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# Evaluation of Thermal Conductivity of Insulations Prepared from Mixture of Rice Husk and Plaster of Paris

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**Abstract—***The present insulating materials used in industry are harmful to environment and also causes health problems in humans. The purpose of this experimental investigation was to find out an insulating material which could be readily available locally, relatively cheaper and also more environmental friendly than existing industrial insulators. The mixture of Rice husk and Plaster of Paris was selected to be used as insulation materials. The experimentation was done to analyses the effect of increase in concentration of Rice husk in mixture on the insulating properties of insulation and to determine that what could be the best possible combination of mixture of these two insulating materials which could provide better thermal conductivity as well as strength to the insulation. The set-up was designed to measure temperature across two sides of insulation that was prepared by mixing Rice husk and Plaster of Paris. Three different samples containing different proportions of mixture of Rice husk and Plaster of Paris were prepared. Temperature differences were measured across both the sides of insulations by using thermocouples and thermal conductivity was measured using Fourier's law of heat conduction. The results revealed that selected materials namely mixture of Rice husk and Plaster of Paris are good alternative sources for industrial insulators as their thermal conductivity values are comparable to the existing industrial insulators and also that addition of rice husk to mixture should be made only up to an certain level as large concentration may increase porosity of insulation used which may allow more heat to flow through it and hence increasing thermal conductivity.*

## 1. INTRODUCTION

Thermal conductivity is the physical property denoting the ease with which a particular material allows the transmission of heat energy by molecular motion through conduction mode of heat transfer. To prevent the conduction of heat energy, there is a need for insulation. Insulation is the act of preventing the flow or passage of heat, electric, or sound energy through a material, medium or system. However thermal conductivity is specifically used in such cases in which one wishes to obstruct the flow of heat between enclosure and its surroundings. Therefore, determining the thermal conductivity of selected materials namely a mixture of Rice husk and Plaster of Paris will determine whether they can be used for thermal insulation purposes or not.

The use of inorganic insulating materials may be harmful to human health and body and causes environmental pollution **[**1**]**. The production of these materials require high energy consumption and the eventual disposal can cause environmental hazard[2]**.**Common thermal insulators are fiberglass, rock wool, asbestos sheet, mineral wool, but they are environmentally hazardous. The small particles from fiber glass and glass wool insulation can cause health hazard and respiratory or skin irritant (Occupational Safety and Health Administration, 2003, a federal agency of USA that regulates workplace safety and health abbreviated as **OSHA**). Most thermal insulation baths contain formaldehyde resin that can cause asthma (US Environment Protection Agency 2000). Cellulose insulation with toxic, fire-retarding chemicals like boric acid have been identified as having the potential for significant health effects (**OSHA, 1999**). Thermal insulation materials must contain the following physical properties- low thermal conductivity, moisture protection and mould and fire resistance. In addition to these environmental and health impact must also be considered. Since current popular insulation materials have negative side effects from the production stage until the end of their useful lifetime the search for alternative insulation materials become necessary. Therefore the alternatives materials with same or better properties as the conventional materials need to be exploded as it can offer lower cost **[**3**]**.

Renewable fibrous thermal insulation from trees, plant or animals has the ability to regenerate itself and it requires less energy for production and biodegrade easily when disposed as waste hence have low environmental impact **[**4**]**. Using agricultural by products as thermal insulation also generates economic development for farming in rural areas.

A cheap reliable and abundant supply of biodegradable fibrous materials can be obtained as waste by-products from many commercial agricultural processing industries [5]**.**

Materials such as Rice husk, coconut and sugarcane fiber, cotton, wheat straw, palm leaves, oil palm fiber and others consist of lignocelluloses fibers which can be used as alternative insulation materials. Agricultural wastes such as rice hulls, sugarcane stalks, coconut husk, corn cob or stalk oil palm shell and leaves or straw from cereal crops have high degree of fibrous content (ligno-cellulosic compound) and can serveAs the main ingredient for composite materials making them suitable for manufacturing insulation boards.

## 2. MATERIALS AND METHODS

The materials used in this work are Rice husk and Plaster of Paris. Rice husk contains 75-90 % organic matter such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements. Presence of high amount of silica makes it a valuable material for use in industrial application. Other constituents of Rice Husk Ash (RHA), such as Potassium oxide ($K_2O$), Aluminum oxide ($Al_2O_3$) Calcium Oxide (CaO), Magnesium Oxide (MgO), Sodium oxide ($Na_2O$), Iron oxide ($Fe_2O_3$) are available in less than 1% [6]. Plaster of Paris**,** quick-setting gypsum plaster consisting of a fine, white powder, calcium sulphate hemihydrate($CaSO4.2H_2O$)which hardens when moistened and allowed to dry. Plaster of Paris is prepared by heating calcium sulphate dehydrate, or gypsum, to 120°–180° C (248°–356° F). The results obtained show that, P.O.P exhibits the one of the best insulation properties with thermal conductivity of 0.1185w/mk, and thermal resistivity of 8.4388mk/w [7].

Three Insulating boards each of different compositions made from mixture of Rice husk **and** Plaster of Paris (P.o.p) were prepared. The weight of each board was 2000grams.All three insulating boards contained different concentrations of mixture of rice husk and plaster of Paris (P.o.P).Three samples are shown in Fig. 1.

**Fig. 1: Samples being prepared**

Each of the samples weighs 2000grams and has dimensions of 400mm x 400mm x 10mm.

Sample A = 1% Rice husk and 99% Plaster of Paris [20 grams Rice husk and 1980grams Plaster of Paris].

Sample B = 3% Rice husk and 97% Plaster of Paris [60 grams Rice husk and 1940grams Plaster of Paris].

Sample C = 5% Rice husk and 95% Plaster of Paris [100gramsRice husk and 1900grams Plaster of Paris].

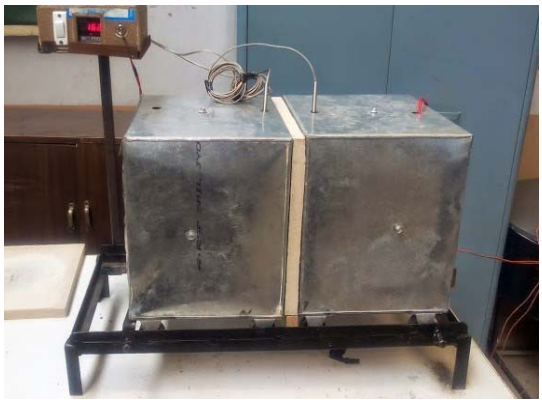

**Fig. 2: A set up designed for conducting experiment**

An experimental set up as shown in Fig. 2 used to conduct an experiment. Heating coil of 1000 watt capacity was placed in one of the boxes (in the right box shown in Fig. ).In between the two boxes were placed Samples A, B, C one by one .Thermocouples were placed in each of the inner boxes on both right as well as left side for measuring temperature$T_1$and $T_2$.Thermocouples were connected with thermal indicator which indicated exact temperatures in both the inner boxes. Temperatures $T_1$ and $T_2$ were recorded at initial time ($t_{1=}$ 0 minutes) and again after ($t_2$=45minutes) for each of the samples. Temperature differences were measured across both the sides of insulations by using thermocouples and thermal conductivity was measured using Fourier's law of heat conduction. Following readings were recorded.

| Insulating Boards | Times at which readings were taken [t1=initial time and t2= time after 45 minutes] | Temperature in Box 1 containing Heating coil [T1 in o C ] | Temperature in Box 2 [T2 in o C] |
|---|---|---|---|
| Sample A | t1= 0 minutes | 35o C | 35o C |
| | t2= 45 minutes | 426o C | 97 o C |
| Sample B | t1= 0 minutes | 38o C | 38 o C |
| | t2= 45 minutes | 443o C | 85o C |
| Sample C | t1= 0 minutes | 38 o C | 38o C |
| | t2 = 45 minutes | 432o C | 95 o C |

### Thermal Conductivity Measurements

Fourier's Law of heat conduction was used to find thermal conductivity. It states that the rate of heat flow, Q, through a homogeneous solid is directly proportional to the area, **A**, of

the section at right angles to the direction of heat flow, and to the temperature difference along the path of heat flow, d**T**/d**x.**

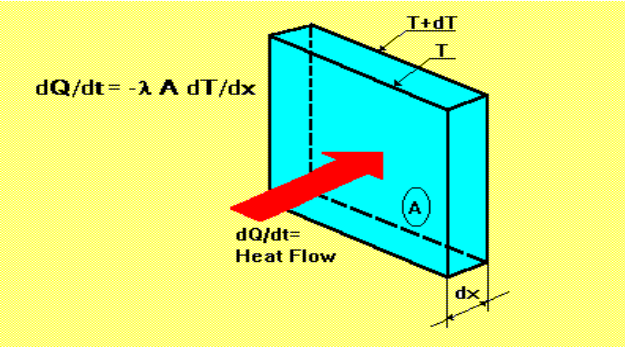


**Fig. 3: Fourier Law of heat conduction**

The rate equation for one dimensional steady flow of heat by conduction is prescribed by the Fourier law:

Q= -kA dT/dx

Where

Q= heat transfer rate [in watts].

A = area of heat transfer surface [in $m^2$].

k = thermal conductivity of material [in Watt/meter Kelvin]

dt = temperature differences in between two boxes [in Kelvins]

dx = thickness of insulating boards[in m]

Following Thermal conductivity values were found for each sample.

Sample A = 0.103794Watt/meter kelvin.

Sample B = 0.099025Watt/meter kelvin.

Sample C = 0.10243 Watt/meter kelvin

## 3. RESULTS AND DISCUSSION

It was seen from the above results that thermal conductivity of all three samples are comparable to thermal conductivity values of some of existing industrial insulators as shown in Table2 . However, unlike some of the existing insulators the selected material used in study is environmental friendly, cheaper and less toxic. Using these materials may result in reduced insulation costs and cleaner environment. Sample A has a thermal conductivity of 0.103794 W/mk while Sample B has a thermal conductivity values of 0.099025 W/mk and Sample C has a thermal conductivity of 0.10243 W/mk. In Sample A where addition of 1% Rice husk was made, it had little effect on insulation properties of Plaster of Paris. Sample a showed thermal conductivity values very similar to Plaster of Paris (P.O.P). Sample B containing 3% Rice husk showed the lowest thermal conductivity of 0.099025 W/mk for all the samples. The reason why sample B showed the lowest thermal conductivity can be attributed to the fact that this sample contained an ideal percentage of mixture of Rice husk and Plaster of Paris which could provide better insulating properties as well as strength necessary for insulation , the 3% Rice husk proved to be an ideal concentration in sample which provides well packed structure and porosity was much less which did not allowed heat to flow through insulation. As concentration of Rice husk was increased to 5% the thermal conductivity again showed increasing trend. The thermal conductivity values of 0.10243W/mk was recorded. The decreasing trend is due to the fact that with the increase in concentration of rice husk in the mixture the porosity of structure increased to an extent that more heat than Sample B could flow through the insulating board and hence thermal conductivity recorded was higher than Sample B.

**Table 2: Insulating Materials and their Thermal Conductivity at Temperatures below 500°C**

| S.NO | Existing industrial insulators | Thermal conductivity [in W/mk] | References |
|---|---|---|---|
| 1. | Glass[ordinary] | 1.4 | [9] |
| 2. | Asbestos sheet | 0.166 | [8] |
| 3. | Rubber | 0.15 | [8][9][10] |
| 4. | Fibre glass | 0.043 | [8][9][10] |
| 5. | Mineral fiber | 0.108 | [9] |
| 6. | Cork board | 0.043 | [8][9][10] |
| 7. | Cellulose | 0.23 | [9] |
| 8. | Glass wool | 0.0543 | [8][10] |

## 4. STRENGTH OF SAMPLE

In view of application of sample we applied load on sample gradually as compared to insulation which is available in the market. Load is gradually increased first on the insulation which is available in the market which goes up to 35kg and after that crakes are appeared as shown in fig.04. Then load is gradually raised on 3 % rice husk sample up to 48 kg and even after that sample B shows no crakes as shown in fig.05.

**Fig. 4: Market Insulation** **Fig. 5: Sample B.**

## 5. CONCLUSION

The result of this study established that selected materials namely mixture of Rice husk and Plaster of Paris are good alternative sources for industrial insulators as their thermal conductivity values are comparable to the existing industrial insulators. Therefore they can be used as industrial insulators. However, unlike some of the existing insulators the selected materials are readily available locally, relatively cheaper and also more environmental friendly than existing industrial insulators. Hence using these materials as alternative sources for Industrial insulators will result in reduced insulation cost and cleaner environment.

It was also found out from the study that in sample A where addition of 1% Rice husk was made ,it hardly had an effect on insulation properties of Plaster of Paris, sample showed thermal conductivity values very similar to Plaster of Paris(P.O.P). As concentration of Rice husk was increased to 3% the better insulating properties were observed as it contained an ideal percentage of mixture of Rice husk and Plaster of Paris which provided best combination of insulating properties, strength and porosity. With further increase in concentration of rice husk in mixture to 5% the porosity of structure increased to an extent that more heat could flow through insulating board and hence thermal conductivity recorded was higher than Sample Hence, it could be concluded that for this materials to be used as insulation in industrial applications, the best possible combinations of both materials should be selected, as larger concentration of Rice husks may increase porosity to an level which may allow heat to easily flow through insulation.

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