Experiment 3
Extended Surface heat transfer

Apparatus

- Manual mode operated
- Long horizontal rod heated at one end with a heater
- Thermocouples are distributed at equal intervals (5 cm) which allow the surface temperature to be measured
- heat transfer is assumed to be one dimensional and heat loss at tip is ignored

Components of the system are:

1. heated rod
   - Solid brass
   - Coated with black paint → Consistent emissivity close to 1

2. Heater
   - Electrical heater, inserted coaxially
   - Power supplied to heater can be changed ($P = VI$)

3. Thermocouple
   - K-type thermocouple

OBJECTIVE :

- Verify Fourier law of conduction.
- Measure conductivity of metals
- Measure temperature profile along a rod.
- Apply fin theory
- Calculate heat losses from fin rod
- Calculate efficiency of fin
- Apply basic extended surface heat transfer.

Calculations

$$h_{conv} = 1.32 \left(\frac{T_s - T_\infty}{D}\right)^{0.25}$$

in K

Rod diameter

$$h_{rad} = \varepsilon \sigma \left(\frac{T_s^4 - T_\infty^4}{T_s - T_\infty}\right)$$

constant

0.95

$$h_{tot} = h_{rad} + h_{conv}$$

Electrical power supplied $= q = VI$

Conduction heat transfer $= q_{cond} = KA_c \left(\frac{T_1 - T_2}{X}\right)$

Cross sectional area

Distance Between T_1 and T_2

Convection heat transfer $= q_{conv} = h_{conv} A_s (T_s - T_\infty)$

surface area $= \pi DL$

Fin Constant $\longrightarrow m_{th} = \sqrt{\frac{h_{tot} P}{A_c K}}$

$P \rightarrow \pi D$

$\longrightarrow m_{Exp} = \left| \frac{\ln\left(\frac{T_x - T_\infty}{T_b - T_\infty}\right)}{X} \right|$

Distance at which T_x is Taken

Fin efficiency $= \frac{q_{fin}}{q_{max}}$ $= h A_f \theta_b$

$q_{fin} \longrightarrow \sqrt{hPKA_c}\, \theta_b \tanh mL$ (Case B: insulated tip)

$\longrightarrow \sqrt{hPKA_c}\, \theta_b$ (Case D: very long fin)

$\eta_{fin} \longrightarrow \frac{\tanh mL}{mL}$ (Case B: insulated tip)

$\longrightarrow \frac{q_{fin}}{h A_f \theta_b}$ (Case D: very long fin)

$\theta_b \rightarrow T_b - T_\infty$

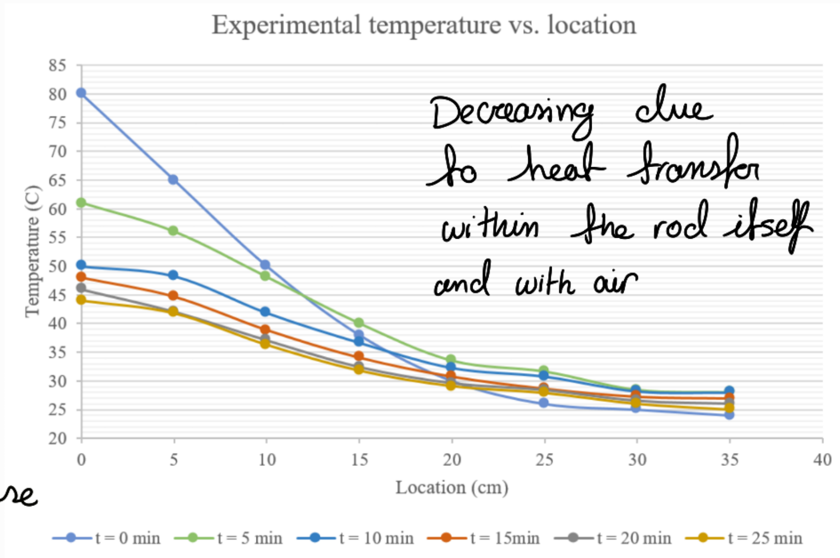
$A_f \rightarrow \pi D L$

Corrected length : $L_c = L + \frac{D}{4}$

Temperature distribution (case B) : $\frac{T_x - T_\infty}{T_1 - T_\infty} = \frac{\cosh m(L_c - x)}{\cosh mL_c}$

Discussion of Results

- Average temperature of Rod ↓ as t ↑
  → That's because voltage provided by the heater is fixed and so power is
  This causes: T_1 to decrease
  h_{conv}, h_{rad} to decrease



Decreasing due to heat transfer within the rod itself and with air

- Since T_1 ↓ → heat dissipated ↓ → Difference between T_1 & T_∞ decreases → heat transfer decrease

- h_{conv} decreases with time since temp of rod is decreasing and so difference between it and air decrease

- Theoretical distribution has lower values than actual since fin provides less heat transfer than expected → (Actual temp of the rod is higher and so heat dissipated is less