Fundamentals of Heat Transfer

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Figure taken from: http://heatexchanger-design.com/2011/10/06/heat-exchangers-6/ Dated: 17-Jan-2012
Course contents mid term

Unlike specific volume, specific heat capacity, specific volume, thermal conductivity is a non-additive property.

**Gases:**
- Thermal conductivity increases with increasing pressure. The effect is small at low pressures and near 1.0 bar the effect is ignorable.
- Generally, thermal conductivity increases with increase in temperature.
- Thermal conductivity increases nearly as square root of the absolute temperature upto few atmospheres.
- At very high pressures (i.e., for dense gases) increasing temperature, decreases the value.
Liquids:
• Generally speaking, thermal conductivity of liquids are relatively not affected by pressure.
• Raising the temperature, usually decreases the thermal conductivity, and the variation may be expressed as linear.

Solids:
• Thermal conductivity of pure metals decreases with an increase in temperature. Explain Why?
Effect of temperature on thermal conductivity [2]
Effect of temperature on thermal conductivity [3]
Estimation of thermal conductivity

• When experimental thermal conductivity data is not available in the literature, we need to do experiments to find the value and when not possible we use a reliable estimation method. Students are referred to Poling, B.E., Prausnitz, J.M., O’Connell, J.P. (2001) The properties of gases and liquids. 5th ed. McGraw-Hill. Singapore.

• Further discussion on thermal conductivity is beyond the scope of this course. Students are expected to go through 9th chapter of Bird, R.B., Stewart, W.E., Lightfoot, E.N. (2000) Transport Phenomena. 2nd ed. John Wiley & Sons, Inc., Singapore in higher semesters to have more insight knowledge.
One-dimensional steady-state heat conduction [3]
Heat conduction through a plane wall

What is the direction of heat?

What is the direction of heat?
Heat conduction through a plane wall: Temperature profile

What about variation of temperature with distance?
Heat conduction through a plane wall: Temperature profile
Heat conduction through a plane wall

Rate of heat transfer: \( q = k \cdot A \cdot \frac{T_1 - T_2}{\Delta x}, \text{ J/s} \)

Heat flux: \( \frac{q}{A} = k \cdot \frac{T_1 - T_2}{\Delta x}, \text{ W/m}^2 \)

Resistance: \( \frac{\Delta x}{k \cdot A}, \text{ °C/W} \)

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q = \frac{T_1 - T_2}{\left(\frac{\Delta x}{k \cdot A}\right)} = \frac{\text{Temperature difference}}{\text{thermal resistance}}, \text{ J/s or W}
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References


