American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-12, pp-34-40
www.ajer.org

Research Paper Open Access

Investigation on Thermal Properties of Composite of Rice Husk, Corncob and Baggasse for Building Thermal Insulation

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ABSTRACT: *The thermal properties of some Agricultural waste (Rice Husk, Bagasse and Corncob) was investigated with the purpose of determining their use as insulators. Using varied composite percentages of each sample wastes at increasing and decreasing quantities to determine best mixtures has assisted in accurate recommendation. The work has explored the potentials for using composite samples of Rice Husk, Bagasse and Corncob as materials for thermal insulation, a solution which offers a reduction in resource use, promote recycle of the wastes, less dependent on toxic chemical types in wood/cellulose based insulators, in addition to reducing energy consumed by altering internal air conditions.The criteria for evaluation includes experimental determination of Thermal Conductivities and Specific Heat Capacities for composites samples and other dependable properties.The results from evaluations have identified that sample G with 0.231Wm^{-1}k^{-1}and 22.114m^{-1} is the best mixed with more rice husk and considerable percentage of bagasse to less percentage of corncob.*

Keywords. *Agricultural Waste, Thermal properties, composites, insulation.*

I. INTRODUCTION

. .For quite some time many buildings seems not to be habitable due to the uncontrollable environmental conditions. Hence the use of artificial air conditioning and the need for cheaper, faster cooling condition around oneself has becomes a necessity. Energy demand in building can be significantly reduced with the use of thermal insulation. The use of thermal insulation in walls and roofs can reduce the demand for air conditioning thereby reducing the cost of cooling and pollution of the environment.(Panyakaew and Fotios 2008, Radhi 2008,)

Municipal and Rural Affairs Minister of Saudi kingdom Prince Mansour bin Miteb announced on 22 october 2014 at the opening of the Saudi Energy Efficiency Forum and Exhibition 2014, being held at the Riyadh International Convention and Exhibition Center. that the government would soon make it mandatory for buildings to have thermal insulation in 24 major cities to save on rising energy costs. According to him about 70 percent of residential buildings in the country lack thermal insulation."Thermal insulation will rationalize the consumption of energy and bring many benefits to the country and its citizens. but the development of new thermal insulation material requires knowledge of the thermo-physical properties of materials.

The use of inorganic insulating materials may be harmful to human health and body and causes environmental pollution. (Liang and Ho, 2007). The production of these materials will require high energy consumption and the eventual disposal can cause environmental hazard (Panyakaew and Fotios, 2008).

Common thermal insulators are fiberglass, rock wool and 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 (OSHA, 2003) most thermal insulation baths contain formaldehyde resin that can cause asthma (US EPA 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 (Papadopoulos, A.M., 2005) 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 (Moh'd Yakama et al 2011), one of the alternative materials that is being widely investigated is natural fiber which is cheap and easy to get (Guilbert et al 2011). 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. (Mamohar, 2012). Using agricultural by products as thermal insulation also generates economical development for farming in rural areas. (Panyakaew and Fotios 2008).A cheap reliable and abundant supply of biodegradable fibrous materials can be obtained as waste by-products from many commercial agricultural processing industries (Rodriguez et al 2011). Materials such as coconut and sugarcane fiber, cotton, wheat straw, palm leaves, oil palm fiber and others consist of lignocelluloses fibers which are alternatives. They are biodegradable, renewable, environmentally friendly building thermal insulators. (Zhou et al 2010).

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 (lingo-cellulosic compound) and can serve as the main ingredient for composite materials making them suitable for manufacturing boards or panels. Baggase can be made into soft bearch, medium density hardboard or particle boards as well as high density hardboards (26) The aim of this research is to investigate the potential of agricultural waste as thermal insulation materials.

II. MATERIALS AND METHODS

2.1. Apparatus

The HILTON Thermal Conductivity Apparatus at Thermodynamics Laboratory of Abubakar Tafawa Balewa University Bauchi was used. The linear section was used to determine thermal conductivity of the samples under investigation. Cooling water was feed into one side of the apparatus to maintain a steady gradient.

The instrumentation provided permits accurate measurement of temperature and power supply. Quick response temperature probes, with a resolution of 0.1^{o} C gives an accurate digital readout in degrees centigrade. On the apparatus, a power control to provide continuous variable electrical output of 0-100 watts with direct readout was made available

2.2. Materials and Sample Production

The materials were collected at the Muda Lawal market and Yelwa metropolis. They were screened for dirt (sands and grease) and other impurities. They were cleaned and grinded to smaller particle sizes of 0.075mm Larger unmeshed particles were re-grinded and sieved again until uniform sizes were obtained. Sample mixed in various percentages were also combined with 5% binder (starch)/water) to ensure proper compaction. The total mixtures were filled into the mould and compacted and allowed to dry for some hours and was cured under the sun for 2 to 5 days (depending on atmospheric condition). A total of nine samples were produced in different percentage composition as shown in Table 1. Below.

Plate A. P.A Hilton Thermal Conductivity Apparatus

Plate B. Pictorial Views of Sample after Curing.

Table 1: Composition of Samples Mixture in Percentages

Samples	Rice husk %	Corncob %	Bagasse %
Sample A:	40	30	30
Sample B:	30	30	40
Sample C:	30	40	30
Sample D:	50	25	25
Sample E:	25	25	50
Sample F:	25	50	25
Sample G:	60	20	20
Sample H:	20	20	60
Sample I:	20	60	20

2.3. Determination of Thermal Conductivity

The HILTON Heat Conduction apparatus was used to measure Heat across a circular sample linearly under various temperatures; it was also used to carry out the Thermal Conductivity measurement across our composite samples,

The temperature displayed on the apparatus in conduction experiments were read from six sensor point as named T_1,T_2,T_3,T_7,T_8 and T_9. These describe temperature profile across heater, sample and cold section. The Power from heater was kept at 15W.

Thermal Conductivity was computed by running a script on MATLAB using the six sensor readings Tabulated on Table 2. Extrapolation between T_4 and T_6 was done to obtain accurate results. Using MATLAB (scripted code), it generated corresponding polynomials to match T_1,T_2 and T3 for hot section to the right above and T_7,T_8 and T_9 cool section below the graph to the left.

III. RESULTS

Table 2. Thermal Properties of Composite Sample of Rice Husk, Bagasse and Corncob

Sample	Thermal Conductivity (k) $Wm^{-1}K^{-1}$	Specific heat Capacity (c) $Jkg^{-1}K^{-1} \times 10^3$	Thermal Resistivity (r) $W^{-1}mk$
Standard Error	**±0.002**	**±0.006**	**±0.1367**
Sample A	0.2749	1.7393	3.6377
	0.3188	1.8610	3.1368
Mean value	**0.29685**	**1.8002**	**3.38725**
Sample B	0.3058	1.1644	3.2701
	0.3142	1.2847	3.1827
Mean value	**0.31**	**1.22455**	**3.2264**
Sample C	0.3768	1.9853	2.6539
	0.3741	1.9162	2.6731
Mean value	**0.37545**	**1.95075**	**2.6635**
Sample D	0.3059	1.1510	3.2690
	0.3363	1.2076	2.9735
Mean value	**0.3211**	**1.1793**	**3.12125**
Sample E	0.2461	0.5775	4.0634
	0.2566	0.7758	3.8971
Mean value	**0.25135**	**0.67665**	**3.98025**
Sample F	0.4445	0.9336	2.2497
	0.5440	0.8877	1.8382
Mean value	**0.49425**	**0.91065**	**2.04395**
Sample G	0.1961	1.1569	5.0994
	0.2660	1.3138	3.7594
Mean value	**0.23105**	**1.23535**	**4.4294**
Sample H	0.3045	0.6613	3.2841
	0.2729	0.8427	3.6644
Mean value	**0.2887**	**0.752**	**3.47425**
Sample I	0.3415	0.6833	2.9283
	0.3085	0.4522	3.2415
Mean value	**0.325**	**0.56775**	**3.0849**

Table 3: Table of Samples Parameters as Determine after Production

Sample	Specimen	Weight kg (10^{-3})	Thickness m (10^{-2})	Diameter m (10^{-2})	Area m^2 (10^{-3})	Volume m^3 (10^{-6})	Density Kg/m^3
Sample A	1	3.0	0.39	4.3	2.904	5.663	529.76
	2	3.6	0.40	4.1	2.641	5.280	681.82
Sample B	1	3.5	0.40	4.1	2.641	5.280	662.88
	2	3.5	0.40	4.1	2.641	5.280	662.88
Sample C	1	4.6	0.50	4.1	2.641	6.600	696.96
	2	4.5	0.50	4.1	2.641	6.60	681.82
Sample D	1	4.3	0.50	4.1	2.641	6.60	651.52
	2	4.3	0.50	4.1	2.641	6.60	651.52
Sample E	1	4.3	0.40	4.6	3.324	6.65	646.62
	2	4.5	0.40	4.5	3.181	6.36	707.55
Sample F	1	5.5	0.40	4.4	3.041	6.08	904.61
	2	5.7	0.40	4.4	3.041	6.08	937.50
Sample G	1	5.8	0.45	5.0	3.927	8.84	656.11
	2	5.8	0.50	4.5	3.181	7.95	729.55
Sample H	1	7.3	0.50	4.6	3.324	8.31	878.46
	2	7.3	0.45	4.5	3.181	7.16	1019.55
Sample I	1	8.0	0.50	4.3	2.904	7.26	1101.93
	2	6.6	0.50	4.5	3.181	7.95	830.19

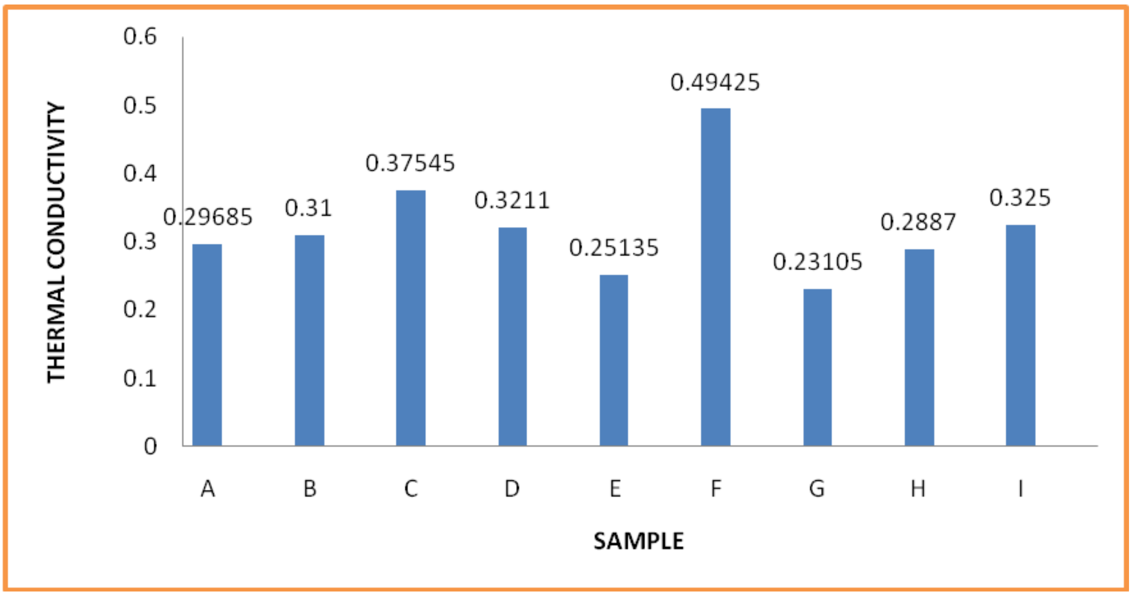

Fig.1. Distribution of Sample's Thermal Conductivity

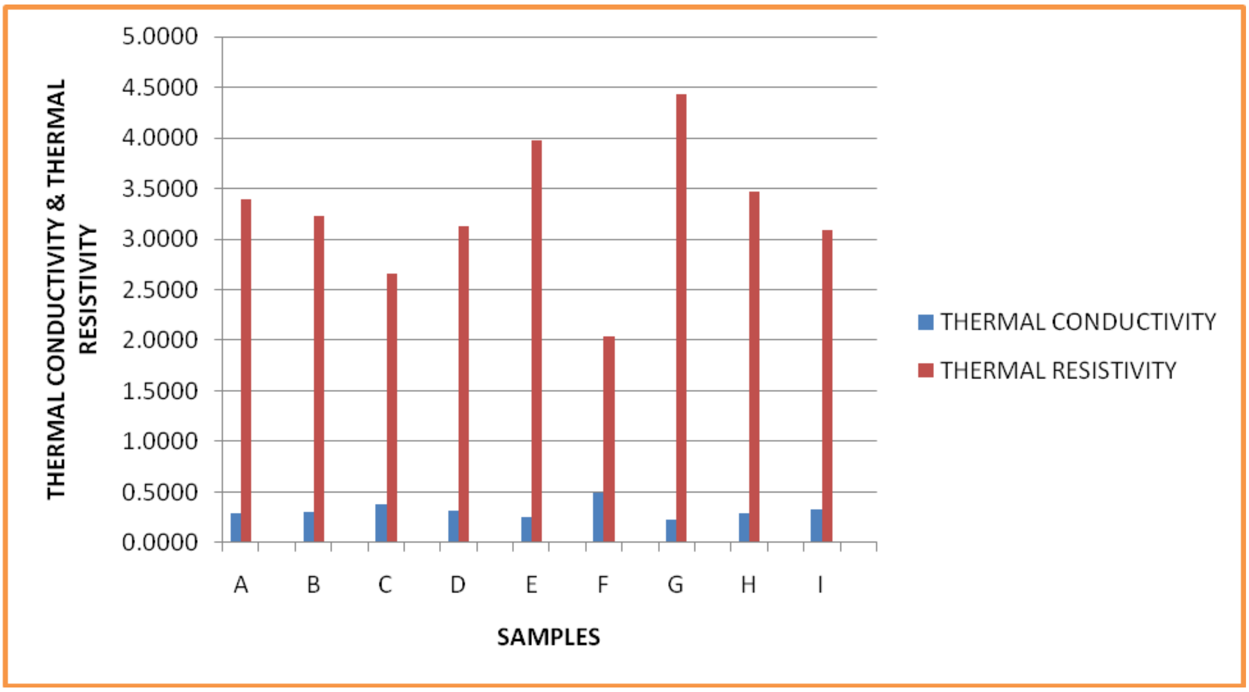

Fig. 4. A Bar chart comparing Thermal conductivity and Thermal resistivity.

IV. DISCUSSION OF RESULTS.

The three key qualities of a thermal insulation material derived from agricultural waste are resource availability, physical properties and environmental impact. Critical physical properties include resistance to fire, mould growth, insect damage and biodegradable. Baggasse has low thermal conductivity and it is environmentally friendly it can be made into boards or panels without using any chemical resin.

Comparing Table 2 and Fig 1. results with the documented values for common wood- based/cellulose insulating material as given by J. Twidell and T.Weir which shows the following thermal conductivity, Asbestos cement sheet 0.319 $W^{-1}mK$ brick building 0.600 $W^{-1}mK$ pine wood 0.138 $W^{-1}mK$ and oak wood 0.160 $W^{-1}mK$. It proofs that our samples fall within the same range. Similarly comparing the computed values on Table 2 with those given for wood-based insulating materials, we have the required ranges as 0.735-8.130 $W^{-1}mK$ which is satisfied by all our sample values. Samples B and E shows bagasse stops at 50% and shows no improvement at high quantity 60% sample H while sample C, F and I with corncob increasing is seen dangling up and downwards.

Fig 4. Shows the results of thermal conductivity and thermal resistivity. It proofs that an increase in thermal resistivity reduces thermal conductivity. Hence increasing the thermal resistivity of a material will lower its thermal conductivity thereby making it a suitable insulation material.

V. CONCLUSION

The bases for recommendation as substitute or replacement are considered under these three key qualities. They are resources availability, physical properties, and environmental impacts when using these waste considered (Rice husk, Bagasse and Corncob). The used of these material cals reduces the risk of environmental pollution. Also we have been able to show that these wastes can be used for the production of panels or broad sheet of required thickness for used as walling materials or thermal resistant materials.

In proving that all samples passed each tests and recommended ranges, it shows that it favors insulation materials for naturally cooled design in sub/tropical region.

Recommendation

In establishing conclusion based on values in this research, a temperature of 120^{o}C was set as optimum; in that regard further studies could be based on sample breaking point instead of getting samples to meet required ranges for acceptance as class A products. These studies could check other life cycle analysis (LCA) method apart from those used in this research work. Also considering Damages Impact approach over various samples to it life cycle. Furthermore the threshold point when all samples fails in each individual properties due to their percentage mixture composition.

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