A Review Paper on MEASURE THERMAL CONDUCTIVITY

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ABSTRACT

Thermal conductivity has many important applications in heat transfer, food material and engineering. In small industries and HMT labs of engineering colleges, the accurate measurement of thermal conductivity is required. This review paper regards with different method for measuring thermal conductivity with respect to different materials. Due to impurities and imperfect mating surfaces, the air is trapped between mating surface of material especially in composite material. So it is required to study different methods and best suitable method can be stated. The different method as a finite element method, transient plane source method, sintering of reaction-bonded silicon nitride (SRBSN) method and Transient methods can be used to calculate thermal conductivity of the material.

KEYWORD: Thermal conductivity, Temperature, interfacial resistance

1. Introduction

1.1 Thermal Conductivity:

[6] “A measure of the ability of a material to transfer heat. Given two surfaces on either side of a material with a temperature difference between them, the thermal conductivity is the heat energy transferred per unit time and per unit surface area, divided by the temperature difference” The continuous desire for increasing heat transfer for various applications is one of the most difficult challenges faced by thermal engineers. With the advancement of technologies, heat transfer at higher rates and efficiency from small cross section areas or over low temperature difference are causing a rise in demands. Because of the wide range of thermal properties, there is no single measure method, which can be used for all thermal conductivity measurements. Desired temperature range, sample size, required accuracy and thermal conductivity range all need to be considered when designing a measurement apparatus. Consequently, over the past decades a wide variety of techniques for the enhancement of heat transfer has been suggested, where the most well-known and promising methods are briefly described in this chapter. The emphasis will be on techniques for thermal conductivity measurements of poorly conduction materials [7]

- Thermal conductivity is a property of the material, which depends mainly on structure of material in terms of chemical composition, phase of material and texture of it.
- Thermal conductivity also depends on content of moisture present in material as well as how closely atoms are packed in lattice, also with operating conditions like pressure and temperature.
- Methods for measuring thermal conductivity are divided into two different groups, namely steady-state methods and transient methods. Steady state conditions refer to constant temperature at each point of the sample, i.e. not a function of time. The transient methods are used to record measurements during the process of heating up or cooling down a material or fluid. These methods have the advantage of giving quicker measurements than the steady state methods. [7]

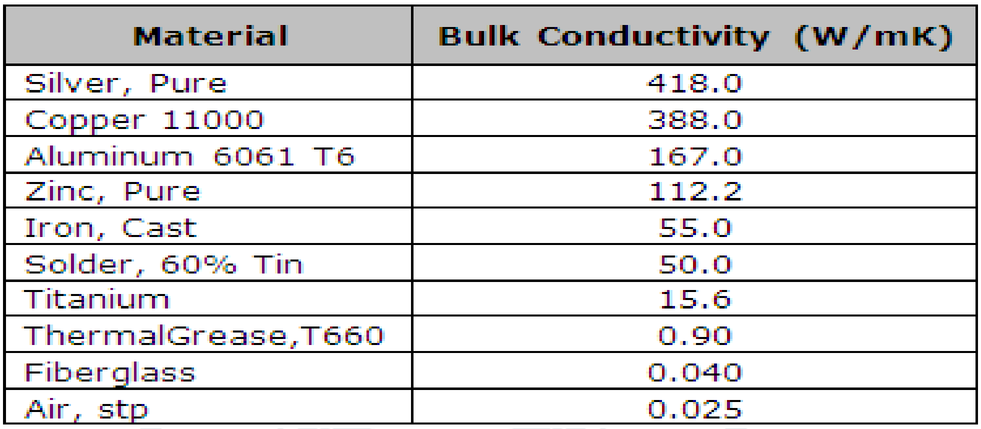
1.2 Different Resistance having impact on thermal conductivity: [6]

- An interface material enhances the thermal contact between imperfect mating surfaces. A highly thermally conductive material, with good surface wetting ability, will reduce interfacial resistance.
- Spreading resistance is used to describe the thermal resistance associated with a small heat source coupled to a larger heat sink. Among other factors, the thermal conductivity of the base of the heat sink directly impacts spreading resistance.
- Conduction resistance is a measure of the internal thermal resistance in a heat sink as heat travels from the base to the fins, where it dissipates into the environment. In regard to heat sink design, conduction resistance is less important in natural convection and low air flow conditions, becoming more important as flow rates increase.

1.3 Factors influencing thermal conductivity

1. Free Electrons
2. Purity of Material
3. Effect of Forming
4. High Temperature
5. Pressure
6. Density
7. Crystalline Structure

Table 1: Different material with their thermal conductivity [6]



Material	Bulk Conductivity (W/mK)
Silver, Pure	418.0
Copper 11000	388.0
Aluminum 6061 T6	167.0
Zinc, Pure	112.2
Iron, Cast	55.0
Solder, 60% Tin	50.0
Titanium	15.6
ThermalGrease,T660	0.90
Fiberglass	0.040
Air, stp	0.025

2. LITURATURE REVIEW

Gou Jian-Jun et el. [1] measure thermal conductivity by Finite element analysis method, and Finite element method is used to measure the thermal conductivity of the woven composite. And on behalf of those results of the unit cells (matrix), the effective thermal conductivity is predicted by considering woven yarns as a unidirectional fibre reinforced composites.

Muhammad Zain-ul-abdein et el. [2] Investigates the effect of interfacial thermal resistance (TR) upon the effective thermal conductivity of Cu/Diamond composites through experimental and numerical means. The composite samples were made using uncoated, Cu-coated and Cr-coated diamond particles Finite element model is created by using micrographs of specimen and transient plane source method was used to measure thermal conductivity. Coating material also has effects on thermal resistance (TR)

You Zhou et el. [3] In this paper, recent development of Si_3N_4 which has higher thermal conductivity using sintering of reaction-bonded silicon nitride (SRBSN) method are shown. SRBSN ceramics could attain substantially higher thermal conductivities than the Si_3N_4.The effect of Al and Fe impurities on thermal conductivity of Silicon nitride (Si_3N_4) has been studied. Al by wt.% has less effect on degrading thermal conductivity than Fe.

Lindon C. Thomas et el. [4] A practical thermal circuit method for analysing heat transfer in composite walls with energy generating sections is developed in this paper. The method applies to plane walls as well as solid and hollow circular and spherical geometries. The method provides a means of efficiently dealing with a class of practical heat transfer problems that would otherwise require a much more involved set of solution steps.

Adrien Aubert et el. [5] The following work is dedicated to assessing the performance of a falling water film as a thermal protection for composite walls exposed to a radiant flux. Temperature is measured at different locations inside the composite panel and at the water inlet and outlet. Three different experiments are considered: one without water film, to serve as a reference, another where the composite and the film are exposed to the radiant flux without initial heating, and finally a wall at 100 C before the film is triggered.

2.1 Thermal conductivity

Gou Jian-Jun et el. [1] The woven yarn can be considered as unidirectional fibre reinforced composites and presents transversely isotropic characteristic. Its axial thermal conductivity is often determined by so-called classic mixture rule, while the transverse thermal conductivity is usually numerically calculated. For composites like plane woven materials with appropriately boundary conditions derived from symmetric/antisymmetric characters a unit cell with smallest size can be found to predict the effective thermal conductivity with a significantly saving in computational sources and time. thermal conductivities of studied plain woven composites decrease with the increase of porosity.

You Zhou et el. [3] Studies on the influences of two typical metallic impurity elements, Fe and Al, on thermal conductivities of the SRBSN ceramics revealed that the tolerable content limits for the two impurities were different. While 1 wt% of impurity Fe hardly degraded thermal conductivity, only 0.01 wt% of Al caused large decrease in thermal conductivity.

2.2 Interfacial resistance

Muhammad Zain-ul-abdein et el. [2] Experimental findings have shown that the K_{eff} of the Cu/DComposites vary with varying volume fractions of diamond as well as coating of the diamond particles. In general, theoretical models fall short of predicting the conduction behaviour of these composites, mainly because they ignore the interfacial thermal resistance. Even the closest estimates through Hassel man–Johnson model account up to 10% error at least.

2.3 Temperature

Adrien Aubert et el. [5] In order to investigate the protection provided by the water film, temperature measurements are made inside the composite wall. As temperature increase change in thermal conductivity is started depend on the material there is different effect on temperature.

2.4 Heat Transfer

Lindon C. Thomas et el. [4] The thermal circuit relations developed in this paper can be used to efficiently analyse the heat transfers for a wide range of practical applications involving composite walls with heat generating Sections.
Adrien Aubert et el. [5] The cooling of the wall by the water film is so fast that within seconds after the start of the film, heat transfer is partially reversed. After a quarter of an hour, the system is almost in a steady state.

3. SUMMARY

- By using the numerical model, the effective thermal conductivity of composite can be predicted, which saves computing time. The effective thermal conductivity of plain-woven material increase with decrease of porosity.
- Interfacial thermal resistance is important factor in limiting the thermal conductivity values of composites.
- The effect of impurities on thermal conductivity does not depend on content percentage of impurities e.g. different impurities with same content may have different intensity on thermal conductivity degradation.
- As temperature gradient increase thermal conductivity of composite wall is decrease and heat transfer rate decrease for metal.

4. REFERENCES

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