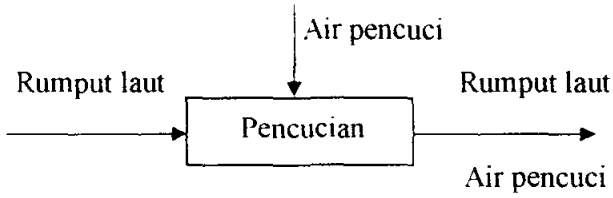
APPENDIX A
PERHITUNGAN NERACA MASSA

Kapasitas produksi : 4000 ton / tahun = 12,1212 ton / hari

Basis Perhitungan : 1000 kg rumput laut; 1 hari

1. Belt Conveyor



Pencucian rumput laut ini bertujuan untuk menghilangkan kotoran.

Data :

1. Kebutuhan air pencucian sebesar 2 kali berat rumput laut masuk belt conveyor (Singgih,1993)
2. Air yang terikut rumput laut 11,14 % dari berat rumput laut (hasil percobaan di laboratorium)
3. kotoran (impuritis) yang terikut sebesar 0,1 % dari massa masuk.

Kebutuhan air = 2 x berat rumput laut masuk belt conveyor

= 2 x 1000 kg

= 2000 kg

Air yang terikut rumput laut = 11,14 % x 1000 Kg

= 111,4 Kg

massa impuritis = 0,1 % × 1000 kg = 1 kg

Data : Rumput laut yang masuk belt conveyor tidak ada yang hilang

Impuritis terbawa air pencuci.

Komposisi rumput laut yang dijual di pasaran :

Komponen	% berat	berat (kg)
Karbohidrat	62,67	626,7
Protein	4,95	49,5
Lemak	0,95	9,5
Abu	4,65	46,5
Serat	9,93	99,3
H_2O	16,85	168,5
Total	100,00	1000,00

Sumber : Daftar komponen Bahan Makanan Direktorat Gizi Departemen Kesehatan RI

Jadi , komposisi kimia rumput laut dalam 1000 kg :

Karbohidrat : 62,67 % × 1000 kg = 626,7 kg

Protein : 4,95 % × 1000 kg = 49,5 kg

Lemak : 0,95 % × 1000 kg = 9,5 kg

Abu : 4,65 % × 1000 kg = 46,5 kg

Serat : 9,93 % × 1000 kg = 99,3 kg

H_2O : 16,85 % × 1000 kg = 168,5 kg

Impuritis : 0,1 % × 1000 kg = 1 kg

Rumput laut masuk belt conveyor 1000 kg dengan komposisi:

Karbohidrat : 626,7 kg

Protein : 49,5 kg

Lemak : 9,5 kg

Abu : 46,5 kg

Serat : 99,3 kg

H_2O : 168,5 kg

Impuritis : 1 kg

Air yang terikut rumput laut setelah pencucian = 111,4 + 168,5

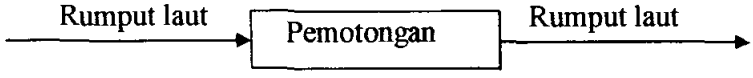
= 279,9 kg

Karena tidak ada rumput laut yang hilang, maka :

rumput laut yang masuk = rumput laut yang keluar.

Masuk (kg)		Keluar (kg)	
Rumput laut	1001	Rumput laut menuju rotary	1111,4
Karbohidrat : 626,7		cutter	
Protein : 49,5		Karbohidrat : 626,7	
Lemak : 9,5		Protein : 49,5	
Abu : 46,5		Lemak : 9,5	
Serat : 99,3		Abu : 46,5	
H_2O : 168,5		Serat : 99,3	
Impuritis : 1		H_2O : 279,9	
Air Pencuci	2000	Air Pencuci yang dibuang	
		+ impuritis	1889,6
	3001		3001

2. Rotary Cutter



Rumput laut masuk pemotong dengan komposisi:

Karbohidrat : 626,7 kg

Protein : 49,5 kg

Lemak : 9,5 kg

Abu : 46,5 kg

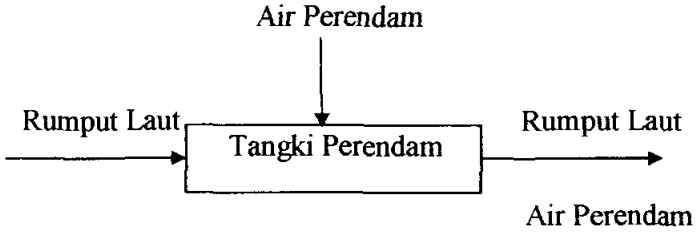
Serat : 99,3 kg

H_2O : 279,9 kg

Karena tidak ada rumput laut yang hilang maka rumput laut yang masuk = rumput laut yang keluar.

Masuk (kg)		Keluar (kg)	
Rumput Laut dari pencucian Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O : 279,9	1111,4	Rumput Laut menuju tangki perendaman Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O : 279,9	1111,4
	1111,4		1111,4

3. Tangki Perendaman



Perendaman rumput laut ini bertujuan untuk menghilangkan kotoran dan melunakkan rumput laut.

Data :

1. Kebutuhan air perendam sebesar 20 kali berat rumput laut kering (Singgih, 1993)
2. Tidak ada bahan yang tertinggal dalam Tangki Perendaman (Asumsi)

3. Air yang terikut dalam rumput laut sebesar 70 % (hasil percobaan di laboratorium)

Rumput laut masuk Tangki Perendaman = 1111,4 kg

Karbohidrat	:	626,7 kg
Protein	:	49,5 kg
Lemak	:	9,5 kg
Abu	:	46,5 kg
Serat	:	99,3 kg
H_2O	:	279,9kg

Kebutuhan air = 20 × berat rumput laut kering

= 20 × 1000 kg

= 20000 kg

Air yang terikut rumput laut pada perendaman = 70 % × 1111,4 Kg

= 777,98 Kg

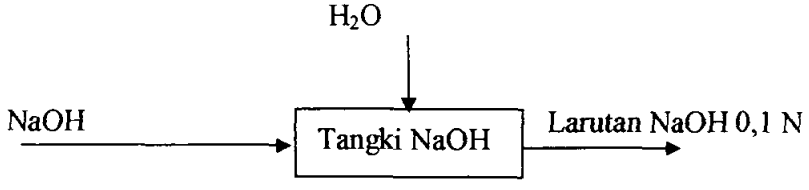
Rumput laut keluar Tangki Perendaman

Karbohidrat	:	626,7 kg
Protein	:	49,5 kg
Lemak	:	9,5 kg
Abu	:	46,5 kg
Serat	:	99,3 kg
H_2O	:	268,5 kg
H_2O yang terikut:		777,98 kg

Air Perendaman keluar = 19222,02 kg

Masuk (kg)		Keluar (kg)	
Rumput Laut dari rotary cutter / pemotongan	1111,4	Rumput laut menuju tangki pengaturan pH	21111,4
Karbohidrat : 626,7		Karbohidrat : 626,7	
Protein : 49,5		Protein : 49,5	
Lemak : 9,5		Lemak : 9,5	
Abu : 46,5		Abu : 46,5	
Serat : 99,3		Serat : 99,3	
H_2O : 279,9		H_2O : 1057,88	
Air Perendaman	20000	Air Perendaman : 19222,02	
	21111,4		21111,4

4. Tangki NaOH



Kebutuhan NaOH 0,1 N

Diinginkan pH = 8 – 10

Diambil pH antara → pH = 9

pOH = 14 – pH

= 5

pOH = - log [OH^-]

5 = - log [OH^-]

[OH^-] = 1.10^{-5} M = 1.10^{-5} mol/L

Massa H_2O = (1057,88 + 19222,02)

= 20279,9

Volume H_2O = $\frac{20279{,}9 kg}{995{,}68 \frac{kg}{m^3}}$

= 20,3679 m^3

= 20367,9 L

1.10^{-5} (20367,9 + x) L = 0,1 x L

$0{,}2037 + 1.10^{-5}$ = 0,1 x

0,2037 = 0,0999 x

x = 2,0390 L

NaOH 0,1 N dalam 2,039 L

Berat NaOH yang dibutuhkan = $\frac{N \times Mr \times L}{n}$

= $\frac{0{,}1 \times 40 \times 2{,}039}{1}$

= 8,1560 gram

= $8{,}1560.10^{-3}$ kg

ρ_{NaOH} = 2130 kg / m^3

volume NaOH = $\frac{m}{\rho}$

= $\frac{8{,}1560.10^{-3} kg}{2130 \frac{kg}{m^3}}$

= $3{,}8291 . 10^{-6}$ m^3

= $3{,}8291 . 10^{-3}$ L

Volume H_2O = volume larutan – volume NaOH

= 2,0309 – 0.0038291

= 2,0271 L

ρ H_2O (30 °C) = 995,6800 kg/m^3 = 62,1580 lb/ft^3

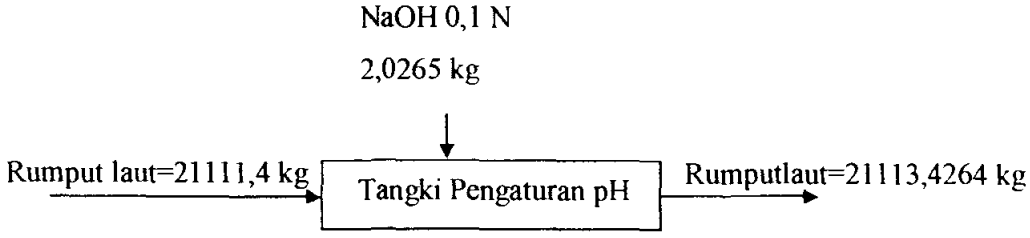
massa H_2O = $v \times \rho$

= 0,002023277 × 995,6800

= 2,0183 kg

Masuk, kg		Keluar, kg	
NaOH	$8,1560.10^{-3}$	Larutan NaOH menuju	2,0265
H_2O	2,0183	tangki pengaturan pH	
Total	2,0265	Total	2,0265

5. Tangki Pengaturan pH



Masuk(kg)		Keluar(kg)	
Rumput Laut dari tangki perendaman	21111,4	Rumput Laut menuju tangki Ekstraktor	21113,4264
Karbohidrat : 626,7		Karbohidrat : 626,7	
Protein : 49,5		Protein : 49,5	
Lemak : 9,5		Lemak : 9,5	
Abu : 46,5		Abu : 46,5	
Serat : 99,3		Serat : 99,3	
H_2O : 1057,88		H_2O : 1057,88	
Air Perendaman : 19222,02		NaOH : $8,1560.10^{-3}$	
		Air Perendaman 19224,0383	
Larutan NaOH 0,1 N	2,0265		
Total	21113,4265	Total	21113,4265

6. Tangki Ekstraktor

Data: pemanasan pada 80 °C selama 3 jam (Singgih, 1993)

Massa masuk = massa keluar

Masuk(kg)		Keluar(kg)	
Rumput Laut dari tangki pengaturan pH Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat 99,3 H_2O : 1057,88 NaOH : $8,1560.10^{-3}$ Air Perendaman: 19224,0383	21113,4265	Gel Rumput Laut menuju tangki penambahan NaCl Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O :1057,88 NaOH : $8,1560.10^{-3}$ Air Perendaman: 19224,0383	21113,4265
Total	21113,4265	Total	21113,4265

7. Tangki NaCl

Data: 1. Penambahan NaC 10%l sebanyak 5% dari jumlah filtrat (winarno,1996)

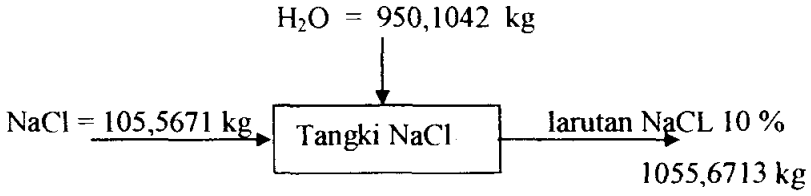
Berat filtrat = 20938,6705 kg

Berat larutan NaCl 10% = 5% × 21113,4264

= 1055,6713 kg

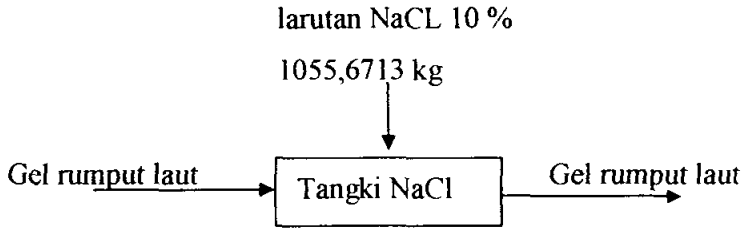
- NaCl = 10% × 1055,6713 = 105,5671 kg

- H_2O = 90% × 1055,6713 = 950,1042 kg



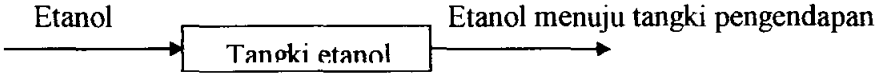
Masuk, Kg		Keluar, kg	
NaCl	105,5671	Larutan Nacl 10% me-	1055,6713
H_2O	950,1042	nuju tangki penambahan	
		NaCl	
		NaCl : 105,5671	
		H_2O : 950,1042	
Total	1055,6713	Total	1055,6713

8. Tangki Penambahan NaCl



Masuk(kg)		Keluar(kg)	
Gel rumput laut dari ekstraktor	21113,4264	Gel rumput laut menuju tangki pengendapan	22169,0977
Karbohidrat : 626,7		Karbohidrat : 626,7	
Protein : 49,5		Protein : 49,5	
Lemak : 9,5		Lemak : 9,5	
Abu : 46,5		Abu : 46,5	
Serat : 99,3		Serat : 99,3	
H_2O : 1057,88		H_2O : 1057,88	
NaOH : $8,1560.10^{-3}$		NaOH : $8,1560.10^{-3}$	
Air Perendaman: 19224,0383		NaCl : 105,5671	
		Air Perendaman: 20174,1425	
Lartuan NaCl 10%	1055,6713		
NaCl : 105,5671			
H_2O : 950,1042			
Total	22169,0977	Total	22169,0977

9. Tangki Etanol



Data: 1. Etanol yang digunakan adalah etanol 95%

2. Penambahan Etanol = 2× berat filtrat(Singgih, 1993)

Berat filtrat = 22169,0977 kg

Berat Etanol 95% = 2 × 22169,0977 = 44338,19551 kg

Berat Etanol = 0.95 × 44338,19551

= 42121,29 kg

Berat Air = 0.05 × 44338,19551

= 2216,91 kg

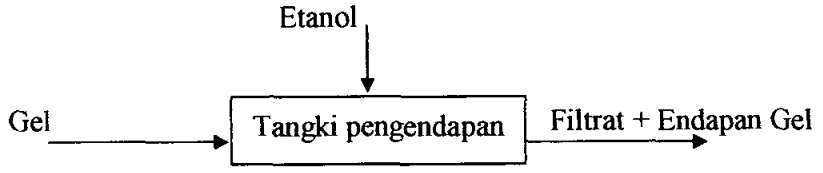
ρ_{etanol} = 0,789 kg/L

$$\text{Volume Etanol} = \frac{42121,29}{0,789}$$

= 53385.6654 L

Masuk, kg		Keluar, kg	
Etanol 95 % Etanol = 42121,28574 Air = 2216,909776	44338,19551	Etanol menuju tangki pengendapan Etanol = 42121,28574 Air = 2216,909776	44338,19551
Total	44338,19551	Total	44338,19551

10. Tangki Pengendapan



Gel masuk tangki pengendapan

Karbohidrat : 626,7

Protein : 49,5

Lemak : 9,5

Abu : 46,5

Serat : 99,3

H_2O : 1057,88

NaOH : $8,1560.10^{-3}$

NaCl : 105,5671

Air Perendaman: 20174,1425

Total : 22169,0977

Etanol 95% masuk tangki pengendapan = 44338.19551 kg

Yang keluar dari tangki pengendapan

Karbohidrat : 626,7

Protein : 49,5

Lemak : 9,5

Abu : 46,5

Serat : 99,3

H_2O : 1057,88

NaOH : $8,1560.10^{-3}$

NaCl : 105,5671

Air Perendaman: 20174,1425

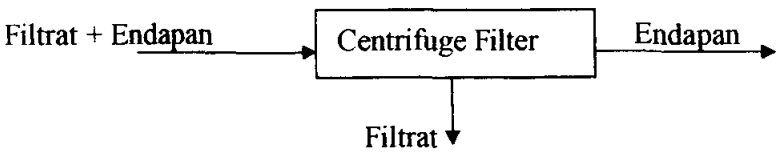
Etanol : 42121,28574

Air : 2216,9098

Total : 66507,29327 kg

Masuk, kg		Keluar, kg	
Gel dari tangki penam-bahan NaCl Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O : 1057,88 NaOH :8,1560.10^{-3} NaCl : 105,5671 Air Perendaman: 20174,1425 Etanol 95 % Etanol = 42121,28574 Air = 2216,909776	22169,0977 44338.1955	Filtrat yang manuju centri-fuge filter Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O : 1057,88 Air perendaman: 22391,0523 NaOH : 8,1560.10^{-3} NaCl : 105,5671 Etanol : 42121.2857	66507.2933
Total	66507.2933	Total	66507.2933

12. Centrifuge Filter



Data: Liquida(filtrat) yang terbawa cake sebesar 60% dari berat cake (percobaan di lab)

Umpan masuk berupa padatan:

Karbohidrat : 626,7

Protein : 49,5

Lemak : 9,5

Abu	:	46,5
Serat	:	99,3
Total	:	831,5 kg

Cairan dalam umpan masuk = 66507.2933 - 831,5 kg

= 56575,7933 kg

Hasil percobaan menunjukkan kadar air dalam cake = 60%

$$\frac{x}{x+831,5} = 60\%$$

$$x = 0,6\ (x + 831,5)$$

$$x - 0,6x = 0,6 \times 831,5$$

$$x = \frac{0.6 \times 831.5}{0,4}$$

$$= 1247.25 \text{ kg}$$

Cairan yang terbawa cake keluar centrifuge filter menuju rotary dryer

H_2O	$= \frac{23448.93}{65675.79} \times 1247.25$	= 445.3190kg
NaOH	$= \frac{8,1560.10^{-3}}{65675.79} \times 1247.25$	$= 1,5489.10^{-5}$ kg
NaCl	$= \frac{105,5671}{65675.79} \times 1247.25$	= 2.0048 kg
Etanol	$= \frac{42121.36}{65675.79} \times 1247.25$	= 799.9260 kg
Total		= 1247.25 kg

Massa filtrat yang menuju pembuangan terdiri dari:

H_2O	= 23448.93 – 445.3190 kg	= 23003.61kg
NaOH	$= 8,1560.10^{-3} - 1,5489 .10^{-4}$ kg	$= 8,0011.10^{-3}$ kg

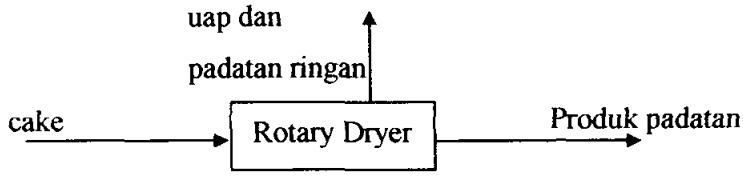
NaCl = 105,5671 – 2.0048 kg = 103,5623 kg

Etanol = 42121.29 – 799.9260 kg = 41321.36 kg

Total = 64428.5433 kg

Masuk, kg		Keluar, kg	
Filtrat dan endapan dari tangki pengendapan Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O :3448.93 NaOH : $8,1560.10^{-3}$ NaCl : 105,5671 Etanol : 42121.2857	66507.29333	Cake menuju rotary dryer Endapan Karbohidrat : 626,7 Protein : 49,5 Lemak : 9,5 Abu : 46,5 Serat : 99,3 H_2O : 445.319 NaOH : $1.5489.10^{-4}$ NaCl : 2.0048 Etanol : 799.926 Filtrat yang keluar H_2O : 23003.61 NaOH : $8,0011.10^{-3}$ NaCl : 103,5623 Etanol : 41321.36	2078.75 64428.5433
Total	66507.2933	Total	66507.2933

13. Rotary Dryer



Data: 1. Efisiensi rotary dryer 90%(Perry,1984)

2. Produk(padatan)keluar rotary dryer dengan kadar air 15 % (winarno,1996)

3. Etanol menguap seluruhnya dalam Rotary dryer

Padatan masuk rotary dryer:

Karbohidrat	:	626,7
Protein	:	49,5
Lemak	:	9,5
Abu	:	46,5
Serat	:	99,3
H_2O	:	445.319
NaOH	:	$1.5489.10^{-4}$
NaCl	:	2.0048
Etanol	:	799.926
Total	:	2078.75

Padatan kering(tanpa air) sebagai produk:

Karbohidrat	:	626,7
Protein	:	49,5
Lemak	:	9,5
Abu	:	46,5
Serat	:	99,3
NaOH	:	$1.5489.10^{-4}$
NaCl	:	2.0048
Total	:	833.5050

Kadar air pada cake = 15 %

$$\frac{x}{x+833{,}505} = 15\%$$

$$x = 0{,}15\ (x + 833{,}505)$$

$$x - 0{,}15x = 0{,}15 \times 833{,}505$$

$$x = \frac{0.15 \times 833.505}{0{,}85}$$

$$= 147.0891 \text{kg}$$

Total padatan keluar rotary dryer = 833.5050 + 147.0891

= 980.5941

Air yang menguap => 445.319 – 147.0891 = 298.2299

Padatan keluar rotary dryer menuju ball mill:

Karbohidrat	: 0.9 × 626,7	= 564.0300
Protein	: 0.9 × 49,5	= 44.5500
Lemak	: 0.9 × 9,5	= 8.5500
Abu	: 0.9 × 46,5	= 41.8500
Serat	: 0.9 × 99,3	= 89.3700
NaOH	: 0.9 × $1.5489.10^{-4}$	= $1.394.10^{-4}$
NaCl	: 0.9 × 2.0048	= 1.8043
H_2O	: 0.9 × 147.0891	= 132.3802
Total		: 882.5347

padatan keluar rotary dryer menuju cyclone:

Karbohidrat	: 0.1 × 626,7	= 62.67
Protein	: 0.1 × 49,5	= 4.95
Lemak	: 0.1 × 9,5	= 0.95

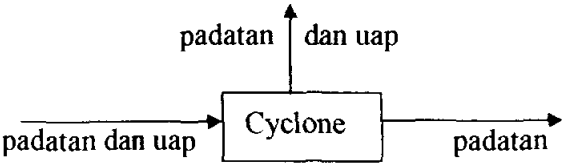
Abu	: 0.1 × 46,5	= 4.65
Serat	: 0.1 × 99,3	= 9.93
NaOH	: 0.1 × $1.5489.10^{-4}$	= $1.5489.10^{-5}$
NaCl	: 0.1 × 2.0048	= 0.20048
H_2O	: 0.1 × 147.0891	= 14.7089
Total		: 98.0594

Filtrat keluar Rotary dryer sebagai uap menuju cyclone

H_2O = (445.319 – 132.3802 – 14.7089) kg	=	298.2299 kg
Etanol	=	799.9260 kg
Total	=	1098.1559 kg

Masuk, kg		Keluar, kg	
Cake dari rotary filter	2078.75	Padatan(produk) menuju ball mill	882.5347
Karbohidrat : 626,7		Karbohidrat :564.0300	
Protein : 49,5		Protein : 44.5500	
Lemak : 9,5		Lemak : 8.5500	
Abu : 46,5		Abu : 41.8500	
Serat : 99,3		Serat : 89.3700	
H_2O : 445.319		NaOH : $1.394.10^{-4}$	
NaOH : $1.5489.10^{-4}$		NaCl : 1.8043	
NaCl : 2.0048		H_2O : 132.3802	
Etanol : 799.926		Padatan menuju cyclone	98.0594
		Karbohidrat : 62.67	
		Protein : 4.95	
		Lemak : 0.95	
		Abu : 4.65	
		Serat : 9.93	
		NaOH : $1.5489.10^{-5}$	
		NaCl : 0.20048	
		H_2O : 14.7089	
		Uap menuju cyclone	1098.1559
		H_2O : 298.2299	
		Etanol : 799.9260	
Total	2078.75	Total	2078.75

14. Cyclone



Data:

1. Efisiensi cyclone 80%(Ulrich, 1984)
2. Uap yang keluar menuju udara bebas

Bahan masuk cyclone :

* Padatan menuju cyclone

Karbohidrat: 62.67

Protein : 4.95

Lemak : 0.95

Abu : 4.65

Serat : 9.93

NaOH : $1.5489.10^{-5}$

NaCl : 0.20048

H_2O : 14.7089

* Uap menuju cyclone

H_2O : 298.2299

Etanol : 799.9260

Padatan keluar cyclone menuju Ball mill

Padatan menuju ballmill dengan komposisi

Karbohidrat = 0.8 × 62.67 = 50.1360

Protein	= 0.8 × 4.95	= 3.9600
Lemak	= 0.8 × 0.95	= 0.7600
Abu	= 0.8 × 4.65	= 3.7200
Serat	= 0.8 × 9.93	= 7.9440
NaOH	= 0.8 × $1.5489.10^{-5}$	= $1.2391.10^{-5}$
NaCl	= 0.8 × 0.20048	= 0.1604
H_2O	= 0.8 × 14.7089	= 11.7671
	Total	78.4475

Padatan keluar cyclone ke udara bebas dengan komposisi:

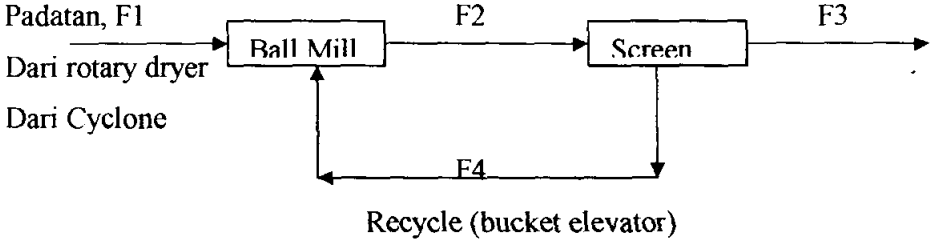
Karbohidrat	= 0.2 × 62.67	= 12.5340
Protein	= 0.2 × 4.95	= 0.9900
Lemak	= 0.2 × 0.95	= 0.1900
Abu	= 0.2 × 4.65	= 0.9300
Serat	= 0.2 × 9.93	= 1.9860
NaOH	= 0.2 × $1.5489.10^{-5}$	= $3.0978.10^{-6}$
NaCl	= 0.2 × 0.20048	= 0.0401
H_2O	= 0.2 × 14.7089	= 2.9418
	Total	19.6119

Uap keluar cyclone ke udara bebas:

H_2O	: 298.2299
Etanol	: 799.9260
Total	1098.1559

Masuk, kg		Keluar, kg	
Bahan masuk Rotary dryer	1196.2153	Padatan menuju ball mill	78.4475
Karbohidrat : 62.67		Karbohidrat : 50.1360	
Protein : 4.95		Protein : 3.9600	
Lemak : 0.95		Lemak : 0.7600	
Abu : 4.65		Abu : 3.7200	
Serat : 9.93		Serat : 7.9440	
NaOH : $1.5489.10^{-5}$		NaOH : $1.2391.10^{-5}$	
NaCl : 0.20048		NaCl : 0.1604	
H_2O : 14.7089		H_2O : 11.7671	
Uap menuju cyclone		Padatan yang hilang	19.6119
H_2O : 298.2299		Karbohidrat : 12.5340	
Etanol : 799.9260		Protein : 0.9900	
		Lemak : 0.1900	
		Abu : 0.9300	
		Serat : 1.9860	
		NaOH : $3.0978.10^{-6}$	
		NaCl : 0.0401	
		H_2O : 2.9418	
		Uap yang menuju udara bebas	1098.1559
		H_2O : 298.2299	
		Etanol : 799.9260	
Total	1196.2153	Total	1196.2153

15. Ball Mill, Screen dan Bucket Elevator



Data:

1. Karaginan dalam bentuk tapung 99% lolos Screen 60 mesh(winarno,1996)
2. Tidak ada bahan yang tertinggal di Ball mill

Padatan dari rotary dryer menuju ball mill(F1) = 882.5347 kg

Karbohidrat	: 564.0300
Protein	: 44.5500
Lemak	: 8.5500
Abu	: 41.8500
Serat	: 89.3700
NaOH	: $1.394.10^{-4}$
NaCl	: 1.8043
H_2O	: 132.3802

Neraca pada massa aliran F2

$$\text{MNT} = F1 = F3 = 0{,}99\ F2 = 882.5347 \text{ kg} \longrightarrow F2 = \frac{882.5347}{0{,}99}$$

$$= 891.4492 \text{ kg}$$

NMK di F1 = 0,99 di F2

Karbohidrat	: 564.0300	=	0,99 di F2	$\Rightarrow F2 = \frac{564.0300}{0{,}99}$	= 569.7273
Protein	: 44.5500	=	0,99 di F2	$\Rightarrow F2 = \frac{44.5500}{0{,}99}$	= 45.0000
Lemak	: 8.5500	=	0,99 di F2	$\Rightarrow F2 = \frac{8.5500}{0{,}99}$	= 8.6364
Abu	: 41.8500	=	0,99 di F2	$\Rightarrow F2 = \frac{41.8500}{0{,}99}$	= 42.2727

Serat : 89.3700 = 0,99 di F2 $\Rightarrow F2 = \frac{89.3700}{0,99} = 90.2727$

NaOH : $1.394.10^{-4}$ = 0,99 di F2 $\Rightarrow F2 = \frac{1.394.10^{-4}}{0,99} = 1.4081.10^{-4}$

NaCl : 1.8043 = 0,99 di F2 $\Rightarrow F2 = \frac{1.8043}{0,99} = 1.8226$

H_2O : 132.3802 = 0,99 di F2 $\Rightarrow F2 = \frac{132.3802}{0,99} = 133.7174$

Menuju bucket elevator

NMT F2 = F1 + F4

891.4492 = 882.5347 + F4

F4 = 8.9145kg

NMK di F2 = di F1 + di F4

Karbohidrat = 569.7273 – 564.0300 = 5.6973

Protein = 45.000 – 44.5500 = 0.4500

Lemak = 8.6364 – 8.5500 = 0.0864

Abu = 42.2727 – 41.8500 = 0.4227

Serat = 90.2727 – 89.3700 = 0.9027

NaOH = $1.4081.10^{-4}$ - $1.3940.10^{-4}$ = $1.4081.10^{-6}$

NaCl = 1.8226 – 1.8043 = 0.0182

H_2O = 133.7174 – 132.3802 = 1.3372

Lolos screen menuju ke screw conveyor

NMT F2 = F3 + F4

891.1275 = F3 + 8.9113

F3 = 882.5347

NMK	di F2 =	di F3 +	di F4
Karbohidrat	= 569.7273 – 5.6973		= 564.0300
Protein	= 45.0000 – 0.4500		= 44.5500
Lemak	= 8.6364 – 0.0864		= 8.5500
Abu	= 42.2727 – 0.4227		= 41.8500
Serat	= 90.2727 - 0.9027		= 89.3700
NaOH	= $1.4081.10^{-4}$ - $1.4081.10^{-6}$		= $1.394.10^{-4}$
NaCl	= 1.8226 - 0.0182		= 1.8043
H_2O	= 133.7174 - 1.3340		= 132.3802
		Total	882.5347

Masuk, kg		Keluar, kg	
Bahan masuk:	882.5347	Pruduk karaginan menuju	882.5347
Dari rotary dryer		screw conveyor	
Karbohidrat :564.0300		Karbohidrat :564.0300	
Protein : 44.5500		Protein : 44.5500	
Lemak : 8.5500		Lemak : 8.5500	
Abu : 41.8500		Abu : 41.8500	
Serat : 89.3700		Serat : 89.3700	
NaOH : $1.394.10^{-4}$		NaOH : $1.394.10^{-4}$	
NaCl : 1.8043		NaCl : 1.8043	
H_2O : 132.3802		H_2O : 132.3802	
Produk karaginan dari		Produk karaginan menuju	8.9145
bucket elevator	8.9145	bucket elevator	
Karbohidrat : 5.6973		Karbohidrat : 5.6973	
Protein : 0.4500		Protein : 0.4500	
Lemak : 0.0864		Lemak : 0.0864	
Abu : 0.4227		Abu : 0.4227	
Serat : 0.9027		Serat : 0.9027	
NaOH :$1.4081.10^{-6}$		NaOH :$1.4081.10^{-6}$	
NaCl : 0.0182		NaCl : 0.0182	
H_2O : 1.3372		H_2O : 1.3372	
Total	891.4492	Total	891.4492

Total produk keluar

Produk dari screen = 891,4492

Produk dari cyclone = 78,4475 +

Total Produk = 960,9822

Cairan yang masuk ke Destilator:

Etanol = 41321,36 + 799,9260 = 42121,286

H_2O = 23003,61 + 298,2299 = 23301,8399

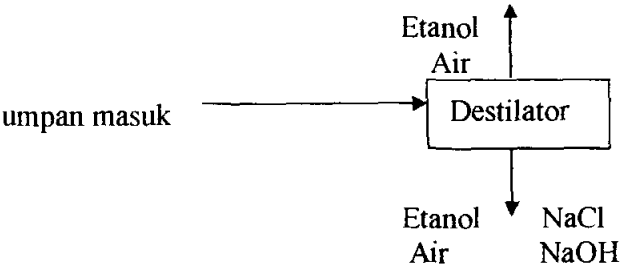
NaOH = $8{,}0011.10^{-3}$ kg

NaCl = 103,5623 kg

Total = 65526,6962

Data: Destilat berupa etanol 95 %

Asumsi etanol menguap sebesar 99,9%



Pada destilat:Etanol = 99,9% × 42121,286 = 42079,1647

$$\text{Air} = \frac{42079{,}1647}{95\%} \times 5\% = 2214{,}6929$$

Pada Bottom =

Etanol = 42121,286 – 42079,1647 = 42,1213

H_2O = 23301,8399 – 2214,6929 = 21087,147

NaOH = $8{,}0011.10^{-3}$ kg

NaCl = 103,5623 kg

Masuk, kg		Keluar, kg	
Umpan masuk berupa cairan Etanol : 42121,286 H_2O :23301,8399 NaOH : $8,0011.10^{-3}$ NaCl :103,5623	65526,6962	Pada destilat Etanol :42079,1647 Air : 2214.6929 Pada Bottom = Etanol :42,1213 H_2O :21087,147 NaOH $8,0011.10^{-3}$ NaCl :103,5623	44293,8576 21232,8386
Total	65526,6962	Total	65526,6962

Perhitungan neraca massa dengan kapasitas 12,1212 ton/hari

Perhitungan yang dilakukan diatas didasarkan dengan menggunakan basis 1000 kg rumput laut kering sebagai bahan baku per hari

Jika waktu operasi 330 hari/tahun; 24 jam/hari

$$\text{Konversi} = \frac{12121{,}2\ \frac{kg}{hari}}{960{,}9822\ \frac{kg}{hari}}$$

$$= 12{,}6133$$

APPENDIX B
PERHITUNGAN NERACA PANAS

APPENDIX B
PERHITUNGAN NERACA PANAS

Kapasitas produksi = 4000 ton/tahun

$$= \frac{4000\ ton/tahun\ .\ 1000\ kg/ton}{330\ hari/tahun\ .\ 24\ jam/hari}$$

= 505,05 kg/jam

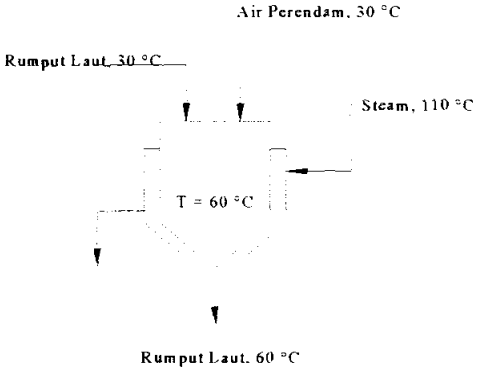
Bahan baku = rumput laut

Produk = karaginan

Waktu operasi produksi = 330 hari/tahun; 24 jam/hari

Satuan = kkal

1. Tangki Perendaman



Data : 1. Qloss[1] = 5 %.Q1

2. Q2 = Qloss[2] = Qloss[1]

Panas untuk menaikkan suhu dari 30 °C → 60 °C dianggap membutuhkan waktu selama 30 menit (0,5 jam)

RUMPUT LAUT

1. Karbohidrat

m1 = 7904,7551 kg/hari

= 329,3648 kg/jam

H1 = m1 x Cpkarbohidrat x ΔT

= 329,3648 kg/jam x 0,3791 kkal/kg.°C x (60 – 30) °C

= 3745,8659 kkal/jam x 0,5 jam

= 1872,9330 kkal

2. Protein

m2 = 624,3584 kg/hari

= 26,0149 kg/jam

H2 = m2 x Cpprotein x ΔT

= 26,0149 kg/jam x 0,4218 kkal/kg.°C x (60 – 30) °C

= 329,1925 kkal/jam x 0,5 jam

= 164,5963 kkal

3. Lemak

m3 = 119,8264 kg/hari

= 4,9928 kg/jam

H3 = m3 x Cplemak x ΔT

= 4,9928 kg/jam x 0,4668 kkal/kg.°C x (60 – 30) °C

= 69,9192 kkal/jam x 0,5 jam

= 34,9596 kkal

4. Abu

m4 = 586,5185 kg/hari

= 24,4383 kg/jam

H4 = m4 x Cpabu x ΔT

= 24,4383 kg/jam x 0,2239 kkal/kg.°C x (60 – 30) °C

= 164,1521 kkal/jam x 0,5 jam

= 82,0761 kkal

5. Serat

m5 = 1252,5007 kg/hari

= 52,1875 kg/jam

H5 = m5 x Cpserat x ΔT

= 52,1875 kg/jam x 0,32 kkal/kg.°C x (60 – 30) °C

= 501 kkal/jam x 0,5 jam

= 250,5 kkal

6. H_2O (l)

m6 = 3530,4627 kg/hari

= 147,1026 kg/jam

H6 = m6 x CpH_2O (l), 30 °C x ΔT

= 147,1026 kg/jam x 0,9987 kkal/kg.°C x (60 – 30) °C

= 734,5568 kkal/jam x 0,5 jam

= 367,2784 kkal

AIR PERENDAM

7. Air Perendam (H_2O (l), 30 °C)

m7 = 252266 kg/hari

= 10511,0833 kg/jam

H7 = m7 x Cp Air Perendam (H_2O (l), 30 °C) x ΔT

= 10511,0833 kg/jam x 0,39987 kkal/kg.°C x (60 – 30) °C

= 314922,5668 kkal/jam x 0,5 jam

= 157461,2833 kkal

ΔH in = (H1 + H2 + ... + H7) x 0,5 jam

= 320467,2533 kkal/jam x 0,5 jam

160233,6267 kkal

Q1 = ΔH in + Qloss[1]

= 160233,6267 kkal + 0,05.Q1

0,95Q1 = 160233,6267 kkal

Q1 = 168666,9755 kkal

Qloss[1] = 0,05.Q1

= 0,05 x 168666,9755 kkal

= 8433,3488 kkal

$= \left(\frac{8433,3488}{0,5}\right)$ kkal/jam

= 16866,6976 kkal/jam

KEBUTUHAN STEAM

Steam yang digunakkan bersuhu 110 °C dari Geankoplis, APP A.2 – 9, pp 800 mendapat harga : Hv = 2691,50 kj/kg

H_L = 461,30 kj/kg

λsteam = Hv - H_L

= 2691,50 kj/kg – 461,30 kj/kg

= 2230,20 kj/kg

$$= \left(\frac{2230,20}{4,184}\right) \text{ kkal/kg}$$

= 533,0306 kkal/kg

$$\text{m steam[1]} = \frac{Q1}{\lambda steam}$$

$$= \frac{168666,9755\ kkal}{533,0306\ kkal/kg}$$

= 316,4302 kg

Panas untuk mempertahankan suhu 60 °C membutuhkan waktu selama 60 menit (1 jam)

Q2 = Qloss[2] = Qloss[1] = 16866,6976 kkal/jam x 1 jam = 16866,6976 kkal/jam

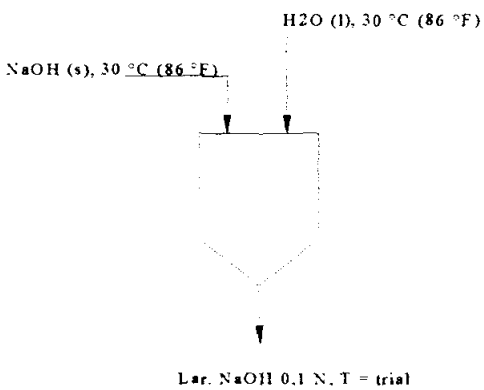
$$\text{m steam[2]} = \frac{Q2}{\lambda steam}$$

$$= \frac{16866,6976\ kkal}{533,0306\ kkal/kg}$$

= 31,6430 kg

Panas yang dibutuhkan, kkal		Panas yang diberikan, kkal	
ΔH in untuk menaikkan suhu 30 °C → 60 °C		Q1 untuk menaikkan suhu 30 °C → 60 °C	168666,9755
RUMPUT LAUT	2772,3434	Q2 untuk mempertahankan suhu 60 °C	16866,6976
Karbohidrat = 1872,9330			
Protein = 164,5963			
Lemak = 34,9596			
Abu = 82,0761			
Serat = 250,5000			
H_2O = 367,2784			
Air Perendam	157461,2833		
Qloss[1] untuk menaikkan suhu 30 °C → 60 °C	8433,3488		
Qloss[2] untuk mempertahankan suhu 60 °C	16866,6976		
TOTAL	185533,6731	TOTAL	185533,6731

2. Tangki NaOH



Data : 1. Basis 1 jam

2. Qloss = 10 %.Q

m NaOH (s) = 0,1029 kg/hari = $4,2875 \times 10^{-3}$ kg/jam

m H_2O (l) = 25,4574 kg/hari = 1,0607 kg/jam

m campuran = m NaOH (s) + m H_2O (l)

$= 4{,}2875 \times 10^{-3}$ kg/jam + 1,0607 kg/jam

= 1,0650 kg/jam

Cp NaOH (s) = (1 x 6,2) + (1 x 4,0) + (1 x 2,3) (Kopp Rule)

= 12,5 kal/mol. °C

= 0,3125 kkal/kg. °C

Cp H_2O (l), 30 °C = 0,9987 kkal/kg. °C (Geankoplis, 1993)

$$\text{X NaOH} = \frac{4{,}2875 \times 10^{-3}\ kg/jam}{1{,}0650\ kg/jam}$$

$= 0{,}0040 \cong 0$

H NaOH (s) = 478,7 btu/lbm (Literatur)

= 266,1133 kkal/kg

H H_2O (l), 30 °C = 125,79 kj/kg (Geankoplis, 1993)

= 30,0645 kkal/kg

Cp larutan NaOH 0,1 N = (X x Cp) NaOH (s) + (X x Cp) H_2O (l), 30 °C

$$= \left(\frac{4{,}2875 \times 10^{-3}}{1{,}0650}\right) x\ 0{,}3125\ \frac{kkal}{kg.\ ^{o}C} + \left(\frac{1{,}0607}{1{,}0650}\right) x\ 0{,}9987\ \frac{kkal}{kg.\ ^{o}C}$$

= 0,9959 kkal/kg. °C

Trial T larutan NaOH 0,1 N

T1 = 30,90 °C (87,35 °F)

H NaOH 0,1 N = 54 btu/lbm (Fig. 11.22, Smith, pp. 407)

= 30,0190 kkal/kg

Q = ΔHs = (1,0650 x 30,0190) kkal – (1,0607 x 30,0645) kkal – (2,2875 x 10^{-3} x 266,1133) kkal

= – 1,0601 kkal

Qloss = 10 %.Q

= 0,1 x – 1,0601 kkal

= – 0,1060 kkal

$$|Q| = |\Delta Hs| = |Qloss| + (mxCp)\ H_2O(l),\ 30\ ^{o}C\ (T-30) + (mxCp)\ NaOH(s)\ (T-30)$$

$$= |-1{,}0601\ kkal|$$

Dengan memasukkan harga – harga diatas, maka memperoleh harga :

T = 30,8999 °C (87,6198 °F)

Trial dianggap benar T ≅ T1, sehingga suhu larutan NaOH 0,1 N adalah 30,90 °C

ΔT = (30,90 – 30) °C

= 0,90 °C (sangat kecil, sehingga dianggap tidak berpengaruh)

Panas yang digunakan untuk menaikkan suhu dari 30 °C → 30,9 °C, Hout

$$Hout = (mxCp)\ H_2O(l),\ 30\ ^{o}C\ \Delta T + (mxCp)\ NaOH(s)\ \Delta T$$

= (1,0607 x 0,9987 x 0,9) kkal + ($4{,}2875.10^{-3}$ x 0,3125 x0,9) kkal

= 0,9529 kkal + 0,0012 kkal

= 0,9541 kkal

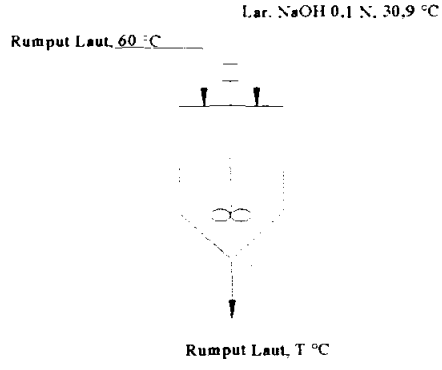
ΔHout = |Qloss| + Hout

= (0,1060 + 0,9541) kkal

= 1,0601 kkal

Masuk, kkal		Keluar, kkal	
Q = ΔHs panas yang terjadi karena proses pelarutan	1,0601	ΔHout untuk menaikkan suhu 30 °C → 30,9 °C Qloss = 0,1060 Hout = 0,9541	1,0601
TOTAL	1,0601	TOTAL	1,0601

3. Tangki Pengaturan pH



Data : 1. Qloss = 5 %.Q

2. waktu pengisian 30 menit (0,5 jam)

Bahan masuk Tangki Pengaturan pH

RUMPUT LAUT (Cp, kkal/kg. °C)

1. Karbohidrat = 329,3648 kg/jam → X1 = 0,0297;Cp1 = 0,3791
2. Protein = 26,0149 kg/jam → X2 = 0,0023;Cp2 = 0,4218
3. Lemak = 4,9928 kg/jam → X3 = 0,0005;Cp3 = 0,4668
4. Abu = 24,4383 kg/jam → X4 = 0,0022;Cp4 = 0,2239
5. Serat = 52,1875 kg/jam → X5 = 0,0047;Cp5 = 0,3200
6. H_2O (l), 60 °C = 147,1026 kg/jam → X6 = 0,0501;Cp6 = 1,0001
7. Air Perendam (l), 60 °C =10511,0833 kg/jam+→ X7 = 0,9105;Cp7 = 1,0001

TOTAL =11095,1842 kg/jam

m Rumput Laut = 11095,1842 kg/jam x 0,5 jam

= 5547,5921 kg

Cp Rumput Laut = X1.Cp1 + X2.Cp2 + ... + X7.Cp7

= 0,9752 kkal/kg. °C

Larutan NaOH 0,1 N

m larutan NaOH 0,1 N = 1,0650 kg/jam x 0,5 jam

= 0,5325 kg

Cp larutan NaOH 0,1 N = 0,9959 kkal/kg. °C

Panas sensible Rumput Laut (Q) = Quntuk menaikkan suhu NaOH 0,1 N + Qloss

(m.Cp)Rumput Lautx(T–60)°C =(m.Cp)larutan NaOH 0,1 Nx(T–30,9) °C+ 0,05.Q

Dengan memasukkan harga – harga diatas, maka memperoleh harga :

T = 59,9969 °C ≅ 60 °C

Panas sensible Rumput Laut (Q) = (m.Cp)Rumput Lautx(T–60) °C

= (5547,5921x0,9752x(59,9969 – 60)) kkal

= – 16,7710 kkal

= 16,7710 kkal (melepas panas)

Q untuk menaikkan suhu NaOH 0,1 N = (m.Cp)larutan NaOH 0,1 Nx(T–30,9) °C

= (0,5325x0,9959x(59,9969 – 30,9)) kkal

= 15,9324 kkal

Qloss = 5 %.Q

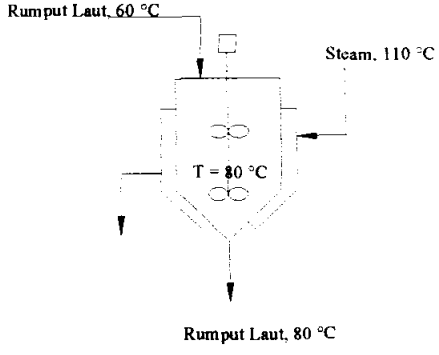
= 0,05 x (– 16,7710 kkal)

= – 0,8386 kkal

= 0,8386 kkal (melepas panas)

Panas yang dilepas, kkal		Panas yang diterima, kkal	
Q panas sensible	16,7710	Q untuk meniakkan suhu	15,9324
Rumput Laut		NaOH 0,1 N	
		Qloss untuk menurunkan suhu	0,8386
		60 °C → 59,9969 °C	
TOTAL	16,7710	TOTAL	16,7710

4. Tangki Ekstraktor



Data : 1. Qloss[1] = 5 %.Q1

2. Q2 = Qloss[2] = Qloss[1]

Panas untuk menaikkan suhu dari 60 °C → 80 °C dianggap membutuhkan waktu selama 25 menit (0,42 jam)

RUMPUT LAUT

1. Karbohidrat

m1 = 7904,7551 kg/hari

= 329,3648 kg/jam

H1 = m1 x Cpkarbohidrat x ΔT

= 329,3648 kg/jam x 0,3791 kkal/kg.°C x (80 – 60) °C

= 2497,2439 kkal/jam x 0,42 jam

= 1048,8424 kkal

2. Protein

m2 = 624,3584 kg/hari

= 26,0149 kg/jam

H2 = m2 x Cpprotein x ΔT

= 26,0149 kg/jam x 0,4218 kkal/kg.°C x (80 – 60) °C

= 219,4617 kkal/jam x 0,42 jam

= 92,1739 kkal

3. Lemak

m3 = 119,8264 kg/hari

= 4,9928 kg/jam

H3 = m3 x Cplemak x ΔT

= 4,9928 kg/jam x 0,4668 kkal/kg.°C x (80 – 60) °C

= 46,6128 kkal/jam x 0,42 jam

= 19,5774 kkal

4. Abu

m4 = 586,5185 kg/hari

= 24,4383 kg/jam

H4 = m4 x Cpabu x ΔT

= 24,4383 kg/jam x 0,2239 kkal/kg.°C x (80 – 60) °C

= 109,4347 kkal/jam x 0,42 jam

= 45,9626 kkal

5. Serat

m5 = 1252,5007 kg/hari

= 52,1875 kg/jam

H5 = m5 x Cpserat x ΔT

= 52,1875 kg/jam x 0,32 kkal/kg.°C x (80 – 60) °C

= 334 kkal/jam x 0,42 jam

= 140,28 kkal

6. H_2O (l), 60 °C

m6 = 13343,3578 kg/hari

= 555,9732 kg/jam

H6 = m6 x CpH_2O (l), 30 °C x ΔT

= 555,9732 kg/jam x 1,0001 kkal/kg.°C x (80 – 60) °C

= 11120,5760 kkal/jam x 0,42 jam

= 4670,6419 kkal

7. Air Perendam (H_2O (l), 60 °C)

m7 = 242478 kg/hari

= 10103,2734 kg/jam

H7 = m7 x Cp Air Perendam (H_2O (l), 60 °C) x ΔT

= 10103,2734 kg/jam x 1,0001 kkal/kg.°C x (80 – 60) °C

= 202085,6745 kkal/jam x 0,42 jam

= 84875,9833 kkal

8. NaOH (l)

m8 = 0,1029 kg/hari

= 4,2875 x 10^{-3} kg/jam

Cp NaOH (l) = (1 x 8,0) + (1 x 6,0) + (1 x 4,3) (Kopp Rule)

= 18,3 kal/mol. °C

= 0,4575 kkal/kg. °C

H8 = m8 x Cp NaOH (l) x ΔT

= 4,2875 x 10^{-3} kg/jam x 0,4575 kkal/kg. °C x (80 – 60) °C

= 0,0392 kkal/jam x 0,42 jam

= 0,0165 kkal

ΔH in = H1 + H2 + ... + H8

= 90893,4780 kkal

Q1 = ΔH in + Qloss[1]

= 90893,4780 kkal + 0,05.Q1

0,95Q1 = 90893,4780 kkal

Q1 = 95677,3453 kkal

Qloss[1] = 0,05.Q1

= 0,05 x = 95677,3453 kkal

= 4783,8673 kkal

$$= \left(\frac{4783,8673}{0,42}\right) \text{ kkal/jam}$$

= 11390,1602 kkal/jam

KEBUTUHAN STEAM

Steam yang digunakkan bersuhu 110 °C dari Geankoplis, APP A.2 – 9, pp 800 mendapat harga : Hv = 2691,50 kj/kg

H_L = 461,30 kj/kg

λsteam = Hv - H_L

= 2691,50 kj/kg – 461,30 kj/kg

= 2230,20 kj/kg

$$= \left(\frac{2230,20}{4,184} \right) \text{ kkal/kg}$$

$$= 533,0306 \text{ kkal/kg}$$

$$\text{m steam[1]} = \frac{Q1}{\lambda steam}$$

$$= \frac{95677,3453 \ kkal}{533,0306 \ kkal/kg}$$

$$= 179,4969 \text{ kg}$$

Panas untuk mempertahankan suhu 60 °C membutuhkan waktu selama 60 menit (1 jam)

Q2 = Qloss[2] = Qloss[1] = 11390,1602 kkal/jam x 3 jam = 34170,4806 kkal

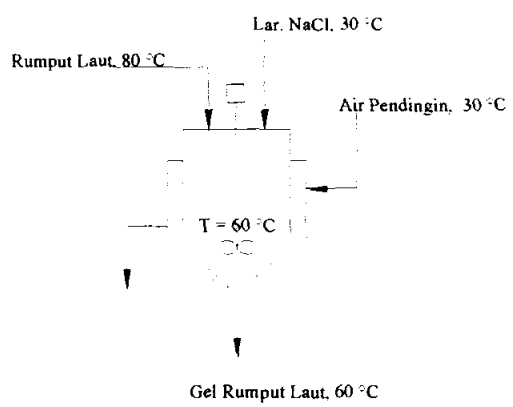
$$\text{m steam[2]} = \frac{Q2}{\lambda steam}$$

$$= \frac{34170,4806 \ kkal}{533,0306 \ kkal/kg}$$

$$= 64,1060 \text{ kg}$$

Panas yang dibutuhkan, kkal		Panas yang diberikan, kkal	
ΔH in untuk menaikkan suhu 60 °C → 80 °C	90893,4780	Q1 untuk menaikkan suhu 60 °C → 80 °C	95677,3453
RUMPUT LAUT		Q2 untuk mempertahankan suhu 80 °C	34170,4806
Karbohidrat = 1048,8424			
Protein = 92,1739			
Lemak = 19,5774			
Abu = 45,9626			
Serat = 140,2800			
H_2O = 4670,6419			
Air Perendam = 84875,9833			
Qloss[1] untuk menaikkan suhu 60 °C → 80 °C	4783,8673		
Qloss[2] untuk mempertahankan suhu 80 °C	34170,4806		
TOTAL	129847,8259	TOTAL	129847,8259

5. Tangki Penambahan NaCl



Data : 1. Qloss = 5 %.Q

Panas yang dilepas untuk menurunkan suhu dari 80 °C → 60 °C dianggap membutuhkan waktu selama 15 menit (0,25 jam)

RUMPUT LAUT

1. Karbohidrat

m1 = 7904,7551 kg/hari

= 329,3648 kg/jam

H1 = m1 x Cpkarbohidrat x ΔT

= 329,3648 kg/jam x 0,3791 kkal/kg.°C x (60 – 80) °C

= - 2497,2439 kkal/jam x 0,25 jam

= - 624,3110 kkal = 624,3110 kkal (melepas panas)

2. Protein

m2 = 624,3584 kg/hari

= 26,0149 kg/jam

H2 = m2 x Cpprotein x ΔT

= 26,0149 kg/jam x 0,4218 kkal/kg.°C x (60 – 80) °C

= - 219,4617 kkal/jam x 0,25 jam

= - 54,8654 kkal = 54,8654 kkal (melepas panas)

3. Lemak

m3 = 119,8264 kg/hari

= 4,9928 kg/jam

H3 = m3 x Cplemak x ΔT

= 4,9928 kg/jam x 0,4668 kkal/kg.°C x (60 – 80) °C

= - 46,6128 kkal/jam x 0,25 jam

= - 11,6532 kkal = 11,6532 kkal (melepas panas)

4. Abu

m4 = 586,5185 kg/hari

= 24,4383 kg/jam

H4 = m4 x Cpabu x ΔT

= 24,4383 kg/jam x 0,2239 kkal/kg.°C x (60 – 80) °C

= - 109,4347 kkal/jam x 0,25 jam

= - 27,3587 kkal = 27,3587 kkal (melepas panas)

5. Serat

m5 = 1252,5007 kg/hari

= 52,1875 kg/jam

H5 = m5 x Cpserat x ΔT

= 52,1875 kg/jam x 0,32 kkal/kg.°C x (60 – 80) °C

= - 334 kkal/jam x 0,25 jam

= - 83,5 kkal = 83,5 kkal (melepas panas)

6. H_2O (l), 80 °C

m6 = 13343,3578 kg/hari

= 555,9732 kg/jam

H6 = m6 x CpH_2O (l), 80 °C x ΔT

= 555,9732 kg/jam x 1,0029 kkal/kg.°C x (60 – 80) °C

= - 11151,7105 kkal/jam x 0,25 jam

= - 2787,9276 kkal = 2787,9276 kkal (melepas panas)

7. Air Perendam (H_2O (l), 80 °C)

m7 = 242478 kg/hari

= 10103,2734 kg/jam

H7 = m7 x Cp Air Perendam (H_2O (l), 80 °C) x ΔT

= 10103,2734 kg/jam x 1,0029 kkal/kg.°C x (80 – 60) °C

= - 202651,4579 kkal/jam x 0,25 jam

= - 50662,8645 kkal = 50662,8645 kkal (melepas panas)

8. NaOH (l)

m8 = 0,1029 kg/hari

= 4,2875 x 10^{-3} kg/jam

Cp NaOH (l) = (1 x 8,0) + (1 x 6,0) + (1 x 4,3) (Kopp Rule)

= 18,3 kal/mol. °C

= 0,4575 kkal/kg. °C

H8 = m8 x Cp NaOH (l) x ΔT

= 4,2875 x 10^{-3} kg/jam x 0,4575 kkal/kg. °C x (60 – 80) °C

= - 0,0392 kkal/jam x 0,25 jam

= - 0,0098 kkal = 0,0098 kkal (melepas panas)

ΔH Rumput Laut = H1 + H2 + ... + H8

= - 51464,5626 kkal

= 51464,5626 kkal (melepas panas)

Larutan NaCl

Cp NaCl (s) = (1 x 6,2) + (1 x 6,2) (Kopp Rule)

= 12,4 kal/mol. °C

= 0,2120 kkal/kg. °C

Cp NaCl (l) = (1 x 8,0) + (1 x 8,0) (Kopp Rule)

= 16 kal/mol. °C

= 0,2735 kkal/kg. °C

CpH_2O (l), 30 °C = 0,9987 kkal/kg. °C

m H_2O (l) = 11983,9493 kg/hari

= 499,3312 kg/jam

ΔH larutan NaCl= $(mxCp)\ H_2O(l),\ 30\ ^{o}C\ \Delta T\ +\ (mxCp)\ NaCl(s)\ \Delta T$

= (499,3312x0,9987x(60–30)+55,4812x0,2120x(60–30)) kkal

= 15313,3225 kkal/jam x 0,25 jam

= 3828,3306 kkal

Q = ΔH Rumput Laut - ΔH larutan NaCl - Qloss

= 51464,5626 kkal - 3828,3306 + 0,05.Q

1,05Q = 47636.2320 kkal

Q = 45367,8400 kkal

Qloss[1] = 0,05.Q1

= 0,05 x 45367,8400 kkal

= 2268,3920 kkal

KEBUTUHAN AIR PENDINGIN

Air pendingin yang digunakan bersuhu 30 °C

Q = m air x Cp air, 30°C x (60 – 30) °C

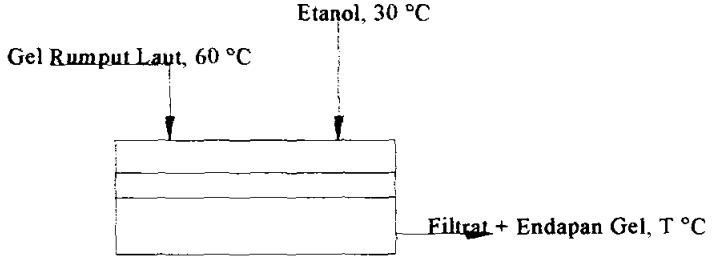
$$\text{m air} = \frac{Q}{Cp\ air,\ 30\ ^{o}C\ x\ (60-30)\ ^{o}C}$$

$$= \frac{45367{,}8400\ kkal}{0{,}9987\ kkal/kg.\ ^{\circ}C\ x\ (60-30)\ ^{\circ}C}$$

= 1514,2298 kg

Panas yang dilepas, kkal		Panas yang diterima, kkal	
		Q untuk	45367,8400
ΔH Rumput Laut untuk		menurunkan suhu	
menurunkan suhu 80 °C → 60 °C		80 °C → 60 °C	
RUMPUT LAUT	51464,5626	ΔH larutan NaCl	3828,3306
Karbohidrat = 624,3110		Qloss untuk	2268,3920
Protein = 54,8654		menurunkan suhu	
Lemak = 11,6532		80 °C → 60 °C	
Abu = 27,3587			
Serat = 3,5000			
H_2O = 2787,9276			
Air Perendam = 50662,8645			
NaOH = 0,0098			
TOTAL	51464,5626	TOTAL	51464,5626

6. Tangki Penambahan Etanol



Data : 1. Qloss = 5 %.Q

2. waktu pengisian 30 menit (0,5 jam)

Bahan masuk Tangki Penambahan Etanol

RUMPUT LAUT (Cp, kkal/kg. °C)

1. Karbohidrat = 329,3648 kg/jam → X1 = 0,0283;Cp1 = 0,3791

2. Protein = 26,0149 kg/jam → X2 = 0,0022;Cp2 = 0,4218

3. Lemak = 4,9928 kg/jam → X3 = 0,0004;Cp3 = 0,4668

4. Abu = 24,4383 kg/jam → X4 = 0,0021;Cp4 = 0,2239

5. Serat = 52,1875 kg/jam → X5 = 0,0045;Cp5 = 0,3200

6. H_2O (l), 60 °C = 555,9732 kg/jam → X6 = 0,0477;Cp6 = 1,0001

7. Air Perendam (l), 60 °C =10602,6047kg/jam → X7 = 0,9100;Cp7 = 1,0001

8. NaOH (l) = $4,2875.10^{-3}$kg/jam → X8 = 0,0000;Cp7 = 0,4575

9. NaCl (l) = 55,4812 kg/jam+→ X9 = 0,0048;Cp7 = 0,2735

TOTAL =11651,0617 kg/jam

m Rumput Laut = 11651,0617 kg/jam x 0,5 jam

= 5825,5309 kg

Cp Rumput Laut = X1.Cp1 + X2.Cp2 + ... + X7.Cp7

= 0,9729 kkal/kg. °C

Etanol 95 %, 30 °C

m Etanol 95 %= 559250,9610 kg/hari

= 23302,1234 kg/jam x 0,5 jam

= 1651,0617 kg

Cp Etanol 95 % = 0,77 kal/g. °C (Geankoplis, 1993)

= 0,77 kkal/kg. °C

Panas sensible Rumput Laut (Q) = Quntuk menaikkan suhu Etanol 95 % + Qloss

(m.Cp)Rumput Lautx(T–60)°C =(m.Cp)larutan Etanol 95 %x(T–30) °C+ 0,05.Q

Dengan memasukkan harga – harga diatas, maka memperoleh harga :

T = 41,2519 °C ≅ 42 °C

Panas sensible Rumput Laut (Q) = (m.Cp)Rumput Lautx(T–60) °C

= (5825,5309x0,9729x(41,2519 – 60)) kkal

= – 106257,8379 kkal

= 106257,8379 kkal (melepas panas)

Q untuk menaikkan suhu Etanol 95 % = (m.Cp)larutan NaOH 0,1 Nx(T–30,9) °C

= (1651,0617x 0,77x(41,2519–30)) kkal

= 100944,9460 kkal

Qloss = 5 %.Q

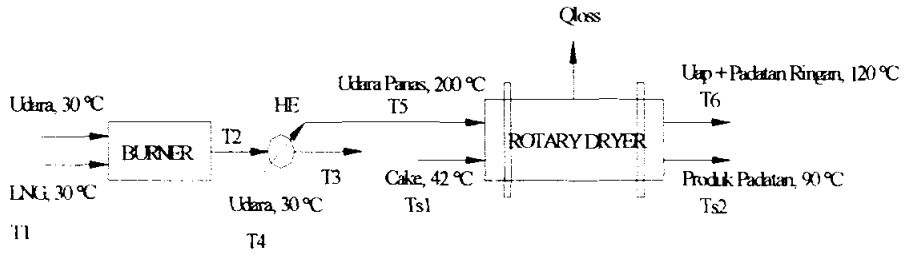
= 0,05 x (– 106257,8379 kkal)

= – 5312,8919 kkal

= 5312,8919 kkal (melepas panas)

Panas yang dilepas, kkal		Panas yang diterima, kkal	
Q panas sensible Rumput Laut	106257,8379	Q untuk meniakkan suhu Etanol 95 %	100944,9460
		Qloss untuk menurunkan suhu 60 °C → 41,2519 °C	5312,8919
TOTAL	106257,8349	TOTAL	106257,8379

7. Rotary Dryer



Data : 1. Qloss = 30 %.Q

2. Basis 1 jam

Kondisi suhu operasi

- Suhu udara dan LNG masuk Burner (T1) = 30 °C
- Suhu gas keluar Burner = suhu gas masuk HE (T2) = T2 °C
- Suhu gas keluar HE (T3) = 500 °C
- Suhu udara masuk HE (T4) = 30 °C
- Suhu udara keluar HE = suhu udara masuk Rotary Dryer (T5) = 200 °C
- Suhu udara keluar Rotary Dryer (T6) = 120 °C
- Suhu cake masuk Rotary Dryer (Ts1) = 42 °C
- Suhu cake keluar Rotary Dryer (Ts2) = 90 °C

Panas yang diberikan udara(Q)= panas untuk menaikkan suhu produk + panas untuk menaikkan suhu H_2O yang terikut bahan + panas untuk menguapkan H_2O, 90 °C + panas untuk menaikkan suhu uap air dari 90 ke 120 °C + Qloss ..... (6.1)

PANAS YANG DIBERIKAN UDARA (Q)

Dari Himmelblau TABEL E.1, mendapat data sebagai berikut :

Komponen	T1, °C	T2, °C	a	$b.10^2$	$c.10^5$	$d.10^9$	Persamaan
Udara (g)	200	120	28,94	0,4147	0,3191	- 1, 965	1

$$Cpudara\ (g) = a + \frac{b}{2} x(T2+T1) + \frac{c}{3} x(T2^2+T2.T1+T1^2) + \frac{d}{4} x(T2^2+T1^2)x((T2+T1)..(1)$$

Dengan mamasukkan data yang ada kedalam rumus diatas, maka memperoleh :

Cp udara (g) = 29,6784 j/mol. °C

= 0,2446 kkal/kg. °C

Q udara = m udara x Cp udara x ΔT

= (m udara x 0,2446 x (200 – 120)) kkal/kg

= 19,5680.m udara kkal/kg

PANAS UNTUK MENAIKKAN SUHU PRODUK, (ΔHproduk)

H = m x Cp x ΔT (H, kkal; m, kg; Cp, kkal/kg. °C; ΔT, °C)

1. Karbohidrat = 296,4283 x 0,3791 x (90 – 42) °C = 5394,0465
2. Protein = 23,4143 x 0,4218 x (90 – 42) °C = 474,0553
3. Lemak = 4,4935 x 0,4668 x (90 – 42) °C = 100,6832
4. Abu = 21,9944 x 0,2239 x (90 – 42) °C = 236,3782
5. Serat = 46,9688 x 0,3200 x (90 – 42) °C = 721,4408
6. H_2O (l), 90 °C = 69,5730 x 0,0050 x (90 – 42) °C = 16,6975
7. NaOH (s) = $7,5000.10^{-5}$ x 0,3125 x (90 – 42) °C = 0,0011
8. NaCl (s) = 0,9483 x 0,2120 x (90 – 42) °C = 9,6499 +

ΔHproduk TOTAL = 6952,9525 kkal

PANAS UNTUK MENAIKKAN SUHU H_2O YANG TERIKUT BAHAN

(ΔH H_2O bahan)

m air total = 5616,9426 kg/hari

= 234,0393 kg/jam

H air, 42 °C = 175,8 kj/kg (Smith Vann Ness, 1996, pp. 669)

= 42,0172 kkal/kg

H air, 90 °C = 376,9 kj/kg (Smith Vann Ness, 1996, pp. 671)

= 90,0813 kkal/kg

ΔH H_2O bahan= m air total x (H air, 90 °C - H air, 42 °C)

= 234,0393 kg x (90,0813 - 42,0172) kkal/kg

= 11248,8883 kkal

PANAS UNTUK MENGUAPKAN H_2O, 90 °C (ΔH H_2O, 90 °C)

m air menguap= 3761,6634 kg/hari

= 156,7360 kg/jam

H^{evap}, 90 °C = 2283,2 kj/kg (Smith Vann Ness, 1996, pp. 670)

= 545,6979 kkal/kg

ΔH H_2O, 90 °C = m air menguap x H^{evap}, 90 °C

= 156,3760 kg x 545,6979 kkal/kg

= 85530,5061 kkal

PANAS UNTUK MENAIKKAN SUHU UAP AIR DARI 90 °C ke 120 °C

(ΔH uap air)

m air menguap= 3761,6634 kg/hari

= 156,7360 kg/jam

Dari Himmelblau TABEL E.1, mendapat data sebagai berikut :

Komponen	T1, °C	T2, °C	a	$b.10^2$	$c.10^5$	$d.10^9$	Persamaan
Uap air (g)	90	120	33,46	0,6880	0,7604	- 3,593	1

$$Cpuap\ air(g)=a+\frac{b}{2}x(T2+T1)+\frac{c}{3}x(T2^2+T2.T1+T1^2)+\frac{d}{4}x(T2^2+T1^2)x((T2+T1)..(1)$$

Dengan mamasukkan data yang ada kedalam rumus diatas, maka memperoleh :

Cp uap air (g) = 34,2626 j/mol. °C

= 0,4549 kkal/kg. °C

ΔH uap air = m uap air x Cp uap air x ΔT

= (156,7360 x 0,4549 x (120 – 90)) kkal

= 2138,9762 kkal

Qloss

Qloss = 30 %.Q

= 0,3 x 19,5680.m udara kkal/kg

= 5,8704 m udara kkal/kg

Dengan memasukkan harga – harga diatas dalam persamaan (6.1), maka memperoleh harga :

m udara = 7729,1878 kg

Q udara = 19,5680.m udara kkal/kg

= (19,5680 x 7729,1878) kkal

= 151244,7472 kkal

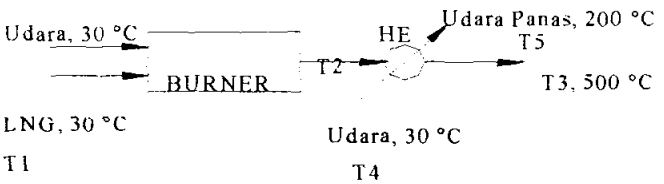
Qloss = 5,8704 m udara kkal/kg

= (5,8704 x 7729,1878) kkal

= 45373,4241 kkal

Panas yang dibutuhkan, kkal		Panas yang diberikan, kkal	
ΔHproduk	6952,9525	Q udara	151244,7472
ΔH H_2O bahan	11248,8883		
ΔH H_2O, 90 °C	85530,5061		
ΔH uap air	2138,9762		
Qloss	45373,9762		
TOTAL	151244,7472	TOTAL	251244,7472

8. Burner



Data : 1. Basis 1 kmol LNG

2. Qloss = 20 %.ΔHp (pada Burner)

2. Qloss = 20 %.Q (pada HE)

Kondisi suhu operasi

- Suhu udara dan LNG masuk Burner (T1) = 30 °C
- Suhu gas keluar Burner = suhu gas masuk HE (T2) = T2 °C
- Suhu gas keluar HE (T3) = 500 °C
- Suhu udara masuk HE (T4) = 30 °C
- Suhu udara keluar HE = suhu udara masuk Rotary Dryer (T5) = 200 °C

Komposisi LNG (Ullman's)

1. Metana = 87,10 % = 0,8710 kmol
2. Etana = 3,41 % = 0,0341 kmol

3. Propana = 1,73 % = 0,0173 kmol

4. N_2 = 7,10 % = 0,0710 kmol

5. CO_2 = 0,31 % = 0,0031 kmol

6. Helium = 0,35 % = 0,0035 kmol

Reaksi pembakaran pada Burner :

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \quad (1)$$

$$C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \quad (2)$$

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \quad (3)$$

Berdasarkan persamaan reaksi mendapat harga :

CO_2 yang dihasilkan = {(1x0,8710)+(2x0,0341)+(3x0,0173)}

= 0,9911 kmol

CO_2 yang dihasilkan dari reaksi (1) $= \frac{0,8710}{0,9911} \times 100\ \% = 87,88\ \%$

O_2 yang dibutuhkan = $\{(2x0,8710)+(\frac{7}{2}x0,0341)+(5x0,0173)\}$

= 1,94785 kmol

H_2O yang dihasilkan = {(2x0,8710)+(3x0,0341)+(4x0,0173)}

= 1,9135 kmol

Udara yang dibutuhkan $= \frac{100\ \%}{21\ \%} \times 1,94785$ kmol

= 9,2755 kmol

Untuk pembakaran menggunakan udara berlebih sebesar 20 %. Jadi, jumlah udara yang digunakan = 1,2 x 9,2755 kmol

= 11,1306 kmol

Udara terdiri dari :

O_2 = 21 % x 11,1306 kmol = 2,33742 kmol

N_2 = 79 % x 11,1306 kmol = 8,79318 kmol

Komposisi gas keluar :

CO_2	= (0,9911 + 0,0031) = 0,9942 kmol	= 43,7448 kg
H_2O	= 1,9135 kmol	= 34,4430 kg
O_2	= (2,33742 – 1,94785) = 0,38597 kmol	= 12,4662 kg
N_2	= (8,79315 + 0,0710) = 8,86415 kmol	= 248,1962 kg
He	= 0,0035 kmol	= 0,0140 kg
	TOTAL	= 338,8642 kg

$$\% \text{ Berat } CO_2 = \frac{43{,}7448\ kg}{338{,}8642\ kg} \times 100\ \%$$

= 12,9092 % (X1)

% Berat H_2O = 10,1642 % (X2)

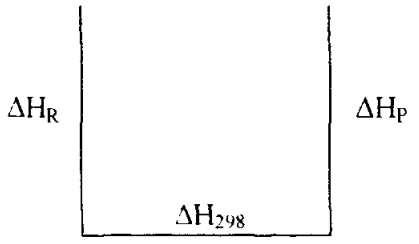
% Berat O_2 = 3,6788 % (X3)

% Berat N_2 = 73,2436 % (X4)

% Berat He = 0,0042 % (X5)

MENGHITUNG SUHU GAS KELUAR BURNER (T2)

30 °C = 303 °K T2 = ?



25 °C = 298 °K 25 °C = 298 °K

ΔH_R

Dari Himmelblau TABEL E.1, mendapat data sebagai berikut :

Komponen	T1, °C	T2, °C	a	$b.10^2$	$c.10^5$	$d.10^9$	Persamaan
CH_4 (g)	303 °K	298 °K	34,31	5,469	0,3661	-11,00	1
C_2H_6 (g)	30	25	49,37	13,92	-5,816	7,280	1
C_3H_8 (g)	30	25	68,032	22,59	-13,11	31,71	1
N_2 (g)	30	25	29,00	0,2199	0,5723	-2,871	1
CO_2 (g)	30	25	36,11	4,233	-2,887	7,464	1
He (g)	30	25	20,8	-	-	-	1
O_2 (g)	30	25	29,10	1,158	-0,6076	1,311	1

$$C_{prata\text{-}rata} = a + \frac{b}{2}x(T2+T1) + \frac{c}{3}x(T2^2+T2.T1+T1^2) + \frac{d}{4}x(T2^2+T1^2)x((T2+T1)...(1)$$

Dengan mamasukkan data yang ada kedalam rumus diatas, maka memperoleh :

Cp Gas

Cp CH_4 (g) = 50,7764 j/mol. °C = 12,1359 kkal/kmol. °C

Cp C_2H_6 (g) = 53,1540 j/mol. °C = 12,7041 kkal/kmol. °C

Cp C_3H_8 (g) = 74,1455 j/mol. °C = 17,7212 kkal/kmol. °C

Cp N_2 (g) = 29,0648 j/mol. °C = 6,9466 kkal/kmol. °C

Cp CO_2 (g) = 37,2523 j/mol. °C = 8,9035 kkal/kmol. °C

Cp He (g) = 20,8000 j/mol. °C = 4,9713 kkal/kmol. °C

Cp Udara

Cp O_2 (g) = 29,4138 j/mol. °C = 7,0301 kkal/kmol. °C

Cp N_2 (g) = 29,0648 j/mol. °C = 6,9466 kkal/kmol. °Cp

ΔH, kkal = n x Cp x ΔT

= n x Cp x (T2 – T1)

Komponen	T1, °C	T2, °C	n, kmol	Cp, kkal/kmol. °C (°K)	ΔH, kkal
CH_4 (g)	303 °K	298 °K	0,8710	12,1359	-52,8517
C_2H_6 (g)	30	25	0,0341	12,7041	-2,1661
C_3H_8 (g)	30	25	0,0173	17,7212	-1,5329
N_2 (g)	30	25	0,0710	6,9466	-2,4661
CO_2 (g)	30	25	0,0031	8,9035	-0,1380
He (g)	30	25	0,0035	4,9713	-0,0870
O_2 (g)	30	25	2,33742	7,0301	-82,1611
N_2 (g)	30	25	8,79318	6,9466	-305,4154
ΔH_R TOTAL					-446,8182

ΔH^{o}_{298}

Komponen	n, kmol	ΔH^{o}_{298}, kj/kmol	ΔH^{o}_{298}, kkal/kmol
CH_4 (g)	0,8710	-74,84	-17887,1893
C_2H_6 (g)	0,0341	-84,667	-20235,8987
C_3H_8 (g)	0,0173	-103,85	-24820,7457
O_2 (g)	1,94785	0	0
CO_2 (g)	0,9911	-393,51	-94051,1472
H_2O (g)	1,9135	-241,826	-57797,8011

$\Delta H^{o}_{298} = \Sigma$ (n x ΔH_f hasil) - Σ (n x ΔH_f reaktan)

Dengan memasukkan harga diatas, maka memperoleh harga :

ΔH^{o}_{298} = -187110,9996 kkal

ΔH_P

Dari Himmelblau TABEL E.1, mendapat data sebagai berikut :

Komponen	T1, °C	T2, °C	a	$b.10^2$	$c.10^5$	$d.10^9$	Persamaan
CO_2 (g)	25	**T2**	36,11	4,233	-2,887	7,464	1
H_2O (g)	25	**T2**	33,46	0,6880	0,7604	-3,593	1
O_2 (g)	25	**T2**	29,10	1,158	-0,6076	1,311	1
N_2 (g)	25	**T2**	29,00	0,2199	0,5723	-2,871	1
He (g)	25	**T2**	20,8	-	-	-	1

$$Cprata\text{-}rata = a + \frac{b}{2}x(T2+T1) + \frac{c}{3}x(T2^2+T2.T1+T1^2) + \frac{d}{4}x(T2^2+T1^2)x((T2+T1)) \quad ..(1)$$

Dengan mamasukkan data yang ada kedalam rumus diatas, maka memperoleh :

ΔH CO_2 (g), kkal/ °C

Cp CO_2 (g)= 36,11+0,0212(**T2**+25)–9,6233.10^{-6}(**T2**^{2}+25**T2**+625)+1,866.10^{-9}

(**T2**^{2}+625)(**T2**+25)

= 36,6340+0,0210.**T2**–9,5767.10^{-6}.**T2**^{2}+1,866.10^{-9}.**T2**^{3} j/mol. °C

= 8,7557+0,0050.**T2**–2,2889.10^{-6}.**T2**^{2}+4,4599.10^{-10}.**T2**^{3} kkal/kmol.°C

ΔH = (n x Cp) CO_2 (g) x ΔT

= 0,9942 kmol x Cp CO_2 (g) x (T2 – 25) °C

=4,4340.10^{-10}.**T2**^{4}–2,2867.10^{-6}.**T2**^{3}+4,9569.10^{-3}.**T2**^{2}+8,5806.**T2**–217,6229

ΔH H_2O (g), kkal/ °C

Cp H_2O (g)= 33,46+0,0034(**T2**+25)–2,5347.10^{-6}(**T2**^{2}+25**T2**+625)–8,985.10^{-10}

(**T2**^{2}+625)(**T2**+25)

=33,5466+3,4628.10^{-3}.**T2**+2,5122.10^{-6}.**T2**^{2}–8,985.10^{-10}.**T2**^{3} j/mol. °C

=8,0178+8,2763.10^{-4}**T2**+6,0043.10^{-7}**T2**^{2}–2,1475.10^{-10}**T2**^{3}kkal/kmol.°C

ΔH = (n x Cp) H_2O (g) x ΔT

= 1,9135 kmol x Cp H_2O (g) x (T2 – 25) °C

=–4,1092.10^{-10}.**T2**^{4}+1,1529.10^{-6}.**T2**^{3}+1,555.10^{-3}**T2**^{2}+15,3025**T2**–383,5515

ΔH O_2 (g), kkal/ °C

Cp O_2 (g) = 29,10+0,0058(**T2**+25) –2,2533.10^{-7}(**T2**^{2}+25**T2**+625)+3,2775.10^{-10}

(**T2**^{2}+625)(**T2**+25)

=29,2449+5,7946.10^{-3}.**T2**–2,1714.10^{-7}.**T2**^{2}+3,2775.10^{-10}.**T2**^{3} j/mol. °C

=6,9897+1,3849.10^{-3}**T2**–5,1898.10^{-8}**T2**^{2}+7,8334.10^{-11}**T2**^{3}kkal/kmol.°C

ΔH = (n x Cp) O_2 (g) x ΔT

= 0,38597 kmol x Cp O_2 (g) x (T2 – 25) °C

$=3{,}0234.10^{-11}.\mathbf{T2}^4-2{,}0787.10^{-8}.\mathbf{T2}^3+5{,}3504.10^{-4}.\mathbf{T2}^2+2{,}6845.\mathbf{T2}-67{,}4457$

ΔH N_2 (g), kkal/ °C

Cp N_2 (g) $= 29{,}0+1{,}0995.10^{-3}(\mathbf{T2}-25)+1{,}9077.10^{-6}(\mathbf{T2}^2+25\mathbf{T2}+625)-7{,}1775.10^{-10}$

$(\mathbf{T2}^2+625)(\mathbf{T2}+25)$

$=29{,}0287+1{,}1467.10^{-3}.\mathbf{T2}+1{,}8898.10^{-6}.\mathbf{T2}^2-7{,}1775.10^{-10}.\mathbf{T2}^3$ j/mol. °C

$=6{,}9380+2{,}7407.10^{-4}\mathbf{T2}+4{,}5167.10^{-7}\mathbf{T2}^2-1{,}7155.10^{-10}\mathbf{T2}^3$kkal/kmol.°C

ΔH = (n x Cp) N_2 (g) x ΔT

= 8,86415 kmol x Cp N_2 (g) x (T2 – 25) °C

$=-1{,}5206.10^{-9}\mathbf{T2}^4+4{,}0418.10^{-6}\mathbf{T2}^3+2{,}3378.10^{-3}\mathbf{T2}^2+61{,}4390\mathbf{T2}-1537{,}4929$

ΔH He (g), kkal/ °C

Cp He (g) = 20,8 j/mol. °C

= 4,9713 kkal/kmol.°C

ΔH = (n x Cp) He (g) x ΔT

= 0,0035 kmol x Cp He (g) x (T2 – 25) °C

$=0{,}0174.\mathbf{T2}-0{,}4350$

ΔH_P, kkal/ °C

CO_2 (g) = $4{,}4340.10^{-10}.\mathbf{T2}^4-2{,}2867.10^{-6}.\mathbf{T2}^3+4{,}9569.10^{-3}.\mathbf{T2}^2+8{,}5806.\mathbf{T2}-217{,}6229$

H_2O (g)= $-4{,}1092.10^{-10}.\mathbf{T2}^4+1{,}1529.10^{-6}.\mathbf{T2}^3+1{,}555.10^{-3}\mathbf{T2}^2+15{,}3025\mathbf{T2}-383{,}5515$

O_2 (g) = $3{,}0234.10^{-11}.\mathbf{T2}^4-2{,}0787.10^{-8}.\mathbf{T2}^3+5{,}3504.10^{-4}.\mathbf{T2}^2+2{,}6845.\mathbf{T2}-67{,}4457$

$N_2(g) = -1{,}5206.10^{-9}\mathbf{T2}^4+4{,}0418.10^{-6}\mathbf{T2}^3+2{,}3378.10^{-3}\mathbf{T2}^2+61{,}4390\mathbf{T2}-1537{,}4929$

$He(g) = 0{,}0174.\mathbf{T2} - 0{,}4350 +$

$= -1{,}4579.10^{-9}.\mathbf{T2}^4+2{,}8935.10^{-6}.\mathbf{T2}^3+ 9{,}3847.10^{-3}\mathbf{T2}^2+88{,}0240\mathbf{T2}-2206{,}5480$

$\Delta H_R + \Delta H^o_{298} + \Delta H_P = \Delta H_T = -$ Qloss

$\Delta H_R + \Delta H^o_{298} + \Delta H_P = 20\,\%.\Delta H_P$

$\Delta H_R + \Delta H^o_{298} + 1{,}2.\Delta H_P = 0$

-446,8182 kkal + (-187110,9996 kkal) + $1{,}2.(-1{,}4579.10^{-9}.\mathbf{T2}^4 + 2{,}8935.10^{-6}.\mathbf{T2}^3 + 9{,}3847.10^{-3}.\mathbf{T2}^2 + 88{,}0240.\mathbf{T2} - 2206{,}5480) = 0$

$-187557{,}8178 - 1{,}7495.10^{-9}.\mathbf{T2}^4 + 3{,}4722.10^{-6}.\mathbf{T2}^3 + 0{,}0113.\mathbf{T2}^2 + 105{,}6288.\mathbf{T2} - 2647{,}8576 = 0$

Dari trial mendapat harga **T2** = 1524,9283 °C ≅ 1525 °C

Dari Himmelblau TABEL E.1, mendapat data sebagai berikut :

Komponen	T1, °C	T2, °C	a	b.10^2	c.10^5	d.10^9	Persamaan
CO_2 (g)	1525	500	36,11	4,233	-2,887	7,464	1
H_2O (g)	1525	500	33,46	0,6880	0,7604	-3,593	1
O_2 (g)	1525	500	29,10	1,158	-0,6076	1,311	1
N_2 (g)	1525	500	29,00	0,2199	0,5723	-2,871	1
He (g)	1525	500	20,8	-	-	-	1
Udara (g)	30	200	28,94	0,4147	0,3191	-1,965	1

$$C_{prata\text{-}rata} = a + \frac{b}{2}x(T2+T1) + \frac{c}{3}x(T2^2+T2.T1+T1^2) + \frac{d}{4}x(T2^2+T1^2)x((T2+T1)\ldots(1)$$

Dengan mamasukkan data yang ada kedalam rumus diatas, maka memperoleh :

No.	Komponen	X, %	Cp, j/mol. °C	Cp, kj/kg. °C	Cp, kkal/kg. °C
1.	CO_2 (g)	12,9092	56,5776	1,2859	0,3073
2.	H_2O (g)	10,1642	44,2021	2,4557	0,5869
3.	O_2 (g)	3,6788	35,7734	1,1179	0,2672
4.	N_2 (g)	73,2436	33,8510	1,2090	0,2889
5.	He (g)	0,0042	20,8000	5,2000	1,2428
6.	Udara (g)	-	29,4622	1,0159	0,2428

Cp gas panas = X1.Cp1 + X2.Cp2 + ... + X5.Cp5

= 0,3208 kkal/kg. °C

Cp udara = 0,2428 kkal/kg. °C

MENGHITUNG KEBUTUHAN GAS PANAS

Neraca Massa pada alat HE :

Q gas panas = Q udara + Qloss

= (m x Cp x ΔT) udara+ 20 %.Q gas panas

$|0,8.(m \times Cp \times \Delta T)\ \text{gas panas}| = (m \times Cp \times \Delta T)\ \text{udara}$

$$\text{gas panas} = \frac{(m\ x\ Cp\ x\ \Delta T)\ udara}{0,8.(Cp\ x\ \Delta T)\ gas\ panas}$$

$$= \frac{7729,1878\ kg\ x\ 0,2428\ kkal/kg.\ ^{o}C\ x\ (200-300)\ ^{o}C}{|0,8\ x\ 0,3208\ kkal/kg.\ ^{o}C\ x\ (500-1525)\ ^{o}C|}$$

= 1212,7834 kg

Komposisi gas panas keluar :

CO_2 (g) = 12,9092 % x 1212,7834 kg = 156,5606 kg = 3,5582 kmol

H_2O (g) = 10,1642 % x 1212,7834 kg = 123,2697 kg = 6,8483 kmol

O_2 (g) = 3,6788 % x 1212,7834 kg = 44,6159 kg = 1,3942 kmol

N_2 (g) = 73,2436 % x 1212,7834 kg = 888,2862 kg = 31,7245 kmol

He (g) = 0,0042 % x 1212,7834 kg = 0,0509 kg = 0,0127 kmol +

TOTAL = 212,7834 kg = 43,5380 kmol

CO_2 yang dihasilkan dari reaksi (1) = 87,88 % x 3,5582 kmol

= 3,1269 kmol

CO_2 yang bereaksi : CO_2 yang terbentuk = 1 : 1

CH_4 yang bereaksi = CO_2 yang terbentuk = 3,1269 kmol

LNG yang dibutuhkan $= \frac{100\ \%}{87{,}1\ \%} \times 3{,}1269$ kmol

= 3,5900 kmol

BM LNG = 17,8586 g/gmol

= 17,8586 kg/kmol

Massa LNG yang dibutuhkan = 17,8586 kg/kmol x 3,5900 kmol

= 64,1124 kg

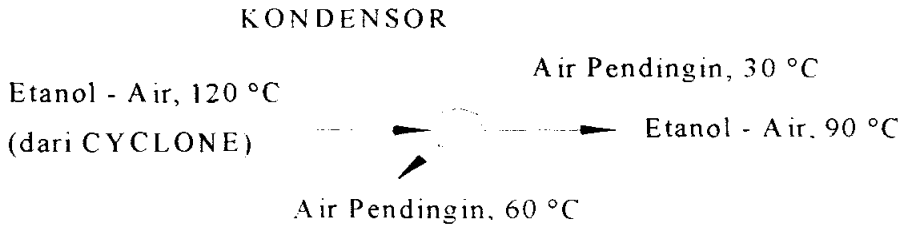
Massa udara yang dibutuhkan untuk membakar LNG

$= 11{,}1306 \frac{kmol\ udara}{kmol\ LNG} \times 3{,}5900$ kmol LNG

= 39,9589 kmol udara

= 1158,8081 kg udara

9. Kondensor



Data : 1. Qloss = 5 %.Q

Panas yang dilepas untuk menurunkan suhu dari 120 °C → 90 °C dianggap membutuhkan waktu selama 45 menit (0,75 jam)

Feed Etanol – Air masuk (dari Cyclone) :

Etanol = 10089,7064 kg/hari = 420,4044 kg/jam

Air = 3761,6634 kg/hari = 156,7360 kg/jam +

TOTAL = 13851,3698 kg/hari = 577,1404 kg/jam

Q air pendingin = (m x λ) air, 120 °C + (m x λ) etanol, 120 °C +

m air.(H air, 60 °C – H air, 120 °C) + (m x Cp) etanol x

(60-120) °C (9.1)

ΔH air, 120 °C

ΔH air, 120 °C = (m x λ) air, 120 °C

= 156,7360 kg/jam x (Hv^{120} – $H_L{}^{120}$) x 0,75 jam

= 156,7360 kg/jamx(2706,3–503,71) kj/kgx0,75 jam

= 258918,8597 kj

= 61833,0927 kkal

ΔH etanol, 120 °C

ΔH etanol, 120 °C = (m x λ) etanol, 120 °C

Dari Smith Vann Ness TABEL B.1 mendapat data :

Etanol : BM = 46 g/gmol

Tc = 513,9 °K = 240,9 °C

Pc = 61,48 bar = 60,6760 atm

Tn = 351,4 °K = 78,4 °C

Mencari λetanol, 1atm, 78,4 °C (351,4 °K) (ΔHn = ΔH1)

R = 8,314 j/mol. °K

$$\frac{\Delta Hn}{Tn} = R.\ \frac{1{,}092.\ (\ln\ Pc\ -\ 1{,}013)}{0{,}930\ -Trn} \qquad (4.18)$$

$$Trn = \frac{Tn}{Tc} = \frac{351{,}4\ ^{o}K}{513{,}9\ ^{o}K}$$

Trn = 0,6840

$$\frac{\Delta Hn}{351{,}4\ ^{o}K} = 8{,}314\ j/mol.\ ^{o}K.\ \frac{1{,}092.\ (\ln\ 61{,}48\ bar\ -\ 1{,}013)}{0{,}930\ -0{,}6840}$$

ΔHn = 40277,3118 j/mol = ΔH1

Mencari λetanol, 1atm, 120 °C (393 °K) (ΔH2)

$$\frac{\Delta H2}{\Delta H1} = \left(\frac{1\ -\ Tr2}{1\ -\ Tr1}\right)^{0{,}38} \qquad (4.19)$$

$$Tr1 = \frac{T1}{Tc} = \frac{351{,}4\ ^{o}K}{513{,}9\ ^{o}K} = 0{,}6840$$

$$Tr1 = \frac{T2}{Tc} = \frac{393\ ^{o}K}{513{,}9\ ^{o}K} = 0{,}7647$$

$$\Delta H2 = 40277{,}3118\ j/mol. \left(\frac{1 - 0{,}7647}{1 - 0{,}6840}\right)^{0.38}$$

= 36007,7279 j/mol

= 187,0881 kkal/kg

ΔH etanol, 120 °C = (m x λ) etanol, 120 °C

= 420,4044 kg/jam x 187,0881 kkal/kg x 0,75 jam

= 58989,4953 kkal

<u>ΔH air, 120 °C → 90 °C</u>

ΔH air, 120 °C → 90 °C =m air.(H air, 90 °C – H air, 120 °C)

=156,7360kg/jamx(Hair,90°C–Hair,120°C)x0,75jam

=156,7360kg/jamx(376,92–503,71)kj/kgx0,75 jam

= - 14904,4181 kj

= - 3562,2414 kkal

= 3562,2414 kkal (melepas panas)

<u>ΔH etanol, 120 °C → 90 °C</u>

ΔH etanol, 120 °C → 90 °C =(m x Cp) etanol x (90-120) °C

= (420,4044x0,3885x (90-120)) kkal/jamx0,75 jam

= - 3674,8599 kkal

= 3674,8599 kkal (melepas panas)

Memasukkan harga – harga diatas kedalam pers. (9.1)

Q air pendingin = (61833,0927 + 58989,4953 + 3562,2414 + 3674,8599) kkal

= 128059,6893 kkal

$$\text{m air pendingin} = \frac{128059{,}6893\ kkal}{H_L,\ 60\ ^oC\ -\ H_L,\ 30\ ^oC}$$

Dari APP A.2 – 9, Geankoplis, 1993 mendapat data :

H_L, 30 °C = 128,79 kj/kg = 30,7815 kkal/kg

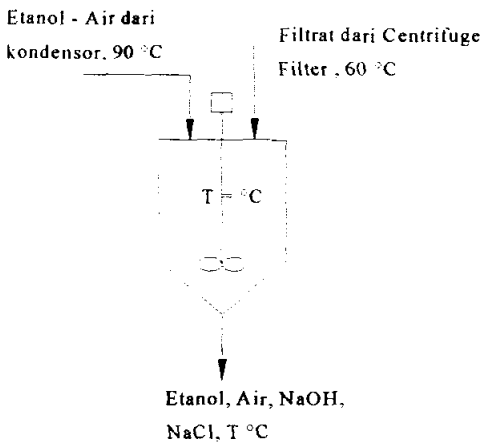
H_L, 60 °C = 251,13 kj/kg = 60,0215 kkal/kg

$$\text{m air pendingin} = \frac{128059{,}6893\ kkal}{(60{,}0215 - 30{,}7815)\ kkal/kg}$$

= 4379,6063 kg

Panas yang dilepas, kkal		Panas yang diterima, kkal	
ΔH air, 120 °C	61833,0927	Q air pendingin untuk	135318,6951
ΔH etanol, 120 °C	58989,4953	menurunkan suhu	
ΔH air, 120 °C → 60 °C	7096,3872	120 °C → 60 °C	
ΔH etanol,120 °C → 60 °C	7349,7199		
TOTAL	135318,6951	TOTAL	135318,6951

10. Tangki Pencampuran



Data : 1. Qloss = 5 %.Q

2. waktu pengisian 30 menit (0,5 jam)

Panas yang dilepas untuk menaikkan suhu campuran (Q) dari Kondensor :

H = m x Cp x ΔT (H, kkal; m, kg/jam; Cp, kkal/kg. °C; ΔT, °C)

1. Etanol = 420,4044 x0,97x(T–90)°Cx0,5 = 203,8961.(T–90)kkal

2. Air = 156,7360 x1,0050x(T–90)°Cx0,5 = 78,7598.(T–90)kkal +

TOTAL = 282,6559.(T–90)kkal

Panas untuk menaikkan suhu campuran (ΔHin) dari Centrifuge Filter :

3. Etanol = 21716,6128x0,92x(T–60) °Cx0,5 = 9989,6419.(T–60)kkal

4. Air = 12089,6448x1,0001x(T–60) °Cx0,5 = 6045,4269.(T–60)kkal

5. NaOH (l) = 0,0042x0,4575x(T–60) °Cx0,5 = 0,0010.(T–60)kkal

6. NaCl (l) = 54,4276x0,2735x(T–60) °Cx0,5 = 7,4430.(T–60)kkal +

TOTAL =16042,5128.(T–60)kkal

Q = ΔHin + Qloss

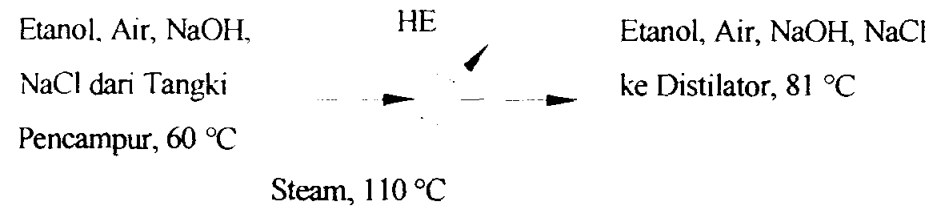
0,95.Q = ΔHin

- 0,95.(282,6559.(T–90)) = 16042,5128.(T–60)

-16311,0359.T = -986717,8475

T = 60,4939 °C ≅ 61 °C

11. HE



Data : 1. Qloss = 5 %.Q

Panas untuk menaikkan suhu dari 60 °C → 81 °C dianggap membutuhkan waktu selama 15 menit (0,25 jam)

H = m x Cp x ΔT (H, kkal; m, kg/jam; Cp, kkal/kg. °C; ΔT, °C)

1. Etanol = 22137,0172x0,925 x(81–60)°Cx0,25 =107502,8898 kkal
2. Air = 12246,3808x1,0001x(81–60)°Cx0,25 = 64299,9286 kkal
3. NaOH (l) = 0,0042x0,4575x(81–60)°Cx0,25 = 0,0101 kkal
4. NaCl (l) = 54,4276x0,2735x(81–60)°Cx0,25 = 78,1512 kkal +

TOTAL =171880,9797 kkal

Q = 171880,9797 kkal + Qloss

0,95.Q = 171880,9797 kkal

Q = 180927,3471 kkal

KEBUTUHAN STEAM

Steam yang digunakkan bersuhu 110 °C dari Geankoplis, APP A.2 – 9, pp 800 mendapat harga : Hv = 2691,50 kj/kg

H_L = 461,30 kj/kg

λsteam = Hv - H_L

= 2691,50 kj/kg – 461,30 kj/kg

= 2230,20 kj/kg

$$= \left(\frac{2230,20}{4,184}\right) \text{ kkal/kg}$$

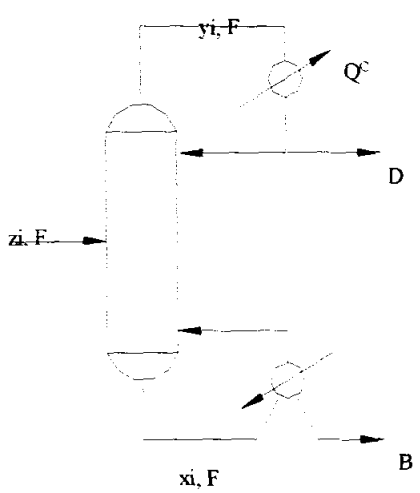
= 533,0306 kkal/kg

m steam $$= \frac{Q}{\lambda steam}$$

$$= \frac{180927,3471 \ kkal}{533,0306 \ kkal/kg}$$

= 339,4315 kg

12. Distilator



Data : 1. basis 1jam

UMPAN MASUK (F)

Komponen	Kg/hari	Kg/jam	xf = zi
Etanol	531288,4133	22137,0172	0,6428
H_2O	293913,1383	12246,3808	0,3556
NaOH	0,1009	0,0042	0,0000
NaCl	1306,2620	54,4276	0,0016
TOTAL	826507,9145	34437,8298	1,0000

PADA DISTILAT (D)

Komponen	Kg/hari	Kg/jam	$x_{D,i}$
Etanol	530757,1281	22114,8803	0,9500
H_2O	27934,5860	1163,9411	0,0500
TOTAL	558691,7141	23278,8214	1,0000

PADA BOTTOM (B)

Komponen	Kg/hari	Kg/jam	$x_{B,i}$
Etanol	531,2886	22,1370	0,0020
H_2O	265978,5113	11082,4380	0,9931
NaOH	0,1009	0,0042	0,0000
NaCl	1306,2620	54,4276	0,0049
TOTAL	267816,1628	11159,0068	1,0000

a.) Menentukan kondisi – kondisi operasi puncak

Dari APP A.3 – 23, pp. 887, Geankoplis, 1993 memperoleh data kesetimbangan untuk sistem Etanol – Air pada 1 atm.

Dari grafik kurva kesetimbangan :

Tekanan distilat (P_D) = 1 atm = 14,7 psia

X_A, Y_A = 0,95

maka mendapatkan harga :

Titik didih distilat = 78,15 °C

Titik embun distilat = 78,20 °C

b.) Menentukan kondisi – kondisi operasi dasar

Penentuan titik didih hasil dasar di reboiler. Asumsi penurunan tekanan uap sepanjang kolom, ΔP = 5 psia. P dasar = (14,7 + 5) = 19,7 psia. Suhu dasar merupakan titik didih dari cairan dasar yang keluar dari reboiler. Karena pengaruh kenaikan titik didih Etanol, NaOH dan NaCl sangat kecil, sehingga dapat dianggap sebagai titik didih air (H_2O) pada P dasar.

P dasar = 19,7 psia = 1,34 atm = 135,74 kPa (P^{sat})

Dari Smith Vann Ness, pp. 464 memperoleh harga :

Air : A = 16,2620

B = 3799,89

C = 226,35

$$\ln P^{sat}, \text{kPa} = 16{,}2620 - \frac{3799{,}89}{T, ^{o}C + 226{,}35}$$

$$\ln 135{,}74 = 16{,}2620 - \frac{3799{,}89}{T, ^{o}C + 226{,}35} \Rightarrow \quad T = 108{,}4037\ ^{o}C$$

$$\cong 109\ ^{o}C$$

Kondisi operasi puncak : P_D = 1 atm

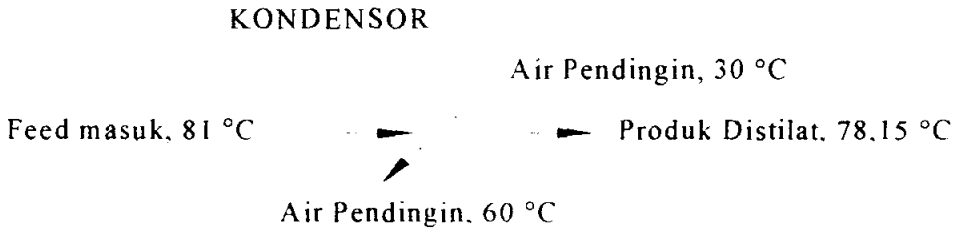
T didih= 78,15 °C

T dew = 78,2 °C

Kondisi operasi puncak : P dasar= 1,34 atm

T didih= 109 °C

Kondensor pada Distilator



Data : 1. Qloss = 5 %.Q

Panas yang dilepas untuk menurunkan suhu dari 81 °C → 78,15 °C dianggap membutuhkan waktu selama 5 menit (0,0833 jam)

H = m x Cp x ΔT (H, kkal; m, kg/jam; Cp, kkal/kg. °C; ΔT, °C)

1. Etanol = 22114,8803x0,95x(78,15–81)°Cx0,0833 =-4987,6740 kkal

2. Air = 1163,9411x1,0050x(78,15–81)°Cx0,0833= -277,1268 kkal +

TOTAL =-5264,8008 kkal

= 5264,8008 kkal

(Melepas panas)

KEBUTUHAN AIR PENDINGIN

Air pendingin yang digunakan bersuhu 30 °C

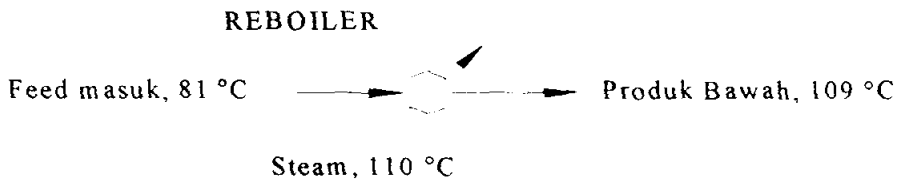
Q = m air x Cp air, 30°C x (60 – 30) °C

$$\text{m air} = \frac{Q}{Cp\ air,\ 30\ ^{\circ}C\ x\ (60-30)\ ^{\circ}C}$$

$$= \frac{5264{,}8008\ kkal}{0{,}9987\ kkal/kg.\ ^{\circ}C\ x\ (60-30)\ ^{\circ}C}$$

= 175,7218 kg

Reboiler pada Distilator



Data : 1. Qloss = 5 %.Q

Panas untuk menaikkan suhu dari 81 °C → 109 °C dianggap membutuhkan waktu selama 25 menit (0,42 jam)

H = m x Cp x ΔT (H, kkal; m, kg/jam; Cp, kkal/kg. °C; ΔT, °C)

1. Etanol = 22,1370x0,97x(109–81)°Cx0,42 = 252,5212 kkal
2. Air = 11082,4380x1,0029x(109–81)°Cx0,42 = 130707,4263 kkal
3. NaOH (l) = 0,0042x0,4575x(109–81)°Cx0,42 = 0,0226 kkal
4. NaCl (l) = 54,4276x0,2735x(109–81)°Cx0,42 = 175,0586 kkal +

TOTAL = 131135,0287 kkal

Q = 131135,0287 kkal + Qloss

0,95.Q = 131135,0287 kkal

Q = 138036,8723 kkal

KEBUTUHAN STEAM

Steam yang digunakkan bersuhu 110 °C dari Geankoplis, APP A.2 – 9, pp 800 mendapat harga : Hv = 2691,50 kj/kg

H_L = 461,30 kj/kg

λsteam = Hv - H_L

= 2691,50 kj/kg – 461,30 kj/kg

= 2230,20 kj/kg

$$= \left(\frac{2230,20}{4,184}\right) \text{ kkal/kg}$$

= 533,0306 kkal/kg

$$\text{m steam} = \frac{Q}{\lambda steam}$$

= 258,9661 kg

APENDIK C
SPESIFIKASI ALAT

APENDIK C
SPESIFIKASI ALAT

1. Belt Conveyor

Fungsi: - membawa rumput laut ke rotary cutter

- tempat pencucian rumput laut

Tipe: Chain Belt Conveyor

Bahan: stainless steel

Data-data:

- massa rumput laut: 525,5542 kg/jam

- air pencuci: 1051,1083 kg/jam

Total: 525,5542 + 1051,1083

= 1576,6625 kg/jam

Sudut elevasi: 0°

Dari Perry edisi 7 halaman 21-11 tabel 21-7 untuk lebar belt 35 Cm memperoleh:

- kecepatan belt: 30.5 m/menit

- kapasitas belt: 32 ton/jam

- Hp/10 ft – lift: 0,34 hp

- Hp/100 ft – centers: 0,44 hp

- Trippers: 2,0 hp

Perhitungan:

$$\text{Kecepatan Belt} = \frac{1576{,}6625\ kg/jam}{32000\ kg/jam} \times 30{,}5\ m/menit$$

= 1,5028 m/menit

Menentukan power:

1. Power untuk memindahkan rumput laut dengan jarak 8 m

$$\text{Hp untuk 100 ft} = \frac{1576{,}6625\ kg/jam}{32000\ kg/jam} \times 0{,}44 hp = 0{,}0217 \text{ hp}$$

$$\text{Hp untuk 8 meter} = \frac{8m \times 3{,}2808\ ft/m}{100 ft} \times 0{,}0217 hp = 5.6955 \,.\, 10^{-3} \text{ hp}$$

2. Power untuk sandungan/tripper

Kecepatan belt 1,5028 m/menit maka power untuk tripper:

$$\frac{1{,}5028\ m/menit}{30{,}5\ m/menit} \times 2{,}0 hp = 0{,}0985 \text{ hp}$$

Total power = $5.6955 \,.\, 10^{-3} + 0{,}0985 = 0{,}1042$ hp

Efisiensi = 80 % (Peter & Timmerhaus, gb. 14-18 hal. 521)

Jadi power yang dibutuhkan = $\frac{0{,}1042}{0{,}8} = 0{,}13025$ hp

Diambil power motor 0,2 hp

2. Rotary Cutter

Fungsi: memotong rumput laut

Massa rumput laut masuk: 584,1009 kg/jam

Perry edisi 6 halaman 8-29 tabel 8-16

Feed rate = 1000 lb/jam = 453,5 kg/lam

Power mesin = 11 hp

Screen openning = 1,5 in

Kebutuhan Rotary cutter: $\frac{584,1009}{453,5} = 1,288$

Dengan demikian membutuhkan 2 buah rotary cutter

Total power = 2 × 11 = 22 hp

3. Screw Conveyor

Fungsi: memasukkan rumput laut yang terlah dipotong ke dalam bucket elevator

Tipe: standar pitch screw conveyor

Massa masuk: 584,1009 kg/jam

Perry edisi 7 tabel 21-6 hal. 21-7 untuk kapasitas 5 ton:

- diameter flight = 9 in
- diameter poros = 2 in
- kecepatan screw = 40 rpm
- panjang screw = 5 ft
- Hp motor = 0,43 hp

Perhitungan:

Kecepatan screw untu kapasitas 584,1009 kg/jam

$$= \frac{584,1009\ kg/jam}{5000\ kg/jam} \times 40 rpm = 4,6728 \text{ rpm}$$

Hp motor untuk kapasitas 584,1009 ka/jam

$$= \frac{584,1009\ kg/jam}{5000\ kg/jam} \times 0,43 hp = 0,0502 \text{ hp}$$

Efisiensi = 80 % (Peter & Timmerhaus, gb. 14-18 hal. 521)

Power yag dibutuhkan = $\frac{0,0502}{0,8}$ = 0,0628 hp

Diambil power motor 0,1 hp

4. Bucket elevator

Fungsi: memasukkan rumput laut kedalam tangki perendaman

Tipe: Centirfugal Discharge Bucket on Belt

Tinggi elevasi: 4 meter

Massa masuk: 584,1009 kg/jam

Perry edisi 7 tabel 21-8 halaman 21-15 mendapatkan:

- ukuran bucket = 6 × 4 × 4,5 in
- jarak bucket = 12 in
- elevator center = 25 ft
- kecepatan bucket = 68,8 m/menit
- head shaft = 43 rpm
- shaft diameter = - head = $1\frac{15}{16}$ in

  - tail = $1\frac{11}{16}$ in

  pulley diameter = - head = 20 in

  - tail = 14 in
- belt width = 7 in
- power = 1 hp

Efisiensi motor = 80 %

Power motor = $\frac{1}{0,8}$ = 1,25 hp

5. Tangki Perendaman

Fungsi: merendam rumput laut selama 2 jam agar rumput laut mengembang

Tipe: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan jaket pemanas dan pengaduk

Kondisi operasi: T = 60 °C; P = 1 atm

Kapasitas untuk setiap batch: 22190,3685 kg/batch

Massa rumput laut = 1168,2018 kg/batch

Massa H_2O = 21022,1667 kg/batch

ρ_{RL} = 1544 kg/m^3

$\rho_{H2O,30°C}$ = 995,68 kg/m^3

$$x_{RL} = \frac{1168,2018}{22190,3685} = 0,0526$$

$$x_{H2O} = \frac{21022,1667}{22190,3685} = 0,9474$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{RL}}{\rho_{RL}} + \frac{x_{H_2O}}{\rho_{H_2O}}$$

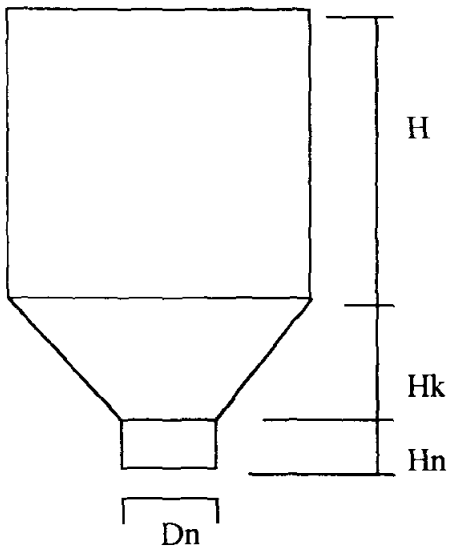
$$\frac{1}{\rho_{rata-rata}} = \frac{0,0526}{1544} + \frac{0,9474}{995,68}$$

$\rho_{rata-rata}$ = 1014,6332 kg/m^3 = 63,3436 lb/ft^3

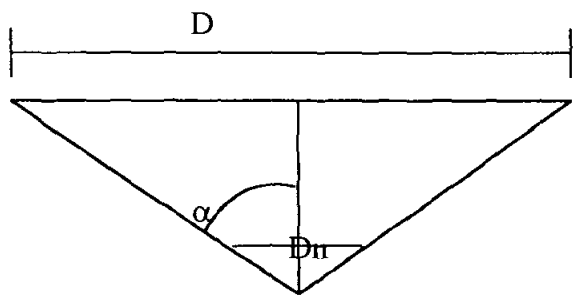
$$\text{Volume perendaman} = \frac{22190,3685\ {}^{kg}/_{batch}}{1014,6332\ {}^{kg}/_{m^3}} \times 1 batch = 21,8703\ \text{m}^3$$

Volume perendaman adaleh 80 % dari volume tangki, sehingga

$$\text{Volume tangki} = \frac{21,8703}{0,8} = 27,3379\ \text{m}^3$$



Untuk mencari persamaan dan menghitung Hn dan Hk memakai gambar sebagai berikut:



$$Hn = \frac{Dn}{2}\frac{1}{tg\alpha} = \frac{Dn}{2tg\alpha}$$

$$Hk = \frac{D}{2tg\alpha} - Hn = \frac{D}{2tg\alpha} - \frac{Dn}{2tg\alpha}$$

$$= \frac{D - Dn}{2tg\alpha}$$

volume Shell $= \frac{\pi}{4} D^2 H$ (D = H)

$= \frac{\pi}{4} D^3$

volume konis $= \frac{1}{3}\frac{\pi}{4}D^2\,Hk - \frac{1}{3}\frac{\pi}{4}Dn^2\,Hn$

volume total = volume shell + volume konis

$$= \frac{\pi}{4}D^3 + \frac{1}{3}\frac{\pi}{4}D^2\,Hk - \frac{1}{3}\frac{\pi}{4}Dn^2\,Hn$$

$$= \frac{\pi}{4}D^3 + \frac{1}{3}\frac{\pi}{4}\left(D^2\frac{D-Dn}{2tg\alpha} - \frac{Dn^3}{2tg\alpha}\right)$$

$$= \frac{\pi}{4}D^3 + \frac{\pi}{12}\left(\frac{D^3}{2tg\alpha} - \frac{D^2Dn}{2tg\alpha} - \frac{Dn^3}{2tg\alpha}\right)$$

$$= \frac{\pi}{4}\left(D^3 + \frac{D^3}{6tg\alpha}\right) - \frac{\pi}{24tg\alpha}D^2Dn - \frac{\pi}{24tg\alpha}Dn^3$$

Diambil:

- Diameter nozzel = 1 ft = 0,3048 m

- $\alpha = 30°$

maka:

$$27{,}3397 = \frac{\pi}{4}\left(1 + \frac{1}{6tg30}\right)D^3 - \frac{\pi}{24tg30}0{,}3048D^2 - \frac{\pi}{24tg30}0{,}3048^3$$

$$0 = 1{,}0121\,D^3 - 0{,}0691\,D^2 - 6{,}4201.10^{-3} - 27{,}3397$$

$$0 = 1{,}0121\,D^3 - 0{,}0691\,D^2 - 27{,}3443$$

dengan trial mendapatkan D = 3,0236 m; sehingga H = 3,0236 m

$$Hk = \frac{D-Dn}{2tg\alpha}$$

$$Hk = \frac{3{,}0236 - 0{,}3048}{2tg30}$$

$$Hk = 2{,}35455$$

Tinggi cairan pada keadaan maksimum = H + Hk

= 3,0236 + 2,35455

= 5,37815 m = 17,6446 ft

$P_{hidrostatis} = \left(\frac{\rho.H}{144}\right)$ (Brownel & Young pers. 3.17 hal. 36)

$P_{hidrostatis} = \frac{63,2170 \times 17,6446}{144}$

= 7,7461 psi

$P = P_{hidrostatis} + P_{udara}$

= 7,7461 + 14,969

= 22,4421 psia

P_{desain} = 1,3 P = 1,3 × 22,4421

= 29,17473 psia

Tebal Shell

$t_s = \frac{P\,ID}{2.f_{all}E} + C$ (Brownel & Young pers. 3.16 hal. 45)

dimana: P = tekanan desain = 29,17473 psia

ID = diameter dalam = 3,0236 m = 119,0391 in

f_{all} = allowable stress = 15600 lb/in^2 (B&Y hal. 342; T = 200 °F

untuk Stainless Stell SA-240 grade A)

E = efisiensi sambungan = 80 % (B&Y hal. 254; tabel 13.2 untuk

double welded butt joint)

C = corrosion allowable = 0,125 in

$t_s = \frac{29,17473 \times 119,0391}{2 \times 15600 \times 0,8} + 0,125$

t_s = 0,2641 in ≈ 0,27 in

Tutup atas(flat)

$t_s = \frac{P\,ID}{2.f_{all}E} + C$ (Brownel & Young pers. 3.16 hal. 45)

$t_s = \frac{29,17473 \times 119,0391}{2 \times 15600 \times 0,8} + 0,125$

t_s = 0,2641 in ≈ 0,27 in

Tutup Bawah(konis)

Untuk sudut puncak (α) tidak lebih dari 30° digunakan pers. 6.154 (B&Y hal, 118)

$t_c = \frac{P.ID}{2\cos\alpha(f_{all}.E - 0,6.P)} + C$ α = ½ sudut puncak = 30°

$= \frac{29,17473 \times 119,0391}{2\cos 30(15600 \times 0,8 - 0,6 \times 29,17473)} + 0,125$

= 0,2859 in ≈ 0,29 in

Pengaduk

Tipe: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

Dari Geankoplis, hal 144, tabel 3.4-1 memperoleh:

$\frac{Da}{Dt} = \frac{1}{3}; \quad \frac{J}{Dt} = \frac{1}{12}; \quad \frac{W}{Da} = \frac{1}{5}; \quad \frac{C}{Dt} = \frac{1}{3}; \quad \frac{L}{Da} = \frac{1}{4}$

Dimana: Dt = diameter tangki

Da = diameter pengaduk

J = lebar baffel

W = tinggi pengaduk

L = lebar pengaduk

C = jarak pengaduk dari dasar

$Da = \frac{1}{3} Dt$

$Da = \frac{1}{3} 3,0236 = 1,00783$

$\mu = 0,324\ \rho^{0,5}$ (perry edisi 5, hal. 3-246, pers. 3.118)

$\mu = 0,324 \times 1014,6332^{0,5}$

$= 0,3264$ cp $= 0,3264.10^{-3}$ $kg/_{m.s}$

$N_{re} = \frac{Da^2 N \rho}{\mu}$

$= \frac{1,00783^2 \times 0,3333 \times 1014,6332}{0,3264.10^{-3}} = 1052370,816$ → turbulen

dari Geankoplis gambar 3.4-4, mendapatkan Np = 5

$Np = \frac{P}{N^3 Da^5 \rho}$

$P = Np\ \rho\ N^3\ Da^5$

$= 5 \times 1014,6332 \times 0,3333^3 \times 1,00783^5$

$= 195,30863$ W $= 0,19530863$ kW

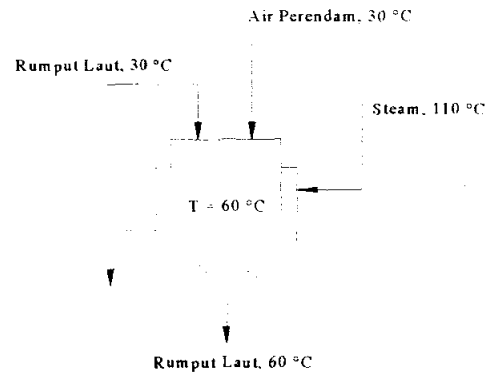
$= 0,2619$ hp

Efisiensi motor = 80 % (P&T gb. 14.38)

$hp = \frac{0,2619}{0,8} = 0,3274$ hp Diambil motor 0,5 hp

$L = \frac{1}{4} Da = 0,2520$ m $C = \frac{1}{3} Dt = 1,00783$ m

$W = \frac{1}{5} Da = 0{,}2016$ m $\qquad J = \frac{1}{12} Dt = 0{,}2520$ m



Jaket Pemanas

Diambil tebal jaket pemanas = tebal konis = 0,29 in

Massa steam = 348,0732 kg/1,5 jam

= 232,0488 kg/jam = 511,5748 lb/jam

$\rho_{steam,\ 110°C} = 0{,}5815$ kg/m^3 = 0,0363 lb/ft^3

$$\text{Rate volumetrik} = \frac{232{,}0488\ kg/jam}{0{,}5815\ kg/m^3} = 399{,}0521\ m^3/jam = 0{,}1108\ m^3/detik$$

Kecepatan aliran steam (v) diambil = 0,5 m/dt

Rate volumetrik = A . v

$$\text{Rate volumetrik} = \frac{\pi}{4}\left(D^2_{ijaket} - D^2_{oshell}\right) . v$$

$D_{o\ shell} = D_{is} + 2\ t_s$

$= 3{,}0236 + 2 \times 6.858.10^{-3}$

$= 3{,}03732$ m

$$0{,}1108 = \frac{\pi}{4}\left(D^2_{ijaket} - 3{,}03732^2\right) . 0{,}5$$

$D_{i\ jaket} = \sqrt{9{,}5075}$

Jaket spacing = 0,02305 m

Perhitungan tinggi jaket pemanas

$$\ln\frac{T_1 - t_1}{T_1 - t_2} = \frac{U.A.\theta}{M.C}$$

dimana: T_1 = suhu steam = 110 °C

t_1 = suhu bahan masuk = 30 °C

t_2 = suhu bahan keluar = 60 °C

θ = waktu penaikkan suhu = 0,5 jam

M = massa bahan = 22190,3685 kg

C = kapasitas panas = 0,9731 kkal/kg °C

$$U = U_D = \frac{1}{\frac{1}{U_c} + R_d}$$

U_C = 175 Btu/jam ft^2 °F (kern, hal)

R_d = 0,005

$$U_D = \frac{1}{\frac{1}{175} + 0{,}005}$$

U_D = 93,3333 Btu/jam ft^2 °F

= 455,9854 kkal/jam m^2 °C

$$\ln\frac{110-30}{110-60} = \frac{455{,}9854 \times A \times 0{,}5}{22190{,}3685 \times 0{,}9731}$$

A = 44,5145 m^2

A = luas jaket pada shell + luas jaket pada konis

$A = \pi D_{o\,shell} H_j + (\pi R_s S - \pi R_n s)$

$$A = \pi D_{o\ shell} H_j + \pi \left(R_s \frac{R_s}{\sin\alpha} - R_n \frac{R_n}{\sin\alpha}\right)$$

$$44{,}5145 = \pi\ 3{,}03732\ H_j + \frac{\pi}{\sin 30}(R_s^2 - R_n^2)$$

$$44{,}5145 = \pi\ 3{,}03732\ H_j + \frac{\pi}{\sin 30}(1{,}51866^2 - 0{,}1524^2)$$

$H_j = 3{,}1617$ m > 5,37815 m

6. Pompa dari tangki perendaman ke tangki pengaturan pH

Data – data:

$\rho_{RL} = 1014{,}6332$ kg/m^3 = 63,3436 lb/ft^3

$\mu = 0{,}324\ \rho^{0,5} = 0{,}324 \times 0{,}10146332^{0,5} = 0{,}3264$ cp = $0{,}3264.10^{-3}$ $^{kg}/_{m.s}$

Kapasitas = 11095,1843 kg/jam = 3,08199 kg/s

Perhitungan:

$$Q = \frac{11095{,}1843\ ^{kg}/_{jam}}{1014{,}6332\ ^{kg}/_{m^3}} = 10{,}9352\ m^3/jam = 3{,}03755.10^{-3}\ m^3/s$$

= 386,1577 ft3/jam = 0,1073 ft^3/detik

Asumsui aliran turbulent

$D_{i\ opt} = 3{,}9\ (Q)^{0,45}\ (\rho)^{0,13}$ (Peterson & Timmerhaus, hal. 525)

$= 3{,}9\ (0{,}1073)^{0,45}\ (63{,}3436)^{0,13}$

$= 2{,}4493$ in $\approx 2{,}5$ in

dari tabel 13 $D_i = 2{,}5$ in sch 40 (Peterson & Timmerhaus, hal. 952)

OD = 2,88 in = 0,073153 m

ID = 2,469 in = 0,06273 m

a" = 4,79 in^2 = $3{,}09.10^{-3}$ m

kecepatan aliran $v_1 = 0$

$$v_2 = \frac{Q}{a''} = \frac{3{,}03755.10^{-3}\ m^3/s}{3{,}09.10^{-3}\ m^2} = 0.9830 \text{ m/s}$$

$$N_{re} = \frac{D.v.\rho}{\mu} = \frac{0{,}06273 \times 0{,}9830 \times 1014{,}6332}{0{,}3264.10^{-3}} = 191684{,}8212 \rightarrow \text{turbulent}$$

Asumsi panjang pipa lurus = 10 m

4 buah elbow 90° → $L_e/D = 35$ → $L_e = 4 \times 35 \times 0{,}06273$

$= 8{,}7822$ m

1 buah gate valve → $L_e/D = 9$ → $L_e = 1 \times 9 \times 0{,}06273$

$= 0{,}56457$ m

$\Sigma L = 10 + 8{,}7822 + 0{,}56457$

$= 19{,}34677$ m

friksi pada pipa karena gesekan

pada gambar 2.10-3 mendapatkan:

jenis pipa comercial steel → $\varepsilon = 4{,}6 \cdot 10^{-5}$ m

dengan aliran turbulen: 191363,4708

$$\frac{\varepsilon}{D} = \frac{4{,}6.10^{-5}}{0{,}06273} = 7{,}333 \cdot 10^{-4}$$

$f = 0{,}0043$

$$F = \frac{4fLv^2}{2D} = \frac{4 \times 0{,}0043 \times 19{,}34677 \times 0{,}9830^2}{2 \times 0{,}06273} = 2{,}5629 \text{ j/kg}$$

Friksi karena kontraksi dari tangki ke pipa(sudden contraction)

$$k_c = 0{,}55\left(1 - \frac{A_2}{A_1}\right)$$ (Geankoplis pers. 2,10-16)

$$\left(\frac{A_2}{A_1}\right) \approx 0 \rightarrow A_1 >>> A_2$$

$k_c = 0,55$

$$h_c = k_c \frac{v_2^2}{2\alpha} = 0,55 \frac{0,9830^2}{2 \times 1} = 0,2657 \text{ j/kg}$$

ΣF = friksi pada pipa + friksi karena kontraksi

$= 2,5629 + 0,2657$

$= 2,8286$ j/kg

$\Delta z = 5,5$ m

$\Delta P = 0$

$$\frac{1}{2\alpha} (\Delta v^2) + g(\Delta z) + \frac{\Delta P}{\rho} + \Sigma F = -W_s \qquad \text{(Geankoplis pers. 2.7-28)}$$

$$\frac{1}{2 \times 1} 0,9830^2 + 9,80665 \times 5,5 + 0 + 2,8286 = - W_p$$

$-W_p = 57,2483$ j/kg

$W_p = |- 57,2483|$ j/kg

$$W_{HP} = \frac{mWp}{1000} = \frac{3,08199 \times 57,2483}{1000} = 0,1764 \text{ kW}$$

Dari peterson & Timmerhaus edisi 3 gambar 13.37

Untuk Q = 386,1577 ft^3/jam × 7,481 gal/ft^3 = 2888,8458 gal/jam = 48,1474 gal/menit

Mendapatkan: $\eta_{pompa} = 55$ %

$$B_{HP} = \frac{0,1764}{0,55} = 0,3207 \text{ kW}$$

Gambat 13.38 peterson & Timmerhaus mendapatkan efisiensi motor = 80 %

Power aktual = $\frac{0,3207}{0,8}$ = 0,4009 kW = 0,5376 Hp

Diambil motor dengan hp = 0,6 hp

7. Tangki Pengaturan pH

Fungsi: tempat penambahan NaOH dengan tujuan untuk pengaturan pH(8 – 10)

Tipe: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan jaket pemanas dan pengaduk

Kondisi operasi: T = 60 °C; P = 1 atm

Kapasitas untuk setiap batch: 22192,4985 kg/batch

Massa rumput laut = 1168,2018 kg/batch

Massa H_2O = 21024,2867 kg/batch

Massa NaOH = 0.01 kg/batch

ρ_{RL} = 1544 kg/m^3

$\rho_{H2O,60°C}$ = 983,24 kg/m^3

ρ_{NaOH} = 2130 kg/m^3

$$x_{RL} = \frac{1168,2018}{22192,4985} = 0,0526$$

$$x_{H2O} = \frac{21024,2867}{22192,4985} = 0,9474$$

$$x_{NaOH} = \frac{0.01}{22192,4985} = 0,4506.10^{-6}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{RL}}{\rho_{RL}} + \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{NaOH}}{\rho_{NaOH}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,0526}{1544} + \frac{0,9474}{983,24} + \frac{0,4506.10^{-6}}{2130}$$

$\rho_{rata\text{-}rata}$ = 1002,3890 kg/m^3 = 62,5791 lb/ft^3

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 27,6745 m^3

D = 3,035375 m = 119,5027 in;

H = 3,035375 m

Hk = 2,36475 m

Tinggi cairan pada keadaan maksimum = 5,400125 m = 17,71673 ft

$P_{hidrostatis}$ = 7,6993 psi

P = 22,3953 psia

P_{desain} = 1,3 P = 1,3 × 22,3953

= 29,11389 psia

Tebal Shell

t_s = 0,264 in ≈ 0,27 in

Tutup atas(flat)

t_a = 0,264 in ≈ 0,27 in

Tutup Bawah(konis)

t_c = 0,2859 in ≈ 0,29 in

Pengaduk

Type: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

$Da = \frac{1}{3}$ 3,035375 = 1,0118

$$hp = \frac{0,2639}{0,8} = 0,3299 \text{ hp}$$

Diambil motor 0,5 hp

$L = \frac{1}{4} Da = 0,25295$ m $\quad C = \frac{1}{3} Dt = 1,0118$ m

$W = \frac{1}{5} Da = 0,20236$ m $\quad J = \frac{1}{12} Dt = 0,25295$ m

8. Tangki NaOH

Fungsi: tempat melarutkan NaOH

Tipe: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan pengaduk

Kondisi operasi: T = 30 °C; P = 1 atm

Kapasitas untuk setiap batch: 178,9221 kg/minggu

Massa H_2O = 178,2018 kg/minggu

Massa NaOH = 0.7203 kg/minggu

$\rho_{H2O,30°C} = 995,68$ kg/m^3

$\rho_{NaOH} = 2130$ kg/m^3

$$x_{H2O} = \frac{178,2018}{178,9221} = 0,9959$$

$$x_{NaOH} = \frac{0,7203}{178,9221} = 0,0041$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{NaOH}}{\rho_{NaOH}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,9959}{995,68} + \frac{0,0041}{2130}$$

$\rho_{rata-rata} = 997,8588$ kg/m^3 $= 62,2963$ lb/ft^3

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 0,2241 m^3

D = 0,6287 m = 24,7519 in;

H = 0,6287 m

Hk = 0,5225 m

Tinggi cairan pada keadaan maksimum = 1,1512 m = 3,7769 ft

$P_{hidrostatis}$ = 1,6339 psi

P = 16,3299 psia

P_{desain} = 1,3 P = 1,3 × 16,3299

= 21,2289 psia

Tebal Shell

t_s = 0,145 in ≈ 0,1857 in

Tutup atas(flat)

t_a = 0,145 in ≈ 0,1857 in

Tutup Bawah(konis)

t_c = 0,1483 in ≈ 0,1857 in

Pengaduk

Type: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

$$Da = \frac{1}{3}\ 0{,}6287 = 0{,}2096$$

$$hp = \frac{0{,}0009022}{0{,}8} = 0{,}001127\ hp$$

Diambil motor 0,1 hp

$L = \frac{1}{4} Da = 0{,}0524$ m $\qquad C = \frac{1}{3} Dt = 0{,}2096$ m

$W = \frac{1}{5} Da = 0{,}04192$ m $\qquad J = \frac{1}{12} Dt = 0{,}0524$ m

9. Pompa dari tangki penambahan NaOH menuju tangki Ekstraktor

Data – data:

$\rho_{RL} = 1002{,}3890$ kg/m^3 = 62,5791 lb/ft^3

$\mu = 0{,}324\ \rho^{0,5} = 0{,}324 \times 0{,}10023890^{0,5} = 0{,}3244$ cp $= 0{,}3244.10^{-3}$ kg/m.s

Kapasitas = 11096,14335 kg/jam = 3,0823 kg/s

Dengan cara perhitungan yang sama didapatkan:

$D_{i\,opt} = 2{,}4568$ in $\approx 2{,}5$ in

OD = 2,88 in = 0,073153 m

ID = 2,469 in = 0,06273 m

a" = 4,79 in^2 = $3{,}09.10^{-3}$ m

F = 2,6264 j/kg

$h_c = 0{,}2723$ j/kg

$\Sigma F = 2{,}8987$ j/kg

$-W_p = 57{,}3303$ j/kg

$W_p = |-57{,}3303|$ j/kg

$W_{HP} = 0{,}1767$ kW

$B_{HP} = 0{,}3213$ kW

Power aktual = 0,5385 Hp

Diambil motor dengan hp = 0,6 hp

10. Tangki Ekstraktor

Fungsi: merendam rumput laut selama 3 jam dalam suasana basa guna mengekstrak karaginan

Type: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan jaket pemanas dan pengaduk

Kondisi operasi: T = 80 °C; P = 1 atm

Kapasitas untuk setiap batch: 22192,4985 kg/batch

Massa rumput laut = 1168,2018 kg/batch

Massa H_2O = 21024,2867 kg/batch

Massa NaOH = 0.01 kg/batch

$\rho_{RL} = 1544\ kg/m^3$

$\rho_{H2O,\ 80°C} = 971,83\ kg/m^3$

$\rho_{NaOH} = 2130\ kg/m^3$

$$x_{RL} = \frac{1168,2018}{22192,4985} = 0,0526$$

$$x_{H2O} = \frac{21024,2867}{22192,4985} = 0,9474$$

$$x_{NaOH} = \frac{0.01}{22192,4985} = 0,4506.10^{-6}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{RL}}{\rho_{RL}} + \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{NaOH}}{\rho_{NaOH}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,0526}{1544} + \frac{0,9474}{971,83} + \frac{0,4506.10^{-6}}{2130}$$

$\rho_{rata\text{-}rata} = 991,1496\ kg/m^3 = 61,8775\ lb/ft^3$

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 27,9884 m^3

D = 3,0472 m = 119,9683 in;

H = 3,0472 m

Hk = 2,3750 m

Tinggi cairan pada keadaan maksimum = 5,4222 m = 17,7892 ft

$P_{hidrostatis}$ = 7,6441 psi

P = 22,3401 psia

P_{desain} = 29,04213 psia

Tebal Shell

t_s = 0,2645 in ≈ 0,27 in

Tutup atas(flat)

t_s = 0,2645 in ≈ 0,27 in

Tutup Bawah(konis)

t_c = 0,286 in ≈ 0,29 in

Pengaduk

Type: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

$Da = \frac{1}{3}$ 3,0472 = 1,0157 m

hp = 0,4314 hp

Diambil motor 0,5 hp

$L = \frac{1}{4} Da$ = 0,2539 m $C = \frac{1}{3} Dt$ = 1,0157 m

$W = \frac{1}{5} Da = 0{,}20314$ m $\qquad J = \frac{1}{12} Dt = 0{,}2539$ m

Jaket Pemanas

Diambil tebal jaket pemanas = tebal konis = 0,29 in

$D_{i\,jaket} = 3{,}10996$ m

Jaket spacing = 0,024015 m

$H_j = 4{,}5091$ m > 5,4222 m

11. Pompa dari tangki Ekstraksi ke tangki penambahan NaCl

Data – data:

$\rho_{RL} = 991{,}1496$ kg/m^3 = 61,8775 lb/ft^3

$\mu = 0{,}324\ \rho^{0,5} = 0{,}324 \times 0{,}9911496^{0,5} = 0{,}3226$ cp $= 0{,}3226.10^{-3}$ $^{kg}/_{m.s}$

Kapasitas = 11096,14335 kg/jam = 3,0823 kg/s

Dengan cara perhitungan yang sama didapatkan:

$D_{i\,opt} = 2{,}4673$ in $\approx 2{,}5$ in

OD = 2,88 in = 0,073153 m

ID = 2,469 in = 0,06273 m

a" = 4,79 in^2 = $3{,}09.10^{-3}$ m

F = 2,6864 j/kg

$h_c = 0{,}2785$ j/kg

$\Sigma F = 2{,}9649$ j/kg

$-W_p = 57{,}4079$ j/kg

$W_p = |-57{,}4079|$ j/kg

$W_{HP} = 0{,}1769$ kW

$B_{HP} = 0{,}3216$ kW

Power aktual = 0,5391 Hp

Diambil motor dengan hp = 0,6 hp

12. Tangki Penambahan NaCl

Fungsi: menambahkan NaCL pada hasil ekstraksi untuk pembentukan gelasi

Type: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan jaket pendingin dan pengaduk

Kondisi operasi: T = 60 °C; P = 1 atm

Kapasitas untuk setiap batch: 23302,1235 kg/batch

Massa rumput laut = 1168,2018 kg/batch

Massa H_2O = 21024,2867 kg/batch

Massa NaOH = 0.01 kg/batch

Massa NaCl = 1109,625 kg/batch

$\rho_{RL} = 1544\ kg/m^3$

$\rho_{H2O,\ 60°C} = 983{,}24\ kg/m^3$

$\rho_{NaOH} = 2130\ kg/m^3$

$\rho_{NaCl,\ 10\%} = 1069{,}80\ kg/m^3$ (perry ed. 6 hal. 3-83)

$$x_{RL} = \frac{1168{,}2018}{23302{,}1235} = 0{,}0501$$

$$x_{H2O} = \frac{21024{,}2867}{23302{,}1235} = 0{,}9022$$

$$x_{NaOH} = \frac{0.01}{23302{,}1235} = 4{,}2915.10^{-7}$$

$$x_{NaCl} = \frac{1109{,}625}{23302{,}1235} = 0{,}0476$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{RL}}{\rho_{RL}} + \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{NaOH}}{\rho_{NaOH}} + \frac{x_{NaCl}}{\rho_{NaCl}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,0501}{1544} + \frac{0,9022}{971,83} + \frac{4,2915.10^{-7}}{2130} + \frac{0,0476}{1068,80}$$

$\rho_{rata-rata}$ = 1005,5089 kg/m^3 = 62,7717 lb/ft^3

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 28,9681 m^3

D = 3,08206 m = 121,3407 in

H = 3,08206 m

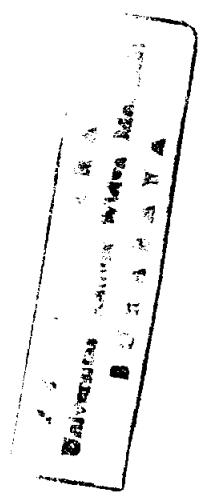
Hk = 2,4052 m

Tinggi cairan pada keadaan maksimum = 5,48726 m = 18,0026 ft

$P_{hidrostatis}$ = 7,9337 psi

P = 22,6297 psia

P_{desain} = 29,4186 psia



Tebal Shell

t_s = 0,268 in ≈ 0,27 in

Tutup atas(flat)

t_a = 0,268 in ≈ 0,27 in

Tutup Bawah(konis)

t_c = 0,29049 in ≈ 0,3 in

Pengaduk

Type: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

Da = 1,02735 m

P = 0,2857 hp

efisiensi motor = 80 % (P&T gb. 14.38)

hp = 0,3571 hp

Diambil motor 0,5 hp

$L = \frac{1}{4} Da = 0{,}2568$ m $\qquad C = \frac{1}{3} Dt = 1{,}02735$ m

$W = \frac{1}{5} Da = 0{,}20547$ m $\qquad J = \frac{1}{12} Dt = 0{,}2568$ m

Jaket Pendingin

Diambil tebal jaket pemanas = tebal konis = 0,3 in = $7{,}62.10^{-3}$ m

Massa air pendingin = 1615,5670 kg/jam = 3561.6790 lb/jam

$\rho_{air\ pendingin,\ 30°C} = 995{,}68\ kg/m^3 = 62{,}1581\ lb/ft^3$

$$\text{Rate volumetrik} = \frac{1615{,}5670\ kg/jam}{995{,}68\ kg/m^3} = 1{,}6226\ m^3/jam = 4{,}5072.10^{-4}\ m^3/detik$$

Kecepatan aliran air pendingin (v) diambil = 2.10^{-3} m/detik

Rate volumetrik = A . v

$$\text{Rate volumetrik} = \frac{\pi}{4}\left(D_{ijaket}^2 - D_{oshell}^2\right) . v$$

$D_{o\ shell} = D_{is} + 2\ t_s$

$= 3{,}08206 + 2 \times 7{,}62.10^{-3}$

$= 3{,}0973$ m

$$4{,}5072.10^{-4} = \frac{\pi}{4}\left(D_{ijaket}^2 - 3{,}0973^2\right) . 2.10^{-3}$$

$D_{i\ jaket} = \sqrt{9{,}8802}$

$D_{i\ jaket}$ = 3,1433 m

$D_{i\ jaket}$ = $D_{o\ shell}$ + 2 jaket spacing

3,1433 = 3,0973 + 2 jaket spacing

Jaket spacing = 0,023 m

Perhitungan tinggi jaket pendingin

$$\ln\frac{T_1 - t_1}{T_2 - t_1} = \frac{U.A.\theta}{M.C}$$

dimana: T_1 = suhu bahan masuk = 80 °C

T_2 = suhu bahan keluar = 41 °C

t_1 = suhu air pendingin masuk = 30 °C

θ = waktu = 0,42 jam

M = massa bahan = 22192,4985 kg

C = kapasitas panas = 0,9751 kkal/kg °C

$$U = U_D = \frac{1}{\frac{1}{U_c} + R_d}$$

U_C = 175 Btu/j ft^2 °F

R_d = 0,005

$$U_D = \frac{1}{\frac{1}{175} + 0{,}005}$$

U_D = 93,3333 Btu/j ft^2 °F

= 455,9854 kkal/j m^2 °C

$$\ln\frac{80-30}{41-30} = \frac{455{,}9854 \times A \times 1{,}5}{22192{,}4985 \times 0{,}9751}$$

A = 47,9044 m^2

A = luas jaket pada shell + luas jaket pada konis

$A = \pi D_{o\ shell} H_j + (\pi R_s S - \pi R_n s)$

$A = \pi D_{o\ shell} H_j + \pi (R_s \frac{R_s}{\sin\alpha} - R_n \frac{R_n}{\sin\alpha})$

$47{,}9044 = \pi\ 3{,}0973\ H_j + \frac{\pi}{\sin 30}(R_s^2 - R_n^2)$

$47{,}9044 = \pi\ 3{,}0973\ H_j + \frac{\pi}{\sin 30}(1{,}5793^2 - 0{,}1524^2)$

$H_j = 3{,}3276$ m > 5,48726 m

13. Tangki NaCl

Fungsi: tempat melarutkan NaCl

Tipe: silinder tegak dengan tutup atas flat, tutup bawah berbentuk konis dan dilengkapi dengan pengaduk

Kondisi operasi: T = 30 °C; P = 1 atm

Kapasitas untuk setiap batch: 13315,4988 kg/hari

$\rho_{NaCl,\ 10\%} = 1069{,}80$ kg/m^3 = 66,7876 lb/ft^3 (perry ed. 6 hal. 3-83)

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 15,5584 m^3

D = 2,51 m = 98,8187 in;

H = 2,51 m

Hk = 2,1517 m

Tinggi cairan pada keadaan maksimum = 4,6617 m = 15,2941 ft

$P_{hidrostatis} = 7{,}0934$ psi

P = 21,7894 psia

$P_{desain} = 28{,}3262$ psia

Tebal Shell

$t_s = 0{,}2326$ in $\approx 0{,}25$ in

Tutup atas(flat)

$t_a = 0{,}2326$ in $\approx 0{,}25$ in

Tutup Bawah(konis)

$t_c = 0{,}2494$ in $\approx 0{,}25$ in

Pengaduk

Type: flat six blade turbine with disk

Kecepatan putaran: 20 rpm = 0,3333 rps

Da = 0,8366

P = 0,1088 hp

efisiensi motor = 80 % (P&T gb. 14.38)

hp = 0,136 hp

diambil motor 0,2 hp

$L = \frac{1}{4}Da = 0{,}20915$ m $\qquad C = \frac{1}{3}Dt = 0{,}8366$ m

$W = \frac{1}{5}Da = 0{,}16732$ m $\qquad J = \frac{1}{12}Dt = 0{,}20915$ m

14. Pompa dari tangki penambahan NaCl ke Bak penambahan Etanol

Data – data:

$\rho_{RL} = 1005{,}5089$ kg/m^3 $= 62{,}7717$ lb/ft^3

$\mu = 0{,}324\ \rho^{0,5} = 0{,}324 \times 1{,}00550589^{0,5} = 0{,}3249$ cp $= 0{,}3249.10^{-3}$ $^{kg}/_{m.s}$

Kapasitas = 11651,06175 kg/jam = 3,2364 kg/s

Dengan cara perhitungan yang sama didapatkan:

$D_{i\,opt}$ = 2,5107 in ≈ 3 in

OD = 3,50 in = 0,0889 m

ID = 3,068 in = 0,07793 m

a" = 7,38 in^2 = 4,7613.10^{-3} m^2

F = 1,0899 j/kg

h_c = 0,2285 j/kg

ΣF = 1,3184 j/kg

Δz = 5,5 m

ΔP = 0

$-W_p$ = 55,5930 j/kg

W_p = |- 55,5930| j/kg

W_{HP} = 0,17992 kW

B_{HP} = 0,32713 kW

Power aktual = 0,4089 kW = 0,5483 Hp

Diambil motor dengan hp = 0,6 hp

15. Bak Penambahan Etanol

Fungsi: tempat penambahan Etanol untuk mengendapkan karaginan

Tipe: bak penampung berbentuk kotak.

bahan

Kondisi operasi: T = 60 °C; P = 1 atm

Kapasitas untuk setiap batch: 69906,3702 kg/batch

Massa rumput laut = 1168,2018 kg/batch

Massa H_2O = 21024,2867 kg/batch

Massa NaOH = 0.01 kg/batch

Massa NaCl = 1109,625 kg/batch

Massa Etanol = 46604,2468

ρ_{RL} = 1544 kg/m^3

$\rho_{H2O,\ 60°C}$ = 983,24 kg/m^3

ρ_{NaOH} = 2130 kg/m^3

$\rho_{NaCl,\ 10\%}$ = 1069,80 kg/m^3 (perry ed. 6 hal. 3-83)

ρ_{etanol} = 789 kg/m^3

$$x_{RL} = \frac{1168,2018}{69906,3702} = 0,0167$$

$$x_{H2O} = \frac{21024,2867}{69906,3702} = 0,3007$$

$$x_{NaOH} = \frac{0.01}{69906,3702} = 1,4305.10^{-7}$$

$$x_{NaCl} = \frac{1109,625}{69906,3702} = 0,0159$$

$$x_{etanol} = \frac{46604,2468}{69906,3702} = 0,6667$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{RL}}{\rho_{RL}} + \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{NaOH}}{\rho_{NaOH}} + \frac{x_{NaCl}}{\rho_{NaCl}} + \frac{x_{etanol}}{\rho_{etanol}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,0167}{1544} + \frac{0,3007}{983,24} + \frac{1,4305.10^{-7}}{2130} + \frac{0,0159}{1068,80} + \frac{0,6667}{789}$$

$\rho_{rata-rata}$ = 849,9621 kg/m^3 = 53,0613 lb/ft^3

$$\text{Volume perendaman} = \frac{69906{,}3702\ kg/batch}{849{,}9621\ kg/m^3} \times 1 batch = 82{,}2465\ m^3$$

Volume perendaman adalah 80 % dari volume bak, sehingga

$$\text{Volume bak} = \frac{82{,}2465}{0{,}8} = 102{,}8081\ m^3$$

Diambil perbandingan bak penampungan (P : L : T) = 2 : 1,5 : 1

Volume $= P \times L \times T$

$= 2y \times 1{,}5y \times y$

$= 3y^3$

$102{,}8081 = 3y^3$

$y = \sqrt[3]{\frac{102{,}8081}{3}}$

$y = 3{,}2481$ m

Dimensi Bak Penampungan adalah: Panjang = 2 × 3,2481 = 6,4962 m

Lebar = 1,5 × 3,2481 = 4,8722 m

Tinggi = 3,2481 m

Tinggi cairan pada keadaan maksimum = H 3,2481 m = 10,6564 ft

Dengan cara perhitungan yang sama didapatkan:

$P_{hidrostatis} = 3{,}9267$ psi

P = 18,6227 psia

$P_{desain} = 24{,}2095$ psia

Tebal dinding bak

t_s = 0,3334 in ≈ 0,36 in

tebal alas = tebal dinding = 0,36 in

16. Tangki Etanol

Fungsi: tempat penampungan etanol

Tipe: silinder tegak dengan tutup atas konis, tutup bawah berbentuk flat

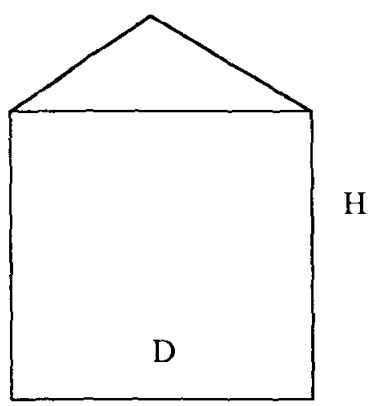
Kondisi operasi: T = 30 °C; P = 1 atm

Kapasitas untuk setiap batch: 559250,961 kg/hari

ρ_{Etanol} = 789 kg/m^3 = 49,2573

Dengan cara perhitungan yang sama didapatkan:

Volume tangki = 886,0123 m^3



Volume tangki $= \frac{\pi}{4} D^2 H$ H = D

$= \frac{\pi}{4} D^2 D$

$= \frac{\pi}{4} D^3$

$$886{,}0123 = \frac{\pi}{4}D^3$$

$$D = \sqrt[3]{\frac{4 \times 886{,}0123}{\pi}}$$

D = 10,4099 m

H = 10,4099 m = 34,1528 ft

$P_{hidrostatis}$ 11,6825 psi

P = 26,3785 psia

P_{desain} = 34,2921 psia

Tebal Shell

t_s = 0,6655 in ≈ 0,67 in

Tutup atas(konis)

t_a = 1,0828 in ≈ 1,13 in

17. Centrifuge filter

Data – data:

Jumlah cake = 2148,99145 kg/batch

Jumlah filtrat = 67721,3787 kg/batch

$\rho_{filtrat}$ = 849,9621 kg/m^3

Dasar pemilihan sesuai dengan Perry edisi 5 halaman 19-89

Jumlah cake = 2148,99145 kg/batch = 1092,4957 kg/jam

Jumlah filtrat = 67721,3787 kg/batch = 33860,68395 kg/jam

$$\text{Volume fitrat} = \frac{33860{,}68395 \ kg/jam}{849{,}9621 \ kg/m^3}$$

= 39,8379 m^3/jam

= 10523,9780 gal/jam

= 175,3996 gal/menitm

Pada tabel 19-29 Perry ed. 5 hal. 19-89 mendapatkan centrifuge filter dengan:

Tipe: Nozzel Discharge Centrifuge

Diameter Bowl: 27 in

Speed: 4200 rpm

Filtrat output = 40 – 400 gal/menit

Cake output: 1 – 11 tom/jam

Power: 125 hp

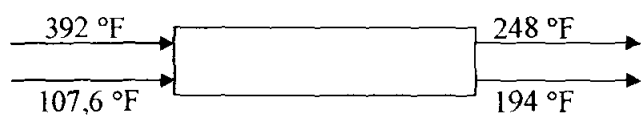
Rata-rata filtrat = $\frac{40+400}{2}$ = 220 gal/menit

Jumlah centri fuge yang dibutuhkan = $\frac{175.3996}{220}$ = 0.80

Membutuhkan 2 centrifuge filter.

Total power = 2 × 125 = 250 hp

18. Rotary Dryer



Data – data:

Suhu operasi = 90 °C

Tekanan operasi = 1 atm

Bahan Masuk = 2184,9915 kg/batch

T udara panas masuk = 200 °C = 392 °F T udara panas keluar = 120 °C = 248 °F

T bahan masuk = 42 °C = 107,6 °F T bahan keluar = 90 °C = 194 °F

Massa udara panas = 7792,1878 kg/jam

Menghitung diameter rotary dryer:

Dari Perry edisi 6, halaman 20-33 mendapatkan

kecepatan udara masuk = G = 0,5 – 5 kg/detik m^2

Diambil G = 1 kg/detik m^2 = 3600 kg/jam m^2 = 737,3485 lb/jam ft^2

$$S = \text{cross sectional of dryer} = \frac{massa\ udara}{G}$$

$$= \frac{7729{,}1878\ kg/jam}{3600\ kg/jam\ m^2}$$

$$= 2{,}1469\ m^2 = 23{,}1085\ ft^2$$

$$S = \frac{\pi}{4}D^2 \rightarrow \qquad D = \sqrt{\frac{4}{\pi}S}$$

$$D = \sqrt{\frac{4}{\pi}2{,}1469}$$

$$D = 1{,}653\ m = 5{,}423\ ft$$

Menghitung panjang rotary dryer

$Q_t = U_a\ V\ \Delta t_m$

$$U_a = 10\ \frac{G^{0.16}}{D}$$, G = lb/jam ft^2; D = ft (Perry ed. 3 pers 60)

$$U_a = 10\ \frac{737{,}3485^{0.16}}{5{,}423}$$

$= 5{,}3038$ Btu/jam ft^3 °F

Q_t = 151244,7472 kkal/jam = 599796,7449 Btu/jam

$$\Delta t_m = \frac{(392-107{,}6)-(248-194)}{\ln\left(\frac{392-107{,}6}{248-194}\right)}$$

$\Delta t_m = 138{,}68$ °F

$$V = \frac{Q_t}{U_a \Delta t_m} = \frac{599796{,}7449}{5{,}3038 \times 138{,}68}$$

$V = 815{,}46$ ft^3

$$L = \frac{V}{S} = \frac{815{,}46}{23{,}1085} = 35{,}29 \text{ ft}$$

$\frac{L}{D} = \frac{35{,}29}{5{,}423} = 6{,}5$ ➔ memenuhi syarat kisaran di Perry ed. 6 hal 20-32,

$$\frac{L}{D} = 4 - 10$$

Menghitung tebal rotary dryer

Dari Perry edisi 3 hal. 831, dryer beroperasi dengan isi 3-12 % dari volume dryer.

Diambil volume bahan dalam dryer sebesar 10 % dari volume dryer.

Volume dryer = 815,46 ft^3

Volume bahan = 10 % × 815,46 ft^3 = 81,546 ft^3

Densitas bahan = 70,3374 lb/Ft^3

Berat bahan dalam rotary dryer = 70,3374 × 81,546

= 5735,7336 lb

Bahan rotary dryer = Stainless steel SA-240 Grade M

Tmax = 200 °C ➔ f_{all} = 17500 psi (B & Y, halaman 342 – 343)

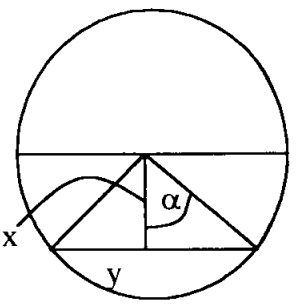
Pengelasan = Double welded butt joint

E = 80 %

Faktor korosi = 0,125

Luas rotary dryer = S = 23,1085 ft^2

Luas penampang material = $\frac{V}{L} = \frac{81,546}{35,29} = 2,3107\ ft^2$



A segi tiga = A juring – A material

A material = A juring – A segitiga

$$= \frac{2\alpha}{360}\pi\ R^2 - \left(2\frac{1}{2} alas \times tinggi\right)$$

$$= \frac{2\alpha}{360}\pi\ R^2 - (y \times x)$$

$$= \frac{2\alpha}{360}\pi\ R^2 - (R\sin\alpha\ \times R\cos\alpha)$$

$$2,3107 = \frac{2\alpha}{360}\pi \left(\frac{5,423}{2}\right)^2 - \left(\left(\frac{5,423}{2}\right)^2 \sin\alpha\ \times R\cos\alpha\right)$$

$$2,3107 = \left(\frac{5,423}{2}\right)^2 \left(\frac{2\alpha}{360}\pi\ - \sin\alpha\ \times R\cos\alpha\right)$$

$$0,3143 = \left(\frac{2\alpha}{360}\pi\ - \sin\alpha\ \times R\cos\alpha\right)$$

$$36,0161 = 2\alpha - \sin\alpha\cos\alpha$$

$$\alpha = 18,15\ °$$

h = tinggi cairan = R – x

= R – R cos α

= R (1 – cos α) = 2,7115 (1 – cos 18,15)

= 0,1349 ft

$P_{hidrostatis} = \left(\frac{\rho.H}{144}\right)$ (Brownel & Young pers. 3.17 hal. 36)

$P_{hidrostatis} = \frac{70,3374 \times 0,1349}{144}$

= 0,0659 psi

$P = P_{hidrostatis} + P_{udara}$

= 0,0659 + 14,969

= 14,7619 psia

$P_{desain} = 1,3\ P = 1,3 \times 14,7619$

= 17,7143 psia

$t_s = \frac{P\ ID}{2.f_{all}E} + C$ (Brownel & Young pers. 3.16 hal. 45)

$= \frac{17,7143 \times (5,423 \times 12)}{2 \times 17500 \times 0,8} + 0,125$

$= 0,166 \text{ in} \approx \frac{3}{16} \text{in}$

Menghitung putaran rotary dryer

Rotary dryer bekerja pada kecepatan peripheral v = 0,25 – 0,5 m/s ➔ perry edisi 6 hal. 20-33

Diambil v = 0,35 m/s

$N = \frac{v}{\pi\ D} = \frac{0,35}{\pi\ 1,653} = 4,044$ rpm

Slope kemiringan rotary dryer

Dari perry edisi 6 hal. 20-33 kemiringan rotary dryer pada umumnya 0 – 8 cm/m

Diambil 4 cm/m

tg α = 0,04

α = 2,29 °

Perencanaan power rotary dryer

Total power rotary dryer pada perry edisi 6, hal. 20-33 → 0,5 D^2 – 1 D^2

Dimana D = diameter, ft

Efisiensi rotary dryer = 55 – 75 % diambil efisiensi = 65 %

Diambil power = 0,6 D^2 = 0,6 × $5,423^2$ = 17,645 hp

$$\text{Power motor} = \frac{17,645}{0,65} = 27,146 \text{ hp}$$

Diambil power motor = 30 hp

19. Cyclone

Fungsi: untuk memisahkan debu yang mengandung produk yang terbawa keluar oleh gas yang keluar dari rotary dryer

Kapasitas = 628,6759 kg/jam = 1385,9789 lb/ft^3

Tekanan gas dianggap = 1,1 atm = 16,17 psia

Perhitungan :

$$\text{Densitas udara} = \frac{BM}{Vo}.\frac{Po}{P}.\frac{To}{T}.1 \text{ lbmol}$$

$$= \frac{29 \text{ lb/lbmo}}{395 \text{ ft}^3}.\frac{16,17}{14,7}.\frac{492°R}{708°R}.1 \text{ lbmol}$$

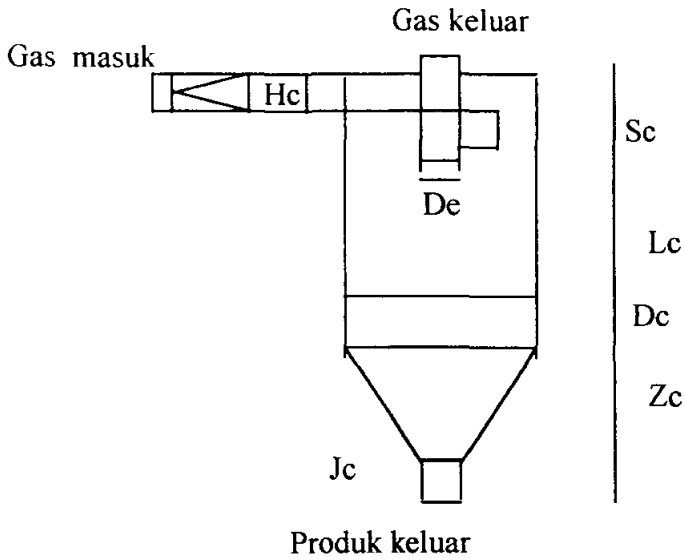
= 0,05612 lb/ft3

$$\text{Rate gas} = \frac{1385,9789 \text{lb/jam}}{0,05612 \text{ lb/ft}^3} = 24696,7017 \text{ ft3/jam} = 6,8602 \text{ ft3/detik}$$

Kecepatan gas = 50 -75 ft/s .....(Perry edisi 6 hal 10-82)

Ditetapkan kecepatan aliran gas = 75 ft/s

Luas penampang gas masuk = $\frac{6{,}8602 ft^3/s}{75 ft/s} = 0{,}09147\ ft^2 = 13{,}17125\ in^2$



Luas penampang gas masuk = $\frac{\pi}{4} D^2 = 13{,}17125\ in^2$

$D = 4{,}09514$ in

Dari Perry edisi 6 hal 20-84, didapatkan penampang gas masuk :

D = Hc = 4,09514 in

Hc = Dc / 4 ➔ Dc = 16,38056 in

De = Dc / 2 ➔ De = 8,19028 in

Lc = 2 Dc ➔ Lc = 2 × 16,38056 = 32,72112 in

Sc = Dc / 8 ➔ Sc = 16,38056 / 8 = 2,04757 in

Zc = 2 Dc ➔ Zc = 2 × 16,38056 = 32,72112 in

Jc = Dc / 4 ➔ Jc = 16,38056 / 4 = 4,09514 in

Spesifikasi :

Nama alat : Cyclone

Type : Effluent Dust Cyclone

Kapasitas : 24696,7017 ft3/jam

Ukuran: Hc = 4,09514 in

Dc = 16,38056 in

De = 8,19028 in

Lc = 2 × 16,38056 = 32,72112 in

Sc = 16,38056 / 8 = 2,04757 in

Zc = 2 × 16,38056 = 32,72112 in

Jc = 16,38056 / 4 = 4,09514 in

20. Ball mill

Fungsi: menghancurkan dan menghaluskan produk karaginan dengan ukuran ± 60 mesh

Tipe: marcy ball mill

Ukuran produk = 60 mesh

➔ $\frac{1}{60}$ = 0,01667 in = 0,423 mm

dari Perry edisi 6 hal. 21-15, tabel 21-6 mendapatkan ukuran bukaan siave pada No. 40

pada halaman 8-34, tabel 8-18 mendapatkan spesifikasi untuk marcy ball mill sebagai berikut:

- kapasitas: 12 ton/hari = 500 kg/jam

- ukuran: 3 × 2 ft

- power: 5 – 6 hp ➔ diambil power: 6 hp

- kecepatan: 35 rpm

- berat bola isian: 0,85 ton

- nomor sieve 35

21. Screen

Fungsi: memisahkan produk dengan ukuran 60 mesh

Tipe: vibrating screen

Dari perry edisi 6 tabel 21-6 mendapatkan ukuran sieve no. 40 dengan bukaan sieve = 0,420 mm

$$\text{Luas Screen} = A = \frac{0{,}4C_t}{C_u F_{oa} F_s}$$

Dengan C_t = flow rate = 0,486505 ton/jam

C_u = unit capacity ----- dari gambar 21-15

F_{oa} = open area faktor ---- dari gambar 21-16

F_s = slotted area faktor ---- dari tabel 21-7

C_u = 0,025 ton/jam

$$F_{oa} = 100\left(\frac{a}{a+d}\right)^2$$

a = sieve openning = 0,0165 in = $1{,}375.10^{-3}$ ft ----- dari tabel 21-6

d = nominal wire diameter = 0,014 in = $9{,}5.10^{-4}$ ft

$$F_{oa} = 100\left(\frac{1{,}375.10^{-3}}{1{,}375.10^{-3} + 9{,}5.10^{-4}}\right)^2$$

$$F_{oa} = 34{,}9751$$

$$A = \frac{0{,}4C_t}{C_u F_{oa} F_s} = \frac{0{,}4 \times 0{,}486505}{0{,}025 \times 34{,}9751 \times 1}$$

$= 0{,}2226\ ft^2$

Power motor = 0,5 hp

22. Bucket elevator

Fungsi: memasukkan rumput laut kedalam tangki perendaman

Tipe: Centirfugal Discharge Bucket on Belt

Tinggi elevasi: 2 meter

Massa masuk: 4,865 kg/jam

Perry edisi 7 tabel 21-8 halaman 21-15 mendapatkan:

- ukuran bucket = 6 × 4 × 4,5 in
- jarak bucket = 12 in
- elevator center = 25 ft
- kecepatan bucket = 68,8 m/menit
- head shaft = 43 rpm
- shaft diameter = - head $= 1\frac{15}{16}$ in

  - tail $= 1\frac{11}{16}$ in

pulley diameter = - head = 20 in

- tail = 14 in

- belt width = 7 in
- power = 1 hp

Efisiensi motor = 80 %

Power motor = $\frac{1}{0{,}8}$ = 1,25 hp

23. Screw Conveyor

Fungsi: memasukkan produk yang telah dihaluskan ke dalam tangki penyimpanan produk

Tipe: standar pitch screw conveyor

Massa masuk: 463,8198 kg/jam

Perry edisi 7 tabel 21-6 hal. 21-7 untuk kapasitas 5 ton:

- diameter flight = 9 in
- diameter poros = 2 in
- kecepatan screw = 40 rpm
- panjang screw = 5 ft
- Hp motor = 0,43 hp

Dengan cara perhitungan yang sama didapatkan:

Kecepatan screw: 3,716 rpm

Hp motor: 0,0399 hp

Power yaNg dibutuhkan = 0,0498 hp

Diambil power motor 0,1 hp

24. Storage tank produk

Fungsi: tempat penampungan produk

Tipe: silinder tegak dengan tutup atas konis, tutup bawah berbentuk flat

Kondisi operasi: T = 30 °C; P = 1 atm

Kapasitas: 463,8198 kg/jam = 11131,6752 kg/hari

ρ_{produk} = 96 lb/ft^3 = 1537,776 kg/m^3

$$\text{Volume produk} = \frac{11131{,}6752\ kg/hari}{1537{,}776\ kg/m^3} \times 1\ hari = 7{,}239\ m^3$$

Volume cairan adalah 80 % dari volume tangki, sehingga

$$\text{Volume tangki} = \frac{7{,}239}{0{,}8} = 9{,}049 m^3$$

D = 1,4228 im

H = 1,4228 m = 4,6679ft

$P_{hidrostatis}$ = 17.808,112 psi

P = 17,808 psia

P_{desain} = 23,1504 psia

Tebal Shell

t_s = 0,1748 in ≈ 3/16 in

Tutup atas(konis)

t_c = 0,2248 in ≈ 0,23 in

25. Burner

Fungsi: tempat pembakaran LNG untuk menghasilkan gas panas.

Tipe: thermal direct fired heater

Kondisi operasi: P = 1 atm

$T_{udara\ masuk}$ = 30 °C = 86 °F

$T_{udara\ keluar}$ = 1525 °C = 2777 °F

LNG yang dibutuhkan = 64,1124 kg/jam

Udara yang dibutuhkan = 1158,8081 kg_{udara} / jam

= 0,7096 lt/detik

Pada suhu 86 °F, humudity udara = 0,028 $lb_{H2O\ uap}$ / $lb_{H2O\ kering}$

Volume spesifik = (0,0252 + 0,045 H) (T °R)

= (0,0252 + 0,045 × 0,028) (546)

= 14,3784 ft^3/ $lb_{udara\ kering}$

Rate volumetrik udara = 14,3784 × 0,7096

= 10,2029 ft^3/detik

panas yang disuplai = Q = m . cp . Δt

Q = 1212,7834 × 0,3208 × (30 – 500)

Q = 581646,0675 kkal/jam

=

berdasarkan perry edisi 5 halaman 9-33, gambar 9-28 mendapatkan dimensi burner:

A = 48 in

B = 42 in

C = 84 in

D = 54 in

Gambar burner

26. Doubel Pipe HE

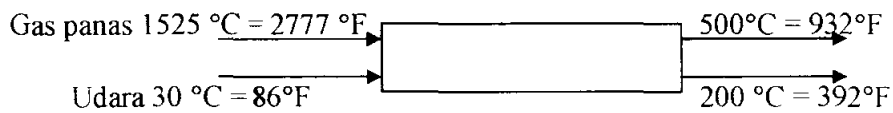
Fungsi: memanaskan udara dari suhu 30 °C menjadi 200°C

Tipe: double pipe heat exchanger

Kondisi operasi: R_d = 0,002

ΔP shell yang diijinkan = 10 psi

ΔP tube yang diijinkan = 10 psi



Perhitungan:

a. Neraca panas: $W_{gas\ panas}$ = 1212,7834 kg/jam = 2673,7023 lb/jam

$Q_{gas\ panas}$ = 581646,0675 kkal/jam = 2306654,773 Btu/jam

W_{udara} = 7729,1878 kg/jam = 17039,7674 lb/jam

b. $\Delta t_1 = 2777 - 86 = 2691$ °F

$\Delta t_2 = 932 - 392 = 540$ °F

$$LMTD = \frac{\Delta t_2 - \Delta t_1}{\ln \frac{\Delta t_2}{\Delta t_1}} = \frac{540 - 2691}{\ln \frac{540}{2691}} = 1339.3\ °F$$

c. T_c dan t_c

$$T_c = \frac{T_1 + T_2}{2} = \frac{2777 + 932}{2} = 1854{,}5\ °F$$

$$t_c = \frac{t_1 + t_2}{2} = \frac{86 + 392}{2} = 239\ °F$$

Digunakan DPHE dengan ukuran 8 × 6 IPS dengan schedule 40

Fluida panas (Gas panas) Bagian Annulus	Fluida dingin (udara) Bagian Inner pipe
d'. $D_2 = 9,781$ in $= 0,6651$ ft $D_1 = 6,625$ in $= 0,5521$ ft $a_a = \pi/4\ (D_2^2 - D_1^2)$ $= \pi/4\ (0,6651^2 - 0,5521^2)$ $= 0,10801$ ft^2 $D_e = \frac{D_2^2 - D_1^2}{2} = \frac{0,6651^2 - 0,5521^2}{0,5521}$ $= 0,2491$ ft e'. Mass velocity $G_a = \frac{W}{a_a} = \frac{2673,7023}{0,10801} = 24754,2107$ lb/jam ft^2 f'. Pada $T_c = 1854,5$ °F $\mu = 0,049$ cp (Kern, hal. 825) $= 0,11854$ lb/ft jam g'. $R_{ea} = \frac{De\ Ga}{\mu} = \frac{0,2491\ 24754,2107}{0,11854}$ $= 52018,50755$ h'. dari Kern gambar 24, hal. 834 menda- patkan $J_H = 150$ i'. c = 0,3 Btu/lb °F k = 0,0265 btu/jam ft °F	d. $D_i = 6,065$ in $= 0,50542$ ft $a_p = \pi/4\ D_i^2 = \pi/4 \times 0,50542$ $= 0,20063$ ft^2 e. Mass velocity $G_a = \frac{W}{a_p} = \frac{17039,7674}{0,20063} = 84931,3034$ lb/jam ft^2 f. pada $t_c = 239$ °F $\mu = 0,0215$ cp (Kern, hal 825) $= 0,05201$ lb/jam ft g. $R_{ep} = \frac{D_i\ G_p}{\mu} = \frac{0,50542\ 84931,3034}{0,05201}$ $= 825340,8838$ h. Dari Kern gambar 24, hal. 834 menda- patkan $J_H = 1000$ i. . c = 0,25 Btu/lb °F k = 0,0189 btu/jam ft °F $\left(\frac{c\ \mu}{k}\right)^{1/3} = \left(\frac{0,25\ 0,05201}{0,0189}\right)^{1/3} = 0,8828$ j. $h_i = J_h \frac{k}{Di}\left(\frac{c\ \mu}{k}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14}$ $= 1000 \times \frac{0,0189}{0,50542} \times 0,8828 \times 1$

$\left(\frac{c\ \mu}{k}\right)^{1/3} = \left(\frac{0,3\ 0,11854}{0,0265}\right)^{1/3} = 1,10301$	$= 33,0120$
j'. $h_o = J_h \frac{k}{De}\left(\frac{c\ \mu}{k}\right)^{1/3}\left(\frac{\mu}{\mu_w}\right)^{0.14}$	$h_{io} = h_i \frac{ID}{OD} = 33,0120 \times \frac{0,50542}{0,5521}$
$= 150 \times \frac{0,0265}{0,2491} \times 1,10301 \times 1$	$= 30,2208$
$= 17,5984$	

Overall $U_c = \frac{h_{io} h_o}{h_{io} + h_o} = \frac{30,2208 \times 17,5984}{30,2208 + 17,5984}$

$U_c = 11,1218$ Btu/jam ft^2 °F

$U_D = \frac{1}{\frac{1}{U_c} + R_d} = \frac{1}{\frac{1}{11,1218} + 0,002}$

$U_D = 10,8798$ Btu/jam ft^2 °F

$Q = U_D\ A\ \Delta t$

$A = \frac{Q}{U_D\ \Delta t} = \frac{2306654,773}{10,8798 \times 1339,3} = 158,3$ ft^2

Kern, tabel 11 halaman 844 mendapatkan a" = 2,258 ft^2/ft

$L = \frac{A}{a"} = \frac{158,3}{2,258} = 70,1063$ ft

Dipilih panjang pipa = 9 ft

1 hair pin = $2 \times 9 = 18$ ft

jumlah hair pin yang dibutuhkan = $\frac{70,1063}{18} = 3,8 \approx 4$ hair pin

panjang DPHE yang baru = $4 \times 2 \times 9 = 72$ ft

luas DPHE baru = 72 × 2,258 = 162,576 ft^2

$$U_{D\ koreksi} = \frac{Q}{A\ \Delta t} = \frac{2306654,773}{162,576 \times 1339,3} = 10,5937 \text{ Btu/jam ft}^2\ ^\circ\text{F}$$

$$R_d = \frac{U_c - U_D}{U_c\ U_D} = \frac{11,1218 - 10,5937}{11,1218 \times 10,5937} = 0,00448 \quad > \quad 0,002 \text{ (memenuhi syarat)}$$

Fluida panas (Gas panas) Bagian Annulus	Fluida dingin (udara) Bagian Inner pipe
a'. $D_e' = D_2 - D_1$ $= 0,6651 - 0,5521 = 0,113$ ft $R_{ea}' = \frac{De'\ Ga}{\mu} = \frac{0,113\ 24754,2107}{0,11854}$ $= 23597,3158$ $f = 0,0035 + \frac{0,264}{(R_{ea}')^{0,42}}$ $f = 0,0035 + \frac{0,264}{(23597,3158)^{0,42}}$ $= 7,3459.10^{-3}$ $\rho_{udara} = 0,0413$ lb/ft^3 b'. $\Delta F_a = \frac{4\ f\ G_a^2\ L}{2\ g\ D_e\ \rho^2}$ $= \frac{4 \times 7,3459.10^{-3} \times 24754,2107^2 \times 72}{2 \times 4,18.10^8 \times 0,113 \times 0,0413^2}$ $\Delta F_a = 8045,4592$ c'. $v = \frac{G}{3600\rho} = \frac{24754,2107}{3600 \times 0,0413}$ $= 166,4932$	a. $D_i = 0,50542$ ft $R_{ep}' = \frac{Di'\ Gp}{\mu} = \frac{0,50542\ 84931,3034}{0,05201}$ $= 825340,8838$ $f = 0,0035 + \frac{0,264}{(R_{ea}')^{0,42}}$ $f = 0,0035 + \frac{0,264}{(825340,8838)^{0,42}}$ $= 0,004364$ b. $\Delta F_p = \frac{4\ f\ G_p^2\ L}{2\ g\ D_i\ \rho^2} =$ $\frac{4 \times 0,004364 \times 84931,3034^2 \times 32}{2 \times 4,18.10^8 \times 0,50542 \times 0,05685^2}$ $\Delta F_p = 1844,1263$ $\Delta P_p = \frac{\Delta F_p\ \rho}{144}$ $\Delta P_p = \frac{1844,1263 \times 0,05685}{144}$

$$F_L = n\left(\frac{v^2}{2g'}\right) = 2\left(\frac{166{,}4932^2}{2\times 32{,}2}\right)$$

$= 430{,}4345$

$$\Delta P_a = \frac{(\Delta F_a + F_L)\rho}{144}$$

$$= \frac{(8045{,}4592 + 430{,}4345)\ 0{,}0413}{144}$$

$= 2{,}43$ psi $<$ 10 psi

(memenuhi syarat)

$= 0{,}728$ psi $<$ 10 psi

(memenuhi syarat)

27. Tangki filtrat

Fungsi: tempat penampungan filtrat

Tipe: silinder tegak dengan tutup atas konis, tutup bawah berbentuk flat

Kondisi operasi: T = 60 °C; P = 1 atm

Kapasitas untuk setiap batch: 34437,8298 kg/batch

Etanol = 22137,0172 kg/batch

H_2O = 12246,3808 kg/batch

NaOH = 0,0042 kg/batch

NaCl = 54,4276 kg/batch

$\rho_{Etano} = 789$ kg/m^3

$\rho_{H2O,\ 60°C} = 983{,}24$ kg/m^3

Dianggap semua filtrat hanya air dan etanol.

$$x_{H2O} = \frac{12246{,}3808}{34437{,}8298} = 0{,}3556$$

$$x_{etanol} = \frac{22137{,}0172}{34437{,}8298} = 0{,}6428$$

$$\frac{1}{\rho_{rata-rata}} = \frac{x_{H_2O}}{\rho_{H_2O}} + \frac{x_{etanol}}{\rho_{etanol}}$$

$$\frac{1}{\rho_{rata-rata}} = \frac{0,3556}{983,24} + \frac{0,6428}{789}$$

$\rho_{rata-rata}$ = 850,0773 kg/m^3 = 53,0703 lb/ft^3

Dengan cara perhitungan yang sama mendapatkan:

Volume tangki = 50,6393 m^3

$P_{hidrostatis}$ = 4,8485 psi

P = 19,5445 psia

P_{desain} = 25,4079 psia

Tebal Shell

t_s = 0,2857 in ≈ 0, in

Tutup atas(konis)

t_c = 0,3108 in ≈ 0, in

28. Pompa dari tangki filtrat ke distilator

Data – data:

ρ_{camp} = 850,0773 kg/m^3 = 53,0703 lb/ft^3

$\mu = 0,324\ \rho^{0,5} = 0,324 \times 0,8500773^{0,5} = 0,2987$ cp $= 0,2987.10^{-3}$ $^{kg}/_{m.s}$

Kapasitas = 17218,9149 kg/jam = 4,7830 kg/s

Dengan cara perhitungan yang sama mendapatkan:

$D_{i\ opt}$ = 3,15 in ≈ 4 in

OD = 4,50 in = 0,1143 m

ID = 4,026 in = 0,1023 m

a" = 12,7 in^2 = 8,1936.10^{-3} m

F = 1,0007 j/kg

h_c = 0,1297 j/kg

ΣF = 1,1304 j/kg

Δz = 10 m

ΔP = 0

$-W_p$ = 58,3027 j/kg

W_p = |- 58,3027| j/kg

W_{HP} = 0,2545 kW

B_{HP} = 0,4609 kW

Power aktual = 0,4683 Hp

Diambil motor dengan hp = 0,5 hp

29. Heat Exchanger / heater

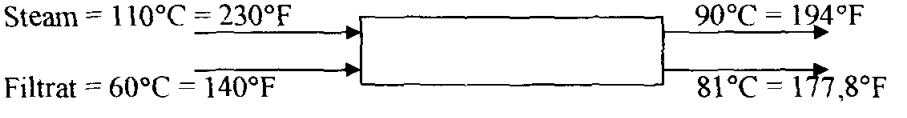
Fungsi: memanaskan filtrat sampai mencapai suhu 81 °C

Tipe: double pipe heat exchanger

Kondisi operasi: R_d = 0,002

ΔP shell yang diijinkan = 10 psi

ΔP tube yang diijinkan = 10 psi



Dengan cara perhitungan yang sama mendapatkan:

U_c = 6,3859 Btu/jam ft^2 °F

U_D = 6,3054 Btu/jam ft^2 °F

A = 1656,3749 ft^2

Kern, tabel 11 halaman 844 mendapatkan a" = 2,258 ft^2/ft

$$L = \frac{A}{a''} = \frac{1656,3749}{2,258} = 733,5584 \text{ ft}$$

Dipilih panjang pipa = 15 ft

1 hair pin = 2 × 15 = 30 ft

jumlah hair pin yang dibutuhkan = $\frac{733,5584}{30}$ = 24,45 ≈ 25 hair pin

panjang DPHE yang baru = 25 × 2 × 15 = 750 ft

luas DPHE baru = 750 × 2,258 = 1693,5 ft^2

$U_{D\ koreksi}$ = 6,1672 Btu/jam ft^2 °F

R_d = 0,005553 > 0,002 (memenuhi syarat)

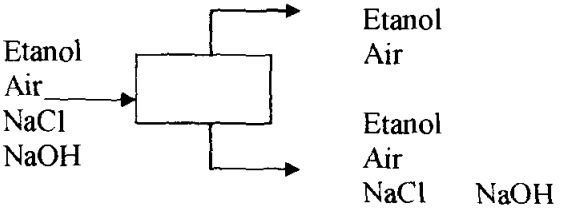
ΔP_a = 2,6369 psi < 10 psi

(memenuhi syarat)

ΔP_p = 0,1367 psi < 10 psi

(memenuhi syarat)

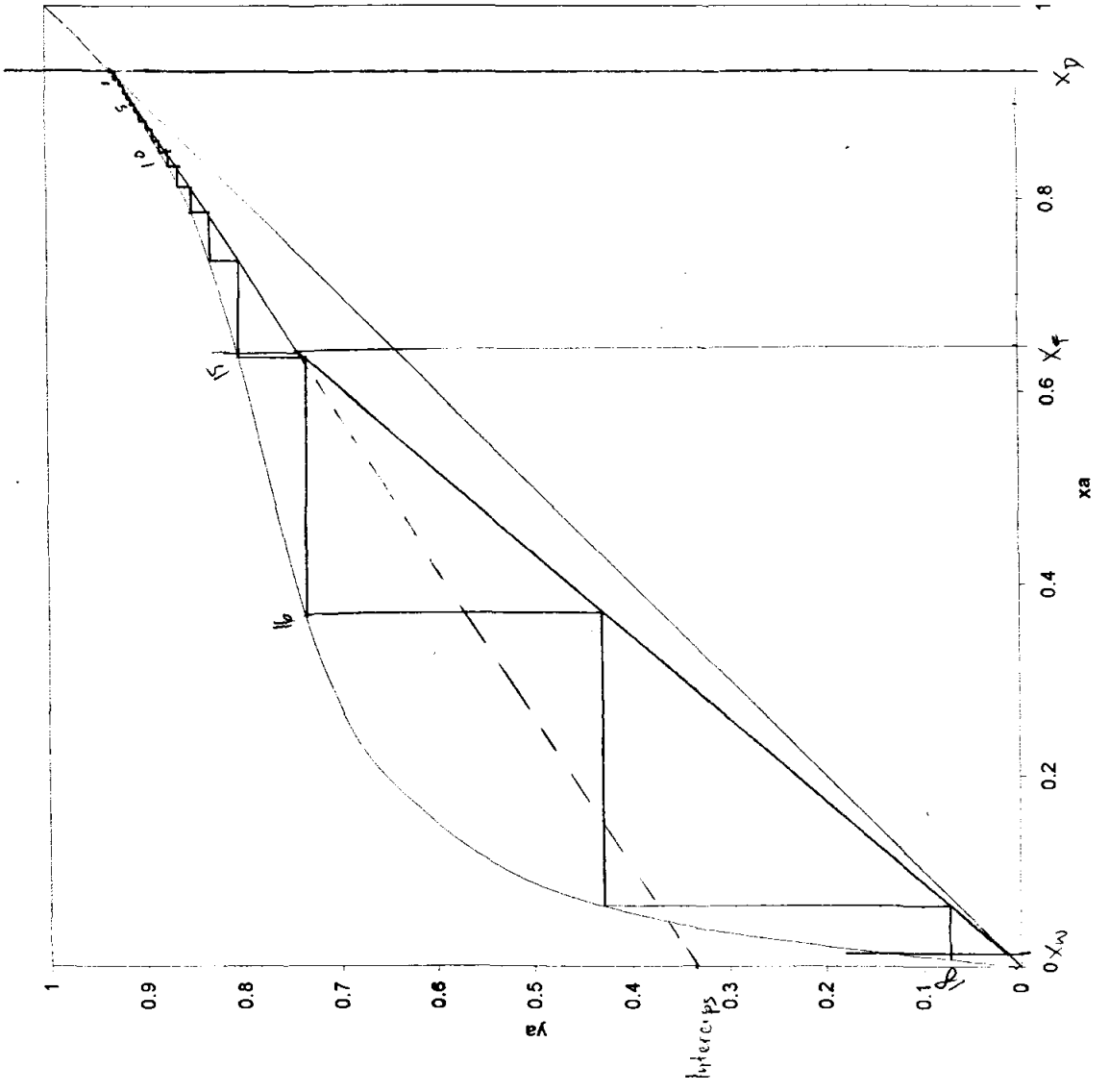
30. Menara Distilasi



Asumsi: ϵ_s = 60 %

D_m =diameter menara = 1,5 m

Data-data: X_D = 0,95 X_F = 0,6428 X_W = 0,002



Kurva etanol - air

L_n = 680,3545 mol/jam

D = 480,7583 + 64,6634 = 545,4217 mol/jam

$$R_{min} = \frac{L_n}{D} = \frac{680,3545}{545,4217} = 1,25$$

$$R = 1,5 \times R_{min} = 1,5 \times 1,25$$

$$= 1,875$$

$$\text{Menghitung intercep} = \frac{X_D}{R+1} = \frac{0,95}{1,875+1} = 0,33$$

Dengan menggunakan kurva kesetimbangan Etanol – Air, mendapatkan jumlah plate teoritis = 18 plate(halaman 55a)

$$\text{Jumlah plate aktual} = \frac{N_t}{\epsilon_s} = \frac{18}{0,6} = 30 \text{ plate}$$

$$\rho_G = \frac{BM}{Vo}\frac{To}{Tv}Po = \frac{46}{359}\frac{460+32}{460+174,76}1$$

$$= 0,0993 \text{ lb/ft}^3$$

ρ_L = 53,0703 lb/ft^3

$\mu_{campuran}$ = 0,2987 cp

$$\text{Absis} = \frac{L}{G}\sqrt{\frac{\rho_G}{\rho_L - \rho_G}} = \frac{680,3545}{545,4217}\sqrt{\frac{0,0993}{53,0703 - 0,0993}} = 0,053$$

Dari gambar 3-9 Diktata Perancangan Alat Proses, mendapatkan

$$\frac{G_V^2 C_f \mu_L^{0.1} J}{g_c \rho_G (\rho_L - \rho_G)} = 0,28$$

Asumsi packet terdiri dari rashig ring ukutan 1 in didaptkan C_f = 155

$g_c = 4,08.10^8$ ft/J^2 J = 1,052

$$\rightarrow \frac{G_V^2 C_f \mu_L^{0.1} J}{g_c \rho_G (\rho_L - \rho_G)} = \frac{G_V^2 \times 155 \times 0,2987^{0.1} \times 1,052}{4,18.10^8 \times 0,0933 \times (53,0703 - 0,0993)} = 0,28$$

$G_V = 1727,4$

$G_{op} = 40 - 70\ \% G_{flood}$, jika diambil 60% G_{flood}

$G_{op} = 60\ \% \times 1727,4$

$= 1036,4$

$$S - \frac{G}{G_{op}} = \frac{545,4217}{1036,4} = 0,52 \text{ ft} = \frac{\pi}{4} D^2$$

$$D = \sqrt{\frac{4 \times 0,52}{\pi}}$$

$D = 0,814$ ft

Dari Ulrich:

$H_t = 0,5 \times D^{0,5} = 0,5 \times 0,814^{0,5}$

$= 0,4511$ ft

$$\text{Tinggi packet} = H_a = \frac{N \times H_t}{\epsilon} = \frac{30 \times 0,4511}{0,6} = 22,555 \text{ ft}$$

Diambil tinggi untuk bagian reflux = 1 ft

Bagian Bawah kolom = 1 ft

Bagian redistributor = 1 ft

$$\text{Jumlah redistributor} = \frac{22,555}{3 \times 0,814} = 9,23 = 9 \text{ redistributor}$$

Total tinggi menara $= 22,555 + 1 + 1 + 9$

$= 33,555$ ft $= 10,22$ m

Spesifikasi: Bahan: Carbon steel

$N_{aktual} = 30$ plate

$D = 0,814$ ft

H = 33,555 ft = 10,22 m

Packing = rashig ring 1 in

31. Kondensor

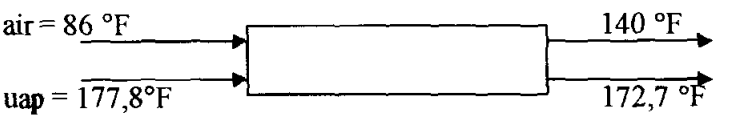
Fungsi: mengkondensasikan seluruh uap

Tipe: double pipe heat exchanger

Kondisi operasi: R_d = 0,002

ΔP shell yang diijinkan = 10 psi

ΔP tube yang diijinkan = 10 psi



Dengan cara perhitunga yang sama mendapatkan:

U_c = 5,8061 Btu/jam ft^2 °F

U_D = 5,7394 Btu/jam ft^2 °F

A = 61,76 ft^2

Kern, tabel 11 halaman 844 mendapatkan a" = 1,734 ft^2/ft

$$L = \frac{A}{a''} = \frac{61,76}{1,734} = 35,617 \text{ ft}$$

Dipilih panjang pipa = 9 ft

1 hair pin = 2 × 9 = 18 ft

jumlah hair pin yang dibutuhkan = $\frac{35,617}{18}$ = 1,9 ≈ 2 hair pin

panjang DPHE yang baru = 2 × 2 × 9 = 36 ft

luas DPHE baru = 36 × 1,734 = 62,424 ft^2

$U_{D\ koreksi}$ = 5,678 Btu/jam ft^2 °F

R_d = 0,0039 > 0,002 (memenuhi syarat)

ΔP_a = 6,697.10^{-5} psi < 10 psi

ΔP_p = 2,2189 psi < 10 psi (memenuhi syarat)

32. Reboiler

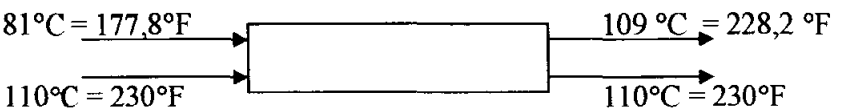
Fungsi: memanaskan bottom produk sehingga berbentuk uap lagi

Tipe: kettle reboiler/shell and tube

Kondisi operasi: R_d = 0,002

ΔP shell yang diijinkan = 10 psi(diabaikan)

ΔP tube yang diijinkan = 10 psi



Perhitungan:

1. Neraca panas: W_{steam} = 258,9661 kg/jam = 570,9167 lb/jam

Q_{steam} = 138036,8723 kkal/jam = 547417,7994 Btu/jam

$W_{filtrat}$ = 24601,1464 kg/jam = 54235,6874 lb/jam

$Q_{filtrat}$ = 131135,0287 kkal/jam = 520046,9095 Btu/jam

$\rho_{filtrat}$ = 53,0703 lb/ft^3

2. Δt = 109 °C = 228,2 °F

3. T_c

$\Delta t_c = 228,2 - 177,8 = 50,4$ °F

$\Delta t_h = 230 - 177,8 = 52,2$ °F

$$T_c = \frac{\Delta t_c}{\Delta t_h} = \frac{50,4}{52,2} = 0,965$$

$$K_c = \frac{U_h - U_c}{U_c} = \frac{547417,7994 - 520046,9095}{520046,9095} = 0,0526$$

$F_c = 0,5$

$T_c = 228,2 + (0,5 \times (230 - 228,2))$

$T_c = 229,1$ °F

Bagian shell: D = 15,25 in

Bagian tube: N = 68, panjang = 12 in

OD = 1 in; 14 BWG; 1,25 square pitch

Pases = 6

Fluida panas (steam) Bagian pipa(tube)	Fluida dingin (filtrat) Bagian shell
4. flow area a'_t =0,546 in^2 $a'_t = \frac{N_t \, a'_t}{144_n}$ $a'_t = \frac{68 \times 0,546}{144 \times 6} = 0,043$ ft^2	
5. $G_t = \frac{W}{a_t} = \frac{570,9167}{0,043} = 13277,1326$ lb/jam ft^2	9. trial ho = 50
6. pada Tc = 229,1 μ0,026 cp = 0,026 ×2,4191 = 0,06289	10. $t_w = t_c + \frac{h_{io}}{h_{io} + h_o}(T_c - t_c)$ $= 177,6 + \frac{10,6096}{10,6096 + 50}(229,1\text{-}177,6)$

D = 0,834/12 = 0,0694 ft $R_{et} = \frac{D\ G_t}{\mu} = \frac{0,0694 \times 13277,1326}{0,069289}$ = 14651,5027 7. hi = 1500 10. $h_{io} = hi\frac{ID}{OD} = 1500 \times \frac{0,834}{1}$ h_{io} = 1251	= 186,61 °F h_o = 140 > 50 dipakai h_o = 140 (Kern,gb. 15.11)

12. Clean overall coefisien:

$$U_c = \frac{h_{io} h_o}{h_{io} + h_o} = \frac{1251 \times 140}{1251+140} = 125,9094 \text{ btu/jam ft}^2 \text{ °F}$$

13. desain overall coefisien U_D:

a" = 0,2618 ft^2/lin ft

total luas permukaan: 68 × 12 × 0,2618 = 214 ft

$$U_D = \frac{Q}{A\ \Delta t} = \frac{520046,9095}{214 \times 228,2} = 10,6491$$

Chek minimum refluks: $\frac{520046,9095}{214} = 2430,1257$ btu/jam ft^2

15. $R_d = \frac{U_c - U_D}{U_c\ U_D} = \frac{125,9094 - 10,6491}{125,9094 \times 10,6491} = 0,08596$

Pressure drop

1. R_{et} = 14,651,5027 ➔ f:0,00025

s = 0,81 ➔ tabel 6.

2. . $\Delta P_t = \frac{f\ G_t^2\ L\ n}{5{,}22.10^{10} D\ s\ \Phi_t} = \frac{0{,}00025 \times 13277{,}1326^2 \times 12 \times 6}{5{,}22.10^{10} \times 0{,}0694 \times 0{,}81 \times 1} = 1{,}08134.10^{-3}$

3. $G_t = 13277{,}1316$ ➔ $\frac{V^2}{2_g^1} = 0{,}01$

$$\Delta P_r = \frac{4n}{0{,}81} \frac{V^2}{2_g^1} = \frac{4 \times 6}{0{,}81} \times 0{,}01 = 0{,}2923$$

4. $\Delta p_t = \Delta P_T + \Delta P_r$

$= 1{,}08134.10 + 0{,}2963$

$= 0{,}2974$ psi $<$ 10 psi

APPENDIX D
PERHITUNGAN ANALISA EKONOMI

APPENDIX D
PERHITUNGAN ANALISA EKONOMI

Penafsiran harga alat-alat setiap waktu akan berubah-ubah, tergantung pada kondisi ekonomi. Karena itu, untuk menafsirkan harga peralatan diperlukan suatu indeks yang dapat mengkonversi harga peralatan pada masa lalu, sehingga diperoleh harga ekuivalen pada saat ini.

Persamaan yang digunakan adalah sebagai berikut:

$$\text{harga tahun 2005} = \frac{\text{indeks harga tahun 2005}}{\text{indeks harga tahun x}} \times \text{harga tahun x}$$

Harga alat yang digunakan dapam prarencana pabrik ini didasarkan harga alat yang terdapat pada pustaka Peter & Timmerhaus, dan Ulrich G. D.

Dalam perhitungan ini digunakan indeks harga sebagai berikut:

Chemical Engineering Plant Cost Index

Tahun 1982 = 315 (Ulrich, fig. 5-1, hal. 270)

Tahun 2005 = 425,3 (ekstrapolasi)

A. Peralatan

Contoh Perhitungan:

Nama alat: Tangki perendaman

Kapasitas = 27,3379 m^3

Bahan konstruksi = Stainless steel

Jumlah : 1 unit

Harga tahun 1990 : US$ 261.000 (Peter & Timmerhaus, fig. 14.56, hal. 539)

$$\text{Harga tahun 2005} = \frac{425{,}3}{315} \times 261{,}000$$

$$= \text{US\$ } 352391{,}43$$

Dengan cara yang sama harga pealatan disajikan pada tabel D.1 unutk alat-alat proses dan tabel D2. untuk alat-alat utilitas.

Tabel D.1 Harga Peralatan Proses

No	Nama Alat	Kode	Harga 2005 ($)	Jumlah	Harga 2005 (Rp.)
1	Belt Conveyor	J-111	6,750.79	1	57,381,715.00
2	Rotary Cutter	C-112	12,759.00	2	216,903,000.00
3	Screw Conveyor	J-113/J-433	6,075.71	2	103,287,070.00
4	Bucket Elevator	J-114/J432	10,126.19	2	172,145,230.00
5	Tangki Peremdaman	F-110	352,391.43	1	2,995,327,155.00
6	Tangki Pengaturan pH	F-220	352,391.43	1	2,995,327,155.00
7	Tangki NaOH	F-222	25,842.04	1	219,657,340.00
8	Tangki Ekstraktor	F-210	352,391.43	2	5,990,654,310.00
9	Tangki Penambahan NaCl	F-310	352,391.43	1	2,995,327,155.00
10	Tangki NaCl	F-312	152,702.95	1	1,297,975,075.00
11	Bak Penambahan Etanol	F-320	207,924.44	1	1,767,357,740.00
12	Tangki Etanol		371,293.65	1	3,155,996,025.00
13	Centrifuge filter	H-410	94,511.11	1	803,344,435.00
14	Rotary dryer	B-420	135,015.87	1	1,147,634,895.00
15	Cyclone	H-424	1,350.16	1	11,476,360.00
16	Ball Mill	C-430	223,046.22	1	1,895,892,870.00
17	Vibrating Screen	H-431	22,682.67	1	192,802,695.00
18	Pompa		135.02	5	5,738,350.00
19	Storage Tank Produk	F-434	5,387.13	2	91,581,210.00
20	Burner	Q-422	7,500.00	1	63,750,000.00
21	HE	E-423	5,400.63	1	45,905,355.00
22	Tangki Filtrat	F-411	234,927.62	1	1,996,884,770.00
23	HE	E-512	5,400.63	1	45,905,355.00
24	Menara Distilator	D-510	14,022.75	1	119,193,375.00
25	Reboiler	E-514	1,026,120.63	1	8,722,025,355.00
26	Kondensor	E-513	1,350.16	1	11,476,360.00
				Total	37,120,950,355.00

Tabel D.2 Harga Peralatan Utilitas

No.	Nama Alat	Kode	Harga 2005	Jumlah	harga total(Rp.)
1	Sand Filter	H-417	67,575.44	1	574,391,240.00
2	Kation Exchanger	H-424	54,006.35	1	459,053,975.00
3	Anion Exchanger	H-426	5,400.63	1	45,905,355.00
4	Pompa air sungai	L-411	135.02	2	2,295,340.00
5	Pompa	L-413	135.02	1	1,147,670.00
6	Pompa	L-416	135.02	1	1,147,670.00
7	Pompa	L-425	135.02	4	4,590,680.00
8	Pompa air bercabang	L-428	162.02	1	1,377,170.00
9	Cooling Tower	E-431	4,725.56	1	40,167,260.00
10	Boiler		34,121.21	1	290,030,285.00
				Total	1,420,106,645.00

Tabel D.3 Luas Bak Penampung

No.	Nama Alat	Kode	luas	Harga, Rp/m2	harga bak (Rp.)
1	Bak penampung air sungai	F-412	16.25	300,000	4,875,000.00
2	Bak Koagulator dan flokulator	F-414	21.50	300,000	6,450,000.00
3	Bak Penampung air jernih	F-415	5.50	300,000	1,650,000.00
4	Bak Penampung air bersih	F-418	5.50	300,000	1,650,000.00
5	Bak penampung air demineralisasi	F-427	1.50	300,000	450,000.00
6	Bak penampung air proses	F-420	9.30	300,000	2,790,000.00
7	Bak penampung air pendingin	F-430	4.00	300,000	1,200,000.00
8	Bak penampung air umpan boiler	F-429	0.50	300,000	150,000.00
9	Bak penampung air sanitasi	F-422	12.50	300,000	3,750,000.00
				Total	22,965,000.00

Harga bak: Rp. 300.000 per m^2 (supplier)

Harga total bak: Rp. 300.000 × 76,55

Harga total bak: Rp. 22,965,000.00

Harga total semua alat: 37,120,950,355.00 + 1,420,106,645.00 + 22,965,000.00

Rp. 38,564,022,000.00

B. Tanah dan Bangunan

Tabel D.4 Harga Tanah dan Bangunan

	Luas, m2	Harga, Rp/m2	Harga Total
Tanah	36610	50000	1,830,500,000
Bangunan	14480	250000	3,620,000,000
		Total	5,450,500,000

C. Harga bahan Baku dan Harga Jual Produk

Tabel D.5 Harga Bahan Baku

No.	Nama Bahan	Kebutuhan, Kg/th	Harga, Rp/kg	Total harga, Rp/th
1	Rumput Laut	4162389	3,500.00	14,568,361,500.00
2	NaOH	33.957	199,000.00	6,757,443.00
3	NaCl	439411.335	2,000.00	878,822,670.00
4	Etanol	3329603.112	5,000.00	16,648,015,560.00
5	Pengemasan	4000000	5,000.00	20,000,000,000.00
	TOTAL BIAYA BAHAN BAKU			52,101,957,173.00

Harga jual produk

Harga: Rp 45.000/kg

Produksi: 4000.000 kg/tahun

Total: Rp 180.000.000.000/tahun

D. Gaji Karyawan

Total Karyawan = 95 orang

Gaji Karyaan per bulan:

Ditetapkan 1 tahun produksi adalah 12 bulan + THR 1 bulan, jadi:

Total Gaji 13 × 101400000 = Rp. 1,318,200,000

Rincian gaji karyawan ditampilkan pada tabel D.6

Tabel D.6 Rincian Gaji Karyawan

No.	Jabatan	Jumlah	Gaji/orang/bulan	Gaji total/bulan
1	Direktur Utama	1	5,000,000.00	5,000,000.00
2	Wakil Direktur Utama	1	4,000,000.00	4,000,000.00
3	Sekretaris	1	2,000,000.00	2,000,000.00
4	Manager Produksi dan Teknik	1	3,500,000.00	3,500,000.00
5	Kabag Produksi	3	3,000,000.00	9,000,000.00
6	Karyawan Proses	30	750,000.00	22,500,000.00
7	Karyawan Quality Control	6	850,000.00	5,100,000.00
8	Karyawan Utilitas	6	750,000.00	4,500,000.00
9	Kabag Teknik	1	3,000,000.00	3,000,000.00
10	Karyawan Maintenance	6	800,000.00	4,800,000.00
11	Manager Administrasi dan Umum	1	3,500,000.00	3,500,000.00
12	Kabag Administrasi dan Pemasaran	1	3,000,000.00	3,000,000.00
13	Karyawan Keuangan	2	750,000.00	1,500,000.00
14	Karyawan Pembukuan	2	750,000.00	1,500,000.00
15	Karyawan Pembelian	2	750,000.00	1,500,000.00
16	Karyawan Penjualan	7	750,000.00	5,250,000.00
17	Karyawan Gudang	9	750,000.00	6,750,000.00
18	Kabag Umum	1	3,000,000.00	,000,000.00
19	Karyawan Personalia	2	750,000.00	1,500,000.00
20	Karyawan Keamanan	10	750,000.00	7,500,000.00
21	Karyawan Humas	2	750,000.00	1,500,000.00
22	Pekerja harian	2	750,000.00	1,500,000.00
23	Sopir	3	600,000.00	1,800,000.00
		100	Total	103,200,000.00

E. Biaya Utilitas

1. Air

Kebutuhan: 351,84227 m^3/hari

Biaya pengolahan: Rp. 1000/m^3 (termasuk biaya regenerasi Exchanger)

Biaya total: Rp. 116.107.949,10 /tahun

2. LNG

kebutuhan LNG: 64.1124 kg/jam

Harga LNG: Rp. 500/kg

Biaya total: Rp. 769.348,80 /hari

3. Solar

Kebutuhan: 518.9742 L/bulan

Biaya solar: Rp. 1650 /L

Biaya Total: Rp. 10,275,689.16 /tahun

4. Listrik

beban listrik terpasang =1267.6296 kWh

Biaya per kW = Rp. 700

Biaya listrik total = Rp. 21.296.177,28 / hari

Untuk kebutuhan listrik selama 1 tahun kerja (330 hari)

= Rp. 7.773.104.707,20 / tahun

Jumlah penerangan pada saat libur (35 hari)

= 35 × 114,55 kW/jam × 700 Rp/kW × 24 jam

=Rp. 67.355.400

Jumlah kebutuhan total = Rp 7,648,794,511.68

5. Batubara

Kebutuhan batubara: 56 lb/jam = 609,625 kg/hari

Harga batubara = Rp. 200 / kg

Total biaya batubara = Rp. 40,235,250.00 / tahun

Total biaya untuk utilitas = Rp. 8,001,943,103.94 /tahun

F. Jadwal Kerja Karyawan

Jam Kerja Karyawan
Shift 1 07.00 - 15.00
Shift 2 15.00 - 23.00
Shift 3 23.00 - 07.00

Jadwal Shift

Shift \ Hari	1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	A	A	A	A	A	A	A	C	C	C	C	C	C	C
II	B	B	B	B	B	B		A	A	A	A	A	A	
III	C	C	C	C	C	C	B	B	B	B	B	B	B	A

Shift \ Hari	15	16	17	18	19	20	21	22	23	24	25	26	27	28
I	B	B	B	B	B	B	B	A	A	A	A	A	A	A
II	C	C	C	C	C	C		B	B	B	B	B	B	
III	A	A	A	A	A	A	C	C	C	C	C	C	C	B

Keterangan: Jadwal kerja 3 shift dengan 3 group (A; B; C)