DESIGNING A SET-UP FOR EVALUATING THERMAL PROPERTY OF CONSTRUCTION MATERIALS

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Abstract
The determination of the thermal conductivity properties of construction materials is particularly important in terms of energy efficiency. For this reason, cheapness and easiness are necessary to make the thermal behavior evaluations of the materials to be used for insulation purposes in the constructions. However, this can not be achieved with conventional devices. Because these conventional devices operate at a certain conductivity value range as well as being expensive and fail to respond to high temperature applications. In addition, these devices can only test specimens with certain dimensions and can not provide visual monitoring of heat progression. In this study, a set-up is designed to overcome these pronounced disadvantageous.

Keywords: construction material; thermal property; designing

1. Introduction

Determination of behavior under the existence of temperature difference has a crucial importance when insulation properties of different materials are needed [1-4]. The assessment of the thermal properties is essential for accurate building energy simulations that are needed to make effective energy-saving policies [5]. In general, the techniques employed for thermal properties characterization can be categorized based on the time dependence of the thermal response as steady-state or transient methods [6].

One of the properties of a material is thermal conductivity which is a measure of steady heat transport. Heat transfer takes place at a lower rate through materials having low thermal conductivity than through materials having high thermal conductivity. In addition, heat flows in a direction from higher temperature to the lower one in accordance with the second law of thermodynamics. Therefore, transport of heat energy is also described
by thermal conductivity across a body of mass in terms of temperature gradient (ΔT/d). In other words, thermal conductivity is an intensive property of material which gives heat transfer through a unit area and unit length body for given temperature difference. Fourier’s Law is primarily used to evaluate heat conduction [7]. The thermal conductivity coefficient (k) of a material is determined by using the equation below:

\[
\frac{Q}{t} = \frac{kA\Delta T}{d}
\]  

(1)

Q is the transfer of heat in time t, A represents the area through which the heat flows perpendicularly at a steady rate, \( \Delta T \) is the difference in temperature within the material, \( d \) is the thickness of the material tested.

Thermal conductivity coefficient values of materials are determined by using guarded hot plate method according to ASTM C 177 [8]. A sample is placed between two chambers. One chamber is heated up to a specified temperature and the other is cooled at a predetermined temperature value. Temperatures of the chambers are monitored until they are constant. The steady state temperatures, the thickness of the sample and the heat input to the hot chamber are used to calculate thermal conductivity by using the equation above.

Two different methods of sample preparation are adopted. First, all sides of samples are isolated by an insulator having lower thermal conductivity coefficient with the exception of the top and bottom surfaces. Second, uninsulated samples are cut to observe longitudinal heat flow. Figure 1 illustrates the samples prepared for experimental study.
2. Design Parameters and Obtained Data Set of Arranged Set-Up

Devices measuring thermal conductivity coefficient are sold quite expensive. Besides, the number of easily accessible devices which are capable of measuring for high temperature applications is very limited. That’s why, in this study, a device is installed that can determine the thermal conductivity coefficient at both low and high temperatures. For this purpose, firstly a heating chamber provided by a hot plate for the hot surface of material and cooling chamber for the cold surface are formed. Then, the walls of these chambers are built with a transparent material. Calibrated and sensitive thermal imaging camera is positioned at a
suitable distance. This thermal camera has the ability to transfer instantaneous data to a computer and can graphically display any kind of heat flow across the material. Designed set-up is exhibited in Figure 2.

**Figure 2. Designed set-up for evaluating thermal property**

![Diagram of designed set-up for evaluating thermal property](image)

To verify that this set-up works correctly, the data set of same prepared samples using a commercially supplied device is compared with those obtained by designed device. The results show that designed set-up gives almost the same values as the data of the commercially expensive device. It is proved that accurate measurements of isolated samples can be made by designed set-up. Furthermore, additional feature of designed device is the detection of the progress of the heat occurring along the length of a material placed in such a way that the cross-sectional area is exposed. The ability to observe the heat transfer has a great importance especially in composite materials. From the engineering point of view, how and in what degree the components affect the final product regarding thermal properties can be analyzed. For example, particle size distributions of the constituents of the nodular composite materials can be determined. Likewise, the behavior of the transition zone between the components under temperature change can be visually detected. Another important feature is that conventional devices can work in certain and limited range of thermal...
conductivity coefficient values for the sake of accuracy. Actually, it is not easily measured especially for materials with low conductivity but reliable data can readily be obtained by using this designed set-up. Besides, unlike traditional devices used to test materials, this designed device offers the possibility to test samples in different sizes.

3. Conclusion

Unlike other expensive and conventional devices, the designed device can visually determine how the heat propagates. Thus, the right component selection can be made for the design of composite materials in terms of heat transfer and thermal conductivity. When compared data of the device that is currently used in market and those of the device that is designed, very close thermal conductivity values are obtained. Also, designed device presents the possibility of analyzing materials within a wide range of coefficients of thermal conductivity.

References