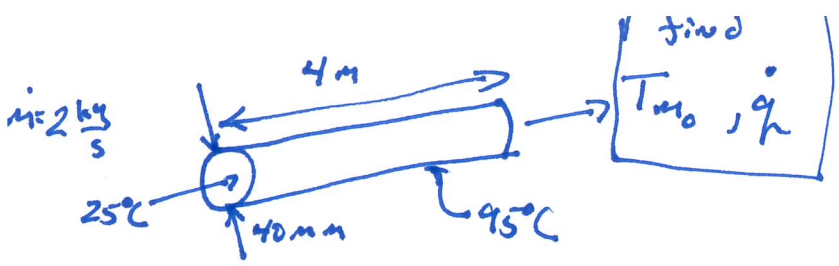

Water flow properties

speed of water

$$\dot{m} = \rho A V$$

$$\Rightarrow V = \frac{\dot{m}}{\rho A} = \frac{2\frac{kg}{s}}{10^3\frac{kg}{m^3}\,\pi(0.02m)^2} = 1.59 m/s$$

guess for $T_{m_o} = 40°C$

$T_{m_i} = 25°C \Rightarrow \overline{T} = 32°C$ or $305K$

@ $305K$

$C_p = 4.178\frac{kJ}{kgK}$

$\mu = 0.769\times10^{-3}\frac{Ns}{m^2}$

$k_T = 0.62\frac{W}{mK}$

$Pr = 5.2$

$$Re = \frac{\rho V D}{\mu} = \frac{10^3\frac{kg}{m^3}\times 1.59 m/s \times 4\times10^{-2} m}{0.769\times10^{-3}\frac{Ns}{m^2}} = 82.7\times10^3$$

$$Nu = 0.023\, Re^{0.8} Pr^{0.4}$$

$$= 0.023\left(82.7\times10^3\right)^{0.8}(5.2)^{0.4} = 382 = \frac{hD}{k_T}$$

so

$$\bar{h} = \frac{382\,k_T}{D} = \frac{382\times0.62\frac{W}{mK}}{0.04 m}$$

$$= 5922\frac{W}{m^2K} = 5.92\frac{kW}{m^2K}$$

$$\frac{\Delta T_o}{\Delta T_i} = e^{-\frac{PL\bar{h}}{C_p\dot{m}}}$$

$$\Delta T_o = \Delta T_i\, e^{-\frac{PL\bar{h}}{C_p\dot{m}}}$$

$$T_s - T_{m_o} = (T_s - T_{m_i})\, e^{-\frac{PL\bar{h}}{C_p\dot{m}}}$$

$$95°C - T_{m_o} = (95-25)°C \times e^{-\left[\frac{\pi DL\bar{h}}{C_p\dot{m}}\right]}$$

$$= 70°C \times e^{-[0.356]} = 49°C$$

so $T_{m_o} = 95 - 49°C = 46°C$

$$\dot{q} = \dot{m} c_p \Delta T$$

$$= 2 \frac{kg}{s} \; 4.178 \frac{kJ}{kgK} (46 - 25)$$

$$= 175.5 \frac{kJ}{s} = 175.5 \, kW$$