Q.1 A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side and 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and convective heat transfer coefficient at surface is 90 W/m2K. Calculate the heat dissipation rate from the rod.

Q.2Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 180^oC, while they are exposed to air at 30^oC. The end temperature of rod A is 100^oC while that of the rod B is 80 ^oC. If thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. These fins can be assumed as short with end insulated.

Q.3 Which of the following arrangement of pin fins will give higher heattransfer rate from a hot surface? (i) 6 fins of 10 cm length (ii) 12 fins of5 cm length. The base temperature of the fin is maintained at 200^oCand the fin is exposed to a convection environment at 15^oC with h=25W/m^2C. Each fin has cross sectional area 2.5 cm^2, perimeter 5 cm andis made of a material having thermal conductivity 250 W/mC. Neglectthe heat loss from the tip of fin

Q.4A metallic rod 1cm in diameter and 5 cm long, k= 30 w/mk protrudes from a wall which is maintained at 100^oC. The rod is insulated at its tip and is exposed to an environment with h=50 w/m^2k and air temperature of 30^oC. Calculate the heat dissipation rate, temperature at tip of the fin and fin efficiency.

Q.1 A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side and 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and convective heat transfer coefficient at surface is 90 W/m2K. Calculate the heat dissipation rate from the rod. Assume Tip of the rod is insulated.

Given Data

$K = 54 \ W/mK$

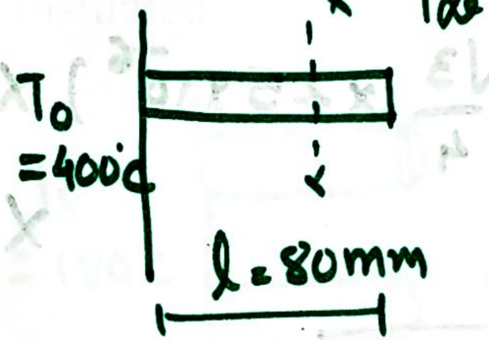
$a = 5 \ mm$

$l = 80 \ mm$

$T_0 = 400^\circ C$

$T_\infty = 50^\circ C$

$h = 90 \ W/m^2K$



$P = 3a$

$= 3 \times 5 = 15 \ mm$

$= 15 \times 10^{-3} \ m$

$$q_{fin} = K A_{cs} \, m (T_0 - T_a) \tanh ml$$

$$= \sqrt{h P A_{cs} \cdot K} \, (T_0 - T_a) \tanh ml$$

$$m = \sqrt{\frac{P \cdot h}{A_{cs} k}} = \sqrt{\frac{15 \times 10^{-3} \times 90}{\sqrt{3}/4 \times 25 \times 10^{-6} \times 54}} = 48.06 \ m^{-1}$$

$$A_{cs} = \frac{1}{2} b h = \frac{1}{2} a \left(\frac{\sqrt{3}}{2} a\right) = \frac{\sqrt{3}}{4} a^2 = \frac{\sqrt{3}}{4} \times 25 \times 10^{-6} \ m^2$$

$m = 48.06\ m^{-1}$

$$Q_{fin} = k\,A_{cs}\,m\,(T_0 - T_\alpha)\tanh ml$$

$$= 54 \times \left(\frac{\sqrt{3}}{4} \times 25 \times 10^{-6}\right) \times 48.06 \times (400 - 50) \times \tanh\left(48.06 \times 80 \times 10^{-3}\right)$$

$$\boxed{Q_{fin} = 9.82\ W}$$

Q.2 Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 180°C, while they are exposed to air at 30°C. The end temperature of rod A is 100°C while that of the rod B is 80 °C. If thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. These fins can be assumed as short with end insulated.

$K_A = 380$ W/mK

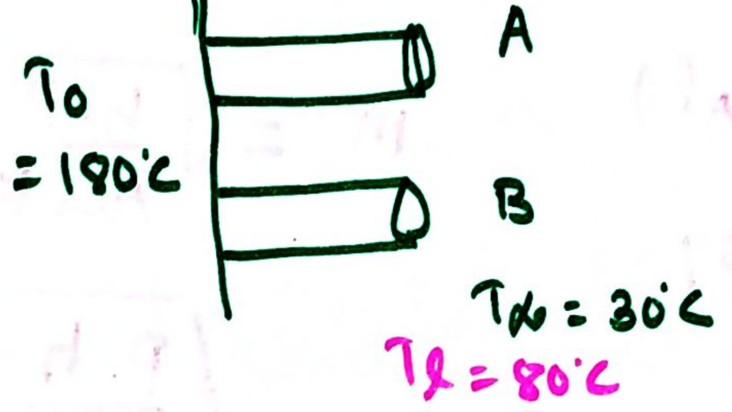
$K_B = ?$

$T_0 = 180°C$

$T_\infty = 30°C$

$T_{lA} = 100°C$

$T_{lB} = 80°C$



$d_A = d_B$

$l_A = l_B$

$K_A \neq K_B$

Temp. Distribution in case of insulated fin.

$$\theta = \theta_0 \frac{\cosh m(l-x)}{\cosh ml}$$

$$\frac{T - T_\infty}{T_0 - T_\infty} = \frac{\cosh m(l-x)}{\cosh ml} \qquad \frac{T_l - T_\infty}{T_0 - T_\infty} = \frac{1}{\cosh ml}$$

T at $x = L$

$$\frac{T_l - T_\infty}{T_0 - T_\infty} = \frac{1}{\cosh ml}$$

for Rod A

$$\frac{100 - 30}{180 - 30} = \frac{1}{\cosh(m_A l)}$$

$$\cosh(m_A l) = 1.857$$

$$m_A l = 1.23$$

→ for rod B

$$\frac{80 - 30}{180 - 30} = \frac{1}{\cosh(m_B . l)}$$

$$\cosh(m_B . l) = 2.6$$

$$m_B l = 1.609$$

Now.

$$\frac{m_A \cancel{l}}{m_B . \cancel{l}} = \frac{1.23}{1.609}$$

$$m = \sqrt{\frac{h . P}{A_{cs} K}}$$

$$\frac{\sqrt{\frac{P . h}{A_{cs} . K_A}}}{\sqrt{\frac{P . h}{A_{cs} . K_B}}} = 0.764$$

$$\sqrt{\frac{K_B}{380}} = 0.764$$

$$\boxed{K_B = 221.94 \text{ W/mK}}$$

Q.3 Which of the following arrangement of pin fins will give higher heattransfer rate from a hot surface? (i) 6 fins of 10 cm length (ii) 12 fins of5 cm length. The base temperature of the fin is maintained at 200°Cand the fin is exposed to a convection environment at 15°C with h=25W/m²C. Each fin has cross sectional area 2.5 cm², perimeter 5 cm andis made of a material having thermal conductivity 250 W/mC. Neglectthe heat loss from the tip of fin

Given Data

$T_0 = 200°C$

$T_\infty = 15°C$

$h = 25\ W/m^2C$

$A_{cs} = 2.5\ cm^2$

$= 2.5 \times 10^{-4}\ m^2$

$P = 5\ cm = 5 \times 10^{-2}\ m$

$k = 250\ W/mC$

$$Q_{fin} = n\left[k A_{cs}\, m\, (T_0 - T_\infty) \tanh ml\right]$$

$$m = \sqrt{\frac{h \cdot P}{A_{cs} \cdot k}} = \sqrt{\frac{25 \times 5 \times 10^{-2}}{2.5 \times 10^{-4} \times 250}}$$

$$m = 4.47\ m^{-1}$$

Case - I

$n = 6 \quad l = 10\ cm = 10 \times 10^{-2}\ m$

$ml = 4.47 \times 10 \times 10^{-2} = 0.447$

$$Q_1 = 6\left[250 \times 2.5 \times 10^{-4} \times 4.47 \times (200-15) \times \tanh(4.47 \times 10 \times 10^{-2})\right]$$

$$\boxed{Q_1 = 89.99\ W}$$

Case - II

$n = 12 \quad l = 5\,cm = 0.05\,m$

$$Q_2 = n\left[K A_{cs}\, m\,(T_0 - T_\infty)\tanh(ml)\right]$$

$$= 12\left[250 \times 2.5\times10^{-4} \times ~~0.44~~\ 4.47 \times (200-15) \times \tanh(4.47 \times 0.05)\right]$$

$$\boxed{Q_2 = 94.34\ W}$$

$Q_2 > Q_1$

Q.4 A metallic rod 1cm in diameter and 5 cm long, k= 30 w/mk protrudes from a wall which is maintained at 100°C. The rod is insulated at its tip and is exposed to an environment with h=50 w/m^2k and air temperature of 30°C. Calculate the heat dissipation rate, temperature at tip of the fin and fin efficiency.

Given Data

$d = 1\,cm = 1 \times 10^{-2}\,m$

$l = 5\,cm = 5 \times 10^{-2}\,m$

$k = 30\,W/mK$

$T_0 = 100°C$

$h = 50\,W/m^2K$

$T_\infty = 30°C$

$Q_{fin} = ?$

$T_l = ?$

$\eta_{fin} = ?$

a) Rate of Heat Transfer

$$Q_{fin} = \sqrt{h.P.A_{cs}.k}\,(T_0 - T_\infty)\tanh ml$$

$$m = \sqrt{\frac{h.P}{A_{cs}k}} = \sqrt{\frac{h.\pi d}{k.\pi/4\,d^2}} = \sqrt{\frac{h}{k}.\frac{4}{d}}$$

$$= \sqrt{\frac{4 \times 50}{30 \times 0.01}} = 25.82\,m^{-1}$$

$$Q_{fin} = \sqrt{h.\pi d \times \pi/4\,d^2 \times k}\,(T_0 - T_\infty)\tanh ml$$

$$= \sqrt{\pi \times 0.01 \times 50 \times \pi/4 \times (0.01)^2 \times 30}\,(100 - 30)\tanh(25.82 \times 5 \times 10^{-2})$$

$$Q_{fin} = 3.658\,W$$

b) $\theta = \theta_0 \frac{\cosh m(l-x)}{\cosh ml}$

$x = l$

$\frac{T_l - T_{\infty}}{T_0 - T_{\infty}} = \frac{1}{\cosh ml}$

$\frac{T_l - 30}{100 - 30} = \frac{1}{\cosh(25.82 \times 0.05)}$

$\boxed{T_l = 65.80^\circ C}$

c) fin efficiency

$\eta_{fin} = \frac{\tanh ml}{ml}$

$= \frac{\tanh(25.82 \times 0.05)}{25.82 \times 0.05}$

$\eta = 0.665$

$\boxed{\eta_{fin} = 66.57\%}$