Thermal Conductivity of Insulators

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Abstract

In this paper various ASTM & other methods are reviewed for measuring the thermal conductivity of insulators. These methods are classified as Steady-state & Non-steady-state probes. The latter provides the practical & fast measurement, while the first one includes many of the conventional methods. One method also proposed to calculate the thermal conductivity is investigated. The principle of this method is that when a potential difference is applied across specimen through resistance wire, heat will produce & it will transmit through specimen. This method has a simple set up & is simple to carry out.

1. Introduction

Thermal conductivity is a property of materials that expresses the heat flux that will flow through the material if a certain temperature gradient exists over the material. Measurement of thermal conductivity of grout material (insulators) is quite a difficult task due to inhomogenities in the sample, its thermal contact resistance & different measurement methods. Currently we have different methods for thermal conductivity determination a few of them are summarized below:

Method	ASTM Standard	Committee	Temperature Range (K)	Suitability	Remarks
Axial flow methods (steady-state)			90 to 1300	Homogeneous opaque solids	Most consistent, highest accuracy, Cryogenic temperatures
Guarded hot plate method (steady-state)	ASTM C 177	C16.30	Extremes of temperatures (high or low) or under vacuum	Insulations	Absolute method of measurement, widely used & versatile
Hot wire method (steady-state)	ASTM C1113	C08.02	Room temp. to 1773	Refractories (insulating bricks, fibrous materials.)	Transient radial flow technique
TP02 Non-steady-state probe	ASTM D 5334-92, D 5930-97		243.15 to 453.15	Suitable in soils,	Fast, absolute& sample size is not critical

Following are some of the standard values of thermal conductivity of some materials:

Material	Thermal conductivity @ 20°C W / mK	Density kg /m^3
Air	0.025	1.29
Water	0.6	1000
Concrete	1.28	2200
Sand(Dry)	0.35	1600
Sand (Sat.)	2.7	2100
Glass	0.93	2600
Mineral insulation materials	0.04	100
Plastic insulation materials	0.03	50

2. Objective

- To develop an experimental set-up to measure thermal conductivity using electric field.
- Review different methods for measuring thermal conductivity.

3. Description of Method

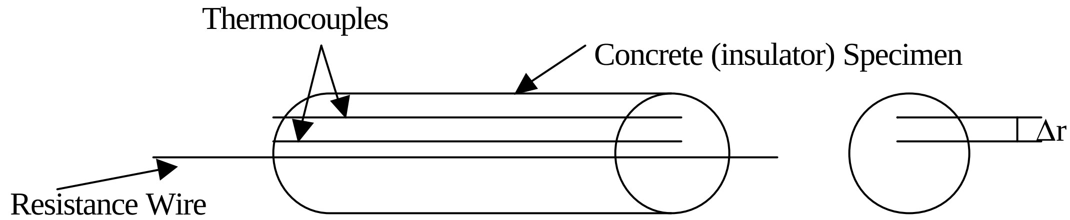

Fig.1 Grout specimen embedded with Resistance Wire & Thermocouples

The experimental set-up consists of electrical circuit (Power supply, Ammeter, Voltmeter etc.), Resistance wire (Ni-Cr), Thermocouples & grout specimen.

A specimen was cast in a cylindrical shape with the resistance wire embedded in it as shown in fig1. Casting thermocouples were also placed at a selected location to measure the temperature gradient. After preparation of the specimen, the potential difference was applied across the specimen. Changes in temperature, Current, Voltage were measured & thermal conductivity is calculated as follows:

$$P = I * V$$
$$= k\ A\ \Delta t / \Delta r$$
$$\therefore k = (P/A) * (\Delta r/\Delta t)$$

Where, k = Thermal Conductivity
P = Power; I = Current; V = Voltage; A = Cross sectional area
Δr = Change in Radius; Δt = Change in temperature

Thus knowing all other terms thermal conductivity is calculated.

4. Conclusion

- The modified Hot wire method is a simple method to determine the thermal conductivity of an insulator under a steady-state condition.

5. References

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