LAMPIRAN

8.1 Hasil Perhitungan Pengujian Alat

8.1.1 Hasil Perhitungan *Heat Exchanger* Tipe *Shell and Tube*

Shell side		Tube side		Temperatur :	
IDs	= 10 in	IDt	= 0,62 in	Th1 = 81 ^{O}C	177,8
B	= 7	ODt	= ¾	^{O}F	
Baffle space	= 6 in	BWG	= 16	Th2 = 77 ^{O}C	170,6
Passes	= 1	pitch	= triangular	^{O}F	
Pt	= 0,9375	passes	= 2	Th1 = 4 ^{O}C	7,2 ^{O}F
C	= 0, 99	C	= 0,98 (fig2	Th2 = 25 ^{O}C	77 ^{O}F
(fig. 2 Kern)		Kern)		Tc2 = 33 ^{O}C	91,4 ^{O}
de	=0,045833333 ft	Nt	= 12	ΔTc = 8 ^{O}C	14,4 ^{O}F

Shell

1) Heat Balance :

Q = AU ΔTLMTD

= 232988,87 Btu/jam

A = 7080 cm^2

0,708 m^2

7,618 ft^2

U = 340 btu/jam ft^2 ^{o}F

ΔTLMTD = (Th1-Tc2)-(Th2-Tc1)/(ln(Th1-Tc2)/(Th2-Tc1))

= 89,952 ^{o}F

Q shell = W x C(Th1-Th2)

W shell = Q/C(Th1-Th2)

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

= 48068,28 lb/jam

Q tube = W x C(Th1-Th2)

W tube = Q/C(Th1-Th2)

= 232988,87/ (0,98 x 14,4 ^{o}F)

= 32686,43 lb/jam

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 ^{o}F

R = $\frac{7,2}{14,4}$

= 0,5

S = $\frac{14,4}{177,8-91,4}$

= 0,167

Ft = 0,98 (Fig 18 Kern)

Δt = Ft x ΔTLMTD

= 0,98 x 89,952 ^{o}F

= 88,153 ^{o}F

Shell

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

= $\frac{39{,}370079\ \text{in}}{6\ in}$

= 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

Tube

3) Cold Fluid; tube side, water

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

at = Ntxa't / 144xn

= 12 x (0,302 in^2 /144x 2

= 0,0503 ft^2

5) Gt = w/at

=16509,98lb/jam/0,0503 ft^2

= 328012,89 lb/jamft^2

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 = ((0,95.2,42)+(0,8.2,42))/2

= 0,8712 lb/jamft

= 2,118 lb/jamft (fig. 14)

μ = ((0,35.2,42)+(0,37.2,42))/2

= 0,8712 lb/jamft

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)

$(c\mu/k)^{(1/3)}$=(0,99x 0,8712/0,898)$^{(1/3)}$

= 0,98664

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

=380x0,898 Btu/(jam)(ft^2)(°F) / (0,045833333 ft) x 0,98664)

= 90552,580 Btu/jam $ft^{2o}F$

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 / 2,118lb/jamft

= 8003,4629 (laminar)

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

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

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

= 341,772 Btu/(jam)(ft^2)(°F)

14) 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

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 Ø̀s)

= ((0,001 x (358661,651)^2 x 0,833 x 78,74)) / (5,22 x 10^{10} x 0,833 x 1)

= 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 Øt)

= ((0,00015 x (328012,89)^2 x 1 x 2) / (5,22 x 10^{10} x 0,052 x 1)

= 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

= 0,012+ 0,24

= 0,252 psi

8.1.2 Hasil Perhitungan Percobaan 1

Pada percobaan ke-1, didapat data dari hasil pengamatan

Th1 50 ℃ = 122 ℉ Tc1 20℃ = 68 ℉

Th2 42 ℃ =107,6 ℉ Tc2 27 ℃ = 80,6 ℉

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

$\Delta LMTD = \frac{(34,2)-(43,2)}{\ln\frac{(34,2)}{(43,2)}}$

$\Delta LMTD = 38,63\ ^{\circ}F$

Q = A . U. ΔLMTD

Q = 7,618 ft^2 . 340 btu/jam$ft^2{}^{\circ}F$. 38,63 °F

Q = 100.056,336 btu/jam

W = Q / C (Th1-Th2)

W = 9358,056 lb/jam

As = $\frac{iDs\ .\ C'.\ B}{144\ Pt}$

As = 0,091 ft^2

Gs = W / As

Gs = 102.835,780 lb/jamft^2

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

Re = $\frac{0,046\ ft\ .\ 102835,780\ lb/jam ft^2}{0,871\ lb/ftjam}$

Re = 5429,805

Pr = 0,970

Nu = 0,036 . $Re^{0.8}$. $Pr^{1/4}$

Nu = 34,725

8.1.2 Hasil Perhitungan Percobaan 2

Pada percobaan ke-2, didapat data dari hasil pengamatan

Th1 50 ℃ = 122 ℉ Tc1 20℃ = 68 ℉

Th2 42 ℃ =109,4 ℉ Tc2 27 ℃ = 82,4 ℉

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

ΔLMTD = $\frac{(36)-(43,2)}{\ln\frac{(36)}{(43,2)}}$

ΔLMTD = 39,34 ℉

Q = A . U. ΔLMTD

Q = 7,618 ft^2 . 340 btu/jamft^2℉ **.** 39,34 ℉

Q = 101.895,321 btu/jam

W = Q / C (Th1-Th2)

W = 9530,052 lb/jam

As $= \frac{iDs\ .\ C'.\ B}{144\ Pt}$

As = 0,091 ft^2

Gs = W / As

Gs = 104.725,846lb/$jamft^2$

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

Re $= \frac{0{,}046\ ft\ .\ 104725{,}846\ lb/jam\text{ft}^2}{0{,}871\ lb/ftjam}$

Re = 5529,602

Pr = 0,970

Nu = 0,036 . $Re^{0.8}$. $Pr^{1/4}$

Nu = 35,235

8.1.3 Hasil Perhitungan Percobaan 3

Percobaan ke-3, didapat data

Th1 50 ℃ = 122 ℉ Tc1 20℃ = 68 ℉

Th2 42 ℃ =111,2 ℉ Tc2 27 ℃ = 86 ℉

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

ΔLMTD = $\frac{(39,6)-(41,4)}{\ln\frac{(39,6)}{(41,4)}}$

ΔLMTD = 40,91 °F

Q = A . U. ΔLMTD

Q = 7,618 ft^2 . 340 btu/jamft^2°F **.** 40,91 °F

Q = 105.961,809 btu/jam

W = Q / C (Th1-Th2)

W = 8.494,614 lb/jam

As = $\frac{iDs\ .\ C'.\ B}{144\ Pt}$

As = 0,091 ft^2

Gs = W / As

Gs = 93.347,407 lb/jamft^2

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

Re = $\frac{0,046\ ft\ .\ 93347,407\ lb/jam ft^2}{0,871\ lb/ftjam}$

Re = 4.928,812

Pr = 0,970

Nu = 0,036 . $Re^{0.8}$. $Pr^{1/4}$

Nu = 32,137

8.1.4 Hasil Perhitungan Percobaan 4

Percobaan ke-4 didapat

Th1 50 ℃ = 122 ℉ Tc1 20℃ = 68 ℉

Th2 42 ℃ =111,2 ℉ Tc2 27 ℃ = 87,8 ℉

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

ΔLMTD = $\frac{(41,4)-(39,6)}{\ln\frac{(41,4)}{(39,6)}}$

ΔLMTD = 40 ℉

Q = A . U. ΔLMTD

Q = 7,618 ft^2 . 340 btu/jamft^2℉ . 40 ℉

Q = 103.604,800 btu/jam

W = Q / C (Th1-Th2)

W = 7.267,452 lb/jam

As = $\frac{iDs\ .\ C'.\ B}{144\ Pt}$

As = 0,091 ft^2

Gs = W / As

Gs = 79.862,109 lb/jamft^2

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

Re = $\frac{0{,}046\ ft\ .\ 79862{,}109\ lb/jam\text{ft}^2}{0{,}871\ lb/ftjam}$

Re = 4216,778

Pr = 0,970

Nu = 0,036 . $Re^{0.8}$. $Pr^{1/4}$

Nu = 28,36

8.2 Tabel Hasil Pengamatan

Percobaa Ke-	**Waktu (menit)**	**Bukaan Valve**	**Kecepatan Aliran (lit/m)**	**Th in (°C)**	**Th out (°C)**	**Tc in (°C)**	**Tc out (°C)**	n_{Nu}	n_{Re}
1	10	$^1/_4$	32,95	50	42	20	27	28,36	4216,778
2	10	$^1/_2$	53,84	50	43	20	28	32,137	4928,812
3	10	$^3/_4$	64,42	50	44	20	30	35,235	5529,602
4	10	Penuh	89,52	50	44	20	31	34,725	5429,805

8.2 Foto