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STUDIES AND RESEARCH ON THE REPLACEMENT OF PIPES MADE OF STEEL P355N, INTENDED FOR DOMESTIC WATER

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ABSTRACT

The paper presents an analysis regarding the need to replace pipes made of P355N steel, intended for domestic water. This replacement presents a necessity, due to the degradation and exceeding the lifespan of the domestic water network in the city of Galati. The microscopic analysis of the samples from steel pipe, shows an advanced degree of degradation of the steel pipes. The pipes will be replaced with polypropylene pipes, which have certain advantages in terms of corrosion resistance and in terms of ease of intervention in case of damage in the water network.

KEYWORDS: pipes, replacement, corrosion

1. General information regarding the drinking water supply system, in the municipality of Galati

The water distribution network serves 99.6% of the population of the city of Galati, which according to the last census is approximately 250,000 inhabitants. The city of Galati is fed from two sources: the surface source and the underground source.

The Danube is the source of raw surface water. The intake of raw water from the Danube is carried out through the outlet located on the left bank of the Danube, upstream of the confluence with the Siret, and is pumped through a Dn 1200 mm pipeline, with a length of 6 km, to the station for water treatment.

After micro-sieving (removal of solids) the raw water is treated with coagulants and reaches the decanters, where the turbidity of the water and the content of organic substances are reduced.

After settling, the water is directed to the filters, where an advanced water clarification process takes place by passing the settled water through a filter layer (quartz sand). This treatment step is the last clarification phase for drinking water production and has an essential role in obtaining quality indicators.

The filtered water is stored in tanks, where disinfection with chlorine gas takes place. The physico-chemical indicators, to control the quality of the water sampled, treated and distributed, is determined in the technological process laboratory, is within the Plant. The laboratory staff constantly monitors the characteristics of the water throughout the technological flow and sets the working doses for the water treatment reagents (aluminium sulphate and chlorine).

The raw deep-water source is represented by the two catchment fronts: Salcia-Liesti and Vadu-Roșca. The technical solutions required that the fronts be built approximately 70 km apart, one in the west of Galați city (Salcia-Liesti front), and the other in Vrancea county (Vadu-Roșca front). The aquifer is fed by the Siret River [1, 2].

From the two intakes, the raw water reaches the Șerbești Pumping Station, through a reinforced concrete and steel pipe, Dn 1200 mm, respectively Dn 1000 mm, for crossings, and from here to the Filești Pumping Station through two supply lines: Dn 1000 mm, respectively Dn 800 mm.

The water distributed from the catchment fronts is disinfected by chlorination in the Filești Pumping Station before being pumped into the distribution network.

From the surface source, the water is pumped into the distribution network directly or pumped back into the distribution network through Turnul de Apă and Traian Reservoir.

The drinking water distribution network of the municipality of Galati has a total length of 572 km.

In terms of the age of the drinking water networks, 24% have less than 10 years of use, 32% have between 10-36 years of use, 44% have more than 36 years of use.

Practically, more than 50% of the drinking water distribution networks in the municipality of Galati

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have exceeded their normal operating life according to HG 2139/2004 (they have a usage life of more than 24 years [1, 2].

2. Study regarding of the need to replace degraded pipes made of steel P355N, intended for domestic water

The cumulative study of the data, shows us the need to replace degraded pipes made of P355N steel, intended for domestic water.

The rehabilitation of the sewage system contributes to the significant reduction of the quantities of pollutants, discharged into the water resources, and to the registration of the discharged wastewater in the quality conditions, regulated by the technical norm NTPA 001/2002 [6].

P355N steel domestic water mains are known for their high-pressure resistance and durability over time. P355N steel has high mechanical strength, being able to withstand high pressures and various environmental conditions. It is usually used in industrial applications and in the construction of underground water pipes.

The pipes used in the water distribution networks in the old water supply network were made of P 355 N steel. Although steel has advantages in terms of resistance to high temperatures, the weight with which an intervention is carried out after a damage to the supply system and last but not least its high cost, leads to the replacement of pipes with other lighter and more flexible materials [5].

Also, exceeding the normal duration of operation, led to their advanced corrosion, endangering the health of the population. Corrosion leads to reduced life of metal components, loss of structural integrity and high maintenance and replacement costs.

The pipes of the domestic water circuit suffered the phenomenon of corrosion, deposits of oxidizing residues and mineral deposits, and for this reason it is necessary to replace them with pipes made of polypropylene and polyvinyl chloride (Fig. 1).

Fig. 1. *The pipes with an advanced degree of corrosion and deposits*

In order to study the degree of degradation of the pipes in the distribution network, it took a sample from a pipe that needs to be replaced and was made a microscopic analysis of the surface (Fig. 2).

The analysis was carried out at the metallurgy-physics laboratory within the Faculty of Engineering, following examination with the optical microscope OLYMPUS BX51M.

The P355N steel sample was examined using an electron microscope. On both sides of the sample, it can be observed an advanced degree of oxidation and corrosion.

Following the examination, with the help of the electron microscope and with the help of a monitor, the image materialized that gives a wider view of the microstructure of the material (Fig. 3).

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Sample preparation – side 1 *Sample preparation – side 2*

Fig. 2. *Preparing the sample for examination*

Fig. 3. *Microstructure of the material*

As can be seen, the surface is strongly corroded and almost entirely covered by oxides, requiring the urgent replacement of the P355N steel pipes, with polypropylene pipes.

Metal corrosion is the process of damage or degradation of metals as a result of their interaction with the environment. Corrosion usually occurs when metals come into contact with water, moist air, chemicals, or other elements that cause chemical oxidation reactions.

The main mechanism of metal corrosion is oxidation, where metals react with oxygen in the air or other chemicals in the environment. This process can lead to the formation of solid chemical compounds such as rust on iron or aluminium oxide on aluminium. These compounds are generally weaker and more brittle than the original metal, resulting in the loss of the metal's mechanical and chemical properties.

Corrosion of metals can have significant negative consequences in many fields, such as the chemical industry, building and ship construction, energy infrastructure and many others. This can lead to reduced life of metal components, loss of structural integrity and high maintenance and replacement costs.

To prevent or control the corrosion of metals, are used various methods, such as applying protective layers such as paints and enamels, using corrosion-resistant metals (such as stainless steel), adding inhibitory substances to the environment, or applying electrochemical protection processes such as galvanizing or anodizing.

Fig. 4. *Main steel P335N*

As can be seen in the Figure 4, the pipes of the domestic water circuit have suffered the phenomenon of corrosion, deposits of oxidizing residues and

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mineral deposits, and for this reason it is necessary to replace them with pipes made of polypropylene and polyvinyl chloride.

PP (polypropylene) pipes, and PVC (polyvinyl chloride) pipes, are used in a variety of applications, including potable water distribution systems, sewer and drainage systems, heating and cooling systems, irrigation systems, and more.

Polypropylene (PP) pipes have many advantages:

- Chemical resistance: PP pipes are resistant to a wide range of chemicals, including diluted acids and bases. This chemical resistance makes them suitable for use in the transport or storage systems of chemicals and aggressive fluids.

- Durability: PP pipes are durable and have a long service life. They are resistant to corrosion, rust and degradation, making them suitable for applications where durability is important, such as drinking water systems, heating and cooling systems, sewage systems and more.

- Impact resistance: PP pipes have good impact resistance, which makes them more resistant to mechanical damage or cracks compared to other materials. This aspect gives them a greater ability to cope with external forces and withstand difficult conditions of use.

- Light weight: PP pipes are lighter than other types of pipes such as steel or cast iron. This facilitates their handling, transport and installation, reducing the costs and effort required.

- Thermal resistance: PP pipes have good thermal resistance and can be used in a wide range of temperatures. They can withstand high and low temperatures, making them suitable for heating and cooling applications as well as transporting fluids at extreme temperatures.

- Pressure resistance: PP pipes can withstand high pressures, which makes them suitable for potable water distribution systems or other applications where pressure is important [3].

- Easy installation: PP pipes are flexible and can be installed easily. They are available in different shapes and sizes, and their connection can be done by various methods, such as welding, soldering or using special fittings. This facilitates installation and reduces the associated time and costs.

- Hygienic: PP is an inert material and does not allow the development of bacteria or the formation of deposits inside the pipes. This makes PP pipes suitable for use in potable water systems and other applications where hygiene is crucial.

Although polypropylene (PP) pipes have many advantages, there are also some disadvantages associated with them:

- Temperature sensitivity: PP pipes are more sensitive to high temperatures than other materials such as steel or copper pipes. In case of extreme temperatures or prolonged exposure to high temperatures, PP pipes can suffer deformation or even melting.

- Thermal expansion: PP has a higher coefficient of thermal expansion than other materials, which means that PP pipes can undergo significant expansion at large temperature variations.

- Resistance to extreme chemical shocks: Although PP pipes are resistant to a wide range of chemicals, there are some very aggressive chemicals that can damage or corrode their surface. In highly corrosive environments, other materials such as stainless-steel pipes may be more suitable.

- Pressure and diameter limitations: Compared to other materials such as steel pipes, PP pipes have lower pressure and diameter limitations. This means that thicker pipes or additional fittings may be required to provide adequate strength in high pressure applications or larger system sizes.

- UV protection: PP is sensitive to prolonged exposure to ultraviolet (UV) radiation from sunlight. If PP pipes are exposed to direct sunlight for long periods of time, they may suffer damage such as discoloration or embrittlement of the material.

The same disadvantages we find at the PVC pipes [4].

PVC domestic water mains do not provide the same thermal insulation as steel and may require the addition of additional insulation to control heat loss or prevent condensation. In addition, PVC mains may be more susceptible to noise generated by water flow compared to steel, and this may require additional soundproofing measures.

The rigid multilayered PVC-U pipes are used for buried sewage installations, comply with the SR EN 13476 quality standard and the maximum temperature at which they can be used is 60 °C.

Fig. 5. *Polypropylene pipes for the water network*

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3. Conclusions

P355N steel domestic water mains are known for their high-pressure resistance and durability over time. P355N steel has high mechanical strength, being able to withstand high pressures and various environmental conditions. It is usually used in industrial applications and in the construction of underground water pipes.

PVC domestic water mains do not provide the same thermal insulation as steel and may require the addition of additional insulation to control heat loss or prevent condensation. In addition, PVC mains may be more susceptible to noise generated by water flow compared to steel, and this may require additional soundproofing measures.

P355N steel domestic water mains can be more expensive compared to PVC or PP. Steel is a more expensive material and the manufacturing process of steel mains can require specialized equipment. Steel mains can also be more complex and expensive to install and maintain.

PVC domestic water mains are generally more affordable from a financial point of view. Plastics are cheaper than steel and the manufacturing process of PVC busbars can be simpler and faster. PVC mains are easier and less expensive to install and maintain than steel mains.

Keeping these aspects in mind, PVC pipes are favourable for cities because there are lower costs involved, their easier maintenance of course, and the durability and fluidity of the liquids inside that they offer. We also take into account the fact that they are affordable in terms of price and installation and do not require such complex work as traditional ones.

In conclusion, this pipes are clearly superior to the traditional ones for the fact that they are financially more profitable, in addition to the other advantages that the PVC material offers.

More than 50% of the drinking water distribution networks in the municipality of Galati have exceeded their normal operating life. HG 2139/2004 (have a duration of use greater than 24 years) and it requires replacing the pipes.

The pipes used in the water distribution networks in the old water supply network were made of P355 N type steel. Although steel has advantages in terms of resistance to high temperatures, the weight with which an intervention is carried out following a breakdown in the supply system and last but not least its high cost, leads to the replacement of pipes with other lighter and more flexible materials.

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PREDICTION OF DEFORMATION OF HEXAGONAL HONEYCOMB BLAST STRUCTURE UNDER EXPLOSIVE LOADING USING DEEP LEARNING

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ABSTRACT

Honeycomb composites are widely used in blast structure under explosive loading because of mechanical properties. The simulation of high-pressure explosion is time consuming in order to simulate an important number of scenarios. New deep learning neural models might approximate results with low computational resources outputting the result very fast. The purpose of this study is to propose using deep learning model using a relative low amount of training fata to approximate deformation in honeycomb structures subjected to a blast load. This study employed variation of hexagonal honeycomb dimensions to determine the deformation using deep learning model.

KEYWORDS: honeycomb, deep learning, blast simulation, explosion

1. Introduction

Honeycomb composites are widely used in aerospace, automotive, and civil engineering industries due to their remarkable mechanical properties, such as high strength-to-weight ratio, stiffness, and energy absorption. Understanding the deformation behavior of honeycomb structures under different loading conditions is critical for optimizing designs and ensuring structural integrity [1-3]. Traditional methods, such as Finite Element Analysis (FEA), are widely used for simulating the mechanical response of these structures. However, FEA can be computationally expensive and time-consuming, especially when dealing with complex geometries or large-scale simulations such in case of blast.

Aluminium honeycomb structures are highly effective for attenuating explosion effects due to their excellent energy absorption properties, low density, and high strength-to-weight ratio.

Recent advancements in artificial intelligence (AI) and machine learning (ML), particularly deep learning (DL), have shown great potential in providing faster and more efficient predictions for various engineering applications [4-6]. Deep learning models, once trained on sufficient data, can offer near-instant predictions of mechanical behavior, bypassing the need for extensive simulation or experimental testing [7-9]. This study aims to explore how a deep learning algorithm can be trained to predict the deformation of honeycomb composites under different loading conditions using a reduced amount of training data. Traditionally, deformation analysis of honeycomb composites is performed using FEA, which involves solving complex differential equations to simulate the mechanical response of materials under loading conditions. However, FEA simulations can be resource-intensive and time-consuming, particularly for large-scale or real-time applications [10, 11].

Deep learning offers an alternative approach to predict deformation behavior based on prior knowledge (i.e., training data). Once trained, deep learning models can provide near-instant predictions of deformation for various configurations of honeycomb composites under different loading conditions [12-14]. Honeycomb structures can be represented as a graph, where the nodes correspond to the joints, and the edges represent the walls of the honeycomb. Graph Neural Networks (GNNs) are particularly suitable for this type of data, as they can effectively capture the relationships between the nodes and edges, allowing the model to predict deformation based on the underlying structure. If the deformation prediction is formulated as a classification task (e.g., predicting failure or non-

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failure), precision can be used to evaluate the model's ability to correctly classify the outcomes.

Deep learning models, once trained, can provide real-time predictions [15]. Using deep learning provide cost-effectiveness as it reduces the need for repeated simulations or experiments. Deep learning models can generalize to unseen data, allowing for predictions on new honeycomb configurations or loading scenarios. In this paper we aim to propose a deep neural architecture to predict deformation of honeycomb structure as effect of explosion using a low amount of training data.

2. Experimental procedure

The first step in training a deep learning model is to collect or generate a sufficient amount of labelled data. In this case, the data consists of various configurations of honeycomb structures, along with their corresponding deformation results under different loading conditions.

Finite Element Analysis (FEA) allows us to simulate different honeycomb configurations varying cell size and wall thickness under a range of loading pressure conditions as effect of explosion. For each simulation, the deformation results stress and displacement fields are stored.

Experimental data is further used to validate and augment the simulation data. Experiments involve loading honeycomb samples and measuring their deformation one by one.

Varying honeycomb cell sizes and wall thickness was performed within 10% variation. We used 20 different simulations for the following scenario: Far-Field Explosion at a distance far 5 meters, using a pressure 14000 psi and the material is Aluminium 1060.

The raw data generated from FEA simulations or experiments must be pre-processed before feeding it into the deep learning model. Normalizing input data (material properties, geometry parameters) and output data (stress, strain) ensures that all features are on a similar scale, which improves model performance.

For large-scale simulation data, dimensionality reduction techniques like Principal Component Analysis (PCA) can be applied to reduce the number of features while retaining the essential information.

Selecting an appropriate deep learning architecture is crucial for capturing the complex relationships between input parameters (geometry, material properties, loading conditions) and output (deformation). Several model architectures can be considered.

CNNs are well-suited for tasks involving spatial data, such as images or maps. In the case of deformation prediction, CNNs can be used to capture the spatial distribution of strain, stress, or displacement fields. This approach is particularly effective when using 2D or 3D simulation data as input.

We used the input data consists of scalar values (material properties, cell size, loading conditions), a fully connected neural network (FCNN). In this case, the model learns the relationships between these input features and the corresponding deformation responses.

Once the data is prepared and the model architecture is selected, the next step is to train the deep learning model.

The loss function quantifies the difference between the predicted deformation and the actual deformation (from simulations or experiments).

Mean Squared Error (MSE) measures the average squared difference between predicted and actual values.

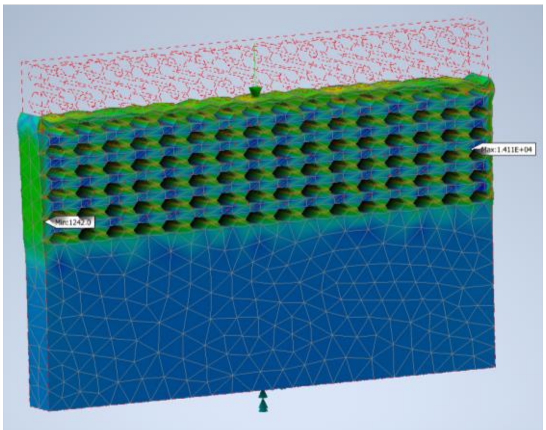

Fig. 1. *Deformation in honeycomb*

The optimizer is responsible for updating the model parameters to minimize the loss function during training. We used Adam optimizer as is a popular optimizer that adapts the learning rate during training, often leading to faster convergence.

Regularization is essential to prevent over fitting, especially when the dataset is limited. Randomly "drops" neurons during training to prevent the model from becoming overly reliant on specific neurons. Adds a penalty to the loss function based on the magnitude of the model's weights, encouraging smaller weights. We used a network architecture consisting of 10 hidden layers dropout layer after hidden layer 2 and 4 output neurons.

To further enhance the model's ability to generalize, data augmentation techniques can be used to artificially expand the training set. For example, random noise can be added to the input features, or the honeycomb geometry can be slightly perturbed in

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this research. From the 50 samples of training 10 were obtained using mean estimates of results.

3. Results and discussions

Once the model is trained, it must be evaluated to ensure that it generalizes well to unseen data. This is done by splitting the data into training, validation, and test sets: As training set, we used for fitting the model during training 50 simulation performed in Inventor Nastran with hexagon shape varying dimension to 10% (Fig. 1, Fig. 2). The dimension of the part used for simulation is 400 m X 500 mm. The hexagon side dimension is varying starting from 15 mm up to 16.5 mm and we used 6 rows.

Root Mean Squared Error (RMSE) Measure the magnitude of the errors in the predicted deformations.

Hyperparameters, such as the learning rate, batch size, number of layers, and number of neurons per layer, play a critical role in the performance of the model. Hyperparameter tuning can be performed using techniques like grid search or random search.

Once the model has been trained, evaluated, and optimized, it can be deployed for real-time prediction of deformation in honeycomb composites. The model can be used in various applications, such as:

The model can quickly evaluate different honeycomb configurations to find the optimal design based on the desired mechanical performance. While the FEA simulation needs for one single simulation approximate 10 hours on a processor i913700 Kf and 128 Gb RAM, the deep learning algorithm needs only 30 seconds to predict the result. The prediction rate is 82% for 10 testing data. Though the prediction rate is not as high as we would expect, the low amount of training data mean translates a reduced prediction rate. However, the experiments show that the use of neural model can lead to good result. More trained data will translate in a higher prediction rate.

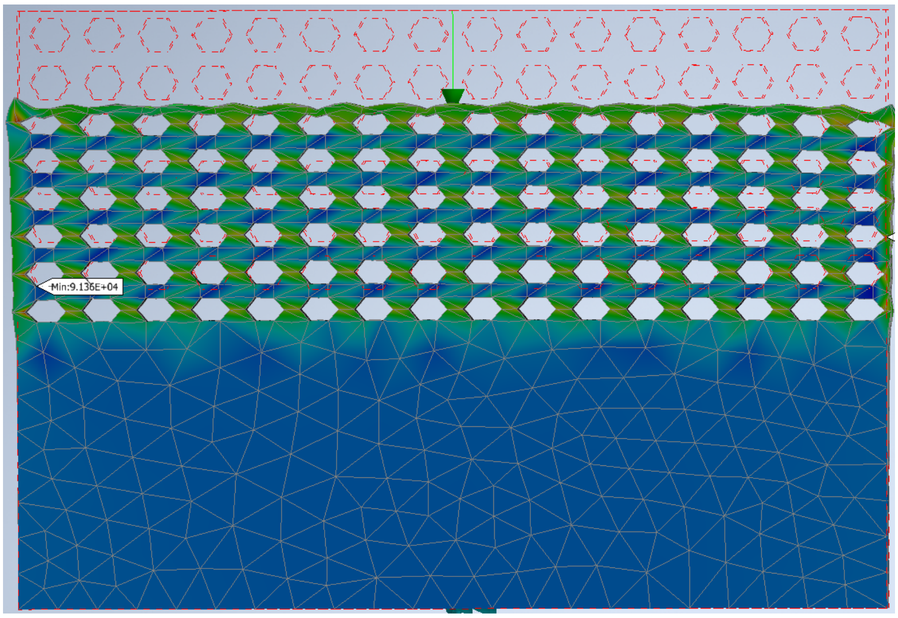

Fig. 2. *Deformation and stress distribution in structure*

4. Conclusions

In applications where honeycomb composites are subjected to varying loads the model can be used to predict deformation in real-time and provide early warnings of potential failures.

The model can assist in selecting the appropriate materials for honeycomb structures based on the predicted deformation under different loading conditions.

Deep neural networks (DNNs) demonstrate high accuracy in predicting deformation patterns in honeycomb structures under various loading conditions, showing significant promise in real-time structural monitoring and failure prevention.

Compared to conventional finite element analysis (FEA) methods, DNNs reduce computational time without compromising prediction accuracy, making them suitable for applications requiring rapid response, such as aerospace and defence.

DNN models excel in capturing complex, nonlinear deformation behaviours, especially under dynamic or impact loading conditions, where traditional linear models may struggle.

Deep learning models trained with diverse datasets (including different materials, cell geometries, and load types) show robust performance across variable conditions, indicating versatility in predicting deformations for a wide range of honeycomb configurations.

Combining DNNs with physics-based methods, like FEA, enhances the model's interpretability and accuracy, making hybrid models a valuable approach for understanding deformation mechanisms and for validating deep learning predictions.

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AN INTELLIGENT SYSTEM FOR TEMPERATURE BODY MONITORING USING ARDUINO PLATFORM

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ABSTRACT

An accurate measurement of the body temperature is a critical component in monitoring the human health, with applications ranging from clinical diagnostics to wearable health monitoring systems. Using the Arduino platform for body temperature monitoring provides an affordable, customizable and efficient solution for a wide range of applications, from personal care to patient monitoring in hospitals, this type of device can significantly contribute to improving health and safety. The MLX90614 sensor is an innovative and efficient solution for temperature measurement in the medical engineering field. With its outstanding accuracy and adaptability in measuring body temperature and medical devices, this device asserts itself as an indispensable tool in monitoring and managing the health of patients and medical devices in a variety of clinical and treatment settings.

KEYWORDS: body temperature, monitoring system, MLX90614 sensor, Arduino

1. Introduction

The body temperature is an indicator of health. Both high and low ambient temperatures are heat stressors that, like other physiological responses, induce activation of the hypothalamic-pituitary-adrenal (HPA) axis and secretion of arginine-vasopressin (AVP) or antidiuretic hormone. This hormone has an important role in controlling fluid balance and a role in blood pressure regulation through its vasoconstrictor effects on blood vessels [1-3].

Body temperature is universally considered a constant, approximately 37 °C. However, this can vary depending on age, sex, environment, etc. Studies in recent years have shown that the ideal body temperature, in which the body functions normally, would be between 36 and 37 °C. Body temperature regulation is a strict process [4-7]. In critically ill patients, an abnormal body temperature is associated with adverse clinical outcomes [8-14]. Furthermore, body temperature abnormalities are used to identify certain phenotypes of the immune response to infections [15] and in evaluating the body's response to certain interventions (e.g. antibiotic or anti-inflammatory therapies) [16-17].

Body temperature monitoring methods are classified into invasive methods and non-invasive methods. Thus, as non-invasive methods of temperature measurement we have: axillary thermo, infrared tympanic and temporal scanner, but their accuracy in estimating the central body temperature in intensive care patients is uncertain [18-22]. The invasive methods of temperature measurement, such as intravenous and intravesical catheters, provide accurate and continuous monitoring of core body temperature, particularly in critically ill patients, in surgical settings, or in situations where accurate temperature control is vital [23-26]. The invasive procedures involving catheter insertion may cause discomfort or pain to the patient. Appropriate anaesthesia or pain management strategies may be used to alleviate patient discomfort during and after the procedure.

Traditional thermometry methods, while effective, often lack the adaptability required for continuous or remote monitoring. Recent advancements in microcontroller technology, particularly with open-source platforms as Arduino,

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have introduced a novel approach for building cost-effective and customizable temperature measurement systems [27-32]. By integrating Arduino with precision sensors, such as infrared (IR) or contact-based temperature sensors, it is possible to construct versatile devices that provide real-time body temperature readings with a high degree of accuracy [33-36]. The MLX90614 sensor is a particularly useful tool in the field of medical engineering, providing an accurate and non-invasive method of measuring the temperature of the body and medical devices using infrared technology. This type of sensor has a wide range of applications in medical engineering. Primarily, it is used to measure body temperature without the need for direct skin contact, providing an accurate and hygienic alternative to traditional thermometers [38-41]. This is particularly useful in monitoring the health status of patients during hospitalization or on an outpatient basis. The sensor can also be used for temperature monitoring in various medical devices such as: incubators, infusion pumps or medical imaging devices [42-46].

2. Experimental procedure

The operation of infrared thermometers is based on the phenomenon of absorption of infrared radiation by objects in the field of view of the device. Infrared radiation, similar in behavior to visible light, can be focused, reflected or absorbed. Using an optical lens, infrared thermometers direct infrared radiation from the object being analysed to a thermal detector, known as a thermopile.

As indicating the block diagram proposed in Figure 1, the temperature monitoring system comprises: Arduino Uno board, MLX90614 temperature sensor, OLED SH1306 screen, breadboard and wires with different types of connections. Within the circuit, essential connections include a screen for displaying data, the MLX sensor, and an Arduino board used as the central control unit. The communication between the sensor and the board is carried out via the SDA and SCL pins, according to the I2C communication protocol. This protocol allows multiple devices to be connected to the same data and clock line, thus simplifying the circuit management. The circuit is powered at 5 volts DC. Through this complex configuration, the infrared thermometer asserts itself as an accurate and efficient measurement tool, providing relevant and necessary information in a variety of applications, including body temperature monitoring and industrial process control.

Body temperature data collected by the MLX90614 non-contact infrared temperature sensor is instantly displayed on the project's OLED screen. This list is achieved by detecting infrared radiation emitted by the human body by the MLX90614 sensor, without the need for direct contact. Using advanced technology, this system allows immediate interpretation and display of temperature data, eliminating any perceptible delay. With this technological solution, body temperature monitoring is instantaneous, and the smallest temperature fluctuations are detected and interpreted by the sensor. Compared to traditional thermometers, which may involve a waiting time in obtaining results, this system provides continuous and accurate temperature monitoring, providing real-time information for health assessment. Infrared technology allows the detection of thermal radiation emitted by objects and its transformation into electrical signals, which are subsequently processed to provide accurate data about the object's temperature.

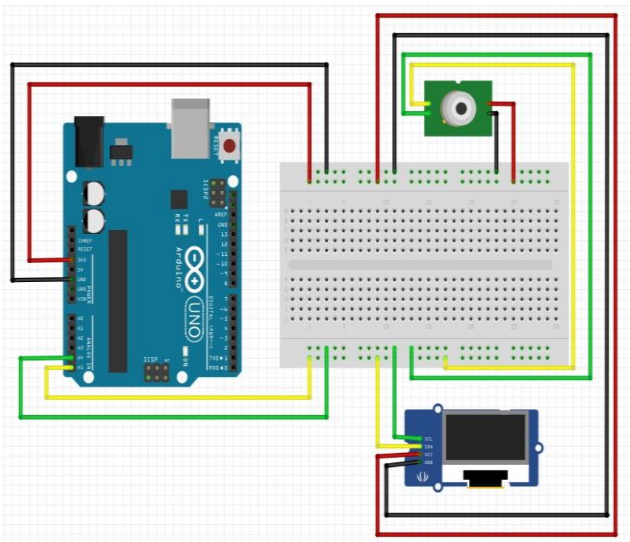

Fig. 1. *The block diagram of the proposed system architecture*

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The MLX90614 sensor (Figure 2) uses this technology to identify and interpret thermal radiation emitted by objects at a certain frequency, associated with their temperature. This complex device consists of an infrared detector through which thermal radiation is captured and then converted into electrical signals, and a processing circuit that interprets these signals to provide accurate temperature readings. The ambient temperatures and object temperatures are available in RAM with a resolution of 0.01 °C. The calibration of the MLX90614 sensor is in extended temperature ranges, starting from -40 °C to 125 °C for ambient temperature and starting from -70 °C to 380 °C for object temperature. The final temperature resulting represents the average temperature of all objects in the field of view of the sensor with an accuracy standard of ±0.5 °C. It is important to mention is that for medical applications, there is a version with an accuracy of ±0.2 °C in a limited temperature range around the human body.

Fig. 2. *The MLX90614 sensor pin connections*

The MLX90614 has in its component a built-in optical filter that has the ability to stop visible light and near-infrared light, these being in the advantage of making the most accurate measurements. Also, thanks to this filter, the sensor is immune to ambient light and sunlight. In Figure. 3 is presented the OLED screen pin connections.

Fig. 3. *The OLED screen pin connections*

3. Results and discussions

Once the components are connected, the USB cable must be mounted between the Arduino board and the laptop. The following will be selected from the Arduino menu: the corresponding port and the board, then to test the created code to find the errors and be able to solve them. The code steps are: introducing libraries, defining variables, and the two essential functions, void setup and void loop.

In Figure 4 is represented the sensor connections to the Arduino Uno board. In Figure 5 is depicted the connection between the OLED screen and the system components to the breadboard The monitoring system display and the results on the OLED screen are presented in Figure 6. The OLED screen pin connections are: GND, VCC, SDA and SCL. GND (Ground) is the screen's ground terminal and should be connected to any available GND pin on the Arduino board to establish a common reference for the circuit. VCC (Voltage Common Collector) is the screen's power terminal and connects to the Arduino board's power source, set to 5V. SDA (Serial Data) and SCL (Serial Clock) are the screen's serial communication terminals, which connect to the Arduino board's A4 (Serial Data) and A5 (Serial Clock) pins, respectively. These connections enable the Arduino to communicate with the OLED SH1306 display via the I2C protocol.

The device output verification procedure includes comparing the device output values to the output values from an infrared thermometer device. To make this comparison, several measurements were made. Body temperatures were measured at the index

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finger using two different thermometers. Each body region was measured five times, with a time interval of 15 minutes between measurements (Figure 7). For each thermometer, the measurements were performed three times (Table 1). The differences between the measurements registered by the two thermometers were analysed to validate the results of the proposed system. To validate the results is important to verify if the temperature of the object is much lower than the ambient temperature (in this case, by more than 5 °C). This threshold can be adjusted as is necessary. If it is not a valid object it will be display the message "No Object" on the OLED screen and in the serial monitor. If it is a valid object, will be display the temperature of the object on the OLED screen and in the serial monitor.

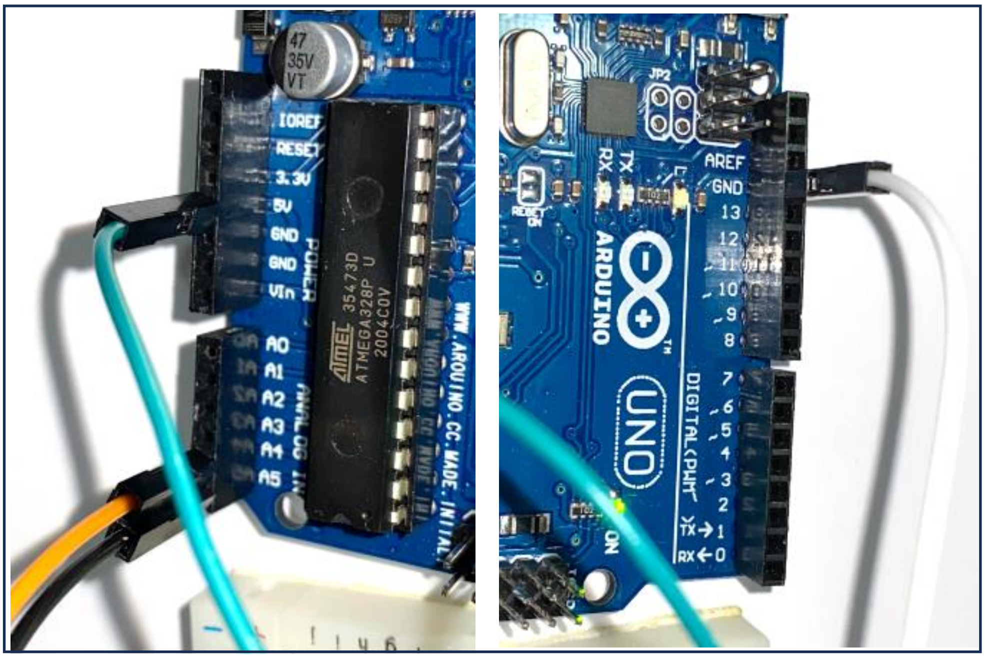

***Fig. 4.** The sensor connections to the Arduino Uno board*

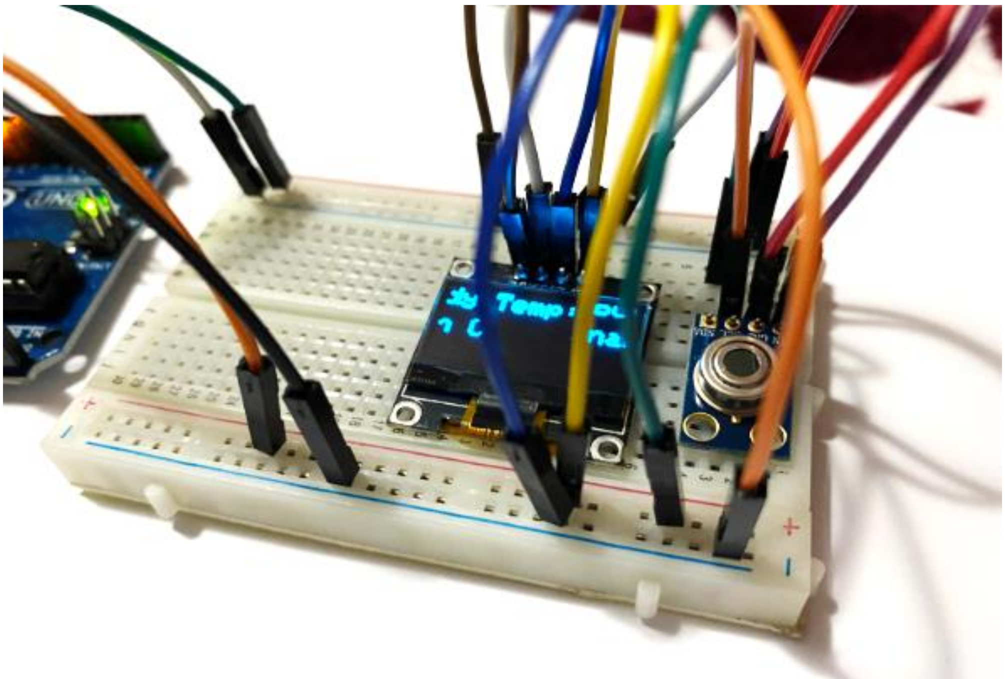

***Fig. 5.** Connecting the OLED screen and the system components to the breadboard*

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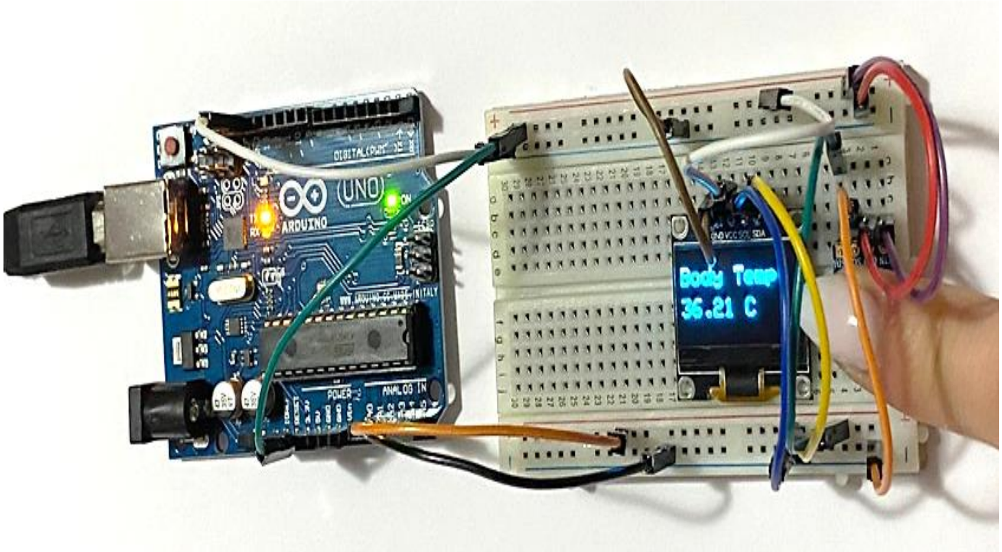

Fig. 6. *Monitoring the system display and the results on the OLED screen*

Table 1. *The comparison of measurements made with the proposed system and an infrared thermometer*

No. det.	Thermometer 1 (°C)	Thermometer 2 (°C)	Difference (°C)
1	36.5	36.6	+0.1
2	36.6	36.6	+0.0
3	36.6	36.7	+0.1
4	36.5	36.6	+0.1
5	36.7	36.8	+0.1
6	36.4	36.5	+0.1
7	36.5	36.6	+0.1
8	36.5	36.6	+0.1
9	36.4	36.5	+0.1
10	36.6	36.7	+0.1
11	36.7	36.8	+0.1
12	36.8	36.9	+0.1
13	36.7	36.8	+0.1
14	36.7	36.8	+0.1
15	36.8	36.9	+0.1
16	36.6	36.7	+0.1
17	36.7	36.8	+0.1
18	36.6	36.7	+0.1
19	36.6	36.7	+0.1
20	36.7	36.8	+0.1
21	36.8	36.9	+0.1
22	36.9	37.0	+0.1
23	36.8	36.9	+0.1
24	36.8	36.9	+0.1
25	36.9	37.0	+0.1
26	36.7	36.8	+0.1
27	36.8	36.9	+0.1
28	36.7	36.8	+0.1
29	36.7	36.8	+0.1
30	36.7	36.8	+0.1

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4. Conclusions

In conclusion, both thermometers give very similar results, with minor differences of 0.1 °C. This suggests that both devices are suitable for measuring body temperature and can be used interchangeably without compromising data accuracy.

Body temperature measurements showed stability and consistency both between different measurements of the same subject and between different subjects. The minor fluctuations observed are consistent with normal variations in human body temperature and do not indicate any significant abnormality.

The analysis of the results obtained from temperature monitoring in various experimental situations provided valuable information about the performance of the system.

Using a body temperature monitoring device using the Arduino platform has multiple advantages and applications.

1. Such a device can detect increases in body temperature immediately, enabling rapid interventions, which are essential in medical emergencies, as a real-time monitoring (rapid fever detection).

2. Enables constant temperature monitoring without the need for repeated manual intervention, providing a clear picture of temperature fluctuations throughout the day.

3. The ability to add additional functionality, such as alarming when a temperature threshold is exceeded or data transmission via the Internet.

Using the Arduino platform for body temperature monitoring provides an affordable, customizable and efficient solution for a wide range of applications, from personal care to patient monitoring in hospitals, this type of device can significantly contribute to improving health and safety.

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EXPERIMENTAL RESEARCH ON THE INFLUENCE OF LENS CLEANING PRODUCTS, ON THEIR HARDNESS

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ABSTRACT

The paper presents a study on the influence of optical lens cleaning products for vision correction on their hardness. The lenses under study were previously cleaned repeatedly with different cleaning products, namely, special eyeglass wipes and liquid detergent. The research was carried out on a group of lenses with and without protection, of different thicknesses and diopters.

KEYWORDS: hardness, optical lenses, diopter

1. Introduction

Mechanical and optical properties are important properties in assessing the quality of spectacle lenses intended for vision correction. The quality and maintenance of optical lenses are of particular importance for the efficiency of the vision correction process as well as for their lifespan [1, 3].

The mechanical properties of optical lenses are:

• Hardness: Lens hardness is important for resistance to scratches and abrasions. Glass lenses are harder than plastic lenses and are more scratch resistant.

• Tensile and compressive strength: Lenses must be able to withstand external forces without distorting or cracking. Tensile and compressive strength is important in applications where lenses are subjected to mechanical loads.

• Impact resistance: Impact resistance refers to the ability of lenses to withstand bumps and impacts without breaking or cracking. Plastic lenses are often preferred in applications where impact resistance is important, such as safety glasses and sports applications.

• Resistance to extreme temperatures: Lenses must be able to withstand temperature variations and extreme environmental conditions without changing their optical or mechanical properties. Lens materials, as well as additional treatments applied to their surfaces, can influence resistance to extreme temperatures.

• Chemical resistance: Lenses must be resistant to chemicals and solvents that could damage or corrode their surface. This is especially important in medical and industrial applications where lenses may be exposed to harsh chemicals.

• Moisture resistance: Lenses must withstand moisture and condensation without losing optical clarity or suffering damage. Optical treatments can be applied to improve moisture resistance and prevent condensation on the lens surface.

• Thermal stability: Lenses must retain their optical properties over a wide range of temperatures. Materials used in the manufacture of lenses must be thermally stable to avoid distortion or cracking caused by temperature variations.

• Chemical stability: Lenses must be resistant to chemical attack to maintain their optical clarity in aggressive environments.

• Dimensional stability: It is important that lenses maintain their shape and dimensions under varying conditions of temperature and humidity to ensure adequate optical performance. Materials and manufacturing processes must ensure adequate dimensional stability over time.

2. Experimental research on the influence of maintenance products on lens hardness

Hardness is a physical property of a material that indicates its resistance to permanent deformation or scratching under the action of an external force.

It can be measured by various methods, such as penetration or indentation measurement, and is important in evaluating the quality and performance of materials in a wide range of industrial and engineering applications.

Hardness determination is the process of evaluating a material's resistance to permanent

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deformation, especially breaking or scratching, under the action of an external force [2].

The hardness of optical lenses refers to their resistance to scratches and other forms of mechanical damage. This is an important property for optical lenses, as a scratched or damaged surface can affect image quality and reduce the optical performance of the lens. Factors that influence the quality of optical lenses are:

- Lens material: The hardness of optical lenses is strongly influenced by the material from which they are made. For example, mineral glass such as borosilicate and silicate are known for its hardness and is often used in optical lenses. In comparison, plastic such as polycarbonate is less durable and can be scratched more easily.

- Protective coatings: Some optical lenses are treated with special coatings to protect them from scratches and other forms of damage. Anti-reflective coatings can, in some cases, also offer some protection against scratches. These coatings can affect the hardness of the lens, depending on the material and the technology used to apply them.

- Lens surface: The surface of the lens can also influence its hardness. Lenses with harder or specially treated surfaces may be more resistant to scratches than those with softer surfaces or less protective finishes.

- Care and handling: How optical lenses are cared for and handled can also affect their hardness over time. Using the wrong cleaning solutions or harsh wiping materials can result in scratches and damage to the lens surface [5].

In general, optical lenses are designed to be durable and scratch-resistant under normal conditions of use, but it is important to pay attention to their care and handling to extend their life and maintain image quality.

As part of the research, we determined the hardness of a group of 12 lenses of different thicknesses and diopters, which were cleaned with different maintenance solutions, namely:

- Reference lens with medium protection, diopter -0.50.

- Reference lens without protection, diopter -0.50.

- Lens with medium protection, diopter -0.50, cleaned with detergent.

- Lens with medium protection, diopter -0.50, cleaned with a tissue.

- Lens without protection, diopter -0.50, cleaned with a detergent.

- Lens without protection, diopter -0.50, cleaned with a tissue.

- Reference lens with medium protection, diopter -0.25.

- Reference lens without protection, diopter -0.25.

- Lens with medium protection, diopter -0.25, cleaned with a detergent.

- Lens with medium protection, diopter -0.25, cleaned with a tissue.

- Lens without protection, diopter -0.25, cleaned with a detergent.

- Lens without protection, diopter -0.25, cleaned with tissue.

Hardness determinations were performed on the Micro-Vickers HDT-VS1D INSIZE automatic digital hardness tester (Fig. 1).

***Fig. 1.** Micro-Vickers HDT-VS1D INSIZE device*

The technical specifications of the device, are: load 0.5 (kg), replacement time 10 (s), objective at 40x, brightness of 4.

The stages of making the determinations are:

- placing the lens on the device support;

- fixing the specifications used for all determinations;

- focusing the area and marking the length and width;

- data generation by turning on the device. (Fig. 2).

The data obtained after determining the hardness of the lenses, have been centralized in Table 1.

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Fig. 2. Data generation by Micro-Vickers HDT-VS1D INSIZE device

***Table 1.** Hardness of optical lenses*

LENS	D1 (Distance 1)	D2 (Distance 2)	HV (hardness)
Medium protection reference lens -0.50	81.46	79.76	30.2
Reference lens without protection -0.50	79.81	78.64	29.5
Medium protection lens -0.50, cleaned with detergent	64.73	49.13	28.6
Lens with medium protection -0.50, cleaned with tissue	55.59	57.28	29.1
Lens without protection -0.50, cleaned with detergent	67.24	82.65	16.5
Lens without protection -0.50, cleaned with tissue	70.27	66.54	19.8
Medium protection reference lens -0.25	63.52	65.61	25.3
Reference lens without protection -0.25	61.06	70.11	24.96
Medium protection lens -0.25, cleaned with detergent	63.35	63.23	23.1
Lens with medium protection -0.25, cleaned with tissue	61.59	63.40	23.7
Lens without protection -0.25, cleaned with detergent	70.65	68.94	19.0
Lens without protection -0.25, cleaned with tissue	56.06	69.06	22.5

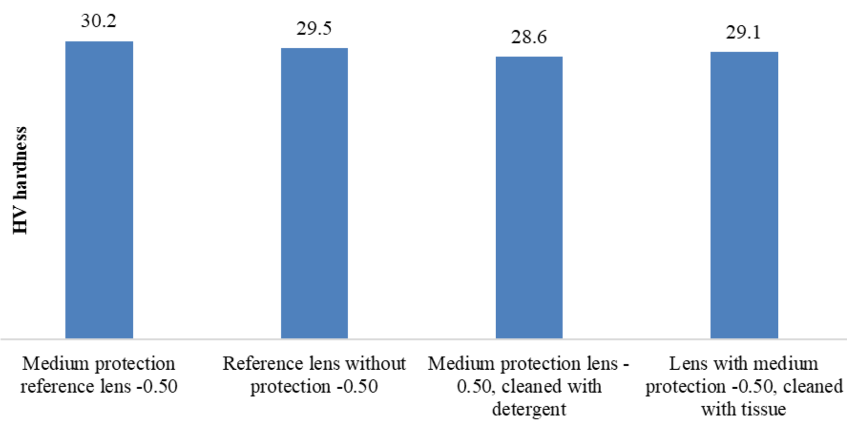

Fig. 3. Comparing the hardness of the reference lenses

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For the control lenses, we obtained higher hardness values than for the protective lenses, for both diopters. In terms of lens thickness, we obtained the maximum hardness for the thicker lenses, namely 1.25 mm, for those with -0.50 diopters, compared to 1.17 mm, for those with -0.25 diopters, which means that the lens thickness positively influences the hardness.

For lenses cleaned with a tissue, the maximum hardness was obtained for lenses with protection, with diopter -0.50, and thickness 1.25 mm.

For lenses cleaned with detergent, the hardness is lower than for those cleaned with a tissue. The highest hardness being at the lens with diopters of -0.50, and with a thickness of 1.25 mm.

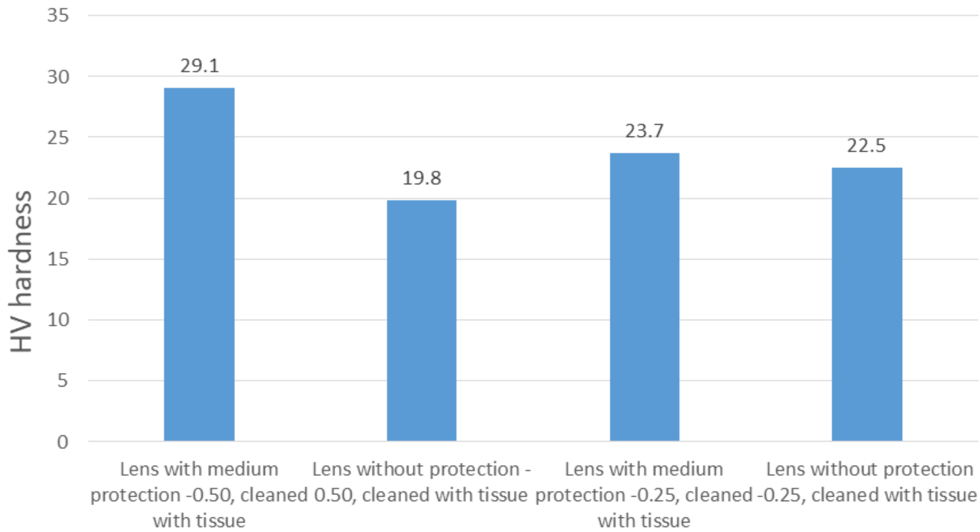

Fig. 4. *Comparison of hardness of lenses, cleaned with eyeglass wipes*

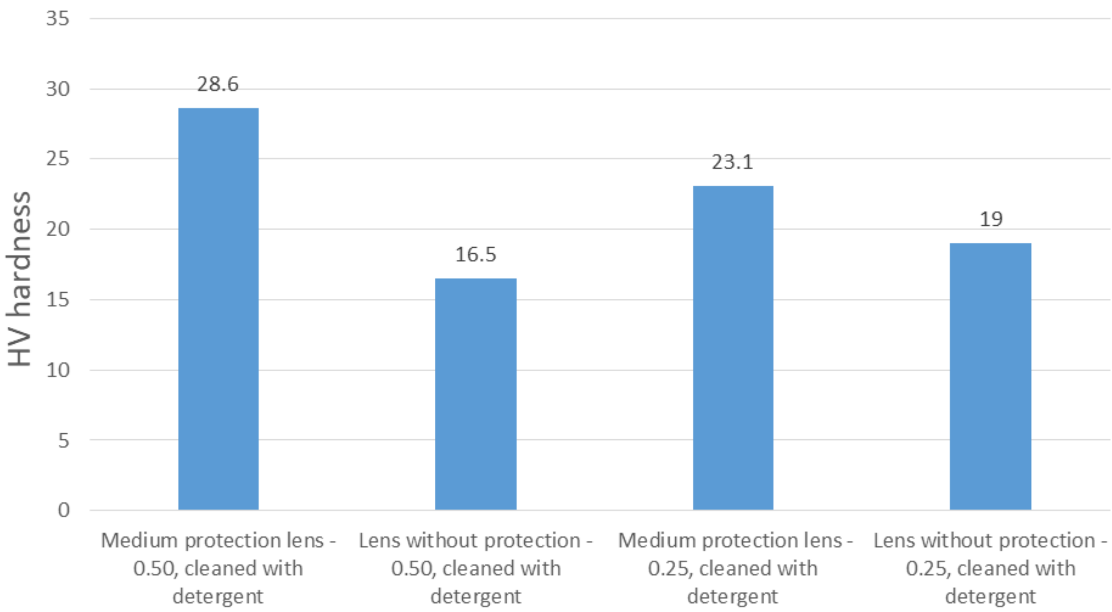

Fig. 5. *Comparison of hardness of lenses cleaned with detergent*

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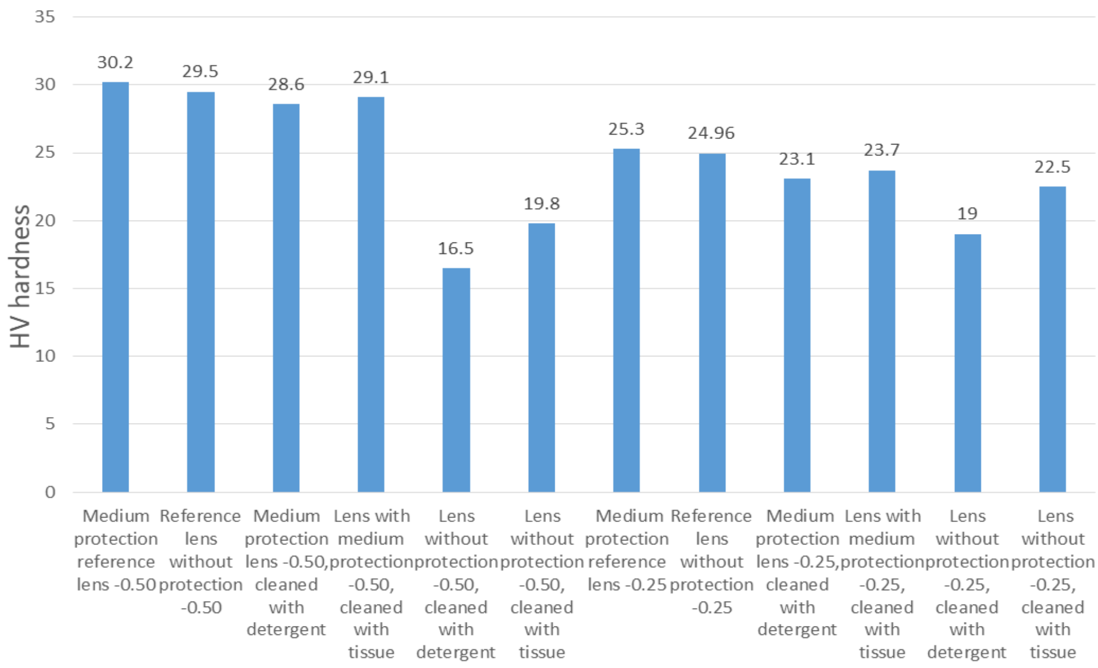

Fig. 6. *Comparison of the hardness of the studied lenses*

Repeated and prolonged application of cleaning solutions leads to a decrease in the hardness of the lens. In lenses cleaned with detergent, the hardness is lower than in those cleaned with a tissue, because the detergent attacks the protective layer more than the tissue.

The determinations were made after the lenses were repeatedly cleaned with special eyeglass cleaning wipes, and repeated washings with dishwashing detergent.

3. Conclusions

Following the data obtained for the hardness of the lenses studied, we concluded that the lenses cleaned with dishwashing detergent have a lower hardness than those cleaned with a wipe, because the chemical composition of the dishwashing detergent damaged the lens surface more deeply than the special wipe.

I noticed that the quality of the lens surface is influenced by the protective layer, regardless of the diopter value. Both for lenses with diopters of -0.50 and those with diopters of -0.25.

The results of this study are essential for improving the quality of lenses and associated maintenance products.

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DESIGN AND MANUFACTURING OF A CUSTOM GUITAR AMPLIFIER: OPTIMIZING MATERIALS FOR ACOUSTIC PERFORMANCE AND DURABILITY

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ABSTRACT

The project sought to design a guitar amplifier that would easily integrate into the decor of an apartment, imitating a piece of furniture. The design aims to create an aesthetic appearance that fits harmoniously in different types of homes, eliminating the need to bend down to adjust volume, tone, etc. The amplifier was built from a wooden case, with an accessory storage system in a lower drawer, and the functionality was achieved by integrating an Arduino board and a PCB circuit to implement the audio effects. The study details the stages of designing the amplifier prototype, including making the printed circuit board and processing the audio signal in four distinct stages: analogue signal amplification, digital processing by Arduino, signal output stage, and power supply. The project also includes the careful design of the amplifier components, using quality materials such as spruce panel to ensure superior acoustics. The result demonstrates the complexity and innovation in the field of musical equipment, combining aesthetic with technical aspects.

KEYWORDS: custom guitar amplifier, acoustic performance, industrial design

1. Introduction

Guitar amplifiers generally have a design that does not easily blend into the decor of an apartment room. Amplifiers have evolved exponentially over time, resulting in a great diversity of products for both amateurs and professionals. The market is extensive, catering to the most demanding requirements, while also offering products for those on a budget. Most of today's products, regardless of category and budget, have a professional look strictly geared toward use in a recording studio or rehearsal room [1].

Another important aspect is the height of a combo guitar amplifier, which is low, requiring the user to bend down to adjust volume, tone, etc.

This project aims to combine the appearance of a furniture piece with the functionality of an audio system with guitar effects (Fig. 1). The components will be housed in a wooden casing, with the height of the entire system adjusted so that bending down is unnecessary, and a drawer for accessory storage will be included at the bottom.

In the following study, we will discover how to design a guitar amplifier that can easily integrate into apartment decor by being disguised as a piece of furniture. Additionally, the size will be adjusted to make amplifier controls more accessible to the user. The project will seek to integrate elements like an Arduino board together with a PCB circuit to implement amplifier functionality and add various effects through these circuits.

Guitar amplifiers are complex products requiring careful design, both functionally and aesthetically. Their characteristics can vary by manufacturer, each having the freedom to express their vision through the product and incorporate various types of effects and programs.

A guitar amplifier is made up of several components that work together to amplify and process sound: the preamplifier is the first section where the signal from the guitar is amplified, also offering the possibility of adjusting the frequencies (high→medium→low) and applying effects such as

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distortion or reverberation [2]; the tone correction, placed before the final amplification stage, that allows the frequencies and tone of the signal to be adjusted; the amp also includes effects, which can change the shape of the waveform (i.e. distortion and fuzz) or add delay (echo or reverb); the final amplifier increases the power of the processed signal so that it is effectively played through the speaker, which in turn converts the electrical signal into sound. All these components are mounted on printed circuit boards (PCBs), and amplifiers can be built by various methods (Point to Point, Tag/Turret Board, PCB) to meet different performance and cost requirements [3].

Wood is prized as a material for amplifier enclosures due to its unique acoustic properties, which is why often is used in both musical instrument manufacturing and performance halls, where it contributes to superior sound quality. In the case of musical instruments, wood is preferred for its resonance, which improves tone quality, and in performance halls, also wood amplifiers can transmit sound efficiently, providing a quality listening experience [4].

Instruments like guitars, violins and pianos contain a type of sound box that is meant to amplify the sound of the strings. The vibrations are captured inside the box, and the tone emitted is influenced by the type of wood used. Each type of wood offers unique tones, having the properties of resonance, porosity and density that affect the sound. For example, spruce produces a “clear” tone, mahogany a “rich and warm” tone, maple a “concentrated” tone, and rosewood is known for sustaining low notes.

In the case of guitar amps, opinion is divided on the impact of construction on tone. A significant element is the speaker, whose materials and dimensions influence the tone. Materials used to build amplifiers include plywood, MDF and chipboards. Birch plywood, often found in speaker boxes, resonates better than MDF and chipboard, providing a “powerful and lively” tone, increased resistance to moisture. MDF is durable and heavy but does not add a “live” resonance to the sound, while chipboard is denser and cheaper, but less durable.

There are, however, many subjective opinions regarding the tone of amplifiers, and their impact on tone is difficult to quantify objectively.

In experimental studies, tests were carried out to observe the influence of the material on the tone. One of the studies looked at whether the type of box material (plywood, MDF, chipboard) affects the sound, using the same size and speaker [5]. The recordings, made without indicating the material used, showed that auditory differences were almost nonexistent, indicating a possible psychological effect in pitch perception [5].

A second reference study focused on box construction and size differences (1x12, 2x12, 4x12), showing that the back of the box (open or closed) affects low frequencies below 200 Hz, and box size influences the tone [6].

The third study compared Fender, VOX, and Marshall amplifiers, revealing that the order of components in each circuit contributes to differences in tone [7].

2. Custom amplifier prototype design

For this project, the code sequence and circuit layout from ElectroSmash were used [8], with some modifications to make the assembly compatible with the product propose.

2.1. PCB board design

The first step in creating this prototype is to develop the electronic circuit that will contain the audio signal manipulation elements, specifically the effects. The “Press-n-Peel” or PnP method was used to create the circuit board, as it is the most popular due to its simplicity. Is easy to perform, low–cost, and provides good accuracy.

The steps to create the printed circuit board (see Fig. 2):

- Printing the circuit layout on the PnP sheet (the circuit layout was printed on a glossy A4 sheet using a laser printer with toner);
- Cutting the fiberglass board and trimming the layout (a cutter was used to remove the unused paper, and the board was cut to the layout’s dimensions using a saw);
- Transferring the layout onto the board (the PnP sheet was heated with an iron and pressed onto the board to transfer the toner, thus printing the circuit onto the copper foil);
- Sodium persulfate bath (the printed board was immersed in a sodium persulfate solution until the unprinted copper areas dissolved);
- Cleaning with acetone (after the copper was completely removed from the unprinted surfaces, the board was taken out of the sodium persulfate bath, and the printed side was cleaned with acetone, leaving the copper circuit intact);
- Drilling the board (after completing the circuit printing, holes were drilled for mounting the electronic components and connections using a drill);

Soldering the components (finally, the electronic components were soldered onto the board using a soldering iron to secure the parts and ensure electrical connections).

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Audio Signal Processing of the assembly is divided into four distinct stages (see Fig. 3):

- Analog Input Stage − the low-amplitude signal from the guitar pickup is amplified, filtered, and prepared to be read by the analogue–to–digital converter or ADC in the Arduino Mega processor;
- Arduino Mega Stage − receives the digital signal from the ADC, thus, it processes according to the programmed sequence (distortion, fuzz, delay, etc.);
- Output Stage − the processed signal in the Arduino Mega stage is output through two PWM outputs, resulting in an analogue audio signal that passes through a tone correction (bass, midrange, and treble) before entering the amplification stage;
- Power Supply Stage − provides power voltages of +15V and -15V for the input and output stages and a 9V power supply for the Arduino processor.

The operation of the assembly is as follows: the first operational amplifier in the input stage prepares the analogue signal for conversion to a digital signal by amplifying and filtering the sinusoidal signal from the guitar; the second operational amplifier in the output stage receives the signal from the Arduino Mega processor through two 8-bit PWM outputs, which it combines to produce an analogue signal.

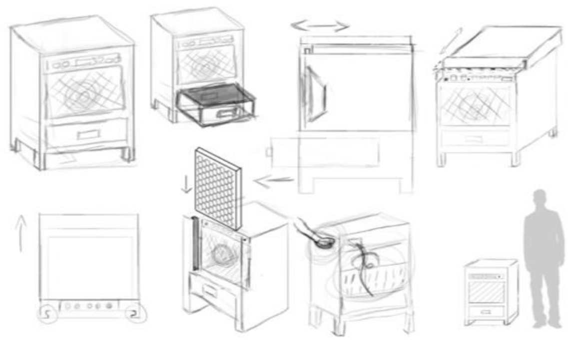

Fig. 1. *Concept sketch of the custom amplifier*

The user interface consists of two configurable momentary switches that allow switching from one effect to another and adjusting levels for certain effects, a toggle switch that changes the mode between effect scrolling or level adjustment, and an OLED display that shows the selected effect or its level. The Arduino Mega connectors link the board with the analogue stages to the board with the Arduino Mega processor. The connection is made through male–female pin lines.

The code sequence for the amplifier was sourced from the ElectroSmash website, specifically from their documentation on the pedalSHIELD MEGA Arduino Guitar Pedal project [8]. This code sequence has been adapted and customized to meet specific project requirements, ensuring optimal integration between components and facilitating precise, real-time control of effects and audio signal level. Thus, the user can easily navigate through the effects and adjust their parameters, benefiting from an interactive and intuitive experience, all functions being accessible through the simplified interface.

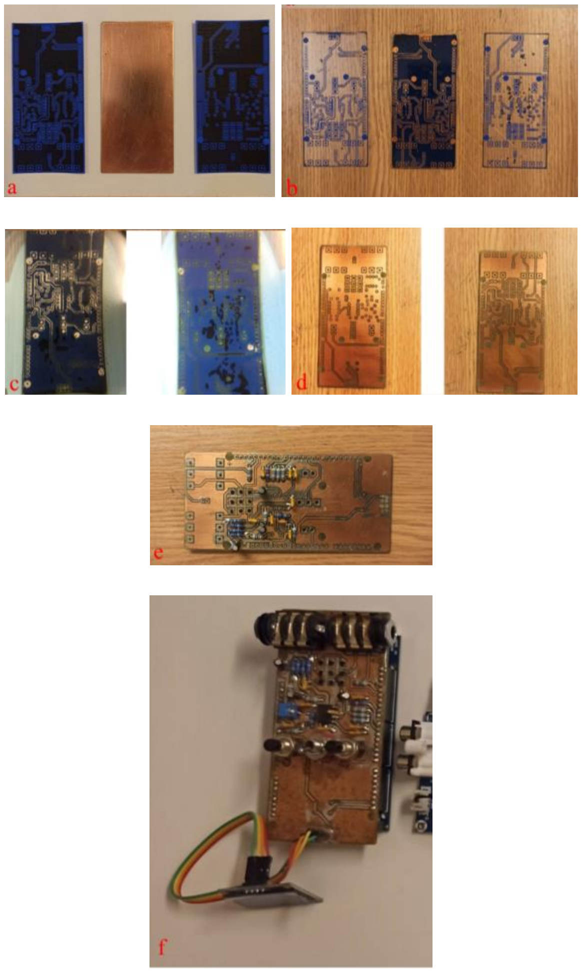

Fig. 2. *PCB manufacturing: a. Cutting the printed circuit board and trimming the schematic; b. Printing the circuit layout; c. Etching the copper; d. Board cleaning with acetone; e. The board along with various components; f. The completed board inserted into amplifier assembly*

2.2. Component design method

Autodesk Inventor Professional 2024 software was used to design the elements of the amplifier, as shown in Fig. 4.

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The product requires the following elements: the walls of the box, namely two side plates and one top plate, the drawer parts (total 5 elements), the interface support together with the circuit support shelf, the speaker support, another support shelf, the outer cover that will support on said shelf, 2 drawer supports and a back cover. These components have been designed to ensure both structural stability and easy accessibility to all internal amplifier modules, allowing for efficient assembly and simplified maintenance.

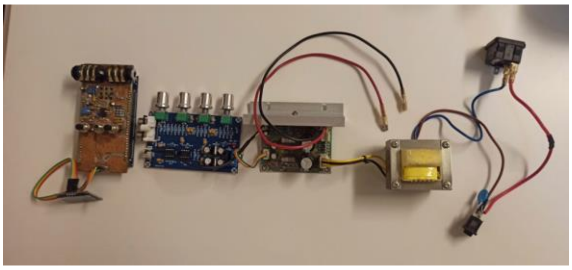

***Fig. 3.** The electronic elements used*

Each element is designed individually and introduced for design verification.

In the case of this project, an 18 mm spruce panel thickness, with dimensions of 3000 x 1220 mm was used, from which the parts necessary for the product were cut.

To obtain the final product, a series of processes were carried out (Fig. 5):

- To begin with, the pieces were framed on the panel, an operation performed on the computer using the Optim Cut program.
- Cutting subassemblies, operation performed on circular saw. The circular saw is fitted with a blade that has special Vidia teeth for cutting softwood.
- The joining of subassemblies is done with 8 mm diameter wooden dowels and 15 mm diameter eccentric cams.
- The holes are made on the multi–drilling machine (is a machine that can make 20 holes at the same time).
- The next step is sanding – the sanding operation is very important, it must be done very carefully, because a good sanding leads to obtaining a uniform and pleasant surface after varnishing. Sanding is performed on an abrasive belt machine. In this project we start sanding with 100–grit abrasive, then switch to a smaller grit, i.e. 150.
- The first time after sanding, the parts are "blown" with compressed air to remove dust and wiped easily with a damp cloth.

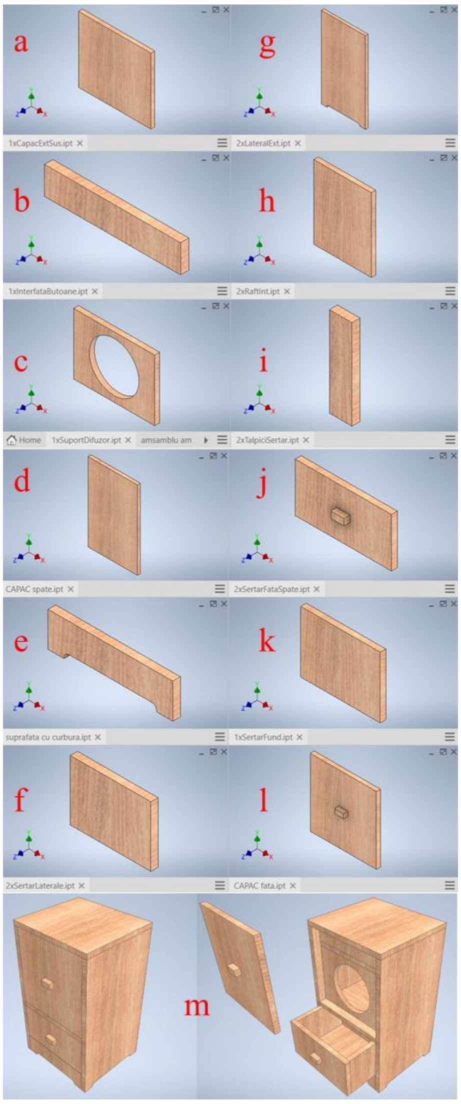

***Fig. 4.** Amplifier case design: a. box cover; b. button interface; c. speaker support; d. back cover; e. curved surface; f. drawer sides; g. box side; h. shelf; i. drawer bottom pieces; j. drawer front; k. drawer base; l. front cover; m. prototype assembly*

- A primer layer is applied – the primer has the role of covering the pores. After the primer has dried (approximately 2 hours), we continued sanding the surfaces with 150-grit abrasive. After sanding the primer, the surfaces are inspected, and where there are knots, marks in the wood, etc., the respective area is grouted with wood putty. It is left until the grout dries and the grouted tiles are sanded.
- Then the varnish was applied and let to dry – we sand the parts after the varnish has dried using an abrasive less than 180-grit.

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• Varnish again, we left to dry, then sand the parts with 240-grit abrasive. After drying, the last layer of varnish was applied, and the parts are ready. Priming and varnishing are done using a compressed air paint gun with a 1.5 mm nozzle.

Fig. 5. *Processing stages of the wooden amplifier case: a. Circular saw for material cutting; b. Eccentric cam for fastening; c. Wood dowels for fastening; d. Belt sander; e. Spray gun*

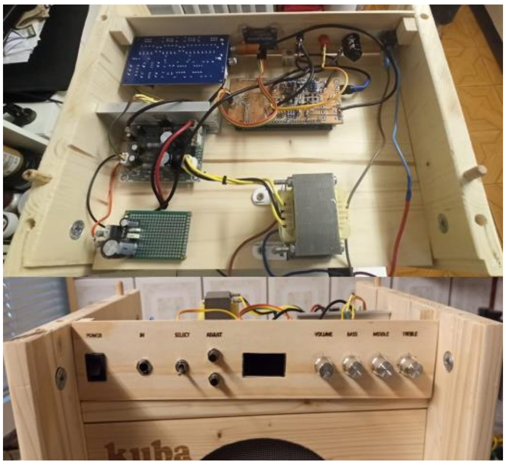

Fig. 6. *Final assembly of the amplifier*

Finally, the electronic parts are mounted in the created assembly, and the product is completed (see Fig. 6).

Fig. 7. *The final design of the custom amplifier*

3. Conclusions

The purpose of this study, thus, was to design a guitar amplifier that could be integrated easily into an apartment environment, going unnoticed, being easily confused with a piece of furniture. The main goal was to create an aesthetic design that harmoniously can

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integrate into various types of homes. Guitar amplifiers will always remain products with high complexity both functionally and aesthetically, being an indispensable object for music enthusiasts.

The study emphasizes the potential for innovation in musical equipment by combining the aesthetic and technical aspects.

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ADVANCED MODELING AND 3D PRINTING TECHNIQUES FOR GAME AND CGI CHARACTERS

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ABSTRACT

This article explores the methods of designing 3D elements used in video games and CGI, highlighting the impact of these techniques on the perception and experience of digital art. 3D models are fundamental to create immersive virtual worlds, and the 3D modeling process extends from conception to execution, combining engineering principles with industrial design. Advanced three-dimensional modeling software such as Blender or Adobe Substance 3D Painter are built to create realistic models, while additive manufacturing with SLA technology allows rapid prototype development of game characters. The article also discusses the interoperability between certain three–dimensional modeling platforms on the current market and the impact of new technologies such as the so-called digital twins or the metaverse, on the future of three-dimensional graphics and three-dimensional modeling of game characters. Through these technological advances, 3D modeling is redefining the boundaries of design, offering limitless opportunities for innovation in the gaming industry.

KEYWORDS: game characters, CGI, additive manufacturing, SLA

1. Introduction

The design methods for 3D elements used in video games and CGI have radically transformed how we envision and experience digital art, bringing creativity into previously unexplored territories. 3D models represent the visual backbone for most video games and CGI content, essential not only in film but also across many visual media. These models are fundamental in constructing captivating and highly realistic virtual worlds, with lifelike characters and settings that interact naturally with their environment. The goal of 3D modeling in this context is to give a sense of realism and immersion, offering viewers and players an intense "lost and found" experience within the fictional world created.

The flexibility in customizing and varying 3D models allows creators to quickly transform basic models into complex objects and characters, adjusting features to build a unique, rich, and dynamic world. Thus, introduces a sense of novelty and surprise, essential for an engaging experience. The unlimited possibilities of 3D modeling appear in a wide range of projects: from creating futuristic, lifelike characters in video games to highly detailed objects used in film and advertising. In such projects, the 3D modeling process becomes a flexible creative tool that can be adjusted and optimized to meet project needs without compromising the product's final purpose.

To create a 3D model for a mecha-type character, the process begins with fundamental research and the development of a visual concept [1]. This is followed by the actual modeling of the distinctive and complex elements of such a robot character, rendering, and integrating the finalized model into its intended use scenario, whether in films, games, or other platforms. The purpose of this work is to detail the complete process from concept to execution, highlighting how engineering and industrial design principles combine to create realistic and functional mechanical structures. Furthermore, this approach highlights methods for joining mechanical parts, texturing, and the application of light and shadow to render materials (metal, leather, plastic) characteristic of a mecha.

Three–dimensional design and modeling are now simplified and accessible thanks to advanced

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software, enabling designers to preview and manipulate models from any angle, in detailed and intuitive ways. This technology removes the need for costly physical prototypes and enables quick testing and modification at each design stage. Thus, 3D modeling not only reduces production costs and time but also improves team collaboration by providing a clear and precise visual representation of concepts.

Another important aspect is interoperability among different 3D modeling software platforms, such as Blender, AutoCAD, or Maya. Commonly used 3D file formats like FBX, OBJ, or gLTF/GLB facilitate data exchange and ensure compatibility across software applications. Choosing the right format is essential to avoid data loss or compatibility issues in the design process. Modern software allows exporting and converting between different formats, ensuring that 3D models can be adapted and reused in various contexts and platforms, from augmented and virtual reality simulations to film and gaming industries.

Nowadays, the future of 3D modeling, emerging technologies like digital twins [2] and the metaverse [3] offer new opportunities to connect physical and virtual reality. For instance, digital twins enable real-time monitoring of physical entities through virtual replicas, useful in engineering, medicine, or complex simulations. Similarly, the metaverse concept, a collective digital space, allows the use of 3D objects and avatars for social interactions and immersive virtual experiences.

Through the continuous evolution of 3D modeling software, economic benefits, increased efficiency, customization capacity, and precision of detail are fundamental reasons for the popularity of these technologies.

Over time, the development of video games has evolved significantly, allowing 3D modelers to create immersive and highly realistic experiences for players. From 2D effect, games have progressed to 3D effect, offering vibrant scenes like those in movies. 3D artists develop animated textures and plan the design of each model to ensure the quality and performance of the game. Thus, the 3D video game industry has established itself as a representative of cutting–edge technology in entertainment, and 3D games are gradually becoming an important part of everyday life. 3D models are created using specialized software, which enables the generation of environments, characters, and other visible objects in games. Textures and animations are integrated to enhance the realism [4], and the models are then introduced into the game engine to create the final product.

3D technology can be divided into three main categories: 2D games, 3D games, and pseudo-3D games (or 2.5D), each with specific characteristics. In 2D games, graphic elements are composed of unique maps, while 3D games use geometric polygons to provide a more realistic gameplay screen. Pseudo-3D games combine the two techniques to meet the diverse needs of players, 3D technology brings stereoscopic visual perception, creating three−dimensional coordinates that generate a distinct virtual space.

3D technology manifests through four essential aspects in games: character modeling, scenario modeling, particle systems, and the 3D engine. Character modeling refers to the creation of virtual characters, adding living objects in the environment. This includes researching movements and facial expressions, contributing to a more engaging gameplay experience. Scenario modeling deals with generating virtual environments, integrating computer graphics, artificial intelligence, and sensor technology to create interactive experiences.

The particle system is responsible for generating special effects, such as glowing light or flames, which enhance the visual appeal of the game and attract players' attention. The 3D engine, on the other hand, is the piece that controls all these elements, abstracting materials into polygons or curves and generating final images through complex algorithms.

The game engine is essential for the development and operation of video games. It includes a complex composition made up of components such as rendering, scene structure, movement system, and collision system.

Rendering is the fundamental part that allows the display of 3D images on 2D screens, divided into software and hardware rendering. Hardware rendering is used for real−time rendering, while software rendering is primarily used for offline rendering.

The scene structure allows for the organization of 3D objects within a common space, creating a hierarchy of interconnected nodes that facilitate the management of coordinates. The movement system ensures the dynamics of the game, managing changes and movements in the 3D space through a time control program. The collision system detects interactions between objects, enhancing the game's reality by implementing surrounding structures that facilitate interaction between nodes.

Important technical aspects include polygon optimization, balance between CPU/GPU and memory, as well as level optimization. Optimization techniques aim to reduce the size of 3D model files by decreasing polygon numbers and efficiently using textures. Expert interviews highlight the importance of balancing optimization and aesthetics.

CGI (Computer Generated Imagery) is a broad term that includes 3D modeling and animation, with diverse applications in the industry, ranging from games and films to marketing and education. The

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advantage of CGI is the reuse of the 3D model, but it consumes a lot of storage space.

2. Advanced modelling process for a game character

To demonstrate the practical process of creating a 3D asset from scratch, we assembled a general step-by-step guide with the general ideas necessary for brainstorming. This case study idea and challenge was to build a fictional robot character, known in pop culture as a mecha, from the ground up. To do this, there needed to be a foundation upon which to create this mecha.

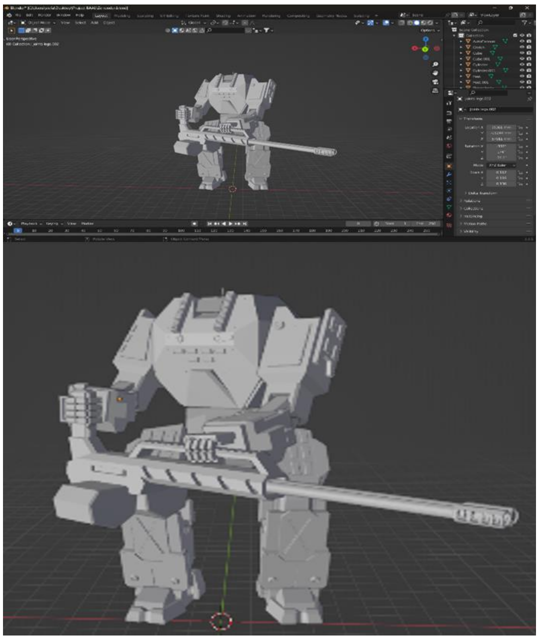

Fig. 1. *The mecha game character designed in Blender open-source software*

The first step was brainstorming some ideas, starting from the background in industrial engineering, which greatly assisted this study.

Asking ourselves, knowing that we had complete freedom regarding the size and shape and how impossible it was for it to exist, what purpose it would serve? How far into the future would exist? What size and shape would it need to have to fulfil its purpose, would it have a humanoid form, or would it reflect the technology we already have? In this study, was decided to combine all these elements into a simple description: a mecha with a heavy military unit, humanoid shape, but its mechanisms would be inspired by some real-life technologies.

Some of the real-life shape inspirations for the mecha included actual features from military vehicles. For example, as an inspiration for the torso, the cab of the Oshkosh FMTV truck was used. For the mecha head, the main source of inspiration was the the M-TADS/PNVS sensor system found in the AH-64 Apache attack helicopter. The final source of general inspiration was the concept of reactive armour used on many armoured vehicles worldwide, but well represented in this image of a Bradley M2A2.

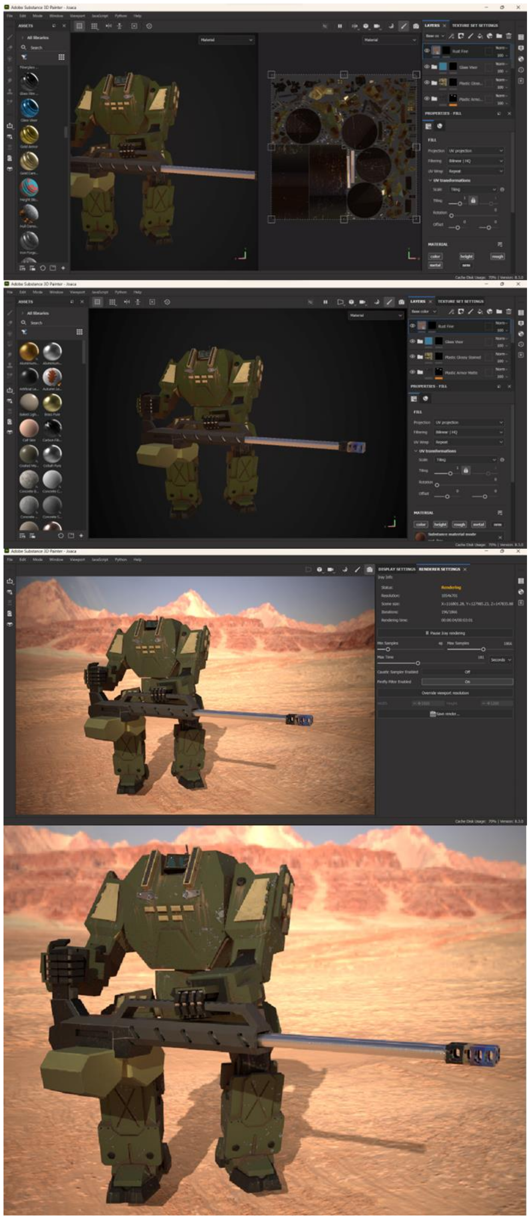

Fig. 2. *Generating textures for the video game character with Adobe Substance 3D Painter*

To simplify the 3D modeling process, isometric views of each subassembly were resorted, so that we could more accurately describe the shapes of the mecha.

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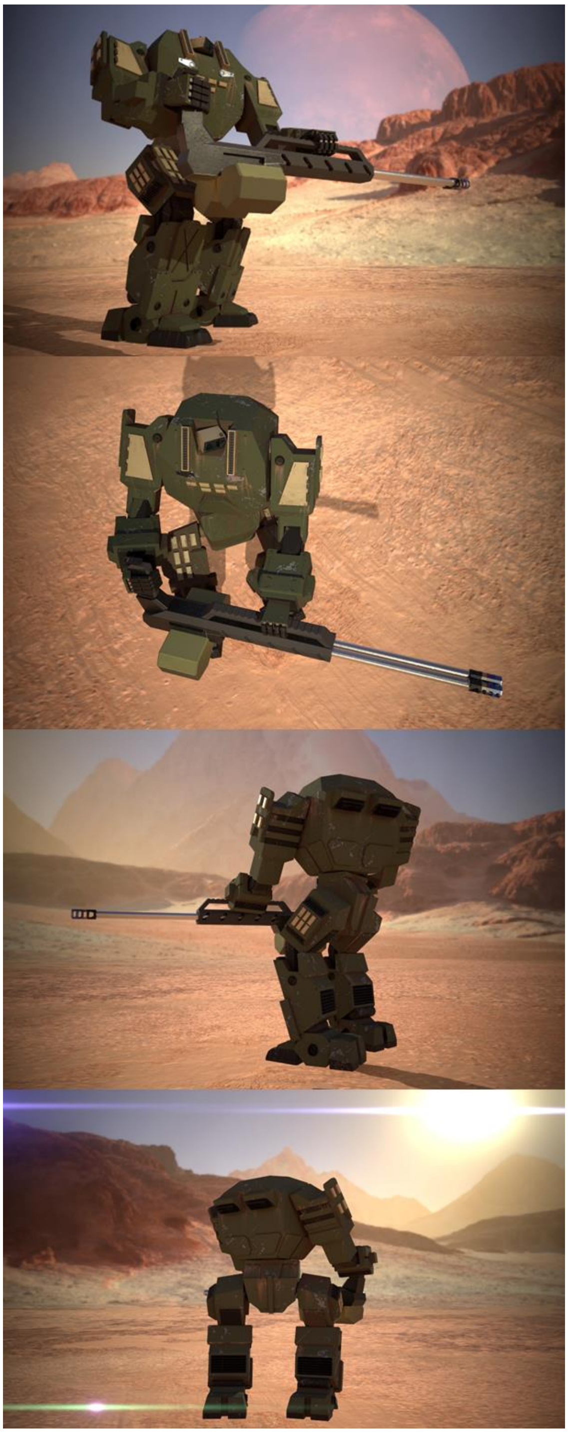

Fig. 3. *Gaming character final scenes in Substance Painter*

Creativity plays a crucial role in 3D modeling, influencing the process of creating engaging environments and characters for video games and computer graphics (CGI). Is defined as the generation and implementation of original ideas, involving innovative solutions to challenges encountered in modeling. Thus, creativity manifests through design innovation, allowing experimentation with shapes, textures, and colours to create memorable models. It also serves as a form of artistic expression, providing the freedom to communicate complex ideas and emotions, thus contributing to the construction of fantastic worlds that stimulate the audience’s imagination.

Creativity is also vital to finding ingenious technical solutions, transforming limitations into opportunities, such as optimizing geometry and creating impressive visual effects. In the context of this study, the impact of creativity on the techniques and practices within the 3D modeling industry will be explored, highlighting its influence on the audience’s experience.

Simultaneously, quality is a fundamental aspect of 3D modeling, having a direct impact on the difference between mediocre and remarkable creations. It refers to the extent to which a model meets established requirements, including shape accuracy, topology efficiency, textures, and overall coherence. The importance of quality in polygonal modeling is reflected in the level of detail and realism achieved, as well as the efficiency and performance of the model, which are essential for a smooth gaming experience. Well–thought–out topology facilitates the editability and manipulation of the model, offering flexibility in the processes of texturing, rigging, and animation. Thus, creativity and quality are interconnected, contributing to the success of 3D modeling process.

After, the finished surface model was exported in FBX (Filmbox) format to be imported in the texture software Substance Painter, as shown in Fig. 2 and Fig. 3.

FBX extension is an essential file format for efficiently transferring 3D models, animations and the textures between different 3D modeling software such as Blender and game engines like Unity or Unreal Engine. When developing a video game character in Blender, we can use FBX to export the complete model, including rigging (bone structure for animation) and animations, ensuring all details are preserved. This allows the character to be seamlessly integrated into video games so that it functions correctly in the game engine of choice while maintaining the desired visual quality and animations.

3. Additive manufacturing techniques for video game characters

Additive manufacturing has modeled completely the way production processes across various industries were built, and SLA, the abbreviation of stereolithography technology is known for precision and versatility, being also the oldest 3D printing

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technology. This printing technology uses the photosensitive resin as raw material, a well−known material, that facilitates the manufacturing of highly detailed objects, making it suitable for the development of prototypes and custom objects. This technology provides engineers with the freedom to generate complex forms, and very fine details, that is essential in fields such as gaming and entertainment.

SLA technology uses an ultraviolet laser to cure each liquid resin thin layers. Every 3D printing process begins with a 3D model that is sliced into thin layers in a special software generally called slicer, then the file is exported into a G-code which is transferred into the 3D printer [5]. After the printing process is started, each layer is being cured by the laser until the object is built. SLA printing offers numerous advantages: it allows the manufacturing of objects with fine details, provides design versatility, accelerates the prototyping process, and use a wide variety of materials, including transparent and flexible resins. However, there are also limitations. The higher cost of resins and the need for post–processing, such as cleaning and additional curing, are aspects that must be considered. The durability of SLA–printed objects also may be inferior to other printing methods [6].

SLA 3D printing plays an important role in the gaming industry, by developing prototypes for video games. Engineers create physical models of characters and scenarios, allowing for testing and improvement before final production. Gamers often seek custom figurines of their favourite characters, and SLA technology meets this demand by producing unique objects with a high level of detail.

A concrete example is XYZ Company, which use SLA to produce custom figurines for the game HeroQuest. The process included detailed 3D modeling, prototype testing, and the rapid production of final figures, all contributing to the fabrication of high–quality products. This technology not only facilitates rapid prototyping but also opens new horizons for creativity and innovation in this industry. Engineers can create any imaginable shape or detail without the constraints imposed by traditional methods.

In the future, SLA technology will continue to evolve, integrating artificial intelligence and machine learning, which will optimize the design and production process. The growing demand for personalized products and the need for sustainability in production will drive wider adoption of this technology in gaming and entertainment, ensuring that it remains relevant and competitive in the market.

Additive manufacturing of the game character began with the printing of components using SLA technology. This method was chosen due to its ability to produce parts with fine details and smooth surfaces, essential for a quality aesthetic appearance. A gray resin base was used, an important choice as each piece would later undergo post–processing (Fig. 4).

Fig. 4. *Components printed using SLA technology*

After the printing was complete, each component was treated with a UV curing light to ensure the necessary durability and strength. This step is vital to achieve the desired physical properties of the parts. Afterwards, layered airbrush painting was done, which allows for an even application of colour and fine detail. This technique helps create impressive visual effects, enhancing the overall look of the character and ensuring that it blends seamlessly into the gaming universe.

Fig. 5. *Components painted with different coloured layers using an airbrush*

To achieve certain details and avoid interlacing colours, paper scotch tape was used to mask the

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desired areas during painting. Later, several layers were applied with an airbrush to create shading and achieve detailed visual effects, as shown in Fig. 6.

Fig. 6. *Painting the details of the mecha game character*

Fig. 7. *Manufactured and post-processed mecha game character*

Each piece was then coated with a white paint, used as a neutral base, which allowed for an even application of the colours. Later, several layers were applied with an airbrush to create shading and achieve detailed visual effects, as shown in Fig. 5. This technique helps to improve the overall appearance of the character, ensuring that it blends seamlessly into the gaming universe.

After painting was completed, all components were assembled by soldering, ensuring that each part fits together perfectly and that the final structure is stable. This assembly stage is essential to integrate the elements and achieve a coherent and well-defined character. In Fig. 7 is shown the final SLA manufactured mecha model.

4. Conclusions

The process of designing and making 3D elements of video games and CGI has evolved significantly, redefining the way we interact with digital art. Starting the detailed modeling of characters and scenarios to their integration into graphics engines shown in this study, every step of this process involves a combination of creativity and advanced technology. Advanced modeling techniques use software such as Blender and Adobe Substance 3D Painter which provide essential tools for designers and engineers, making it easy to create realistic and captivating models. This study also shows how additive manufacturing methods allow rapid creation of prototypes and custom figures, opening new horizons in the gaming industry. New trends such as digital twins and the metaverse also promise to further transform the 3D modeling landscape, creating unique opportunities for innovation. Thus, 3D modeling continues to redefine the boundaries of design and offer immersive and captivating experiences to users, consolidating itself as an essential element of modern entertainment.

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A COMPARATIVE STUDY REGARDING THE PERFORMANCE OF CORPULS 3 AND ZOLL DEFIBRILLATORS

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ABSTRACT

The purpose of this paper is to provide a detailed and accessible overview of the Corpuls 3 and Zoll defibrillators, highlighting their features, functionalities and advantages in the monitoring and treatment of patients in emergency and intensive care settings. The comparison was based on seven main criteria: modularity, design, CPR capacity, performance, vital parameters monitoring, monitoring screens and maintenance costs.

KEYWORDS: defibrillator, Corpuls 3, Zoll, performance

1. Introduction

The circulatory system's blood pumping function is carried out by the heart, an essential organ of the human body. There are four chambers in the heart: two ventricles and two atria. The heart's left side pumps oxygenated blood from the lungs to the rest of the body, while the right side takes in deoxygenated blood from the body and delivers it to the lungs for oxygenation [1-3]. The blood supply to the heart is provided by the coronary arteries. Heart attacks and coronary heart disease can result from blockages in these arteries. The heart also has an electrical conduction system that coordinates the heartbeat. The sinoatrial node, also known as the "natural pacemaker", initiates the electrical impulses that regulate the heart rate. A cardiac arrhythmia is an irregular heartbeat that occurs when the electrical signals that coordinate the heartbeat don't work properly [4-6]. The heart can beat too fast (tachycardia), too slowly (bradycardia) or irregularly [7-10]. While some arrhythmias are not dangerous, some can be harmful and need medical attention. For example, tachycardia includes types such as atrial fibrillation [11-14], atrial flutter [15-16], supraventricular tachycardia [17-18], and ventricular fibrillation [19-20].

Various health conditions can affect heart health, including heart disease, heart failure, arrhythmias, and congenital heart defects. Lifestyle factors such as diet, exercise and stress management play a crucial role in maintaining heart health.

Defibrillation is a medical procedure that involves delivering electric shocks to the heart to restore normal heart rhythm in the event of cardiac arrest or severe arrhythmias. Defibrillation is essential in treating ventricular tachycardia and ventricular fibrillation, which can lead to death if not treated fast. It is a crucial step in cardiopulmonary resuscitation (CPR) and must be performed as soon as possible after the onset of ventricular fibrillation to be effective. Correct use of defibrillators and proper electrode placement are critical to successful procedures and prevention of arrhythmias.

A vital component of equipment for resuscitation in a scenario of cardiac arrest is a manual defibrillator. A defibrillator operating improperly or slowly might have a negative impact on acute treatment [21]. A self-explanatory interface reduces the possibility of operational faults while also rendering handling easier.

Continuous monitoring from the scene of the incident to the hospital is essential to ensure effective and rapid medical intervention in emergency situations. Modern monitoring devices, such as the Corpuls 3 or Zoll, allow emergency teams to constantly monitor the patient's condition and provide appropriate treatment throughout transport or at the scene of the incident.

An ergonomic approach in transporting the patient is important to ensure his comfort and safety during the medical intervention. By dividing the modules, modern monitoring devices facilitate handling and transport of the patient, allowing medical staff to focus on treatment and continuous monitoring. Improving patient safety by recording and saving parameters directly on the patient is an innovative feature of modern monitoring devices. This allows quick access to the patient's vital data and

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provides accurate recording of the evolution of his clinical condition throughout.

2. Experimental research

For this case study, we used images of the monitoring screens of the Corpuls 3 (Figure 1) and Zoll (Figure 2) defibrillators. The analysis focuses on the displayed parameters, including heart rate, oxygen saturation (SpO_2), blood pressure, modularity, design, CPR capability, performance, vital signs monitoring and maintenance costs between Corpuls 3 and Zoll.

Fig. 1. *Zoll defibrillator display results*

Fig. 2. *Corpuls 3 defibrillator display results*

3. Results

Modularity of defibrillators include aspects such as configurability, compatibility with accessories, portability and flexibility of use. In Figure 3 presented is the radar chart comparing the modularity between Corpuls 3 and Zoll based on five key criteria: module configurability, accessory compatibility, portability, flexibility of use, and integration with other medical systems.

The chart above provides a clear view of the strengths and weaknesses of each device according to the modularity criteria analysed. Corpuls 3 stands out with superior modularity in almost all criteria compared to Zoll, which makes it more suitable for uses that require high configurability and portability.

Regarding the design between Corpuls and Zoll, we analyse several criteria relevant to the design of medical devices. These criteria could include: ergonomics, accessibility, ease of use, durability and aesthetics. In Figure 4 the major design difference between the two devices is clearly highlighted. Corpuls 3 stands out through a superior design in all the analysed criteria: ergonomics excellent, high accessibility, maximum ease of use, durability and modern and attractive aesthetics. Zoll's performance is good in all criteria, but inferior to Corpuls in terms of ergonomics, accessibility, ease of use, durability and aesthetics.

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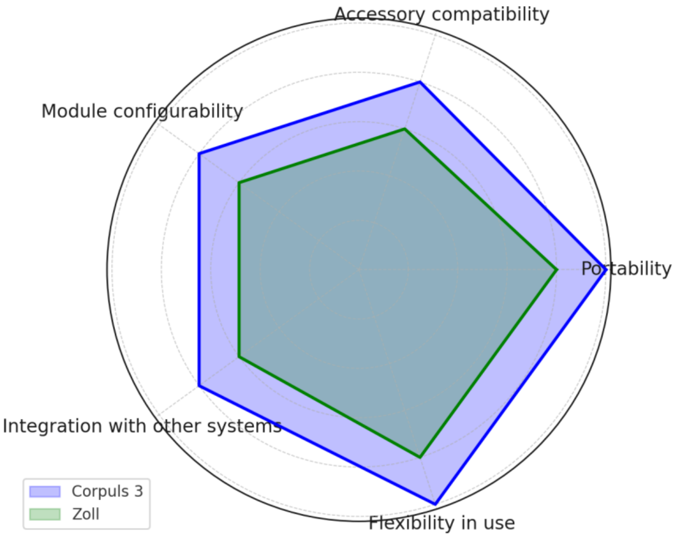

Fig. 3. *Comparison of modularity between Corpuls 3 and Zoll*

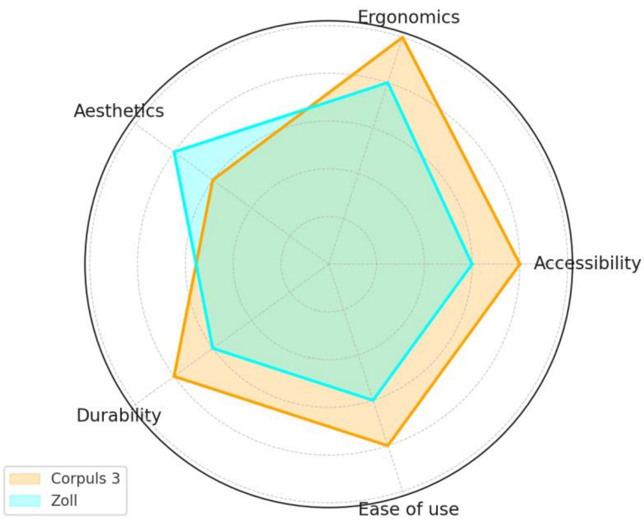

Fig. 4. *Comparison of design between Corpuls 3 and Zoll*

To conduct a comparative study on cardiopulmonary resuscitation (CPR) capability between the Corpuls 3 and Zoll devices, we analysed several key criteria such as: CPR efficiency, real-time feedback capabilities, ease of use, compatibility with other equipment, innovations and additional technologies. Figure 5 shows the comparative graph regarding the PCR capacity between Corpuls 3 and Zoll.

As seen in Figure 5, regarding the CPR efficiency, Corpuls 3 is well supported by the advanced technologies included, the device provides accurate feedback and helps maintain appropriate compressions. Zoll is known for its efficiency in CPR, thanks to patented technologies, the device ensures an optimal depth and frequency of compressions. As for the real-time feedback capabilities of the two devices, the Corpuls 3 provides real-time feedback for the depth and rate of compressions, as well as for ventilation, and includes a metronome to help maintain the correct rhythm. Zoll is famous for its Real CPR Help technology, which provides real-time visual and auditory feedback. Monitors compressions and suggests adjustments to optimize CPR performance.

Figure 6 shows a comparison between the performances of the medical devices, Corpuls 3 and Zoll, represented in a radar plot. Each axis of the graph represents a different performance category: user Interface, design and portability, core functionality, cost, durability and reliability, connectivity and integration, battery and power, defibrillation, monitoring capabilities.

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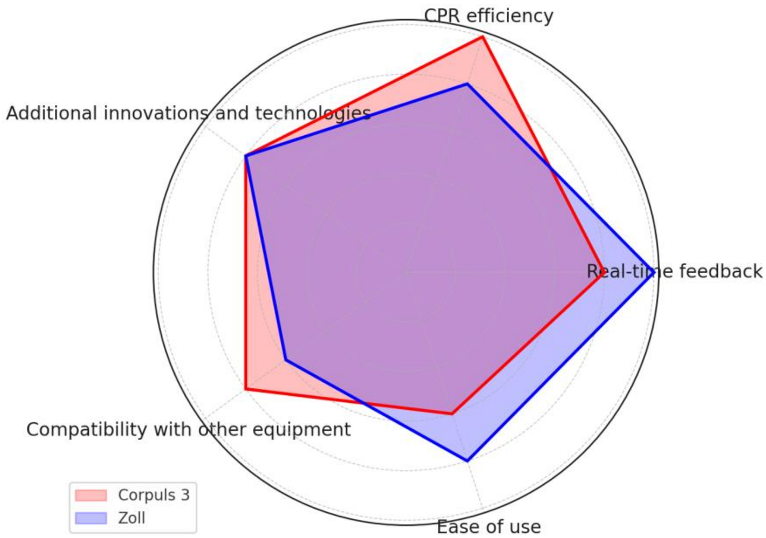

Fig. 5. *Comparison of CPR capacity between Corpuls 3 and Zoll*

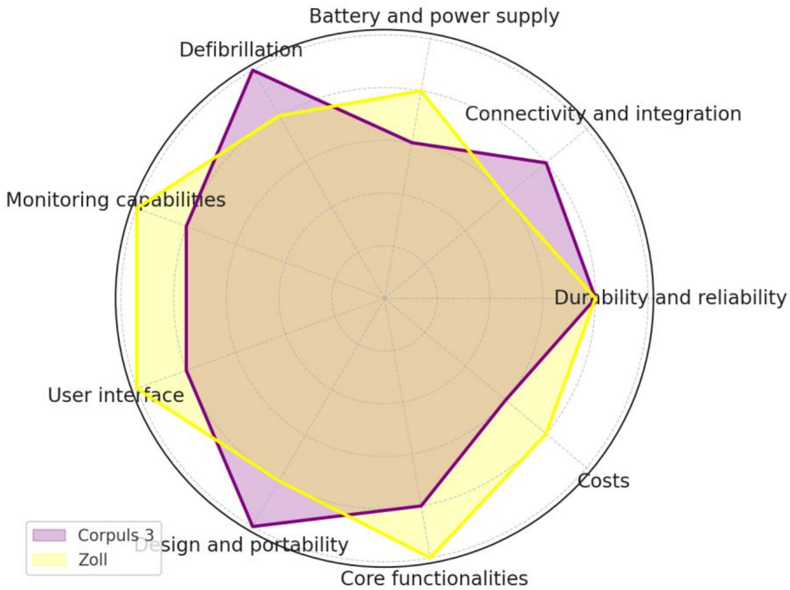

Fig. 6. *Performance comparison Corpuls 3 vs. Zoll*

Looking at the graph, it can see that Corpuls 3 has superior performance in the "User Interface" and "Main Features" categories. Zoll excels in "Design and Portability" and "Durability and Reliability". In the categories "Cost", "Connectivity and Integration", "Battery and Power" and "Defibrillation", the performances of the two devices are very similar, with a slight advantage for Zoll in "Connectivity and Integration". In "Monitoring Capabilities", both devices perform similarly, with a slight edge for the Corpuls 3. The Corpuls 3 excels in most criteria, with an excellent user interface, superior design and portability, and advanced monitoring capabilities. The costs are moderate, being the only criterion where the Corpuls 3 has a lower value than the Zoll. Zoll stands out for lower costs compared to Corpuls 3 and excellent performance in most of the analyzed criteria. It is also easy to use, reliable and offers advanced defibrillation and monitoring capabilities.

In Figure 7 the radar graph is presented that compares how two medical devices, Corpuls 3 and Zoll, perform in monitoring essential vital parameters: ECG (electrocardiography), SpO_2 (blood oxygen saturation), NIBP (non-invasive blood pressure), Temperature and CO_2 (carbon dioxide). The Corpuls 3 excels in ECG, SpO_2 and NIBP

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monitoring, while also performing very well in temperature and CO_2 monitoring, although slightly inferior to the Zoll in these two areas. The Zoll performs excellently in ECG, temperature and CO_2 monitoring, being slightly weaker in SpO_2 and NIBP monitoring compared to the Corpuls 3.

The Corpuls 3 excels in ECG, SpO_2 and NIBP monitoring, while also performing very well in temperature and CO_2 monitoring, although slightly inferior to the Zoll in these two areas. The Zoll performs excellently in ECG, temperature and CO_2 monitoring, being slightly weaker in SpO_2 and NIBP monitoring compared to the Corpuls 3.

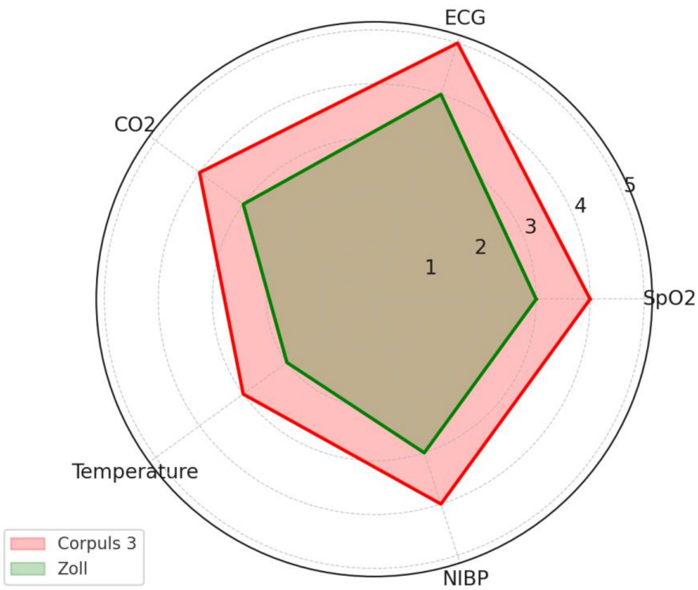

Fig. 7. *Comparison of vital parameters monitoring between Corpuls 3 and Zoll*

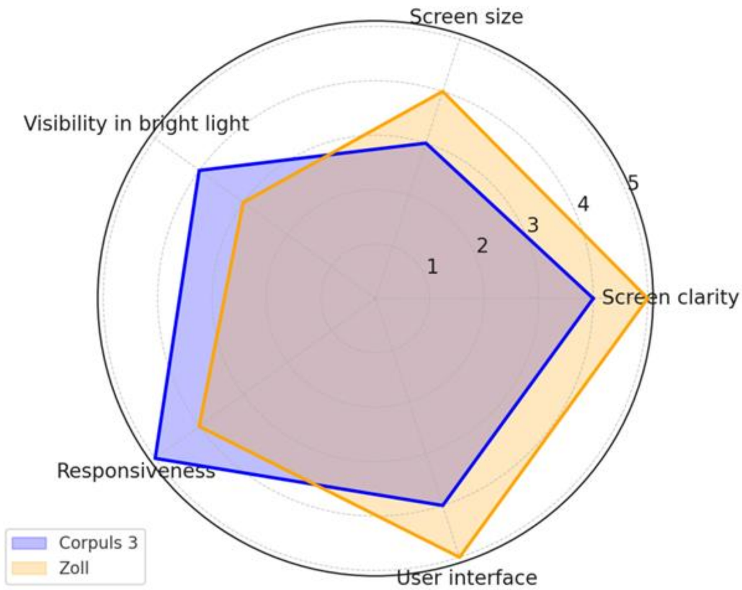

Fig. 8. *Comparison regarding the analysis of monitoring screens between Corpuls 3 and Zoll*

In Figure 8 is presented the radar chart that comparatively illustrates how two medical devices, Corpuls 3 and Zoll, perform on several criteria related to monitoring screens: screen size, screen clarity, user interface, responsiveness, and visibility in bright light.

The Corpuls 3 excels in screen size, user interface, and responsiveness, performing very well in

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screen clarity and bright light visibility as well, though slightly inferior to the Zoll in these two areas. The Zoll performs excellently in screen clarity and visibility in bright light, falling slightly short in screen size, user interface, and responsiveness compared to the Corpuls 3.

Figure 9 shows the radar graph that provides a clear visualization of the maintenance costs for each device according to the analysed criteria.

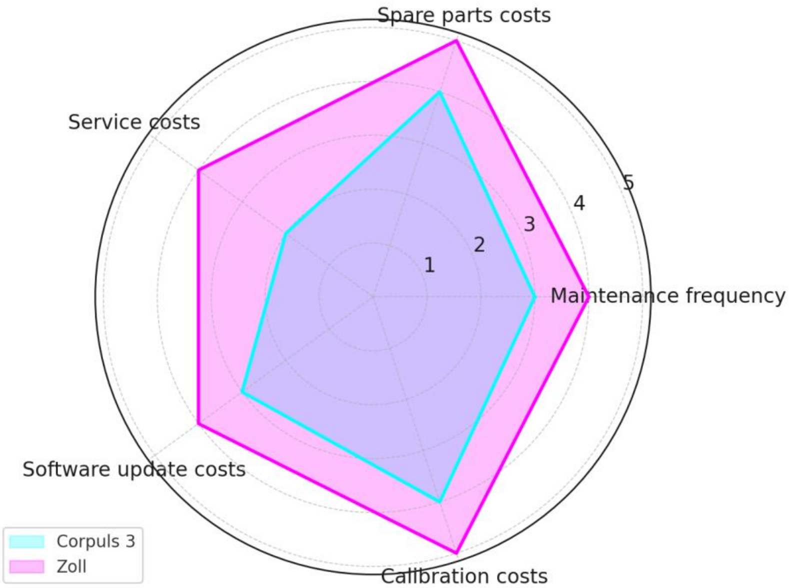

Fig. 9. *Comparison of maintenance costs Corpuls 3 vs. Zoll*

Corpuls 3 stands out with more moderate costs in all compared aspects, while Zoll presents higher costs, especially in terms of maintenance frequency and service costs. Corpuls 3 has more moderate costs for spare parts, calibration and service due to its modular design and component accessibility. Costs for software updates are lower compared to Zoll.

Zoll has higher costs for spare parts, calibration and service due to its complexity. Maintenance frequency is higher compared to Corpuls 3 and software update costs are moderate. This can be an important factor to consider when deciding whether to invest in one of these pieces of equipment.

4. Conclusions

Corpuls 3 is distinguished by its modular design, which allows increased flexibility in use and customization according to the specific needs of medical interventions. This aspect is crucial in emergency situations, where quick adaptability can mean the difference between life and death. The device is not just a defibrillator, but a complete patient monitoring system, offering advanced vital sign monitoring features including ECG, pulse oximetry, blood pressure and capnography. This allows medical staff to get an overview of the patient's condition and get informed decisions in real time.

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THE RECOVERY OF VEGETAL WASTE IN THE FORM OF HOME-COMPOSTING

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ABSTRACT

Composting the vegetable waste is an ecological alternative to their treatment by incineration or storage on landfills. The recovery of vegetable waste for obtaining compost is a beneficial method both by keeping a clean environment and enriching the soil. The vegetable waste decomposes and leave its intake nutrient in the soil for plants and other crops growth. The paper includes the chemical analysis and testing results of the compost obtained with garden vegetable waste (dried leaves, branches, bark, stems, flowers and herbs).

KEYWORDS: waste, vegetable, recovery, composting

1. Introduction

A common method of vegetable waste management consists in burning plant debris and crop residue or disposing it in landfill. These two approaches are very polluting, the first by releasing large amounts of carbon dioxide in air, and the second with greenhouse gases and odor in air, and microbes and chemicals in soil or water [1]. In addition, the compost law namely Law 181/2020 on the management of non-hazardous compostable waste prohibits the burning of dry plant residues in one's own yard since 2021.

Although it is considered a method of recovery of organic waste, composting is associated with the release of greenhouse gases (CO_2, NO_2, SO_2) and odors resulted due to fermentation process. There are concerns among specialists about improving the composting process in terms of controlling the temperature and oxygen concentration, which can reduce the production of greenhouse gases [1].

Thus, an environmentally friendly alternative to organic waste management is composting. Composting is a natural recycling process by which microorganisms (bacteria, fungi) and invertebrates (insects, worms) break down organic matter and turn it into a stable material called compost. The compost can be used in agriculture as natural fertilizer instead of chemical fertilizer, and soil improvement by increasing chemical (nutritive) regime [2].

The composting is very important for the management of organic materials and for the waste flow produced by human activities as: kitchen waste (vegetable and fruit peels, coffee grounds, filter paper, leftovers, bones and eggshells), farm waste (manure, straw), restaurant waste, leaves and vegetable waste from gardens and yards, wood, cardboard products and paper, sewage sludge [2].

The compostable waste can be composted both in households in individual composting units and at industrial level in closed or open installations. In the households are used for composting kitchen waste, vegetable waste from the yard and the streets, bones, wool, insects, leaves and stems of chopped corn and sunflower, rotten feed, faeces. Compost can be implemented for all agricultural crops, vegetable and fruit growing, depending on the nutritional needs of the soil and plants [3].

The organic waste from individual gardens is converted into compost by aerobic method, which is an open system and isolated from the inhabited area due to fermentation odours [4].

2. The compost preparation

The compost consists of the mixture in equal parts by volume, between soil (1300 cm^3) and plant matter (1300 cm^3), using the Berkeley method, to which a quantity of bio enzymes (compost accelerator Biopon) was added for supporting and accelerating the composting process of organic matter. The Berkeley method is an aerobic and very fast method that produces compost in just 18 days and release a small amount of methane into the atmosphere. The method is called "hot composting" and has the advantage of destroying both weed seeds and

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pathogenic germs. The application of the Berkeley method requires the following requirements to be met: the C:N (carbon: nitrogen) ratio must be 25:1; the temperature in the composting mass can reach 55-65 ºC; mixing materials is a must. At the end of the process, no more undecomposed materials will be found in the mixture [5]. Other sources believe that the C:N ratio of the compost pile is 30:1 and the humidity is 50% [6].

The vegetable waste used were dry leaves, branches, stems (carbon source), peels, flowers, medicinal plants (mint) (nitrogen source) (Fig. 1). The compost preparation was carried out in a plastic box (Fig. 2) equipped with evenly distributed ventilation areas.

Fig. 1. *Preparation of soil and plant material samples*

Fig. 2. *Preparing the compost in layers with the addition of green leaves to observe the transformation process*

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The first layer placed in the box consists of gravel with sand, followed by the mixture of soil and plant material to which 100 g of process accelerator (bio enzymes) has been added. The vegetable matter consisting of green leaves of mint, raspberry, currant and lettuce were introduced into the mixture so that the transformation process could be observed with the naked eye. Water spraying was done by spraying in sufficient quantity to start the process. The compost mixture was watered daily and mixed for aeration using a small rake or other gardening tool. The compost mixture was kept in a shady place, because the organic matter oxidizes under the sun's rays.

2.1. The compost pile treatment

Day 1:

- Mix the materials and lay them in alternate layers, the dry ones with the green ones.
- Water the compost heap abundantly with water.
- As activators can be used (in the middle of the pile) teas of horsetail, valerian, mouse tail.

Day 4:

- The first four days the pile is left to start the decomposition process.
- The pile is opened and mixed so that the materials that were on the outside reach the inside and vice versa.
- The mixture should be moist so that 1-2 drops can be squeezed out of a handful of composted material.
- Excess moisture should be avoided by adding a few branches as drainage.

Day 6 and 8:

- Break up the sides and build a new pile next to it, placing the decomposed material at the surface.
- The heat inside can be sensed and can be measured with a thermometer.
- The optimal temperature should be of 55-65 ^{o}C.
- The pile is turned every 2 days, avoiding overheating of the pile.

Day 18:

- The appearance of earthworms in the compost is a sign that the process has ended.
- The resulting compost is brown and smells like damp.

3. Evaluation of compost quality

3.1. Analysis methods

The physical and chemical quality indicators of the compost obtained from garden soil mixed with crushed plant matter were determined.

The moment the composting process was completed, we took a sample of compost to carry out the following physical and chemical analysis:

- Reaction or pH.
- Humidity or moisture.
- Total Soluble Salts (TSS) in soil.
- Bicarbonate ions content HCO_3^-.
- Chloride ions content Cl^-.
- Calcium and Magnesium ions content Ca^{2+}, Mg^{2+}.
- Soil organic carbon and humus concentration.

The pH and TSS were determined using potentiometric methods by mean of the pH meter and the TDS meter respectively. The ions of bicarbonate, chloride, calcium and magnesium were identified by volumetric methods according to current analysis norms.

The determination of soil organic carbon is based on the Walkley & Black chromic acid wet oxidation method. The humidity was determined by gravimetry (at 105 °C). The parameters' measurement units were pH units, milli Siemens/cm for electrical conductivity EC, total dissolved solids in g/Kg dw (dw = dry weight), the ions in g/Kg dw, humidity H, humus content and organic carbon in percentage.

Fig. 3. *The mixture of soil and plant material transformed into compost*

3.2. Results and discussions

It was found that on the 9th day, the composition had an earthy aspect where the plant matter had completely decomposed, thus the composting process was reduced from 18 days to 9 days due to the application of the bio enzyme accelerator.

The compost must be a stable and homogeneous product, contain no seeds or contaminants, and the particle size must be less than 1.2 cm. The compost reaction is recommended in the range of 6-7.8, and humidity below 50%. The compost law does not provide the optimal quality parameters of the compost, but the values can be used as a reference: pH = 5.5-7.5; salt content (as conductivity < 5

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mS/cm); humidity (35-55%); 0.04% accessible nitrogen (as nitrate) and 0.8% organic nitrogen [7].

The chemical composition varies, but the average concentrations are of 0.15-0.95% nitrogen, 0.14-1.2% phosphorus, 0.3-1.85% potassium [3]. Thus, the compost mixture was well aerated because the pH is weakly alkaline (pH = 7.76) (Table 1), while poor aeration would have produced an acidic pH of the compost. The compost salt content as conductivity is less than 1 mS/cm, what is below the reference range. If we refer to the specific humus content of the soil, the humus supply class is good (between 4-6%) in the studied compost. The content of ions and cations of compost is very low because of a low concentration of nutrients both in the soil used in the composting mixture and in the plant material.

Table 1. *The compost parameters*

Parameter	pH	Conductivity EC, mS/cm	TDS [g/Kg dw]	HCO_3^+ [g/Kg dw]	Cl^- [g/Kg dw]	Ca^{2+} [g/Kg dw]	Mg^{2+} [g/Kg dw]	H [%]	Humus [%]	OC [%]
Value	7.76	0.985	3.155	2.5	1.013	0.8	0.063	32.038	4.9196	2.8536

The compost made from just a mixture of soil and plant material has low nutrient concentrations and moisture below the ideal range of 40-65%. Plant materials are rich in carbon, but the nitrogen content is low. To obtain a compost rich in nitrogen and carbon, food scraps, fruit and vegetable residues can be added to the household in addition to plant materials.

4. Conclusions

The results showed that the mixture of soil and vegetable matter in equal parts by volume was completed in 18 days, resulting in a compost with a certain nutritional value. The nutritional value of compost is given usually by nutrients such as phosphorus, nitrogen, potassium, but also by chemical elements such as sodium, calcium, magnesium and others.

The main benefits of home-composting are:
- recycling of organic and vegetable waste;
- reduces pollution with methane from landfills;
- reduces the load from landfills;
- neutralization of biodegradable waste;
- reducing the carbon footprint of the household;
- ecological alternative to the use of synthetic fertilizers;
- simple and effective method and low application costs to reduce waste and support a clean environment [2].

The main effects of compost as organic fertilizer on soils are:
- helps to improve the content of nutrients and minerals in soils;
- enhances the soil structure and the humus amount;
- maintains the water longer in soil;
- regulates the oil temperature;
- prevents erosion and uncontrolled weed development [2].

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