LAMPIRAN

1. **Perhitungan Neraca Panas**

$$\text{Qsteam} = m \times Cp \times \Delta t$$

$$\text{Qsteam} = 62641{,}51 \frac{lb}{hour} \; X \; 0{,}50148 \frac{\text{Btu}}{lb° \; f} \; x \; (215{,}9184 - 186{,}418) \; ° f$$

$$\text{Qsteam} = 926721{,}8485 \text{ Btu/jam}$$

$$\text{Qbrine} = m \times Cp \times \Delta t$$

$$\text{Qsteam} = 344248{,}357 \frac{lb}{hour} X \; 0{,}97908 \; \frac{\text{Btu}}{lb° \; f^o} \; X \; (186{,}418 - 158) \; ° f$$

$$\text{Qsteam} = 9578052{,}229 \text{ Btu/jam}$$

1. **Menghitung Logarithmic Mean Temperature Difference (LMTD)**

$$\Delta t1 = T2 - t1 = \; 194 - 158 = 36 \; ^oF$$

$$\Delta t2 = T1 - t2 = \; 215,\, 9184 - 186{,}418 = 29{,}501^oF$$

$$LMTD = \frac{(T1 - t2) - (T2 - t1)}{ln \; \frac{(T1 - t2)}{(T2 - t1)}}$$

$$LMTD = \frac{36 - 29{,}501}{\ln \frac{36}{29{,}501}}$$

$$= 32{,}64 \; °F$$

2. **Menghitung True Temperature Difference**

$$R = \frac{T1 - T2}{t2 - t1}$$

$$R = 0{,}771$$

$$S = \frac{t2 - t1}{T1 - t1}$$

$$S = \frac{186{,}418 - 158}{215\,,9184 - 158}$$

S= 0,491

Dari nilai R dan S, didapatkan nilai Ft dari grafik 18 pada Buku *"Process Heat Transfer"* milik D.Q. Kern.

$$Ft = 0{,}92$$

3. Menghitung Caloric Temperature

$$Tc = T2 + Fc\ (T1 - T2)$$

$$Tc = \ 194 + 0{,}5\ x\ 21{,}918$$

$$Tc = 204{,}959$$

$$Tc = \ t2 + Fc\ (t2 - t1)$$

$$Tc = \ 186{,}418 + (0{,}5\ x\ (186{,}418 - 158)\ )$$

$$Tc = 200{,}626\ °F$$

4. Menghitung Flow Area Pada Area Shell Dan Tube

$$as = \frac{IDs.C'.B}{Pt}$$

$$as = \frac{2{,}84795\ \ x\ 0{,}2356}{37{,}126\ \ x\ 0{,}866}$$

$$as = 0{,}1998\ ft^2$$

Berdasarkan T. 10 Kern dengan data OD dan BWG diperoleh luas area per tube
Dengan nilai a't = 0,334

$$At = \frac{Nt\ .a't}{N}$$

$$At = \ \ 6{,}9583 ft^{\ 2}$$

5. Perhitungan *Mass Velocity*

Shell Side

$$Gs = \frac{Ws}{as}$$

$$Gs = \frac{625641{,}511}{0{,}1998}$$

$$Gs = 313586{,}0754\ \frac{lb}{hr.ft^2}$$

Tube side

$$Gt = \frac{Wt}{at}$$

$$Gt = \frac{344248{,}3574}{6{,}9583}$$

$$Gt = 4115{,}451708$$

6. **Menentukan factor for heat transfer**

   Pada Shell

   Didapatkan nilai Jh senilai 90 diambil dari buku kern table 28

   Pada Tube

   Didapatkan nilai jg senilai 15 diambil dari buku kern table 24

7. **Menghitung *Reynold Number* Pada Area *Shell* Dan *Tube***

   Shell Side

$$Res = \frac{De\ .Gs}{\mu}$$

$$Res = \frac{0{,}0458\ X\ 313586{,}0754}{0{,}65}$$

$$Res = 2205{,}069$$

   Tube Side

$$Ret = \frac{ID\ x\ Gt}{\mu}$$

$$Ret = \frac{0{,}054\ X\ 49472{,}818}{0{,}65}$$

$$Ret = 4115{,}451708$$

8. **Menentukan Nilai Outside Film Coefficient (ho)**

$$\frac{ho}{\emptyset s} = \frac{Jh.k.\ cp\ .\mu}{De\ .K}$$

$$\frac{ho}{\emptyset s} = 90\ X\ \left(\frac{0{,}966}{0{,}0458}\right) x1{,}71$$

$$\frac{ho}{Øs} = 221,06 \ \frac{Btu}{hr\ .ft^{2}.°F}$$

9. Menentukan Nilai Inside Film Coefficient (hi)

$$hi = \frac{jhx\ k\ x\ cp\ x\ \mu}{ID\ X\ k}$$

$$hi = \ 90\ x\ \left(\frac{0,069}{0,054}\right)\ x\ 2,10$$

hi = 40,01 Btu/(hr ft² °F) øt

$$\frac{hio}{Øt} = \frac{hi\ ID}{Øt\ OD}$$

$$\frac{hio}{Øt} = 40,01\ X\ \left(\frac{0,054}{0,0525}\right)$$

$$\frac{hio}{Øt} = 41,38\ Btu/(hr\ ft^{2}\ °F)$$

10. Menghitung *Tube Wall Temperature*

$$tw = tc + \frac{\frac{ho}{Øs}}{\frac{ho}{Øs} + \frac{hio}{Øt}}\ (Tc - tc)$$

$$tw = 200,62 + (\frac{221,06}{221,06} + 41,38)x(204,959 - 200,626)$$

$$tw = 204,276\ °F$$

10. Mencari nilai Φs *(Shell Side)*

$$Øs = \left(\frac{\mu}{\mu w}\right)\ \text{^}0,14$$

$$Øs = \left(\frac{0,65}{0,63}\right)\text{^}0,14$$

$$Øs = 1,0053$$

Sehingga Nilai ho

$$ho = \frac{ho\ x\ Øs}{Øs}$$

$$ho = \frac{221,06}{1,0053}$$

$$ho = 222,2327\frac{Btu}{hr.ft^{2}.°F}$$

11. Mencari Nilai Øt (Tube Side)

$$Øt = \left(\frac{\mu}{\mu w}\right) \text{^}0{,}14$$

$$Øt = \left(\frac{0{,}65}{0{,}63}\right)^{0{,}14}$$

$$Øt = 1{,}0053$$

Sehingga nilai hi

$$hio = \frac{hio\ x\ Øt}{Øt}$$

$$hio = \frac{41{,}38}{1{,}0053}$$

$$hio = 41{,}6033\ \frac{Btu}{hr.ft^2.°\text{F}}$$

12. Menghitung *Clean Overall Heat Transfer Coefficient* Atau Uc

$$Uc = \frac{ho\ .\ hio}{ho + hio}$$

$$Uc = \left(\frac{221{,}2327\ .\ 41{,}0633}{221{,}2327 + 41{,}0633}\right)$$

$$Uc = 35{,}0431\ \frac{Btu}{hr.ft^2.°\text{F}}$$

13. Menghitung Dirty Overall Heat Transfer Coefficient Desain Atau Ud
Shell side

Dari data OD = 3/4 in dan BWG= 14 diperoleh eksternal surface didapatkan data 0,1963 Ft dari buku Kern Table 10

$$Ud = \frac{Q}{A.\Delta T\ LMTD}$$

$$Ud = \frac{9578052{,}229}{14522{,}6274\ .\ 32{,}64}$$

$$Ud = 20{,}2044\ \frac{Btu}{hr.ft^2.°\text{F}}$$

Tube Side

Dari data OD = 3/4 in dan BWG= 14 diperoleh eksternal surface didapatkan data 0,1963 Ft dari buku Kern Table 10

$$Ud = \frac{Q}{A.\Delta T\ LMTD}$$

$$Ud = \frac{9578052{,}229}{14522{,}6274\ .\ 32{,}64}$$

$$Ud = 20{,}2044\ \frac{Btu}{hr.ft^2.°F}$$

14. Menghitung Nilai Rd

Shell tube

$$Rd = \frac{Uc - Ud}{Uc\ .Ud}$$

$$Rd = \frac{35{,}0431 - 20{,}20244}{35{,}0431\ .\ 20{,}20244}$$

$$Rd = 0{,}020957749\ \frac{Btu}{hr.ft^2.°F}$$

Tube side

$$Rd = \frac{Uc - Ud}{Uc\ .Ud}$$

$$Rd = \frac{35{,}0431 - 20{,}20244}{35{,}0431\ .\ 20{,}20244}$$

$$Rd = 0{,}020957749\ \frac{Btu}{hr.ft^2.°F}$$

Rd Total

$$Rd\ Total = \frac{Rd\ shell + Rd\ tube}{2}$$

$$Rd\ total = \frac{0{,}020957749 + 0{,}020957749}{2}$$

$$= 0{,}020957749$$

15. Menghitung Pressure Drop Pada Area Shell Dan Tube

Shell Side

$$\Delta Ps = \frac{f\ (GS^2.IDs.(N+1))}{5{,}22\ .10^{10}.IDs.sg\ steam\ .Øs}$$

$$\Delta ps = \frac{0{,}0018\ x\ (313586{,}0754^2.0{,}237329183\ .95{,}6506591)}{5{,}22\ .10^{10}.0{,}237329183\ .0{,}9440\ .1{,}0053}$$

$$= 0{,}341772299\ Psi$$

Tube Side

$$\Delta Pt = \frac{f.(Gt^2.L.n)}{5{,}22.10^{10}.ID.sg\ brine.Øt}$$

$$\Delta Pt = \frac{0{,}00033\ x\ (49472{,}81783^2\ .\ 24{,}6606.1)}{5{,}22.10^{10}.\ 0{,}054\ .\ 0{,}9970\ .1{,}0053}$$

$$= 0{,}007006872\ Psi$$