Investigate the Thermal Conductivity of Insulating Powders

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Abstract **– Thermal insulation is one of the major requirements for various industrial applications such as welding, forging, machining, electrical circuits and automotive etc. In this study the evaluation of thermal conductivity is depend upon various temperatures. Initially done the experimental setup followed by s9tandard electrical circuit. By changing the input voltage of heater, then the temperature will be raises. This concept is applied to find the thermal conductivity of various type of insulating powders. In this experiment analyses the conduction heat transfer from outer metal solid body to insulating powder at various controllable heat input. The powders are silica fumed, sodium silicate, mica, foundry sand, wood, cement, white cement, red soil, coal, cement + foundry sand, silica fumed + sodium silicate, and silica fumed + sodium silicate + mica. After, calculate the thermal conductivity of the various powders by using standard calculation procedure. Finally compare the thermal conductivity of above mentioned insulating powders. From this comparison best choice of the insulating powder is select for industrial application.**

Key words: **Thermal Conductivity, Conduction, Insulating Powders, Heat Transfer and thermocouple.**

I. INTRODUCTION

Heat transfer is the transition of thermal energy from a heated item to a cooler item. When an object or fluid is at a different temperature than its surroundings or another object, transfer of thermal energy, also known as heat transfer, or heat exchange, occurs in such a way that the body and the surroundings reach thermal equilibrium. Heat transfer always occurs from a hot body to a cold one, a result of the second law of thermodynamics. Where there is a temperature difference between objects in proximity, heat transfer between them can never be stopped; it can only be slowed down. Classical transfer of thermal energy occurs only through conduction, convection, radiation or any combination of these. Heat transfer associated with carriage of the heat of phase change by a substance (such as steam which carries the heat of boiling) can be fundamentally treated as a variation of convection heat transfer. In each case, the driving force for heat transfer is a difference of temperature.

Conduction is the transfer of thermal energy from a region of higher temperature to a region of lower temperature through direct molecular communication within a medium or between mediums indirect physical contact without a flow of the material medium. The transfer of energy could be primarily by elastic impact as in fluids or by free electron diffusion as predominant in metals or phonon vibration as predominant in insulators. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from atom to atom. Conduction is greater in solids, where atoms are in constant close contact. In liquids (except liquid metals) and gases, the molecules are usually further apart, giving a lower chance of molecules colliding and passing on thermal energy. Heat conduction is directly analogous to diffusion of particles into a fluid, in the situation where there are no fluid currents.

1.1 Thermal Conductivity

In physics, thermal conductivity is the property of a material's ability to conduct heat. It appears primarily in Fourier's Law for heat conduction. Thermal conductivity is measured in watts per kelvin-meter.

1.2 Insulating Material

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions, Conserve energy by reducing heat loss or gain. Control the surface temperatures for personnel protection and comfort. Facilitate temperature control of process, Prevent vapor flow and water condensation on cold surfaces, Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations, Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres, Assist mechanical systems in meeting criteria in food and cosmetic plants, Reduce emissions of pollutants to the atmosphere, The temperature range within which the term "thermal insulation" will apply, is from -75°C to 815°C.

The industrial application of insulating material is increasing day by day. Thermal resistance and crushing strength are most important properties from their application point of view. Like all the other cases, the structure property relationship plays very vital role in achieving and modifying the desired properties in. For example, how much heat flux will flow through the section of refractory body will be determined by the conductivity of the individual phases present, the nature of their interfaces, their distribution etc. The main challenge in producing insulating fire brick is the desired balance between mechanical and thermal properties. For example, in corporation of increased amount of pores may improve thermal resistance but at the same time deteriorate strength. For that reason, optimization of the properties by varying manufacturing parameters can be very significant area of investigation. Among many methods available for manufacturing the insulating bricks, burnout process is most common. In this method, normally an easily combustible bio material is incorporated in the slurry which during firing burns out producing a pore similar to its size. Rice husk saw dust, coal dust etc. have been tried as combustible additives. Different types of additives create their characteristic pores. For example, rice husk gives shaped or longitudinal pores saw dust gives pores of irregular size and coal dust gives spherical size pores. In this present study, coal was first collected and ball milled, then a sieve analysis was carried out to segregate particles of different size range. Chemical analysis of locally collected clay was made and then several batches of specimens (bricks) were made varying the coal particle size and percentage of coal incorporated. The specimens were fired in a furnace after required periods of drying cycle.

1.3 Insulating Types

1. Perpendicular or parallel to the surface being insulated, and they may or may not be bonded together. Silica, rock wool, slag wool and alumina silica fibers are used. The most widely used insulations of this type are glass fiber and mineral wool. Glass fiber and mineral wool products usually have their fibers bonded together with organic binders that supply the limited structural integrity of the products.
2. Cellular Insulation - composed of small individual cells separated from each other. The cellular materials maybe glass or foamed plastic such as polystyrene (closed cell), polyisocyanurate and elastomeric.
3. Granular Insulation - composed of small nodules which may contain voids or hollow spaces. It is not considered a true cellular material since gas can be transferred between the individual spaces. These types are maybe produced as a loose or pourable material or combined with a binder and fibers or undergo a chemical reaction to make a rigid insulation. Examples of these insulations are calcium silicate, expanded vermiculite, partite, cellulose, diatomaceous earth and expanded polystyrene.

1.4 Insulating Properties

Not all properties are significant for all materials or applications. Therefore, many are not included in manufacturers' published literature or in the Table of Properties which follows this section. In some applications, however, omitted properties may assume extreme importance (i.e. when insulations must be compatible with chemically corrosive atmospheres.)

If the property is significant for an application and the measure of that property cannot be found in manufacturers' literature, effort should be made to obtain the information directly from the manufacturer, testing laboratory or insulation contractors association.

The following properties are referenced only according to their significance in meeting design criteria of specific applications more detailed definitions of the properties themselves can be found in the Glossary

1.5 Thermal Properties of Insulation

Thermal properties are the primary consideration in choosing insulations. Refer to the following Glossary for definitions.

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.
6. Thermal resistance "R": Resistance of a material to the flow of heat.

II. EXPERIMENTAL WORK

It is desirable to reduce the heat loss to the surroundings in many heat exchange equipment’s. Insulating materials have a very low value of thermal conductivity and are used in different shapes, sizes and forms. Insulating powder such as sodium silicate, silica fumed, mica, 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.

The power supply to the heating coil by using a dimmer stat and is measured by Voltmeter and Ammeter. Thermocouples are used to measure the temperatures. Thermocouples 1 to 3 are embedded on inner hollow tube and 4 to 6 are embedded on the outer iron tube. Temperature readings in turn enable to find out the thermal conductivity of the insulating powder packed between the two hollow tubes.

Fig 2.1 Experimental components

We assume the insulating powder as an isotropic material and the value of thermal conductivity to be constant. The apparatus assumes one-dimensional radial heat conduction across the powder and thermal conductivity can be determined.

2.1 Raw Material Used

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.

2.2 Specifications

Copper Tube

Inner diameter = 46mm

Outer diameter = 51mm

Length = 22 mm

Iron tube

Inner diameter = 82.6 mm

Outer diameter = 87 mm

Length = 25 mm

III. RESULT AND DISCUSSION

By changing the, input current temperature has been varied. The temperature tabulated based on various power input.

3.1 FORMULAE USED

Heat transfer $Q = \frac{\Delta T}{R}$

Change in temperature $\Delta T = T_i - T_o$

Thermal Resistance $R = \frac{L}{KA}$

Input Power Q = VI

Table 3.1 Sodium Silicate +Silica Fumed

S. No	Voltage	Current	Power Input	Inner Temperatures In °C				Outer Temperatures In °C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	80	1.45	116	61	53	60	58	52	47	51	50	0.10
2	100	1.80	180	100	78	91	82.6	72	65	70	66	0.13
3	100	1.79	179	130	90	118	89.6	83	77	81	69	0.17

Table 3.2 Wood Powder

S. No	Voltage	Current	Power Input	Inner Temperatures In °C				Outer Temperatures In °C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	50	0.93	4605	50	46	51	49	47	46	49	47.3	0.03
2	50	0.93	46.5	60	55	61	58.6	53	53	57	54.3	0.13
3	50	0.93	46.5	70	60	68	66.6	58	58	62	59.3	0.22

Table 3.3 Sodium Silicate Powder

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in°C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	80	1.45	116	70	56	73	66.3	51	59	53	54.3	0.19
2	80	1.45	116	80	66	85	77	60	69	61	66.3	0.17

Table 3.4 Sodium Silicate+Silica Fumed+Mica

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in°C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	70	1.27	88.9	70	65	65	66.6	56	55	68	59.6	0.11
2	80	1.45	116	80	72	74	75.3	62	61	75	66	0.12
3	90	1.62	145.8	100	95	95	96.6	77	76	97	83.3	0.13

Table 3.5 Foundry Sand

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	80	1.46	116.8	80	70	71	73.6	70	64	68	67.3	0.08
2	80	1.46	116.8	90	79	81	83.3	79	70	78	75.6	0.09
3	90	1.62	145.8	100	88	92	93.3	89	77	87	84.3	0.092

Table 3.6 Red Soil

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	80	1.46	116.8	80	74	80	78	78	65	62	68.3	0.12
2	90	1.63	146.7	90	80	89	86.3	87	72	68	75.6	0.10
3	90	1.62	145.8	100	87	96	94.3	95	77	74	82	0.12

Table 3.7 Cement

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	80	1.45	116	80	86	84	83.33	74	67	73	71.33	0.156
2	90	1.64	147.6	100	107	102	103	88	80	88	85.3	0.17
3	90	1.63	146.7	110	118	111	113.3	96	87	96	93	0.205

Table 3.8 White Cement

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	70	1.27	88.9	80	64	70	71.3	56	53	70	59.6	0.19
2	80	1.45	116	90	69	77	78.6	60	57	78	65	0.17

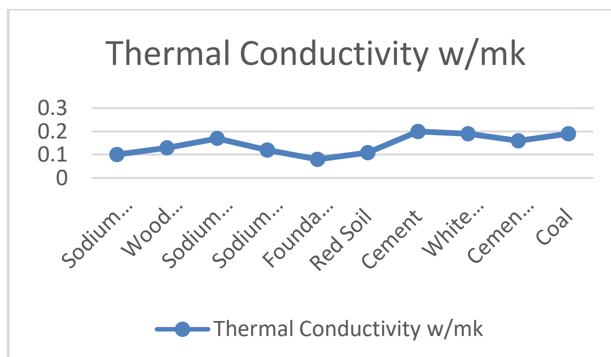
Table 3.9 Cement + Foundry Sand

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	70	1.27	88.9	70	73	71	71.3	64	59	61	61.3	0.16
2	80	1.45	116	90	93	91	91.3	83	75	76	78	0.17
3	90	1.64	147.6	100	94	99	97.6	93	82	95	90	0.05

Table 3.10 Coal

S. No	Voltage	Current	Power Input	Inner Temperatures in°C				Outer Temperatures in° C				Thermal conductivity
	V Volts	A Amps	Q Watts	T_1	T_2	T_3	T_i	T_4	T_5	T_6	T_0	K W/m K
1	60	1.09	65.4	64	62	56	60.6	49	60	48	52.3	0.19
2	70	1.27	88.9	76	70	64	70	59	69	58	62	0.13
3	80	1.45	116	88	80	72	80	78	64	62	68	0.15

Fig 4.1 Thermal Conductivity of insulating powders



As the tabulation and graph shows in figure the thermal conductivity of various insulating powders .the low thermal conductivity materials are sodium silicate +silica fumed, wood, foundry sand, sodium silicate +silica fumed +mica and red soil. The high thermal conductivity of materials is sodium silicate, cement, white cement, coal, foundry sand + cement.

The high thermal conductivity, materials are widely used in IC packages, heats sink application etc. The low thermal conductivity materials are used in thermal insulation, air plane engines etc.

IV. CONCLUSION

Sodium silicate thermal conductivity 0.15 it is used as binder of, it is used to vermiculite and pearlite .it is used to make hard, high temperature insulation boards used for reface to rise and moulded pipe insulation application. Wood thermal conductivity is 0.11 are used for light up cement has long been used when erecting motors has long been used when bonding logs together.

Coal thermal conductivity is 0.19 coal is used for teeth brushing stained from coffee, tea, wine or berries is used for charcoal helps white on teeth white promoting good oral healthy. The ph balance in, water filtration activated char coal is used coal

Foundry sand having thermal conductivity of is used for moulding sand also used as automotive industry and its parts major generator of foundry sand. it is used to control the temperature of sand.

Red soil is having thermal conductivity of is 0.10 used agriculture for crops such as paddy , sugarcane it having high iron content and it is fit for crops it is used for manufacture of bricks from red soil.

Cement is having thermal conductivity of 0.12 is used in silica and silica fumed as add to mixture ,the specific heat to increase by up to and the thermal conductivity to increase by up to 38 %

White cement thermal conductivity 0.17 is used for combination of aggregates for produce white cement concrete for construction work of the project and decorative work it is also used for concrete specially application to increase safety.

Mica having thermal conductivity of 0.58 it is used as decorate traditional water clay pots, mica powders used as filler in rubber as flax extends in paints as in electrode coating and water proof packing and roof material. it is also used in cosmetics because high thermal conductivity. In this experimental setup conclude that thermal conductivity various insulating powders have been found.

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