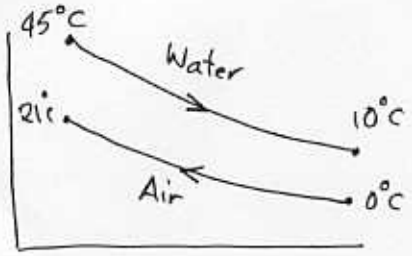
Q4.



If there is no thermal resistance on the water side or through the walls then $U = h_{air\ side}$

$\therefore \dot{Q} = U A \Delta T_{log}$ becomes

$\dot{m} C_p \Delta T = h A \Delta T_{log}$

but $\dot{m} = \rho A_x V = \rho \frac{\pi}{4} d^2 V$ (air) & $St = \frac{h}{\rho V C_p}$ $\therefore h = St \rho V C_p$

and $A = \pi d L$

$\therefore \rho \frac{\pi}{4} d^2 V C_p \Delta T = St \rho V C_p \pi d L \Delta T_{log}$

or $\frac{\Delta T}{\Delta T_{log}} = 4 St \frac{L}{d}$ ——————(i)

From fluid flow $h_f = 4 f \frac{L}{d} \left(\frac{V^2}{2g}\right)$ or $\Delta p = 4f \frac{L}{D} \left(\rho \frac{V^2}{2}\right)$ —(ii)

From (i) & (ii) $\frac{\Delta T}{\Delta T_{log}} = St \frac{\Delta p}{f\left(\rho \frac{V^2}{2}\right)}$

We are given that: $\frac{St}{f} = \frac{1.17}{2}$ $\therefore \frac{\Delta T}{\Delta T_{log}} = \frac{1.17}{2} \frac{\Delta p}{\left(\rho \frac{V^2}{2}\right)}$

from which we can find V

$\Delta T_{log} = \frac{(45-21)-(10-0)}{\ln\left(\frac{45-21}{10-0}\right)} = \underline{16.0\,K}$ $\therefore \frac{21}{16} = \frac{1.17 \times 0.10 \times 10^3}{1.23 \times V^2}$

$\therefore \underline{V = 8.51\ m/s}$

(For air @ 10°C, $\rho = 1.23\ kg/m^3$, $\mu = 0.018 \times 10^{-3}\ kg/ms$)

$\therefore Re = \frac{1.23 \times 8.51 \times 0.015}{0.018 \times 10^{-3}} = 8700$, $f = 0.0791\ 8700^{-\frac{1}{4}} = 0.00818$

& $St = \frac{1.17}{2} \times 0.00818 = 0.00479$

To find tube length use (i) above:

$\frac{21}{16} = 4 \times 0.00479 \times \frac{L}{0.015}$ $\therefore \underline{L = 1.03\ m}$

To find no. of tubes use $\dot{m}_{air} = \rho \frac{\pi}{4} d^2 N \times V$

$\therefore 0.08 = 1.23 \times \frac{\pi}{4} \times 0.015^2 \times N \times 8.51$ $\therefore \underline{N = 43}$