LAMPIRAN

8.1 Hasil Perhitungan Dimensi Alat *Heat Exchanger*

Shell side		Tube side		Temperatur :
IDs	= 10 in	IDt	= 0,62 in	Th1 = 81°C = 177,8 °F
B	= 7	ODt	= ¾	Th2 = 77°C = 170,6 °F
Baffle space	= 6 in	BWG	= 16	
Passes	= 1	pitch	= triangular	ΔTh= 4°C = 7,2 °F
Pt	= 0,9375	passes	= 2	Tc1 = 25°C = 77 °F
C	=0,99(fig.2Kern)	C	=0,98(fig2 Kern)	Tc2 = 33°C = 91,4 °F
de	= 0,045833 ft	Nt	= 12	ΔTc = 8°C = 14,4 °F

ΔT LMTD = (Th1-Tc2)-(Th2-Tc1)/(ln(Th1-Tc2)/(Th2-Tc1)) = 89,952 ^{o}F

Q = AU ΔTLMTD = 232988,87 Btu/jam

W shell = Q/C(Th1-Th2)

= 342630,69 /(0,99x 7,2 ^{o}F)

= 32686,43 lb/jam

W tube = Q/C(Th1-Th2)

= 342630,69 / (0,98 x 14,4 ^{o}F)

= 16509,98 lb/jam

Shell

1) Heat Balance : Q = AU ΔTLMTD = 232988,87 Btu/jam

   dengan, A = 7080 cm^2 = 0,708 m^2 = 7,618 ft^2

   U = 340 btu/jam ft^2 ^oF

2) Δt

Hot fluid		cold fluid	Diff
177.8	Higher Temp	77	100.8
170.6	Lower Temp	91.4	79.2
7.2	Differences	14.4	21.6

L = 1 m = 3,2808399 ft = 39,370079 in

LMTD = 89,952 ^oF

R = $\frac{7,2}{14,4}$ = 0,5; S = $\frac{14,4}{177,8-91,4}$ = 0,0167; Ft = 0,98 (Fig 18 Kern)

Δt = Ft x ΔTLMTD = 0,98 x 89,952 ^oF = 88,153 ^oF

3) Hot Fluid; shell side, water

4) As = ID x C'B / 144Pt

dengan C' = Pt – OD = 0,9375 – ¾ = 0,188 in

B = L/b = $\frac{39,370079 \text{ in}}{6\ in}$ = 6,56167979 = 7

As = ID x C'B / 144Pt = 10 in x 0,188 x (7 / 144) x 0,9375= 0,091 ft^2

5) Gs = W/as = 32686,43 lb/jam / 0,091 ft^2 = 358661,651 lb/jam ft^2

6) At Ta = (Th1 +Th2) /2 = (177,8 ^oF + 170,6 ^oF) / 2 = 174,2 ^oF

μ = 0,8712 lb/jam ft (fig. 14 Kern)

Ds = IDs/12 = 10 in / 12 = 0,833 ft

Res = (Ds x Gs) / μ

= (0,833 ft x 358661,651 lb/jam ft^2) / 0,8712 lb/jam ft

= 343072,439 (Turbulen)

7) jH = 380 (fig 28 Kern)

8) At Ta = 174,2 ^oF; c = 1 Btu/lb °F

k = 0.898 Btu/(jam)(ft2)(°F/ft) (Tabel 4 Kern)

$(c\mu/k)^{(1/3)}$ = (0,99 x 1,186/0,898) $^{(1/3)}$ = 0,986640431

9) ho = jH x k/de x $(c\mu/k)^{(1/3)}$

=380x0,898 Btu/(jam)(ft^2)(°F) / (0,045833333 ft) x 0,986640431

=90552,580 Btu/(jam)(ft^2)(°F)

Tube

3) Cold Fluid; tube side, water

4) a't = 0,302 in^2 (table 10 Kern)

at = Nt x a't / 144xn = 12 x (0,302 in^2 /144) x 2 = 0,503 ft^2

5) Gt = w/at = 16509,98 lb/jam / 0,503 ft^2 = 328012,89 lb/jam

vel, v = $Gt/3600_{\varrho}$ = 328012,89 lb/jam / (3600 X62,5) = 1,458 ft/sec

6) At ta = (Tc1+Tc2) / 2 = (77 °F + 91,4 °F) / 2 = 84,2 °F

μ = 2,118 lb/jamft (fig. 14 Kern)

7) D = IDt/12 = 0,62/12 = 0,052 ft

8) Ret = D x Gt/μ

= 0,052 ft x 328012,89 lb/jamft^2 / 2,118 lb/jamft = 8003,4629 (Turbulen)

9) hi = 415 Btu/jam (ft2) (°F) (fig 25 Kern)

10) hio = hi x ID/OD = 415 Btu/jam (ft2) (°F) x (0,62 in / ¾) = 343,067

Clean overall (Uc) = hio x ho/hio + ho

= (343,067 x 90552,580) / (343,067+ 90552,580)

= 341,772 Btu/(jam)(ft^2)(°F)

Rd = Uc-UD / UcxUD

= (341,772 – 340) / (341,772 x 340)

= 0,00002 (hr))(ft^2)(°F) / Btu

Summary

90552,580	h outside	343,067
Uc	341,772	
U_D	340	
Rd Calculated	0,00002	
Rd Required	0,001	

Pressure Drop

Shell

1) Res = 343072.4395 ; f = 0,001 ft/in^2 (fig 29 Kern)

2) No. of crosses, N + 1 = 12L/B = 12 x 6,56167979 = 78,74

Ds = 10/12 = 0,833 ft

3) ΔPs= (f x Gs^2 x Ds x (N+1)) / (5,22 x 10^{10} x Ds x Ǿs)

= 0,194 psi\

Tube

1) Ret= 8003,462882 = 0,00015 ft^2 / in^2

2) ΔPt = (f x Gt^2 x L x n) / (5,22 x 10^{10} x Ds x Ǿt)

= 0,012 psi

3) Gt = 328012,89 lb/jamft^2

V^2/2G' = 0,03

4) ΔPr = 4 n/s (v^2/2G') = 4 x (2/1) x 0,03 = 0,24 psi

ΔPT = ΔPt + ΔPr = 0,026 + 0,24 = 0,252 psi

8.2 Hasil Perhitungan Percobaan

8.2.1 Hasil Perhitungan Percobaan 1

Pada percobaan ke-1, Dengan bukaan valve penuh didapat data dari hasil pengamatan

Waktu (sekon)	Bukaan Valve	Kecepatan Aliran(kg/s)	Th in (^oC)	Th out (^oC)	Tc in (^oC)	Tc out (^oC)	Luas Perpindahan Panas
600	Penuh	1,3	35	31	28	29	16,087 ft^2

Th1 : 35 ^oC = 95 ^oF Tc1 : 28 ^oC = 82,4 ^oF

Th2 : 31 ^oC = 87,8 ^oF Tc2 : 29 ^oC = 84,2 ^oF

Kecepatan aliran = 78 kg/menit

m $= \frac{Laju\ alir}{60\ s} = \frac{78\ kg/menit}{60\ s}$ = 1,3 kg/sekon

C = 0,99 (fig.2Kern)

Q = m x C x ΔT

= 1,3 kg/sekon . 0,99 btu/kg ^oF. (95-87,8) ^oF

= 9,266 btu/s

$$\Delta TLMTD = \frac{(Th1-Tc2)-(Th2-Tc1)}{\ln\frac{(Th1-Tc2)}{(Th2-Tc1)}}$$

$$= \frac{(10,8)-(5,4)}{\ln\frac{(10,8)}{(5,4)}}$$

$$= \frac{(5,4)}{(0,693)}$$

$$= 7,792\ ^{o}F$$

U = 500 btu/jam $ft^2\ ^{o}F$

= 0,139 btu/s $ft^2\ ^{o}F$

Q = A . U. ΔLMTD

$$A = \frac{Q}{U.\Delta LMTD}$$

$$= \frac{9,266}{0,139\ x\ 7,792}$$

$$= 8,555\ ft^2$$

8.2.2 Hasil Perhitungan Percobaan 2

Pada percobaan ke-2, Dengan bukaan valve penuh didapat data dari hasil pengamatan

Waktu (sekon)	Bukaan Valve	Kecepatan Aliran(kg/s)	Th in (^{o}C)	Th out (^{o}C)	Tc in (^{o}C)	Tc out (^{o}C)	Luas Perpindahan Panas
600	Penuh	1,3	40	33	28	30	16,818 ft^2

Th1 : 40 ^{o}C = 104 ^{o}F Tc1 : 28 ^{o}C = 82,4 ^{o}F

Th2 : 33 ^{o}C = 91,4 ^{o}F Tc2 : 30 ^{o}C = 86 ^{o}F

Kecepatan aliran = 78 kg/menit

m = $\frac{Laju\ alir}{60\ s}$ = $\frac{78\ kg/menit}{60\ s}$ = 1,3 kg/sekon

C = 0,99 (fig.2Kern)

Q = m x C x ΔT

= 1,3 kg/sekon . 0,99 btu/kg ^{o}F. (104-91,4) ^{o}F

= 16,216 btu/s

$$\Delta TLMTD = \frac{(Th1-Tc2)-(Th2-Tc1)}{\ln\frac{(Th1-Tc2)}{(Th2-Tc1)}}$$

$$= \frac{(18)-(9)}{\ln\frac{(18)}{(9)}}$$

$$= \frac{(9)}{(0{,}693)}$$

= 12,987 ^{o}F

U = 500 btu/jam ft^2 ^{o}F

= 0,139 btu/s ft^2 ^{o}F

Q = A . U. ΔLMTD

$$A = \frac{Q}{U.\Delta LMTD}$$

$$= \frac{16{,}216}{0{,}139\ x\ 12{,}987}$$

= 8,983 ft^2

8.2.3 Hasil Perhitungan Percobaan 3

Pada percobaan ke-2, Dengan bukaan valve penuh didapat data dari hasil pengamatan

Waktu (sekon)	Bukaan Valve	Kecepatan Aliran(kg/s)	Th in (^oC)	Th out (^oC)	Tc in (^oC)	Tc out (^oC)	Luas Perpindahan Panas
600	Penuh	1,3	45	34	28	31	20,275 ft^2

Th1 : 45 ^oC = 113 ^oF Tc1 : 28 ^oC = 82,4 ^oF

Th2 : 34 ^oC = 93,2 ^oF Tc2 : 31 ^oC = 87,8 ^oF

Kecepatan aliran = 78 kg/menit

m $= \frac{Laju\ alir}{60\ s} = \frac{78\ kg/menit}{60\ s}$ = 1,3 kg/sekon

C = 0,99 (fig.2Kern)

Q = m x C x ΔT

= 1,3 kg/sekon . 0,99 btu/kg ^oF. (113 – 93,2) ^oF

= 25,483 btu/s

$$\Delta TLMTD = \frac{(Th1-Tc2)-(Th2-Tc1)}{\ln\frac{(Th1-Tc2)}{(Th2-Tc1)}}$$

$$= \frac{(25,2)-(10,8)}{\ln\frac{(25,2)}{(10,8)}}$$

$$= \frac{14,4}{0,847}$$

$$= 17,001\ ^{o}F$$

U = 500 btu/jam $ft^2\ ^{o}F$

= 0,139 btu/s $ft^2\ ^{o}F$

Q = A . U. ΔLMTD

$$A = \frac{Q}{U.\Delta LMTD}$$

$$= \frac{25,483}{0,139 \text{ x } 17,001}$$

$$= 10,784\ ft^2$$

8.2.4 Hasil Perhitungan Percobaan 4

Pada percobaan ke-4, Dengan bukaan valve penuh didapat data dari hasil pengamatan

Waktu (sekon)	Bukaan Valve	Kecepatan Aliran(kg/s)	Th in (^{o}C)	Th out (^{o}C)	Tc in (^{o}C)	Tc out (^{o}C)	Luas Perpindahan Panas
600	Penuh	1,3	50	36	28	33	26,36 ft^2

Th1 : 50 ^{o}C = 122 ^{o}F Tc1 : 28 ^{o}C = 82,4 ^{o}F

Th2 : 36 ^{o}C = 96,8 ^{o}F Tc2 : 33 ^{o}C = 91,4 ^{o}F

Kecepatan aliran = 78 kg/menit

m $= \frac{Laju\ alir}{60\ s} = \frac{78\ kg/menit}{60\ s}$ = 1,3 kg/sekon

C = 0,99 (fig.2Kern)

Q = m x C x ΔT

= 1,3 kg/sekon . 0,99 btu/kg ^{o}F. (122 – 96,8) ^{o}F

= 32,432 btu/s

$$\Delta TLMTD = \frac{(Th1-Tc2)-(Th2-Tc1)}{\ln\frac{(Th1-Tc2)}{(Th2-Tc1)}}$$

$$= \frac{(30,6)-(14,4)}{\ln\frac{(30,6)}{(14,4)}}$$

$$= \frac{16,2}{0,754}$$

= 21,485 ^{o}F

U = 500 btu/jam ft^2 ^{o}F

= 0,139 btu/s ft^2 ^{o}F

Q = A . U. ΔLMTD

$$A = \frac{Q}{U.\Delta LMTD}$$

$$= \frac{32,432}{0,139\ x\ 21,485}$$

= 10,86 ft^2

8.2.5 Hasil Perhitungan Percobaan 5

Pada percobaan ke-4, Dengan bukaan valve penuh didapat data dari hasil pengamatan

Waktu (sekon)	Bukaan Valve	Kecepatan Aliran(kg/s)	Th in (^oC)	Th out (^oC)	Tc in (^oC)	Tc out (^oC)	Luas Perpindahan Panas
600	Penuh	1,3	55	35	28	34	27,109 ft^2

Th1 : 55 ^oC = 131 ^oF Tc1 : 28 ^oC = 82,4 ^oF

Th2 : 37 ^oC = 98,6^oF Tc2 : 34 ^oC = 93,2 ^oF

Kecepatan aliran = 78 kg/menit

m $= \frac{Laju\ alir}{60\ s} = \frac{78\ kg/menit}{60\ s}$ = 1,3 kg/sekon

C = 0,99 (fig.2Kern)

Q = m x C x ΔT

= 1,3 kg/sekon . 0,99 btu/kg ^oF. (131 – 98,6) ^oF

= 41,7 btu/s

$$\Delta TLMTD = \frac{(Th1-Tc2)-(Th2-Tc1)}{\ln\frac{(Th1-Tc2)}{(Th2-Tc1)}}$$

$$= \frac{(37{,}8)-(16{,}2)}{\ln\frac{(37{,}8)}{(16{,}2)}}$$

$$= \frac{21,6}{0,847}$$

$$= 25,502\ ^{o}F$$

U = 500 btu/jam $ft^2\ ^{o}F$

= 0,139 btu/s $ft^2\ ^{o}F$

Q = A . U. ΔLMTD

$$A = \frac{Q}{U.\Delta LMTD}$$

$$= \frac{41,7}{0,139\ x\ 25,502}$$

$$= 11,764\ ft^2$$