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Title: Prototype for thermal conductivity measurement of materials made in forest agro-residue

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Introduction

Heat transfer is transmitted in three ways:

Conduction

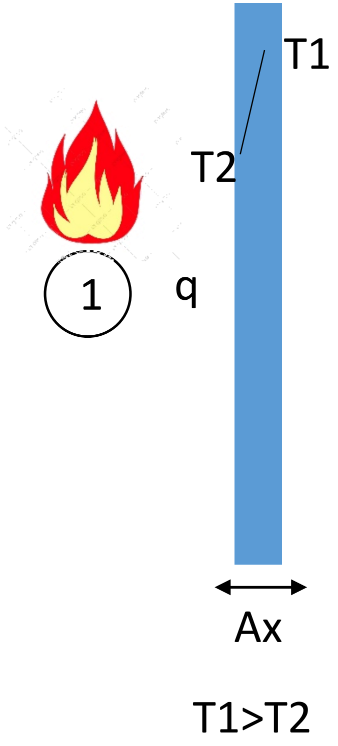
Convection

Radiation

Conduction is a process where one system transfers heat to another system of lower temperature and both systems must be in direct contact with each other.

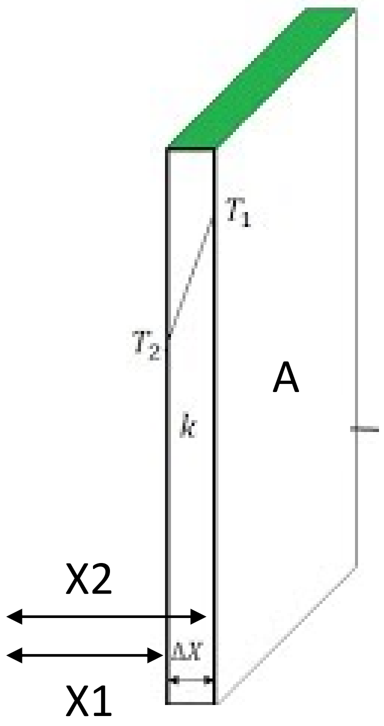
Determining the thermal conductivity of a material is fundamental in many areas of science and technology, as well as in industry.

FOURIER´S LAW:



q= heat flux (W)
Δx= wall thickness(m)
T1= Surface temperature 1 (°K)
T2= Surface temperature 2 (°k)

2



A= heat transfer area (m)
K= thermal conductivity (w/m*K)

$$q = \frac{T_1 - T_2}{\frac{\Delta X}{KA}}$$

$$\frac{\Delta x}{KA} = heat\ flow\ resistance$$

$$q = \frac{KA}{(X_2 - X_1)}(T_1 - T_2)$$

$$q = -\frac{KA}{(X_2 - X_1)}(T_2 - T_1)$$

$$q = -KA\frac{\Delta T}{\Delta X}$$

There are different methods for measuring thermal conductivity such as steady state and transient methods, the steady state methods measure the rate of heat flow within the sample and the temperature gradient between sample interfaces. Among the methods used to measure thermal conductivity is the hot plate method, which is notable for its accuracy and ease of adaptation, this procedure provides an effective way to determine how a material transfers heat across plates.

A thermal insulator prevents energy exchanges with the external environment, when produced from renewable resources it has the advantage of biodegradability and low thermal conductivity.

Methodology

The construction of the prototype is based on the protected hot plate method, following the specifications of ASTM C-177-13, which provides guidelines for the construction of thermal conductivity measuring machines. The process is divided into the following stages:

a) Determination of the materials to be used.

b) Design of the prototype in SolidWorks program.

c) Procurement of equipment materials.

d) Construction of the metallic structure.

e) Installation of electronic elements.

f) Installation and elaboration of the program that will register the temperatures.

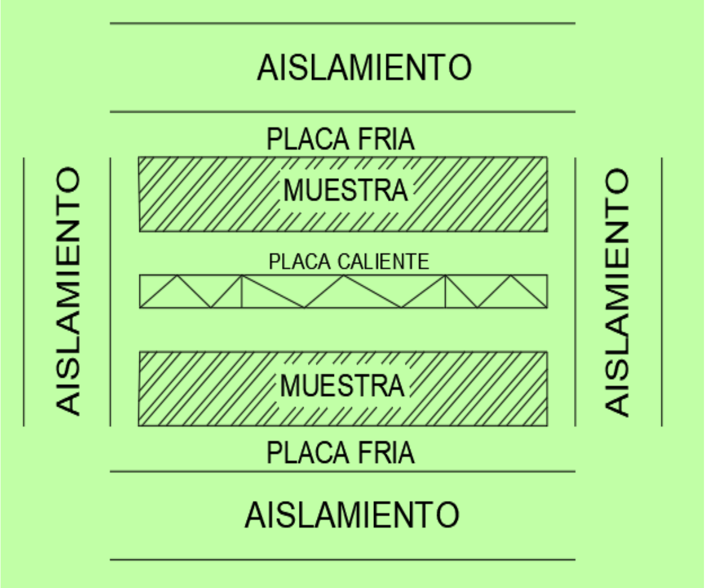
Results

The following table shows the physical specifications of the prototype

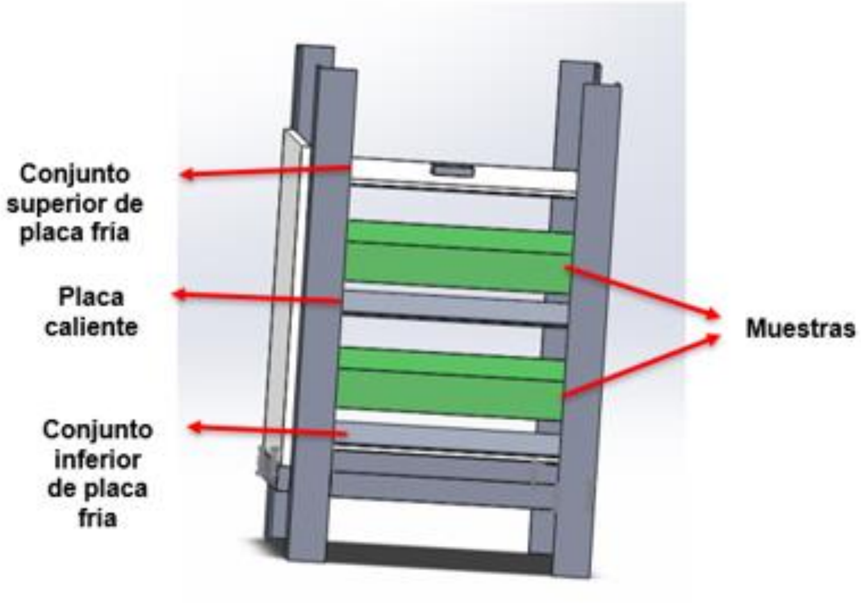
Physical specifications of the prototype	
Cooling system material	Alumninum plate
Cooling system specifications	30 x 30 cm cal. 16
Refrigeration System Components	Peltier cells with cooling system
Temperature control system	PID digital temperature controllers
Temperature recording system	Arduino one Aluminum
Hot plate material	30 x 30 cm cal. 16
Hot plate specifications	1 x 1/8 in. angle
Structure materials	1/8 in. angle1/8 x ¾ in sill plate
Type of temperature sensors	Type K thermocouples
Type of heat source on the hot plate	120 W flat resistors

PREPARATION OF THE PROTOTYPE DESIGN IN SOLIDWORKS SOFTWARE.

The system consists of a Peltier cell, the operation of this system is that one side of the cell is heated and the other side of the surface is cooled so the cold side will be placed to the aluminum plate and the hot side will be placed to a heat sink to avoid overloading the cell. The following figure shows the representative of the components distribution.



The design has a thermal protection on the side of the prototype, insulated with refractory ceramic fiber, this insulation is placed on the 4 sides of the prototype including both the base where the lower cold plate and the upper cold plate are placed.

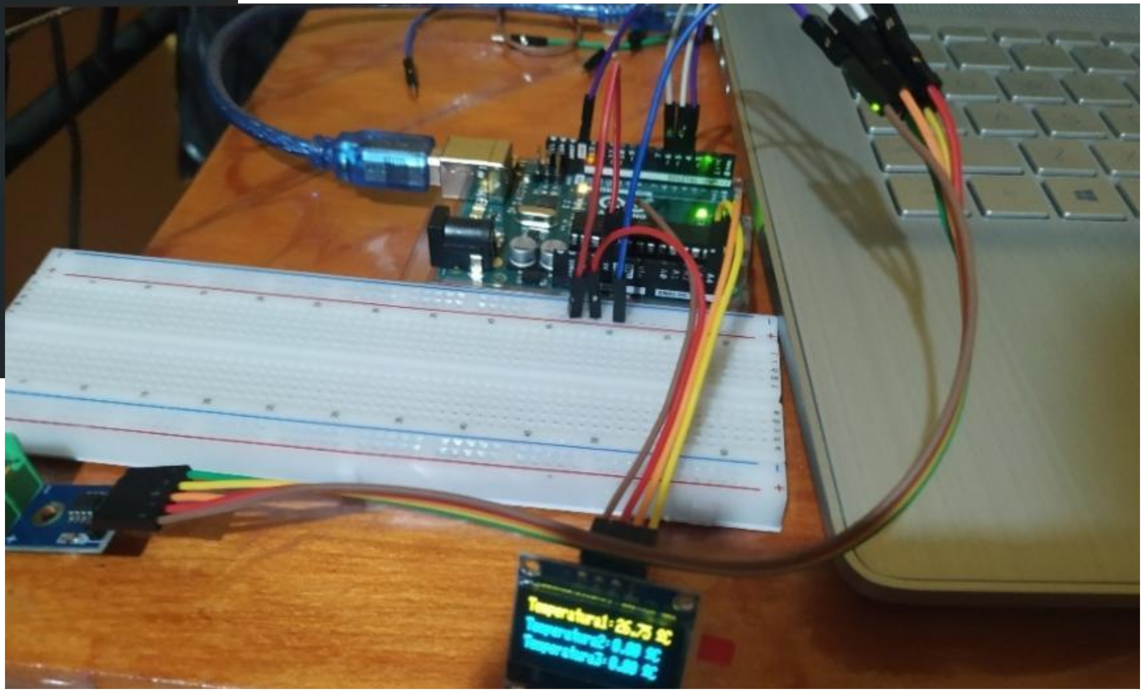


CONSTRUCTION OF THE THERMAL CONDUCTIVITY MEASUREMENT EQUIPMENT BASED ON THE PREVIOUS DESIGN.

It began with the construction of the heating plate which was created from an aluminum plate due to its great thermal conductivity and a pair of electrical resistances. The dimensions of the plate are 30x30 cm and the electrical resistances are 2 x10 cm with a power of 150 W.

CREATION OF THE PROGRAMMING CODE FOR TYPE K THERMOCOUPLE WITH ARDUINO AND IMPLEMENTATION OF THE SAME

```
#include "max6675.h"
#include <SPI.h>
#include <Adafruit_GFX.h>
#include <Wire.h>
#include <Adafruit_SSD1306.h>
#include <Adafruit_Sensor.h>

#define Largo 128
#define  Ancho 32

#define OLED_RESET -1
Adafruit_SSD1306 Oled(Largo, Ancho,&Wire, OLED_RESET);

// TERMOPAR Sensor 1
int termopar1D0 = 4;
int termopar1CS = 5;
int termopar1CLK = 6;
float temp1;
MAX6675 sensorK1(termopar1CLK, termopar1CS, termopar1D0);


// TERMOPAR Sensor 2
int termopar2D0 = 8;
int termopar2CS = 9;
int termopar2CLK = 10;
float temp2;
MAX6675 sensorK2(termopar2CLK, termopar2CS, termopar2D0);

// TERMOPAR Sensor 3
int termopar3D0 = 11;
int termopar3CS = 12;
int termopar3CLK = 13;
float temp3;
MAX6675 sensorK3(termopar3CLK, termopar3CS, termopar3D0);

void setup()
{
  Serial.begin(9600);
  Oled.begin(SSD1306_SWITCHCAPVCC, 0x3C);
  delay(2000);
    Oled.clearDisplay();
  Oled.setTextColor(WHITE);
}

void loop()
{
  temp1 = sensorK1.readCelsius();
  delay(1000);
  Serial.println(temp1);
  temp2 = sensorK2.readCelsius();
  delay(1000);
   Serial.println(temp2);
  temp3 = sensorK3.readCelsius();
  delay(1000);
   Serial.println(temp3);
  Oled.clearDisplay();
```



Calculations:

Calculation of the intensity of the current on hot plate:

$$P = VI \qquad (1.17)$$

$$150W = (127V)I$$

$$\frac{150W}{127V} = I$$

$$I = 1.25A$$

Total resistance:

$$V = IR \qquad (1.18)$$

$$127V = (1.25A)R$$

$$\frac{127V}{1.25A} = R$$

$$RT = 101.6ohms$$

Individual resistance:

$$Resistencia\ individual = RT/5 \qquad (1.19)$$

$$Rind = 20.32ohms$$

Power of every resistance:

$$Pr = (Rind)(I) \qquad (1.20)$$

$$\mathrm{Pr} = (20.32ohms)(1.25A)$$

$$Pr = 31.75W$$

REGISTRATION AND TEST RESULTS

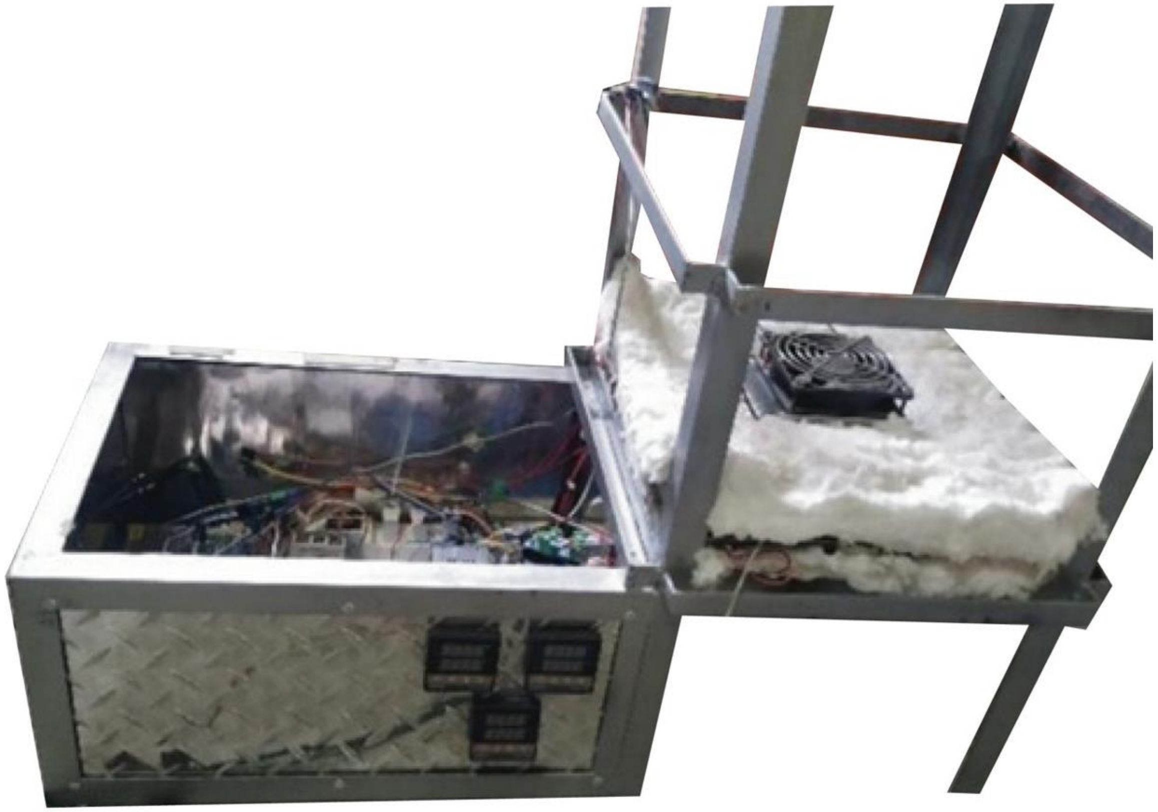
Tests were carried out to determine the efficiency of the prototype. We began the tests with a material whose thermal conductivity value is already known. In this case, the tests were carried out with a piece of drywall whose thermal conductivity value is 0.1005 W/ m · K.

[redacted]

Eficiencia de la máquina prototipo

Conductividad térmica de la Tablaroca	Prueba 1	Prueba 2	Prueba 3
0,1005 W/ m · K	0.1650 W/m*K	0.1190 W/m*K	0.0950 W/m*K
Diferencia del valor de k			
	+0.0645W/m*K	+0.0185W/m*K	-0.0055W/m*K
	Eficiencia		
	60.90%	84.45%	94.52%

Annexes



Conclusions

The design and creation of a prototype machine based on the hot plate method to determine the thermal conductivity of materials represents a significant step towards the optimization of thermal efficiency in various products, in this case the creation of thermal insulators.

The design of a machine to determine thermal conductivity will provide university institutions with efficient and low-cost equipment, allowing students to perform practical experiments that complement their theoretical training, giving them a deeper understanding of the concepts and phenomena related to heat transfer.

References

- Yunus A. Cengel, (2011), 4a. edición, Transferencia de calor y masa: Fundamentos y aplicaciones, México, Mc Graw Hill
- Vėjelis S, Vaitkus S, Skulskis V, Kremensas A, Kairytė A. (2024). Performance Evaluation of Thermal Insulation Materials from Sheep's Wool and Hemp Fibres. Materials.; 17(13):3339.
- Qasem, N., Generous, M., Qureshi, B., & Zubair, S. (2023). Thermodynamic and Thermophysical Properties of Saline Water: Models, Correlations and Data for Desalination and Relevant Applications. Springer Nature Switzerland AG.
- García-Escalona, L. V., Benítez-Díaz, P. R., Will Valero, S., & Gutiérrez-Gotera, I. (2019). Elaboración de briquetas a partir de residuos de aserrín aglutinados con almidón de maíz y su posible aplicación como aislante térmico. Ingeniería. Revista de la Universidad de Costa Rica, 29(1), 21-39.
- Velasco Roldán, L., Goyos Pérez, L., Delgado García, R., & Freire Amores, L. (2016). Device for measuring thermal conductivity of composites based on biomass waste. Enfoque UTE, 7(2), pp. 69 – 81.

References

- Method, S. T. (2013). C177-13. Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate, 1–23.
- J. Diez Campos, E. García Breijo. I Perez Clemente, J.V. Ros Lis, J. Soto Camino (2007). Determinación experimental de la conductividad. In XI Congreso Internacional de Ingeniería de Proyectos
- Rodríguez, F. (2007). Diseño, fabricación y calibración de un dispositivo para la caracterización de las propiedades termofísicas en materiales secos de alta resistencia térmica y baja temperatura de uso. Universidad Autónoma de Barcelona.
- Ruiz Torres R. P, (2016). CENAM. Retrieved from Simposio de Metrología.
- Velasco Roldán, L., Goyos Pérez, L., Delgado García, R., & Freire Amores, L. (2016). Device for measuring thermal conductivity of composites based on biomass waste. Enfoque UTE, 7(2), pp. 69 – 81.

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