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Preparation and Investigation on Thermal Insulating Material for HVAC Application

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Abstract-This experiment was carried out to show the application of waste plastic in the HVAC field as an insulative material. As we know that in HVAC field there are many insulative materials are available, excluding material which is prepared in this project normally silicon rubber can be used as an insulative material because of its porous physical structure and low density. In this project efforts have been made insist the use of polymer component made by waste plastic and reinforcement materials like sorrel fiber, glass fiber, and thermocol. The polymer itself is having low thermal conductivity. Hardness is high compared to silicon rubber because of that it may fail during its use that is the reason some other insulative materials like sorrel fiber, glass fiber, thermocol are used as reinforcement material. The use of the waste plastic in HVAC field as an insulative material minimizes maximum pollution in the environment. These prepared insulative material are also more cost effective compared to other conventional materials because waste plastic is fully available in environment only few reinforcement have to be purchased in a minimum quantity. This may not add material cost because of its minimum quantity requirement(less than 5% by weight of that material). The result observed from this experiment has shown that the insulative property of the plastic material can be improved by adding sorrel fibers, glass fibers and thermocol effectively.

Keywords: - Thermal Conductivity, Polymer composite, Sorrel Fiber, Glass Fiber, Thermocol, HVAC, Insulative Material.

I. INTRODUCTION

Supply air duct and return air duct have to be insulated to avoid heat losses. For supply air duct more thicker insulation(19mm) have to be applied because of maximum temperature between inside air and outside environment. For return air duct insulation have to be applied to avoid heat losses of having less thickness than supply air duct insulation because of minimum temperature between inside air and outside environment. Types of insulation available are Silicon rubber, Fiberglass Glass wool, Rock wool, Mineral wool, Cellulose, Polyurethane foam, Polystyrene, Plastic materials, Ceramic materials, Glass fiber.

A. Why Insulation Is Necessary

Thermal insulation is the reduction of heat transfer (the transfer of thermal energy between objects of differing temperature) between objects in thermal contact or in range of radioactive influence. Thermal insulation can be achieved with specially engineered methods or processes, as well as with suitable object shapes and materials. Heat flow is an inevitable consequence of contact between objects of differing temperature. Thermal insulation provides a region of insulation in which thermal conduction is reduced or thermal radiation is reflected rather than absorbed by the lower-temperature body. The insulating capability of a material is measured with thermal conductivity (k). Low thermal conductivity is equivalent to high insulating capability (R-value). In thermal engineering, other important properties of insulating materials are product density (ρ) and specific heat capacity (c).

II. PROBLEM STATMENT

Many of the researchers have done research work on polymer matrix composite material but they not concentrated on its applications in HVAC filed. In our project we are going to prepare polymer matrix composite by focusing polymer matrix application in HVAC field. In this project we are preparing polymer matrix composite material we studying its thermal properties with the help of Lee's disc method and we are analyzing the result and lastly we predicting its scope in HVAC field.

III. EXPERIMENTAL PROCEDURE

Polymer matrix composite material has been prepared with the help of stir casting method. Matrix used is polypropylene and the reinforcements are sorrel fiber, glass fiber and thermocol grains. Sorrel fiber and glass fiber are added to add the strength to the matrix material as well as to improve insulative property of the same thermocol grains are added to improve insulative property of

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the material because it is having air pockets in it and air is having good insulative material. The material preparation and there composition are as given below.

A. Polymer Composite Material Preparation Reinforced with Sorrel Fiber

We have taken polypropylene in a container and heated to a 150°C temperature. In that molten polymer reinforcement like sorrel fibers are added of size 3mm to 5mm in length and the mixture has been stirred upto 5minutes then it has been poured into die to get required shape and it has been kept for cooling upto 1hour. Finally the required material is machined to get required shape circular disc of smooth surface finish.

1) Sorrel Fiber Reinforcement Polymer Matrix Composite Material Composition.

Material	Quantity (weight %)				
	1st Component	2nd Component	3rd Component	4th Component	5th Component
Waste Plastic	99.5%	99%	98.5%	98%	97.5%
Sorrel Fiber	0.5%	1%	1.5%	2%	2.5%

B. Polymer Composite Material Preparation Reinforced with Glass fiber

We have taken polypropylene in a container and heated to a 150°C temperature. In that molten polymer reinforcement are added like Glass fiber of size 3mm to 5mm and the mixture has been stirred upto 5minutes then it has been poured into die to get required shape and it has been kept for cooling upto 1hour. Finally the required material is machined to get required shape circular disc of smooth surface finish.

1) Glass Fiber Reinforcement Polymer Matrix Composite Material Composition

Material	Quantity (weight or %)				
	1st Component	2nd Component	3rd Component	4th Component	5th Component
Waste Plastic	99.5%	99%	98.5%	98%	97.5%
Glass Fiber	0.5%	1%	1.5%	2%	2.5%

C. Polymer Composite Material preparation Reinforced with Thermocol Grains

We have taken polypropylene in a container and heated to a 150°c temperature. In that molten metal polymer reinforcement are added like thermocol grains of size 3mm to 5mm and the mixture has been stirred upto 5minutes then it has been kept for cooling upto 1hour. Finally the material is machined to get required shape of circular disc of smooth surface finish.

1) Thermocol Reinforcement Polymer Matrix Composite Material Composition.

Material	Quantity (weight or %)				
	1st Component	2nd	3rd Component	4th	5th Component
Waste Plastic	99.5%	99%	98.5%	98%	97.5%
Thermocol Grains	0.5%	1%	1.5%	2%	2.5%

IV. SPECIMEN PREPARATION

The chief source of aluminium is bauxite which is a hydrated oxide of aluminium. It occurs in abundance on the surface of the earth.

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It is a very good conductor of heat and electricity its melts at 660°c and boiling point is 2056°c. The metal was chosen because of it good electrical and thermal conductivity. The size of the aluminium is machined to 100mm in diameter and 14mm thick. The specific heat capacity of aluminium is 921.096 JKg^{-1} K^{-1} the faces were also smoothen for good thermal contact.

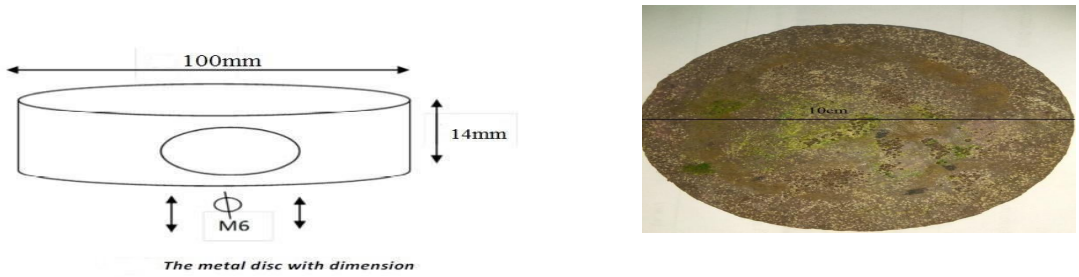

Fig. 1 Polymer Matrix Specimen

V.EXPIRIMENTAL SETUP

Fig. 2 Lee's Disc Apparatus

A. Elements of Lee's disc apparatus are as follows

1) Aluminium disc: Two aluminum disc have been used for making lee's disc apparatus of having following dimensions radius- 5cm, thickness- 1.4cm ,3Holes- 0.6cm and one, hole- 2cm. One hole for thermometer installation and three holes for fixing purpose. Out of two disc, one disc is hanged with the help of three supporting screws one more hole is provided of 6mm diameter for installing thermometer. One more disc has been used in the aluminium box of dimensions 6mm holes for installing thermometer.

2) Aluminium cylinder: Aluminium cylinder of the above dimensions have been used to the top disc uniformly.

3) Steam generator: Steam generator has been used to generate the steam and pass to the steam chamber which is above the top disc.

4) Heat source: LPG gas cylinder has been used to supply heat to the steam generator

5) Stand: The stand is made up of cast iron has been used to support top and bottom disc, steam chambers and specimen.

6) Thermometers: Two thermometers are used to measure the temperature of top and bottom disc with respect to time

B. Testing Procedure

1) The experimental arrangement is shown in steam is allowed to pass through the inlet of the vessel and it escapes out through the outlet. The temperature indicated by the two thermometers will start rising.

2) After the steady state is reached (there will be no change in the temperature with time), the temperatures in both the thermometers are noted as T_1 and T_2 respectively. This is the static part of the experiment.

3) The bad conductor is removed by gently lifting the upper steam chamber. Now the lower metallic disc is allowed to be

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directly in contact with the steam chamber.

4) When the temperature of the lower disc attains a value of about 10° C more than its steady state temperature (T_2), the steam chamber is then removed and the lower metallic disc is allowed to cool down on its own.

5) A stop watch is started when the temperature is 5ºC above the steady temperature T_2 and time is noted for every 1ºC fall in temperature until the metallic disc attains 5ºC below T_2.

6) A graph between temperature and time is drawn. Rate of cooling dT/dt at T_2 is calculated from the graph.

7) The mass of the disc (m) is found using rough balance and the thickness (d) of the bad conductor and thickness of the metallic disc (h) is measured using screw gauge.

Formula of thermal conductivity of bad conductor is given by

$$k = \frac{m\,C\,(dT/dt)\,d\,(r+2h)}{\pi r^2\,(T_1-T_2)\,(2r+2h)}$$

C. Observations

Steady temperature of steam chamber (T_1) = It is taken from the experiment in K

Steady temperature of the metallic disc (T_2) = It is taken from the experiment in K

Mass of metallic disc (m) = 0.312 Kg

Specific heat capacity of metallic disc = 921.096 $JKg^{-1}\,K^{-1}$ Thickness of bad conductor (d) = 0.5cm = 0.005m

Thickness of metallic disc (h) = 1.4cm = 0.014m

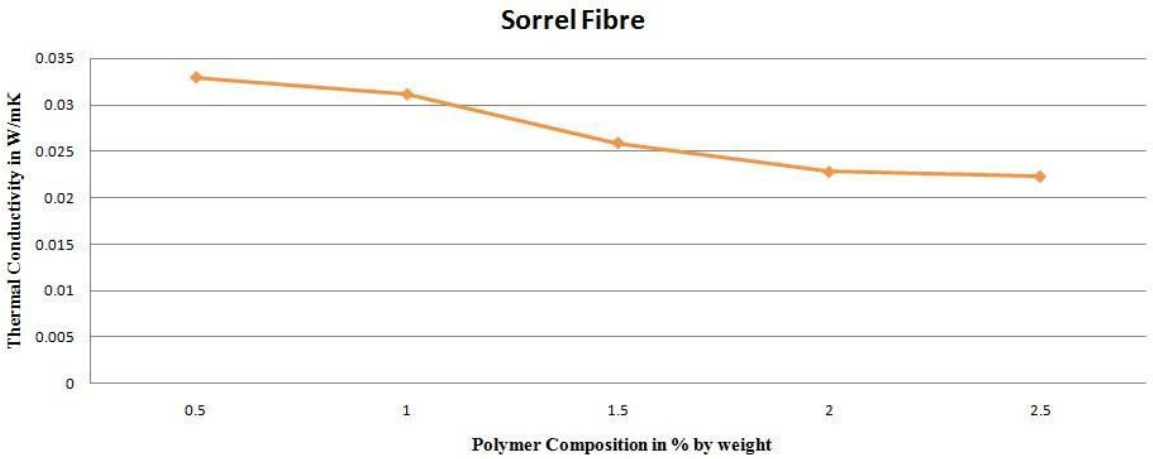
Radius of metallic disc (r) = 5cm = 0.05m

Mean rate of fall temperature at mean temperature T_2 (dT/dt) = It is taken from the graph K/s

VI. RESULT AND DISCUSSION

Thermal conductivity of Polymer composite reinforced with Sorrel fiber

Weight (%)	Thermal Conductivity
0.5%	0.0329 W/m K
1%	0.0311 W/m K
1.5%	0.0259 W/m K
2%	0.0228 W/m K
2.5%	0.0223 W/m K



Thermal Conductivity of sorrel fiber reinforced with plastic material decreases with increases with weight % of Sorrel fiber this indicates sorrel fiber addition increases thermal resistivity of the composite material and also it increases strength of the composition because of the addition of sorrel fiber.

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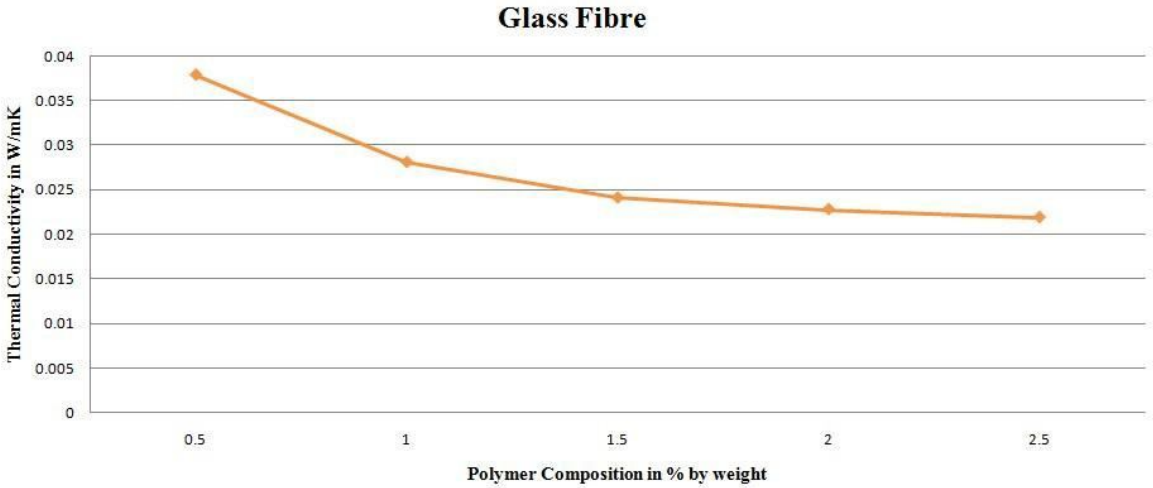
Thermal conductivity of Polymer composite reinforced with Glass fiber

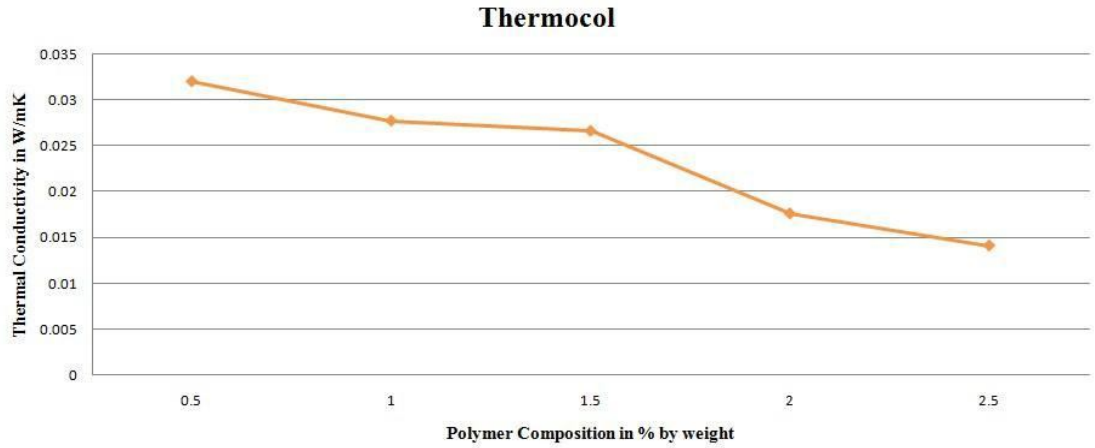
Weight (%)	Thermal Conductivity
0.5%	0.0379 W/m K
1%	0.0281 W/m K
1.5%	0.0241 W/m K
2%	0.0228 W/m K
2.5%	0.0219 W/m K



Thermal conductivity of plastic reinforced with Glass fiber decreases with increases in weight % of glass fiber this indicates glass fiber addition increases thermal resistivity of the composite material and also it increases strength of the composition because of the addition of glass fiber.

Thermal conductivity of Polymer composite reinforced with Thermocol

Weight (%)	Thermal Conductivity
0.5%	0.0320 W/m K
1%	0.0277 W/m K
1.5%	0.0266 W/m K
2%	0.0176 W/m K
2.5%	0.0141 W/m K



As per the above graph which has been observed that the thermal conductivity of the thermocol reinforced composite reduces with addition of reinforcements to the plastic matrix material. Because thermocol is having more air pockets, they itself act as an insulative material that is the reason with increases in weight % of thermocol thermal resistivity increases.

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VII. CONCLUSIONS

A. In this project waste plastic has been taken to produce insulative material which may reduce environment pollution.

B. Adding sorrel fiber and glass fiber increases strength of material which is needed to avoid material failure during its usage.

C. From the above table we can say that thermal conductivity of polymer composite materials is less than the silicon rubber. Hence these materials can be used for insulation in the HVAC filed.

D. The thermal conductivity of thermocol is 0.0141 W/m K which is less than thermal conductivity of silicon rubber which is 0.0537 W/m K

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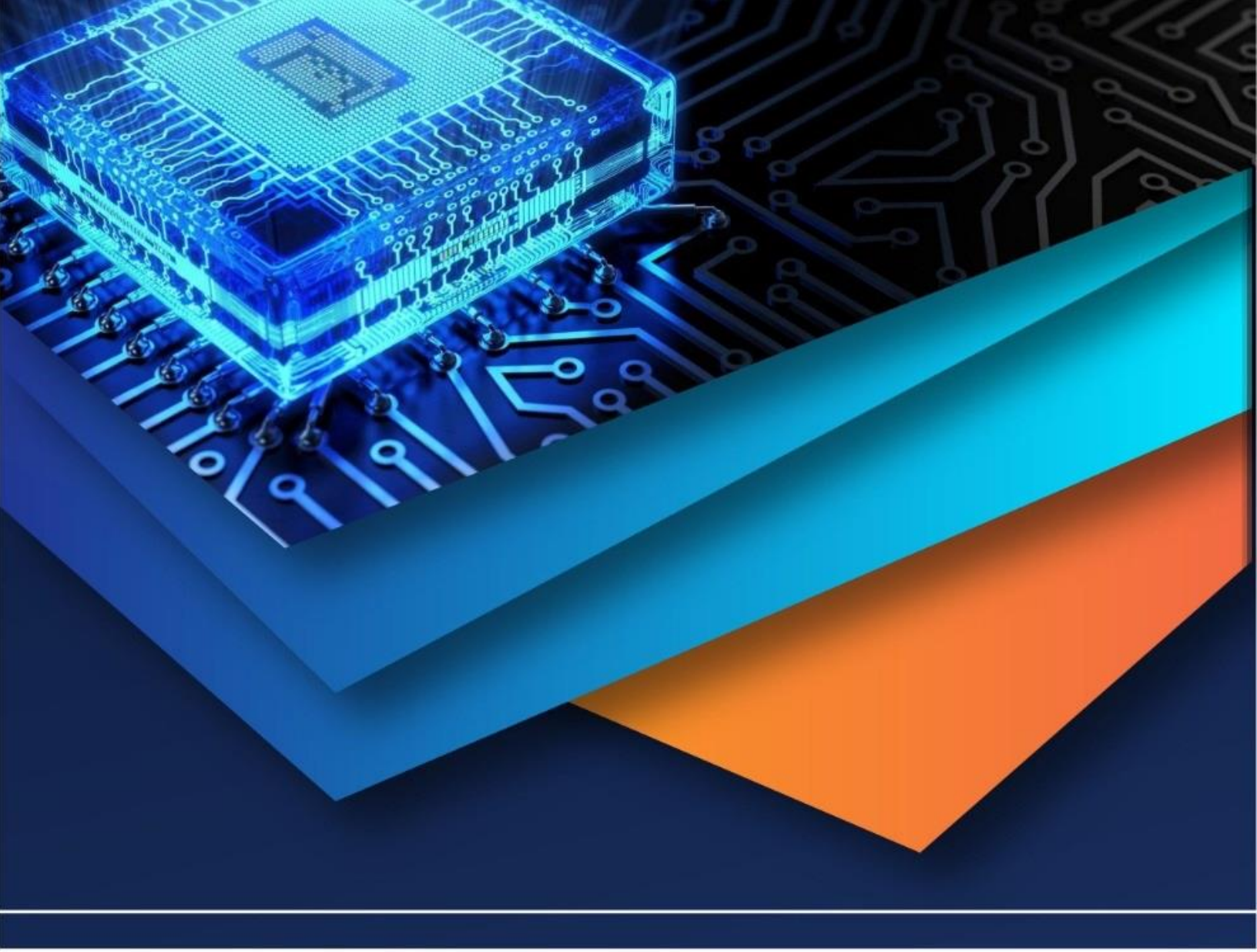

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