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FACULTY OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering

BME504:Heat and Mass Transfer

Lecture 1

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Heat Transfer Vs Thermodynamics

- Thermodynamics is concerned with the amount of heat transfer as a system undergoes a process from one equilibrium state to another, and it gives no indication about how long the process will take.
- A thermodynamic analysis simply tells us how much heat must be transferred to realize a specified change of state to satisfy the transferred to realize a specified change of state to satisfy the conservation of energy principle.
- *We are normally interested in how long it takes for the hot coffee in a thermos to cool to a certain temperature, which cannot be determined from a thermodynamic analysis alone thermodynamic analysis alone.*

Heat Transfer Vs Thermodynamics

- Determining the rates of heat transfer to or from a system and thus the times of cooling or heating as well as the system and thus the times of cooling or heating, as well as the variation of the temperature, is the subject of heat transfer
- Heat transfer is energy transfer due to a temperature difference in a medium or between two or more media
- Different types of heat transfer processes are called different modes of heat transfer

Heat Transfer Vs Thermodynamics

- **Conduction** heat transfer is due to a temperature gradient in a stationary medium or media
- **Convection** heat transfer occurs between a surface and a moving Convection heat transfer occurs between a surface and a moving fluid at different temperatures
- **Radiation** heat transfer occurs due to emission of energy in the form of electromagnetic waves by all bodies above absolute zero temperature
  - Net radiation heat transfer occurs when there exists a temperature difference between two or more surfaces emitting radiation energy

CONDUCTION

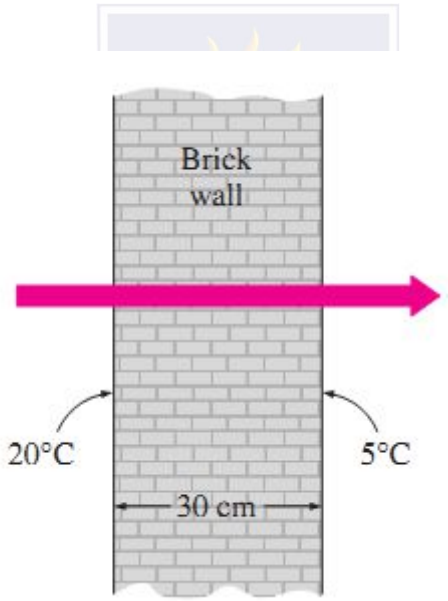
- Conduction heat transfer is due to random molecular and atomic vibrational, rotational and translational motions
- High temperature and more energetic molecules vibrate more and transfer energy to less energetic particles as a result of molecular collisions or interactions
- The heat flux (a vector) $\dot{Q}$ is characterized by a transport property know as the
  - Thermal Conductivity, k ($W / m \cdot K$)
  - W = watts m = Meters K = temperature in Kelvin
- Conduction is the transfer of energy from the more energetic particles of a substance to the adjacent less energetic ones as a result of interactions between the particles.

CONDUCTION

- Conduction can take place in **solids, liquids, or gases**. In gases and liquids, conduction is due to the **collisions and diffusion** of the molecules during their random motion. In solids, it is due to the **combination of vibrations** of the molecules in a lattice and the **energy transport by free electrons**
- The rate of heat conduction through a medium depends on the rate of heat conduction through a medium depends on the geometry of the medium, its thickness, and the material of the medium, as well as the temperature difference across the medium
  - $Rate\ of\ Heat\ Conduction\ \alpha\ \frac{(Area)(Temperature\ Difference)}{Thickness}$

Questions

Q1 The inner and outer surfaces of a 5-m X 6-m brick wall of thickness 30 cm and thermal conductivity 0.69 W/m · °C are maintained at temperatures of 20°C and 5°C, respectively. Determine the rate of heat transfer through the wall, in W.



Questions

Q2 Consider steady heat transfer between two large parallel plates at constant temperatures of T1 = 290 K and T2 = 150 K that are L = 2 cm apart. Assuming the surfaces to be black (emissivity = 1), determine the rate of heat transfer between the plates per unit surface area assuming the gap between the plates is (a) filled with atmospheric air, (b) evacuated, (c) filled with fiberglass insulation, and (d) filled with superinsulation having an apparent thermal conductivity of 0.00015 W/m · °C.

Q3 The average specific heat of the human body is 3.6 kJ/kg · °C. If the body temperature of a 70-kg man rises from 37°C to 39°C during strenuous exercise, determine the increase in the thermal energy content of the body as a result of this rise in body temperature.

Questions

Q4 A 15-cm-diameter aluminum ball is to be heated from 80°C to an average temperature of 200°C. Taking the average density and specific heat of aluminum in this temperature range to be 2700 kg/m3 and Cp = 0.90 kJ/kg · °C, respectively, determine the amount of energy that needs to be transferred to the aluminum ball.

Q5 An aluminum pan whose thermal conductivity is 237 W/m · °C has a flat bottom with diameter 20 cm and thick-ness 0.4 cm. Heat is transferred steadily to boiling water in the pan through its bottom at a rate of 800 W. If the inner surface of the bottom of the pan is at 105°C, determine the temperature of the outer surface of the bottom of the pan.