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Analyzing The Thermal Conductivity of Brick Insulating Powder Using the Concentric Sphere Method

***D Kiran Kumar[1,2], M Naga Rajani[2], P King[2]**

[1,2] Department of Pharmaceutical Engineering, B.V. Raju Institute of Technology, Narsapur, Medak, Telangana, INDIA. *Corresponding author: dasarikirankumar018@gmail.com[1]

[2] Department of Chemical Engineering, College of Engineering, Andhra University, Visakhapatnam, Andhra Pradesh, INDIA.

ABSTRACT - Since the brick powder is porous than the asbestos powder, the thermal conductivity is more for brick powder. The results are in fair agreement with experiments and show distinct thermal conduction for Brick powder is found to be more than that of Asbestos powder. We have also compared for Variation of Thermal Conductivity with Voltage for both Brick Powder and Asbestos powder. The fundamental motivation behind this work is to decide the warm conductivity dependent on the concentric circular technique. In this work, we derive a Variation of Thermal Conductivity with Voltage for Brick powder (Fly Ash); as the voltage increases, the thermal conductivity decreases. We can observe a significant decrease in thermal conductivity when the voltage varies from 40V to 60V and is almost constant after 60 V and the variation of thermal conductivity with temperature (brick powder). It is observed that as the temperature difference increases, the thermal conductivity decreases. After that, the reduction of thermal conductivity is minimal even though the Asbestos Powder temperature difference increases. We can also observe a significant decrease in thermal conductivity when the voltage fluctuates from 40V to 60V and the thermal conductivity is almost constant after 60V.

KEY WORDS: Asbestos powder, Brick Powder, Thermal Conductivity, Voltage.

I. INTRODUCTION

Brick Powder and Asbestos powder is helpful to decrease the heat loss to the surrounding in many heats exchange equipment. The thermal conductivity values are shallow in Insulating materials. Insulating materials are used in different shapes, sizes and appearances. In this Experiment are using Insulating powder such as asbestos, brick powder. It is show in figure 1& 2. It is easy to take any complex form between the confining surfaces, and their having ample air space in between particles is in great demand in present days. The thermal conductivity of the insulating powder depends on the geometry of the surface, the size, the thermal conductivity of the particles, the amount of air space contained and the method of heat transfer in different applications.

Figure 1: Asbestos Powder

Figure 2: Brick Powder

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For metals and non-metals, the effect of temperature on thermal conductivity is different. In metals, conductivity is mainly due to free electrons. Asbestos is non-flammable even at very high temperatures and is highly flexible and durable. Asbestos has been nicknamed the "miracle mineral" because of its physical properties and chemical composition, and it can be used in thousands of products such as floor tiles, signs, and sewer lines. water and insulation mattress products. Boilers and pipework were lagged with asbestos products in hospitals, power stations and throughout the heavy industry. Asbestos insulation products were popular in the shipbuilding, railway industries, House of Commons Chamber, dockyards, etc. The brick will have abrasion resistance and the toughness of the brick, which helps to give permanent properties to the brick structure. Due to this feature, the brick will not be damaged by scratches. Bricks must have a low thermal conductivity so that buildings made of them are cool in summer and warm in winter. Heavier bricks have poor sound insulation, while lightweight hollow bricks provide good sound insulation.

The concentric sphere method is designed to eliminate end effects and guard plates associated with the concentric cylinder and guarded hot plate methods. A schematic of their concentric sphere apparatus is shown in Figure 3. The thin nylon bracket and electrical assembly minimize the heat leakage between the cylinders, making it negligible. The small holes on the outer cylinder covered with a filter can evacuate the isolated space. The temperature of the outer sphere is maintained by adjusting the level of refrigerant in the copper rod and the healing power of the steam heater. The insulating space is evacuated, and the inner ball heater is energized to generate a temperature difference between the balls. In this way, any temperature range between the refrigerant temperature and the ambient temperature can be achieved. A filler spout is placed atop the outer sphere to replace any powder lost from settling. A concentric sphere method is a novel approach to measuring the effective thermal conductivity of powder. However, spheres are expensive to manufacture and difficult to work within. Therefore, other configurations would be more suitable for the standardization of a powder insulation thermal conductivity testing method.

At present, research on the measurement of solid thermal conductivity is being widely carried out. Calculate the thermal conductivity of molten salt in the range of 100～500℃ [1]. Determining the thermal conductivity of solids at high and low temperatures is essential, especially when the solid in question can be used as a phase change material for energy storage purposes. Determine the thermal conductivity of a binary mixture of alkali metal nitrates[2]. It is essential to have accurate thermal conductivity data for the solid in question within the temperature range that will be encountered during the use of the solid as a storage medium. Thermal conductivity comparison Insulating materials measured by various methods[3]. Under high temperature conditions, use the comparative flow meter method (CFM) to determine the thermal conductivity of insulating materials[4]. Experimental and computational techniques to characterize cellular metals[5]. The effect of the carbide-coated graphite / aluminum composite interface structure on thermal conductivity and strength[6]. An experimental study of the thermal conductivity of lightweight foam concrete for thermal insulation[7]. Crushed ice is added to the fly ash that exceeds the optimal moisture content and compacted for higher porosity and a stronger matrix. The effect of various actual snow mix ratios on fly ash and its evaluation of insulation performance[8].

II. MATERIAL AND METHODS

The thermal insulation powder meter is designed for measuring the thermal conductivity of thermal insulation powder. The device consists of two thin-walled concentric copper balls. The inner ball is equipped with a nickel-chromium alloy wire heating coil. The insulating powder is filled between the spheres. The heat flows radially outward. The temperature sensor is installed in an appropriate position to measure the surface temperature of the sphere. The heat input of the heater is given by variation and measured with a digital voltmeter and a digital ammeter. By changing the heat input rate, a wide range of experiments can be performed.

We assume that the insulating powder is an anisotropic material, and the value of thermal conductivity is constant. The device assumes one-dimensional radial heat conduction through the powder, and the thermal conductivity can be determined. Consider conductive heat transfer through the wall of a hollow sphere formed by a layer of insulating powder filled between two thin copper spheres.

Let r_i = Radius of the interior sphere in meters

r_o = Radius of the exterior sphere in meters

T_i = Average temperature of the interior sphere in Kelvin(K)

T_o = Average temperature of the exterior sphere in Kelvin(K)

2.1 SAMPLE POWDER PREPARATION:

For the present Experiment, the sample of brick powder is prepared by crushing the bricks and sieved to a fine powder. This fine powder is allowed to dry in sunlight to remove the moisture content and then cooled to room temperature. The insulating powder is filled inside the spherical surfaces without any air gaps and sealed with insulating tape. Similarly, chalk powder and Asbestos powder are also filled inside the spherical surfaces of the Apparatus to measure thermal conductivity.

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Figure 3: Insulating powder apparatus

2.2 SPECIFICATIONS:

1. Inner radius of copper sphere, r_i = 50mm
2. outer radius of copper sphere, r_o = 100mm
3. Voltmeter (0 – 240V).
4. Temperature-0-2500C
5. Ammeter (0 – 2 Amps.)
6. Dimmer stat 0 – 2A, 0 – 240 V.
7. The Heater coil Strip (Heating Element sandwiched between mica sheets) – 200Wats
8. Chromel Alumel Thermocouples –No. (1) to (6) embedded on an inner sphere to measure T_i.
9. Chromel Alumel Thermocouples –No. (7) to (12) embedded on an outer sphere to measure T_o.
10. Insulating Powders used – Asbestos powder and Brick powder

III. RESULTS AND DISCUSSIONS

The temperatures at different locations are noted for different heat input values, and thermal conductivity is calculated for the insulating powders.

3.1 BRICK POWDER:

For brick powder, the voltage is varied from 40V to 80V, and the corresponding temperature readings are noted from the temperature indicator. Thermal conductivity values for different heat inputs are calculated and tabulated in Table 1 below.

S. No	Voltage (V)	Heat Input, Q (W)	Average Temperature of Inner Sphere, Ti(K)	Average Temperature of Outer Sphere, To(K)	Thermal Conductivity (W/m-K)
1	40	8	315.41	310.08	1.195
2	50	12.5	324.25	311.3	0.768
3	60	17.4	345.08	313.15	0.432
4	70	23.1	365.15	319.5	0.403
5	80	28	385.8	329.75	0.398

Table 1: Experimental values for different heat inputs (Brick powder)

For different heat input values, thermal conductivity is calculated by using the relations given below,

$$Ti = \frac{T1 + T2 + T3 + T4 + T5 + T6}{6}, \text{ in K}$$

Were,

T_1, T_2, T_3, T_4, T_5, T_6 are the temperatures measured using thermocouples on the surface of the inner sphere T_7, T8, T_9, T_{10}, T_{11}, T_{12} are the temperatures measured using thermocouples on the surface of the outer sphere Thermal conductivity, K(W/m-K) is calculated using the formula,

$$K = \frac{Q(r0-ri)}{4\pi riro(Ti-TO)}$$

Where,

Q=Heat input in Watts

Among the thermal properties of insulation materials, the thermal conductivity (k) is regarded to be the most important since it affects directly the resistance to transmission of heat that the insulation material must offer. The variation of thermal conductivity with voltage is plotted and shown in Figure 4. It is observed that as the voltage increases, the thermal conductivity of the insulating powder (brick powder) decreases. We can also observe a steep decrease in thermal conductivity when the voltage varies from 40V to 80V and almost remains constant after 80V.

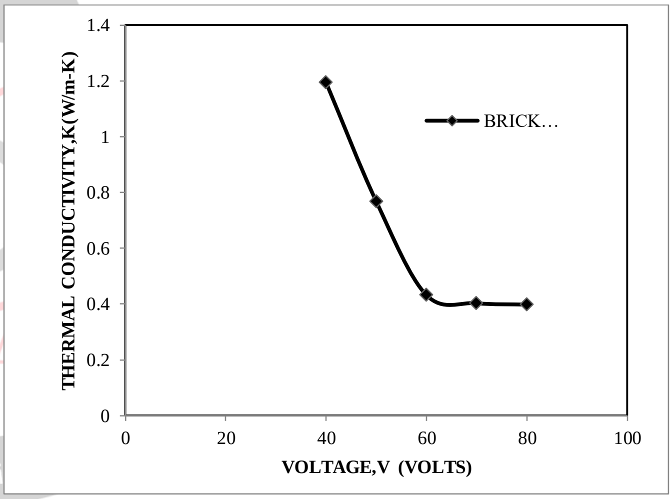

Figure-4: Variation of Thermal Conductivity with Voltage (brick powder).

The temperatures are measured at different locations on the inner sphere's surface, and the outer sphere and the average temperatures of both inner and outer spheres are calculated. The variation of thermal conductivity with the temperature difference between inner and outer spheres (T_i-T_0) is plotted and shown in Figure-5. As the temperature difference increases, the thermal conductivity decreases. The decrease in thermal conductivity is more up to a specific range of temperature differences. After that, it is observed that the reduction of thermal conductivity is minimum even though the temperature difference increases.

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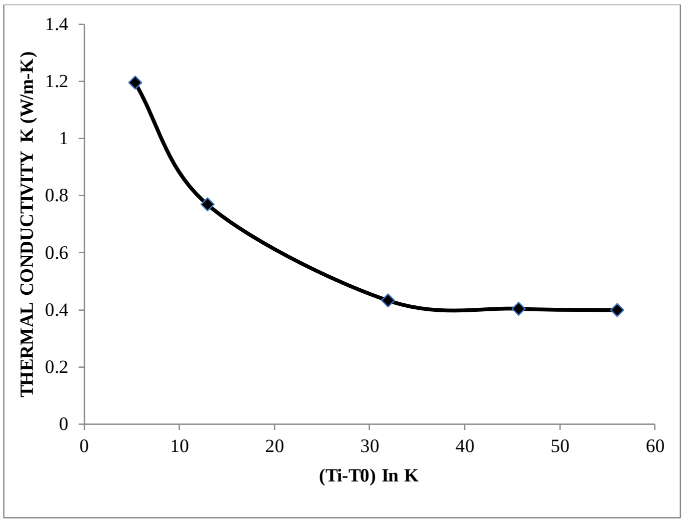

Figure-5: Variation of Thermal Conductivity with Temperature (brick powder)

The variation of thermal conductivity with voltage is plotted for asbestos powder and shown in Figure-6. It is observed that as the voltage increases, the thermal conductivity of the insulating powder (asbestos powder) decreases. We can also observe a sharp decrease in thermal conductivity when the voltage changes from 40V to 80V.

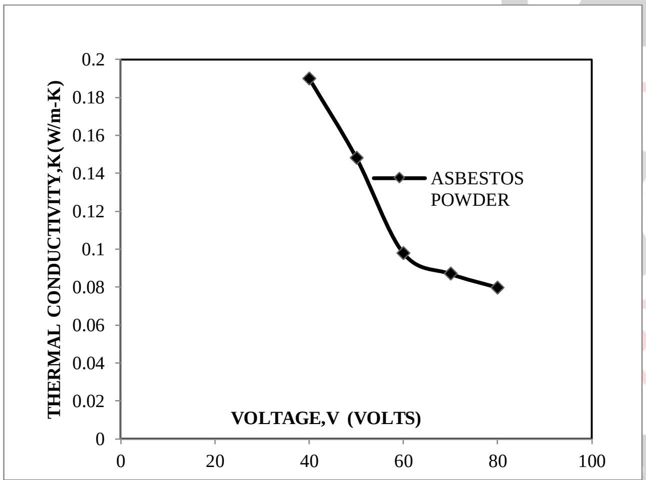

Figure-6: Variation of Thermal Conductivity with voltage (Asbestos powder).

Figure-7 shows the comparison of thermal conductivities for asbestos and brick powders. The comparison is made by giving the same voltage as input. Both the insulating powders follow the same trends. The thermal conductivity for brick powder is found to be more than that of asbestos powder. Since the brick powder is porous than the asbestos powder, the thermal conductivity is more for brick powder.

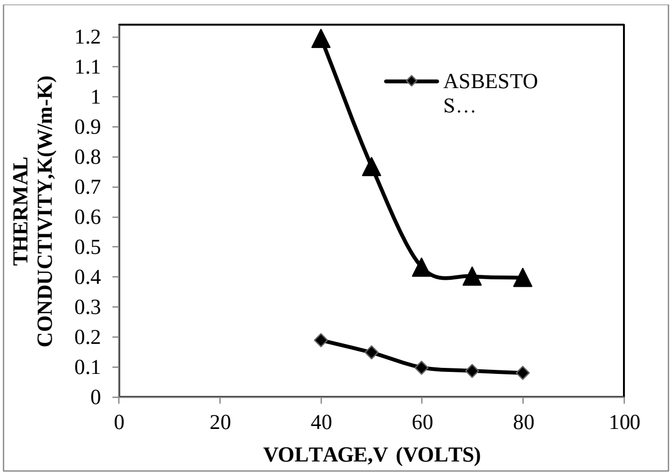

Figure-7: Comparison of Thermal Conductivities with voltage for asbestos and brick powder

IV. CONCLUSION

- Thermal conductivities for two insulating powders (asbestos powder, brick powder) are computed and compared.
- The variation of thermal conductivity with heat input is plotted.
- It is observed that the thermal conductivity for brick powder is more than that of asbestos powder for the same heat input.

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CONFLICTS INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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