2 spheres.

- one-dimensional
- temp is a function of radius only.

$$q = \frac{4\pi K (T_i - T_o)}{\frac{1}{r_i} - \frac{1}{r_o}}$$

$$R_{th} = \frac{\frac{1}{r_i} - \frac{1}{r_o}}{4\pi K}$$

P.2.17 sphere.

Aluminum

$d_i = 4\,cm$ $\quad r_i = 2\,cm$

$d_o = 8\,cm$ $\quad r_o = 4\,cm.$

$T_i = 100^\circ c$, $T_o = 50^\circ C.$

Find q.

$K \rightarrow$ from Table A-2. Aluminum pure

$K = 204\ w/m.^\circ C$

$$q = \frac{4\pi * 204\,(100-50)}{\frac{1}{0.02} - \frac{1}{0.04}} = \boxed{5127\ W}$$

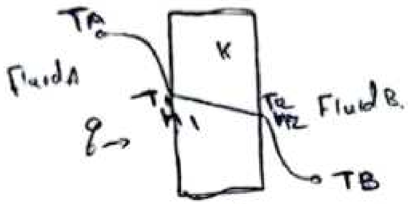
* Convection Boundary conditions.

$$q_{conv} = hA(T_w - T_\infty)$$

صورة أخرى $\quad q_{conv} = \dfrac{(T_w - T_\infty)}{\frac{1}{hA}} = \dfrac{\Delta T}{R_{th}}$

$R_{th} = \dfrac{1}{hA} \rightarrow$ convection resistance.

x plane wall exposed to hot fluid A on one side and a cooler fluid B on the other side.



convection + conduction + convection

T_A — $\frac{1}{h_1 A}$ — T_1 — $\frac{\Delta x}{kA}$ — T_2 — $\frac{1}{h_2 A}$ — T_B

$$R_{th} = \frac{1}{h_1 A} + \frac{\Delta x}{kA} + \frac{1}{h_2 A}$$

$$q = \frac{T_A - T_B}{\frac{1}{h_1 A} + \frac{\Delta x}{k_A} + \frac{1}{h_2 A}}$$

P. 2.16 **2-16** A spherical tank, 1 m in diameter, is maintained at a temperature of 120 ∘ C and exposed to a convection environment. With h=25W/m2 · ∘ C and $T\infty$ =15 ∘ C, what thickness of urethane foam should be added to ensure that the outer temperature of the insulation does not exceed 40 ∘ C? What percentage reduction in heat loss results from

$$q_{without\ insulation} = hA(T_w - T_\infty) = 25 \times 4\pi(0.5)^2(120-15)$$

$h = 25$

$T_\infty = 15$

$T_o = 40C$

$k_f = 0.018$

$$q = \frac{4\pi K(T_i - T_o)}{\frac{1}{r_i} - \frac{1}{r_o}} = h(4\pi r_o^2)(T_o - T_\infty)$$

$$\frac{0.018(120-40)}{\frac{1}{0.5} - \frac{1}{r_o}} = 25\, r_o^2\,(40-15)$$

$$r_o = 0.5023$$

thick of insul. $= r_o - r_i = \boxed{0.023\ m}$

$$q\ (\text{with insulation}) = 25(4\pi(0.5023)^2)(40-15) = \boxed{1982\ W}$$

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* over all Heat. T. coeff. (**U**)

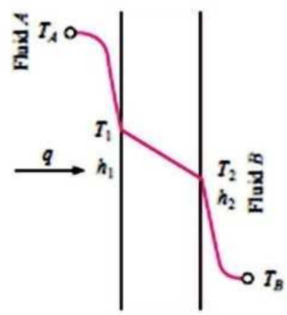
U :- has the same unit of h $W/m^2 . C$

$$q = U A \Delta T_{overall}$$

$$q = h A \Delta T$$

$$U = \frac{q}{A \Delta T}$$

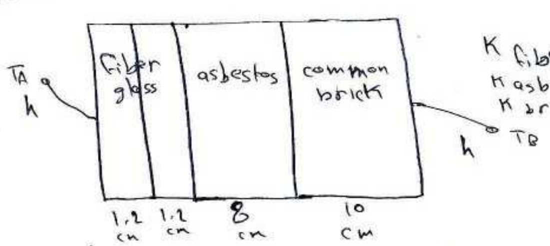
* For plane wall.



$$q = \frac{\Delta T}{\frac{1}{h_1 A} + \frac{\Delta x}{K A} + \frac{1}{h_2 A}}$$

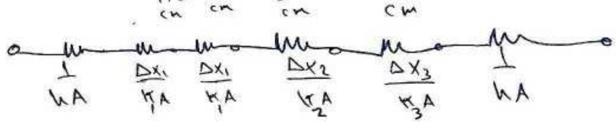
$$U = \frac{1}{\frac{1}{h_1} + \frac{\Delta x}{k} + \frac{1}{h_2}}$$

Q. 2.27



K fiberglass K_1 = 0.038
K asbestos = K_2 = 0.154
K brick = K_3 = 0.69

$h = 12 \ W/m^2 . °C$



$$U = \frac{q}{A \Delta T}$$

$$q = \frac{\Delta T}{\frac{1}{hA} + \frac{\Delta x_1}{K_1 A} + \frac{\Delta x_1}{K_1 A} + \frac{\Delta x_2}{K_2 A} + \frac{\Delta x_3}{K_3 A} + \frac{1}{hA}}$$

$$\therefore U = \frac{1}{\frac{1}{h} + \frac{\Delta x_1}{K_1} + \frac{\Delta x_1}{K_1} + \frac{\Delta x_2}{K_2} + \frac{\Delta x_3}{K_3} + \frac{1}{h}} = \frac{1}{\frac{1}{12} + \frac{0.012}{0.038} + \frac{0.012}{0.038} + \frac{0.08}{0.154} + \frac{0.1}{0.69} + \frac{1}{12}}$$

$$U = 0.634 \ W/m^2 . C$$ #

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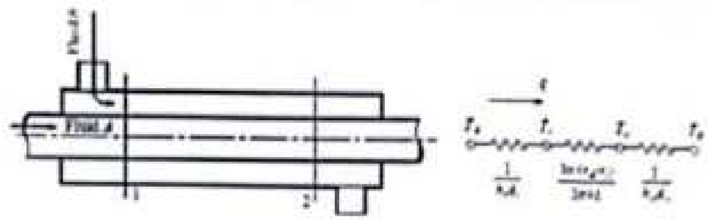
* U for cylindrical system

Figure 2-4 | Resistance analogy for hollow cylinder with convection boundaries



$$q = \frac{T_A - T_B}{\frac{1}{h_i A_i} + \frac{\ln(r_o/r_i)}{2\pi k L} + \frac{1}{h_o A_o}}$$

U_i : overall H.T.C. Based on inside area. $U_i = \frac{q}{A_i \, \Delta T}$

$$U_i = \frac{1}{\frac{1}{h_i} + \frac{A_i \ln(r_o/r_i)}{2\pi k L} + \frac{A_i}{A_o}\frac{1}{h_o}}$$

U_o : overall H.T.C. Based on outside area. $U_o = \frac{q}{A_o \, \Delta T}$

$$U_o = \frac{1}{\frac{A_o}{A_i}\frac{1}{h_i} + \frac{A_o \ln(r_o/r_i)}{2\pi k L} + \frac{1}{h_o}}$$

---

ex) A plastic ($k = 0.5$ W/m.K) pipe carries fluid such that the convection H.T.C is 300 W/m².C. The average fluid temp is 100 C°, the pipe has an id (internal diameter) of 3cm and outer diameter of 4cm if the h.t rate through the pipe per unit length is 500 W/m determine

Solu:- ① the external pipe temp
② U_o

$r_i = 1.5$ cm
$r_o = 2$ cm
$T_\infty = 100$ °C
$h = 300$ W/m².C

① $$q = \frac{T_\infty - T_e}{\frac{1}{h_i (2\pi r_i L)} + \frac{\ln(r_o/r_i)}{2\pi k L}}$$

$A_i = 2\pi r_i L$

$$\frac{q}{L} = 500 = \frac{100 - T_e}{\frac{1}{300(2\pi \times 1.5 \times 10^{-2})} + \frac{\ln(2/1.5)}{2\pi(0.5)}}$$

$T_e = 36.5$ °C

$$q = U_o A_o \Delta T = U_i A_i \Delta T$$

$$\frac{q}{A_o \Delta T} = U_o$$

إشارة → لاحظ لا يوجد A_o

$$q = \frac{\Delta T}{\frac{1}{h_i A_i} + \frac{\ln(r_o/r_i)}{2\pi K L}}$$

$$\frac{q}{\Delta T} = U_o A_o = \frac{1}{\frac{1}{h_i A_i} + \frac{\ln(r_o/r_i)}{2\pi K L}}$$

$$U_o = \frac{1}{\frac{A_o}{h_i A_i} + \frac{A_o \ln(r_o/r_i)}{2\pi K L}} = \frac{1}{\frac{2\pi r_o L}{h_i (2\pi r_i L)} + \frac{2\pi r_o L \ln(r_o/r_i)}{2\pi K L}}$$

$$U_o = \frac{1}{\frac{r_o}{h_i r_i} + \frac{r_o \ln(r_o/r_i)}{K}} = \frac{1}{\frac{0.02}{300 \times 0.015} + \frac{0.02 \ln(2/1.5)}{0.5}}$$

$$U_o = 62.7 \ W/m^2 . C$$

#

إذا اردت التحقق من الحل

$$q = U_o A_o \Delta T$$
