

7. An oil is cooled to 100°C in a concurrent heat exchanger by transferring its heat to cooling water, that leaves the exchanger at 30°C . However, it is now required that the oil must be cooled down to 75°C by increasing the length of heat exchanger, while oil and water flow rates, their inlet temperatures and other dimensions of the exchanger keeping constant. The inlet temperatures of water and oil being 15°C and 150°C , respectively. If the original cooler was 1m long, calculate

- (i) Outlet temperature of water in new cooler,
- (ii) Length of new cooler.

8. Atmospheric air at 25°C flows at 50 m/s velocity past a flat plate 0.6 m long with its surface maintained at 295°C . Under these conditions, the air may be treated as incompressible. Make calculation for heat transferred to air from entire plate length taking into account both laminar and turbulent portion of boundary layer. Presumes unit width of the plate and the critical Reynolds's number to be 5×10^5 . What % error would be introduced if the boundary layer is presumed to be of turbulent nature from the very leading edge of the plate? Take thermo-physical properties of air at mean bulk temperature is- $k=0.1310 \text{ kJ/m-hr-k}$, $\nu=30.9 \times 10^{-6} \text{ m}^2/\text{s}$, $\text{Pr}=0.682$.

Use following co-relations- $h=0.664 k/x (\text{Re})^{0.5} (\text{Pr})^{0.33}$ for laminar boundary layer.

And $h=0.036 k/x (\text{Pr})^{0.33} (\text{Re})^{0.8}$ for turbulent boundary layer.

9. Two parallel discs 50 cm in diameter are spaced 40 cm apart with one disc located directly above the other disc. One disc is maintained at 500°C and other is at 227°C . The emissivities of the discs are 0.2 and 0.4, respectively. The discs are located in a very large room whose walls maintained at 67°C . Determine the heat loss by radiation from the inside surfaces of each disc.

SECTION-C:

10. Attempt any two questions from this section.

(15X2=30)

- (a) Derive the general heat conduction equation in cylindrical co-ordinate for homogeneous and isotropic material.
- (b) A layer of 5 cm refractory brick ($k=2 \text{ W/m K}$) is to be placed between two 4 mm thick steel ($k=40 \text{ W/m K}$) plates. The both faces of brick adjacent to the plates have rough solid to solid contact over 20% of the area, where the average height of asperities are 1 mm. The outer surface temperature of steel plates is 400°C and 100°C , respectively.
 - (i) Find the rate of heat flow per unit area and assume that the cavity area is filled with air ($k=0.02 \text{ W/m K}$).
 - (ii) Find the rate of heat flow if the faces of brick are smooth and have solid to solid perfect contact over entire area.

11.

- (a) Write down the name of some common types of fin with neat sketch. Also derive the expression for heat dissipation through rectangular fin insulated at the tip.
- (b) Consider two long cylinder rods (A and B) (assume infinite fins) of the same diameter but different materials. One end of each rod is attached to a base surface at 100°C , and the rods