

Heat Transfer

Introduction

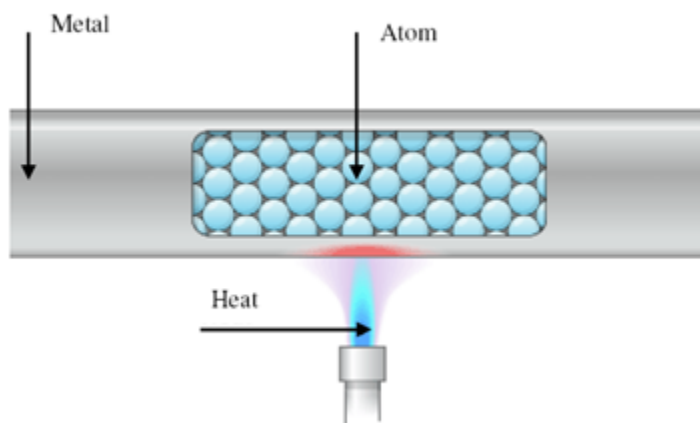
Heat transfer is a science, which deals with the flow of heat from a higher temperature to lower temperature. Heat cannot be stored and it is defined as the energy in transit due to the difference in the temperatures of the hot and cold bodies. The study of heat transfer not only explains how the heat energy transports but also predicts about the rate of heat transfer. When a certain amount of water is evaporated or condensed, the amount of heat transferred in either of the processes is same. However, the rate of heat transfer in both the cases may be different.

Mode of heat transfer

In this section, we will discuss about the three different modes of heat transfer. The discussion will help us to understand about the conduction, convection, and radiation. Moreover, we would be able to understand the basic difference between the three modes of heat transfer.

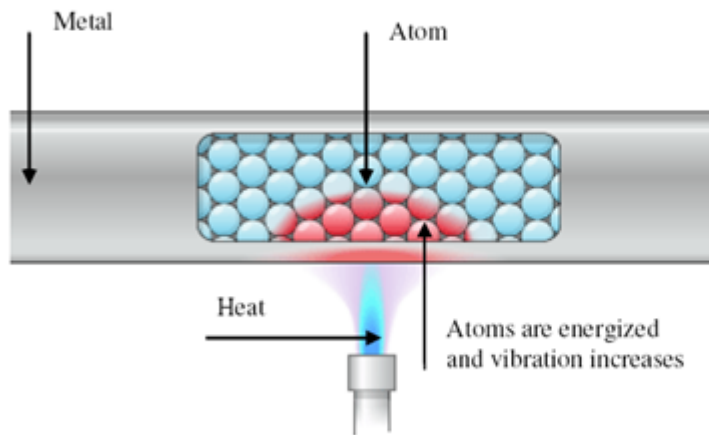
a) Conduction

Conduction is the transfer of heat in a continuous substance without any observable motion of the matter. Thus, heat conduction is essentially the transmission of energy by molecular motion. Consider a metallic rod being heated at the end and the other end of the rod gets heated automatically. The heat is transported from one end to the other end by the conduction phenomenon. The molecules of the metallic rod get energy from the heating medium and collide with the neighbouring molecules. This process transfers the energy from the more energetic molecules to the low energetic molecules. Thus, heat transfer requires a temperature gradient, and the heat energy transfer by conduction occurs in the direction of decreasing temperature. Figure 1.2 shows an illustration for the conduction, where the densely packed atoms of the rod get energized on heating and vibration effect transfers the heat as described in fig.1.1.



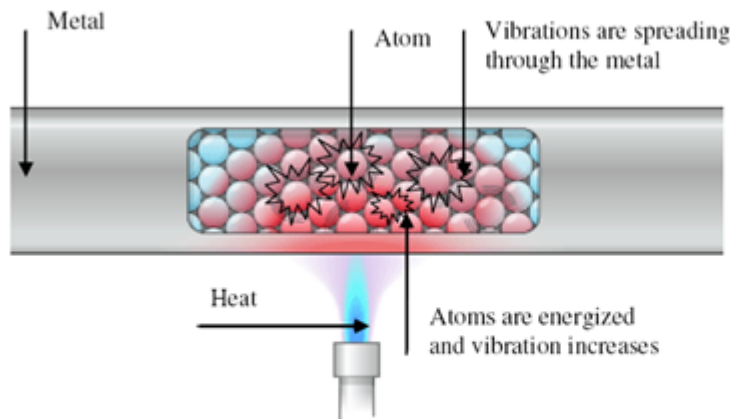
Step 1: The
metallic rod is
being heated

(a)



Step 2: The energy is transferred to the atoms and vibration of the atoms started

(b)



Step 3: As more energy is transferred to the atoms, the vibration increases as well as transferred to the other atoms

(c)

Fig.1.1: Different stages during conduction in a metallic rod

b) Convection

When a macroscopic particle of a fluid moves from the region of hot to cold region, it carries with it a definite amount of enthalpy. Such a flow of enthalpy is known as convection. Convection may be natural or forced. In natural convection, the movement of the fluid particles is due to the buoyancy forces generated due to density difference of heated and colder region of the fluid as shown in the fig.1.3a. Whereas, in forced convection the movement of fluid particles from the heated region to colder region is assisted by some mechanical means too (eg., stirrer) as shown in fig.1.2b.

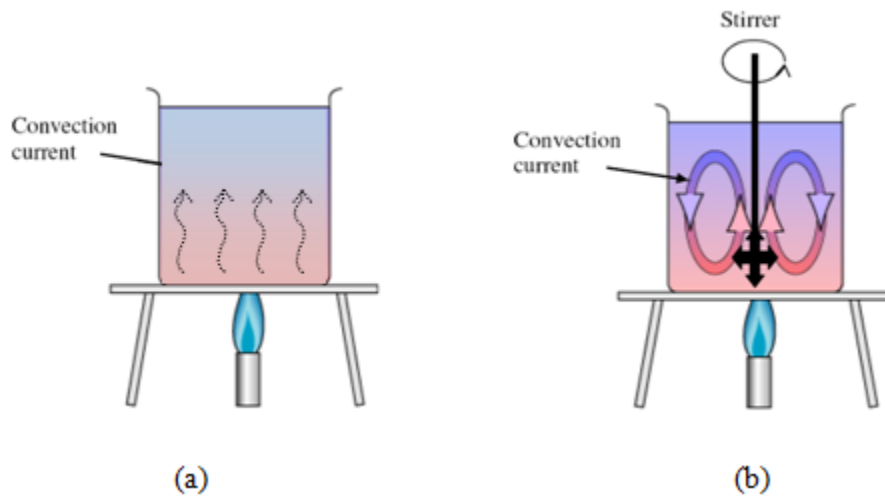


Fig.1.3: Heat transfer through convection (a) natural, and (b) forced

c) Radiation

We have seen that a medium is required for the heat transfer in case of conduction and convection. However, in case of radiation, electromagnetic waves pass through the empty space. Electromagnetic waves travel at the velocity of light in vacuum. These waves are absorbed, reflected, and/or transmitted by the matter, which comes in the path of the wave. We will limit our discussion (in this NPTEL course) to the thermal radiation. Thermal radiation is the term used to describe the electromagnetic radiation, which is observed to be emitted by the surface of the thermally excited body. The heat of the Sun is the most obvious example of thermal radiation.

There will be a continuous interchange of energy between two radiating bodies, with a net exchange of energy from the hotter to the colder body as shown in the fig.1.3.

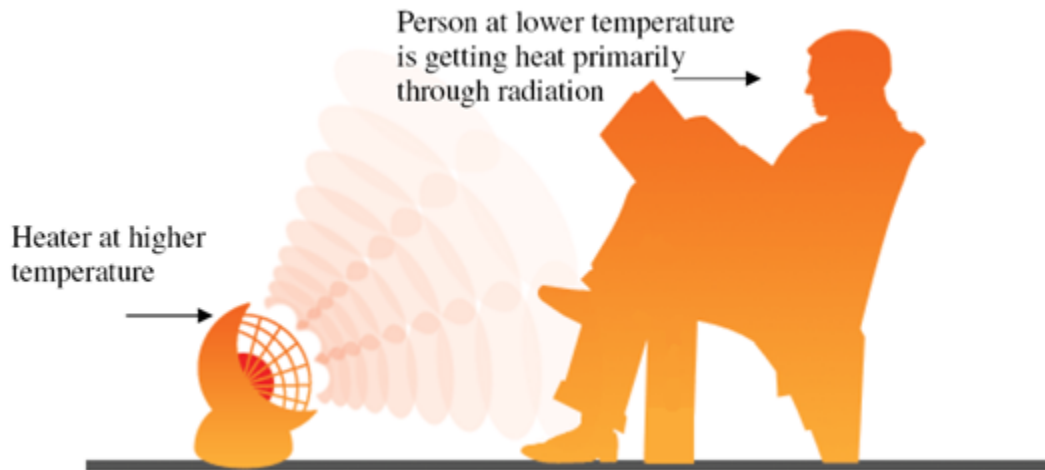


Fig.1.3: Heat transfer through radiation