Heat Transfer and Industrial Furnaces

1. (a) What are fins? What is the reason for their widespread use?
   (b) Obtain a relation for the heat transfer rate from infinite fin, in addition to a relation for the temperature variation along its length.
   (c) Define fin efficiency and fin effectiveness. What are their limits?

2. A brass rod ($k = 133\ W/m°C$) has length of 25 cm and 5 mm in diameter extends horizontally from a casting at 200°C. The surface of the rod is exposed to ambient air at 20°C with convection heat transfer coefficient of $h = 100\ W/m^2°C$. Determine the temperature of the rod at 15 cm from the casting. What is the rate of heat loss from the rod?

3. A very long rod 25 mm in diameter has one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with a convection heat transfer coefficient of $10\ W/m^2°C$.
   a) What are the heat losses from rod constructed of pure copper ($k = 398\ W/m°C$) and type AISI 316 stainless steel ($k = 14\ W/m°C$)?
   b) Estimate how long the rods must be to be considered infinite.

4. The aluminum ($k = 190\ W/m°C$) square fins (0.5 mm x 0.5 mm) of 1 cm long are provided on the surface of electronic semi-conductor device to carry 46 mW of energy generated by the electronic device and the temperature at the surface of the device should not exceed 70°C. The temperature of the surrounding medium is 40°C with a convection heat transfer coefficient of $7\ W/m^2°C$. Find out the number of the fins required to carry out the above duty. Neglect the heat loss from the end of the fin.

5. Two long copper rods ($k = 379\ W/m°C$) of diameter $D = 10$ mm are soldered together end to end, with solder having a melting point of 650°C. The rods are in air at 25°C with convection coefficient of $10\ W/m^2°C$. What is the minimum power input needed to effect the soldering?

6. A stainless steel ($k = 20\ W/m°C$) fin has a circular cross-sectional area with a diameter of 2 cm and a length of 10 cm. The fin is attached to a wall that has a temperature of 300°C. The fluid surrounding the fin has an ambient temperature of 50°C and the heat-transfer coefficient is $10\ W/m^2°C$. The end of the fin is insulated. Determine:
   a) The rate of heat dissipated from the fin,
   b) The temperature at the end of the fin,
   c) The rate of heat transfer from the wall area covered by the fin if the fin is not used,
   d) The fin efficiency.

7. A copper ($k = 379\ W/m°C$) fin with circular cross section with an area of $0.25\ cm^2$ and length of 2.5 cm is attached to a wall with temperature of 175°C. The ambient fluid temperature is 20°C, with $h = 35\ W/m^2°C$. Calculate the heat transfer rate and tip temperature for two cases: (a) the fin has an insulated tip, and (b) heat is convected from the tip surface area.