Group - 2

Power requirment (TDP) of a 136 mm long 49 mm tall DDR4 RAM in a computer is 3 W. Assuming the RAM to be thin, estimate its surface temperature if fan blows 50°C air along the length of the RAM at 100 km/hr.

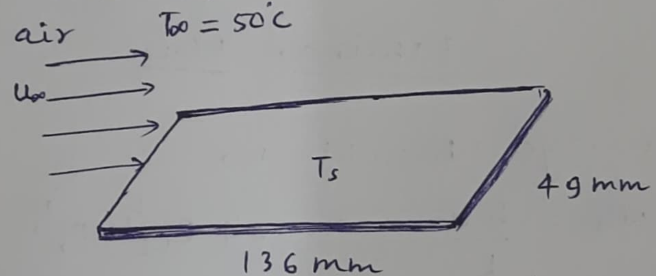
Solution: Assumptions

→ Steady state.
→ Air is an ideal gas.
→ The local atmospheric pressure is 1 atm.
→ Thermal properties are const.
→ The critical Reynold's number is $Re_{cr} = 5\times10^5$.
→ Radiation effects are negligible.
→ RAM to be an isothermal plate (flat plate).
→ Air is blown on one side only.

$V = u_\infty = 100\ km/hr$

$L_c = 136\ mm$

$T_\infty = 50°C$



surface area, $A_s = (49\ mm)\times(136\ mm) = 6.664\times10^{-3}\ m^2$

the properties of air @ 50°C & 1 atm.

$\nu = 1.798\times10^{-5}\ m^2/s$, $P_r = 0.7228$ $(P_r > 0.6)$

$k = 0.02735\ W/mK$

$$Re_L = \frac{u_\infty L}{\nu} = 2.1\times10^5 < Re_{cr}$$

∴ Laminar flow

∵ Average Nusselt no. for flow over an isothermal flat plate are: (for laminar flow)

$$Nu = \frac{hL}{k} = 0.664\ Re_L^{1/2}\ P_r^{1/3} \quad \{ P_r > 0.6\ \&\ Re_L < 5\times10^5$$

$$\Rightarrow \quad h = \frac{k}{L}\left(0.664\ Re_L^{1/2}\ P_r^{1/3}\right) = 54.9164\ W/m^2K$$

Now

$\because \quad Q = h A_s (T_s - T_\infty)$

$$T_s = \frac{Q}{h A_s} + T_\infty = \frac{3}{54.9164 \times 6.664 \times 10^{-3}} + 50$$

$$\boxed{T_s = 58.19°C}$$

Now for 2^{nd} iteration,

$$T_f = \frac{T_s + T_\infty}{2} = \frac{58.2 + 50}{2} = 54.1 °C$$

$\therefore$ properties of air @ 54.1°C & 1 atm.

$k = 0.02765 \ W/mK$, $\nu = 1.8382 \times 10^{-5} \ m^2/s$

$P_r = 0.7217$

$$\therefore Re_L = \frac{u_\infty L}{\nu} = 2.055 \times 10^5 < Re_{cr}$$

$\therefore$ Laminar flow.

$\therefore$ Average Nusselt no.

$$Nu = \frac{hL}{k} = 0.664 \, Re_L^{1/2} \, P_r^{1/3}$$

$$h = \frac{0.02765}{0.136} \times 0.664 \times (2.055 \times 10^5)^{1/2} \times (0.7217)^{1/3}$$

$$\therefore \quad h = 54.8928 \ W/m^2K$$

$$Q = h A_s (T_s - T_\infty)$$

$$\therefore T_s = \frac{Q}{h A_s} + T_\infty = \frac{3}{54.8928 \times 6.664 \times 10^{-3}} + 50$$

$$\boxed{T_s = 58.201 °C}$$

error in T_s after 2^{nd} iteration is less than 0.01%.

Hence, surface temp. $\boxed{T_s = 58.2 °C}$