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# LAMPIRAN

# REAKTOR

Jenis : Reaktor Alir Tangki Berpengaduk

Fungsi : Tempat berlangsungnya reaksi pencampuran Brine dengan Katalis

Kondisi Operasi : Suhu = 90 $^{o}$C

Tekanan = 1 atm

Reaksi yang terjadi dalam reaktor :

Reaksi 1 :

| | | | | | | |
|---|---|---|---|---|---|---|
| $Na_2CO_3$ | + | $Ca(OH)_2$ | → | 2 NaOH | + | $CaCO_3$ |
| Natrium Karbonat | | Kalsium Hidroksida | | Natrium Hdiroksida | | Kalsium Karbonat |

Reaksi 2 :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $NaHCO_3$ | + | $Ca(OH)_2$ | → | NaOH | + | $CaCO_3$ | + | $H_2O$ |
| Natrium Bikarbonat | | Kalsium Hidroksida | | Natrium Hidroksida | | Kalsium Karbonat | | Air |

1. Neraca Massa :

Umpan Masuk :

a. Umpan Masuk CSG :

| | | | |
|---|---|---|---|
| NaCl | = 114,3220 Kgmol/j | = | 6.687,8374 Kg/j |
| $Na_2CO_3$ | = 14,0607 Kgmol/j | = | 1.490,4324 Kg/j |
| $NaHCO_3$ | = 8,5304 Kgmol/j | = | 716,5540 Kg/j |
| $CaCO_3$ | = 1,1943 Kgmol/j | = | 119,4257 Kg/j |
| $H_2O$ | = 2.153,1121 Kgmol/j | = | 38.756,0156 Kg/j |
| Jumlah | = 2.291,2195 Kgmol/j | = | 47.770,2656 Kg/j |

b. Umpan katalis

| | | | |
|---|---|---|---|
| $Ca(OH)_2$ | = 22,5911 Kgmol/j | = | 1.671,7404 Kg/j |
| $H_2O$ | = 835,8702 Kgmol/j | = | 15.045,6641 Kg/j |
| Jumlah | = 858,4613 Kgmol/j | = | 16.717,4043 Kg/j |

Hasil reaksi :

| | | | |
|---|---|---|---|
| NaCl | = 114,3220 Kgmol/j | = | 6.687,8374 Kg/j |
| $Na_2CO_3$ | = 0,2812 Kgmol/j | = | 29,8086 Kg/j |
| $NaHCO_3$ | = 0,1706 Kgmol/j | = | 14,3311 Kg/j |
| $CaCO_3$ | = 23,3335 Kgmol/j | = | 2.333,3523 Kg/j |

$H_2O$ = 2.997,3420 Kgmol/j = 53.952,1563 Kg/j

$Ca(OH)_2$ = 0,4518 Kgmol/j = 33,4348 Kg/j

NaOH = 35,9187 Kgmol/j = 1.436,7494 Kg/j

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Jumlah = 3.171,8201 Kgmol/j = 64.487,6680 Kg/j

2. Neraca Panas

Diketahui Cp rata-rata untuk masing-masing komponen sebagai berikut :

Cp NaCl = 8,55 Kcal/kmol K

Cp $Na_2CO_3$ = 26,53 Kcal/kmol K

Cp $NaHCO_3$ = 20,98 Kcal/kmol K

Cp $CaCO_3$ = 19,57 Kcal/kmol K

Cp $H_2O$ = 17,99 Kcal/kmol K

Cp $Ca(OH)_2$ = 20,91 Kcal/kmol K

Cp NaOH = 14,23 Kcal/kmol K

a. Enthalpi umpan masuk reaktor :

Suhu Umpan masuk Reaktor = 90,0 $^oC$

Suhu referensi = 25 $^oC$

| Komponen | M<br>Kmol | Cp dT<br>kcal/kmol | H = m CP dT<br>kcal/jam |
|---|---|---|---|
| NaCl | 114,3220 | 555,7500 | 63.534,4515 |
| $Na_2CO_3$ | 14,0607 | 1.724,4500 | 24.246,9741 |
| $NaHCO_3$ | 8,5304 | 1.363,7000 | 11.632,9065 |
| $CaCO_3$ | 1,1943 | 1.272,0500 | 1.519,2093 |
| $H_2O$ | 2.988,9823 | 1.169,3500 | 3.495.166,4525 |
| $Ca(OH)_2$ | 22,5911 | 1.359,1500 | 30.704,6936 |
| | 3.149,6808 | | 3.626.804,6875 |

H1 = 3.626.804,6875 kcal/jam

b. Enthalpi produk Keluar reaktor :

Suhu Umpan masuk Reaktor = 90,0 $^{o}$C

Suhu referensi = 25 $^{o}$C

| Komponen | M Kmol | Cp dT kcal/kmol | H = m CP dT kcal/jam |
|---|---|---|---|
| NaCl | 114,3220 | 555,7500 | 63.534,4515 |
| $Na_2CO_3$ | 0,2821 | 1.724,4500 | 486,4673 |
| $NaHCO_3$ | 0,1706 | 1.363,7000 | 232,6472 |
| $CaCO_3$ | 23,3335 | 1.272,0500 | 29.681,3787 |
| $H_2O$ | 2.997,3421 | 1.169,3500 | 3.504.941,9846 |
| $Ca(OH)_2$ | 0,4518 | 1.359,1500 | 614,0640 |
| NaOH | 35,9178 | 924,9500 | 33.222,1691 |
| | 3.171,8199 | | 3.632.713,1625 |

H2 = 3.632.713,1625

c. Panas Reaksi

Reaksi 1 :

Panas Pembentukan $Na_2CO_3$ = -270,30 Kcal/mol = -11.316.916,55 kj/kmol

Panas Pembentukan $Ca(OH)_2$= -235,70 Kcal/mol = -986.828,332 kj/kmol

Panas Pembentukan NaOH = -101,99 Kcal/mol = -427.011,54 kj/kmol

Panas Pembentukan $CaCO_3$ = -269,80 Kcal/mol = -1.129.598,151 kj/kmol

$Na_2CO_3$ + $Ca(OH)_2$ $\rightarrow$ 2 NaOH + $CaCO_3$

$\Delta$Hf produk = -1.983.621,25 Kj/kmol

$\Delta$Hf reaktan = -2.118.519,88 Kj/kmol

$\Delta$HR 298 = $\Delta$Hf produk - $\Delta$Hf reaktan

= 134.898,64 Kj/kmol

$\Delta$Hr = 3.083,60 Kj/kmol

ΔHp = 3.121,9500 Kj/kmol

ΔHR = 134.936,9876 Kj/kmol

= 32.229,15974 kkal/kmol

Reaksi 2 :

Panas Pembentukan $Na2CO_3$ = -270,30 Kcal/mol = -11.316.916,55 kj/kmol

Panas Pembentukan $Ca(OH)_2$= -235,70 Kcal/mol = -986.828,332 kj/kmol

Panas Pembentukan NaOH = -101,99 Kcal/mol = -427.011,54 kj/kmol

Panas Pembentukan $CaCO_3$ = -269,80 Kcal/mol = -1.129.598,151 kj/kmol

Panas Pembentukan H2O = -68,32 Kcal/mol = -286.042,0522 kj/kmol

$NaHCO_3$ + $Ca(OH)_2$ → NaOH + $CaCO_3$ + $H_2O$

ΔHf produk = -1.842.651,75 Kj/kmol

ΔHf reaktan = -1.935.138,12 Kj/kmol

ΔHR 298 = ΔHf produk - ΔHf reaktan

= 92.486,37 Kj/kmol

ΔHr = 2.722,8500 Kj/kmol

ΔHp = 3.366,3500 Kj/kmol

ΔHR = 93.129,8720 Kj/kmol

= 22.243,6974 kkal/kmol

ΔHR total = 54.472,8571 kkal/kmol

= 228.066,8596 Kj/kmol

| Panas Masuk (kcal/jam) | | Panas Keluar (kcal/jam) | |
|---|---|---|---|
| Panas masuk | 3.626.804,6875 | Panas keluar | 3.632.713,1625 |
| Panas reaksi | 54.472,8571 | Panas yang diambil | 48.564,3822 |
| Total | 3.681.277,5446 | Total | 3.681.277,5446 |

3. Menentukan Konstanta Kecepatan Reaksi

Dari data di Perry's Hand Book diperoleh :

| Komponen | Densitas (kg/lt) |
|---|---|
| NaCl | 2,1640 |
| $Na_2CO_3$ | 2,5330 |
| $NaHCO_3$ | 2,2000 |
| $CaCO_3$ | 2,7100 |
| $H_2O$ | 1,0000 |
| $Ca(OH)_2$ | 2,2400 |

Konstanta kecepatan

Reaksi untuk kondisi operasi T = 90,0 $^oC$ dan Tekanan 1 atm

Volume cairan :

| Komponen | Massa, kg | Densitas, (kg/lt) | Volume |
|---|---|---|---|
| NaCl | 6.687,837 | 2,164 | 3.090,498 |
| $Na_2CO_3$ | 1.490,432 | 2,533 | 588,406 |
| $NaHCO_3$ | 716,554 | 2,200 | 325,706 |

| | | | |
|---|---|---|---|
| $CaCO_3$ | 119,426 | 2,710 | 44,069 |
| $H_2O$ | 53.801,680 | 1,000 | 53.801,680 |
| $Ca(OH)_2$ | 1.671,740 | 2,240 | 746,313 |
| | | | 58.596,672 |

Konstanta kecepatan reaksi ditentukan berdasarkan data Patent no. CA 2870073 A1 dengan persamaan reaksi :

$Na_2CO_3 + Ca(OH)_2 \rightarrow 2\ NaOH + CaCO_3$

Kondisi Awal : Konsentrasi awal $Na_2CO_3$ = 0,000240 Kgmol/lt

Konsentrasi awal $Ca(OH)_2$ = 0,000386 Kgmol/lt

Perbandingan konsentrasi = 1,607

Konversi Reaktor ( Xa ) = 0,98

Waktu reaksi dalam reaktor = 1,00 jam

Untuk Reaktor Alir Tangki Berpengaduk berlaku :

$$(V / Fv) = \frac{CA_o \cdot xa}{(-ra)}$$

$$(V / Fv) = \frac{CA_o \cdot xa}{k \cdot CA\ CB}$$

$$(V / Fv) = \frac{xa}{k \cdot CA_o\ (1 - xa)(M - xa)}$$

$$k = \frac{xa}{(V / Fv)\ CA_o\ (1 - xa)(M - xa)}$$

$$= \frac{0.980}{1{,}00 \times 0{,}000240\ (1 - 0{,}98)(1{,}61 - 0{,}98)}$$

= 325.847,09 Lt/(Kmol jam)

4. Perhitungan Volume dan ukuran reaktor

Anggapan :

- Volume cairan selama reaksi tetap
- Bisa dianggap isothermal karena cairan dalam tangki mixed flow
- Reaksi sederhana orde dua semu

Reaksi : $A + B \rightarrow$ Produk

dengan -ra = -dCA/dt = k1.CA CB

= k1. $CA_o(1 - xa)$ $CA_o(M - xa)$

Kondisi Awal : Konsentrasi awal $Na_2CO_3$ = 0,000240 Kgmol/lt

Konsentrasi awal $Ca(OH)_2$ = 0,000386 Kgmol/lt

Perbandingan konsentrasi = 1,607

maka diperoleh volume reaktor dengan volume:

Konversi Reaktor ( Xa ) = 0,98

Volume cairan dalam reaktor :

$$V = \frac{Fv \,.\, xa}{k \,.\, CA_0 \,(1 - xa)\,(M - xa)}$$

$$= \frac{(58.596,672) \times 0,9800}{325.847,09 \times 0,00024\,(1 - 0,98)(2 - 0,98)}$$

= 58.596,668 lt

Over Design : 20 %

Volume reaktor = 1,2 X 58.596,668 lt

= 70.316,008 lt

Dipakai Volume reaktor = 70,32 $m^3$

Menghitung ukuran reaktor :

Reaktor berbentuk silinder tegak dengan perbandingan H : D = 1,5 : 1

$$Vt = \frac{\pi \cdot D^2 \cdot (h/d) \cdot D}{4} + \frac{\pi}{12} D^2 \cdot D$$

Atau :

$$\text{Diameter (D)} = \left[ \frac{Vt}{\pi/4\ (h/d) + \pi / 12} \right]^{1/3}$$

$$= \left[ \frac{70{,}316}{\pi/4\ .\ 1{,}50 + \pi / 12} \right]^{1/3}$$

$$= 3{,}66 \text{ m}$$

Tinggi ( H ) = 1,5 x 3,66

= 5,48 m

Diperoleh ukuran Reaktor : Diameter = 3,66 m

Tinggi = 5,48 m

Volume cairan dalam head = (1/2) (π/12) 3,656$m^3$

= 6,392 $m^3$

Volume cairan dibadan Reaktor = 58,597 $m^3$ – 6,392 $m^3$

= 52,204 $m^3$

Tinggi cairan dibadan Reaktor = 52,204 / 10,491 m

= 4,976 m

Ukuran yang di peroleh terlalu besar maka di lakukan proses optimasi yang dipasang secara seri :

Kecepatan Volume Umpan :

| Komponen | BM | Kgmol/jam | Kg/jam | densitas | Volume |
|---|---|---|---|---|---|
| NaCl | 58,5 | 114,3220 | 6.687,8373 | 2,1640 | 3090,4978 |
| $Na_2CO_3$ | 106 | 14,0607 | 1.490,4323 | 2,5330 | 588,4060 |
| $NaHCO_3$ | 84 | 8,5304 | 716,5540 | 2,2000 | 325,7064 |
| $CaCO_3$ | 100 | 1,1943 | 119,4257 | 2,7100 | 44,0685 |
| $Ca(OH)_2$ | 74 | 22,5911 | 1.671,7404 | 2,2400 | 746,3127 |
| $H_2O$ | 18 | 2.988,9823 | 53.801,6811 | 1,0000 | 53.909,5001 |
| | | 3.149,6807 | 64.487,6709 | | 58.704,4915 |

Optimasi jumlah Reaktor

persamaan umum

$$XAn_{-1} = XAn - \frac{V\ kCA_o(1- XAn)(M- XAn)}{Fv}$$

1. Jumlah Reaktor = 1

$XA_1$ = 0,98

k = 325.846,97 lt/kgmol jam

Fv = 58.704,4915 lt/jam

$Ca_o$ = 0,000240 Kgmol/lt

M = B/A = 1,606685

V Coba = 112.131,1107 liter

q reaktor = 1,9100942 jam

$$XA_0 = XA_1 - \frac{V\ kCA_o(1- XA_1)(M- XA_1)}{Fv}$$

$$XA_0 = 0,98 - \frac{112.131,1107 \times 325.846,97 \times 0,00024 \times 0,02 \times 0,626685}{58.704,4915}$$

= -8,885E-01

2. Jumlah Reaktor = 2

$XA_2$ = 0,98

k = 325.846,97 liter/kgmol jam

Fv = 58.704,492 liter/jam

$Ca_o$ = 0,0002395 kgmol/liter

M = B/A = 1,606685

V Coba = 12.792,101 liter

q reaktor = 0,2179067 jam

$$XA_1 = XA_2 - \frac{V\ kCA_o(1- XA_2)(M- XA_2)}{Fv}$$

$$XA_1 = 0,98 - \frac{12.792,101 \times 325.846,97 \times 0,0002395 \times 0,02 \times 0,626685}{58.704,4915}$$

= 0,7668435

$$XA_0 = XA_1 - \frac{V\ kCA_o(1- XAn)(M- XAn)}{Fv}$$

$$XA_0 = 0,7668435 - \frac{12.792,101 \times 325.846,97 \times 0,0002395 \times 0,2331565 \times 0,839841}{58.704,4915}$$

= -2,563309

= -25.633,09

3. Jumlah Reaktor = 3

$XA_3$ = 0,98

K = 325.846,97 liter/kgmol jam

Fv = 58.704,492 liter/jam

$Ca_o$ = 0,0002395 kgmol/liter

M = B/A = 1,606685

V Coba = 5.413,9507 liter

q reaktor = 0,0922238 jam

$XA_2 = XA_3 - \frac{V\ kCA_o(1- Xa_3)(M- Xa_3)}{Fv}$

$XA_2 = 0,98 - \frac{5.413,9507 \times 325.846,97 \times 0,0002395 \times 0,02 \times 0,626685}{58.704,4915}$

= 0,8897866

$XA_1 = XA_2 - \frac{V\ kCA_o(1- Xa_2)(M- Xa_2)}{Fv}$

$XA_1 = 0,8897866 - \frac{5.413,9507 \times 325.846,97 \times 0,0002395 \times 0,1102134 \times 0,716898}{58.704,4915}$

= 0,321086

$XA_0 = XA_1 - \frac{V\ kCA_o(1- Xa_1)(M- Xa_1)}{Fv}$

$XA_0 = 0,321086 - \frac{5.413,9507 \times 325.846,97 \times 0,0002395 \times 0,678914 \times 1,285599}{58.704,4915}$

= -5,961117

= -59611,17

4. Jumlah Reaktor = 4

| | | | |
|---|---|---|---|
| $XA_4$ | = | 0,98 | |
| k | = | 325.846,97 | liter/kgmol jam |
| Fv | = | 58.704,4915 | liter/jam |
| $Ca_o$ | = | 0,0002395 | kgmol/liter |
| M = B/A | = | 1,606685 | |
| V Coba | = | 3.265,1681 | liter |
| q reaktor | = | 0,0556204 | jam |

$XA_3 = XA_4 - \frac{V\ kCA_o(1- Xa_4)(M- Xa_4)}{Fv}$

$XA_3$ = 0,98 – $\frac{3.265,1681 \times 325.846,97 \times 0,0002395 \times 0,02 \times 0,626685}{58.704,4915}$

= 0,9255921

$XA_2$ = $XA_3$- $\frac{V\ kCA_o(1- Xa_3)(M- Xa_3)}{Fv}$

$XA_2$ = 0,9255921 – $\frac{3.265,1681 \times 325.846,97 \times 0,0002395 \times 0,0744079 \times 0,681093}{58.704,4915}$

= 0,7055992

$XA_1$ = $XA_2$ - $\frac{V\ kCA_o(1- Xa_2)(M- Xa_2)}{Fv}$

$XA_1$ = 0,7055992 – $\frac{3.265,1681 \times 325.846,97 \times 0,0002395 \times 0,2944008 \times 0,901086}{58.704,4915}$

= -0,445965

$XA_0$ = $XA_1$ - $\frac{V\ kCA_o(1- Xa_1)(M- Xa_1)}{Fv}$

$XA_0$ = -0,445965- $\frac{3.265,1681 \times 325.846,97 \times 0,0002395 \times 1,4459648 \times 2,052650}{58.704,4915}$

= -13,33011

= -133301,1

5. Jumlah Reaktor = 5

| | | | |
|---|---|---|---|
| $XA_5$ | = | 0,98 | |
| K | = | 325.846,97 | liter/kgmol jam |
| Fv | = | 58.704,492 | liter/jam |
| $Ca_o$ | = | 0,0002395 | kgmol/liter |
| M = B/A | = | 1,606685 | |
| V Coba | = | 2.298,5237 | |
| q reaktor | = | 0,0391541 | jam |

$XA_4 = XA_5 - \frac{V\ kCA_o(1- Xa_5)(M- Xa_5)}{Fv}$

$XA_4 = 0,98 - \frac{2.298,5237 \times 325.846,97 \times 0,0002395 \times 0,02 \times 0,626685}{58.704,4915}$

$= 0,9416994$

$XA_3 = XA_4 - \frac{V\ kCA_o(1- Xa_4)(M- Xa_4)}{Fv}$

$XA_3 = 0,9416994 - \frac{2.298,5237 \times 325.846,97 \times 0,0002395 \times 0,0583006 \times 0,664986}{58.704,4915}$

$= 0,8232285$

$XA_2 = XA_3 - \frac{V\ kCA_o(1- Xa_3)(M- Xa_3)}{Fv}$

$XA_2 = 0,8232285 - \frac{2.298,5237 \times 325.846,97 \times 0,0002395 \times 0,1767715 \times 0,783457}{58.704,4915}$

$= 0,4000208$

$XA_1 = XA_2 - \frac{V\ kCA_o(1- Xa_2)(M- Xa_2)}{Fv}$

$XA_1 = 0,4000208 - \frac{2.298,5237 \times 325.846,97 \times 0,0002395 \times 0,5999792 \times 1,206664}{58.704,4915}$

$= -1,812305$

$XA_0 = XA_1 - \frac{V\ kCA_o(1- Xa_1)(M- Xa_1)}{Fv}$

$XA_0 = -1,812305 - \frac{2.298,5237 \times 325.846,97 \times 0,0002395 \times 2,8123049 \times 3,418990}{58.704,4915}$

$= -31,19466$

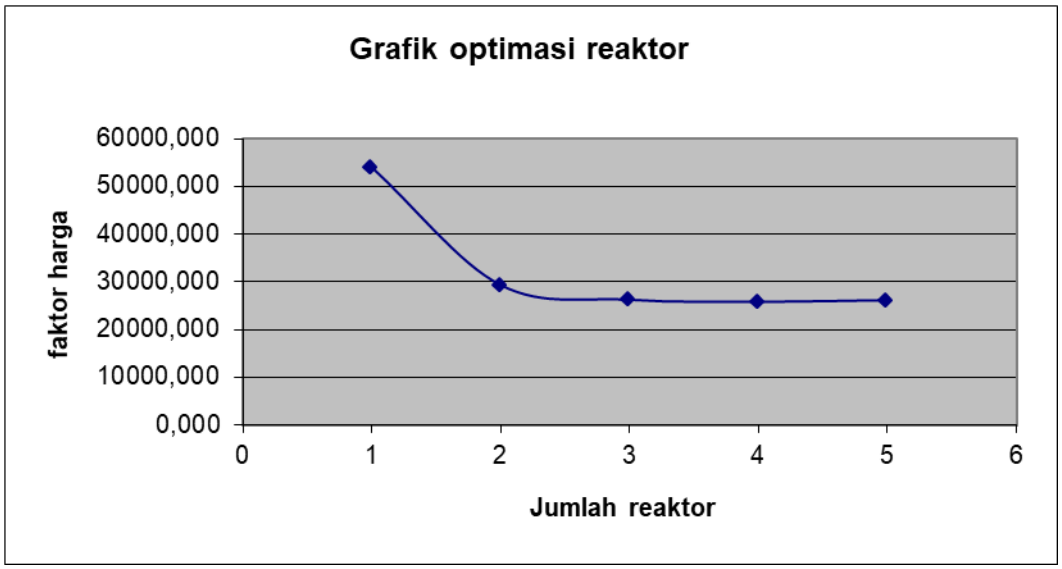
$= -311946,6$

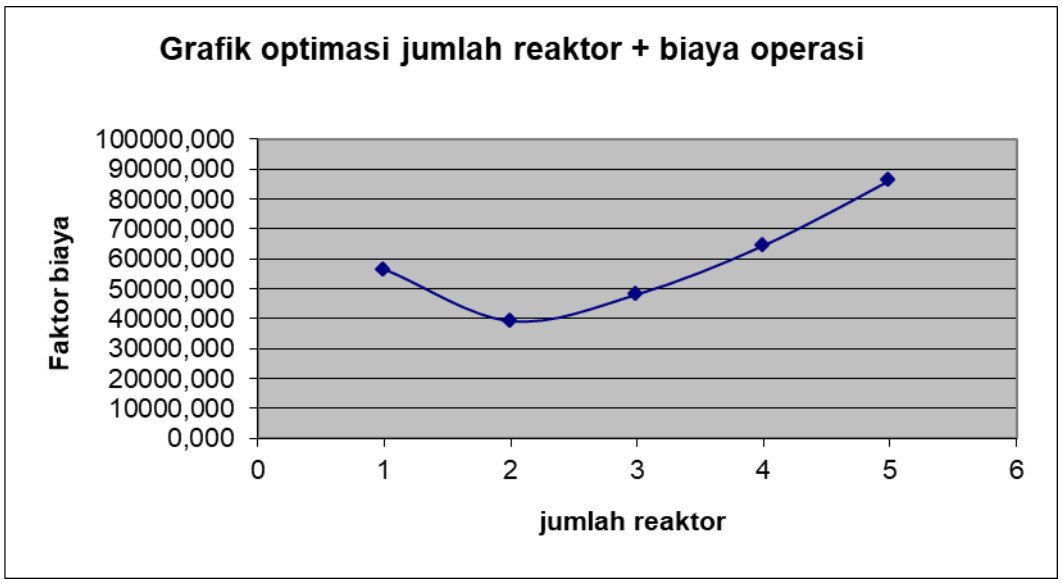
| n | Volume |
|---|---|
| 1 | 112.131,11 |

| | |
|---|---|
| 2 | 12.792,10 |
| 3 | 5.413,95 |
| 4 | 3.265,17 |
| 5 | 2.298,52 |

| Jumlah | Harga | Motor | Harga | Listrik/10th | Harga |
|---|---|---|---|---|---|
| 1 | 54.000,000 | 0,500 | 200 | 29.529,716 | 2.362,377 |
| 2 | 29.359,808 | 1,000 | 400 | 118.118,864 | 9.449,509 |
| 3 | 26.289,839 | 1,500 | 600 | 265.767,444 | 21.261,396 |
| 4 | 25.879,829 | 2,000 | 800 | 472.475,457 | 37.798,037 |
| 5 | 26.205,803 | 2,500 | 1000 | 738.242,901 | 59.059,432 |

| Jumlah | Harga |
|---|---|
| 1 | 56.562,377 |
| 2 | 39.209,317 |
| 3 | 48.151,234 |
| 4 | 64.477,866 |
| 5 | 86.265,235 |




Digunakan jmlah reaktor seri = 2 reaktor

Konversi keluar reaktor 1 = 0,868 reaktor

Konversi keluar reaktor 2 = 0,980 reaktor

Volume tiap reaktor = 6.709,42 Lt

Over Design : 20 %

Volume reaktor = 1,20 X 6.709,42 lt

= 8.051 lt

dipakai Volume reaktor = 8.05 $m^3$

Menghitung ukuran reaktor :

Reaktor berbentuk silinder tegak dengan perbandingan H : D = 1,5 : 1

$$Vt = \frac{\pi \cdot D^2 \cdot (h/d) \cdot D}{4} + \frac{\pi}{12} D^2 \cdot D$$

Atau :

$$\text{diameter (D)} = \left[ \frac{Vt}{\pi/4 \ (h/d) + \pi / 12} \right]^{1/3}$$

$$= \left[ \frac{8{,}051}{\pi/4 \ . \ 1{,}50 + \pi / 12} \right]^{1/3}$$

$$= 1{,}78 \text{ m}$$

Tinggi ( H ) = 1,5 x 1,78

= 2,66 m

Diperoleh ukuran Reaktor : Diameter = 1,78 m

Tinggi = 2,66 m

Volume cairan dalam head = (1/2)(π/12) 1,775 $m^3$

= 0,732 $m^3$

Volume cairan dibadan Reaktor = 6,709 $m^3$ - 0,732 $m^3$

= 5,977 $m^3$

Tinggi cairan dibadan Reaktor = 5,977 / 2,474 m

= 2,416 m

5. Menghitung tebal shell dan head

Tebal shell

Tekanan operasi (p) = 29,40 psi

Tekanan design (p) = 35,28 psi

Allowable stress = 18,750 psi

Efisiensi sambungan = 0,85

Faktor korosi = 0,125 in

Jari-jari Reaktor = 34,95 in

$$t\ shell = \frac{p \cdot ri}{S \cdot e - 0{,}6 \cdot p} + c$$

$$= \frac{35 \times 34{,}95}{18.750 \times 0{,}85 - 0{,}6 \times 35{,}3} + 0{,}125$$

$$= 0{,}202 \text{ in}$$

Dipilih tebal shell 7/16 in

Tebal Head :

$$t\ head = \frac{0.885 \cdot p \cdot d}{2 \cdot S \cdot e - 0.2 \cdot p} + c$$

$$= \frac{0{,}885 \times 35 \times 69{,}89}{2 \times 18750 \times 0{,}85 - 0{,}2 \times 35{,}3} + 0{,}125$$

$$= 0{,}193 \text{ in}$$

Dipilih tebal head 7/16 in

6. Menghitung pengaduk dalam Reaktor

Dipilih : Pengaduk type Marine dengan 3 blade

Jumlah buffle 4 buah

Dari tabel 477 Brown diproleh :

Dt/Di = 3

zi/Di = 0,75 – 1,3

W/Di = 0,1

Diameter Impeler = 59,17 cm

Tinggi Impeler = 59,17 cm

Lebar Buffle = 5,92cm

diambil :

zi/Di = 1

Putaran = 1,5 rps

efisiensi = 80 %

Tinggi baffle diambil sama dengan tinggi cairan

bilangan Reynold dalam Reaktor :

$$Re = \frac{n \cdot di\text{^}2 \cdot den}{visc}$$

$$= \frac{1{,}5 \times 59{,}17^2 \times 2{,}201}{0{,}0095}$$

$$= 1.215.641{,}6$$

Dari fig. 477 brown diperoleh po = 0.94

$$po = \frac{P \cdot gc}{n^3 \cdot den \cdot Di^5}$$ (pers. 461 Brown)

Atau

$$P = \frac{po \cdot n^3 \cdot den. Di^5}{gc}$$

$$= \frac{0{,}94 \times 1{,}50^3 \times 137{,}347 \times 1{,}941^5}{550 \times 32{,}17}$$

$$= 0{,}311 \text{ Hp}$$

Effisiensi : 80 %

$$\text{Power} = \frac{P}{eff} = \frac{0{,}311}{0{,}80}$$

$$= 0{,}388 \text{ Hp}$$

Digunakan motor dengan daya = 0,5 Hp

7. Menghitung perpindahan panas :

Dipilih pemanas Jacket dengan media pemanas Steam Jenuh

Dengan : Suhu masuk = 302 F

Suhu keluar = 302 F

Kebutuhan Steam Jenuh

$$Wa = \frac{Q}{Hfg}$$

Dengan Q : Jumlah panas yang harus diserap = 1.322.067 Btu/j

Hfg : Panas pengembunan steam = 978 Btu/lb

$$Wa = \frac{1.322.067 \text{ Btu/j}}{978{,}0 \text{ Btu/lb}}$$

= 1.351,806396 lb/j

a. Menghitung koeffisien transfer panas :

- Untuk steam dalam reaktor maka dipakai persamaan 20,4 Kern.

$$hc = \frac{0.87 \cdot k}{D}\left[\frac{L^2 \cdot N \cdot den}{visc.}\right]^{2/3}\left[\frac{Cp \cdot visc.}{k}\right]^{1/3}\left[\frac{visc.}{viscw.}\right]^{0.14}$$

dengan :

hc = Koeff. transfer panas steam, Btu/sqft j F

Di = Diameter reaktor = 5,824207 ft

K = Konduktivitas panas = 1,835 Btu/j sqft (F/ft)

L = diameter putar pengaduk = 1,941402 ft

Den = densitas larutan = 2,201069 lb/cuft

Cp = panas jenis = 0,845743 Btu/lb F

Visc = Viskositas bahan = 7,797778E-04 lb/j ft

viscw = Viskositas bahan pada dinding = 5,604974 lb/j ft

$$\frac{L^2 \cdot N \cdot den}{visc.} = \frac{1{,}941402^2 \times 1{,}5 \times 2{,}201069}{0{,}000780}$$

$$= 15.958{,}250977$$

$$\frac{Cp \cdot visc}{k} = \frac{0{,}845743 \times 1{,}160000}{1{,}835000}$$

$$= 0.534639$$

$$\text{asumsi } \frac{visc}{viscw} = 1$$

$$hc = \frac{0.87 \cdot 1.835000}{5{,}824207}\left[15.958{,}251\right]^{2/3}\left[0.535\right]^{1/3}\left[0.21\right]^{0.14}$$

maka diperoleh :

hc = 113,106079 Btu/j sqft F

- Untuk pemanas dalam Jacket :

$$Re = \frac{D \cdot Wa}{Visc \cdot At}$$

$$= \frac{77,1858/12 \text{ x } 1.351,81}{4,348740 \text{ x } 2,732/144}$$

= 105.384,5938

Untk kondensasi steam diperoleh hio = 1.500 Btu/j $ft^2$ F

b. Overall heat transfer Ud :

Overall transfer panas saat start up

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

$$= \frac{1.500,00 \text{ x } 113,11}{1.500,00 + 113,11}$$

= 105,175423 Btu/j $ft^2$ F

Dari Kern p.846 untuk Steam Jenuh Rd = 0,0005

dan untuk bahan organik Rd = 0,001

Jadi Rd total = 0,0015

$$Ud = \frac{Uc}{Uc \cdot Rd + 1}$$

$$= \frac{112,41}{105,18 \text{ x } 0,0020 + 1}$$

maka diperoleh :

Ud = 86,896637 Btu/j sqft F

c. Menghitung Luas transfer panas :

LMTD = T1 - t1

= 302,0 - 194,0

= 108,00 F

maka luas perpindahan panas :

$$Ao = \frac{Q}{Ud \,.\, LMTD}$$

$$= \frac{1.322.066,6250}{86,896637 \times 108,00}$$

= 140,872635 $ft^2$

Tinggi Jacket :

$$H = \frac{A\ Silinder}{Keliling}$$

$$= \frac{114,244339}{\pi\ 5,824207}$$

= 6,246953 ft

= 1,904071 m

Sedangkan tinggi Cairan dalam reaktor = 2,416269 m

Jadi Tinggi cairan lebih tinggi dari tinggi Jacket.

8. Spesifikasi Reaktor

Tugas : Produk NaOH dan NaCl dari limbah CSG dengan kecepatan umpan = 6.313,13131 Kg/jam

Jenis : Reaktor Alir Tangki Berpengaduk

Kondisi Operasi : Tekanan = 1 atm

Suhu = 90 °C

Diperoleh ukuran reaktor : Diameter = 1,78 m

Tinggi = 2,66 m

Volume cairan dalam *head* = 0,732 m

Volume cairan dibadan RATB = 5,977 m

Tinggi cairan dibadan RATB = 2,416 m

Dipilih Tebal shell : 7/16 in

Tebal Head : 7/16 in

Dipilih : Pengaduk tipe Marine dengan 3 blade

Jumlah buffle 4 buah

Diameter Impeler = 59,17 cm

Tinggi Impeler = 59,17 cm

Lebar Buffle = 5,92 cm

Digunakan motor dengan daya = 0,5 Hp

Luas perpindahan Panas : A = 140,8726 $ft^2$

Jacket pendingin : Tebal Jacket = 15,748032 in

Tinggi Jacket = 6,246953 ft

Tebal Isolasi : Tebal Isolasi = 3 in

Jenis bahan Isolasi = Asbes

Jenis Bahan Reaktor : Baja Steinless Steel

Jumlah reaktor = 2