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CONSTRUCTIVE AND FUNCTIONAL CONSIDERATIONS FOR USING THERMALLY INSULATED ENCLOSURE IN 3D RESIN PRINTING PROCESS

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ABSTRACT: 100 – 250 words. A comparative study is carried out in the paper, which aims to determine the need to position a 3D print inside a thermally insulated enclosure. Print the same piece under layout conditions inside an office space and then insert it inside a thermally insulated enclosure made by the author. From the point of view of temperature loss, better management of the thermal process can be achieved from the point of view of the printing process. Also at the level of the printed plane made we can see a reduction in internal tensions in the item due in particular to the temperature variations in the printing process for the printed item in the two 3D printing variants.
KEYWORDS: enclosure for printer, thermal control, DLP 3D Printing, Arduino control system

1. CONSTRUCTIVE CONSIDERATIONS ON A THERMALLY INSULATED ENCLOSURE FOR 3D RESIN PRINTING

In the current economic situation where it is necessary to reduce energy consumption, but also that due to thermal phenomena of polymerisation of the resin subjected to the 3D printing process thermal insulation and temperature control in the work premises and in the workspace respectively becomes more and more important. Although in the literature as well as from the point of view of the manufacturers of 3D printers it is suggested thermal heating to generate the temperature of 25 to 30 degrees Celsius at the resin level in the print vat, it can be said that such a solution is not energy beneficial [1-4].

In order to carry out the most accurate analysis, an extruded polystyrene structure it is used for the construction. This structure allow the printer to be inserted inside the enclosure and at the same time provide a volume of air in the enclosure large enough to measure both thermal energy efficiency and to identify how the ambient-specific thermal and humidity technological parameters have an influence on the printing process.

Temperature measurement is carried out in terms of the printing process at the level of the printing vat in which the resin is used to made the printing process is found. Another level of measurement of temperature and humidity is within the space where printing takes place by inserting a sensor dedicated to measuring the two parameters mentioned above. The third level of measurement shall be at the level of the thermally insulated enclosure where the two-abovementioned physical elements it is determinate by measuring. Finally yet importantly, a sensor for measuring the two components are positioned on the outside of the thermal enclosure where the printer is located. In Figure 1 is presented the position for the two-sensor put inside the printer chamber for the measurement process.

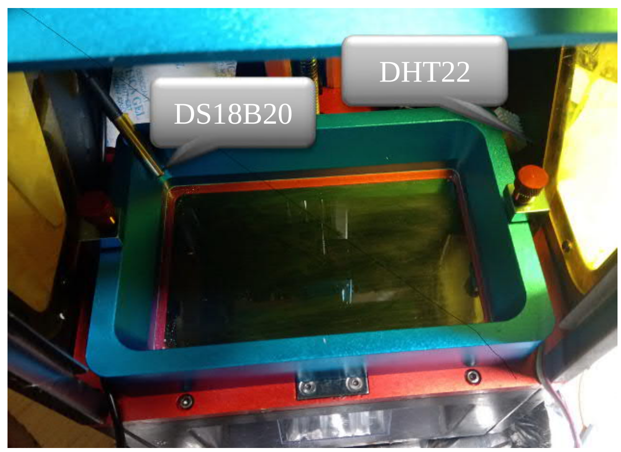

Figure 1. Sensor position for temperature and humidity inside 3D printer

2. CONSIDERATIONS ON THE ELECTRONICAL SOLUTION OF THE TEMPERATURE MEASUREMENT.

From the point of view of the components by which it will be possible to determine how to change the humidity and temperature respectively, we will use three sensors of the same type DHT22. To measure the temperature at the tank level we will use an encapsulated sensor of type DS18B20. It is possible to see from the catalogue data that the first type has the temperature range -40 to 125 degrees Celsius and a resolution of 0.1 degree Celsius and humidity respectively with a measurement accuracy of 0 to 100% with a sensitivity of 0.1%. The second sensor has a temperature range of -55 to 125 degrees Celsius with a sensitivity of ±0.5 degrees Celsius.

An ARDUINO UNO microcontroller with a data acquisition and magnetic system for saving data was used to save data read in the measurement process. In the same time the data are displayed on a digital display with 20 positions and 4 rows with measuring frequency dependent on the reading frequency of the sensors. This is for DS18B20 2 milliseconds for the temperature and for the DTH22 2 seconds for the level of the humidity and temperature sensor. In order not to make the measurement process more difficult, but also because the temperature transfer is not made at a high speed, the data reading was scheduled to be carried out at a level of 2 seconds for all sensors at once.

Another constructive aspect is that of how air transfer is carried out from the inside to outside. On the input side there is an air filtration system at the level of air filter micro particles in the automotive field. In the first phase of the exhaust level system the filtration has not be provided and the extraction of hot air from the inside can be carried out with a ventilation system. The entire ventilation system is set to the temperature at the level of the tank in which the resin medium is found, and has a variation from 25 degrees Celsius for coupling and uncoupling at 29 degrees Celsius.

The first part of the program is to include libraries and define the types of variables in which to save the information taken from the experiment Figure 3.

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3F,20,4);
#include <DHT.h>
#include <DHT_U.h>
#include <SD.h>
#include <SPI.h>
#include <RTClib.h>
#include <OneWire.h>
#include <DallasTemperature.h>

File myFile;
File str;
DateTime now;
const int chipSelect = 10;


int SENSOR1 = 9;
int SENSOR2 = 8;
int TEMPERATURA1;
int TEMPERATURA2;
int TEMPERATURA3;
int UMIDITATE1;
int UMIDITATE2;

String day;
```

Figure 2. Include definition and setting type data

The allocation of ARDUINO digital ports was made in such a way as to comply with the conditions of use of the 4x20 LCD digital display ports and the way in which the specific SD Card is connected. At the same time, the types of sensors with which the measurement will be made must be defined Figure 4.

A very important part of the program is that of initializing the reading of data by sensors, checking the existence of the card and the possibility of writing on it and defining the table head in order to load the data and further process it.

```

DHT dht1(SENSOR1, DHT22);
DHT dht2(SENSOR2, DHT22);

long id=1;
#define ONE_WIRE_BUS 7
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);

```

Figure 3. Setting type of sensors

```
void setup() {
  Serial.begin(9600);
  dht1.begin();
  dht2.begin();
  sensors.begin();

  lcd.init();  //initialize the lcd
  lcd.backlight();  //open the backlight

  Serial.print("Initializing card...");
  pinMode(chipSelect, OUTPUT);

  if (!SD.begin(chipSelect)) {
    Serial.println("SD Card initialization failed!");
    return;
  }
    Serial.println("SD Card OK.");

    Serial.println("Writing to test.txt.");
 myFile = SD.open("textFile.txt", FILE_WRITE);
if (myFile)
{
  myFile.println(" , , , , ");
  String tabel="Nr, T1, Um1, T2, Um2, T3";
    myFile.println(tabel);

    myFile.close();
   Serial.println(tabel);
}
else
{
   Serial.println("Nu am putut deschide fisierul");
}
}
```

Figure 4. Setup part of program

The last part of the program is allocated to the definition of how to display on the LCD screen lines the data recorded from the work process Figure 6 and the preparation and writing row by row of the data on the SD card Figure 7.

In order to be able to check the assembly scheme of the components, as well as that of its operation, the KICAD 5.0 program [5] was used Figure 8. This in addition to ensuring the fulfilment of the above-mentioned conditions also allows the realization and verification of the printed wiring board. It also allows the realization of the two specific elements, namely the negative wiring and the CNC program of making the holes for the completion of the PCB board.

From the diagram in Figure 7 it can be seen that the allocation of ports is quite close to the maximum limit of the ARDUINO UNO module. The only ports left free are the digital ones from 2 to 6 which would allow the connection of 5 sensors of which for the final scheme two are type DHT22 one in the thermally stable enclosure pin 6 and one in the ambient space pin 5. This will cause the control part of the fan speed to be done through port 2.

```
void loop() {
  UMIDITATE1 = dht1.readHumidity();
  TEMPERATURA1 = dht1.readTemperature();
  UMIDITATE2 = dht2.readHumidity();
  TEMPERATURA2 = dht2.readTemperature();
  sensors.requestTemperatures();
  TEMPERATURA3 = sensors.getTempCByIndex(0);

    lcd.clear();
    Serial.print("Umid.1: ");
    Serial.print(UMIDITATE1);
    // Serial.print(" %,");
    Serial.print(" Temp.1: ");
    Serial.print(TEMPERATURA1);
    // Serial.print(" *C");
    lcd.setCursor ( 0, 0 );
    lcd.print("T2 ");
    lcd.print(TEMPERATURA1);
    lcd.setCursor ( 10, 0 );
    lcd.print("Um2 ");
    lcd.print(UMIDITATE1);

    Serial.print(" Umid.2: ");
    Serial.print(UMIDITATE2);
    // Serial.print(" % ,");
    Serial.print(" Temp.2: ");
    Serial.println(TEMPERATURA2);
    lcd.setCursor ( 0, 1 );
    lcd.print("T2 ");
    lcd.print(TEMPERATURA2);
    lcd.setCursor ( 10, 1 );
    lcd.print("Um2 ");
    lcd.print(UMIDITATE2);

    lcd.setCursor ( 0, 2 );
    lcd.print("T3 ");
    lcd.print(TEMPERATURA3);
```

Figure 5. Display data to LCD

```

String linie_val=String(id)+", "+String(TEMPERATURA1)+", "+String(UMIDITATE1)+", "+String(TEMPERATURA2)+",
"+String(UMIDITATE2)+", "+String(TEMPERATURA3);

Serial.println("Writing to test.txt.");
 myFile = SD.open("textFile.txt", FILE_WRITE);
if (myFile)
{
  myFile.println(linie_val);
  myFile.close();
}
else
{
  Serial.println("Nu am putut deschide fisierul");
}
    id++;
 // DHT22 sampling rate is 0.5HZ.
  delay(5000);
```

Figure 6. Save data to SD Card

Because some of the elements in the scheme are ready mounted and no longer require connections (NHO module with PCF, respectively MicroSD with resistors) the connections will no longer be made by making a PCB board. These will be done with direct connecting wires between the ARDUINO UNO module and the components.

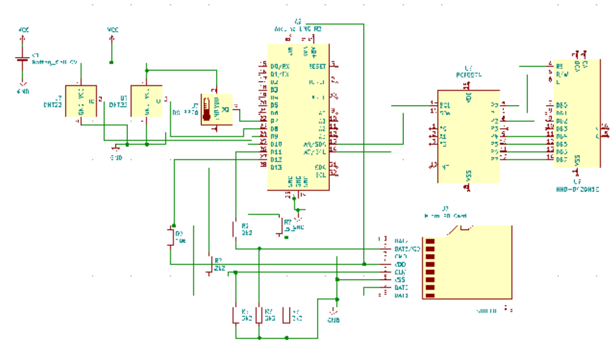

Figure 7. KICAD schema for testing the ARDUINO programme for measuring the temperature

3. CONSIDERATIONS ON THE MECHANICAL CONSTRUCTION OF THE TEMPERATURE MEASUREMENT SOLUTION.

The two electronic plates were inserted in a specially generated structure both for the positioning of the components ARDUINO UNO motherboard and SD Card board as well as to allow the realization of the connections and protection of the electronic assembly made Figure 8.

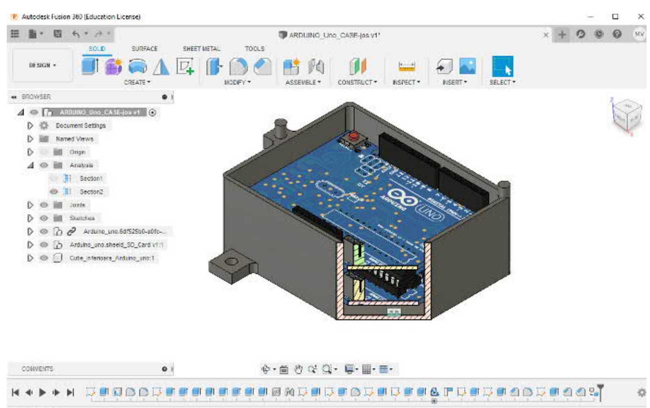

Figure 8. Bottom box with Arduino shield and motherboard

The box was designed in two parts with the possibility of mounting and positioning the component elements with centring bolts at the bottom and positioning the upper part respectively in relation to the bottom Figure 9.

The method take in consideration was preferred to have easier accessibility to the assembly components and due to the fact that there are no vibrations in the process.

The superior part of the case is generated for protect the presented part, but in the same time for sustained the LCD 20x4 screen system.

It is printed in the same system like the last structure and the CAD design can be observe in Figure 10 and the positioned for printing in Figure 11.

For 3D printing it is used and PLA 1,75 mm material, and it is used a 0,4 mm nozzle for printing with 20%

infill linear 45 degree grid with a speed of 35 mm/sec .

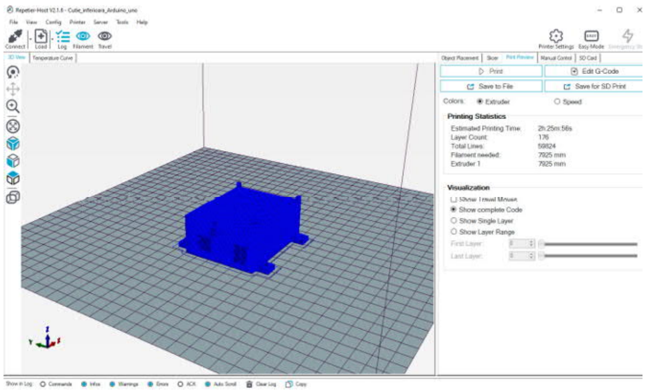

Figure 9. Bottom box generated for 3D printing FDM method

It should be pointed out that in the 3D generated board library of the electronic graphics program such an LCD 20*4 card does not exist configured. Because of this, we have resorted to generating the CAD model to install it from the design data of the circuit board printed in its data sheet.

FUSION 360 was used for CAD design of the two box decided. It is important to note that the FUSION 360 it is in connection with EAGLE electronic design board and ca be used for KICAD 3D electronic elements to generate them [9, 10].

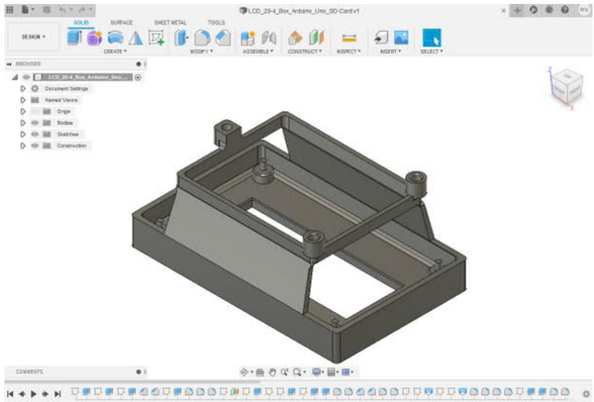

Figure 10. Top box for LCD 20x4

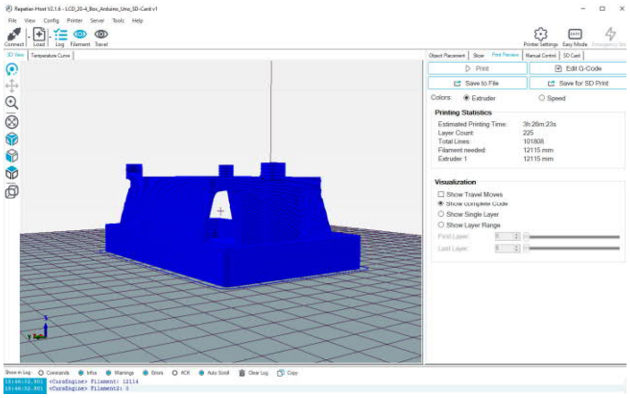

Figure 11. Top box for LCD positioning for 3D printing

The two 3D printed components can be seen in the following photos.

The first in Figure 12 is that of the bottom module after printing and with the two plates mounted can be seen in Figure 13.

The second is the upper one where after printing and removal of the supports structure and put inside the LCD module Figure 14 and the last pictures presented is the one with the ensemble of the two modules.

This structure it is important to be completed with an emission module for a complete study of the 3D printing resin system [6-8]

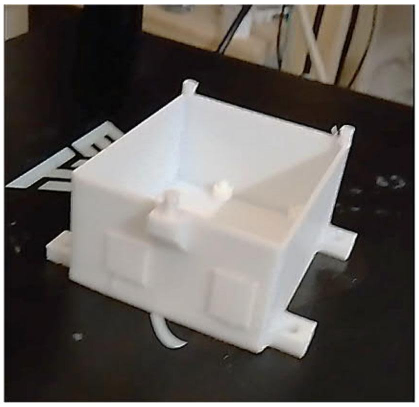

Figure 12. Bottom printed box for ARDUINO UNO

Figure 13. Bottom printed box with ARDUINO UNO

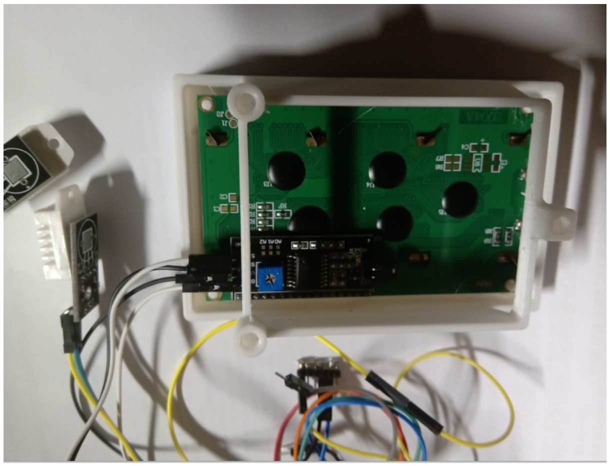

Figure 14. Top box with LCD 20x4

4. CONCLUSION

The present study intended to be a beginning of research on the plan part generation with different resin colour in 3D printing process, which can be used for made components for laboratory work.

The interest are for constructive solution for water jet cutting installation and abrasive water jet cutting installation.

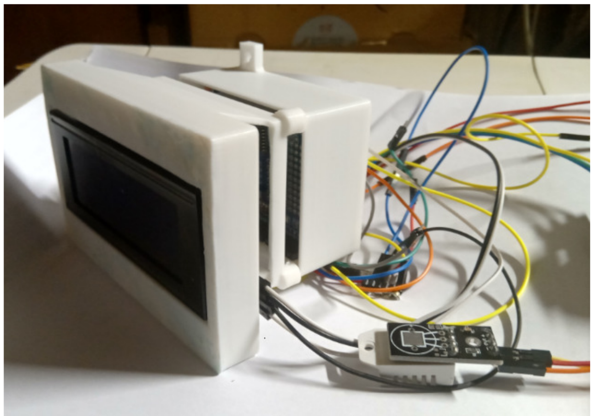

Figure 15. The two module mounted for measuring

Based on this study it is necessary to extend the researches both on the influence side of the temperature in printing process and emissions but also on the dimensional one.

In order to increase the measurement accuracy, it is necessary to introduce a data acquisition system for emission that allows following the way in which the measured parameters evolve.

5. ACKNOWLEDGEMENTS

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