soldier escaping from captivity in 484 BC by cutting off a leg and replacing it with a wooden one. The history of amputation, and therefore of forearm and hand prosthesis in Romania, begins, in terms of recorded sources, about a century ago.

At present, several products are being designed to replace the human hand, most of which are in the testing stage.

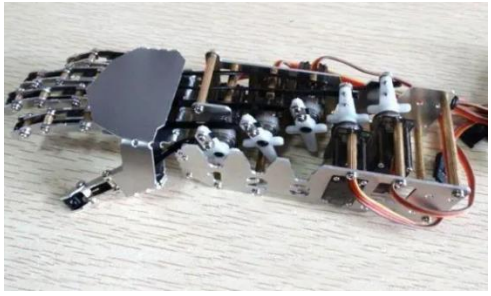
(History, 2021)

2. Current status

Today, there are many solutions to this problem but in most cases they only cover the cosmetic side, not the functional side[1].

In the case of functional prostheses they have an unnatural appearance and in some cases are difficult to use. A table of competing products has been compiled from these solutions, see Table 1.

Table 1 - Identification of competing products

No.	Competing products	Product specifications
1	 DIY 5DOF Robot Five Fingers Metal Manipulator Arm *(Arm 1)*	Mini bionic handheld, innovative and realistic design. Uses five servos to steer, each finger can move individually flexible. Features: Name: DIY 5DOF Robot Five Fingers Metal Manipulator Arm Type: QDS-1601 Age: ≥ 8 years old Weight: Approximately 163g Material: aluminum alloy Model: left hand, right hand Bionic hand size: 181.86*44mm (L*W) Servo size: 27.5 * 12 * 21 mm (L * W * H) Degree of completion: semi-finished product Price: 249,86 lei

No.	Competing products	Product specifications
2	 LOBOT uHand2.0 DIY RC Robot Arm Independent Fingers With LFD-01 Anti0-block Servos *(Arm 2)*	Brand: LOBOT Product: uHand2.0 RC robot arm Features: - With anti-block servo, better protect the arm. - Arm fingers act independently. - M3 install hole, can DIY to many kinds of robot arm. Battery recommendation: 2S 7.4V 2200mah Lipo battery (not included) Materials: acrylic + aluminium Servo: LFD-01 Anti-block servo Product weight: 184.8g Product size: 165*90mm Price: 337,45 lei
3	 Open Source UNO Somatosensory Wearable Robot Gloves *(Arm 3)*	UNO open source somatosensory wearable robot gloves Features: Built-in Bluetooth 4.0 mode Built-in acceleration sensor etc. Can control robot arm, robot machine. Specifications: Microcontroller model: Battery: 7.4V lipo battery Size: 147*113mm Weight: 260g Price: 388,37 lei
4	 DIY 5DOF Robot Arm Five Fingers Metal Mechanical Paw Left and Right Hand *(Arm 4)*	Description: Name: DIY 5DOF Robot Five Fingers Metal Mechanical Paw Type: QDS1605 Age: ≥ 8 years old Weight: Approximately 380g Material: aluminum alloy Model: left hand, right hand Hand length: 200mm Servo working voltage: 5V-6V Control protocol (TCP): 1.0 ms - 2.0 ms for servo from 0 to 180 degrees Degree of completion: semi-finished product Features: Use five servo to drive, each finger can move individually flexible. Mini handheld, innovative and realistic design. Manipulator is focused on demonstrating action, bringing goods in less than 500 grams. Price: 417,80lei

As can be seen from this table the current solutions have an industrial appearance, not a natural upper limb shape. In the following chapters a solution will be presented that covers both design and functional aspects of a prosthesis.

3. Mission statement for the selected product development

Product description:

- a fixed and mobile prosthesis that takes over the functions of the amputated parts;

Key business objectives:

- *the product is placed on the market on 1 July 2023;*
- *to reach 10% of the prosthesis market by the end of 2025;*
- *selling 1000 pieces by the end of 2025;*

The market:

- *people with disabilities;*
- *medical clinics;*
- *hospital;*
- *army;*

Hypothesis:

- *light weight;*
- *spare parts;*
- *anti-abrasion strip;*
- *easy forearm attachment;*
- *control through the wrist;*
- *100% safe use;*

Interested persons:

- *the user (people with disabilities);*
- *hospitals;*
- *private practices;*
- *medical centres;*
- *production department;*
- *health organisations.*

Matrix for selecting interviewees:

	Top users	Users	Retailers	Service centre
Private offices (occasional use)	2	5	1	0
Hospitals and medical clinics (frequent use)	3	5	2	
People with disabilities (heavy use)	2	10	1	

4. Aspects of strategic marketing

Data collected from potential customers. A questionnaire will be used to identify customer requirements. The questionnaire will contain the following questions:

1. Does the current product ensure the handling of objects?
2. Does the current product provide real-time data?
3. Is the product hygienic?
4. Is it easy to fix?
5. Is it safe to use?
6. Is it a durable product?

7. Is there a danger of limb fatigue?
8. If the product is damaged, what do you do?
9. Would a similar product weighing less be useful?
10. Would it be useful to connect it to your phone?
11. Is the aesthetic or functional part more important?

Ranking and determining relative importance

After studying the answers and interpreting them, a selection matrix was drawn up, in which scores from 1 to 5 were given according to their relative importance.

Table 2. Selection matrix

Customer requirements	**Relative importance**
PM can be used to manipulate objects	5
PM provides real-time data	4
PM is a hygienic product	4
PM has an easy-to-use fastening mechanism	5
PM offers safety in operation	5
PM is a durable product	3
PM ensures physical integrity	5
PM provides repair services	3
PM has a low weight	3
PM can be connected to the phone to access collected data	1
PM looks good and performs as expected	4

5. Setting specifications

According to the competition table presented above a table of characteristics was formed (Table 3).

Table 3. Characteristics of competing products

No.	**Size/character**	**Units**	**Competing products**			
			Arm 1	**Arm 2**	**Arm 3**	**Arm 4**
1	Weight	g	163	184,8	190	380
2	Palm size gauge [L x l]	mm X mm	181,86 * 44	165 * 90mm	147 * 113	200*111
3	Customizable	Yes/No	No	No	No	No
4	Operating time	years	2	2	2	2
5	Temperature resistance	°C	40	55	40	30
6	Clamping force	N	10	20	25	18
7	Maximum load capacity	kg	1	0,8	0,5	1,5
8	Self-tightening function	Yes/No	Yes	Yes	No	Yes

No.	Size/character	Units	Competing products			
			Arm 1	**Arm 2**	**Arm 3**	**Arm 4**
9	Water and dust resistant certification	Yes/No	No	No	No	No
10	Proportional control of speed and force	Yes/No	No	No	No	Yes
11	Adjustable clamping settings	Yes/No	No	No	Yes	No
12	Guarantee	months	12	12	12	6
13	Price	lei	949,86	1333,45	1188,37	417,80

Establishing the list of sizes and the characteristics-requirements matrix for the product

Following will be presented the Matrix of Measurements – Requirements, see Table 4.

Table 4. Size-certainty matrix

Requirements			*Sizes/features*												
		Importance of the requirement	Weight	Palm size gauges	Customizable	Operating life	Temperature resistance	Clamping force	Maximum load capacity	Self-tightening function	Water and dust resistant certification	Proportional control of speed and force	Adjustable clamping settings	Guarantee	Real-time data
			1	2	3	4	5	6	7	8	9	10	11	12	13
1	PM can be used to manipulate	5	●	●				●	●	●					
2	PM has an easy-to-use clamping	5	●		●								●		
3	PM offers safety in operation	5	●	●	●		●	●	●	●		●			
4	PM ensures physical integrity	5		●			●					●	●		
5	PM looks good and works as	5			●								●	●	
6	PM provides real-time data	4				●									●
7	PM is a hygienic product	4			●						●				
8	PM provides repair services	3												●	
9	PM has a small weight	3	●												
10	PM is a durable product	3					●				●				
11	PM can be connected to your phone to access collected data	1													●

6. Detailed design

This chapter will present the concept of the prosthesis and how it is manufactured:

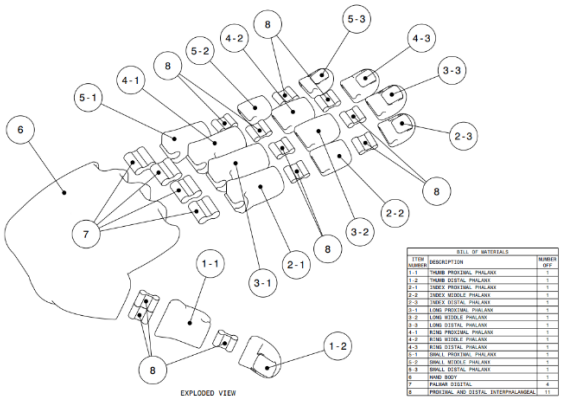


Fig.1 – Bill of materials

Figure 2 shows all the component parts of the prosthesis. Its joints will be made of a flexible material and the rest of the components will be made of a rigid material mimicking the cartilage and bones of a human hand.

The manufacturing method chosen is 3D printing, which is a low-cost solution with high flexibility in terms of materials [6].

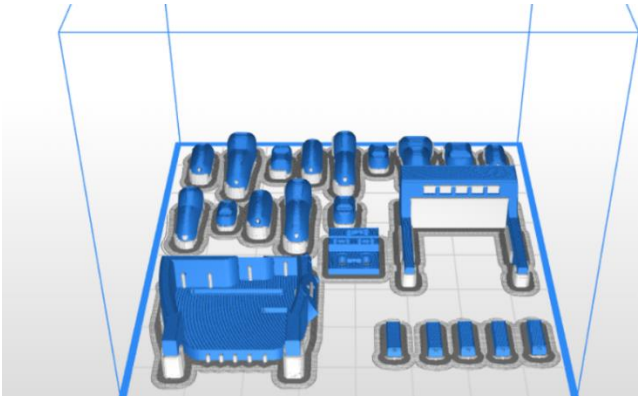


Fig. 2 Print simulation

Figure 2 shows the components on the printer table. In this simulation the z-sheet material was used and the total printing costs were 98 lei.

7. Further developments

In order to improve the user experience of the prosthesis, various sensors are added to the prosthesis to assist the user in everyday activities.

Among the sensors that can be added to a hand prosthesis are:

1. Temperature sensor
2. Humidity sensor
3. Pulse monitoring sensor

The temperature sensor (fig.3) is needed to know the temperature of an object, so there is no risk of touching an object that is too hot.

Fig.3. Temperature sensor

The moisture sensor (fig.4) is used to distinguish between a wet and a dry object. A practical example is washed clothes, where the user can distinguish between wet and dry clothes.

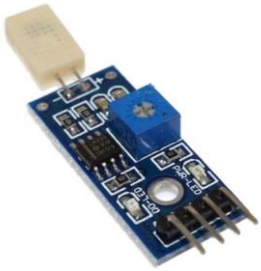


Fig.4 Humidity sensor

The pulse measurement sensor (fig.5) is a function designed to continuously monitor the heartbeat, this sensor is especially beneficial for people with cardiovascular diseases because it can act more quickly in case of heart irregularities.

Fig.5 Pulse measurement sensor

The information provided by the sensors will be displayed on a screen (fig.6) positioned on the wrist.

Fig.6 digital display

8. Conclusions

The main advantages of this prosthesis are:
-low production cost;
-the protector is adjustable and can be used by all those missing one or more fingers;
-data is collected about the objects touched, but also about the user's condition;
-provides safe conditions of use;
-does not require maintenance;

9. Bibliography

[1] Ulmeanu M. & Doicin C., Development of additively manufactured products - Applications of technical functional analysis, ISBN978-606-610-219-3, Editura BREN, București, 2018;

[2] ***, Arm 1 , available at: https://www.banggood.com/DIY-5DOF-Robot-Five-Fingers-Metal-Manipulator-Arm-Left-and-Right-Hand-QDS-1601-p-1063112.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=GB&utm_content=minha&utm_campaign=minha-gb-en-pc&currency=GBP&cur_warehouse=CN&createTmp=1&ID=41322 , accesat la data:23.03.2022;

[3] ***, Arm 2 , available at: https://www.banggood.com/LOBOT-uHand2_0-DIY-RC-Robot-Arm-Independent-Fingers-With-LFD-01-Anti0-block-Servos-p-1527085.html?rmmds=detail-left-hotproducts&cur_warehouse=CN , accessed on: 23.03.2022;

[4] ***, Arm 3 , available at: https://www.banggood.com/Open-Source-UNO-Somatosensory-Wearable-Robot-Gloves-p-1279595.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=US&utm_content=minha&utm_campaign=minha-us-pc&currency=USD&cur_warehouse=CN&createTmp=1&utm_source=google&utm_medium=cpc_ods&utm_content=nancy&utm_campaign=nancy-cdm-test-cart&creative=420128476448&gclid=EAIaIQobChMI-9qS4cLE7wIV1MneCh1nvgS6EAEYASACEgLaYfD_BwE ;

[5] ***, Arm 4 , available at: https://www.banggood.com/DIY-5DOF-Robot-Arm-Five-Fingers-Metal-Mechanical-Paw-Left-and-Right-Hand-p-1099018.html?currency=USD&utm_source=rtbhouse&utm_medium=cpc_brand&utm_content=all&utm_campaign=rtb-toys-and-hobbies-all-en&cur_warehouse=CN&ID=557353 , accesat la data:23.03.2022;

[6] M. Ulmeanu și C. Doicin, „Development of additively manufactured products - Applications of technical functional analysis” Bucuresti, ISBN978-606-610-219-3, BREN, 2018.

[7] .***, History , available at: https://umfcd.ro/wpcontent/uploads/2017/01/Scoala_Doctorala/Sustinere_Teza/in_curs_de_sustinere/POGARASTEANU_M._MARK-EDWARD/rezumat_mark_pogarasteanu.pdf

SHREDDER FOR PLASTIC WASTE RECYCLING PROCESS

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ABSTRACT: The idea of the current presentation is part of the project 'Precious Plastic', of the department of Manufacturing Engineering Department. The idea to implement this project was inspired by the youth community of Precious plastic, which has spread around the world, with an experience in the market of over 7 years, outlined by many good results over time. The project is also supported by the company 'Technobit Automatizări'. After a thorough analysis, it becomes clear how necessary it is that we increase the amount of recycled plastic, so we decided to study mechanical recycling. Specifically, we chose to design as well then build a shredder for plastic waste. Although there are similar devices on the market, it has a number of unique features, such as a larger number of radially arranged blades, power and level interruption sensors, safety and start/stop buttons, and safety caps.

KEYWORDS: plastic, waste, recycling, shredder

1. Introduction

Recycling represents an operation where the waste is introduced into a technological process in order to be reused, to reduce the processing of new raw materials. The benefits of recycling are many: reducing the number of landfills, reducing greenhouse gas emissions, pollutants released into water and air, reducing energy costs and conserving the Earth's natural resources [1-4].

Globally, there is a unique system for identifying plastics, through the ‘Code of Identification of Resins or Plastics of the Plastic Company and Industries, representing the group of polymers which the material belongs, the meanings being shown in Table 1 [5, 6-9].

Table 1. Classification of materials according to the plastic identification code

Symbol	Name	Use	Characteristics
1 PETE	Polyethylene terephthalate	 bottles, jars, food containers, foils.	- the most common packaging; - very easy to recycle; - cheap, transparent, durable, resistant to heat and chemicals
2 HDPE	High density polyethylene	 cosmetic containers, cleaning products, bags.	- opaque, durable and strong, easy to produce and process, safe (low risk of entering the packaged product); - they are easily recycled if they are thoroughly cleaned beforehand, otherwise not.
3 PVC	Polyvinyl chloride	 in construction, in the textile industry, in the medical field, for cleaning products, motor oil bottles, detergent bottles.	- durable and resistant to chemicals and under pressure from external factors; - not suitable for home use (toxic and carcinogenic); - difficult to recycle; - one of the most dangerous types of plastics for health and the environment.

Symbol	Name	Use	Characteristics
4 LDPE	Low density polyethylene	 bags for frozen food, garbage bags, food foil.	- safe for health; - durable and resistant to high temperatures; - rarely used due to high price; - rarely accepted for recycling.
5 PP	Polypropylene	 in the textile industry, for straw, hangers.	- safe for health; - durable and resistant to high temperatures; - it is used for containers in which hot liquids are stored.
6 PS	Polystyrene	 in construction, for the packaging of certain foodstuffs, electronic or household appliances	- it must be used carefully and in small quantities, especially at high temperatures, because it releases styrene; - widely used, but very difficult to recycle.
7 OTHER	Other plastics	 various plastics: polycarbonate, nylon, ABS, acrylic, PLA	- polycarbonate (technical equipment, electronics, appliances, lenses, armored windows, containers, such as bottles) considered toxic, releases bisphenol

The recycling process can be of several types, detailed below, each including three basic steps. The first step is the collection, then the residue goes through any of these procedures and is transformed into a raw material, and in the final stage, it is transformed into a finished product. [5,9-15].

1. Mechanical recycling: is the most widely used method globally and involves the mechanical transformation of residues into new materials, without changing their chemical structures, allowing the polymers to be reused several times. [5,10-11,16];
2. Chemical recycling: it is the most complex method, being in an incipient, which requires technological development, and is represented by the modification of the chemical structures of the materials, being a process that involves high costs and high consumption of energy and resources [5,9-11,13];
3. Energy recovery: consists in the transformation of waste into fuel used for the generation of thermal / electrical energy, being a process that requires little space, but high investments and risks [10,11,16];
4. Biological recycling: applied to biodegradable plastics, microorganisms producing stabilized organic residues, depending on the treatment, aerobic (carbon dioxide, water) and anaerobic (methane) [16].

2. State of the art

Global, plastic production has grown exponentially in just a few decades, from 1,5 million tons in 1950 to 368 million tons in 2019. In the first half of 2020, plastic production dropped sharply, caused by Covid-19, and recovered in the second half of the year. With this return, plastic waste also reappeared [17].

Figure 1 and Figure 2 show the global and European development of plastics production. The figures in the illustrations do not include the production of recycled plastic.

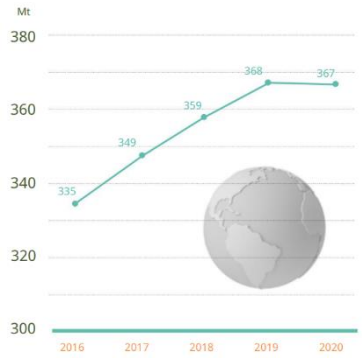


Fig. 1. World plastics production [18]

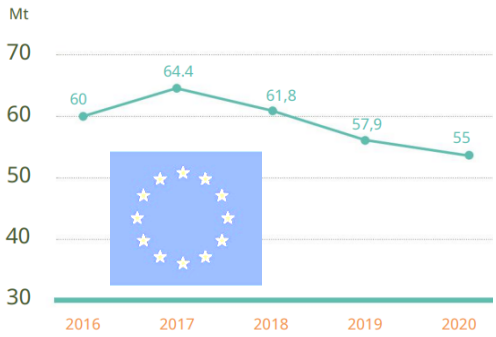


Fig. 2. European plastics production [18]

Table 2 shows the percentage distribution of global plastics production.

Table 2: Distribution of global plastics production [18]

China	NAFTA	Thew rest of the Asia	Europe	Middle East, Africa	Latin America	Japan	CIS
32%	19%	17%	15%	7%	4%	3%	3%

Organic waste, such as food waste, is biodegraded, decomposed or composted shortly after disposal. Plastic products, on the other hand, do not decompose, do not biodegrade and do not compost. These three processes depend heavily on the ability of microscopic organisms to consume and decompose organic waste. Most plastic products are made from synthetic chemical components, such as PET, which cannot be utilized by biodegradable organisms. As such, plastics cannot be easily degraded [19].

In Europe, the most common method of plastic waste disposal is energy recovery, followed by recycling. Landfilling is at 25%.

Half of the plastics collected for recycling are exported for treatment to countries outside the European Union. The main reasons for export are lack of technology, capacity or financial resources for waste treatment locally.

Fig. 3. Time required for decomposition [20]

Due to the low recycling rate of plastics in the European Union, there are enormous losses for both the environment and the economy. Approximately 95% of the value of the plastic packaging material is lost after the short cycle of first use.

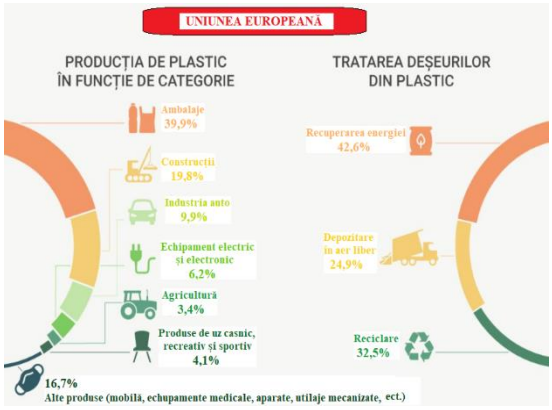


Fig. 4. Production and treatment of waste

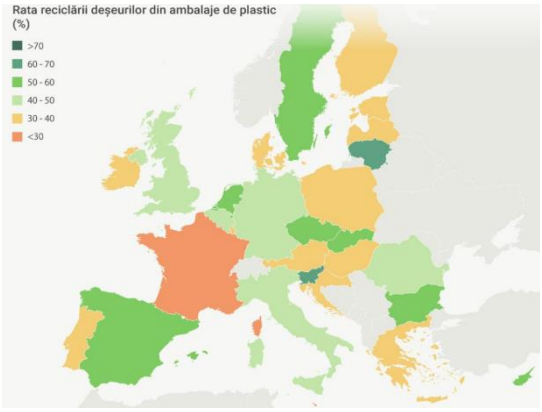


Fig. 5. Waste recycling rate [17].

The researchers found that, the manufacture and combustion of plastics released more than 850 million metric tons of greenhouse gasses into the atmosphere worldwide in 2019. By 2050, those emissions could reach 2.8 billion tons. Some of these emissions can be avoided through better recycling [17]. Considering this, recycling plays an extremely important role in conserving the planet's natural resources, reducing existing waste and contributing to greater energy efficiency. About 500,000 people work in more than 6,000 companies involved in the recycling industry, generating $ 24 billion annually in this segment. The European Union holds about 50% of the global recycling and waste management industry.

While in the Nordic countries, waste is an alternative source for electricity or heat generation, with 50% of the waste being recycled, and the rest up to 99% recovered for energy, in Romania, waste management is another important problem we face.

The practices of improper waste management inherited from the past, which are still applied in Romania today, have resulted in a large number of landfills being ignored and significant produced, being inadequately stored [21].

According to the data provided by AFM, in 2021 the total quantity of plastic introduced on the national market (i.e. including imports) was 45,744,693 tons. Of this amount, 4,935,007 tons were recovered by methods other than recycling.

There are companies that produce plastic "scales" that they export to other countries, and this quantity appears "in methods other than recycling", because it is not a final product recycled for Romania. At the same time, AFM reports 202,619 tons of recycled plastic. Of this amount, PET accounts for only 85,667 tons, considering that the total amount of PET that enters the national market is 144,324 tons. Romania has not used PET in any way other than recycling. From 2015 to 2020, AFM accounts for "0" in this section. Experts say that it requires the heaviest recycling method.

Moreover, if Romania could convert waste into energy, it would have to use the combustion method. This method involves, on the one hand, a profit and, on the other hand, an environmental protection fund that our state does not currently provide. The municipalities, which are not able to manage such a large-scale project, are very controversial.

By 2025, Romania must archive a recycling rate of 55%of all waste, a goal that is difficult for our state to achieve [22].

Table 3 compares some data on plastic production and recycling.

Table 3: Data on plastic production and recycling [17,18, 22 - 24]

The year 2020	Plastic production [t]	Plastic recycling [t]	Plastic recycling [%]
Worldwide	367.000.000	183.500.000	50
European level	55.000.000	19.030.000	34,6
Romania	5.000.000	550.000	11

3. Design and simulation of shredder recycling components

The design and simulation of the chopping plastic equipment, included in the recycling process was done in the Autodesk Inventor Professional design software. The next step was to make the manufacturing drawings, subassembly and assembly, for the components of the machine. A cost analysis was performed to see the final production cost, depending on the classification of the machine parts (purchased from suppliers; manufactured and also those present parts in the stock of the cooperating enterprise – Technobit Automatizări) and we got a total cost of 1500 euros. As future directions, we aim the sustainability of the project, the reduction of costs, an easy maintenance and amortization as soon as possible, generating economic benefits.

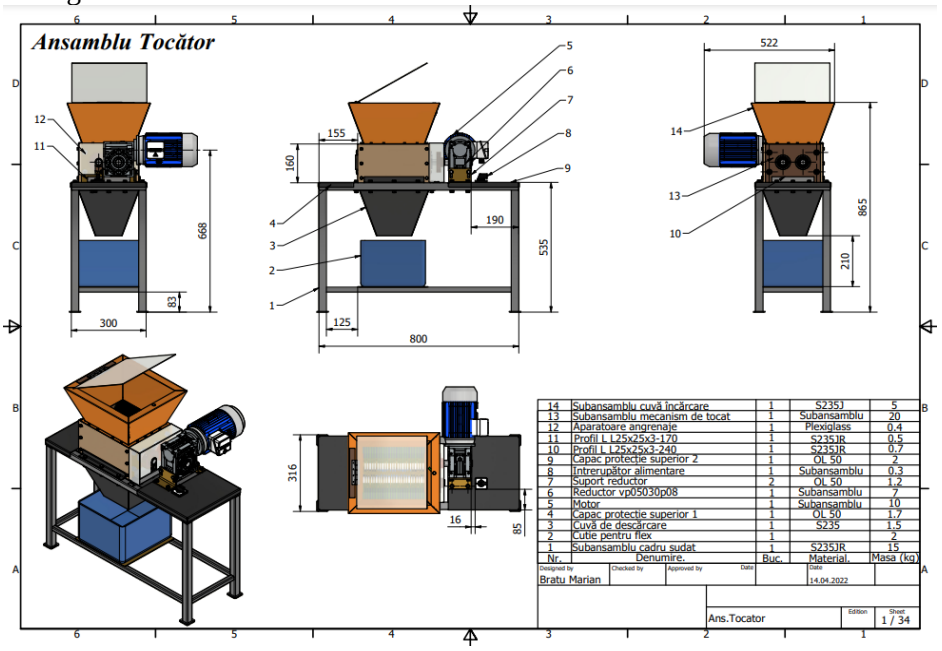


Fig. 6. Assembly drawing components

The shredder can grind any type of recyclable plastic and shape that fits with the intake size of machine. Depending on the chosen engine power and blade configuration, the machine can accept materials with different thicknesses, avoiding equipment jams. The resulting plastic can be used in three different machines: extruder machine, injection molding machine and sheet press. So we defined three different sizes of shredded plastic compatible with each machine. To obtain the plastic flakes a sieve can be installed under the machine in order to shred again thus generating smaller flakes dimensions.

Table 4. Types of flex dimensions

Name	Big	Medium	Small
Visual aspect of the flex [25]			
Flex size [mm]	0-30	0-10	0-7
Works with:	Sheet press	Sheet press Injection molding machine	Sheet press (Figure 14, position 4) Injection molding machine (Figure 14, position 5) Extrusion machine (Figure 14, position 6)

There are distinctive elements that represent competitive advantages over competing products:

- Mounting the blades radially on 12-sided milled shafts, to provide continuous, simultaneous movement through the repositioning frequency, streamlining the time the waste is trapped between the blades;
- Limiting sensor with lever for disconnecting electricity, the safety of the user, positioned on the loading tray of the shredder. When the upper safety cover is lifted, the sensor will stop the operation of the equipment;

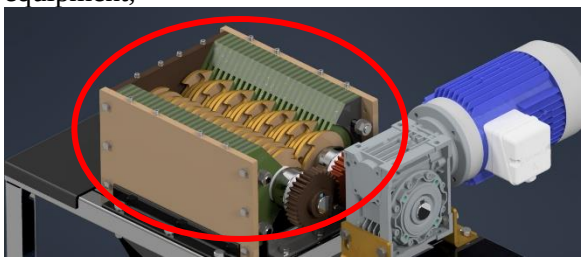


Fig. 7. Blade arrangement

Fig. 8. Electricity disconnection sensor

- Ultrasonic level sensor, to know the flex level from the box.
- Gearing safety cover, implemented for user protection. It prevents injuries in the gears, but also premature gear wear;

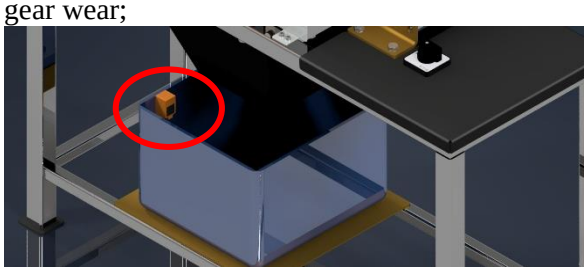


Fig. 9. Level sensor

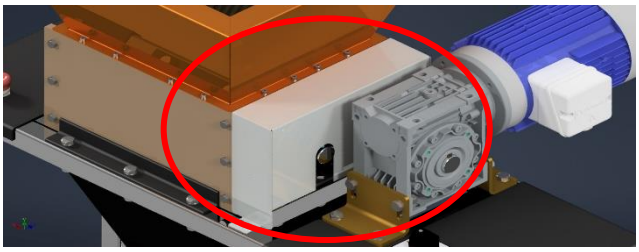


Fig. 10. Gear safety cover

- Security button, with immediate stop function;
- On / off button, which reduces time and energy consumption.

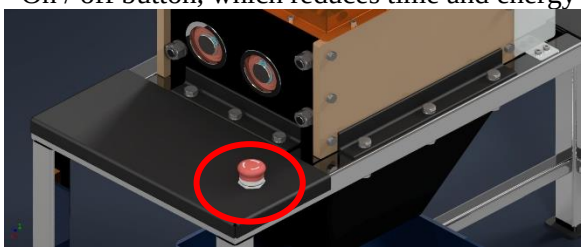


Fig. 11. Security button

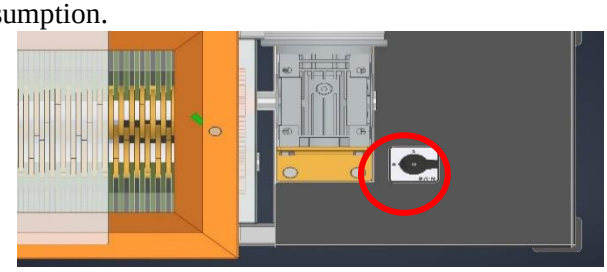


Fig. 12. On / off button

4. Technological flow and the way working of designed equipment.

Description of the technological flow:

1. The first step in recycling is to collect waste. This step is shown in Figure 14, position 1. Subsequently, the plastic waste must be sorted in dedicated containers, differentiated by colors which are shown in Table 1, depending on the classification of the materials from which they were made. The sorting of collected waste can be found in figure 14, position 2. There are two important categories: thermosetting and thermoplastic. Thermosetting materials contain polymers that bind together and creates an irreversible connection, which means they can't be melted, once they have taken a shape, they will be solidified forever, thus eliminating the possibility of recycling. Thermoplastics materials are polymers that become soft when they are heated and hard when are cooled, also this process can be performed several times. 80% of the world's plastics are thermoplastic, which means they can be recycled and turned into new products, which is an advantage. Thermoplastics materials are divided into subsequent subcategories, depending on their structure and properties, classification can be found in table 1 [25].

The different types of plastic should never be mixed, as this will drastically reduce their quality and make the recycling very difficult. When they are melted together, they tend to separate in phases, like oil and water, and settle into layers, resulting structural weakness and inferior products. [25]. Therefore, the first step in the plastic recycling process is to collect it according to the categories mentioned above and sorting according our needs. The next step is to prepare the waste, which consists in cleaning, drying, separating the elements if they are made of different materials (in most cases the label). This step can be done entirely manually or in a combined process, both manually and automated, depending on resources.

2. *Operating steps of the designed machine:* The first machine used in the technological described process is the shredder, which represents the studied product for development in this work paper, found in Figure 13 and Figure 14, heading 3. It starts by connecting the machine to a power source and setting the button to the on position. The material is fed through a loading tank located above the mechanism, which has a sensor attached to turn off the power when the top cover is raised, to eliminate the risk of the user inserting their hand into the area of the blades when they are in operation. The feeding can be done manually or with a conveyor belt. The shredding mechanism consists of a series of blades driven by an electric motor. After the waste is placed in the loading tank and the top lid is brought to the closed position, the shredding process begins. If we want to obtain the smaller flex, a sieve can be installed under the blades. The resulting flex falls into a lower tank or is picked up by a conveyor belt, to be sent to the next machine. In the event of an emergency, press the safety button to switch off the equipment. As a last step, stop the shredder with the stop button.

3. Depending on the needs, the following equipment will be chosen from the technological flow and implicitly the type and dimensions of the flex that we want to obtained by shredding. The resulted plastic can be transferred to the mentioned machines, in Table 4: sheet press, injection machine and extruder.

The sheet press works by inserting the flex, which it will be pressed between two plates at a high temperature. The result is a rectangular plastic sheets, by the size of the plates. The sheet press can take any type of flakes (small, medium and large), but it is recommended to use the large ones, to reduce the shredding time. The sheet press is shown in Figure 14, heading 4.

The injection machine has a fast and high precision production, but it takes a little more effort at first, to design and build a mold. Medium shredded plastic enters to the loading tank and it is heated and pressed by a long shaft into the mold. Different colored materials can also be introduced into this machine. The injection machine is shown in Figure 14 at position 5.

Extrusion is performed using an extruder and is a continuous process where small plastic flakes enter to the loading tank, where is heated and pressed with a screw through a long shaft, and the result is pieces of plastic, with cylindrical shape. With this machine we can create filament, and the obtained material is wrapped around a reel. We can introduce flex with different colors to get certain shades and patterns. The extruder is shown in Figure 14, position 6.

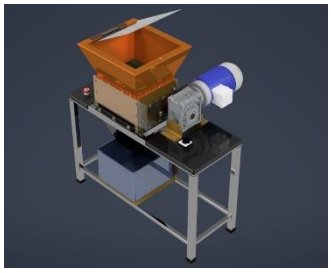
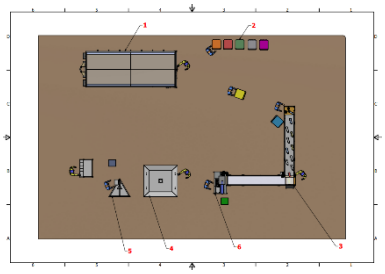


Fig. 13. Shredder assembly



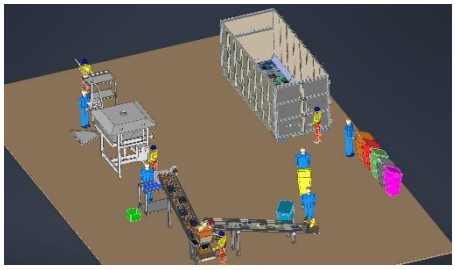


Fig. 14. Technological flow

5. Conclusions

- General

Worldwide, millions of tons of plastic are produced (approximately 359,000,000 t) and the time required for its decomposition varies from a few years (10 years - plastic bag) to several hundred years (600 years of fishing line). The amount of plastic waste recycled varies from country to country. Romania is the penultimate country in the EU in terms of recycling with a percentage of only 11%. The purpose of recycling is to reduce the processing of new raw materials and to reduce environmental pollution. Some of the benefits of recycling are: reducing the amount of landfills, greenhouse gas emissions, pollutants released into water and air, energy costs and conserving the Earth's resources.

- Original contributions in the realization of the plastic shredder

Arranging the blades radially on 12-sided milled shafts to provide continuous, simultaneous movement through the repositioning frequency. This mounting method makes the time in which the waste is trapped between the blades more efficient; Electric safety disconnection sensor for user safety, positioned on the loading tray of the shredder. When the upper protective cover is lifted the sensor will stop the operation of the equipment; Level sensor, with function of determining the degree of filling of the box for the obtained flex; Gear guard cover, implemented for user protection. It prevents damage to the gears, but also premature gear wear; Safety button, with immediate stop function in case of need; On / off button, which reduces time and energy consumption.

- Directions for improving the shredder for the plastic waste recycling process:

Increasing the degree of silence; Reducing production costs by replacing components; Improving the degree of reliability; Easy maintenance.

6. Bibliography

[1]. Free Encyclopedia (2021), “Recycling”, available at: https://ro.wikipedia.org/wiki/Reciclare, accessed on: 28.03.2022.

[2]. Online explanatory dictionary, “Recycling”, available at: https://dexonline.ro/definitie/reciclare, accessed on: 28.03.2022.

[3]. Stratos (2020), “What is recycling - benefits and types of recyclable materials”, available at: https://stratos.ro/ce-este-reciclarea-beneficii-si-tipuri-de-materiale-reciclabile/, accessed at: 28.03.2022.

[4]. Verde Oliva Recycle to live green (2020), “What is recycling - benefits and types of recyclable materials”, available at: http://olivaverde.ro/ce-este-reciclarea/, accessed on: 28.03.2022.

[5]. Waste collection, “Plastic recycling”, available at: https://www.colectaredeseuri.ro/reciclarea-plasticului-cum-se-face/, accessed on: 28.03.2022.

[6]. Inter Consulting Management, “Plastics recycling codes”, available at: https://www.intermanagement.eu/stire/Codurile+de+reciclare+ale+materialelor+plastice, accessed on: 28.03.2022.

[7]. Regional Agency for Environmental Protection, “Guide on selective waste collection”, available at: https://www.intermanagement.eu, accessed on: 28.03.2022.

[8]. Portillo, G..(2021) Green renewable energy, “Types of plastics”, available at: https://www.renovablesverdes.com/ro/tipos-de-plasticos/, accessed on: 28.03.2022.

[9]. Miftode, L ..(2019), “Everything you need to know about plastic types and their recycling”, available at: https://blog.letsdoitromania.ro/uncategorized/tot-ce-trebuie-sa-stii-despre-tipurile-de- plastic-and-recycling-them /, accessed on: 28.03.2022.
[10]. Buzdugan, R ..(2022), “What are the types of recycling?”, Available at: https://sibiuindependent.ro/2022/03/04/care-sunt-cele-trei-tipuri-de-reciclare/, accessed on: 04.04. 2022.
[11]. Postposm (2022), “Types of recycling”, available at: https://www.postposmo.com/ro/tipuri-de-reciclare/#Plastico, accessed on: 04.04.2022.
[12]. Voestalpine (2016), “Durch Einsatz von Altkunststoffen reduziert die voestalpine CO 2-Emissionen in Linz um mehr als 400,000 t / a”, available at: https://ro.wikipedia.org/, accessed on: 04.04.2022.
[13]. Erdyn Consultants (2013), “Chemical recycling of plastics”, available at: https://ro.wikipedia.org/, accessed on: 04.04.2022.
[14]. ISO 472: 2013 (2013), “Plastics - Vocabulary”, available at: https://ro.wikipedia.org/, accessed on: 04.04.2022.
[15]. National Geographic (2017), “91% of plastic waste is not recycled”, available at: https://nationalgeographic.fr/, accessed on: 04.04.2022.
[16]. Wikipedia Free Encyclopedia (2020), “Recycling plastic waste”, available at: https://ro.frwiki.wiki/wiki/Valorisation_des_d%C3%A9chets_en_mati%C3%A8re_plastique, accessed on: 04.04.2022.
[17]. European Parliament (2021), “Plastic waste and recycling in the EU”, available at: https://www.europarl.europa.eu/news/en/headlines/society/20181212STO21610/plastic-waste-and- recycling-in-eu-in-figures, accessed on: 30.03.2022
[18]. Plastics - the Facts 2021, available at: https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf, accessed on: 01.04.2022
[19]. Stratos (2021), “How long does a plastic bottle decompose: Find out the importance of environmental sustainability!”, available at: https://stratos.ro/in-cat-timp-se-descompune-o-sticla-de -plastic /, accessed on: 05.04.2022
[20]. Republica BIO (2020), “How long do they decompose?”, available at: https://republicabio.ro/blogs/stiri/in-cat-timp-se-descompun, accessed on: 14.04.2022
[21]. International Leader (2015), “Technologies for waste recycling”, available at: https://www.uconstruct.ro/tehnologii-pentru-reciclarea-deseurilor/, accessed on: 16.04.2022
[22]. Official figures, “With plastic in nature. How little Romania recycles. .official figures ”, available at: https://zin.ro/02/11/2021/investigatii/plastic-afm-reciclare-peturi-romania-colectare-peturi-hypermarket-peturi-bani-procese/, accessed at: 19.04 .2022
[23]. Alexandra Cheroiu, "How far is Romania from the recycling targets imposed by the European Union", edited on: July 24, 2021, available at: https://adevarul.ro/news/societate/cat-romania-tintes-reciclare-impuse-uniunea-europeana-1_60fac09d5163ec42715f226a/index.html, accessed on: 01.05.2022
[24]. "ROMANIA HAS THE TWO LOWEST WASTE RECYCLING RATE IN THE EU" available at: https://ambasadasustenabilitatii.ro/romania-are-a-doua-cea-mai-slaba-rate-de-reciclare-a-deseurilor -from the EU /, accessed on: 02.05.2022
[25]. Required documentation, available at: https://preciousplastic.com/, accessed on 25.04.2022

7. Abbreviations

The next symbols are used in the current presentation:
ABS = acrylonitrile butadiene styrene;
PLA = polylactic acid;
PET = polyethylene terephthalate;
t = tons (unit of measurement);
mm = millimeters;
AFM = The Environmental Fund Administration;
Mt = million tons;
NAFTA = The North American Free Trade Agreement;
CIS = The Commonwealth of Independent States;
UE = European Union.

CNC SYSTEM FOR LASER ENGRAVING AND MICROTEXTURING

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ABSTRACT: In the research paper we chose to make a CNC laser engraving and microtexturing, used for wooden objects, polypropylene, which has a power of 10W. The points reached by the paper being the strategic marketing of the product, the project management, the establishment of specifications, the conceptual design, the manufacture and testing of the product prototype and last but not least the economic analysis.

KEY WORDS: CNC, engraving, microtexturing, laser.

1. Introduction

Laser CNCs are modern equipment used in many industries. They are mainly found in laboratory environments, production units and various workshops. Laser engraving and cutting machines are used to engrave a variety of surfaces. The machine ensures precise cuts even at very high resolutions.

2. The current stage

The laser offers the fastest cutting method on the market for a wide range of materials, offers competitive and high quality products, incomparable to those made by traditional cutting techniques.

Engraving is a genre of visual arts whose techniques consist of digging, incising, perforating or obturating by various physical or chemical processes a usually flat surface, either in order to print and subsequently multiply the image, or to obtain a self-artistic object. stagnant. [2]

Laser engraving can be done on a wide range of products: wood, plastic, leather, metal, glass, etc. This procedure allows the inscription and personalization of different products with a high precision of the finest details. The market consists of: signboards, keychains, decor accessories, personalized gifts, ornaments, souvenirs, etc. [3]

3. Strategic product marketing

3.1 Identifying market opportunities

In order to identify market opportunities, the needs of future customers must first be found. Needs that will be met by the chosen product.

Thus, 4 needs were identified:

- The need to customize your own objects;
- The need to increase the quality of the processed surface;
- The need to create the product quickly;
- The need to accept the texture easily, quickly and easily

Following these needs, the following market opportunities were determined:

- Need for precise surfaces.
- For some companies or individuals it is important that the product is pleasing from an aesthetic point of view;
- Medium and large enterprises want to make the product more efficient for fast processing.

It is desired that the life of the car be as long as possible, as long as the cost is favorable, thus leading to a reduction in maintenance costs.

3.2 Competing products

This subchapter will illustrate CNC machines for TEXTURING AND LASER ENGRAVING present on the market. Fig. 1, 2, and 3.

Fig. 1 S6 Pro laser engraving machine, SCULPFUN, 60W, 410 x 420 mm, Silver

Fig. 2 S9 laser engraving machine, SCULPFUN, 90W, 410 x 420 mm

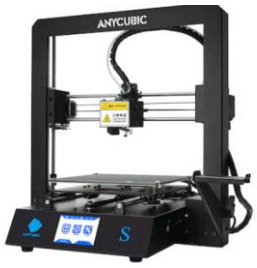

Fig. 3 Laser engraving machine, Anycubic, without SD cards, 100 mm / s, engraving area 210x210x205 mm

3.3 Formulation of the mission

The team aims to create an engraving and microtexturing machine that can be used in all fields at low cost.

The project reveals a device to be processed, with the help of laser power and multi-axis movements, all of which are adjusted with the help of special software.

3.4 Selecting potential customers - Market:

- Research institutions;
- Any person;
- Medium enterprise;
- Large enterprise that performs processing on different materials;
- Industry (metal marking with CO2);
- Architecture (3D architectural models);
- Auto industry.

3.5 Data from potential customers:

The elaboration of the questionnaire used for the market research in the case of the commercialization of the cnc system for texturing and laser engraving can be found in Table 1.

Table 1. Data from potential customers

Client: Popescu Alexandru **Address: Str. Rasaritului, no. 6, Bucharest** **Ye** **Do you want to collaborate?**		**Interviewer:** **Date: 13.12.2021** **User occupation: Engineer**	
No. crt.	Question	Customer statement	The need interpreted
1	In what field do you work?	Production engineer	The need to increase the precision of tool guidance
2	Do you use a CNC device for laser texturing and engraving in your work?	I use such equipment	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface;

Client: Popescu Alexandru Address: Str. Rasaritului, no. 6, Bucharest Ye Do you want to collaborate?		Interviewer: Date: 13.12.2021 User occupation: Engineer	
No. crt.	Question	Customer statement	The need interpreted
3	What engraving method do you use?	Deep printing method (deep engraving);	The need to increase the precision of tool guidance
4	What are the most common types of materials you use when using the CNC device for laser texturing and engraving?	stainless steel, anodized aluminum, titanium alloy;	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface;
5	What are the most used operations, performed with the help of the CNC machine for texturing and laser engraving?	Answeredcreation	The need to perform processing simultaneously
6	Would you like to buy such equipment?	Yes, I would like to buy more efficient equipment.	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface

4. Establishing the objective specifications of the product

4.1 List of primary requirements of relative importance

Table 2 summarizes the primary requirements.

Table 2 Primary requirements summary

Customer needs	Relative importance
DGL is fast	5
DGL is easily removable	4
DGL requires little physical effort.	4
DGL has a complete user manual with instructions	3
DGL is made of durable and lightweight materials.	3
DGL is easy to maintain	3
DGL is protected for overvoltage	4
DGL is portable	1
DGL has a good value for money	3
DGL takes up little space	2
DGL has a fastening and fixing device	4

4.2 Identifying competing products and presenting them

Table 3 summarizes the characteristics of the competing products identified.

Table 3 Product characteristics

Nr.	Size / Feature	unity	Competitive products		
			AROMSTACK A5 20W	Vevor 40w Co2	FIBER LASER 30W
1	Laser power	W	20	40	30W
2	Control software	Subject	LaserGRBL	CorelDraw	EzCad

Nr.	Size / Feature	unity	Competitive products		
			AROMSTACK A5 20W	Vevor 40w Co2	FIBER LASER 30W
3	Print size	MM	410x400	300x200	200x200
4	Total weight	kg	5.6	25.65	38
5	appearance	Subjective	Pleasant	Pleasant	Pleasant
6	Maintenance and installation manual	Yes No	YES	YES	YES
7	Provides user protection	Yes No	Yes	Yes	Yes
8	Assembly / disassembly time for maintenance	min	10	25	15
9	Selling price	She	1137 Lei	2180 Lei	23 780.67 Lei

4.3 Establishing the size list for the product

Table 4 shows the objective specifications, limit and ideal values.

Tab. 4 Objective specifications (Limit values and ideal values)

Nr. Apple.	Nr. requirement	Size / character	Relative Imp	unity	Wave. Lim.	Wave. Ideal
1	1.7	Laser power	5	W	<10	40
2	1.3	Control software	5	Subject	GRBL	GRBL
3	3.12	Print size	4	MM	300x150	340x240
4	5,8,12	Total weight	5	kg	10	8
5	5.11	appearance	3	Subjective	Pleasant	Pleasant
6	4.6	Maintenance and installation manual	4	Yes No	YES	YES
7	3.4	Provides user protection	5	Yes No	YES	YES
8	2.6	Assembly / disassembly time for maintenance	4	min	15	10
9	9	Selling price	5	She	<2400	1600

5.Conceptual design

5.1 Clarification of the problem and definition of the general function

Based on the identified need and customer requirements, it has been established that the general function of the developed product is laser engraving.

5.2 Decomposition of the general function into simpler subfunctions

The list of main functions is presented in table 5.

Table 5 List of main functions

General function	*Laser engraving*
Nr. Service	**The main functions of the product**
Ø1	Allows file transfer with information for burning
Ø2	Allows the laser head to move to the starting area
Ø3	Allows the laser head to be tilted

General function	*Laser engraving*
Ø4	The laser head applies the light beam to the engraving surface
Ø5	The laser head moves left and right in advance
Ø6	The laser head retracts into the initial "home" area

5.3. Establishing critical functions

Table 6 shows the critical functions of the product.

Table 6 List of critical functions

Nr. functions	The critical function of the product
Ø1	Allows file transfer with information for burning
Ø2	Allows the laser head to move to the starting area
Ø3	Allows the laser head to be tilted
Ø4	The laser head applies the light beam to the engraving surface

5.4.Generating new conceptual solutions

The database of conceptual solutions will be established by making sketches of various conceptual solutions. These are shown in Figs. 4, Fig. 5, Fig. 6 and Fig. 7.

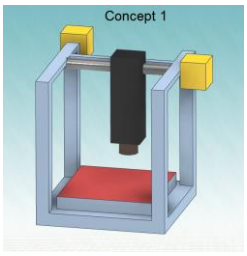

Fig. 4. Outline of the concept 1

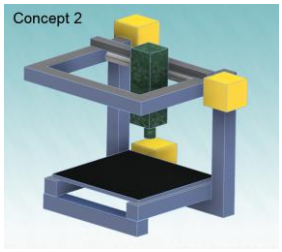

Fig. 5 Outline of the concept 2

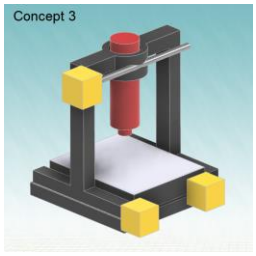

Fig. 6 Outline of the concept 3

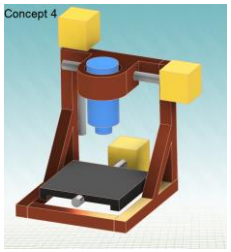

Fig.**7** Concept outline 4

6. Detailed design

The design of the CNC device for laser engraving and microtexturing was done in the Autodesk Inventor Professional program [4]. This CNC shows 3 translational movements and a rotational movement of the laser head, see figure 8. The predominant materials in its manufacture were aluminum and steel, it having a design weight of 6.5 kg.

Description of an operating cycle:

1. Power the CNC device to a 220w power source
2. Connecting the CNC device to a G-code source (stick, computer, tablet)
3. Attaching the semi-finished product to the work table.

The blank is installed on the table of the CNC Engraving Device in a position that allows easy insertion and removal, as well as reaching the laser module at all processing points.

The part is installed in the device as follows:

- place the part on the table of the car
- the T-head screws are inserted in the channels of the machine table
- the processing phases are performed successively
- after finishing the processing, proceed in the opposite direction to remove the part from the device, being able to resume a new processing cycle.

4. Running the G code
5. After finishing the processing, proceed in the opposite direction to remove the part from the device, and a new processing cycle can be resumed.

The device is cleaned of debris and lubricated at the end of each part exchange or whenever needed.

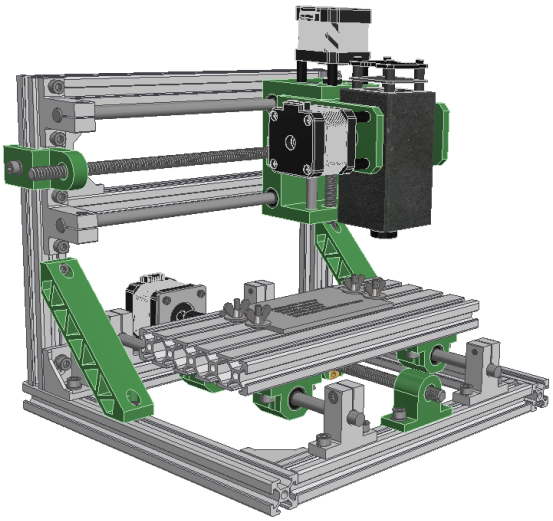

Fig. 8 The 3D model

The components were shown in Figs. 9.

In fig. 10 shows a list of materials but also the name of the elements according to fig. 8.

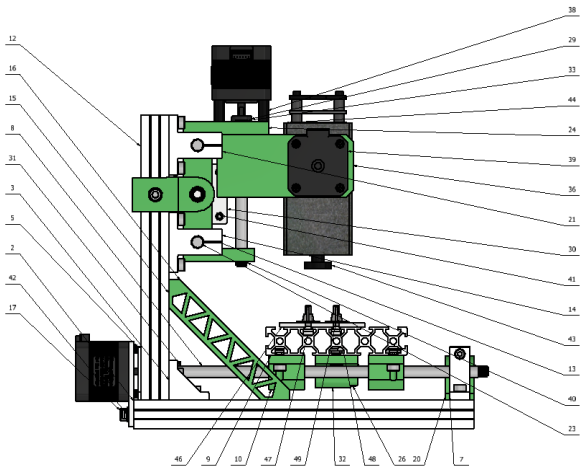

Fig. 9 Component elements

Pos	Name	Qty	MATERIAL	kg	Mass (kg)
1	2020 Extrusion - 220 mm		4 Aluminum		0.297103 kg
2	2020 Extrusion - 240 mm		2 Aluminum		0.323865 kg
3	2020 Corner		10 Aluminum		0.037648 kg
4	SK8 Linear Shaft Support, 8mm		1 Aluminum		0.011793 kg
5	SK8 Linear Shaft Support, 8mm_1		1 Aluminum		0.011793 kg
6	SK8 Linear Shaft Support, 8mm_2		1 Aluminum		0.011793 kg
7	SK8 Linear Shaft Support, 8mm_3		1 Aluminum		0.011793 kg
8	8mm x 240mm Shaft		2 Steel		0.094801 kg
9	20100 Extrusion - 180 mm		1 Aluminum		1.127631 kg
10	LM8UU Holder		4 Aluminum		0.09344 kg
11	LM8UU		8 Steel		0.009525 kg
12	2020 Extrusion - 200 mm		2 Aluminum		0.269887 kg
13	SK8 Linear Shaft Support, 8mm_4		1 Aluminum		0.011793 kg
14	SK8 Linear Shaft Support, 8mm_5		1 Aluminum		0.011793 kg
15	Frame Handle-Support		2 Aluminum		0.200034 kg
16	M5x10 v1		54 Steel		0.003175 kg
17	M5 T-Slot Nut		51 Steel		0.000907 kg
18	X-Axis Bearing Support v5		1 Aluminum		0.098883 kg
19	688-2RS v1		4 Aluminum		0.01 kg
20	Y-Axis Bearing Support v3		1 Aluminum		0.097069 kg
21	SK8 Linear Shaft Support, 8mm_6		1 Aluminum		0.011793 kg
22	SK8 Linear Shaft Support, 8mm_7		1 Aluminum		0.011793 kg
23	8 mm x 255 mm Shaft		2 Steel		0.100698 kg
24	Z-Carrier		1 Aluminum		0.912628 kg
25	M8 x 15 mm Rivet nut		3 Steel		0.00499 kg
26	T8 Lead Screw Nut - 2mm Pitch		3 Steel		0.008165 kg
27	12mm OD Dia., 0.8 mm wire diameter, 30 m		3 Steel		0.003175 kg
28	T8-2 Lead Screw; Length = 255 mm		1 Steel		0.078471 kg
29	Shaft Coupler_5 - 8 mm		3 Steel		0.022226 kg
30	XY Stepper Mounting Bracket		2 Aluminum		0.054431 kg
31	T8-2 Lead Screw; Length = 230 mm		1 Steel		0.07076 kg
32	Y-Axis Move Assembly		1 Aluminum		0.106141 kg
33	8 mm x 97 mm Shaft		2 Steel		0.038102 kg
36	Z-Axis Spindle Holder		1 Aluminum		0.898 kg
37	LM8SUU		4 Steel		0.007257 kg
38	M3 - 7mm x 15 mm Spacer		8 Aluminum		0.004 kg
39	17HS1352-P4130 NEMA17 Stepper		4 Steel		0.5 kg
40	T8-2 Lead Screw; Length = 93.5 mm		1 Steel		0.028576 kg
41	M3 x 6 mm		16 Steel		0.009072 kg
42	M5 Washer		24 Steel		0.004536 kg
43	Laser modul		1 -		0.05 kg
44	Suport Modul Laser		1 Aluminum		0.523 kg
45	Laser catches		2 Aluminum		0.04 kg
46	C5 semi-finished product		1 Aluminum		0.2 kg
47	Screw T		4 Steel		0.04 kg
48	CNS 4373 - M 4		4 Steel		0.02 kg
49	Washer		4 Steel		0.02 kg
					6.502544 kg

Fig. 10 List of materials

7. Testing the breaking strength of the structure

FEA analysis was performed for the upper part of the device. In this analysis, forces were applied on the columns that support the laser head, but also the weight of the fastening system. As a result of these applied forces, all safety parameters have been met (see Fig. 11 and Fig. 12).

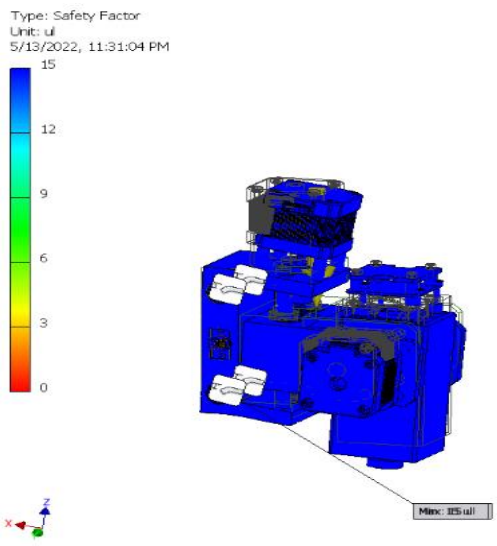

Fig. 11 Resistance factor

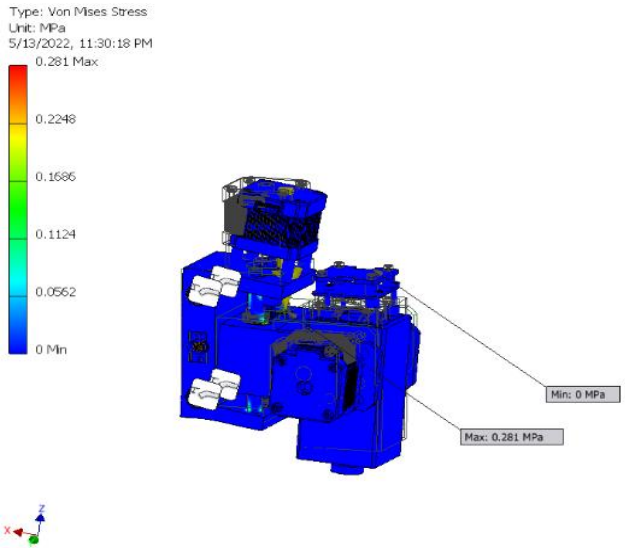

Fig. 12 The stress factor

8. Economic analysis

The CNC system can be traded with the following legal entities and not only, as can be seen in Figure 13:

- Raimar deals with the personalization of watches, it is located in Bucharest, Iuliu Maniu Boulevard 546-560, the distance from the Polytechnic University is 6 km; the transport cost is (15 lei - Fan Curier; 19 lei Cragus);
- Malvensky deals with jewelry personalization and is located at a distance of 5.6 km from the Polytechnic University in Bucharest, Lascăr Catargiu Boulevard 46; the transport cost is (14 lei - Fan Curier; 18 lei Cragus);

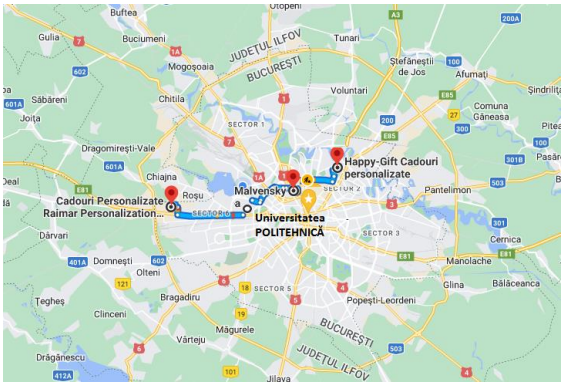

Fig. 13 Representation

All components from which the CNC System is made can be recycled and reused to make other products. Aluminum elements can be melted and reused in another form, as can plastic and steel elements.

The recycling stages of aluminum (fig.14) and steel are similar: collecting products containing aluminum and steel, sorting materials using magnets, reprocessing aluminum and steel consists of 4 steps: shredding, decorating, melting and casting, follow the transport of the cast ingots to a rolling and recycling factory and the last stage, the conversion of aluminum and steel into a wide range of products.

The data, quoted by Forbes, show that, in 2018, approximately 41.5% of plastic packaging waste was recycled in the European Union, which places Romania above the European average.

Fig. 14 Aluminum

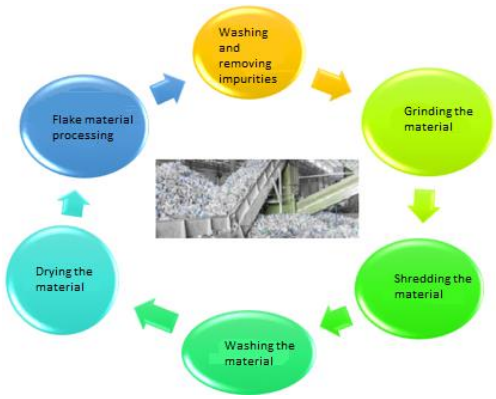

Fig.15 Stages of plastic recycling

Some components of the CNC system are represented in table 7:

Table 7. Composition table

POZ.	NAME	BUC.	COMPANY	PRICE	3D IMAGE
18	X-Axis Bearing Support	1	Fruugo	200 lei / pc	
39	17HS1352-P4130 NEMA17 Stepper	3	Fruugo	120 lei / pc	

9. Conclusions

Following the research, it can be seen that the device meets the economic conditions, market demands, but also FEA diagrams. We propose for future research the addition of a camera for detecting the working temperature, but also the realization of the CNC device.

10. Bibliography

[1.] *** Emag.ro. 2022. Are you looking for a laser engraving machine? Choose from the eMAG.ro offer. [online] accessible at:https://www.emag.ro/search/masina+de+gravat+laser, accessed on 13/04/2022.
[2.]***https://www.rayjetlaser.com/ro/produse/cum-puteti-grava-cu-laser, accessed on 13/04/2022.
[3.] *** Laser engraving, mechanical engraving, CNC engraving and CNC machining. [online] accessible at:https://engraving.ro/, accessed on 13/04/2022.
[4.] *** Autodesk empowers innovators everywhere to make the new possible. [online] accessible at:https://www.autodesk.com/, accessed on 13/04/2022,
[5.] ***https://www.google.com/mapsaccessed on 09/05/2022
[6.] *** Ionescu N., Creativity and Intellectual Property, accessible at:https://curs.upb.ro/, accessed on 13/4/2022.
[7.] *** Ionescu N., Product Development 2, accessible at:https://curs.upb.ro/, accessed on 13/4/2022.

MODULAR ELECTROCHEMICAL POLISHING EQUIPMENT

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ABSTRACT: The paper deals with the current state of processing by electrochemical polishing. The main details in the polishing process are the sizing of the electrode-tool, the choice of the type of back pressure chamber, the choice of the type of electrolytic fluid flow, the type of surface treated and the establishment of a type of processing to streamline the quality of future surfaces. It is desired to build a modular electrochemical polishing equipment to obtain the highest quality surfaces, with the lowest possible roughness, in the shortest possible time. So, this paper will bring information about the process and the existing equipment on the market with the help of patents, to be developed in the dissertation. Finally, you will be presented with a concept proposal for the future equipment.

KEYWORDS: electropolishing, anode, cathode, electrolytic liquid , modular equipment , ECM.

1. Introduction

Electrochemical polishing, also known as anodic polishing or electrolytic polishing (especially in the field of metallography), is an electrochemical process that removes material from a metal part, reducing surface roughness by leveling micro-peaks and valleys, improving surface finish. This process takes the place of galvanizing. It is used for polishing, passivating and deburring metal parts. It can be used instead of fine abrasive polishing in the microstructural preparation of surfaces [1].

2. Current stage

Electrochemical polishing involves an anode consisting of the part to be processed and a cathode represented by the tool to be placed in an electrolyte bath, where basic, acidic or neutral solutions are found. The anode is connected to the positive (+) source of the current source, and the cathode to the negative (-) source. The current passes from the anode, where the surface metal is oxidized and dissolved in the electrolyte, and then the oxidation products pass to the cathode. At the cathode there is a reduction reaction that produces hydrogen. [3] This reduces the roughness of the machining surface according to the scheme in Figure 2.1, based on the anodic dissolution, which occurs in the electrolyte bath, and as a result creates an electric field between the tool and the part. And on the surface of the semi-finished product a passivated layer is formed in the region of the micro-peaks, where the current intensity is higher, so the electrical resistance is lower in these areas. [4]

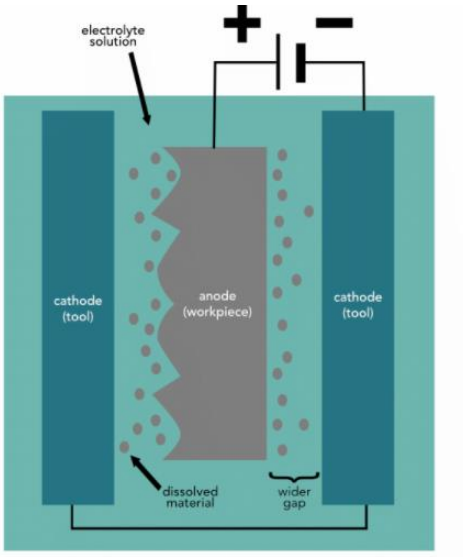

Fig. 1. Schematic of electrochemical polishing process[4]

Fig. 2 Modular equipment structure

3. Strategic product marketing

3.1. Identifying market opportunities

In order to identify the market opportunities, first, must be found the needs of future customers. Needs that will be satisfied by the chosen product.

The 5 needs that were identified:

- The need to create surfaces with high corrosion resistance and to increase the lifetime of the parts;
- The need to increase productivity;
- The need to create surfaces with minimal risk of contamination (sterile);
- The need to remove radioactivity from certain surfaces;
- The need to create surfaces with low roughness.

Following these needs, the following market opportunities were determined:

- Most industries want parts to have a longer lifetime, as long as the cost is favorable. This leads to reduced maintenance costs;
- SMEs and companies that process metal parts by polishing want to streamline the process;
- The existence of areas where the creation of sterilized and uncontaminated surfaces is necessary, such as: the medical field, the pharmaceutical field, the nuclear field, the food industry, etc .;
- The nuclear field is a developing one in the context of the energy crisis;
- Need for precise surfaces for different assemblies.

Competing products

Fig. 3 Competing products[5],[6],[7]

Selection of potential customers – Market:

- Small and medium-sized enterprises (SMEs) that are processing on metal parts;
- Educational units;
- Research institutions.

Data collected from potential customers:

The questionnaire will be used to identify customer requirements. The questionnaire guide used to collect raw data is intended to provide answers to questions such as:

1. In what field do you work?
6. Would electrochemical polishing equipment be useful in your work?
7. Which of the following benefits do you consider most important?

The results of these questions are as follows:

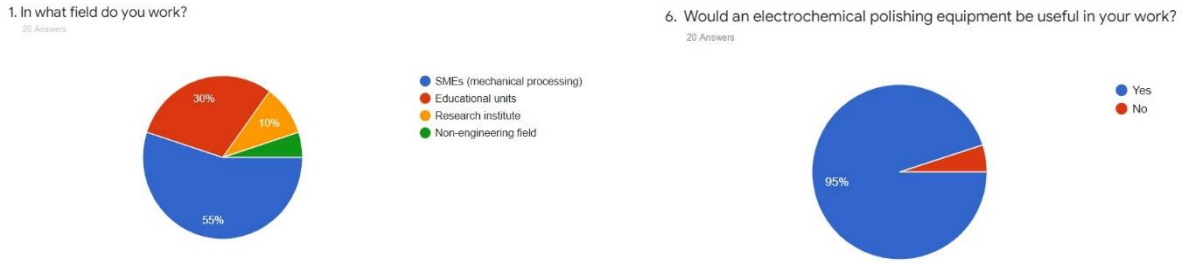

Fig. 4 Questions 1 and 6

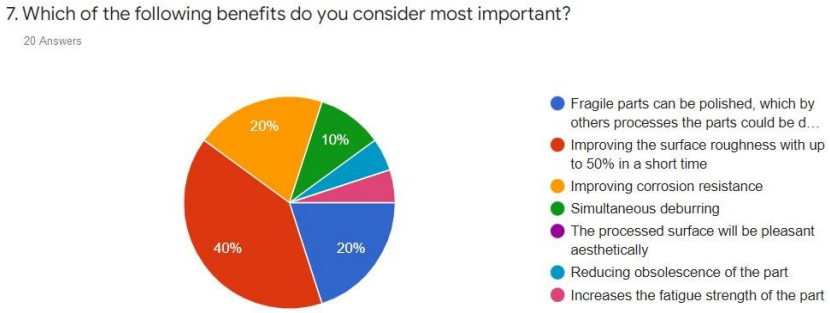

Fig. 5 Question 7

Following the answers received, we can say that there is a great interest in the product. Electrochemical polishing being preferred over mechanical finishing, respondents considered that electrochemical polishing equipment would be useful.

4. Conceptual design

Once the 5 needs have been identified (N1, N2, N3, N4, N5), the development of the interview questionnaire and its application to a population sample according to the Selection Matrix, it is necessary to generate concepts using techniques and methods to stimulate creativity.

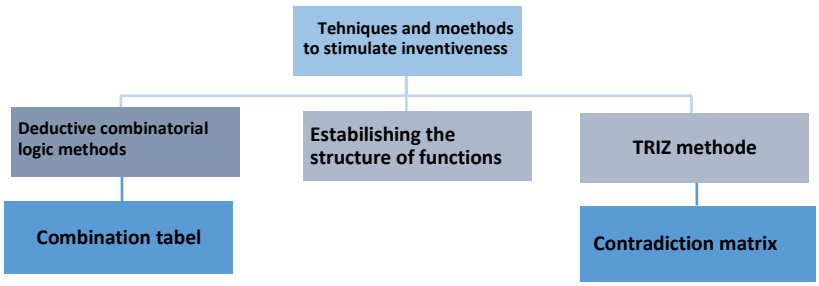

Fig. 9 Tehniques and moethods to stimulate inventiveness

4.1. TRIZ method - Development of concepts with the help of technical contradictions

The contradiction matrix is a tool for selecting the inventive principles used to resolve a particular contradiction. On the rows of this matrix are listed the parameters that need to be improved, and on the columns the parameters that get worse as a result of the improvement of the parameters on the rows.

- *Problem desctription*

The product to be analyzed in the dissertation project is a modular electrochemical polishing equipment. In order to bring something innovative compared to the already existing products on the market, technical contradictions will be formulated, and solving them will lead to the development of an innovative concept.

- *Formulation of the tehnical contradiction*

Technical conflicts arise when an improvement of one feature of the system leads to the worsening of another feature of the system. A technical conflict therefore involves two features of the system, as follows:

- Increasing the complexity of the equipment reduces the ease of manufacture and ease of use operation.
- Reducing the weight of the deburring equipment decreases its strength over time.

Table 1. Tehnical conflict summary table [15]

Parameter that iproves	Worsening parameter	14	32
		Resistance	Manufacture easyness
2.	The weight of the stationary object	3, 16, 22	-
36.	Complexity of the object	-	18, 24, 37

- Estabilishing generic of the TRIZ principles fotm Matrix Contradictions

Generic solutions and specifics solutiuons for modular eletrochemical polishing equimpment can be found in Table 6.

Tabelul 2. Table of generic solutions [15]

Nr. Princ	**Frenquency of occurrences**	**Triz Principles**	**Priciples DFE Strategies**	**Specific solutions**
1	2	Segmentation	A. Divide the objects in parts independent; B. Make the object easy to disassemble ; C. Increase the degree of segmentation.	#1.Equipment wil hae modular compartimentation. #2. The elements to be interconnected.
2	1	Removing from context	Extract the necessary parts of the object Extract the property that bothers you from object	#3. Poka-yoke system to prevents mistakes
13	2	Reverse	A. Reverse the action used to solve the problem. B. Make the moving parts or the external environment fixed. C. Turn the object / process upside down.	#4. Interchange of the working head to increase the complexity of the processed surfaces
26	2	Copy	Instead of fragile, hard-to-obtain, expensive, or environmentally polluting materials, use simple, inexpensive copies. B. Replace the polluting object or process with optical copies.	# 6. Using virtual renderings for easy validation of the concept #5. Using printed prototypes to validate the concept.

4.2. Combination table

Tabelul 3. Combination summary table

Maximum polishing capacity (A)	Tank volume (l)	Electrolyte system	Type of surfaces	Adaptabilty	Portability	Volume of parts machined	Fluid flow	Processing regime
250	30	yes	Intersecting hole	no	yes	1	Tangential flow	DC
200	10	yes	Outside surface	yes	no	3	Reverse flow	DC
300	45	yes	Inside surface	no	no	2	Direct flow	DC

4.3. External research

Analyzing recent patents, it was decided to present electrochemical polishing processing plants. Figure 6 shows the patent for an electrochemical processing device. The tool electrode 2 is connected to the cathode, being on the tool holder head (1), having an adjustable feedrate. The maintenance of a certain gap imposed by the processing process is performed with the help of the automatic feed regulator, depending on the sizes in the workspace.

A technical pump-filter system directs the electrolyte into the space between the electrodes. During the process, the electrolyte comes out under pressure loaded with metal hydroxides, formed as a result of erosion, hydrogen bubbles, oxides, air, vapors, etc., heated to a temperature higher than the inlet.

The machine base, on which the processing unit is mounted, must be of rigid construction, to withstand the deformations produced by the hydrostatic forces of the electrolyte, having high pressure, the mass of the machine and the processing chamber, made of corrosion resistant materials and provided with screen. transparent to stop the visual control of the processing process.

The mass of the machine must be movable in order to center the part in relation to the electrode-tool, its feed system being kept constant.

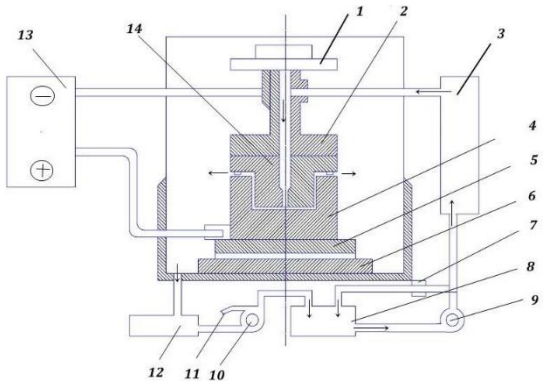

Fig 6. Patent nr.US6699380B1 [2]

Figure 7 shows the patent for an automatic and portable electrochemical polishing equipment. It has advantages such as simplicity of operation, low construction costs, flexibility, occupying a relatively small space. The patent brings as a novelty the portability of the equipment. [3]

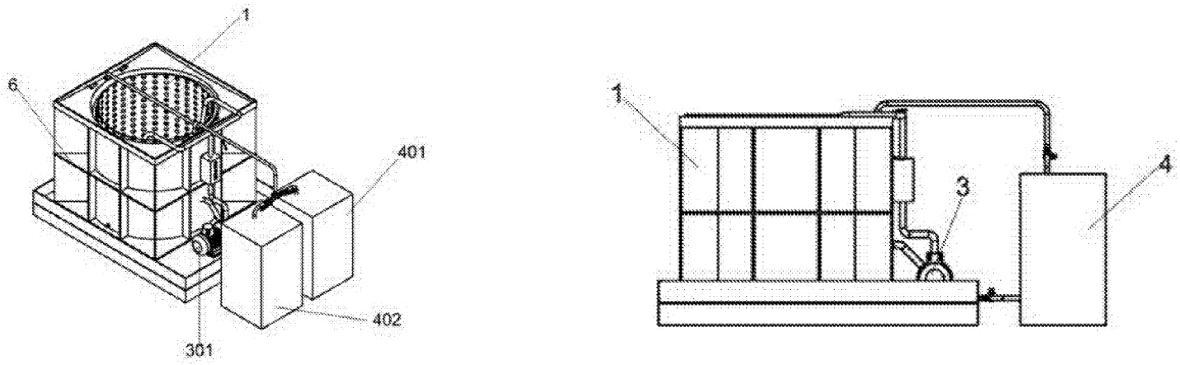

Fig 7. Patent no. US2014076719A1 [3]

5. Partial concept

The designed device is installed on the table of the machine tool
For the processing of PSF the following steps are followed:

1. Attach the PSF to the device as follows: Tightening and orienting the PSF is done with the help of 4 guide and fixing wedges POI, a CII type plate, 4 locking and fixing elements, and then the tightening is done with the help of 4 screws with hexagonal seat DIN 912 M5.
2. Assemble the plexiglass panel;
3. It is fastened with 4 screws with hexagon socket DIN 912 M10;
4. Position the Plexiglas panel using 2 three-dimensional corners;
5. It is fixed with the help of 6 screws with hexagon socket DIN 912 M4;
6. Lower the electrode tool for processing;
7. It is allowed to enter the electrolytic liquid with the help of valve 1 .;
8. Open valve 2 for the flow of electrolytic liquid from the device;
9. PSF is processed;
10. After processing, remove the electrode tool;
11. Turn off valve 1 to stop the electrolyte from entering the device;
12. Remove the 2 three-dimensional corners and the hexagon socket screws to detach the Plexiglas panel;
13. Remove the Plexiglas panel;
14. Loosen the 4 hexagon socket screws, together with the locking and fixing elements;
15. Remove the PSF from the device;
16. The cycle resumes.

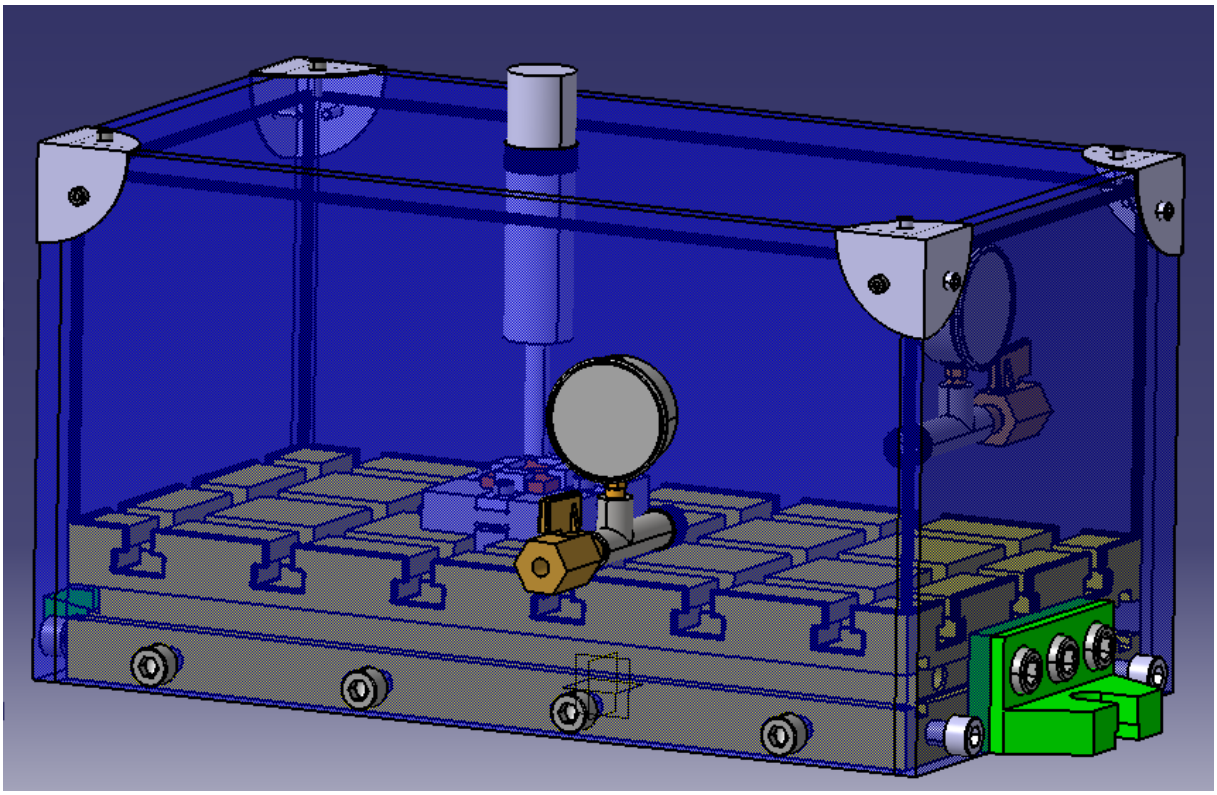

Fig 8. Partial concept

6. Product selling

The next step that we need to follow represents the selling of the product. In order to define a product or a service as being “successful ”, we need to commercialize it above everything else. After we are sure that our product does not break any laws or rules, we consider the problem of the marketplace. Where would we try to sell our product ? Of course, we cannot choose a place like a mall or a supermarket. On the other hand, we can try to create a link between identified appliable domains and the companies that work in that domain. When it comes to new clients, even if they already have a supplier or they consider that they actual equipment is ok, we can try to offer them a “pro-bono”. We can give them a free trial (for example a trial of 30 days) in order to see the efficiency and innovation brought by our product.

6.1. Future potential clients

After analyzing the client’s needs and requirements, we identified a series of clients that might be interested in buying our product. There is to be mentioned that the appliance of ECM is very large, and these potential clients are clients with large application domains.**Universitatea de Medicină și Farmacie ”Carol Davila”**

- Medical and Pharmaceutical College “Carol Davila”
- Feromet
- Carrus Expert
- Electro Optic

6.2. Route planning for distribution. Estimated costs. Product recycling.

After identifying the potential clients, we will consider the eventual distribution cost. Using the free software Google Maps, and having just a car for delivery, with a 10 litters average consumption, we get a daily distribution cost of 60 RONS per day and a total delivery time of 120 minutes. On the same way, we used a professional route planning software called Routific. Therefore , the daily distribution cost is now 29 RONS and the delivery time is 86 minutes.

Fig 9. Recycling process

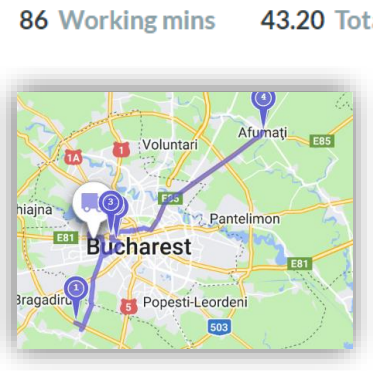

Fig 10. Customer location

7. Conclusions

In conclusion, in the written paper were treated the current state of processing by electrochemical polishing. The main details in the polishing process were the sizing of the electrode tool, the choice of the type of back pressure chamber, the choice of the type of electrolytic fluid flow, the type of treated surface and the stability of a processing type to streamline the quality of future surfaces.

It was wanted to build a modular electrochemical polishing equipment to obtain the highest quality surfaces, with the lowest possible roughness, in the shortest possible time, which was mentioned in the conceptual design chapter.

8. Bibliography

[1] *** Ghiculescu D., Tehnologii de fabricare electrochimica, available https://curs.upb.ro/, accesed 21/4/2022.
[2] Marinescu N.I. et al (2006), Tratat de Tehnologii Neconvenționale, PRINTECH, București, ISBN (10) 973-718-613-3, ISBN (13) 978-973-718-613-3.
[3] *** Electropolishing equipment available at https://worldwide.espacenet.com/patent/search/family/050273331/publication/US2014076719A1 accesed la 24.04.2022.
[4] *** Hegmann S., Electropolishing vs. Pulsed Electrochemical Machining (PECM), Voxel Innovations Inc., Education Portal, Noiembrie 2021, article available athttps://www.voxelinnovations.com/post/electropolishing-vs-ecm, accesed la 22/01/2022
[5] *** https://www.brindustry.ro/lustruirea-otelului-inoxidabil-gama-clinox/ accesed la 12/05/2022
[6] ***https://www.presi.com/en/product/polisec-c25/ accesed 12/05/2022
[7] ***https://www.directindustry.com/prod/otec-praezisionsfinish-gmbh/product-29530-1839877.html accesed 12/05/2022
[8] ***https://lege5.ro/Gratuit/gezdiobqha/reguli-generale-de-comercializare-a-produselor-si-serviciilor-ordonanta-99-2000?dp=gm3tcnruha3tq, accesed 18/03/2022
[9] *** https://www.feromet.ro/servicii/zincare-electrochimica accesed 19/03/2022
[10] *** https://carrusexpert.ro/servicii-atelier-2/ accesed la 19/03/2022
[11] *** https://electro-optic.ro/en/services-2/ accesed 19/03/2022
[12] *** https://conspecte.com/expertiza-merceologica/certificarea-calitatii.html accesed 9/03/2022
[13] *** https://app.routific.com/#/hud/questionnaire accesed la 14/04/2022
[14] *** https://www.google.ro/maps accesed 14/04/2022
[15] *** Ionescu N., Creativitate și proprietate intelectuală, available at https://curs.upb.ro/, accesed 13/4/2022.

HYDRODYNAMIC ENERGIE SYSTEMS USING CELLULAR BIOMIMETIC STRUCTURES

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SUMMARY: Hydrodynamic energy systems produce renewable electricity by harnessing the kinetic energy of a body of water, energy resulting from their movement. Among the objectives of this scientific research are the realization of a preliminary model of a hydroelectric turbine as well as the realization and testing of cellular biomimetic structures that will be used, after optimization, in the manufacture of the turbine blade, increasing efficiency and reducing its weight.

KEY WORDS: turbine, cellular structures, biomimetic, composite, additive manufacturing

1. Introduction

The planet is becoming more and more polluted and new sources of energy made from less pollution methods are being sought. To minimize pollution, the most sought methods are in nature, using water, wind and sun. Analyzing the three main categories, two of them are limited: the sun can be used when it is in the sky and the wind can be used at a certain speed, there is the possibility that it may be non-existent for a certain period. On the other hand, the water (flowing) has no limitations, in the best case, it can increase its flow in certain periods where the precipitations have made this place leading to a much better efficiency.

The hydrographic area is very extensive and deserves to be exploited in this way, the research direction of this work is the development of a small hydroelectric turbine that could be located in the riverbed and springs. In order to develop something special compared to what is on the market, the research focuses on optimizing the structure of the turbine blade, namely to avoid its full filling with the help of sandwich cellular structures inspired by biomimetics.

2. Preliminary hydroelectric turbine

Renewable energy is one of the most important challenge that our planet must win, for this reason the engineers around the world are studying new technologies to overcome the energy production through the carbon.

In our project we have developed a lightweight power generation solution to deliver reliable, predictable and low-cost energy. This kind of technology is represented by a hydroelectric turbine made up by polymeric and composite material for direct use in rivers, irrigation canals or tail races channeling water from existing dams. It has made up by some other subcomponents, as shown in the Figure 1.

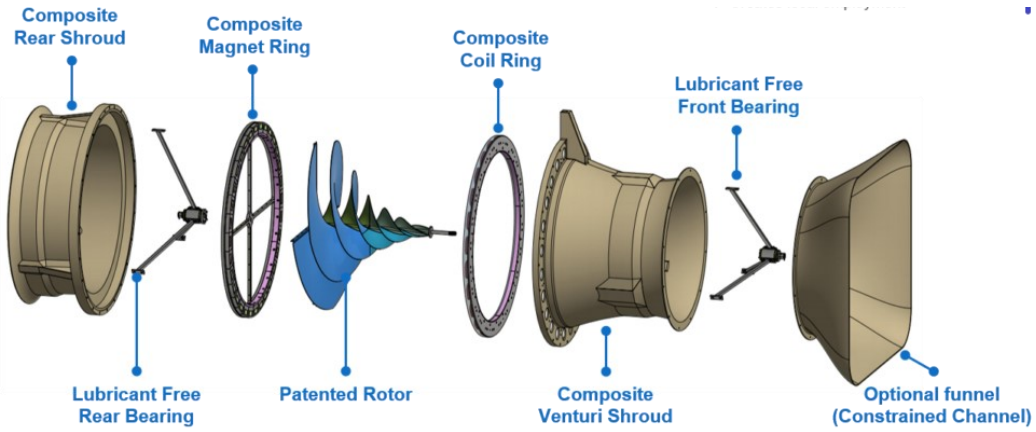


Fig. 1. Hydroelectric turbine components [22]

The first one of them is the composite rear shroud, used to cover the rear part of turbine and it is connected to the turbine through the lubricant free rear bearing and the composite magnet ring.

The front part has made up by the composite Venturi shroud connected to the rear shroud through the composite coil ring. This component is very important, because this kind of turbine works with the axial water flow and the Venturi shroud is useful to increase the speed of the water, accelerating its flow in the throat section.

The next one component is the lubricant free front bearing, its function is to constrain the Venturi shroud with the funnel channel. In this section the water flow enters inside the turbine from the external environment.

The most important component is, of course, the turbine and in the Figure 2 and 3 is shown the design realized on CATIA software. This design is not the final one but could be useful to realize a small prototype of it. As we see in the figure the hydroelectric turbine blade got a very complex spiral-shaped. Spiral blades have been developed and used by others before, but not to this level. Most hydroelectric turbines include propeller or fan shaped blades arranged radially around the center axis and activate a rotor other electricity generating mechanism within the turbine when rotated by water that is channeled downward into the turbine. These turbines work best in high-head water systems, where the water drops over a longer distance, picking-up speed and water pressure to enable higher energy output. The spiral-shaped blade, also called a “full capture”, combined with the nacelle increases water pressure available for capture, extracting more energy than previously thought possible.

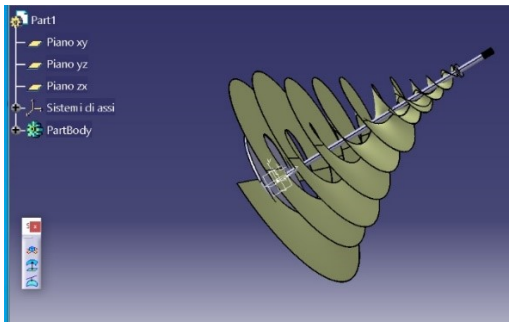


Fig. 2. Hydroelectric turbine blade

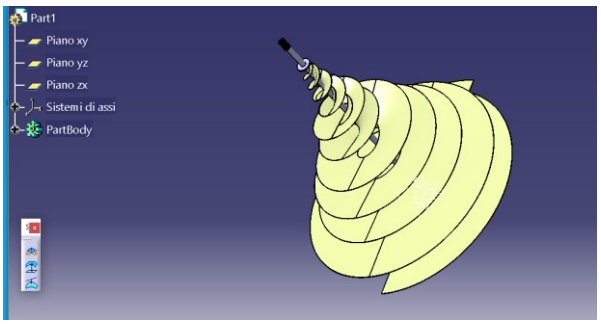


Fig. 3. Hydroelectric turbine blade

The advantages of this kind of technology are various, but the most relevant are:

- Simple modular Design
- No gearbox or lubricants to maintain
- Minimal part count for easy transportation
- Ease of assembly in remote locations
- Creates local employment

In the Figure 4 is shown the full assembled turbine with their dimensions and components.

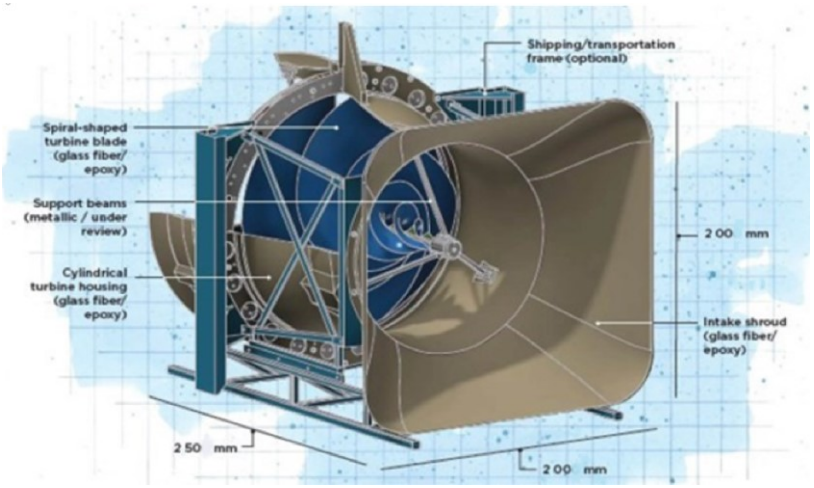


Fig. 4. Hydroelectric turbine assembly [21]

3. Manufacturing and testing equipment

Liquid Crystal MAGNA is a 3D printer that uses DLP technology (Digital Light Processing). This type of printer uses ultraviolet light to polymerize the resin in the tank. The polymerization is done on the printing bed which rises layer by layer, the mark being formed upside down on it. At the bottom of the tank is a transparent screen that reflects the layers of the part to be polymerized. UV light is transmitted by a laser in a matrix of micro-mirrors, micro-mirrors that transpose through a lens the image found on the bottom of the tank (transparent screen). After printing, the finished part must be cleaned of excess resin [6] [7].

Daylight high tensile MAGNA resins fall into three categories: rigid (High tensile white, Draft, Hard, Concept, Dental pattern White, etc.), durable (Durable, Duramax, Durable DL110H) and resins developed by BASF (Badische Anilin-und Soda-Fabrik) [8].

Fig. 5. 3D Liquid Crystal MAGNA printer [6]

Fig. 6. 3D MARKFORGED X7 printer [10]

The MARKFORGED X7 printer works on the principle of 3D printing FDM (Fusion Deposition Modeling), the construction of the part is done by depositing layer by layer of the extruded material. The thermoplastic filament roll is loaded into the printer, and once the extrusion nozzle reaches the set temperature, the filament melts and construction begin on the first layer of the mark on the machine table through the printer's extrusion head. The extrusion head is attached to a three-axis system that moves in the x, y and z directions, allowing movement to make the next layers [9] [10].

The plastics used by this printer are: Onyx, Onyx FR, Onyx ESD and Nylon White, all of which can be reinforced with fiberglass, carbon fiber and kevlar fiber [11]

INSTRON DX is a device with a high capacity for testing tension, compression and flexion. It has two more secure and efficient flexion and compression testing pieces. It features a multi-function productivity panel with an ergonomic display that allows the operator to perform regular tests and view various information.

Typical applications of this machine are: metals (bars, plates, pipes and tubes, reinforcing and structural bars), fasteners, wire and various composites. This test equipment can be used in accordance with international standards, such as: ASTM A370, ISO 6892-1, BS 4449, etc. [20].

4. Used materials

The resin called "Daylight High Tensile" will be used to make the test pieces on the Liquid Crystal MAGNA printer. It can be noted that it has an exceptional tensile strength and elongation comparable to acrylics. Printed parts cannot be easily deformed or compressed, while having high precision and minimal shrinkage. It is one of the most widely used materials in engineering, prototyping, tools and dies [12]. The properties of Daylight High Tensile material can be seen in Table 1.

Onyx is an ideal one-piece material that is based on a very hard nylon that offers parts with a stiffness equal to or greater than any pure thermoplastic material available for professional 3D printers. This material can be used in its pure state or can be further strengthened with different types of fiber: continuous carbon, kevlar or fiberglass [13] [14]. The properties of the Onyx material can be seen in Table 1.

Onyx has a degree of thermal deformation at 145 ° C while Daylight High Tensile has a degree of deformation at only 95 ° C.

Table 1. Material properties [12], [14]

Properties	Daylight High Tensile	Onyx
Density [g/cm^3]	1,16	1,2
Viscosity [cPs]	980	-
Flexural strength [MPa]	95	81
Tensile modulus [MPa]	3060	1400
Flexural modulus [MPa]	2200	2900
Ultimate tensile strength [MPa]	81	36
Impact strength notched izod [J/m]	22,7	330

5. Making test pieces

Taking into account the current standards (ASTM C393, ASTM D638) applied to sandwich structures, test pieces containing cellular structures were tested for stress testing: flexure, traction and DMA. These test pieces were designed using CATIA and SolidWorks design applications and their structure was inspired by nature. When a certain landmark is inspired by nature, we can talk about the concept of "Biomimetics". Biomimetics is the application of existing biological methods and systems in nature to the design of engineering systems and modern technologies and is the way to solve technical problems through models, systems, or elements in nature [15].

For the mechanical dynamic analysis (DMA) pieces, its dimensions can be seen in Figure 7, respectively 66.8 mm long, 8.8 mm wide and 3 mm high and the thickness of the coating layers (the one that forms the sandwich) is 0.4 mm. The flexure test pieces has a length of 150 mm, a width of 20 mm and a height of 15 mm with a thickness of the coating layers identical to the DMA test pieces (Figure 8).

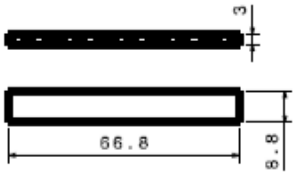


Fig. 7. DMA test piece

Fig. 8. Flexure test piece

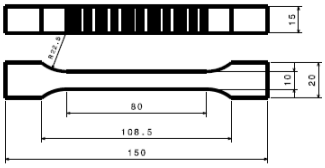
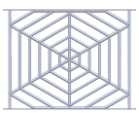
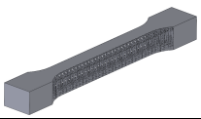
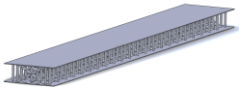
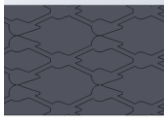
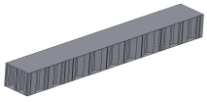
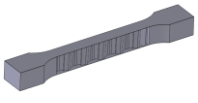
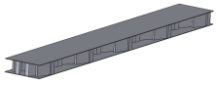
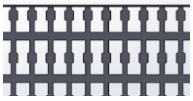
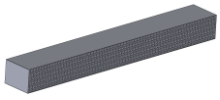
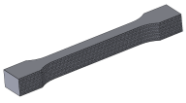
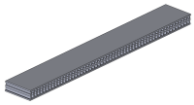


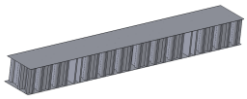
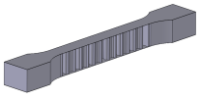
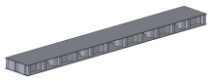
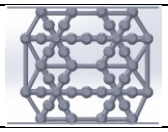
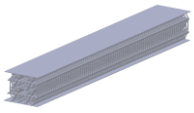
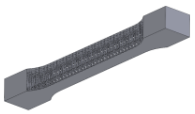
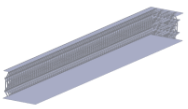
Fig. 9. Traction test piece

For traction, the test piece has the following dimensions: length 150 mm, width 20 mm and height 15 mm, with the observation that it is smaller in the center, having a width of 10 mm, the transition from 10 to 20 mm is done with the help of a radius of 22.5 mm (see figure 9). Like the other two test pieces, it has a thickness of 0.4 mm sandwich layers.

For this research, 30 test pieces were printed, 15 of them on the MAGNA printer using Daylight High Tensile material and the other 15 on the MARKFORGED printer. Classifying them according to the type of test, 10 test pieces were made for flexure, 10 for traction and 10 for mechanical dynamic analysis (5 of them were made of Onyx material and 5 of Daylight High Tensile). Each of these test pieces was designed based on a biomimetic model, namely: spiderweb, water drop, bone and snowflake. All designed test pieces can be seen in Table 2 where their enlarged structure is also found.

Table 2. Test pieces

Biomimetic models	Structures	Flexure	Traction	DMA
Spiderweb [18]				
Drop [16]				
Bone [17]				

Bone [17]				
Snowflake [19]				

Figures 10 and 11 show the test pieces on the table of the 3D printer machine.

Fig. 10. Test pieces on the table of MARKFORCED machine

Fig. 11. Test pieces on the table of MAGNA machine

Due to design errors and improper placement of test pieces on the machine table at the time of the g code for printers, not all test pieces were printed. Properly manufactured test pieces were coded for easy tracking during testing (Table 3).

Table 3. Test pieces codification

Cod	Test	Material	Name
L	Traction	Onyx	Drop
LRI	Flexure	Daylight High Tensile	Drop
O	Traction	Onyx	Horizontally bone
OI	Flexure	Onyx	Vertical bone
RFI	Flexure	Daylight High Tensile	Snowflake
RL	Traction	Daylight High Tensile	Drop
RO	Traction	Daylight High Tensile	Horizontally bone
ROI	Flexure	Daylight High Tensile	Horizontally bone
VRO	Traction	Daylight High Tensile	Vertical bone
VROI	Flexure	Daylight High Tensile	Vertical bone
RDO	DMA	Daylight High Tensile	Horizontally bone
VRDO	DMA	Daylight High Tensile	Vertical bone
DL	DMA	Onyx	Drop
DO	DMA	Onyx	Horizontally bone
RDL	DMA	Daylight High Tensile	Drop

6. Testing of test pieces

The testing of the test pieces was performed on the INSTRON DX equipment, in figure 12 flexure testing can be observed.

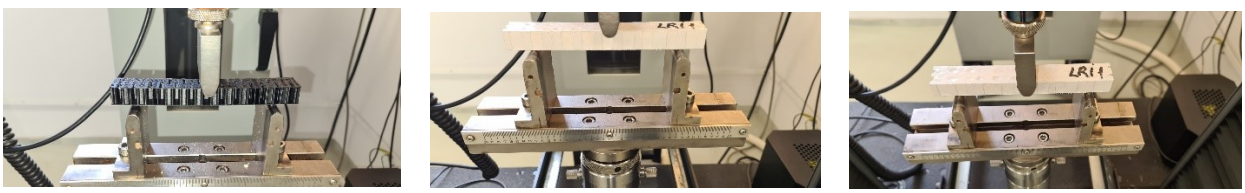


Fig. 12. Flexure testing

Following the samples taken and the results obtained, comparison graphs were made between various parameters of the test pieces but also of the materials from which they were designed. In figure 13

the variation of the deformation of the test pieces depending on the tensile stress is represented and in figure 14 the variation of the deformation depending on the flexure stress.

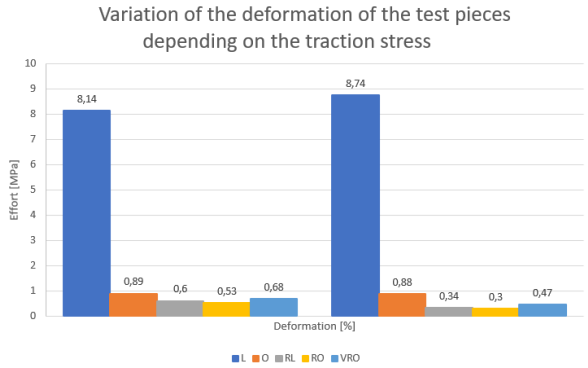


Fig. 13. Variation of the deformation of the test pieces depending on the traction stress

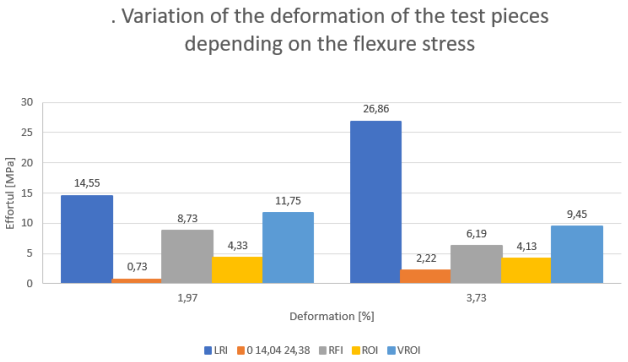


Fig. 14. Variation of the deformation of the test pieces depending on the flexure stress

In figure 15 the comparison of the traction test pieces according to the deformation, the modulus of elasticity and the force is represented. The same comparison is made in the case of flexure according to Figure 16.

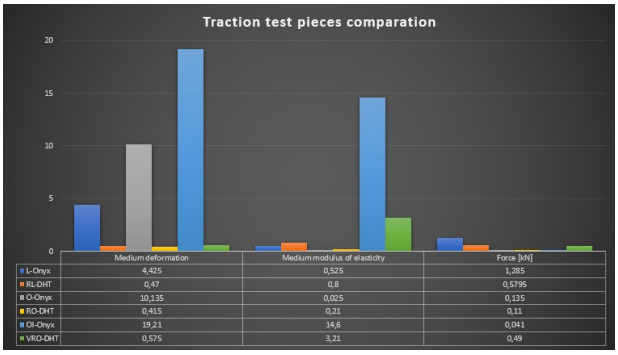


Fig. 15. Traction test pieces comparation

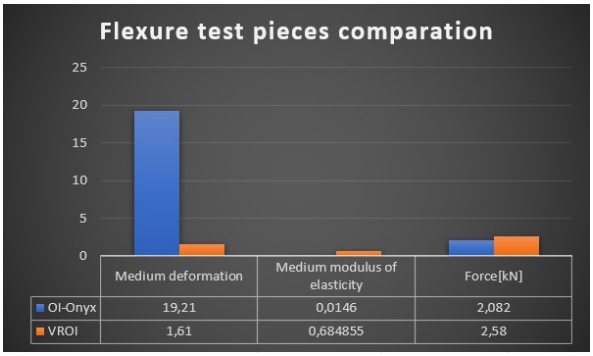


Fig. 16. Flexure test pieces comparation

Figures 17 and 18 represent the overall behavior during testing of tensile and flexure test pieces, with deformation on the x-axis and force on the y-axis.

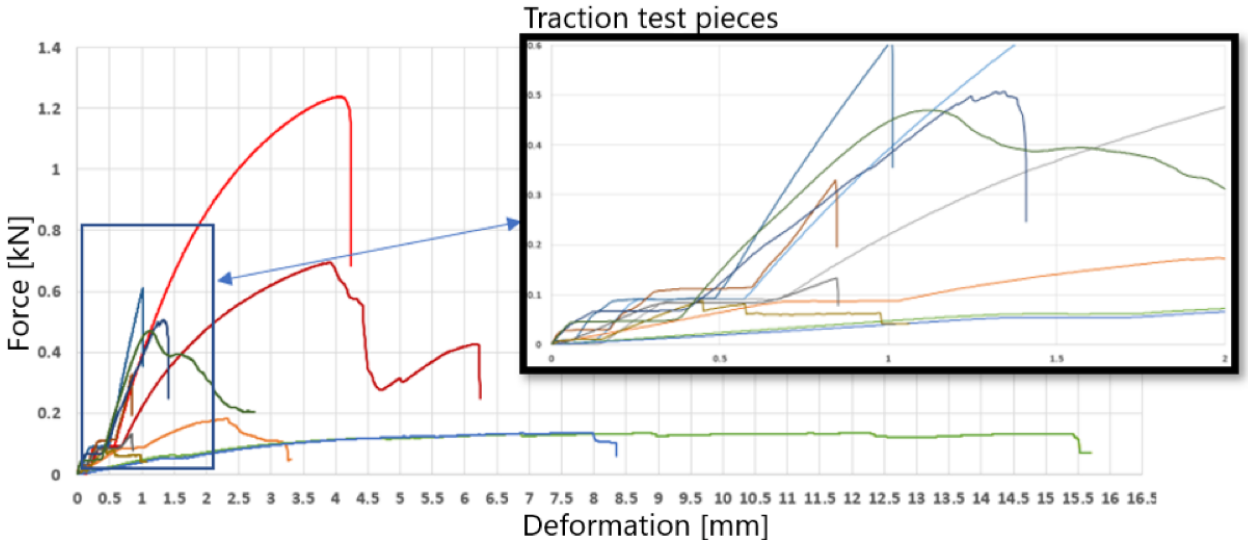


Fig. 17. Global traction behavior

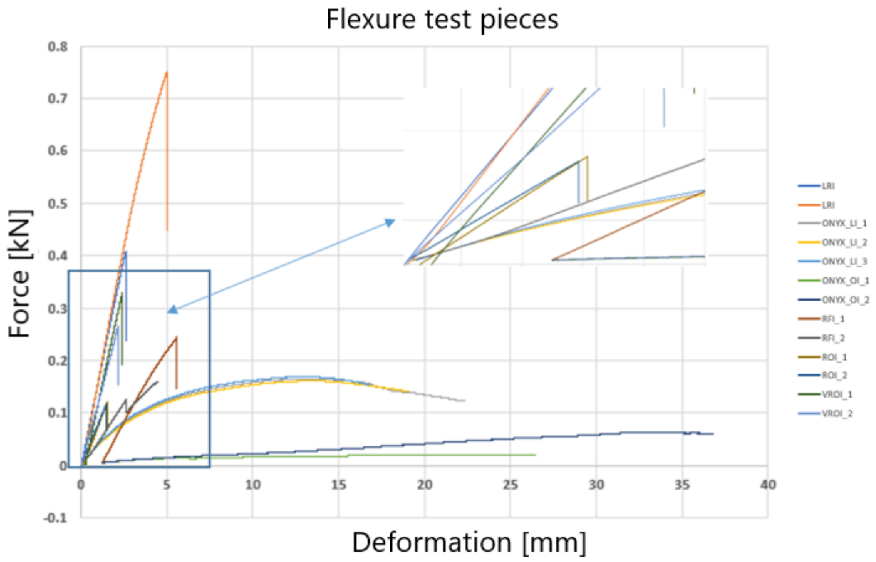


Fig. 18. Global flexure behavior

7. Conclusions

Numerous manufacturing problems have been identified in the early stages of cell development in this research paper. For some concepts it was possible to change the geometry by thickening the plates that supported the sandwich structures to improve the quality of the additive manufacturing process. However, there are still issues that require close attention in order to obtain the optimal structures in terms of current additive manufacturing capabilities.

A similar behavior is observed from the tests tested on traction in the case of all concepts in the first stages of testing. These can be seen in Figure 17 being represented by the thresholds that show the propagation of defects, gradual, which appears in the cellular structures until the moment of breaking the test pieces.

The best results were obtained in the case of structures called "drop". The L1 and L4 test pieces were subjected to modifications in the area of the connection between the cell chains and the tank clamps which were shown to increase the strength of the test pieces twice compared to the L2 and L3 test pieces.

In the case of the flexure test pieces, 2 distinct behaviors were observed, namely a linear behavior until breaking, at which point it occurs suddenly when the maximum force is reached and another type of behavior, ductile which does not show a breaking point of the test pieces. and continues to deform with a decrease in applied force. These two behaviors are given strictly by the material used due to the elastic capacity of the onyx to deform without breaking, thus in the case of resin additive test pieces, the LR concept showing the best resistance to flexure while in the case of test pieces made of onyx additive LI showing the best flexure strength. It can be concluded that the concept that integrates drop geometries has a high resistance compared to other concepts, both flexure and traction.

However, the use of other concepts in the future will not be ruled out, as the aim of the paper was to take the first steps in identifying the behavior for different sandwich structures that can be integrated later in reinforced polymer composite structures, serving several applications where wants both the reduction of the final mass of the component and its final resistance to different types of loads.

What was observed in the previous mechanical tests is also supported by the results obtained from the mechanical-dynamic tests that followed the isolated behavior of the cells investigated in this paper by deforming the samples up to 5 mm. Thus, it could be concluded that in the case of geometric structures with "bones" their modified version could pass the test without breaking.

8. Development directions

The cells can be used as sandwich structures as part of parts made of reinforced polymeric composite materials such as turbine blades or other components of their structure such as those shown in Figure 1. Thus, by determining the cellular structures of interest, the following research will aim at the “customized”

production of sandwich structures such as those found on the market, honeycomb structures such as aluminum and nomex, by using the additive manufacturing technology offered by MARKFORGED, which allows to obtain these structures by depositing continuous reinforcement with wire: carbon, kevlar, fiberglass.

The aim is to develop a code in a programming language that copies the cellular structures from images obtained under microscopy for the geometric optimization of future cells used in sandwich structures.

9. Bibliography

[1]. Composites World, „Hydroelectric turbine blades: COMPOSITES ENABLE ENERGY FROM WATER", vol. 7, nr. 3

[2]. Sebastian Marian Zaharia, Larisa Anamaria Enescu & Mihai Alin Pop (2022), „ Mechanical Performances of Lightweight Sandwich Structures Produced by Material Extrusion-Based Additive Manufacturing", Sesiunea de comunicări științifice studențești, Universitatea Transilvania of Brașov, 09.08.2020

[3]. ASTM C393-C393M-06. Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure; ASTM International: West Conshohocken, PA, USA, 2006

[4]. ASTM D638–14. Standard Test Method for Tensile Properties of Plastics; ASTM International: West Conshohocken, PA, USA, 2014.

[5]. https://photocentricgroup.com/wp-content/uploads/2022/04/Datasheet-LC-Magna-12.4.22.pdf, accessed on 05.05.2022

[6]. https://photocentricgroup.com/wp-content/uploads/2022/04/Datasheet-LC-Magna-12.4.22.pdf, accessed on 05.05.2022

[7]. https://afaceri-poligrafice.ro/alte-modalitati-de-imprimare-inscriptionare/stereolitografia-vs-expunerea-digitala-a-luminii/, accessed on 05.05.2022

[8]. https://photocentricgroup.com/wp-content/uploads/2022/04/LC-Magna-Materials-Comparison-Table-12.4.22.pdf, accessed on 05.05.2022

[9]. https://www.blog.3ddot.ro/introducere-in-fdm/, accessed on 05.05.2022

[10]. https://markforged.com/3d-printers/x7, accessed on 05.05.2022

[11]. https://s3.amazonaws.com/mf.product.doc.images/Datasheets/F-PR-3012.pdf, accessed on 05.05.2022

[12]. https://photocentricgroup.com/wp-content/uploads/2022/04/TDS-Daylight-Magna-High-Tensile-2022.pdf, accessed on 05.05.2022

[13]. https://www-objects.markforged.com/craft/materials/CompositesV5.2.pdf, accessed on 05.05.2022

[14]. https://www.3axis.us/matetials/markforged-materials.pdf, accessed on 05.05.2022

[15]. http://repository.utm.md/bitstream/handle/5014/7652/Simpozion_Cucuteni_5000_Redivivus_2014 pg187-194.pdf?sequence=1&isAllowed=y, accessed on 07.05.2022

[16]. https://www.bunaziuafagaras.ro/trei-premii-pentru-abonatii-care-si-au-platit-facturile-de-apa-la-zi/, accessed on 07.05.2022

[17]. https://www.shutterstock.com/image-vector/dog-bone-icon-simple-cartoon-vector-1314003926, accessed on 07.05.2022

[18]. https://ro.stockfresh.com/image/7427003/spider-web-art, accessed on 07.05.2022

[19]. https://publicdomainvectors.org/tr/bedava-vektor/Siyah-beyaz-kar-tanesi-simge-vekt%C3%B6r-k%C3%BC%C3%A7%C3%BCk-resim/19431.html, accessed on 07.05.2022

[20]. https://www.instron.com/en/products/testing-systems/universal-testing-systems/high-force-universal-testing-systems/static-hydraulic/dx, accessed on 05.05.2022

[21]. https://www.compositesworld.com/articles/hydroelectric-turbine-blade-design-propelled-by-composites, accessed on 07.05.2022

[22]. https://kineticnrg.com.au/technology/, accessed on 07.05.2022

ELECTRIC DISCHARGE DEPOSITION EQUIPMENT

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ABSTRACT: The electric discharge deposition process (EDD) is a new machining process for metal fabrication. In this process, the high level of wear of the tool electrode is used to obtain the deposition of the metallic material. The equipment was modeled in Autodesk Inventor Professional 2022, and the simulation process was simulated in Comsol Multiphysics 5.5. In this paper, the coil was modeled to simulate the variation of the magnetic flux and how it affects the trajectory by changing the intensity.

KEYWORDS: deposition, electric discharge, equipment, simulation, trajectory

1. Introduction

The demand for micro-scale parts production has been increasing day by day. The deposition of thin layers on metals and semiconductors finds a great application in these fields. Electric discharge deposition (EDD) is one of the most important deposition techniques in the research community. The following are reported from the literature currently available.

The μ-EDD process is performed in normal atmosphere, and the tool electrode is connected to the positive terminal, where ions are emitted from its surface and have a path directed by the magnetic field to the surface of the part. (see Fig. 1). Because the ion pulse is higher, they lead to the deposition of the tool's material on the surface of the workpiece [1].

During the discharge process, a voltage is applied between two electrodes (the tool and the workpiece). When the electrodes are very close to each other, under the action of Joule heating and the force of the electric field, the surface of the cathode will emit a mass of electrons. Under the force of the electric field, the electrons are accelerated, going to the anode. High-speed electrons collide with the average electrical particles bringing a large portion of electropositive particles. This collision occurs continuously during the discharge process, so the electrical particles will grow, forming a plasma channel [2].

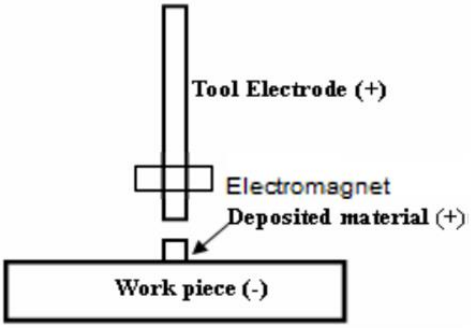


Fig. 1. Diagram of electric discharge [1]

2. Current stage of EDD

The electric discharge equipment is designed to be mounted on an EDM machine, which will change its polarity in order to deposit material on a part with electrical conductivity.

3. Strategic product marketing

3.1 Identifying market opportunities

a. Client's portfolio of needs

There were identified 4 needs numbered N1, N2, N3, N4.

N1: The need of depositioninf material at low costs.

N2: The need to adjust magnetic field strength and ion particle trajectories in EDD so as to increase material deposition rate and quality.

N3: The need to ensure an adequate working head feed rate for the purpose of deposition by electric discharge.

N4: The need to increase productivity and machining times through coordinated CNC movement.

b. Opportunities/ Products/ Customers

For each identified need, the following will be established

1) Market opportunities (causes of the need):

• For N1: Lack of such equipment on the market to achieve deposition of material by electrical discharge at low cost.

• For N2: Lack of an electromagnetic device on the market that directly influences the deposition process by electrical discharge.

• For N3: The non-existence on the Romanian market of a similar product for customers who have an electroerosion machine and and who want an extension into the EDD process

• For N4: Lack of electrical discharge deposition equipment on the market and CNC assisted using electroerosion equipment.

2) Products that satisfy the customer needs:

For need N1: P1. Electroerosion processing equipment

For N2 need: P2. Helmholtz coils

For need N3: P3. Working head for EDM

For need N4: P4. Equipment containing multi-axis travel systems

3) Customers for the sale of products

• Research and educational institutions (students, teachers, research laboratories)

• Enterprises performing non-conventional processing (workshops and production departments within the company)

3.2 Mission formulation

• Magnetic field assisted electrical discharge deposition using EDM equipment improves deposition quality and the molten material particles are directed and concentrated towards the electrode by adjusting the current density on the surface.

• By moving the workhead, it is possible to deposit a larger layer of material on the workpiece.

• The equipment has high productivity and good operating times thanks to the machine table's multi-axis travel ability.

3.3 Selecting potential customers

Customer selection involves identifying actual and potential customers who could benefit from CNC magnetic field assisted electrical discharge deposition equipment. EDD equipment is of interest to: micro-enterprises, small and medium-sized enterprises, large enterprises, research and educational institutions.

3.4 Data collected from potential customers.

Identifying a customer’s needs aims to create a base for the entire product development process. The accuracy and quality of the information gathered from customers will have a decisive influence on the final product. The method used to gather raw information about customer needs was the interview.
Ten people were interviewed and their statements were interpreted in such a way as to prioritise user requirements, Table 2 being significant in this respect.

4. Establishing specifications

4.1 Characteristics - demands matrix

The main characteristics and their classification for the product "Electrical discharge deposition equipment" are presented, and the equipment development stage is the establishment of objective product specifications, for which market success of the product is possible. These characteristics are shown in table 3 to facilitate the identification of the primary sizes and requirements.

Table 1. Interview

Costumer: *PÂRVU GABRIELA*		Interviewer: *Bîțoi Ion-Vlăduț-Valentin*
Question	Costumer statement	Question
Typical uses Do you need equipment to deposit metal material on a surface? If so, on what kind of surfaces?	Yes, in the laboratories of the faculty for laboratory work with students using this equipment for teaching purposes, projects or in research work. I would use this equipment for laying on flat or cylindrical surfaces.	Typical uses Do you need equipment to deposit metal material on a surface? If so, on what kind of surfaces?
If you used this filing procedure, what form and arrangement did you use?	I did not use similar equipment in practice, but from various research papers I noticed that layers of material were deposited in different shapes (circle, star, spiral, hexagon).	If you used this filing procedure, what form and arrangement did you use?
What applications did you use this procedure for?	We have not used similar equipment in practice, but it certainly has to be universal in terms of parts. The equipment should also be able to deposit on cylindrical, spherical, surfaces...	What applications did you use this procedure for?
If you used this procedure, what materials did you submit?	Because this equipment is not found in the laboratories of the faculty, we did not perform material deposition operations, but I know that they can be deposited on metal parts made of copper, tungsten, graphite filiform electrodes.	If you used this procedure, what materials did you submit?
Do you think it is a solid enough product?	The product must be as solid and precise as possible.	Do you think it is a solid enough product?
Why is this useful product?	Because it is a novelty in unconventional processes and I think it will have a positive impact in the coming years.	Why is this useful product?
What kind of parameters, functions or features of the product, do you consider necessary for this equipment?	Positioning accuracy, wire feed rate, intensity, pulse time, magnetic flux	What kind of parameters, functions or features of the product, do you consider necessary for this equipment?
User knowledge issues Do you have knowledge about this field?	Yes	User knowledge issues Do you have knowledge about this field?
Have you ever encountered such equipment?	Yes, I have come across such equipment in research laboratories.	Have you ever encountered such equipment?
Do you consider that you need training to use / adjust this equipment?	Yes, it is necessary to have the possibility to offer training sessions	Do you consider that you need training to use / adjust this equipment?
Pleasant aspects of the current product Is it easy to use?	Yes	Pleasant aspects of the current product Is it easy to use?
How do you maintain your current equipment?	With average ease	How do you maintain your current equipment?
What do you think of the product in terms of maneuverability?	Very good due to the small size	What do you think of the product in terms of maneuverability?
How detailed is the use, installation and maintenance manual?	Detailed, with explicit figures and tables	How detailed is the use, installation and maintenance manual?
What do you think about the cost of the product?	Be as small as possible compared to the competition	What do you think about the cost of the product?
Disadvantages of the current product There is a risk of injury during use.	Yes, if the staff is unskilled and inexperienced	**Disadvantages of the current product** There is a risk of injury during use.
How would this product bother you during processing?	It would bother me if it is not stable and safe in operation	How would this product bother you during processing?
Improvement proposals What is the degree of flexibility for this product?	Pretty big. I have encountered such subsystems in many areas.	**Improvement proposals** What is the degree of flexibility for this product?
You would like something specific from EDDE	Fixing the equipment is easy, with few fasteners, easy maintenance.	You would like something specific from EDDE

Table 2. User requirements and relative importance

No.	*Customer requirements*	*Relative importance*
1	EDDE is used in many areas.	4
2	EDDE allows the deposition of material in different forms and layouts.	5
3	EDDE allows deposition in the form of layers of different materials.	5
4	EDDE prezintă costuri reduse.	4
5	EDDE is low cost.	4
6	EDDE provides the desired processing characteristics.	5
7	EDDE allows the use of qualified persons.	2
8	EDDE makes maintenance easy.	3
9	EDDE provides detailed user manual.	3
10	EDDE offers safety in operation.	4

Table 3. Characteristics - demands matrix

Column #				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Direction of Improvement: Minimize (▼), Maximize (▲), or Target (o)																										
Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") \ Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	External dimensions of the equipment	Equipment weight	Magnetic field assist	Power consumed	Interstitial processing	Energy source	Pulse time	Magnetic flux	Current density on surface	Machine tool precision	Dimensions of the machine table	Diameter of tillform electrode	Maximum electrode weight	Thickness of the deposited layer	Maximum workpiece dimensions	Maximum workpiece weight	Current to be processed	Material deposition speed	Roughness of the deposited layer	Mean Time Between Failures	User safety	Design	Equipment price
9	10.3	4.0	EDDE has uses in many areas			⊙		▲		o	o	o	▲				o	o		o		⊙	⊙			
9	12.8	5.0	EDDE allows the deposition of material in different forms and depositions			⊙		⊙		▲												▲				
9	12.8	5.0	EDDE allows deposition as layers of different materials					⊙		⊙	⊙	⊙	o		o		▲			▲	▲	▲				
9	10.3	4.0	EDDE provides low costs	⊙	⊙	o	▲						⊙	o		o		▲					o		⊙	
9	10.3	4.0	EDDE provides manoeuvrability	⊙	⊙				▲					⊙	▲	▲			o						▲	
9	12.8	5.0	EDDE provides the desired processing characteristics			⊙						⊙	⊙	⊙	▲						⊙	⊙				
3	5.1	2.0	EDDE allows the use of qualified persons			o	o		o	▲	o	o			▲					▲		▲				
9	7.7	3.0	EDDE allows easy maintenance	o	o									▲									⊙		⊙	o
9	7.7	3.0	EDDE provides detailed user manual	⊙	▲	⊙			o			o		o	o	▲	o	o	o	o				⊙		▲
9	10.3	4.0	EDDE offers operational safety	o	o				o					o	▲	▲		o	o	▲			▲	⊙		

⊙ Strong Relationship | o Moderate Relationship | ▲ Weak Relationship

5. Conceptual design

5.1 General function and component functions

The general function of the EDD equipment, which is the subject of this paper, is to deposit material by electric discharge in the magnetic field.

The general function is subjected to an analysis process which will result in first the main functions and then the secondary ones. The main functions are properties of the product that determine the general function. Secondary functions result from the interaction between the main functions and are called internal interactions, and the interactions between the main functions and the environment are external interactions.

The functions of the EDD equipment are listed in Table 4.

Table 4. Functions of the EDD equipment

GF	***Layer deposition***
No.	*EDD functions*
1	Attaching the tool electrode *Secondary functions:* chuck opening; electrode insertion; screwing in the chuck key to tighten the electrode.
2	Adjusting the perpendicularity of the electrode-tool in relation to the surface of the workpiece *Secondary functions:* loosening the perpendicularity adjustment screws; changing the position of the electros-tool; maintaining the position with the openwork of the springs.
3	Workpiece holding *Secondary functions:* vise opening; the introduction of the piece; screwing in the chuck key to tighten the electrode
5	Providing an electromagnetic field: *Secondary functions:* power supply start; Supply of the subassembly of electromagnets with electricity from the source;
6	Ensuring the generation of magnetic flux; *Secondary functions:* pressing the buttons on the control panel, adjusting the voltage and current, in the drives, adjusting the current density on the surface; ensuring a direction of propagation.

7	Providing the working environment. *Secondary functions:* ensures a normal atmosphere; prevents objects from entering the work area.
8.	Secures to the rest of the machine. *Secondary functions:* vibration reduction; positioning on the surface, fixing on the surface, prevention of overturning, prevention of slipping
9.	Ensures the user's safety and health during machining *Secondary functions:* light signaling; audible signaling when the equipment is switched on. visualizing the status of the machine on the control panel

Among the main functions established above, a list of critical functions has been compiled (Table 5), which determines the commercial success of the product. These critical functions correspond to the sizes and requirements with the maximum relative importance.

Table 5. List of critical functions

Function number	***The critical function of the product***
1	Ensuring ion flow generation
2	Providing an electromagnetic field
3	Attaching the tool electrode
4	Workpiece holding

5.2 Internal research for new construction solutions

The need to identify technological and constructive solutions has determined a more intense participation of the creative component of thinking; for this reason, more attention has been paid to the study and use of methods to stimulate technical creativity (both of the group and of the individual).

- Concepts generated individually. For the design and determination of the optimal mechanism of EDD, we proposed the use of the diagram of ideas from table 6:

Table 6. Diagram of ideas

Equipment for material deposition by electric discharge			
A. Electrode shape in cross section	B. Power supply to the equipment	C. Ensuring the power supply in the machining area	D. User protection
A1. Circula	B1. Power from the socket	C1. Source circuit	D1. Protective equipment
A2. Tubular	B2. Power obtained by combustion	C2. Rechargeable battery circuit	
A3. Square	B3. Rechargeable battery power	C3. Battery circuit	
A4. Rectangular	B4. Power obtained by chemical reactions		

- Group-generated concepts. The functions of the product were analyzed and solutions were proposed for their proper accomplishment:

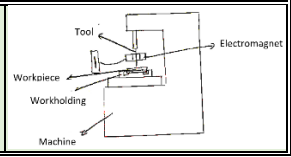
Table 7. Solution diagram

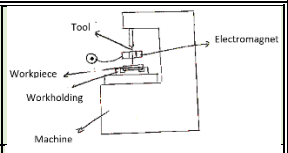
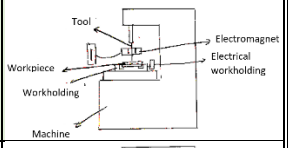
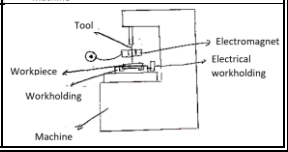
A. Workpiece holding	B. Utilizarea magneților	C. Asigurarea fluxului magnetic	E. Reglarea sculei la cotă	F. Asigurarea mediului de lucru
A1. Mechanical workholding	B1. Temporary	C1. Lever	E1. Preliminary test passes	F1. Normal atmospher
A2. Electrical workholding	B2. Permanent	C2. Button	E2. Adjustment by test pieces	F2. Dielectric fluid
A3. Hydraulic workholding;	-	C3. Switch	-	F3. Vacuum
A4. Pneumatic workholding;	-	C4.Potentiometer	-	-

5.3. Resulting concepts

Following the compilation of the database of known and new conceptual solutions for the main functions of the product, a number of technically possible solutions are established by combining the concepts. As, in general, the number of technically possible solutions is very large, taking into account the objective specifications established in the previous works, a number of conceptual solutions are excluded.

Table 8. Conceptual solutions

Concept		Draft
A	Electric discharge deposition machine with a mechanical part clamping device, a lever-operated electromagnetic field, and the tool adjustment at the dimension is done by preliminary test passes.	

B	Electric discharge deposition machine that has a device for mechanical fastening of the semi-finished part, the provision of an electromagnetic field actuated by a button, and the adjustment of the tool at the dimension is done by preliminary test passes.	
C	Electric discharge deposition machine that has a device for electrically gripping the semi-finished part, ensuring an electromagnetic field actuated by a lever, and adjusting the tool at the level is done by preliminary test passes.	
D	Electric discharge deposition machine that has a device for electrically gripping the semi-finished part, ensuring a button-operated electromagnetic field, and adjusting the tool at the dimension is done with the help of test pieces.	

The concept evaluation matrix is presented in Table 9.

Table 9. Concepts evaluation matrix

Selection criteria	***Weight [%]***	***Concept A***		***Concept B***		***Concept C***		***Concept D***	
		Assessment	*Score*	*Assessment*	*Score*	*Assessment*	*Score*	*Assessment*	*Score*
Ease of operating	20								
Ease of voltage programming	8	3	0.24	3	0.24	3	0.24	3	0.24
Ease of intensity programming	8	3	0.24	3	0.24	3	0.24	3	0.24
Ease of programming feeds	4	3	0.12	3	0.12	3	0.12	3	0.12
Ease of use	15								
Ease of electrode supply	5	3	0.15	3	0.15	3	0.15	3	0.15
Ease of assembly	5	3	0.15	3	0.15	2	0. 1	2	0.15
Ease of cleaning	5	3	0.15	3	0.15	3	0.15	3	0.15
Reliability	25								
Interchangeability of parts	20	3	0.6	3	0.6	3	0.6	1	0.2
Strength, durability of equipment	5	3	0.15	3	0.15	3	0.15	2	0.1
Design and ergonomics	10								
Pleasant design	3	3	0.09	3	0.09	3	0.09	3	0.09
Proportionality of shapes	2	3	0.06	3	0.06	3	0.06	3	0.06
Overall dimensions	3	3	0.09	3	0.09	3	0.09	3	0.09
Stability	2	3	0.06	3	0.06	3	0.06	3	0.06
Safety in exploitation	10								
Trained staff	4	3	0.12	2	0.08	3	0.12	4	0.16
Protective equipment	3	3	0.09	3	0.09	3	0.09	3	0.09
Acousting and light signaling	3	3	0.09	3	0.09	3	0.09	3	0.09
Ease of manufacturing	15								
Type of material	10	3	0.3	2	0.2	3	0.3	4	0.4
Machinability of materials	5	3	0.15	2	0.1	3	0.15	3	0.15
Cost	20								
Manufacturing cost	10	3	0.3	2	0.2	2	0.2	1	0.1
The cost of maintenance	5	3	0.15	3	0.15	3	0.15	2	0.1
Decommissioning cost	5	3	0.15	3	0.15	3	0.15	3	0.15
Total score			3.45		3.16		3.2		2.89
Rank		1		3		2		4	

The variant with the highest score, the concept A, is adopted.

6. Detailed design

Figure 2 shows the components of the magnetic field-assisted electric discharge equipment:

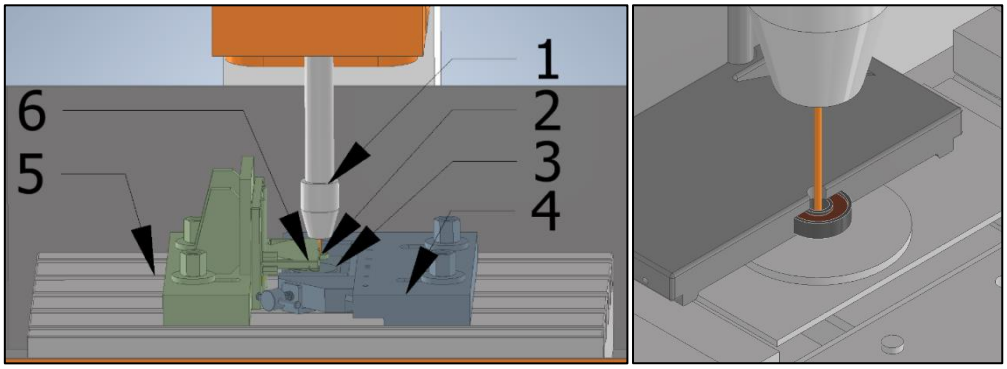


Fig. 2. Components of magnetic field electric discharge equipment which are:
1. Electrode holder; 2. Tool electrode; 3. Electrode-part; 4. Electrode-part clamping device;
5. Worktable; 6. Electromagnet clamping device;

7. Finite element analysis

The Inventor Autodesk 2022 software simulated a force of 0,1 N on the “Clamping device” and “Workhead” subassemblies to observe deformations and determine their safety factor, the results being shown in Figure 3.

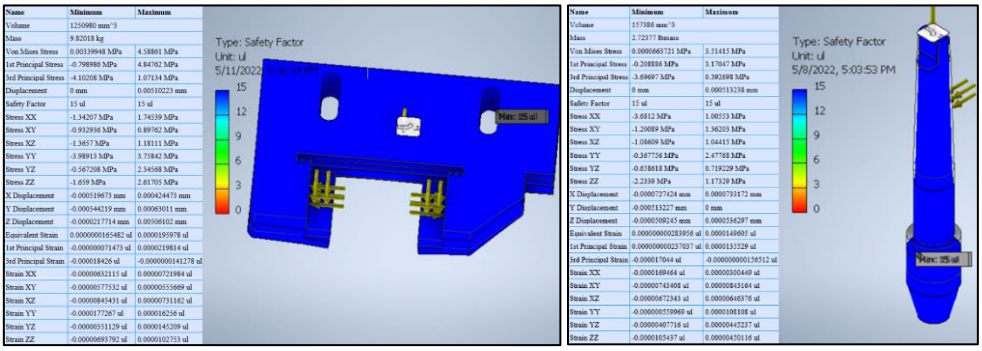


Fig. 3. FEA analysis for " Clamping device" and "Workhead" in Autodesk Inventor 2022

According to the data obtained from the finite element analysis, the "Clamping device" and "Workhead" subassemblies have a safety factor of 15.

Using Comsol Multiphysics 5.5 program, the magnetic flux created by the electromagnet and the particle’s trajectory from the electrode were modeled and simulated, the results of these simulations are shown in figure 4.

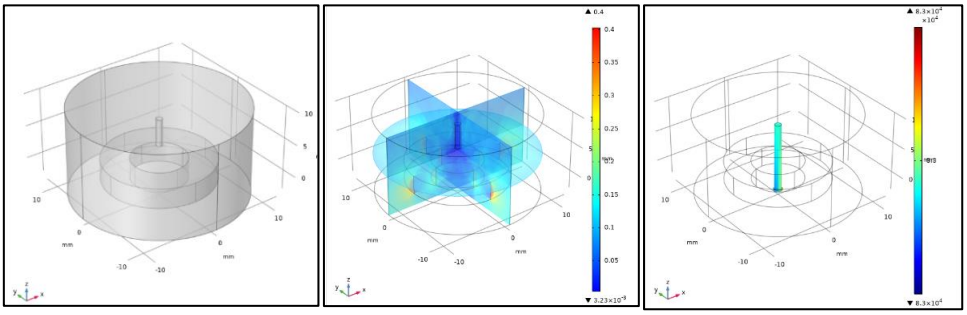


Fig. 4. Geometry modeling, magnetic flux simulation and particle trajectory in Comsol Multiphysics 5.5

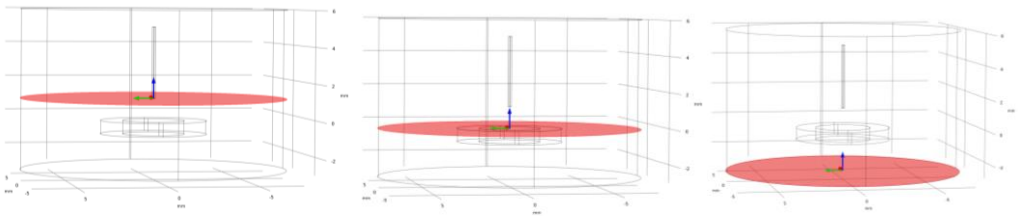


Fig. 5 Cutting planes at Z=1 mm; Z=-1,25 mm; Z=-3 mm;

In order to be able to see the deviation of the beam trajectory, the planes in figure 5 were used to highlight the position of the beam in red, black and blue respectively in the Poincaré graph in figure 6.

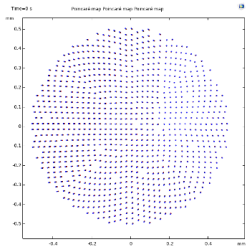


Fig. 6 Poincaré graph

8. Conclusions

The EDD process has a low cost and high precision, because it uses an EDM machine, with the polarity of the tool and the workpiece reversed. Using electrical discharge deposition, products can be manufactured at micro and nano scales.

From the literature it has been found that::

- The weight and height of the layer increases with increasing current, duty cycle, and pulse over time, but decrease with increasing voltage. Increasing the current, the operating cycle and the pulses in time and voltage leads to an increase in the deposited width.
- Important factors influencing this electrical discharge deposition process are current, duty cycle and pulse on time. Voltage has a smaller contribution to the deposition process..
- The multi-layer deposition process also shows the same trend as that followed by the single-layer deposition process.
- Increasing the pulse time increases the heat-affected area, but the deposition diameter is almost constant and the deposition height.

From numerical modelling and simulation of the EDD process we observed that the particle distribution on the part could be kept under control by ED parameters of discharge and magnetic flux. The material deposition dimensions are framed within a range of 0.2 - 0.3 mm if the tool has a similar diameter. If the surface current density increases, a larger and more irregular distribution over the sample results, with an optimal distribution at an average value of magnetic flux.

9. Bibliography

[1]. S. Kanmani Subbu et. al., *Dry Micro-Electric Discharge Deposition of Copper on Die Steel: Effect of Pulse on-Time*, The 7th International Workshop On Microfactories, Daejeon, Korea, 2010
[2]. Z. Wang et. al., *Study on Micro Electrical Discharge Deposition in Air*, International Conference on Mechatronics and Automation, Harbin, China, 2007
[3]. N. Ionescu, course "Product Development 1", available at https://curs.upb.ro/, accessed on 12.05.2022.
[4]. N. Ionescu, course "Product Development 2", available at https://curs.upb.ro/, accessed on 12.05.2022.
[5]. A.C. Iuga, L.D. Ghiculescu, Modeling and simulation of ion implantation and electrical discharge deposition, IC-QIEM & ICNcT 2021, Cluj, Romania, Nonconventional Technologies Review, p. 17-23, 2021.

3D PRINTABLE PORTABLE TESTING STAND FOR CAMSHAFTS AND THEIR CAM PROFILE

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ABSTRACT: This article is referring to a modular testing stand aimed at independent tuners or automotive enthusiasts. The testing stand is the minimum required equipment to check if there is any wear on the surface of the cams, but also to map the profile of an unknown cam in order to further optimize it in CAD. The stand is 3D printable in order to be cheap to manufacture and buy.

KEYWORDS: performance, shaft, cam, testing, optimization

1. Introduction

Camshafts are the second most important element of an engine assembly. This is a shaft made of a metallic material, obtained by various manufacturing methods (cast, billet and forged manufacturing) and which has cams with a profile that's sharp at one end. The camshaft can be compared to the human heart, as it serves the same purpose, the circulation of "fuel" in the system of which it is a part. The role of the camshaft is to actuate the intake and exhaust valves, that is to transform its rotational movement into a translational movement of the valve to achieve the engine cycles. The valves are opened by pressing directly on the cam follower which attached to the valve, or by interacting with an intermediate mechanism called a rocker arm. When the lobe reaches the maximum height of its profile, the valve will be in the fully open position, and when the valve is closed, the cam follower will be on the base circle of the cam profile.

The importance of the paper lies in analyzing the existing testing methods for a camshaft and developing a new testing stand that is cost-effective in terms of production and acquisition.

2. Current State

Currently, the most widely used test equipment is electronic, which is connected to a computer, and which is using a specialized measurement software.

These test stands use an electronic micrometer that sends a digital signal which is then translated by a computer into valve lift graphs and also their entire valve profile, along with the deviations from it caused by wear.

For the rotational movement of the shaft as well as the vertical and horizontal translational movement of the comparator, three electric motors are required, as well as two rails on which the comparator must slide on its two axes. Electric motors also need a controller to actuate them.

This equipment comes at a high cost, as it is necessary to purchase the electric motors, rails, controller and digital comparator, as well as the license for the software that can read the data from the testing assembly.

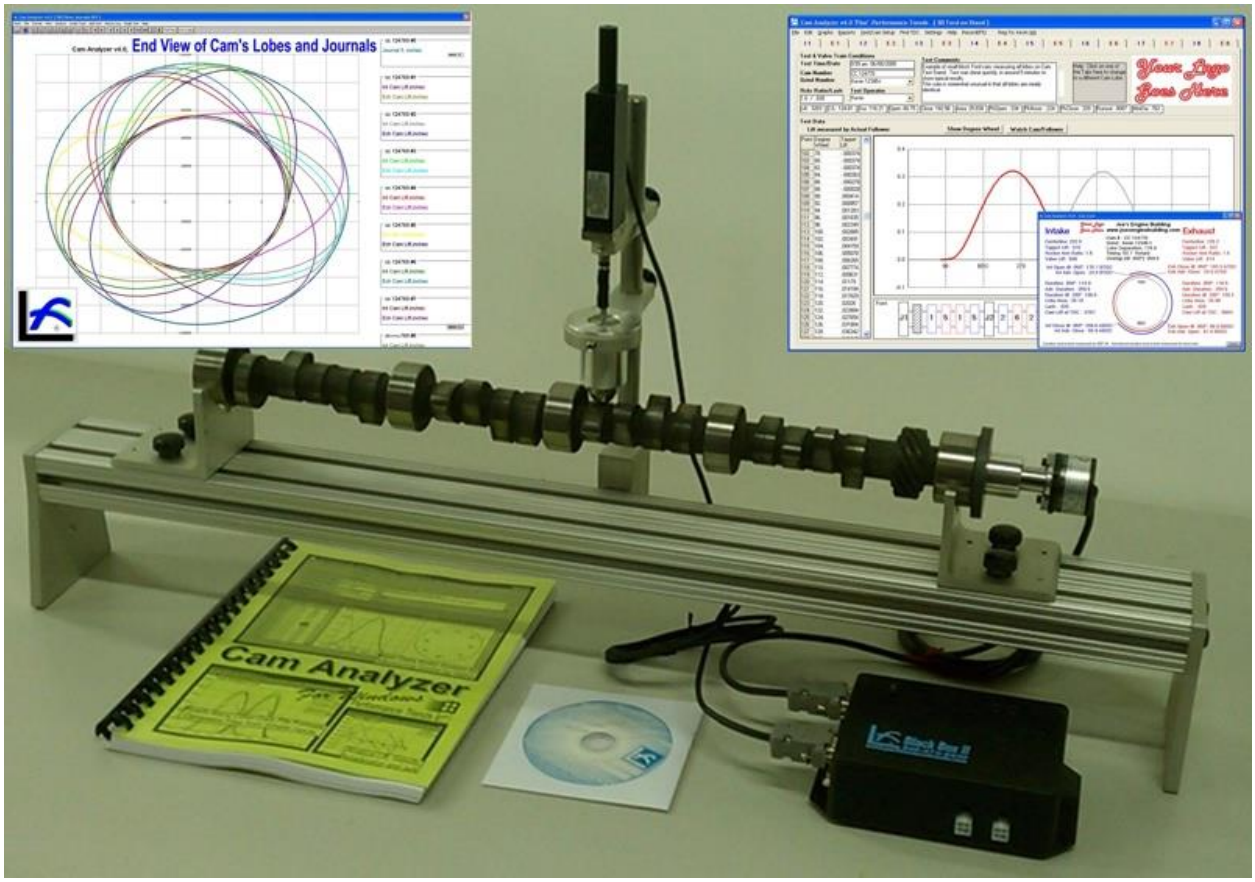

Fig. 1. Cam Analizer (software + hardware) [1]

In Fig. 1. a test stand for a camshaft containing the elements mentioned previously, as well as the installation disc and the user manual of the Cam Analyzer software, can be observed.

This test stand can check both the cams and the camshaft bearing seats.

3. Contributions

As part of this work, a portable test stand assembly was developed, which aims to reduce the purchase price without removing functionality.

In addition to the manual, mechanical comparator, which must be purchased separately, the components of the assembly can be 3D printed with any budget FDM (Fused Deposition Modelling) 3D printer to further reduce the purchasing cost.

Table 1. shows some models of 3D printers that can be used to manufacture the components of the test stand. The sources used can be found in the bibliography at [3 ... 6].

Table 1. 3D Printers

Manufacturer	Name	Functional and economic characteristics		
		Printing dimensions [mm]	Compatible materials	Price [EUR]
DISWAY	01	220*220*250	PLA, ABS, TPU	226
Kuongshun	K10	220*220*260	ABS, PLA, Wood-Polymer, PVA, HIPS, PETG	188
Creality	Ender 3	220*220*250	ABS, PLA, TPU	179
Geeetech	A10 Pro	220*220*260	ABS, PLA	160

The designed test stand consists of several components, as follows:

- **Mounting rail modules**

The mounting rails of the test stand assembly are small in size and can be chained together according to the length of the camshaft that's being tested (Fig. 2.).

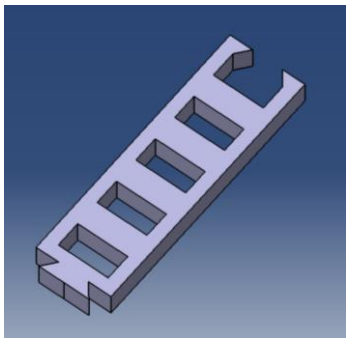

Fig. 2. Mounting rail

- Fasteners of the comparator
    - Mounting support of the comparator

The purpose of this support is to cancel translational movements on the X and Z axes and rotational movements around the X and Z axes of the comparator (Fig. 3.).

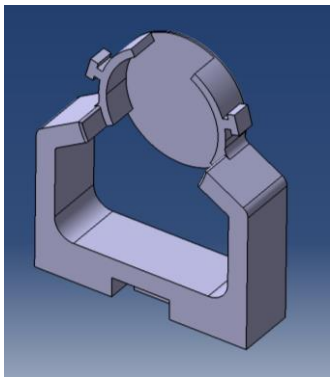

Fig. 3. Mounting support of the comparator

- Closing cover of the comparator’s mounting support

The locking cap is also used to take up the remaining degrees of freedom of the comparator, which are the translation movement on the Y-axis and the rotational movement around the Y-axis (Fig.4.).

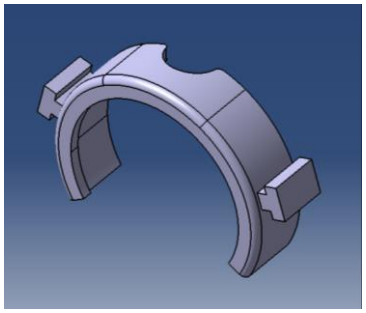

Fig. 4. Closing cover of the comparator’s mounting support

- Cover closing clip

The clip secures the two sections of the mounting support (Fig. 5).

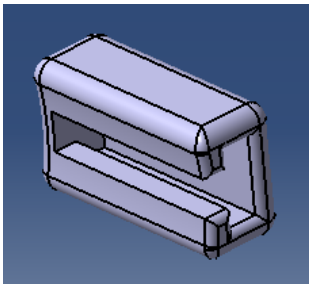

Fig. 5. Clip

- Spacer for raising the comparator's height

This element is used to bring the comparator to the appropriate height (Fig.6.), when it is desired to inspect the camshaft seating bearings.

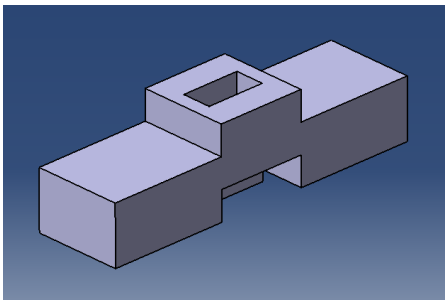

Fig. 6. Spacer

- Camshaft fasteners
  - Camshaft support

The support brackets have four screws in their componence to cancel the translational movements on the X and Z axes and the rotational movements around the X and Z axes of the camshaft (Fig. 7.).

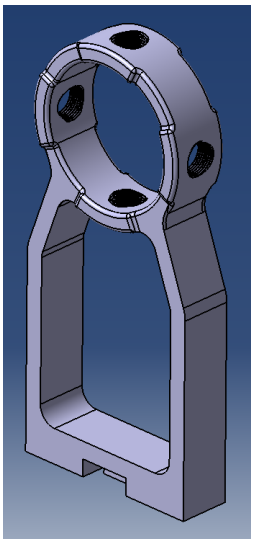

Fig. 7. Camshaft support

- Support screw

Supports use four screws to secure the camshaft (Fig. 8.).

Fig. 8. Screw

- End support with camshaft rotation indicator needle

In addition to canceling the Y+ axis translation movement, this element is intended to help visualise the degree of rotation of the camshaft. This element is height-adjustable by the means of a screw integrated in the construction (Fig. 9.).

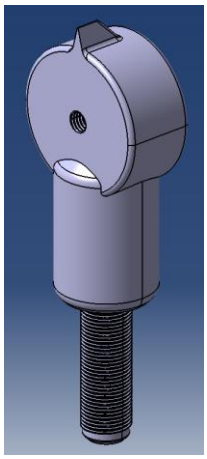

Fig. 9. Support with indicator needle

- End support without camshaft rotation indicator needle

This element is used to cancel the translation movement on the Y- axis, using the centering screw (Fig. 10.).

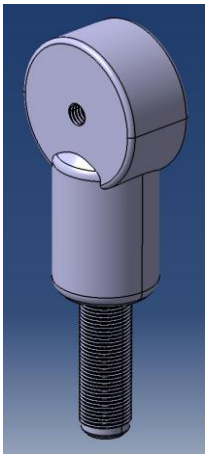

Fig. 10. Support without indicator needle

- Base of camshaft end supports

Into these elements are screwed the two end supports with and without indicator needle (Fig. 11).

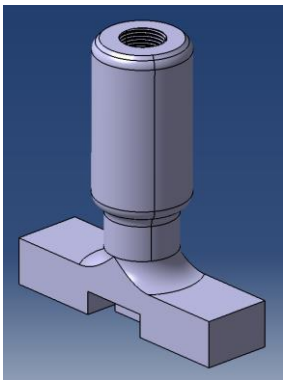

Fig. 11. Base of camshaft end supports

- Centering screw

When mounted in each end bracket, its purpose is to cancel the translational movement on the Y-axis, but not the rotational movement about the Y-axis (Fig. 12.).

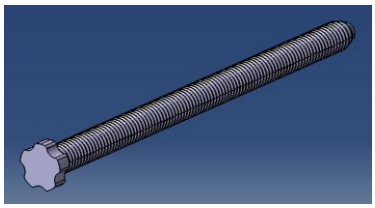

Fig. 12. Centering screw

- Graded bushing

The graded bushing is attached to the camshaft using four screws, and is intended, together with the end support with the indicator pin, to show the rotation of the camshaft in degrees. On one side it shows markings from degree to degree and 10 to 10 degrees, and on the other side it shows markings from 5 to 5 degrees and 15 to 15 degrees. (Fig. 13.).

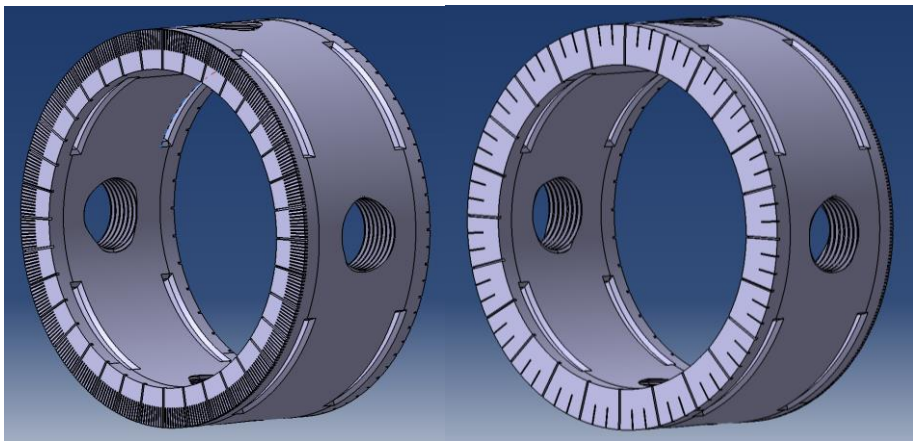

Fig. 13. Graded bushing

- Comparator

After studying several comparator models, the determined size used by the camshaft test stand would be the 58mm in diameter (Fig. 14.).

Fig. 14. Comparator [6]

- Camshaft

The camshaft is the element to be analyzed using this test stand (Fig. 15.).

Fig. 15. Camshaft [7]

6. Conclusions

Through this test stand, camshafts will be able to be checked in terms of cam wear and seating surfaces wear. It will also be possible to map the unknown profile of a camshaft in order to optimize it in a CAD software for performance applications.

The manufacturing cost of such a system is low, as it only requires the purchase of a comparator and the actual 3D printing of the components.

Measurement accuracy is high, but human reading error can occur during measurements, which is completely eliminated by using a fully automatic system.

The assembly can be further developed by adding translation rails for the comparator in the horizontal and vertical directions, but this will increase the complexity of the system and hence the production cost. A digital comparator or even an electronic one could be used to record the values more easily and remove the parallax error which can occur when using a mechanical comparator.

8. Bibliography

[1] https://www.enginebuildermag.com/2014/10/must-shop-tools-measuring-equipment/ (23-04-2022)
[2] https://m.made-in-china.com/product/High-Resolution-Amazing-Print-Quality-Professional-Use-Cheap-3D-Printer-929376965.html (23-04-2022)
[3] https://kuongshun.com/products/best-cheap-3d-printer-k10 (23-04-2022)
[4] https://itslitho.com/product/creality-3d-printer-ender-3/ (23-04-2022)
[5] https://www.3dprintersonlinestore.com/geeetech-a10-3d-printer (23-04-2022)
[6] https://www.industrial-supply.ro/scule-masurare/ceas-comparator-mecanic.html (24-04-2022)
[7] https://www.urotuning.com/products/ie-1-8t-20v-street-intake-camshaft-set-iecva3 (24-04-2022)

PROCESSING EQUIPMENT EDM WITH CONTACT BREAKS

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ABSTRACT: The paper deals with the research, realization and modeling of a portable EDM equipment with contact breaking that is used in the processing of materials using unconventional technologies. The stages of making the equipment are presented as well as all the components used, detailed in an execution drawing and 3D modeled. Comsol Multiphysics was used to model the coil and simulate its operation.

Key words: EDM, contact breaking, conceptual and detailed design.

1. Processing using EDM with contact breaks

Electric discharge processes are the most widespread nonconventional processes in the world. Contact-breaking electrical processing is a process widely used for cutting conductive materials using mainly a solid tool-electrodes. We are witnessing a continuous evolution in the use of new types of metallic materials and the growth of new modern technologies in fields such as aeronautics, automotive, car construction, etc., using so-called unconventional technologies in which materials processing is done by using and directing energy in various forms. [1], [2], [3]. Through this research, it is desired to transmit a special approach regarding the modeling of the technological parameters for the processing with electric discharges with contact brackets, using a transfer object formed by a copper electrode, using an installation formed by an electromagnetic coil, a capacitor that stores electricity and a direct current generator.

2. State of the art

The purpose of EDM is to cut the metal into small sparks. Its advantages are that it will drill holes in metals that cannot be machined by common tools. Cutting of hard steel alloys by electric discharge machining with contact break with electrode tools - metal strip - is one of the modern technological procedures for conventional processing of certain categories of steel alloys (hard and extra hard), in economic conditions of optimum efficiency. [4], [5], [6], [7]. We can highlight the existence of different values of the working parameters, determined by the workpiece. The tool, usually made of copper or graphite, and the workpiece are connected to the poles of a power source. The material of the part is removed by the action of vaporization of the electric discharges in the form of sparks that take place between the tool electrode and the part electrode. The tool usually has the shape of the negative cavity that needs to be processed into the piece, and this can take many very complex shapes. The mechanical part, the head, is simple and portable, but precise, made of copper. The very high current is concentrated in a small point on the workpiece and the metal melts. The molten metal in the workpiece immediately solidifies into the dielectric fluid. Fresh dielectric fluid is continuously pumped to remove metal particles that are separated there by a filter that allows the dielectric to be recycled.

Materials to process:

• Any material that conducts electric current, regardless of its hardness, can be machined by EDM.

• Used mainly for alloy and high-alloy steels, especially for machining die cavities.
• The melting temperature of the processed material and the latent heat of melting are important properties that determine the material removal rate (MRR), which gives the productivity of the process. [8], [9]

3. Identifying Market Opportunities

N1: Customer needs portfolio
N2: The need to process materials by unconventional processes
N3: The need to remove broken tools
N4: The need for small, portable and inexpensive equipment
N5: The need to process materials that have a high hardness.

3.1 Opportunities/ Products / Clients

a) Market opportunities:
For N1:
Need to be a small and portable equipment
For N2,N4:
Processing of materials with high hardness
For N3:
Low cost of processing materials
b) Customers for the sale of products:
-Research institutions;
-Micro-enterprises;
-Small and medium enterprises;
-Large enterprises.
-Individuals
-Repair workshops

3.2 Competitive products

There are already competing products on the market at very affordable prices and with an average accuracy, but our product will tend to be one of very high accuracy, being able to be directed electronically and with multiple working heads, which competing products do not offer. working electrodes in several variants.

Fig 3.2.a Competitor products

4. Conceptual design

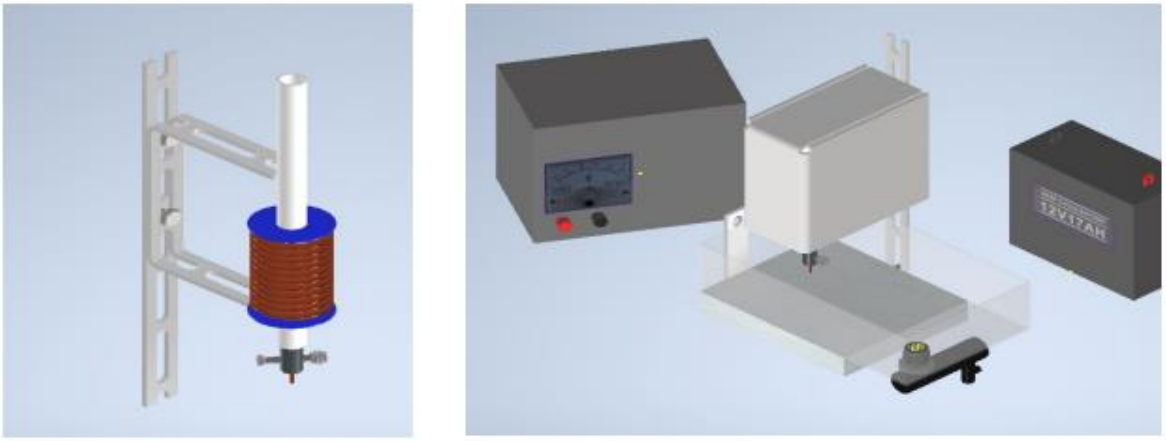


Fig. 1. 3D Modeling of working head and assembly with current generator and supplying battery 12V

The model of the work head and the support was made in Autodesk INVENTOR according to the real dimensions and the calculated data. In fig. 4.3 the execution drawing of the work head is made with the afferent dimensions and the notation of the components.

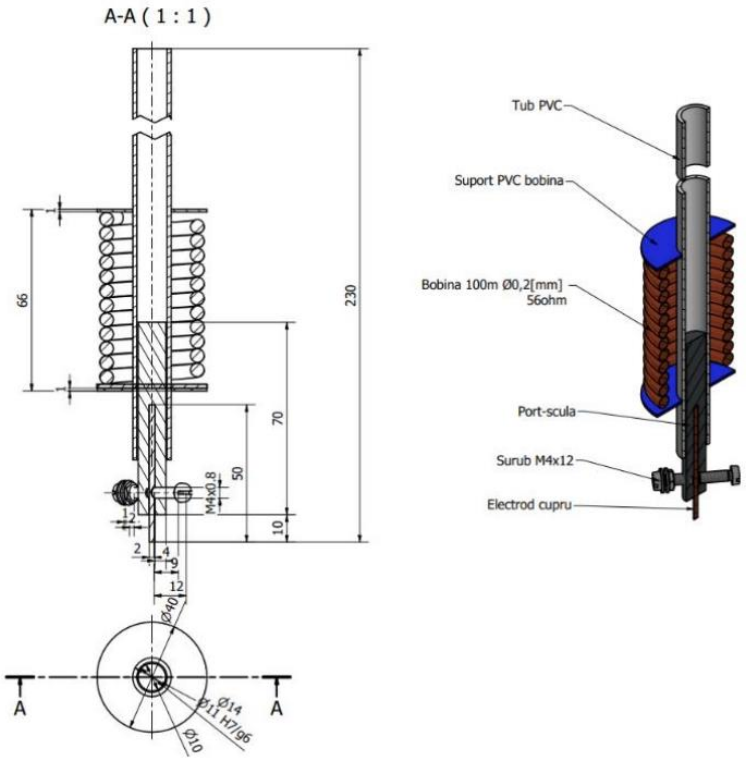


Fig 4.3 Design of the working head

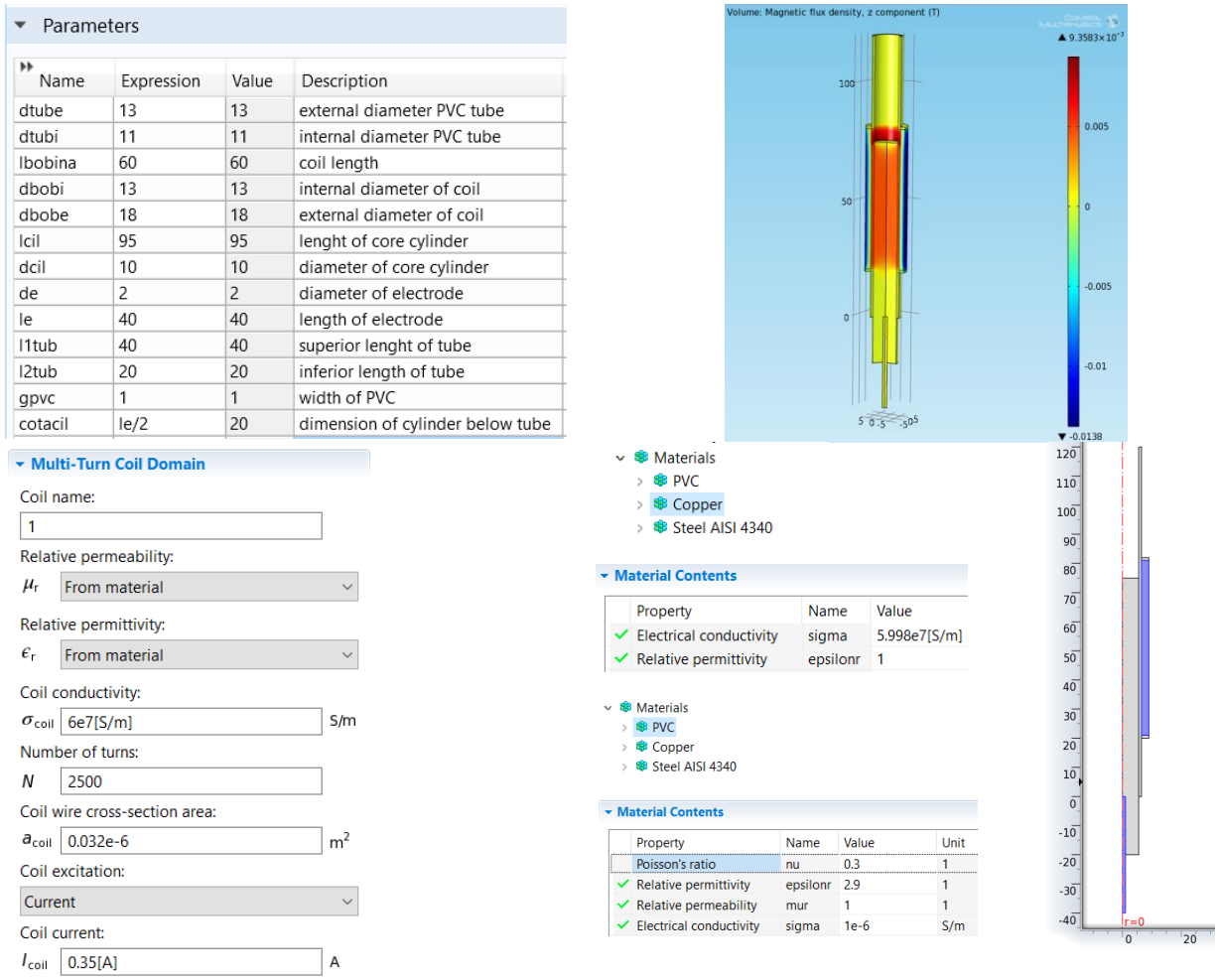
The project consists of several work heads that will be attached:

- circular shape of different diameters
- square shape of different sizes
- other shapes such as triangle, rhombus, ellipse

Fig. 4.4 Shapes of tool-electrode

5. Working head

Before making the coil, a numerical calculation was performed in the COMSOL Multiphysics program to determine the coil characteristics. fig. 5.1.



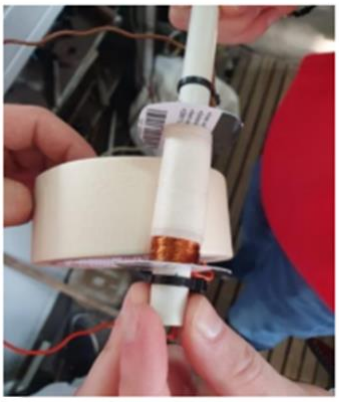
Parameters

Name	Expression	Value	Description
dtube	13	13	external diameter PVC tube
dtubi	11	11	internal diameter PVC tube
lbobina	60	60	coil length
dbobi	13	13	internal diameter of coil
dbobe	18	18	external diameter of coil
lcil	95	95	lenght of core cylinder
dcil	10	10	diameter of core cylinder
de	2	2	diameter of electrode
le	40	40	length of electrode
l1tub	40	40	superior lenght of tube
l2tub	20	20	inferior length of tube
gpvc	1	1	width of PVC
cotacil	le/2	20	dimension of cylinder below tube

Fig. 5.1 Characteristics of the working head

In Fig. 5.1 the parameters of the coil, of the PVC shaft, the details about the electrode and the copper wire from which the coil is made were introduced. Fig. 2.3 represents the force of the coil on the metal rod in which the copper electrode is attached, we can see the red surface where the highest magnetic force takes place.

Respectively in Figs. 2.4 we have the conductivity of the wire, the number of windings, the cross-sectional area of the wire and the current passing through the coil: 0.35A. Fig. 2.5 represents the electrical characteristics of the coil.



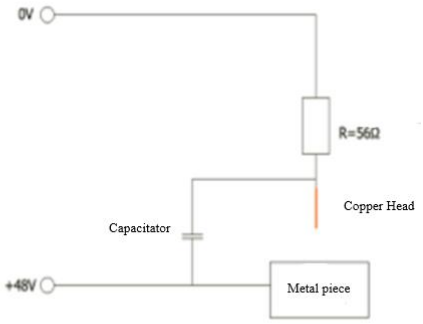


Fig. 5.2 Wiring diagram

Winding calculations were performed which led to the realization of the coil using the following formulas:

$$R = \rho \frac{l}{s} \quad [1]$$

- l= length of winding wire [m] l=100 m

- ρ= wire resistivity $[\Omega \frac{mm^2}{m}]$ $\rho(cupru) = 1{,}68 * 10{-}8\ [\Omega m] = 0{,}0168[\Omega\ mm2\ m\ ]$ [2]

- S= Cross-sectinal area mm^2 S=0.03 mm^2

- Winding wire diameter: Db=0,02[mm]

-Length of winding wire: L=60[mm]

Coil resistance calculation:

$$R = 0{,}0168 \frac{100}{0.03} = 56[\Omega] \quad [3]$$

The wiring diagram contains a coil, a copper electrode, capacitor and circuit power supply. The circuit has a 48V supply, the negative pole enters through the coil, then passes through the capacitor which is in the circuit with the electrode, following that the positive pole is connected to the workpiece and to the other end of the capacitor, thus storing electricity.

Client: Mircea Petre **Adress: Branesti, Makita** **Phone:0722115566**		**Interview: Hatis Bogdan** **Data: 01.11.2012** **Ocupation: Production Manager**	
No.	Questions	Client Answears	Interpreted needs
1	What field do you work in?	Production engineer	The need to increase the precision of tool guidance
2	Do you use EDM processing equipment at your job?	I do not use any such equipment	- The need to increase the quality of the processed surface;
3	What are the disadvantages?	-inefficient dielectric washing of the work area; - difficult orientation of the lamella tool relative to the machining surface;	The need to increase the precision of tool guidance

Client: Mircea Petre **Adress: Branesti, Makita** **Phone:0722115566**		**Interview: Hatis Bogdan** **Data: 01.11.2012** **Ocupation: Production Manager**	
No.	Questions	Client Answears	Interpreted needs
4	What do you think about EDM equipment?	-increases the productivity of processing by simultaneous processing; - allows efficient washing of all processing gaps;	-The need to increase the quality of the processed surface
5	What do you think about using this type of equipment?	I would use such equipment because it has very important advantages	-The need to increase the quality of the processed surface
6	What are the most common types of materials you use for processing?	Alloy steels	-The need to increase the quality of the processed surface
7	What are the most used operations?	Hole processing	The need to process high quality holes
8	Would you like to buy such equipment?	Yes, I would like to buy an equipment	-The need to increase the quality of the processed surface

6. Conclusion

The results of finite element modeling in the dedicated Comsol Multiphysics software allowed the sizing of the work head. Subsequent research will address the realization of a working head with an electromagnetic coil that allows to widen the range of regimes by increasing the current, corresponding to some roughing and semi-finishing processing as well as using different shapes of tool-electrodes.

7. Bibliography

[1]. Rober P. Langlois (1997), Build an EDM, Village Press, Michigan, ISBN 0-94165352-8.

[2] Bucur, V., Contribuții la optimizarea tehnologiei de prelucrare dimensională prin Eroziune Electrică cu Rupere de Contact (E.E.R.C) cu obiect de transfer - banda metalică. Teză de doctorat - Universitatea „Lucian Blaga". Sibiu, (1999)

[3]. The Academy of Romanian Scientists, 54 Splaiul Independent,ei, Sector 5, 050085 Bucharest, Romania3Faculty of Materials Science and Engineering, Gheorghe Asachi Technical University, Blvd. D. Mangeron 71,700050 Iasi, Romania

[4]. Chen, J.; Gu, L.; He, G. A review on conventional and nonconventional machining of SiC particlereinforcedaluminium matrix composites.Adv. Manuf.(2020),8, 279–315.

[5]. Sabyrov, N.; Jahan, M.P.; Bilal, A.; Perveen, A. Ultrasonic Vibration Assisted Electro-Discharge Machining(EDM)—An Overview.Materials(2019)

[6]. Revista de tehnologii neconvenționale. Timișoara: Editura Augusta, (1997-2019).

[7]. Nanu, D., Bucur, V., Asupra oportunității utilizării benzii metalice ca obiect de transfer, la debitarea prin E.E.R.C. Suceava: TEHNOMUS VII, vol IV, (1993).

[8]. Torres, A., Puertas, I., Luis, C.J., Mechanical, Modelling of surface finish, electrode wear and material removal rate in electrical discharge machining of hard-to-machine alloys. Precision Engineering, 40, 33– 45, (2015).

[9]. K.G. Swift, J.D. Booker – MANUFACTURING PROCESS SELECTION HANDBOOK, editura Butterworth Heimemann, Elsevier, Oxford, (2013).

FIRE RESISTANT RECOGNITION SYSTEM

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ABSTRACT: In this paper, we aim to develop a fire-resistant recognition system in order to reduce the risk of those who are involved in intervention. In this system we will use to protect its integrity, the flame retardant polymer and it will be printed entirely in 3D. Also, for its remote control, design of the application will be developed using Python programming language. Data collection from the field will be done with the help of two cameras, one conventional and one thermal. The purpose of the conventional camera is to orient in space, while the thermal camera helps to identify the terminal signatures of potential people in danger.

KEYWORDS: 3D print, flame-retardant, polymeric, video-camera, fireman

1. Introduction

The use of polymeric materials, including clean polymers with mixtures and composites, has significantly improved the quality of our lives. However, there are fire hazards in nature due to climate change. The analysis of the evolution of flame retardant polymers involves exploring the role of conventional systems as well as new flame retardant systems used in polymer technology. The evolution of flame retardant polymeric materials can be analyzed from different perspectives, depending on the materials, techniques and processing applications used. The classification of polymeric materials in terms of fireproofing performance, allows the selection of the best material. The use of confidence indices based on the fire performance of a polymer is very important. [1]

3D printing or additive manufacturing is a process of making three-dimensional solid objects by adding layer after layer. Physical objects are produced using the data of a digital model or a 3D model. 3D printing allows the creation of complex structures and parts, which can not be produced by conventional production methods, can easily create complex geometries, ensuring great freedom in design. Another advantage is that the modeling of complex parts can be done in one thus eliminating the need to assemble component parts. [2]

2. The current stage

To achieve a fire-resistant recognition system, 3D printing is used, with a flame retardant filament, which will ensure the protection of the components of the system.

A thermal camera is a device that creates an image using infrared radiation, similar to an ordinary careme that forms an image using natural light. Compared to the range of 400-700 nanometers in which an ordinary camera falls, infrared cameras are sensitive to wavelengths from about 1000 to 14,000 nanometers. The camera lens focuses infrared energy on a set of detectors which also creates a detailed pattern called a **thermogram**. The thermogram is converted into electrical signals in order to create a terminal image that can be seen and interpreted as well. The thermal camera has internal measuring devices that capture infrared radiation, called microbolometers and each pixel has one. The microbolometer records the temperature and then assigns that pixel to a suitable color, which then shows that they are transmitted on the camera screen. (Fig.1)

Fig.1. Example - thermal camera app [3]

In most cases, polymers initiate or propagate fires because, being organic compounds, they break down into volatile combustible products when exposed to heat. However, in many fields such as electricity, electronics, transportation, construction, etc, the use of polymers is restricted by their flammability, regardless of the importance of the benefits that their use can be considered. To meet these requirements, flame retardants must be added to the polymer in order to slow down the burning and degradation of the polymers (extinguishing the fire), reducing the smoke emission. [4]

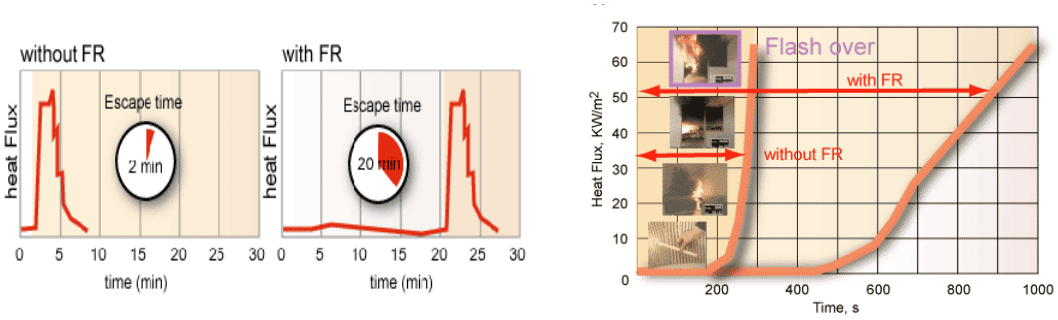


Fig.2. The difference between burning time, in case of usage flame-retardant material over any other [4]

3. Marketing strategic of the proposed product

The portfolio of customer needs has been established taking into account the characteristics of the products already on the market and the demand that exists in the field.

This has led to a main need of studying market opportunities, customers and already existing products that meet this primary need: the one to check risk factors during a fire.

For the identified need, we have as market opportunities the following aspects: the need to obtain information before and during a firefighting intervention and a small variety on the market of existing products of this type. The products that meet this need are: **drones** and **thermal imaging cameras**.

Potential customers for this product are: **fire departments** and **special intervention units**.

Customer selection involves identifying actual and potential customers who could benefit from this product.

The table below shows the customer selection matrix, see Table 1.

Table 1. Customer selection matrix

	Top users	Users	Retailers	Service center
Fire departments	3	4	1	2
Special intervention units	2	2	1	

Data from potential customers:

The following survey is used in order to the case of product marketing, was sent and completed in an online form and it covers the following questions:

1. Are you currently using a device to retrieve data on the spot in an emergency?
2. Do you find such a device useful?
3. Can the current device be used in high temperature conditions?
4. Is it easy to use?
5. Is it easy to maintain?
6. On a scale of 1-5 how maneuverable is it?
7. Does it have a user manual?
8. Does it have a maintenance guide?
9. Is it a durable product?
10. On a scale of 1-5 does the current device increase the safety of the intervention crews?
11. Does it allow the collection of information in dense smoke conditions?
12. What improvements would you make to the current product?
13. Other improvements

Hierarchy and relative importance

After a brief study of the answers and the interpretation of the customers' needs, a group was made of the main ones and then, their relative importance. The form was completed using grades from 1 to 5, depending on importance considered.

Table 2.Selection matrix

No. Crt.	Customer requirments	Relative importance
1	FRRS is used in special interventions	5
2	FRRS can process data in extreme conditions	5
3	FRRS has a maintenance and use manual	4
4	FRRS it is easy to use	5
5	FRRS it is resistant to high temperatures	5

In figures 3 and 4, are presented the result graphics according to two questions from the online survey.

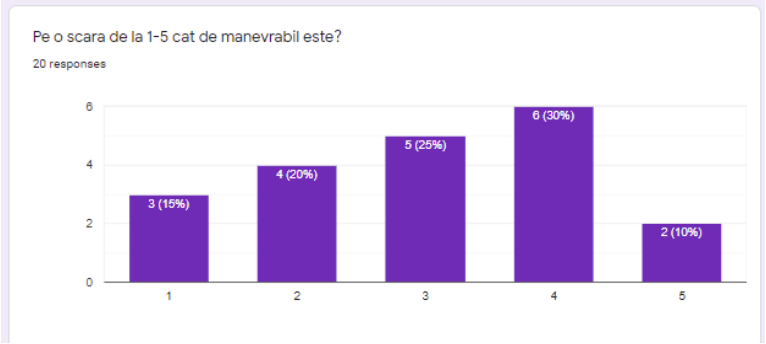


Fig. 3. Graphic representation of the q. regarding to handling

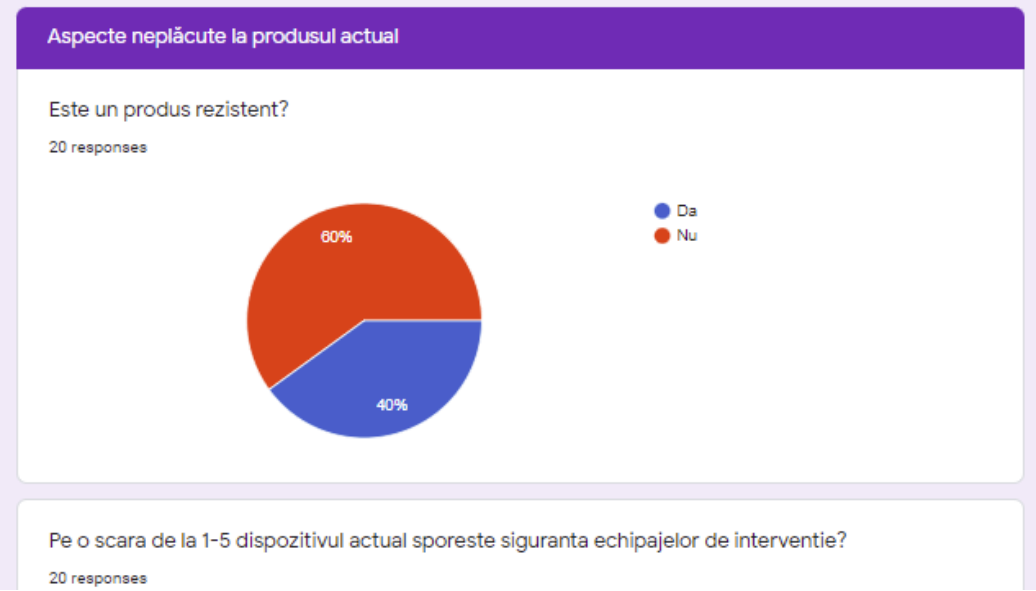


Fig. 4. Graphic representation of the q. related to product resistance

4. Establishing specs

An important step of the product development process, consists in establishing its specifications, those values and characteristics of the requirements,

An important stage in the process of developing a product is to establish the objective specifications of the product, those values of the characteristic sizes of the requirements, for which the market success of the product can be possible. These values are established according to the specifications of the competing products, so that they ensure an advantage, both from a functional and technical point of view of the developed product.

In order to determine the objective specs, a correspondence must be found between each primary requirement and the measurable quantity that characterizes it according to Table 3.

Table 3.Size requirements matrix

Requirements			Competitive products										
		The importance of the requirement	Overall dimensions	Wi-fi	Video camera resolution	Requires Installation	Degree of detail of the maintenance and installation manual	Mass	Material	Speed	Degree of protection at high temperatures	Audible warning	Selling price
			1	2	3	4	5	6	7	8	9	10	11
1	FRRS is used in special interventions	5	●	●	●			●		●	●	●	●
2	FRRS can process data in extreme conditions	5		●	●				●		●		
3	FRRS has a maintenance and use	4				●		●				●	
4	FRRS it is easy to use	5				●	●					●	
5	FRRS it is resistant to high temperatures	5							●		●		

In order to establish the ideal objective values and acceptable limit, a size is chosen for each size ideal goal (the best result the team can hope for) and an acceptable threshold (value that allows the product to be commercially viable) according to Table 4.
The following expressions were used for this purpose:

Table 4.Objective specifications (Limit values and ideal values)

No.	No. requirement	Characteristics/Specs	Feature type	Relative importance	Units	Limit values	Ideal values
1	1	Overall dimensions	STB	5	mm x mm x mm	280 x 242 x 300	256 x 220 x 260
2	1,2	Wi-fi		5	Yes/No	Yes	Yes
3	1,2	Video camera resolution	GTB	5	MP	5	12
4	3,4	Requires installation		5	Yes/No	Yes	No
5	4	Degree of detail of the maintenance and install manual	GTB	4	Scale 1-10	7	10
6	1,3	Mass	STB	4	Kg	3	1.5
7	2,5	Material		5	Material	Aluminium	Fire resistant material
8	1	Speed	GTB	4	m/s	0.5	1
9	1,2,5	Degree of protection at high temperatures	GTB	5	%	70	90
10	1,3,4	Audible warning		3	Yes/No	Yes	Yes
11	1	Selling price	STB	5	Ron	1500	1200

5. Conceptual design

The system of phenomena used to develop the general function **"Facilitate special interventions":**

Table 5. The main functions of the FRRS

No. function	Name of function
1.	Facilitates special interventions
2.	Retrieve data in extreme conditions
3.	High temperature resistance

The classification tree for the product “Fire-resistant recognition system (FRRS)”.

Ø = **Facilitates special interventions**

$Ø_{11}$ = *easy to use a FRRS*

$Ø_{111}$ = severity

$Ø_{112}$ = friction

F_{122} = muscular force in order to press the screen

F_{122} = muscular force in order to press the keys

$Ø_{12}$ = *retrieve data under extreme conditions*

F_{121} = wifi signal diffraction

F_{122} = wifi signal absorption

$Ø_{14}$= *High temperature resistance*

F_{141} = the actuating force of the surrounding elements

6. Detailed design

Detailed design was addressed in the SOLIDWORKS design program, but also using the 3DEXPERIENCE xShape application. The FRRS housing was made by surface modeling, while the locomotor system was based on displacement with the help of a track assembly.

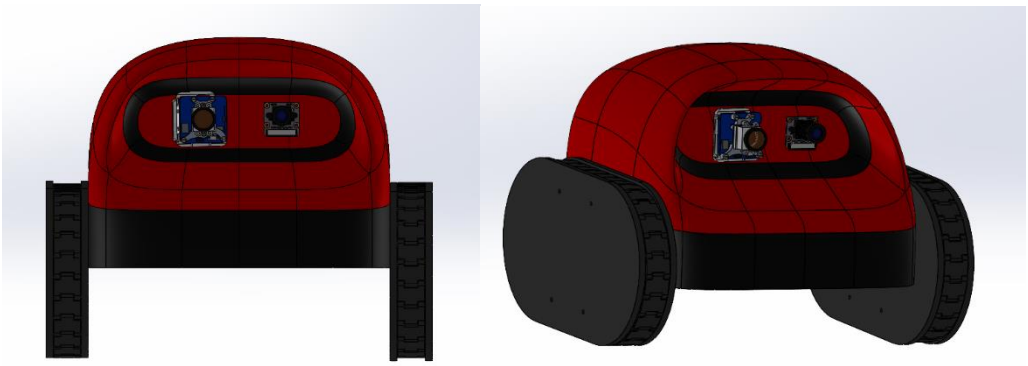


Figure. 5. Fire resistant recognition system (FRRS)

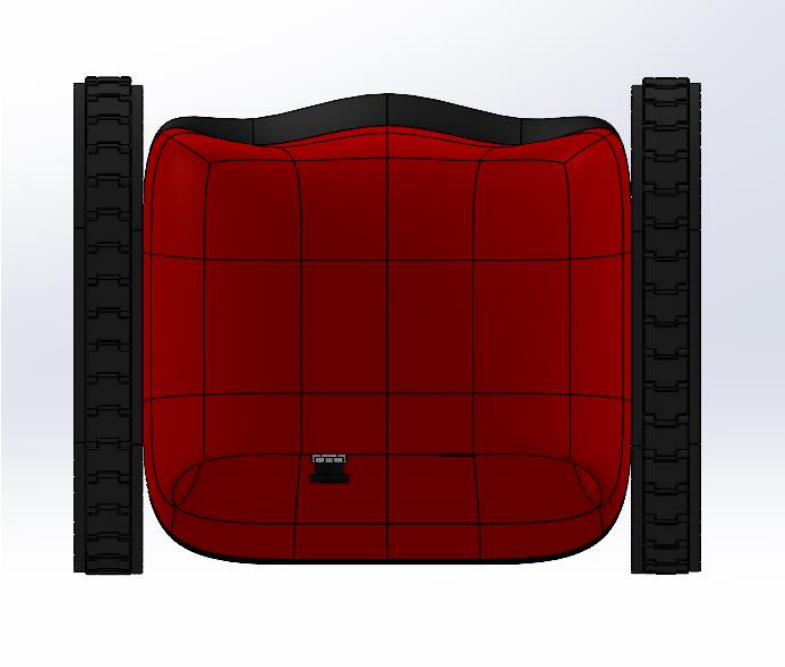


Figure. 6. Fire resistant recognition system (FRRS)

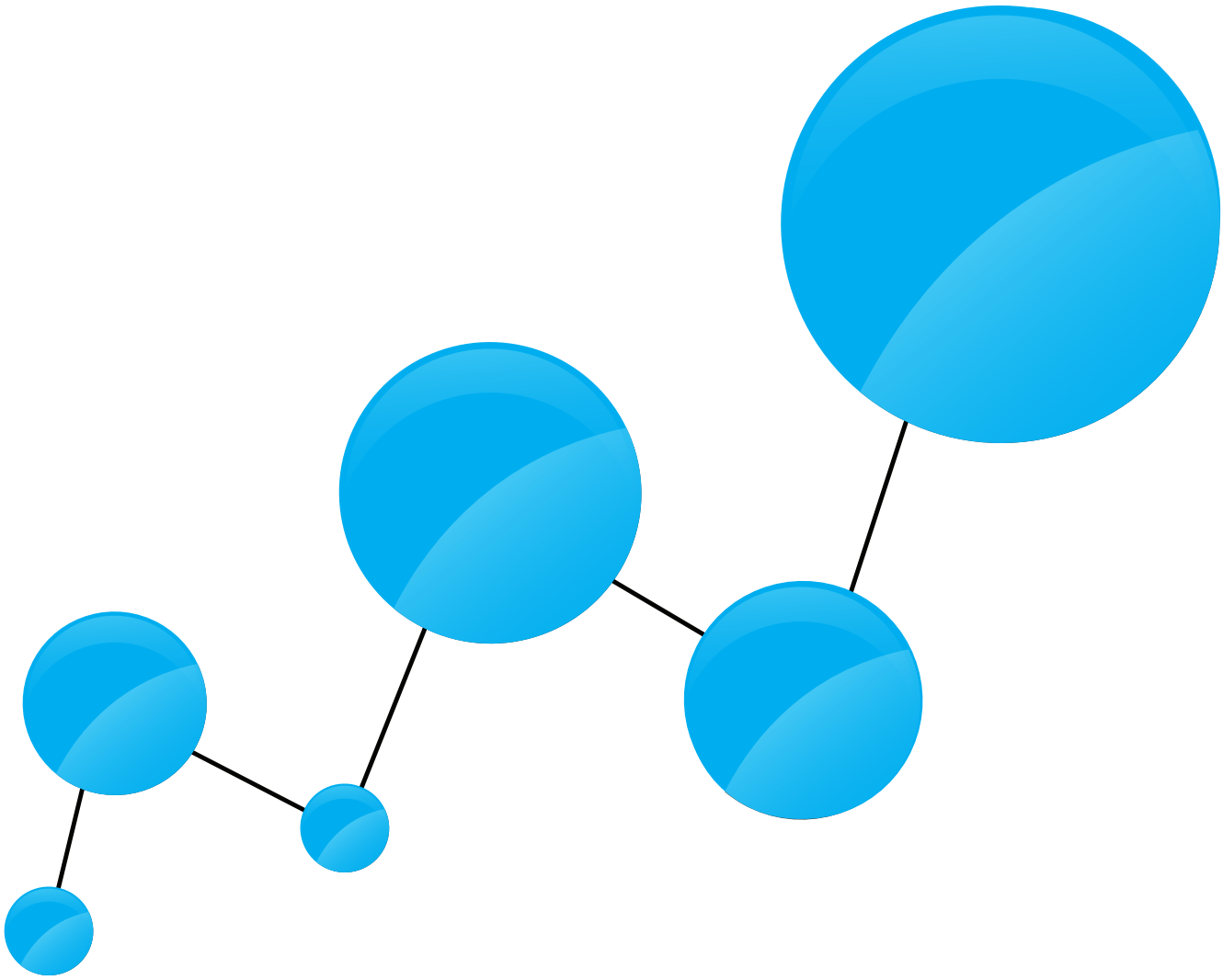
7. Conclusions

To sum up, the main advantages of the presented system are the two cameras that help to control and identify the possible immediate dangers, the reduction of the risk to which the rescue teams are subjected in the rescue mission and the low cost of manufacturing the robot, due to the means used.

Various concepts have been developed in order to achieve the final fire resistance recognition system; Following a thorough analysis, a final version was chosen that was modeled in 3D using the SOLIDWORKS program.

8. Bibliography

[1]. M. Benedetti. şi A. du Plessis. (2021), *Materials Science & Engineering R*, Elsevier;
[2]. Curs de imprimare 3D (shorturl.at/jtuIV), accessed on 13.05.2022;
[3]. Poza camera termala(shorturl.at/iwBEK), accessed on 11.05.2022;
[4].Flame Retardants for fire proof plastics(shorturl.at/mpstH), accessed on 12.05.2022;



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