MADHAV INSTITUTE OF TECHNOLOGY AND SCIENCE GWALIOR (M.P.)

SKILL BASED PROJECT
OF
HEAT AND MASS TRANSFER
ON
THERMAL CONDUCTIVITY

Head
Deptt. of Mechanical Engineering
Madhav Institute of Tech. & Science
Gwalior - 05 (India)

SUBMITTED BY:-
RAMVILAS JAISWAL (0901AU213D01)

SUBMITTED TO:-
Prof. Bhupendra Pandey

TITLE :-

THERMAL CONDUCTIVITY

INTRODUCTION :-

Thermal conductivity refers to the ability of a given material to conduct/transfer heat. It is generally denoted by the symbol ‘k’ but can also be denoted by ‘λ’ and ‘κ’. The reciprocal of this quantity is known as thermal resistivity. Materials with high thermal conductivity are used in heat sinks whereas materials with low values of λ are used as thermal insulators.

SI Unit

Thermal conductivity is expressed in terms of the following dimensions: Temperature, Length, Mass, and Time.
The SI unit of this quantity is watts per meter-Kelvin or $Wm^{-1}K^{-}$
It is generally expressed in terms of power/(length * temperature).

These units describe the rate of conduction of heat through a material of unit thickness and for each Kelvin of temperature difference.

Steady-State Techniques

1.These methods involve measurements where the temperature of the material in question does not change over a period of time.
2.An advantage of these techniques is that the analysis is relatively straightforward since the temperature is constant.
3.An important disadvantage of steady-state techniques is that they generally require a very well-engineered setup to perform the experiments.
4.Examples of these techniques are the Searle's bar method for measuring the thermal conductivity of a good conductor and Lee's disc method.

Transient Techniques

In these methods, the measurements are taken during the heating-up process.
An important advantage of these methods is that the measurements can be taken relatively fast.
One of the disadvantages of transient techniques is the difficulty in mathematically analysing the data from the measurements.
Some examples of these techniques include the transient plane source method, the transient line source method, and the laser flash method.

Effect of Temperature on Thermal Conductivity

Temperature affects the thermal conductivities of metals and non-metals differently.

Metals

The heat conductivity of metals is attributed to the presence of free electrons. It is somewhat proportional to the product of the absolute temperature and the electrical conductivity, as per the Wiedemann-Franz law.

With an increase in temperature, the electrical conductivity of a pure metal decreases.

This implies that the thermal conductivity of the pure metal shows little variance with an increase in temperature.

However, a sharp decrease is observed when temperatures approach 0K.

Alloys of metals do not show significant changes in electrical conductivity when the temperature is increased, implying that their heat conductivities increase with the increase in temperature.

The peak value of heat conductivity in many pure metals can be found at temperatures ranging from 2K to 10K.

Non-Metals

The thermal conductivities of non-metals are primarily attributed to lattice vibrations.

The mean free path of the phonons does not reduce significantly when the temperatures are high, implying that the thermal conductivity of non-metals does not show significant change at higher temperatures.

When the temperature is decreased to a point below the Debye temperature, the heat conductivity of a non-metal decreases along with its heat capacity.

Factor	**Effect on Thermal Conductivity**
The chemical phase of the material	When the phase of a material changes, an abrupt change in its heat conductivity may arise. For example, the thermal conductivity of ice changes from 2.18 $Wm^{-1}K^{-1}$ to 0.56 $Wm^{-1}K^{-1}$ when it melts into a liquid phase
Thermal Anisotropy	The differences in the coupling of phonons along a specific crystal axis causes some substances to exhibit different values of thermal conductivity along different crystal axes. The presence of thermal anisotropy implies that the direction in which the heat flows may not be the same as the temperature gradient's direction.
The electrical conductivity of the material	The Wiedemann-Franz law that provides a relation between electrical conductivity and thermal conductivity is only applicable to metals. The heat conductivity of non-metals is relatively unaffected by their electrical conductivities.
Influence of magnetic fields	The change in the thermal conductivity of a conductor when it is placed in a magnetic field is described by the Maggi-Righi-Leduc effect. The development of an orthogonal temperature gradient is observed when magnetic fields are applied.
Isotopic purity of the crystal	The effect of isotopic purity on heat conductivity can be observed in the following example: the thermal conductivity of type IIa diamond (98.9% concentration of carbon-12 isotope) is 10000 $Wm^{-1}K^{-1}$ whereas that of 99.9% enriched diamond is 41,000 $Wm^{-1}K^{-1}$