



Investigation on Heat Transfer and Thermal Conductivity Measurement in Lagged Pipe Apparatus

P.Prakash¹, A.Parthiban², S.Varunraj³

¹Assistant professor, Mechanical engineering, VELS Institute of Science, Technology and Advanced Studies

²Associate professor, Mechanical engineering, VELS Institute of Science, Technology and Advanced Studies

³Assistant professor, Mechanical engineering, VELS Institute of Science, Technology and Advanced Studies

Abstract: Nowadays more research is going on insulating material to protect our device from damage and to save the input given. If proper insulation is provided, the heat flows from system to surrounding and surrounding to system can be minimized. This all depends on type of insulating material used, so here usage of insulating material varies based on thermal conductivity and application. In this work concentrated on determination of thermal conductivity of two different insulating materials (saw dust and asbestos). This insulating material is logged in-between concentrated pipe and the known amount of heat is supplied, then the calculations were made for find out the thermal conductivity of individual and for the combination of insulating material. And the heat transfers for this combination of insulating material logged between the concentrated pipes are studied.

I. INTRODUCTION

It is very important to find the thermal conductivity of different material used in our engineering field. Nowadays much research is going on materials of asbestos and saw dust. Generally thermal conductivity of material is mainly depends on temperature and the heat transfer is mainly depends on thermal conductivity and temperature difference between system and surrounding. Providing proper insulation is very important for maintain the temperature of application constant. If it is well insulated there is no flow of heat from system to surrounding and surrounding to system. So in summer time to prevent melting of any solid and in winter time to prevent solidifying of any liquid, there is necessity of proper insulation. MicheaelVhukwadiOnyeaju et al studied comparison of the thermal properties of Asbestos and Polyvinyl chloride ceiling sheets and concluded that the thermal conductivity, thermal resistivity, thermal absorptivity, thermal diffusivity and specific heat capacity values of PVC and Asbestos ceiling sheets falls within the range of good insulating materials like pine fibre-board and oak wood. And also found these materials have higher resistivity, low density and thermal conductivity than other insulating materials. S.S. Oluyamo investigated the influences of particle size on the thermal insulation properties of few wood selected materials for solar device applications. He investigated the wood as insulating material at three different particle sizes such as 300 μm , 600 μm , and 850 μm . Concluded that the 600 μm size the thermal conductivity of wood particle are lesser than other wood particle sizes. Also made some comparative analysis of insulating materials generally used in flat plate solar collector. It was seen that using wood of 600 μm size as insulator the thermal conductivity are considerably lower than the general insulating materials. [3] The heat is first transfered from the hot fluid to wall by convection, in the wall heat is transfered by conduction and then the wall to cold fluid again by convection. and also found that heat transfer through wall occur only in one direction where the temperature difference occurs.

II. EXPERIMENTAL SETUP

Main components of experimental setup are heater, outer pipe, middle pipe, outer pipe, support, connection strir, thermocouple socket; board T₁ to T₆ thermocouple position. It consists of three

concentric circular tube of varying cross section. The heater is placed inside the inner pipe and the nichromewire is wound on it and the terminals are connected to power supply for supplying heat. The insulating materials which want to find out thermal conductivity is placed in between concentric circular pipe. The first one between inner and middle, the second one between middle and outer pipe compactly. These pipes are arranged very compactly by providing suitable supporting stands. There are six thermocouples are used for find the surface temperature at different locations. When power supply is switched on the heater first gets heated then the heat starts to flow takes place from inner to towards outward due to temperature difference. So the logged materials and the pipes get heated, then the temperature existing at different locations are sensed by temperature sensors.

The heat transfer from one pipe to other pipe is depends on supplied heat input, the temperature difference and the thermal conductivity of the insulation and the pipe material. In this heat transfer and t5hermal conductivity analysis were carried out in concentric circular tube logged with saw dust and asbestos between the pipes.



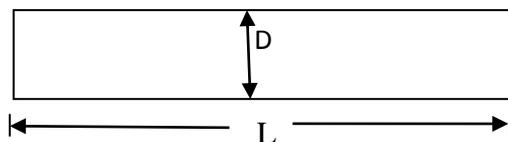
Fig.1 Photographic view of experimental setup

Observation

- Inner diameter of pipe is 14 mm
- Diameter of middle pipe is 34 mm
- Diameter of outer pipe is 60 mm
- Length of pipe is 400 mm

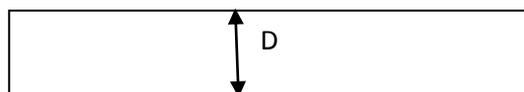
S.No	Voltmeter (Volt)	Ammeter (ampere)	Thermocouple reading in °C					
			T ₁	T ₂	T ₃	T ₄	T ₆	T ₇
1	40	0.313	52	63	57	58	61	48
2	80	0.627	55	77	63	66	74	49

Inner pipe



Diameter of inner pipe is 14 mm; Length of the inner pipe is 400 mm, material - galvanized iron

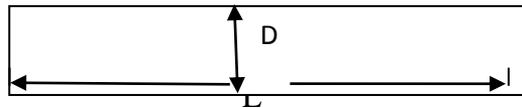
Middle pipe





Diameter of inner pipe is 34 mm; Length of the inner pipe is 400 mm, material - galvanized iron

Outer pipe



Diameter of inner pipe is 60 mm; Length of the inner pipe is 400 mm, material - galvanized iron

Experimental Procedure

Switch on the power supply

Gently rotate the dimmer stat for the desired heat input. Note down the corresponding voltage and ammeter reading for calculating heat supplied.

After setting desired input wait for more than five minutes for attaining steady state.

Then note down the surface temperature which is indicated on the digital meter by rotating the knob of the digital reading indicator.

Then again rotate the dimmerstat for varying the heat supply. Then follow the same procedure mentioned above for measuring surface temperature at different locations.

Finally substitute all the values in the formula for calculating thermal conductivity and heat transfer through the logged pipe.

Limits and precautions

Before switching on power supply, ensure that dimmer stat is in zero position.

Increase the voltage gradually.

Keep the assembly undisturbed while testing.

While removing or changing the logging material, do not disturb the thermocouples.

Do not increase power above 100 watts.

Operate selector switch of indicator gently.

Formula and calculation

$$Q_{actual} = V * I = 40 * 0.313 = 12.52 \text{ W}$$

Where, V - voltage in volts

I - current in Amperes

$$T_{(inside)} = \left(\frac{T_1 + T_2}{2} \right) = \left(\frac{54 + 53}{2} \right) = 53.5 \text{ degree Celsius}$$

$$T_{(middle)} = \left(\frac{T_3 + T_4}{2} \right) = \left(\frac{50 + 50}{2} \right) = 50 \text{ degree Celsius}$$

$$T_{(outer)} = \left(\frac{T_5 + T_6}{2} \right) = \left(\frac{41 + 41}{2} \right) = 41 \text{ degree Celsius}$$

$$K_1 = \frac{Q_a * \ln\left(\frac{r_m}{r_i}\right)}{2\pi * L * (T_i - T_m)} = \frac{12.56 * \ln\left(\frac{0.017}{0.007}\right)}{2 * \pi * 0.4 * (51 - 45.5)} = 0.80 \text{ W/mK}$$

$$K_2 = \frac{Q_a * \ln\left(\frac{r_o}{r_m}\right)}{2\pi * L * (T_m - T_o)} = \frac{12.56 * \ln\left(\frac{0.030}{0.017}\right)}{2 * \pi * 0.4 * (45.5 - 39.5)} = 0.47 \text{ W/mK}$$

$$K = \frac{r_i * \ln\left(\frac{r_o}{r_i}\right)}{\frac{r_m}{k_1} * \ln\left(\frac{r_m}{r_i}\right) + \frac{r_o}{k_2} * \ln\left(\frac{r_o}{r_m}\right)} = \frac{0.007 * \ln\left(\frac{0.030}{0.007}\right)}{\frac{0.017}{0.806} * \ln\left(\frac{0.017}{0.030}\right) + \frac{0.030}{0.473} * \ln\left(\frac{0.030}{0.017}\right)} = 0.010 \text{ W/mK}$$

$$Q = \frac{2\pi * L * (T_i - T_o)}{\frac{\ln\left(\frac{r_m}{r_i}\right)}{k_1} + \frac{\ln\left(\frac{r_o}{r_m}\right)}{k_2}} = \frac{2 * \pi * 0.4 * (53.5 - 41)}{\frac{\ln\left(\frac{0.017}{0.007}\right)}{1.9} + \frac{\ln\left(\frac{0.03}{0.017}\right)}{0.49}} = 13.5 \text{ W}$$

Here, r_i - radius of inner pipe in meter

r_m - radius of middle pipe in meter

r_o - radius of outer pipe in meter

L – Length of pipe in meter

D – Diameter of pipe in meter

K_1 is thermal conductivity of inner insulating material in W/mK

K_2 is thermal conductivity of outer insulating material in W/mK

K is thermal conductivity of combined logging material in W/mK

Q is flow rate of heat transfer in Watts

T is Temperature in degree Celsius

III. CONCLUSIONS

The heat transfer and thermal conductivity of combination of these insulating materials by assuming heater input to be the heat flow rate through lagged pipe is found out as follows

Thermal conductivity of saw dust (K_1) = 0.80 W/mK

Thermal conductivity of asbestos (K_2) = 0.47 W/mK

Thermal conductivity of combination of these insulating materials (K) = 0.010 W/mK

Heat transfer through lagged pipe (Q) = 13.5 Watts

It is also found that heat input supplied increases; the thermal conductivity also increases for both the asbestos and saw dust.

Compare to asbestos that the saw dust shown higher thermal conductivity this is because of vibration of saw dust particle leads to the energy is transferred easily from one place to other.

REFERENCES

- I. Michael Chukwudi Onyeaju^{1*}, Evelyn Osarolube¹, Ephraim Okechukwu Chukwuocha¹, Chinedu Ekuma Ekuma¹, Great Arusuedafe Jacob Omasheye², Comparison of the Thermal Properties of Asbestos and Polyvinylchloride (PVC) Ceiling Sheets, Materials Sciences and Applications, 2012, 3, 240-244, Published Online April 2012
- II. S. S. Oluyamo and O. R. Bello, Particle Sizes and Thermal Insulation Properties of Some Selected Wood Materials for Solar Device Applications, IOSR Journal of Applied Physics, e-ISSN: 2278-4861. Volume 6, Issue 2 Ver. I (Mar-Apr. 2014), PP 54-58
- III. Yunis A Cengel (2011), Heat and Mass Transfer, 4th Edition.