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AN EXPERIMENTAL STUDY FOR THE INVESTIGATION OF THERMAL CONDUCTIVITY FOR DIFFERENT NATURAL INSULATING MATERIALS

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ABSTRACT

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. Thermal insulators are often used in heat exchanging devices for increase in heat transfer. Over the years many theists' have tried to find efficient and safe means to establish thermal insulation between heat generating systems. This report mainly focuses on heat transfer through systems working on a low heat input. The materials used in this experimental project are available in abundance around us. In this paper, the thermal conductivity for the insulating powders have been determined viz., rice husk, rice bran, paddy straw, millet husk, millet straw, jute and combinations. These materials are freely available in nature and are extremely safe when exposed to heat. Mixture of these materials with any sort of resin can be used as an effective heat insulator. The experimental study deals with the estimation of thermal conductivity of various materials in its powdered form. The intermittent temperature values are used to find thermal conductivity. Different trials are conducted using different materials and their mixtures. The study is done at different heat inputs. Comparison between the heat input and the thermal conductivity has been accounted.

INTRODUCTION

Heat transfer occurs at a lower rate across materials of low thermal conductivity than across materials of high thermal conductivity. Correspondingly, materials of high thermal conductivity are widely used in heat sink applications and materials of low thermal conductivity are used as thermal insulation. The thermal conductivity of a material may depend on temperature. Thermal conductivity is actually a tensor, which means it is possible to have different values in different directions. The thermal boundaries are predominantly determined using traditional methods. The values of thermal conductivity are plotted against the respective heat inputs and are compared with different materials.

The importance of heat transfer in day to day life has reached a brim where plastic insulation finds its draw backs. This can be clearly overcome by the use of eco friendly insulators. These insulators work under a low heat input but cause no harm to the ecological balance. Plastic insulators over heating can emit harmful toxins due to high order chemical reactions. The aim of this project is to cut down the hazards caused by plastic insulators and help mankind man over its effects on the environment. The experiment is conducted on a setup made for the estimation of thermal conductivity of insulating powders. The main drawback of these organic insulators is that it can be used only for systems having a maximum heat input of 100 V. Above this temperature these materials lose its conduction property and start to burn. Small gadgets working on low heat inputs can be easily protected from heat surges using these materials. The enhancement of devices over the past few years have forced researchers to find efficient and harmless means to emit the heat generated by these systems. The introduction of such organic insulators will enable users to use these gadgets without being afraid of the hazards that they lay forth. The mixture of these materials with epoxy resin finds a lot of applications in today's world [1].

Insulation materials are the key tool in designing and constructing energy thrifty buildings. This is demonstrated by the increasing thicknesses used in buildings, which also reflects in the growing sales of the branch. The European market of insulation materials is characterised by the domination of two groups of products inorganic fibrous materials and organic foamy materials. They all feature similar performance in terms of insulating capabilities, but otherwise present significant differences. These are discussed in detail in the following paper.

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The materials used here in this experiment are derived from simple fibre category. Rice husk and rice straw is derived from paddy which is grown in abundance around. Jute is derived from fibrous strands of various long strand fibres. Millet husk and millet straw is derived from millet [2, 3].

Despite the fact that the thermal properties of the materials has not improved significantly of the last decade, a series of other features, like reaction to fire and moisture or mechanical properties have improved, sometimes even at the cost of insulation abilities. Furthermore, environmental and public health aspects play an increasing role, both in the search for 'optimum' materials for given applications, and in the aims set by the industry for future developments. These aims, examined within the legislative and market framework, are discussed in this study, both as criteria for evaluating state of the art materials and as goals for future research development. The materials used here are available in abundance and work well when used as insulators. This study deals with the determination and comparison of the thermal conductivity for different natural materials in their powdered form. These materials when combined show good results due to the variation in thickness of the different powders.

Tools for predictions of plasma properties in the last 50 years have evolved from largely analytic representations, for example using Bessel functions, to the present methods, which extensively use computers. Furthermore, there is a marked unification of predictive capabilities, spanning the use of basic atomic and molecular data such as electron–atom cross-sections, leading to the calculation of transport coefficients such as thermal and electrical conductivities and finally to detailed predictions of plasma processing, e.g. the influence of fluxes on weld profiles in arc welding. Present calculations in the range of different directions are outlined, all likely to lead to new developments in the future. There are plenty of cheap and common insulation materials available on the market today. Many of these have been around for quite some time. Each of these insulations have their own ups and downs. As a result, when deciding which insulation material you should use, you should be sure to be aware of which material would work the best in this situation. This research mainly focuses on heat transfer through systems working on a low heat input. The materials used in this experimental project are available in abundance around us. The thermal conductivity of the following insulating powder are determined; Rice husk, rice bran, paddy straw, millet husk, millet straw, jute and combinations. These materials are freely available in nature and are extremely safe when exposed to heat. Mixture of these materials with any sort of resin can be used as effective heat insulation [4, 5].

Attempts to measure the thermal conductivity of poorly conducting materials date back to the mid-19th century when Peclet [1], a French physicist, determined the thermal conductivity of various common solids. Peclet used insulated rectangular plates heated with steam on one side and exposed to ambient air on the other to perform his measurements. Richard Poensgen [1] of Germany developed the original version of the guarded hot-plate insulation test method in 1912. This test method has undergone a number of improvements and modifications, but it continues to be the most widely used thermal conductivity testing method to date.

Previous research has provided an excellent starting point for the current experiment. Many thermal conductivity measurements have been recorded for powder insulation; however, the majority of these measurements are taken between LN2 and room temperature. Several measured thermal conductivity values of different types of insulation. Direct comparison of our data can be made with the data from Rettelbach et al [2].

Jute nanofibers (JNFs) were prepared by treating jute fibres with alkali and dimethyl sulfoxide (DMSO) and then applying acid hydrolysis and were characterized by transmission electron microscopy, scanning electron microscopy, atomic force microscopy, and X-ray diffraction. The JNFs exhibited both spherical an elliptical shapes, with diameter in the range of 50−120 nm. Biocopolyester matrix was reinforced with JNFs at three different loadings (5, 10, and 15 wt %), and the JNF-loaded bio composites were characterized by X-ray diffraction, tensile testing, differential scanning calorimetric, and moisture uptake results. The enhancement in properties was highest for 10 wt % JNF-loaded composites, indicating the most uniform dispersion in this material where the work was carried out by K T B Padal, K Ramji, V V S Prasad [3].

Experimental studies on the mechanical and viscoelastic behaviour of jute fibre reinforced high density polyethylene (HDPE) composites have been conducted in the near past. Variations in mechanical strength, storage modulus (E'), loss modulus (E'') and damping parameter (tan δ) with the addition of fibres and coupling agents were investigated. It was observed that the tensile, flexural and impact strengths increased with the

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increase in fibre loading up to 30%, above which there was a significant deterioration in the mechanical strength. Dynamic mechanical analysis data showed an increase in the storage modulus of the treated composites The tan δ spectra presented a strong influence of fibre content and coupling agent on the α and γ relaxation process of HDPE. The thermal behaviour of the composites was evaluated from Thermo Ggravimetric Analyzer/Dynamic Thermal Analyzer thermo grams. The fibre–matrix morphology in the treated composites was confirmed by Scanning Electron Microscope analysis of the tensile fractured specimens [4].

`Chopped jute fibre-epoxy composites with varying fibre length (2-12 mm) and mass fraction (0.05-0.35) had been prepared by a heat press unit. The cross-linked product was characterized in terms of specific gravity, thermal conductivity, tensile strength, Young modulus and elongation at break. The transverse thermal conductivities for randomly oriented fibres in the composite were investigated by Lees and Charlton's method. The tensile strength, Young modulus and elongation at break were investigated by a Universal Tensile Tester. It has been concluded that, jute fibre-epoxy composite could be used as a good heat-insulating material. Further investigation is recommended on the improvement of the thermal insulation keeping the mechanical properties unchanged or even improved. The thermogravimetric study has been required to ascertain the field of application of the material [5].

Long and random hemp and kenaf fibres were used in the as-received condition and alkalized with a 0.06 M NaOH solution. They were combined with polyester resin and hot-pressed to form natural fibre composites. The mechanical properties of the composites were measured to observe the effect of fibre alignment and alkalization. A general trend was observed whereby alkalized and long fibre composites gave higher flexural modulus and flexural strength compared with composites made from as-received fibres. Alkalized long kenaf–polyester composites possessed superior mechanical properties to alkalized long hemp–polyester composites. For the hemp–polyester composites a high flexural modulus and a high flexural strength are associated with a low work of fracture. Scanning electron microscopy micrographs of the treated hemp and kenaf fibres showed the absence of surface impurities which were present on the untreated fibres. Apparent density measurements on hemp and kenaf fibres did not show a significant change after alkalization with 0.06 M NaOH. Wide endothermic peaks present in differential thermal analysis thermo grams for all of the composites indicated the presence of moisture which leads to inferior mechanical properties. Dynamic mechanical thermal analysis carried out on the polyester matrix composites showed that the alkalized fibre composites have higher E' values corresponding to higher flexural moduli [6].

The current paper deals with the revolution of having insulations with least amount of surface impurities. The materials used in this investigative study have least amount of surface impurities and are least reactive when exposed to extreme conditions. The mixture of these materials with certain organic adhesives can help solve a lot of problems faced in the reaction phase of engineering. Some of these reactions can be hazardous and are highly irreversible. The removal of excess heat generated in systems today focus on some parameters which need to be maintained. The introduction of these materials in powder or any other solid form can relate to subsequent systems without a reactive phase. In context the thermal conductivity and heat flow of these materials are analysed and compared.

METHODOLOGY AND FORMULATION

The experimental study deals with the estimation of thermal conductivity of various materials in its powdered form. The intermittent temperature values are used to find thermal conductivity. Different trials are conducted using different materials and their mixtures. The study is done at different heat inputs. Comparison between the heat input and the thermal conductivity is accounted.

TECHNICAL SPECIFICATIONS:

1) Inner sphere dia. - 50 mm.

2) Outer sphere dia. - 100 mm.

3) Heater – Ni-Chrome wire sandwiched between mica sheets at 60 Ohm and 200 volts.

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4) Control Panel Comprising of –(a) Voltmeter: 0 -100/200 Volts (b)Ammeter : 0 - 2A (c) Dimmer stat: 0 - 240 V, 2A and (d) Digital Temperature Indicator from 0 – 300 C.

INSULATING MATERIALS USED:

1) Asbestos.

2) Rice husk.

3) Rice bran.

4) Rice straw.

5) Millet husk.

6) Millet straw.

7) Jute.

8) Combinations.

The experimental setup used for the determination of the thermal conductivity of the insulating materials is as shown in the fig. 1. The specifications and prerequisites of this experiment are as mentioned above. The spherical shaped container comprises of two cavities i.e. Inner sphere and the outer sphere. This area is completely filled with the insulating material. The temperature values at intermittent points are noted. With these values we are able to calculate the thermal conductivity of the material used. The heat flow and thermal conductivity comparisons are made by plotting respective graphs.

Fig. 1. Experimental setup for the determination of thermal conductivity

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EXPERIMENTAL RESULTS AND DISCUSSIONS

Fig. 2 and 3 depicts the variation of thermal conductivity with heat input and temperature. After comparing the results of different materials we can clearly state that the working heat input of these materials is limited to 100 V. Further higher temperature is noted to be a little less than 373 K. From fig. 2, it can be clearly stated that, asbestos have a reasonable thermal conductivity. However the combination materials exhibit similar thermal conductivity to asbestos. Hence they can be used as a replacement for a variety of applications. From fig. 3, rice husk has maximum thermal conductivity.

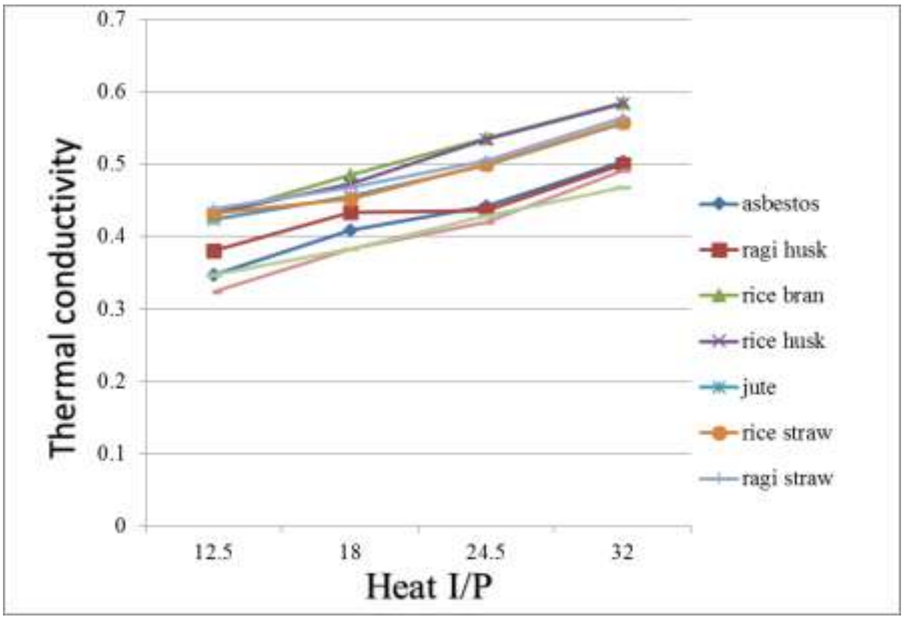

Fig.2. Thermal Conductivity v/s Heat input

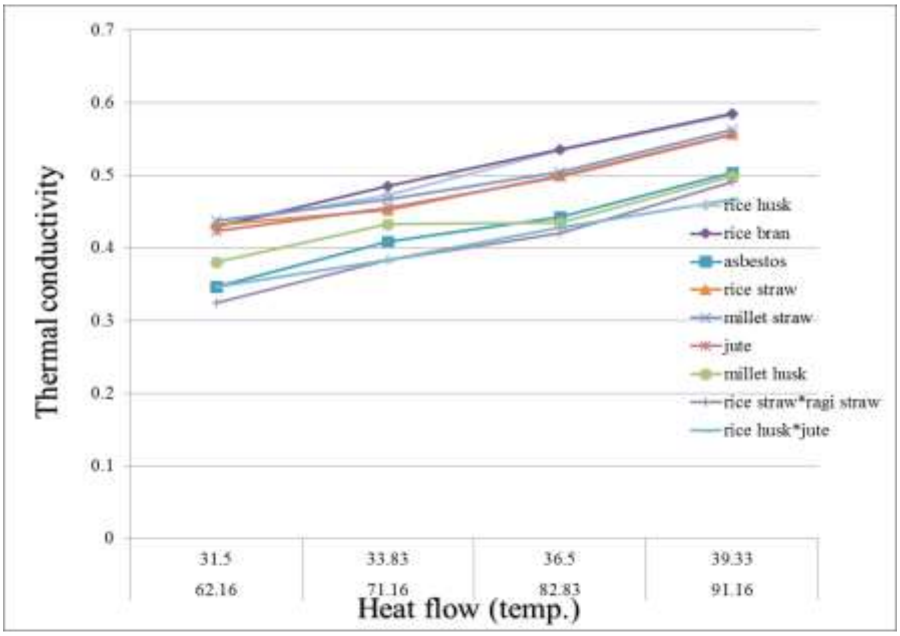

Fig.3 Thermal Conductivity v/s Temperature

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Table 1 depicts the comparison of different insulating materials with heat input.

MATERIALS	THERMAL CONDUCTIVITY	HEAT INPUT
Asbestos powder	0.347, 0.409, 0.422, 0.503	50, 60, 70, 80
Rice husk powder	0.380, 0.433, 0.435, 0.499	50, 60, 70, 80
Millet husk powder	0.429, 0.485, 0.535, 0.669	50, 60, 70, 80
Millet straw powder	0.432, 0.472, 0.524, 0.583	50, 60, 70, 80
Rice bran powder	0.432, 0.452, 0.500, 0.557	50, 60, 70, 80
Rice straw powder	0.438, 0. 467, 0.504, 0.556	50, 60, 70, 80
Jute powder	0.423, 0.455, 0.498, 0.556	50, 60, 70, 80
Rice straw powder millet and husk powder	0.324, 0.383, 0.420, 0.491	50, 60, 70, 80
Rice husk powder andjute powder	0.347, 0.383, 0.428, 0.467	50, 60, 70, 80

CONCLUSIONS

It can be clearly concluded, that these materials can be used in gadgets having a low heat interface. Since the absence of surface impurities reaction over heating is absent. The combination of these materials depicts a much more appreciative result. The above results tell us that these materials are freely available and exhibit a fair amount of conduction property. The conductivity of the combination materials is much better since the particles are closely packed. This allows more amount of heat to be conducted at a faster rate. From this study, it can be concluded that, the use of these materials can bring about great changes in the field of extinguishing the heat generated in thermal systems effectively. The graphs tell us that the best result is obtained for combination of these natural powders. Applications of these materials are vast and find itself in a lot of domestic applications. These insulating materials can be used to make cement which finds a plethora of applications around us.

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