References:

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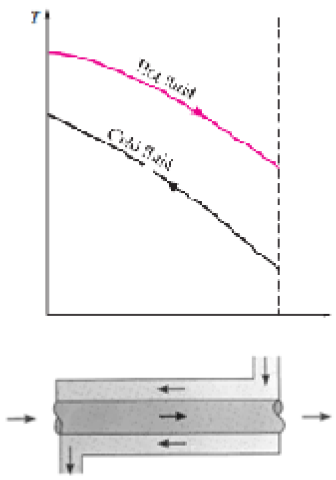
4. **Principles of heat flow in fluids, typical heat exchange equipment**

The general function of a heat exchanger is to transfer heat from one fluid to another. The basic component of a heat exchanger can be viewed as a tube with one fluid running through it and another fluid flowing by on the outside. There are thus three heat transfer operations that need to be described:

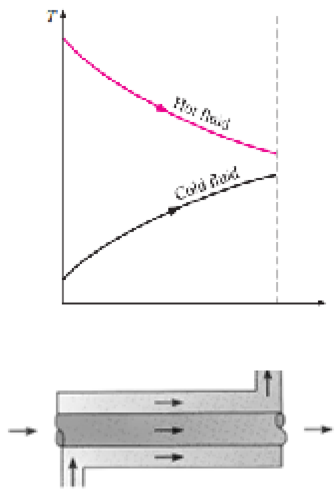
1) Convective heat transfer from fluid to the inner wall of the tube

2) Conductive heat transfer through the tube wall

3) Convective heat transfer from the outer tube wall to the outside fluid

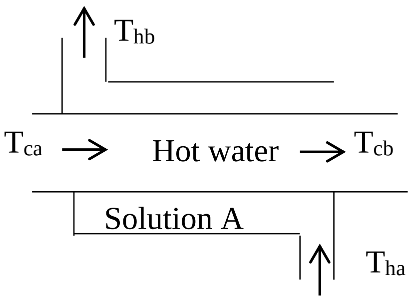


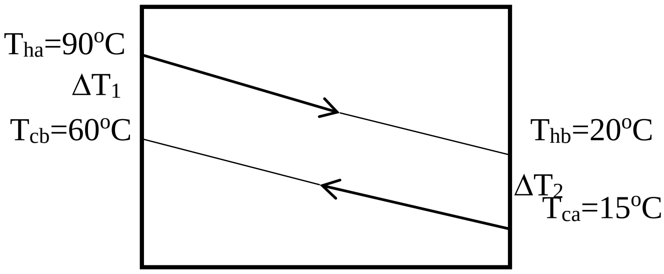
Counter flow



Parallel flow

Example:





$$\overline{T_h} = \frac{90+20}{2} = 55^o C \approx 54.44^o C$$

$$\overline{T_c} = \frac{60+15}{2} = 37.5^o C \approx 37.78^o C$$

Table 8

C_{ph}=4.179 kJ/(kg.C), $\rho_h = 985.7\ kg/m^3$ $\mu_h = 5.13 \frac{kg}{ms}$ k_h=0.649 W/m°C

$$C_{pc} = 0.941 \frac{kcal}{kg^o C} x \frac{4.18\ J}{1\ cal} = 3.93 \frac{kJ}{kg^o C}$$

Table 8

$\rho_c = 993\ kg/m^3$ $\mu_c = 6.82 \frac{kg}{ms}$ k_c=0.63 W/m°C

Table 10

2 in sch 40 D_o=2.375 in D_i=2.067 in

$$D_o = 2.375\ in \frac{2.54\ cm}{1\ in} \frac{1\ m}{100\ cm} = 0.0603\ m$$

$$D_i = 2.067\ in \frac{2.54\ cm}{1\ in} \frac{1\ m}{100\ cm} = 0.052\ m$$

4 in sch 40 D_o=4.5 in=0.11 m D_i=4.026 in =0.102 m

$q = m_c C_{pc}(T_{cb}-T_{ca})$=200 kg/h x3.93 kJ/(kg°C)(60-15)°C=35370 kJ/h

q=35370 kJ/h x 1000J/1kJ x1h/3600 s=9825 J/s

35370 kJ/h=m_hx4.179 kJ/(kg.C)(90-20)°C

m_h=120.9 kg/h

$$\Delta T_L = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}} = \frac{(T_{ha} - T_{cb}) - (T_{hb} - T_{ca})}{\ln \frac{T_{ha} - T_{cb}}{T_{hb} - T_{ca}}}$$

$$\Delta T_L = \frac{(90-60)-(20-15)}{\ln \frac{90-60}{20-15}} = 13.95^o C$$

$$U_o = \frac{1}{\frac{D_o}{D_i h_i} + \frac{x_w}{k_m}\frac{D_o}{\overline{D_L}} + \frac{1}{h_o}}$$

$$\overline{D_L} = \frac{D_o - D_i}{\ln \frac{D_o}{D_i}} = \frac{0.0603 - 0.052}{\ln \frac{0.0603}{0.052}} = 0.056\ m$$

$$D_o = 0.0603\ m$$

$$D_i = 0.052\ m$$

$$\overline{D_L} = 0.056\ m$$

$$x_w = \frac{D_o - D_i}{2} = \frac{0.0603 - 0.052}{2} = 0.0041$$

k_m=59 W/m^{o}C   Wrought iron   (Table 2)

$$U_o = \frac{1}{\frac{0.0603}{0.052 x 7500} + \frac{0.0041}{59} x \frac{0.0603}{0.056} + \frac{1}{3200}} = \frac{1}{0.00015 + 0.000075 + 0.0003} = \frac{1}{5.25 x 10^{-4}}$$

U_o=1904.7 m^{2o}C/W

$$A_o = \frac{q}{U_o \Delta T_L} = \frac{9825\ J/s}{1904.7 x\, 13.95} = 0.369\ m^2$$

$$A_o = \pi D_o L \qquad 0.369\ m^2 = 3.14 x (0.0603) L$$

L=1.9 m