- For two pass design, overall heat transfer calculated came within the range of error.

- But we can still increase the number of passes and get a good design.

- The tube velocity obtained using two pass design is low. Hence calculation for four pass design is done:

For 4 pass design:

calculated No. of tubes $\simeq 154$

Using standard data tabel.

$N_t = 170$ Shell ID $= 21.25''$

$= 0.54 m$

Finding Bundle diameter:

for 4 pass.

$K_1 = 0.175$ $n_1 = 2.285$

$$D_b = 25.4 \left(\frac{170}{0.175}\right)^{\frac{1}{2.285}} \Rightarrow 0.516 m$$

Notes:

Scanned by TapScanner

Adding clearance, for split ring floating head

Shell ID $= 0.516 + \underbrace{(0.057)}_{\text{clearance}} \Rightarrow 0.573\,m$

Tubes per pass $= \frac{170}{4} \Rightarrow 42.5$

Tube ID $= 0.856'' \Rightarrow 0.022\,m$

Flow area per tube $= (0.576'')^2$

$= 3.72 \times 10^{-4}\, m^2$

Total flow area $= 42.5 \times (3.72 \times 10^{-4})$

$= 0.01581\, m^2$

Tube side mass velocity $= \frac{46625.49}{3600 \times 0.01581}$

$= 819.2\ \frac{Kg}{m^2 s}$

$Re_{tube} = \frac{819.2 \times 0.022}{7 \times 10^{-4}}$

Notes:

$= 25746.28$

$$\frac{L}{d} = \frac{16 \times 12}{0.856} \Rightarrow 224.3$$

$$Pr = \frac{4179 \times 7 \times 10^{-4}}{0.64} \Rightarrow 4.57$$

$$j_H = 0.0044.$$

$$h_i = \frac{0.0044 \times 25746.28 \times (4.57)^{1/3} \times 0.64}{0.022}$$

$$= 5468.86 \ \frac{W}{m^2 \, ^\circ C}$$

$$\text{Baffle spacing} = (0.2) \times 0.573$$
$$= 0.1146 \ m$$

$$A_s = \left(\frac{1.25 - 1}{1.25}\right) \times 0.573 \times 0.1146$$
$$= 0.014 \ m^2$$

$$d_e = \frac{1.1}{1 \times 25.4} \left(1.25^2 - 0.917 \times 1^2\right) \frac{25.4^2}{1000}$$

$$= 0.0164 \ m$$

$$G_s = \frac{15500}{3600 \times 0.014} \Rightarrow 307.54 \ \frac{kg}{m^2 s}$$

Notes:

$$Re_{shell} = \frac{307.54 \times 0.0164}{10^{-3}} \Rightarrow 5043.65$$

$$Pr = \frac{2155 \times 10^{-3}}{0.138} \Rightarrow 15.62$$

$$j_H = 0.008$$

$$h_o = \frac{0.138}{0.0164} \times 0.008 \times 5043.65 \times (15.62)^{1/3}$$

$$= 848.71 \ \frac{W}{m^2 \, °C}$$

$$\left.\begin{aligned} h_{id} &= (0.00024)^{-1} \\ h_{od} &= (0.0002)^{-1} \end{aligned}\right\} \frac{W}{m^2 \, °C}$$

$(K_w = 109)$ material thermal conductivity

$$\frac{1}{U_{o\,cal}} = \frac{1}{848.71} + 0.0002 + \frac{1}{0.856}\left(\frac{1}{5468.86} + 0.00024\right)$$

Notes:

$$+ \frac{1 \times 0.0254 \ \ln\left(\frac{1}{0.856}\right)}{2 \times 109}$$

$U_{o\,cal} = 528.99 \ \frac{W}{m^2 \cdot C}$

Mean absolute error $= \left| \frac{528.99 - 550}{550} \right|$

$= 3.82\%$ Within Range of error

Pressure drop calculations :-

j_f (Tube) $= 3.8 \times 10^{-3}$.

$$\Delta P_{tube} = 4\left(8 \times 3.8 \times 10^{-3} \times (224.3) + 2.5\right) \times \left(\frac{819.2 \times 819.2}{2 \times 993}\right)$$

ρ ~~kerosene~~ water at $102\,°F = 993 \left(\frac{Kg}{m^3}\right)$

$\Delta P_{tube} = 12444.1$ Pa.

$U_{tube} = \frac{819.2}{993} \Rightarrow 0.82$ m/s.

Notes:

$\Delta P_{shell} = ?$ $\left(\cancel{S \text{ kerosene at } 167°F} = 775 \frac{kg}{m^3} \right)$

$$U_{shell} = \frac{307.54}{775}$$

$$= 0.39 \left(\frac{m}{s}\right) \quad \left\{ j_f = 4.8 \times 10^{-2} \right\}$$

$$\Delta P_{shell} = \left(8 \times 4.8 \times 10^{-2}\right) \times \left(\frac{0.573}{0.0164}\right) \left(\frac{16 \times 12 \times 0.0254}{0.1146}\right)$$

$$\times 775 \times \frac{(0.39)^2}{2}$$

$$= 33650.63 \text{ Pa}.$$

$$\simeq 0.3 \frac{kg}{cm^2}.$$

Pressure drop are within limit. Hence our data is feasible