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Effect of Additives on the Thermal Conductivity of Clay

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Abstract

This paper reports on the determination of the effect of Additives on the thermal Conductivity of clay. Clay sample was collected from a deposit. The clay sample was cleaned, soaked, dried, crushed and sieved. Various percentages of ashes and sawdust were added. The mixtures were used to form discs of diameter 4.2cm each. Lees' disc apparatus was used to determine the thermal Conductivity of each disc and was found to be 0.25W/mK for no moisture content. The clay sample with sawdust as additive gave the least value of thermal conductivity of (0.06W/m K) than the clay with ashes.

Keywords

Clay, Moisture Content, Thermal conductivity, Lees' disc Apparatus, Porosity.

Introduction

Clay is a very fine grained, unconsolidated rock matter, which is plastic when wet, but becomes hard and stony when heated. It has its origin in natural processes, mostly complex weathering, transported and deposited by sedimentation within geological periods. Clay is composed of silica {SiO_2), Alumina (Al_2O_3) and water (H_2O) plus appreciable concentrations of oxides of iron, alkali and alkaline earth, and contains groups of crystalline substances known as clay minerals such as quartz, feldspar, and mica.

The thermal conductivity of clay, which is the property of a material that indicates its ability to conduct heat, is mostly controlled by water content. Although, obviously, the type of clay is also important. For average clay, the thermal conductivity is 0.25 W/m K for no moisture, about 1.0 W/m K for 10% clay moisture (% by volume), 1.25 W/m K at 14%, 1.67 W/m K at 30% and about 2.0 W/m K at 50 %2 [2]

The objective of the research work is to determine the effect of additives such as sawdust and ashes on the thermal conductivity of clay with no moisture content.

Clay with low thermal conductivity can serve many purposes such as: making clay oven for baking and drying, a good insulator between two metal surfaces where heat is to be conserved within a certain area and heat loss by conduction is to be prevented.

Material and Method

Materials used

Clay sample from a deposit in Minna has been study to investigate the chemical compositions. It was established that it belongs to the group of alumina – silicate refractory i.e. fire clays.

Ashes collected from the burning of dried mango tree and sawdust from mahogany wood were the additives used with the clay [1]

Material preparation and Method

Clay, as collected from the deposit was socked in water and deleterious particles were separated by gravity sedimentation. Thereafter, the clay samples were sun dried for three days then placed inside the oven and further dried for a period of eight hours at a temperature of 50^0C.

The dried clay was finally crushed down to smaller sizes and subsequently ground to finer sizes using the laboratory crusher and the ball mills respectively. It was then sieved.

The sieved clay was shared into three portions; one portion without additives; the second portion was mixed with 1%, 5%, 10%, 20% and 30% ashes and the third portion was mixed with 1%,5%,10%,20%,and 30% of sawdust. Each part was moulded to a thin disc of 4.2cm diameter, and dried until there is no moisture content.

Thermal conductivity

Determination of thermal conductivity of each disc was carried out using Lees' apparatus. Each disc has the same diameter of 4.2cm as the copper disc in the apparatus. The thickness of the sample (d), the exposed surface area of the sample(a_s), the area of copper material (a_A), temperature of thermometers T_A and T_B and the energy supplied (E) in volts by a 6v battery are used in estimating the thermal conductivity of the samples using the relation.

$$K = \{E_d / 2\pi^2 (TB - TA)\} x \{(a_s (TA - TB)/2) + 2a_A T_A\} \text{ W/m K} \quad (1)$$

Results for this test are presented in Tables 1and 2.

Table 1. Variation of Thermal Conductivity with Ashes

Ashes (%)	0	1	5	10	20	30
K (W/m K)	0.250	0.240	0.220	0.195	0.190	0.180

Table 2. Variation of Thermal Conductivity with Sawdust

Sawdust (%)	0	1	5	10	20	30
K(W/m K)	0.250	0.230	0.190	0.130	0.090	0.060

Discussion of results

The results in tables A1and A2 reveal that at no moisture content, clay sample without additive has a thermal conductivity of 0.25W/m K.

Table 1 shows that thermal conductivity values vary with addition of ashes. The variation is not much because ash is the last residue when woods is burnt and cannot be further burnt. The particles of ashes form a sort of bridge between the particles of clay and no vacuum is created in the clay to retard heat. This allows conduction of heat to some level.

Table 2 shows that the thermal conductivity values decrease rapidly with increase in the amount of sawdust. The sawdust particles, which burn off at high temperature of 800°C creates pores in the clays that results in vacuum in the mixture which retards heat flow. Introduction of more percentage of ashes and sawdust would reduce the cold crushing strength of the clay samples.

Conclusion

Investigations have been undertaken to determine the effect of additives on the thermal conductivity of clay. It was found that the clay sample with sawdust gave the least thermal conductivity, and is suitable to make clay oven and good insulator. The least value of thermal conductivity of 0.06W/m K was obtained with addition of 30% sawdust. It is therefore suggested that other additives such as animal dung and bentonite should be used to improve the thermal conductivity.

References

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