International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Development of Insulating Powder Test Rig

Mr. Aakash Ashtankar, Mr. Abhay Rakhade, Mr. Ankit Ghode, Mr. Rahul Katre, Mr. Rushabh Kamble

Department of Mechanical Engineering, Govindrao Wanjari College of Engineering and Technology, Nagpur, Maharashtra, India
Corresponding author: Prof. Rahul. M. Dahekar

ABSTRACT

Insulating Powder apparatus is designed to determine the thermal conductivity of insulating Powder. In this paper we will discuss about different powders testing its insulating properties. How different powders react in the insulating powder tester.The insulating powder, whose thermal conductivity is to be determined, is fitted in the gap between the two spheres. The heat generated by the heat flows through the powder to the outer sphere. The outer sphere loses heat to atmosphere.Thermal conductivity of insulating powder: The apparatus consists of an insulating powder, which is enclosed in a cavity of two concentric spheres. The inner space of inner sphere contains the mica heater. Input to the heater can be adjusted by the dimmerstat. The tapping on the surfaces of the inner sphere and outer sphere are used to find out the temperature difference between the spheres. This enables to find out the conductivity of powder.The removal of heat from system components is essential to avoid damaging effects of burning and heating. Therefore the enhancement of heat transfer is an important subject in thermal engineering.

1 INTRODUCTION

Conduction of heat is flow of heat which occurs due to exchange of energy from one molecule to another without appreciable motion of molecules. In any heating process, heat is flowing outwards from heat generation point. In order to reduce losses heat, various types of insulation's are used in practice. Various powders e.g. asbestos powder, plaster of paris etc, are also used for heat insulation. In order to determine the appropriate thickness of insulation, knowledge of thermal conductivity material is essential. The unit enables to determine the thermal conductivity of insulating powders, using 'sphere in sphere' method

THERMAL CONDUCTIVITY

Different types insulating material such as asbestos, Asbestos, glass wool, mica, etc. are used in engineering practice to prevent the leakage of heat. These materials over a resistance to heat flow and are useful in saving the energy. These materials possess a relatively small value of thermal conductivity.The apparatus consists of an insulating powder, which is enclosed in a cavity of two concentric spheres. The inner space of inner sphere contains the mica heater. Input to the heater can be adjusted by the dimmerstat. The tapping on the surfaces of the inner sphere and outer sphere are used to find out the temperature difference between the spheres. This enables to find out the conductivity of powder Finally we will compare the thermal conductivity of above mentioned powders.

THERMAL INSULATION

Thermal insulation is the reduction of heat transfer (i.e., the transfer of thermal energy between objects of differing temperature) between objects in thermal contact or in range of radiative 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 different 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 as the inverse of thermal conductivity (k). Low thermal conductivity is equivalent to high insulating capability (Resistance value). In thermal engineering, other important properties of insulating materials are product density (ρ) and specific heat capacity (c).

THERMAL PROPERTIES FOR INSULATION MATERIAL

Thermal insulators are meant to reduce the rate of heat transfer by conduction, convention and radiation -- the standard methods by which heat transfers. This can be either in order to prevent heat loss or to keep heat out. The following standard we check in Insulation materials.

1. Temperature limits: Upper and lower temperatures within which the material must retain all its properties.
2. Thermal conductance "C": The time rate of steady state heat flow through a unit area of a material or construction induced by a unit temperature difference between the body surfaces.

3. Thermal conductivity "K": The time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a
direction perpendicular to that unit area.
4. Emissivity "E": The emissivity of a material (usually written ε or e) is the relative ability of its surface to emit.
5. Energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a blackbody at the same temperature.

PRECAUTIONS

1. Keep dimmerstat to zero position before start.
2. Increase voltage gradually.
3. Keep the assembly undisturbed while testing.
4. While removing or changing the lagging material, do not disturb the Thermocouples.
5. Do not increase voltage above 140 volts
(i.e., dimmer stat ranges between 60-120 watts).
6. Operate selector switch of temperature indicator gently.

PROCEDURE

1. Connect the three pin plug to the 230 v, 50 Hz, 15 amps main supply and switch on the unit.
2. Turn the regulator knob clockwise, set the heat input by fixing the voltmeter and
ammeter readings and note down the heat input *Q* in the table.
3. Allow the unit to attain the steady state condition.
4. When the steady state condition is reached note down the temperature indicated by the temperature indicators.
5. In the temperature indicator, the temperatures *T*1, *T*2, *T*3, *T*4 represents the mean temperature of the inner sphere heater, *T5*, *T6*, *T7*, *T8*,*T9*, *T10* represents the mean temperature of the outer sphere sawdust lagging by using the multipoint digital temperature indicator.
6. These values are noted in the table.
7. Calculate *K*1 (Thermal conductivity of asbestos) and *K*2 (Thermal conductivity of asbestos), by using the given formula and note the value in the table.
8. Repeat the experiment from step 2 to step 6 by varying the heat input to the system.

2 LITERATURE REVIEW

Technically, Poensgen was the first inventor, as his apparatus had been in use since 1910 to measure the thermal conductivity of insulating materials, while Dickinson and the NBS didn't start measuring thermal conductivity with their apparatus until 1912.

Poensgens (1910): Multilayer reflective insulations are a combination of several or a dozen low emission screens compressed together, separated by layers of bubble foil or polyethylene foam. This paper presents the results of experimental investigation of thermal conductivity of multilayer reflective insulations. The measurements were made with Poensgens LaserComp FOX 314 apparatus. Five samples of reflective insulation and one sample of foamed polystyrene have been tested. The difficulties of determining the replacement thermal resistance for the discussed materials have been presented. Information about the apparatus used, theory of the measurement method, procedure of the experiment and method of sample preparation were presented. The study was performed for four different temperature pairs representing the real thermal conditions in Poland throughout the year. On the basis of the obtained measurement results the average thermal conductivity and average thermal resistance of the tested materials were determined. The relation between the obtained thermal conductivity and thermal resistance depending on the temperature was discussed.

Hobart Cutler Dickinson Development of the guarded hot plate (GHP) apparatus started in the early 20th century, and was influenced by the Lees Disk method reported in 1898 by English scientist Lees. It is generally well accepted that the GHP apparatus was developed nearly concurrently in the United States and Germany. A request by the American Society of Refrigerating Engineers in 1910 to the National Bureau of Standards (NBS) was what sparked the development of the GHP apparatus in the United States. The request asked the NBS to provide standard data pertaining to heat transmission through insulating materials, which the society of engineers would use for design purposes. At the time, no precise method existed for the measurement of heat transmission through insulating materials, and thus scientist Hobart Cutler Dickinson set to work designing and building the first GHP in The United States.

THE GUARDED HOT PLATE METHOD

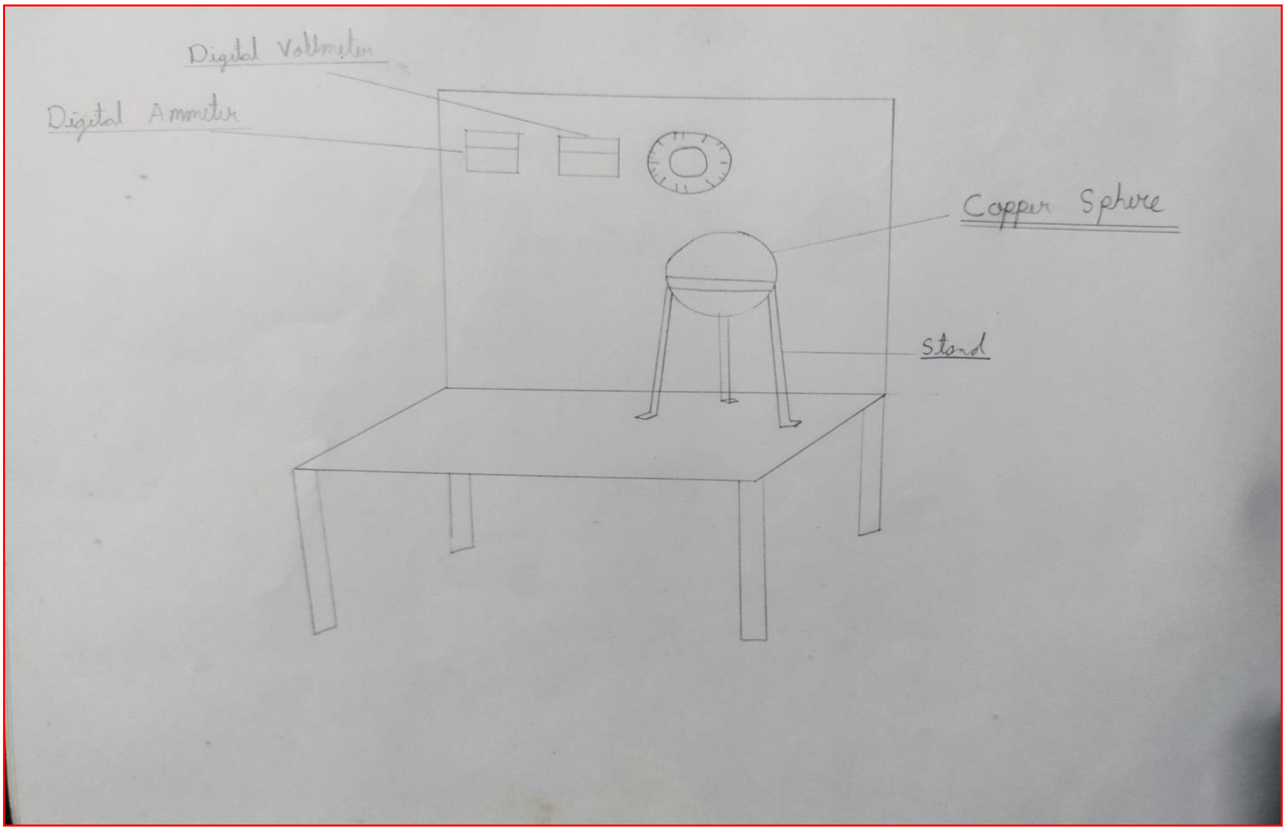
Development of the guarded hot plate (GHP) apparatus started in the early 20th century, and was influenced by the Lees Disk method reported in 1898 by English scientist Lees. It is generally well accepted that the GHP apparatus was developed nearly concurrently in the United States and Germany. A request by the American Society of Refrigerating Engineers in 1910 to the National Bureau of Standards (NBS) was what sparked the development of the GHP apparatus in the United States. The request asked the NBS to provide standard data pertaining to heat transmission through insulating materials, which the society of engineers would use for design purposes.

The guarded hot plate apparatus uses a steady-state method in order to determine the thermal conductivity of an insulating material. Use of a steady-state method requires that the insulating material be in equilibrium with its surroundings in order for accurate thermal conductivity measurements to be obtained.

Literature review of Design and analysis of Thermal insulating powder apparatus is explained in detail below.

Literature review on Design & Development:

Measurements:-



Measurements is a important term of any experimental setup project because in the end in the experimental setup tacking a reading is most important ,cause it indicates the failure or success of the experimental setup project. To take the readings some measurements device are installed in it. Like voltmeter 0 to 200 volt capacity, Ammeter 0-1 Amp and multi-channel digital temperature indicator.

Insulating powder: -

Different types insulating material such as asbestos, Asbestos, glass wool, mica, etc. are used in engineering practice to prevent the leakage of heat. These materials offer a resistance to heat flow and are useful in saving the energy. These materials possess a relatively small value of thermal conductivity.

Asbestos is ussed in this experimental work it is easily available,

Expected thermal conductivity of asbestos is K2. = 0.1662 W/m-K.

Major Insulating Materials

The following is a general inventory of the characteristics and properties of major insulation materials used in commercial and industrial installations.

1. Calcium Silicate

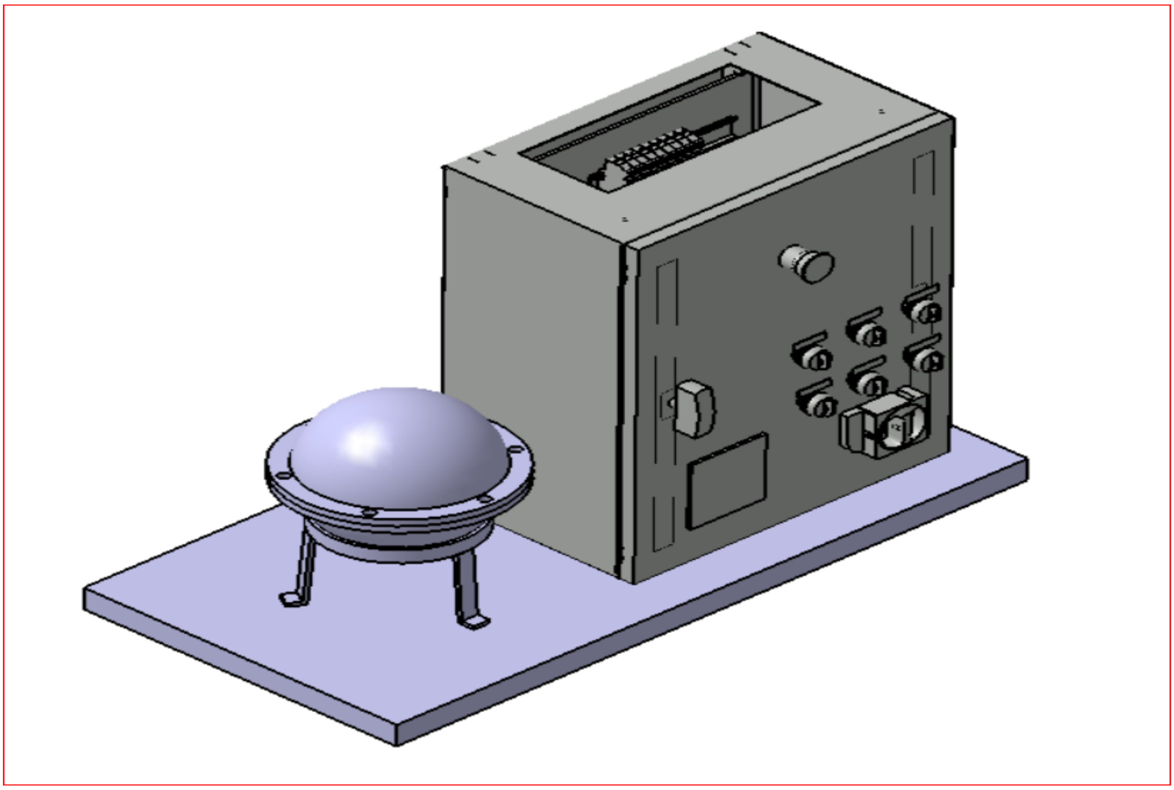
Calcium silicate insulation is composed principally of hydrous calcium silicate which usually contains reinforcing fibers; it is available in molded and rigid forms. Servicetemperature range covered is 35◦C to 815◦C. Flexibility and compressive strength is good. Calcium silicate is water absorbent. However, it can be dried out without deterioration. The material is non-combustible and used primarily on hot piping and surfaces.

2. Mineral Fibre

a) Glass: Available as flexible blanket, rigid board, pipe covering and other pre-molded shapes. Service temperature range is -40◦C to 232◦C. Fibrous glass is neutral; however, the binder may have a pH factor. The product is non-combustible and has good sound absorption qualities.
b) Rock and Slag: Rock and slag fibers are bonded together with a heat resistant binder to produce mineral fiber or wool. Upper temperature limit can reach 1035◦C. The same organic binder used in the production of glass fiber products is also used in the production of most mineral fiber products. Mineral fiber products are non-combustible and have excellent fire properties.
3. Cellular Glass
Available in board and block form capable of being fabricated into pipe covering and various shapes. Service temperature range is -273◦C to 200◦C and to 650◦C in com-posite systems. Good structural strength, poor impact resistance. Material is non- combustible, non-absorptive and resistant to many chemicals.
4. Expanded Silica or Perlite Insulation material composed of natural or expanded perlite ore to form a cellular structure; material has a low shrinkage coefficient and is corrosion resistant; non-combustible, it is used in high and intermediate temperature ranges. Available in pre-formed sections and blocks.
5. Elastomeric Foam Foamed resins combined with elastomers to produce a flexible cellular material. Avail-able in preformed sections or sheets, Elastomeric insulation offer water and moisture resistance. Upper temperature limit is 105◦C. Product is resilient. Fire resistance should be taken in consideration.

Literature Review on Experimental Work

Our objective is to find conductivity of insulating powder. There are two concentric spheres.the heater is connected to the AC supply. When current is flow through this heater the heat will generate and then that heat will transfer radially outword and there is powder filled between these two spheres. So our main objective is to find out the thermal conductivity of that thermal insulating powder.
Thermal Conductiity insulating powder is used for determining values of different Insulating powders such as asbestos, coal, wood, cement, white cement, foundry sand, red soil, because of their ease of taking any complex shape between the confining surfaces and their having large air space in between particles are in great demand these days.The thermal conductivity of an insulating powder will depend upon the geometry of the surface, particle thermal conductivity, size and number of contained air spaces and the modes of the heat transfer in different situations of the application. Material has been selected based on the properties, cost and application, where it is needed sodium silicate, silica fumed, mica, wood, cement, white cement, coal, red soil, foundry sand, to find thermal conductivity.



3 RESULT AND DISCUSSION

As thickness of insulation increases temperature at corresponding layer decreases hence temperature difference also decreases which results in reduction in heat transfer rate. For asbestos as temperature increases thermal conductivity also increases but raise in thermal conductivity is considerably small hence we can say that up to certain temperature thermal conductivity of asbestos remains constant.

The range of the thermal conductivity of the givien insulating powder is must to come same range found from the experiment.
The thermal conductivity increases when the heat input Q increases.
The thermal conductivity of insulating powder increased when the temp. difference between the surface is decreased.

Parameters on which heat transfer depend are:
Heat transfer increases when **thermal conductivity** is increased.
When **area** is increases, heat transfer increases.
When the **temperature difference** is increased, heat transfer increases.
When the length of slab is increased, heat transfer decreases.

	Temperature of thermocouple °c						Heat Input			Avg. inner sphere temp Ti =T1+T2+T3/3 K	Avg. outer sphere temp To=T4+T4+T6/3 k	Thermal condtivity K
S.NO	T1	T2	T3	T4	T5	T6	V (Volt)	I (Amp)	q= V xI watt			K = q (ro – ri) / 4 Π ri x ro (Ti - To) W/mK
1	221	217	221	42	41	45	228	0.19	43.32	492.7	315.7	0.195
2	222	218	222	43	41	46	228	0.23	52.44	493.7	316.3	0.235
3	223	219	223	43	42	46	226	0.25	56.5	494.7	316.7	0.253
4	224	220	223	44	42	47	228	0.3	68.4	495.3	317.3	0.306
5									0	273.0	273.0	#DIV/0!

Calculation:

- Heater input ; q = V × I watts

  q= 226x 0.25= 56.5 watt
- Avg. inner Sphere surface temperature

$$T_i = \frac{T1 + T2+T3}{3} \text{ °C} = 223+219+223/3$$

= 494.7 K

Avg. outer Sphere surface temperature

$$T_o = \frac{T4 + T5+T6}{3} \text{ °C} = 43+42+46/3$$

= 316.7 K

Inner Sphere radius = 50 mm = 0.05 m

Outer Sphere radius = 100 mm = 0.1 m

$$\text{Now} \quad K = \frac{q\,(ro - ri)}{4\,\Pi\, ri \times ro\,(Ti - To)} \text{ W/m K},$$

$$\text{at,} \quad \frac{Ti + To}{2} \;\ldots\ldots\ldots\; ^\circ C$$

$$K = \frac{56.5(0.1-.05)}{4x3.14x\ .05x.1x\ (178)} = 0.253 \text{ W/mK}$$

4 CONCLUSION

1. Comment on the observed temperature distribution and calculation by theory, it is expected that observed temperatures should be slightly less than their calculated values because of radiation and non-insulated tip.
2. Plot the graphs of temperature distribution in both natural and forced convection.
3. The heat transfer coefficient is having a maximum value at the beginning as expected because of the just starting of the building of the layer and it decreases as expected in the upward direction due to thickening of layer and which is laminar one. This trend is maintained up to half of length (approx.) and beyond that there is little variation in the value of local heat transfer coefficient because of the transition and turbulent boundary layers. The last point shows somewhat increase in the value of heat transfer coefficient which is attributed to end loss causing a temperature drop.
4. The comparison of average heat transfer coefficient is also made with predicted values are somewhat less than experimental values due to the heat loss by radiation.

REFFRENCE

Websites:
1. www.researchgate.net
2 . https://thermalenggoer.files.wordpress.com › . ..
3 . Thermal Conductivity of Insulating Powder - WordPress.com
4 . www.wikipedia.com
5. Youtube: https://youtu.be/tQ4FRnESrjE

Books. :.
1. Frank P.Incopera, David P Dewitt, Fundamentals of Heat and Mass Transfer
2. Fundamentals of Heat and Mass Transfer, M.Thirumaleshwar.
3. Book of Heat transfer of S.P.Sukhatme
4. Vander Heijden. G.H.A, Huinink. H.P, Kopinga.K. (2011),
5. Moisture transport and dehydration in heated gypsum, an NMR study, Chemical Engineering Science
6. T. Rettelbach, J. Säuberlich, S. Korder, J. Fricke, .Thermal conductivity of silica aerogel powders at temperatures from 10 to 275 K., Journal of Non-Crystalline Solids 186, pp. 278-284, 1995
7. J.E. Fesmire, S.D. Augustynowicz, .Thermal Performance Testing of Glass Microspheres Under Cryogenic Vacuum Conditions., Advances in ryogenic Engineering, Vol. 710, Issue 1, June 2004
8. 7. M. Handke, M. Sitarz, E. Długo´n (2011), Amorphous SiCxOy coatings from ladder-like polysilsesquioxanes, J. Mol. Struct. Vol. 993 pp.193–197.