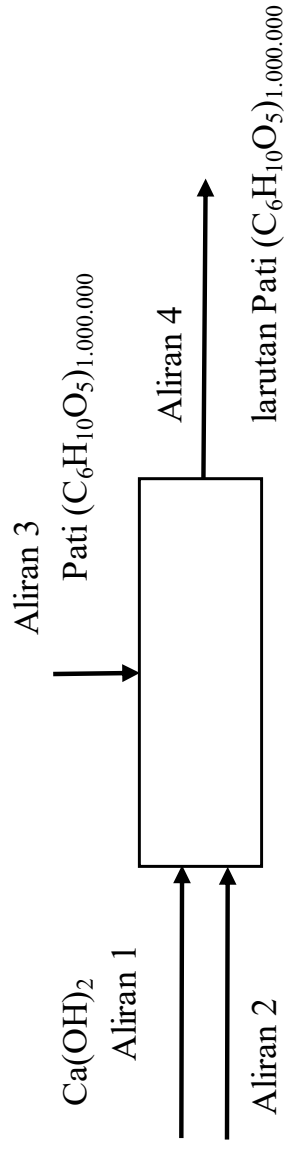


LAMPIRAN A
PERHITUNGAN NERACA MASSA

1. Kapasitas Perancangan	=	100.000 Ton/Tahun
2. Waktu Operasi	=	350 hari/ Tahun
3. Satu Hari Kerja	=	24 jam
4. Basis Perhitungan	=	11.905 Kg/jam
5. Produk Yang Diinginkan	=	100.000 Ton/Tahun

1. Neraca Massa Mixing Tank

Fungsi : Untuk mencampur pati, H₂O dan Ca(OH)₂



Ketentuan :

Kandungan Ion Ca^{2+} = 60 PPM basis Pati Jagung Yang Masuk
 Air yang Dibutuhkan = 200 % basis Pati Jagung Yang Masuk
 Proses pembuatan dan teknologi pengolahan, hal 38

Pati Jagung = 8.732,00 Kg (trial)
 Kebutuhan H_2O = 2 X 8.732,00
 = 17.464,00 Kg
 $\text{H}_2\text{O} + \text{Pati Jagung}$ = 26.196,00 Kg

Kandungan Ion Ca^{2+} = 0,00006 X 26.196,00
 = 1,57 kg

BM Ca^{2+} = 40,08 kg/kgmol
 BM Ca(OH)_2 = 74,09 kg/kgmol



Kebutuhan Ca(OH)_2 = 1,85 X 1,57
 = 2,91 kg

Komposisi Pati Jagung

Pati Jagung = 8.732,00 Kg

Komponen	Komposisi	
	%	(Kg/Jam)
Pati	89,90	7.850,07
Protein	0,70	61,12
Lemak	0,20	17,46
Serat Kasar	0,20	17,46
Air	9,00	785,88
Total	100,00	8.732,00

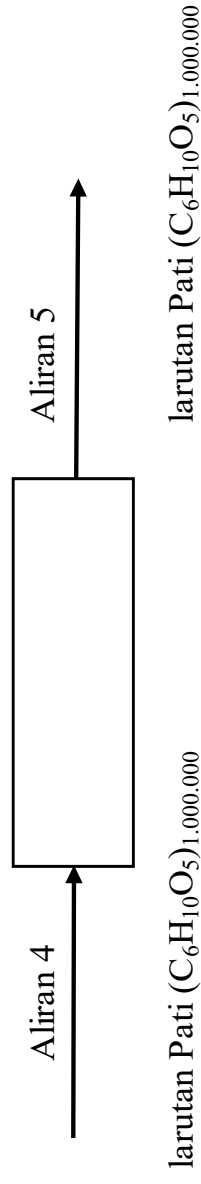
Jagung (BPPP, Pusat penelitian dan pengembangan Tanaman Pangan, Bogor Hal 356)

Masuk (Kg/Jam)		Keluar (Kg/Jam)
Aliran 1 (Ca(OH)_2)		Aliran 4 Larutan Pati ($\text{C}_6\text{H}_{10}\text{O}_5$) _{1.000.000}
Ca(OH)_2	2,91	Pati ($\text{C}_6\text{H}_{10}\text{O}_5$) _{1.000.000}
Total	2,91	Protein
Aliran 2 H_2O		Lemak
H_2O	17.464,00	Serat Kasar
Total	17.464,00	H_2O
Aliran 3 Pati ($\text{C}_6\text{H}_{10}\text{O}_5$) _{1.000.000}		Ca(OH)_2
		7.850,07
		61,12
		17,46
		17,46
		18.249,88
		2,91

Masuk (Kg/Jam)	Keluar (Kg/Jam)
Aliran 3 Pati ($C_6H_{10}O_5$) _{1.000.000}	Ca(OH) ₂ 2,91
Pati ($C_6H_{10}O_5$) _{1.000.000}	7.850,07
Protein	61,12
Lemak	17,46
Serat Kasar	17,46
H ₂ O	785,88
Total	8.732,00
TOTAL	26.198,91 TOTAL
	26.198,91

2. Neraca Massa Heater

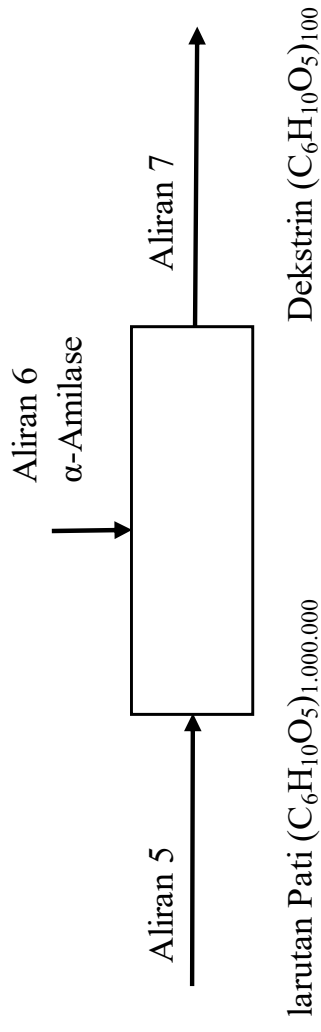
Fungsi : Untuk Memanaskan Pati



Masuk (Kg/Jam)	Keluar (Kg/Jam)
Aliran 4 Larutan Pati (C₆H₁₀O₅)_{1.000.000}	Aliran 5 Larutan Pati (C₆H₁₀O₅)_{1.000.000}
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	7.850,07
Protein	61,12
Lemak	17,46
Serat Kasar	17,46
H ₂ O	18.249,88
Ca(OH) ₂	2,91
TOTAL	26.198,91

3. Neraca Massa Reaktor Liquifikasi

Fungsi : Untuk mengkonversi Pati menjadi Dekstrin



Ketentuan :

$$= 0,000832 - 0,001248 \quad \text{kg/ Kg Pati}$$

Proses pembuatan dan teknologi pengolahan, hal 38

Diambil Nilai Tengahnya

$$\alpha\text{-Amilase} = 0,00104 \quad \text{Kg/Kg Pati}$$

Komposisi Pati Jagung

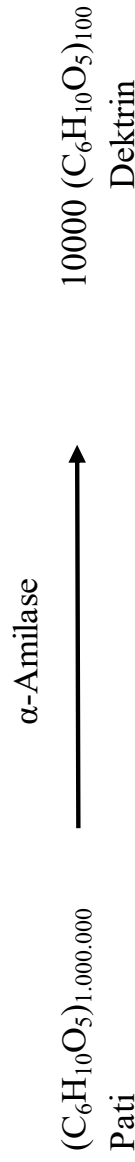
$$\text{Pati} = 89,90 \quad \%$$

$$\text{Pati} = 7.850,07 \quad \text{Kg}$$

$$\begin{aligned} \text{Keb. } \alpha\text{-Amilase} &= 0,00104 \quad \text{X} \quad 7.850,07 \\ &8,16 \quad \text{Kg} \end{aligned}$$

Reaksi Di reaktor Dekstrinasi

Finar I, Organic Chemsitry Vol I hal 527
 Panjang Rantai pati diasumsikan 1.000.000
 Panjang Rantai Dekstrin diasumsikan 100



Konversi reaksi 100 % (Berdasarkan Data dari *PT. Sama Satya Pasifik, Sidoarjo*)

BM Pati

C	12	1.000.000	72.064.200
H	1,01	1.000.000	10.079.400
O	16,00	1.000.000	79.997.000
BM Pati			162.140.600

Basic Principles and calculations in Chemical Engineering Hal 660

BM Dekstrin

C	12	100	7.206
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H	1,01	100	1.008
O	16,00	100	8.000
BM Dekstrin			16.214

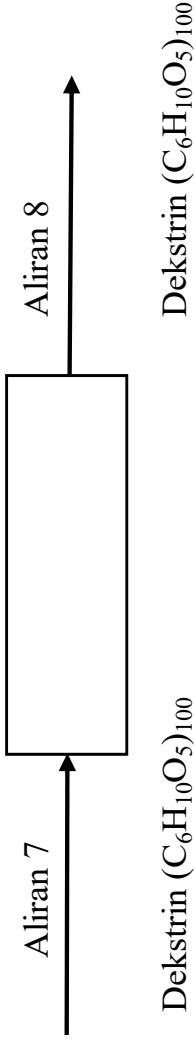
Basic Principles and calculations in Chemical Engineering Hal 660

Massa Pati	=	7.850,07	Kg
	=	0,000048	kmol
Pati Yang Bereaksi	=	1 X	0,000048
		0,000048	kmol
Dekstrin Yang terbentuk	=	0,4842	kmol
	=	7.850	Kg

Masuk (Kg/Jam)		Keluar (Kg/Jam)	
Aliran 5 Larutan Pati ($C_6H_{10}O_5$) _{1.000.000}		Aliran 7 Dekstrin ($C_6H_{10}O_5$) ₁₀₀	
Pati ($C_6H_{10}O_5$) _{1.000.000}	7.850,07	Dekstrin ($C_6H_{10}O_5$) ₁₀₀	7.850,07
Protein	61,12	Protein	61,12
Lemak	17,46	Lemak	17,46
Serat Kasar	17,46	Serat Kasar	17,46
H ₂ O	18.249,88	H ₂ O	18.249,88
Ca(OH) ₂	2,91	Ca(OH) ₂	2,91
Total	26.198,91	α-Amilase	8,16

Aliran 6 α -Amilase	
α -Amilase	8,16
Total	8,16
TOTAL	26.207,07
	26.207,07

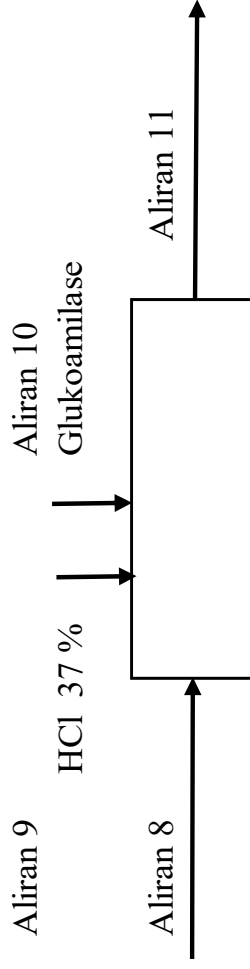
4. Neraca Massa Cooler
 Fungsi : Untuk Mendinginkan Dekstrin



Masuk (Kg/Jam)	Keluar (Kg/Jam)
Aliran 7 Dekstrin ($C_6H_{10}O_5$)₁₀₀	Aliran 8 Dekstrin ($C_6H_{10}O_5$)₁₀₀
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	7.850,07
Protein	61,12
Lemak	17,46
Serat Kasar	17,46
H ₂ O	18.249,88
Ca(OH) ₂	2,91
α-Amilase	8,16
TOTAL	26.207,07

5. Neraca Massa Reaktor Sakarifikasi

Fungsi : untuk mengkonversi Dekstrin Menjadi Glukosa



Dekstrin ($C_6H_{10}O_5$)₁₀₀ Glukosa $C_6H_{12}O_6$

Ketentuan :

$$= 0,000828 - 0,001242 \quad \text{kg/ Kg Pati}$$

(Proses pembuatan dan teknologi pengolahan, hal 38)

Diambil Nilai Tengahnya

$$\text{Glukoamilase} = 0,001035 \quad \text{Kg/Kg Pati}$$

Komposisi Pati Jagung

$$= 89,90 \quad \%$$

$$= 7.850,07 \quad \text{Kg}$$

$$\text{Keb, Glukoamilase} = 0,001035 \quad \text{X} \quad 7.850,07$$

$$8,12 \quad \text{Kg}$$

$$\text{Volume dari Reaktor Liquifikasi} = 24.671,81 \quad \text{liter}$$

Kebutuhan HCl			
PH Dekstrin	=	6,25	
PH Operasi	=	4-4,5	
	=	4,25	
PH	=	6,25	
$[H^+]$	=	0,00000056 M	
PH	=	4,25	
$[H^+]$	=	0,00005623 M	
$[H^+]$ yang ditambahkan	=	0,00005567 M	
Volume HCl yang ditambahkan	=	1,37 Liter	
Konsentrasi HCL yang Digunakan	=	37,00 %	
Asumsi yang tersedia Di pasar			
Volume HCl yang ditambahkan	=	1,37 liter	
Density HCl	=	1,27 Kg/Liter	
Massa HCl	=	1,74 Kg	
Air dalam HCl	=	2,96 Kg	

Reaksi Antara HCl dan $Ca(OH)_2$

Reaksi Antara HCl dan Ca(OH)₂



BM HCl	=	36,46	Kg/Kmol
BM CaCl ₂	=	110,98	Kg/Kmol
BM H ₂ O	=	18,02	Kg/Kmol
Massa Ca(OH) ₂	=	2,91	Kg
BM Ca(OH) ₂		74,09	Kg/Kmol
	=	0,039217526	Kmol
HCl	=	0,08	Kmol
	=	2,86	Kg
Hasil reaksi			
CaCl ₂	=	0,04	Kmol
		4,35	Kg
H ₂ O	=	0,08	Kmol
		1,41	Kg
Total HCl Yang Digunakan	=	4,60	Kg
Air dalam HCl	=	7,83	Kg

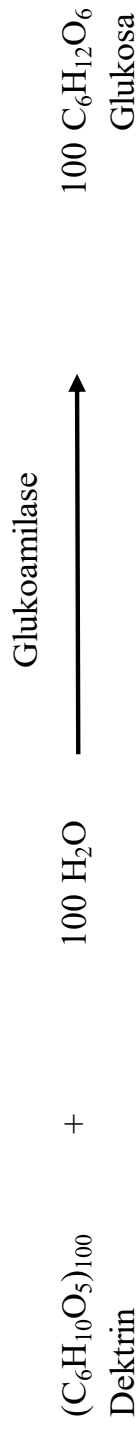
Reaksi Di reaktor Sakarifikasi

Konversi reaksi (Berdasarkan Data dari *PT. Sama Satya Pasifik, Sidoarjo*)

Dektrin menjadi Glukosa = 97,00 %

Dektrin Menjadi Maltosa = 1,00 %

Reaksi 1



BM $(\text{C}_6\text{H}_{10}\text{O}_5)_{100}$ = 16.214,06 Kg/Kmol

BM $\text{C}_6\text{H}_{12}\text{O}_6$ = 180,16 Kg/Kmol

BM H_2O = 18,02 Kg/Kmol

Total Dektrin

= 7.850,07 Kg

Dektrin untuk glukosa

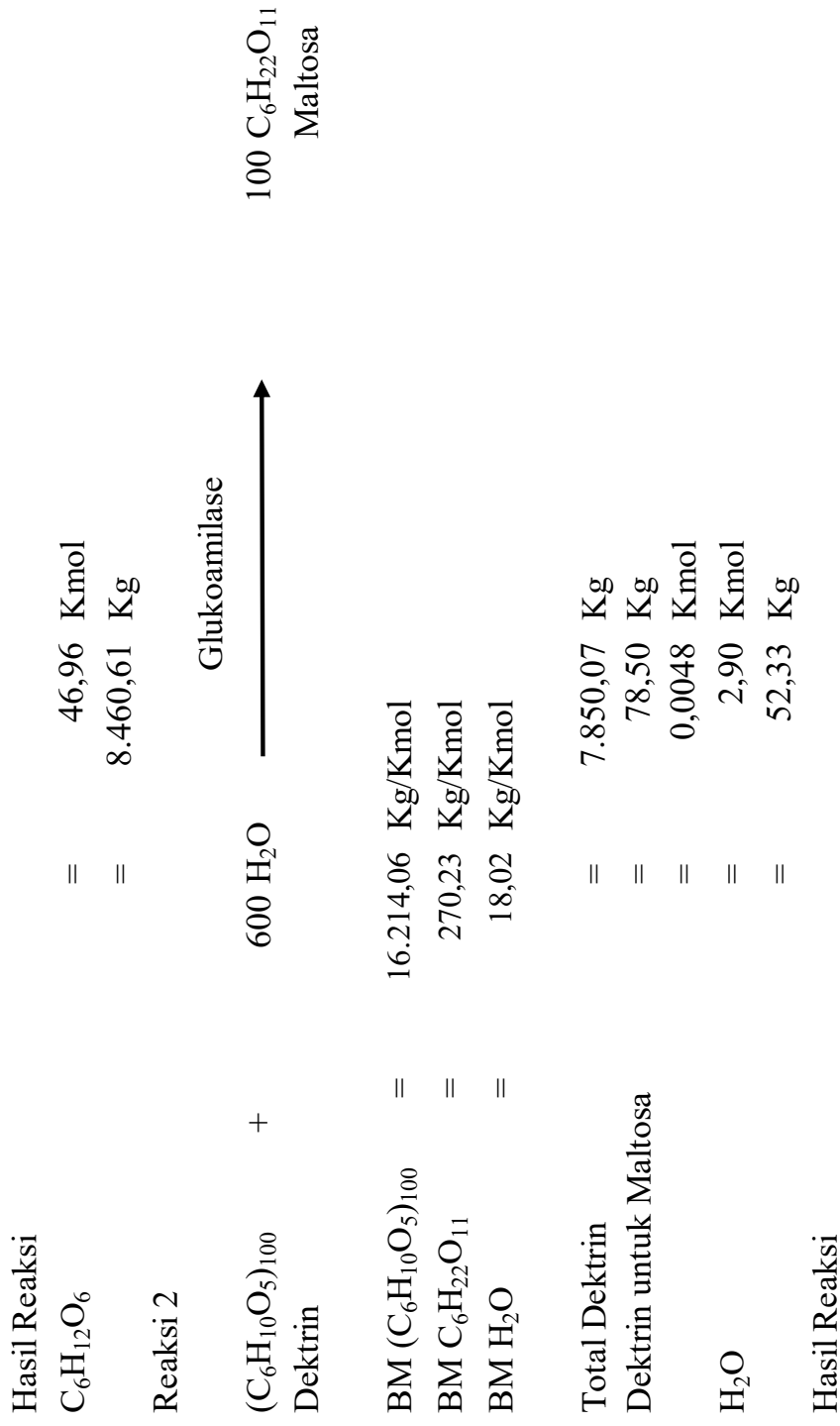
= 7.614,57 Kg

= 0,47 Kmole

= 46,96 Kmole

H_2O

= 846,05 Kg



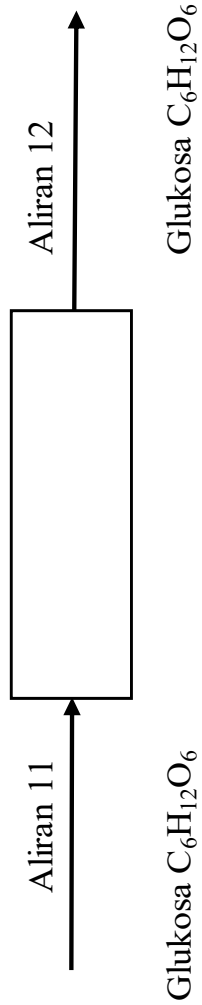
$C_6H_{22}O_{11}$
 = 0,48 Kmol
 = 130,83 Kg

Total Dektrin = 7.850,07 Kg
 Dektrin yang tidak bereaksi 2,00 %
 Dektrin yang tidak bereaksi = 157,00 Kg

	Masuk (Kg/Jam)	Keluar (Kg/Jam)
Aliran 8 Dekstrin ($C_6H_{10}O_5$) ₁₀₀		Aliran 11 Glukosa $C_6H_{12}O_6$
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	7.850,07	Glukosa $C_6H_{12}O_6$ 8.460,61
Protein	61,12	Maltosa $C_6H_{22}O_{11}$ 130,83
Lemak	17,46	Protein 61,12
Serat Kasar	17,46	Lemak 17,46
H ₂ O	18.249,88	Serat Kasar 17,46
Ca(OH) ₂	2,91	H ₂ O 17.360,75
α-Amilase	8,16	Dekstrin ($C_6H_{10}O_5$) ₁₀₀ 157,00
Total	26.207,07	α-Amilase 8,16
Aliran 9 HCl 37 %		HCl 1,74

Aliran 9 HCl 37 %		HCl	1,74
HCl	4,60	CaCl ₂	4,35
H ₂ O	7,83	Glukoamilase	8,12
Total	12,43		
Aliran 10 Glukoamilase			
Glukoamilase	8,12		
Total	8,12		
TOTAL		26.227,63 TOTAL	26.227,63

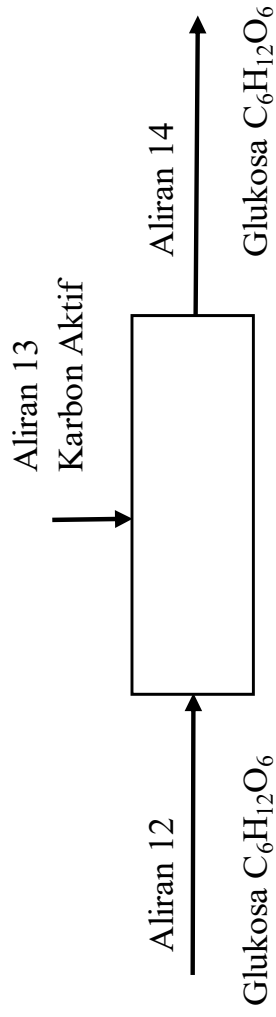
6. Neraca Massa Heater
 Fungsi : Untuk Memanaskan sirup glukosa



Masuk (Kg/Jam)	Keluar (Kg/Jam)
Aliran 11 Glukosa $C_6H_{12}O_6$	Aliran 12 Glukosa $C_6H_{12}O_6$
Glukosa $C_6H_{12}O_6$	8.460,61
Maltosa $C_6H_{22}O_{11}$	130,83
Protein	61,12
Lemak	17,46
Serat Kasar	17,46
H ₂ O	17.360,75
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00
α -Amilase	8,16
HCl	1,74
CaCl ₂	4,35
Glukoamilase	8,12
TOTAL	26.227,63

7. Neraca Massa Tangki Karbonasi

Fungsi : Untuk menyerap zat yang menjadi pengotor



Digunakan karbon aktif dengan kapasitas penyerapan = 0,7 Kg/ Kg karbon Aktif

Jumlah zat yang diserap

Protein	61,1	Kg
Lemak	17,5	Kg
α -Amilase	8,2	Kg
Glukoamilase	8,1	Kg
Total	94,9	Kg

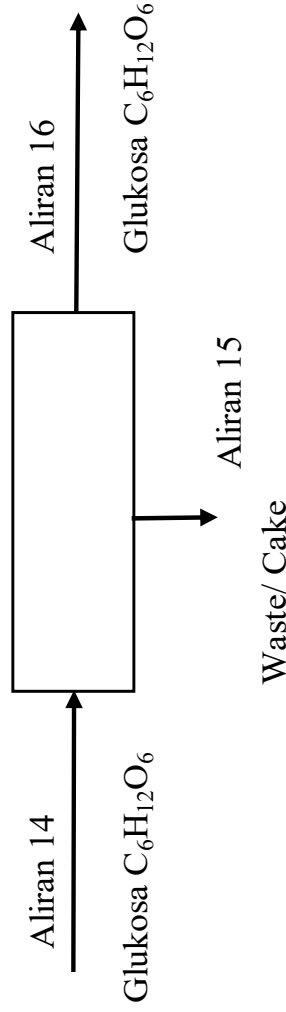
Proses pembuatan dan teknologi pengolahan, hal 38

Karbon Aktif Yang dibutuhkan = 94,9 / 0,7

Masuk (Kg/Jam)		Keluar (Kg/Jam)	
Aliran 13 Glukosa $C_6H_{12}O_6$		Aliran 14 Glukosa $C_6H_{12}O_6$	
Glukosa $C_6H_{12}O_6$	8.460,61	Glukosa $C_6H_{12}O_6$	8.460,61
Maltosa $C_6H_{22}O_{11}$	130,83	Maltosa $C_6H_{22}O_{11}$	130,83
Protein	61,12	Protein	61,12
Lemak	17,46	Lemak	17,46
Serat Kasar	17,46	Serat Kasar	17,46
H ₂ O	17.360,75	H ₂ O	17.360,75
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00	Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00
α -Amilase	8,16	α -Amilase	8,16
HCl	1,74	HCl	1,74
CaCl ₂	4,35	CaCl ₂	4,35
Glukoamilase	8,12	Glukoamilase	8,12
Total	26.227,63	Karbon Aktif	135,54
Aliran 13 Karbon Aktif			
Karbon Aktif	135,54		
Total	135,54		
TOTAL	26.363,17	TOTAL	26.363,17

8. Neraca Massa Di Rotary Vacuum filter

Fungsi : Untuk memurnikan glukosa dari impuritis



Dari data yang ada filtrate yang terikut adalah 3 % refrensi (PT Sama satya Pasifik)

	Masuk	%	Cake	Filtrate
Glukosa C ₆ H ₁₂ O ₆	8.460,61	3	253,82	8206,79
Maltosa C ₆ H ₂₂ O ₁₁	130,83	3	3,93	126,91
Protein	61,12	3	61,12	
Lemak	17,46	3	17,46	

Serat Kasar	17,46	3	17,46	
H ₂ O	17.360,75	3	520,82	16839,92
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	157,00	3	157,00	
α-Amilase	8,16	3	8,16	
HCl	1,74	3	0,05	1,69
CaCl ₂	4,35	3	0,13	4,22
Glukoamilase	8,12	3	8,12	
Karbon Aktif	135,54	3	135,54	

Masuk (kg/jam)		Keluar (kg/jam)	
Aliran 14 Glukosa C ₆ H ₁₂ O ₆		Aliran 15 Cake/ Waste	
Glukosa C ₆ H ₁₂ O ₆	8.460,61	Glukosa C ₆ H ₁₂ O ₆	253,82
Maltosa C ₆ H ₂₂ O ₁₁	130,83	Maltosa C ₆ H ₂₂ O ₁₁	3,93
Protein	61,12	Protein	61,12
Lemak	17,46	Lemak	17,46
Serat Kasar	17,46	Serat Kasar	17,46
H ₂ O	17.360,75	H ₂ O	520,82

Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00	Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00
α -Amilase	8,16	α -Amilase	8,16
HCl	1,74	HCl	0,05
CaCl ₂	4,35	CaCl ₂	0,13
Glukoamilase	8,12	Glukoamilase	8,12
Karbon Aktif	135,54	Karbon Aktif	135,54
		Total	1.183,63
		Aliran 16 Glukosa $C_6H_{12}O_6$	
		Glukosa $C_6H_{10}O_6$	8.206,79
		Maltosa $C_6H_{22}O_{11}$	126,91
		H ₂ O	16.839,92
		HCl	1,69
		CaCl ₂	4,22
		Total	25.179,54
TOTAL	26.363,17	TOTAL	26.363,17

9.Neraca Massa Cooler

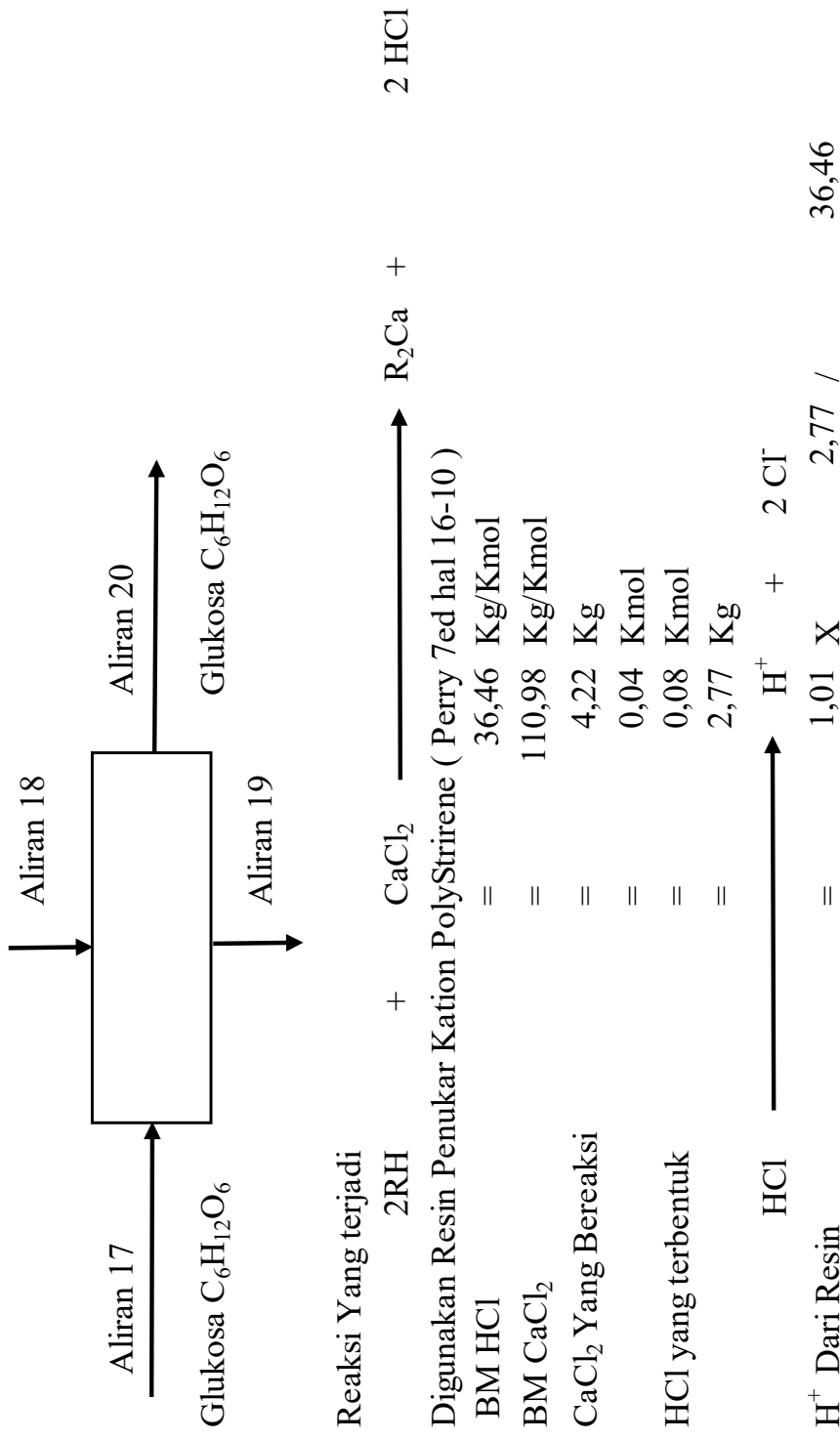
Fungsi : Untuk Mendinginkan larutan



Masuk (kg/jam)	Keluar (kg/jam)
Aliran 16 Glukosa C ₆ H ₁₂ O ₆	Aliran 17 Glukosa C ₆ H ₁₂ O ₆
Glukosa C ₆ H ₁₂ O ₆	8.206,79
Maltosa C ₆ H ₂₂ O ₁₁	126,91
H ₂ O	16.839,92
HCl	1,69
CaCl ₂	4,22
TOTAL	25.179,54

10. Neraca Massa Kation Exchange

Fungsi : Untuk mengambil/ menukar kation



CaCl₂ Yang tertinggal Di dalam Resin

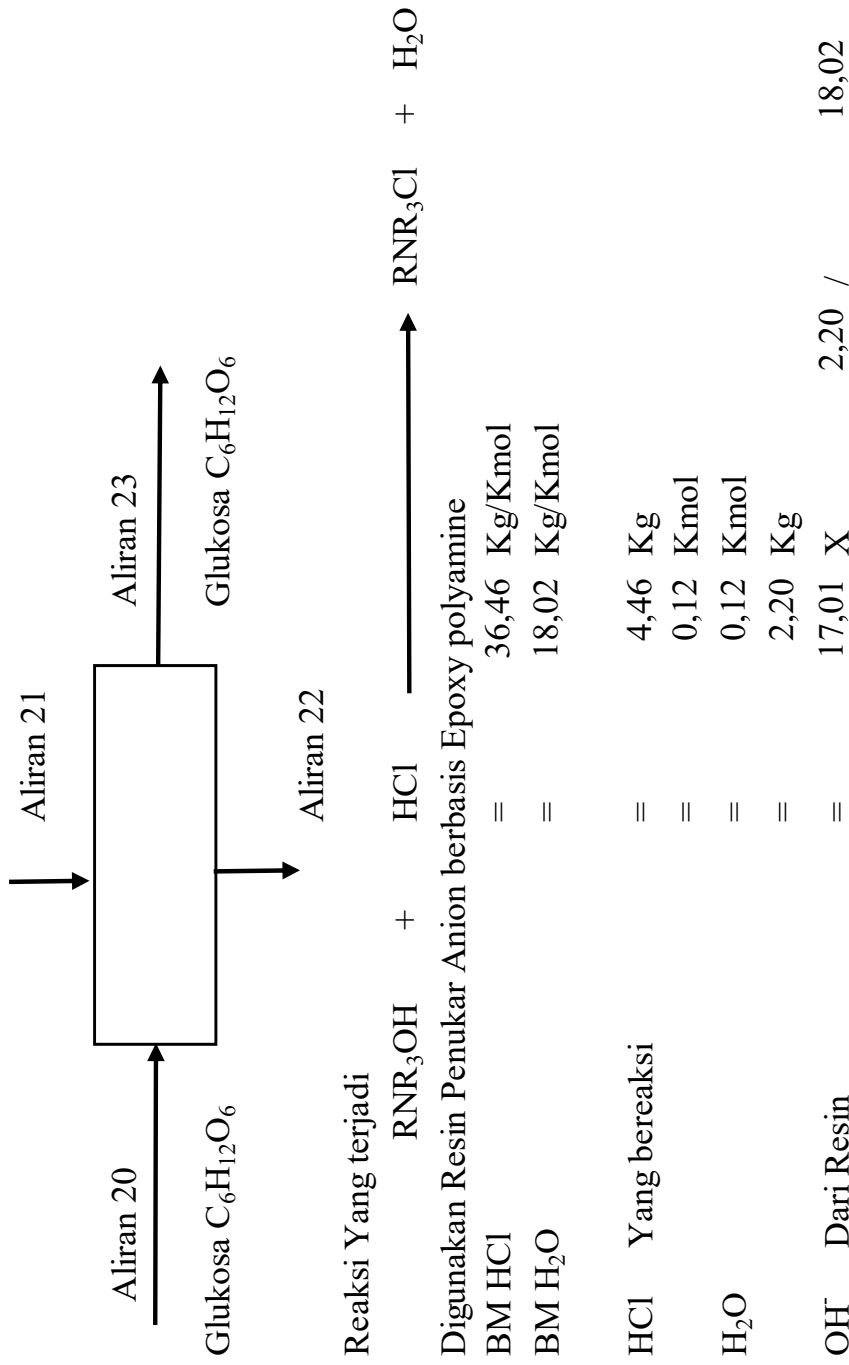


$$\begin{array}{rclcl} \text{Ca}^{2+} & \text{Tertinggal} & = & 40,08 & \text{X} & 4,22 & / & 110,98 \\ & & = & 1,52 & \text{Kg} & & & \end{array}$$

Masuk (kg/jam)		Keluar (kg/jam)	
Aliran 17 Glukosa C ₆ H ₁₂ O ₆		Aliran 19 Ca ²⁺ tertinggal diresin	
Glukosa C ₆ H ₁₂ O ₆	8.206,79	Ca ²⁺	1,52
Maltosa C ₆ H ₂₂ O ₁₁	126,91	Total	1,52
H ₂ O	16.839,92	Aliran 20 Glukosa C ₆ H ₁₂ O ₆	
HCl	1,69	Glukosa C ₆ H ₁₂ O ₆	8.206,79
CaCl ₂	4,22	Maltosa C ₆ H ₂₂ O ₁₁	126,91
Total	25.179,54	H ₂ O	16.839,92
Aliran 18 H ⁺ dari resin		HCl	4,46
H ⁺		Total	25.178,09
Total	0,08		
TOTAL		TOTAL	
25.179,61		25.179,61	

11. Neraca Massa Anion Exchange

Fungsi : Untuk mengambil/ menukar anion

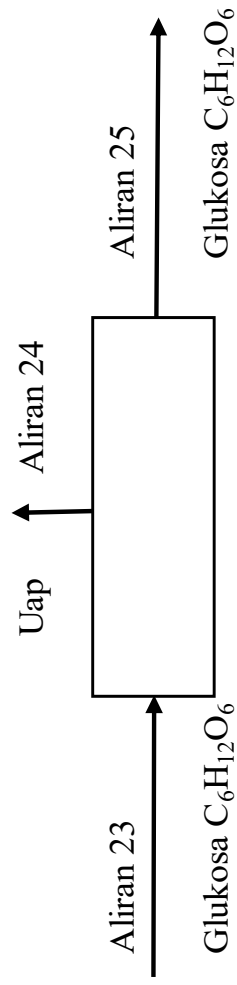


= 2,08 Kg
 Cl⁻ Yang tertinggal Di dalam Resin = 35,46 X 4,46 / 36,46
 = 4,34 Kg

Masuk (kg/jam)		Keluar (kg/jam)	
Aliran 20 Glukosa C ₆ H ₁₂ O ₆		Aliran 22 Cl ⁻ tertinggal diresin	
Glukosa C ₆ H ₁₂ O ₆	8.206,79	Cl ⁻	4,34
Maltosa C ₆ H ₂₂ O ₁₁	126,91	Total	4,34
H ₂ O	16.839,92	Aliran 23 Glukosa C ₆ H ₁₂ O ₆	
HCl	4,46	Glukosa C ₆ H ₁₂ O ₆	8.206,79
Total	25.178,09	Maltosa C ₆ H ₂₂ O ₁₁	126,91
Aliran 21 OH ⁻ dari resin		H ₂ O	16.842,13
OH ⁻	2,08	Total	25.175,83
Total	2,08		
TOTAL		TOTAL	25.180,17

12. Neraca Massa Evaporator

Fungsi : Untuk memekatkan larutan glukosa



Feed yang masuk

$C_6H_{12}O_6$	=	8.206,79
$C_6H_{22}O_{11}$	=	126,91
H_2O	=	16.842,13
Total		25.175,83
Xf	=	0,33

Neraca Massa Di evaporator

Aliran 23	=	Aliran 24	Aliran 25
25.175,83	=	V	P

Neraca Massa Di evaporator

Aliran 23 = Aliran 24 Aliran 25
 25.175,83 = V + P

Dry Basis

0,33 F = V + 0,7 P
 8333,702858 = 0 + 0,7 P
 P = 11.905,29 kg

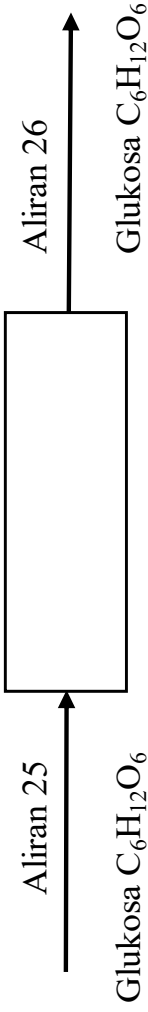
Air yang diuapkan

F = V + P
 25.175,83 = V + 11.905,29
 V = 13.270,5 Kg

	Masuk (kg/jam)	Keluar (kg/jam)
Aliran 23 Glukosa $C_6H_{12}O_6$		Aliran 24 H_2O Yang menguap
Glukosa $C_6H_{12}O_6$	8.206,79	H_2O 13.270,54
Maltosa $C_6H_{22}O_{11}$	126,91	Total 13.270,54
H_2O	16.842,13	Aliran 25 Glukosa $C_6H_{12}O_6$
		Glukosa $C_6H_{12}O_6$ 8.206,79

Masuk (kg/jam)	Keluar (kg/jam)
	Maltosa $C_6H_{22}O_{11}$ 126,91
	H ₂ O 3.571,59
	Total 11.905,29
TOTAL	25.175,83 TOTAL 25.175,83

13.Neraca Massa Cooler
 Fungsi : Untuk Mendinginkan larutan

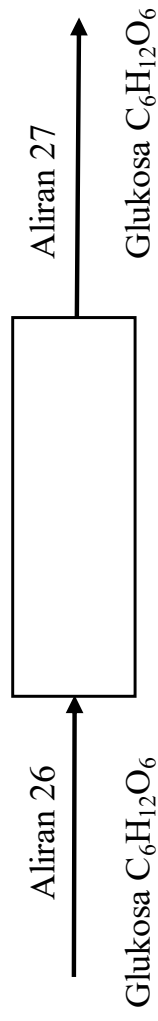


Masuk (kg/jam)	Keluar (kg/jam)
Aliran 25 Glukosa $C_6H_{12}O_6$	Aliran 26 Glukosa $C_6H_{12}O_6$
Glukosa $C_6H_{12}O_6$ 8.206,79	Glukosa $C_6H_{12}O_6$ 8.206,79
Maltosa $C_6H_{22}O_{11}$ 126,91	Maltosa $C_6H_{22}O_{11}$ 126,91

	Masuk (kg/jam)	Keluar (kg/jam)
H ₂ O	3.571,59	3.571,59
TOTAL	11.905,29	11.905,29

14.Neraca Massa Tangki Penyimpanan

Fungsi : Untuk Mendinginkan larutan



Masuk (kg/jam)	Keluar (kg/jam)
Aliran 26 Glukosa C ₆ H ₁₂ O ₆	Aliran 27 Glukosa C ₆ H ₁₂ O ₆
Glukosa C ₆ H ₁₂ O ₆	8.206,79
Maltosa C ₆ H ₂₂ O ₁₁	126,91
H ₂ O	3.571,59
TOTAL	TOTAL
11.905,29	11.905,29

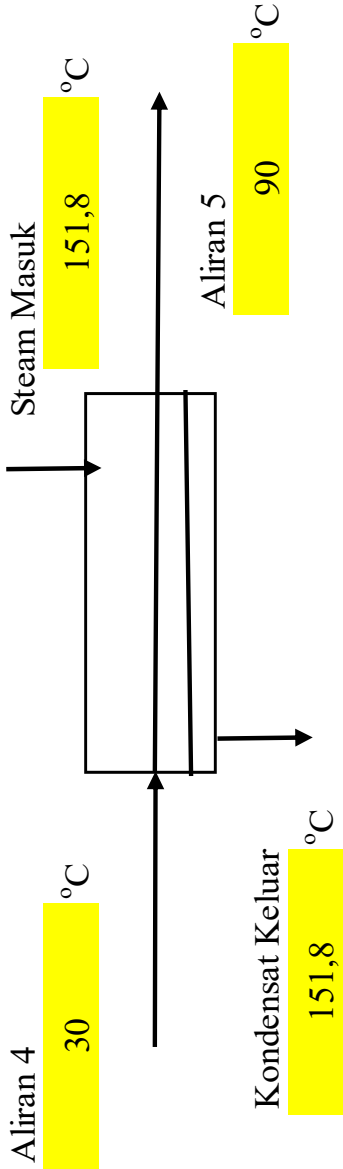
LAMPIRAN B
PERHITUNGAN NERACA PANAS

Neraca Panas		
1. Kapasitas Produksi	=	100.000 Ton/Tahun
2. Waktu Operasi	=	350 hari/ Tahun
3. Satu Hari Kerja	=	24 jam
4. Basis Perhitungan	=	11.904,76 Kg/jam
	=	285.714,29 Kg/hari
5. Suhu Referen	=	25 °C
6. Satuan Energi	=	(kkal/jam)

Komponen	CP (Kkal/Kg°C)	Referensi
H ₂ O	1	Perry Fig 3-11
Glukosa C ₆ H ₁₂ O ₆	0,29	Perry Fig 3-11
Maltosa C ₆ H ₂₂ O ₁₁	0,32	Perry Fig 3-11
Ca(OH) ₂	0,02	Hineblau, app E hal 677
CaCl ₂	0,17	Hineblau, app E hal 677

Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	0,29	Lange, tabel 9-8
Glukoamilase	0,44	Novo Product sheet Enzim
HCl	0,6	Lange, tabel 9-8
Lemak	0,6	Lange, tabel 9-8
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	0,43	Geancoplis, A-4-1
Protein	0,25	Lange, tabel 9-8
Serat Kasar	0,32	Perry tabel 3-206
α-Amilase	0,44	Novo Product sheet Enzim

1. Neraca Panas Heater
 Fungsi untuk memanaskan larutan pati



Panas Bahan Masuk		30 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 5						
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	7.850,07	0,4300	25	30	5	16.877,65
Protein	61,12	0,25	25	30	5	76,41
Lemak	17,46	0,6	25	30	5	52,39
Serat Kasar	17,46	0,32	25	30	5	27,94
H ₂ O	18.249,88	1	25	30	5	91.249,40
Ca(OH) ₂	2,91	0,02	25	30	5	0,29
Total						108.284,08

Panas Bahan keluar		90 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 6						
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	7.850,07	0,43	25	90	65	219.409,40
Protein	61,12	0,25	25	90	65	993,27
Lemak	17,46	0,6	25	90	65	681,10

Komponen	Massa	CP	T1(ref)	T2	ΔT	$Q = M \cdot C_p \cdot \Delta T$
	Kg					Kkal
Serat Kasar	17,46	0,32	25	90	65	363,25
H ₂ O	18.249,88	1	25	90	65	1.186.242,20
Ca(OH) ₂	2,91	0,02	25	90	65	3,78
Total						1.407.692,99

Asumsi Panas Yang Hilang 5 % dari Panas Steam Yang masuk
 Steam Yang Digunakan adalah saturated steam dengan P 5 bar
 Himeblau steam tabel Apendix C hal 861

P	T	H _L	H _V	λ
Kpa	°C	(kj/kg)	(kj/kg)	(kj/kg)
475,8	150	632,2	2746,5	2114,3
543,1	155	653,84	2752,4	2098,56

Mencari T

500

0,561485	155	-	x	-	150
87,03016	-	0,561485	x	-	150

	-	1,561485	x	=	-237,03
			x	=	151,7979
Mencari	H _L				
500					
0,561485	653,84	-	x	=	x
367,1213	-	0,561485	x	=	x
	-	1,561485	x	=	-999,321
			x	=	639,9814
Mencari	H _V				
500					
0,561485	2752,4	-	x	=	x
1545,431	-	0,561485	x	=	x
	-	1,561485	x	=	-4291,93
			x	=	2748,622
					2746,5
					2746,5

P	T	H _L	H _V	λ
Kpa	°C	(kj/kg)	(kj/kg)	(kj/kg)
500	151,7979	639,9814	2748,622	2108,64

P	T	H _L	H _V	λ
Kpa	°C	(kj/kg)	(kj/kg)	(kj/kg)
475,8	150	632,2	2746,5	2114,3
500	151,7979	639,9814	2748,622	2108,64
543,1	155	653,84	2752,4	2098,56

P	T	H _L	H _V	λ
Kpa	°C	(kcal/kg)	(kcal/kg)	(kcal/kg)
500	151,7979	152,9594	656,937	503,9776

$$\begin{aligned}
 &\text{Panas Masuk} = \text{Panas Keluar} \\
 &\text{Panas Umpan} + \text{Panas Steam} = \text{Panas Produk} + \text{Panas Kondensat} + \text{Panas Yang Hilang} \\
 &\Delta Q = \text{Panas Produk} - \text{Panas Umpan} + \text{Panas Yang Hilang} \\
 &\Delta Q = 1.407.692,99 - 108.284,08 + 5\% \times \Delta Q \\
 &0,95 \Delta Q = 1.299.408,91 \\
 &\Delta Q = 1.367.798,86 \text{ Kkal} \\
 &\text{Panas Yang Hilang} = 68.389,94 \text{ Kkal} \\
 &\Delta Q = m, \lambda \\
 &m, \lambda = \Delta Q \\
 &m \times 503,9776474 = 1.367.798,86
 \end{aligned}$$

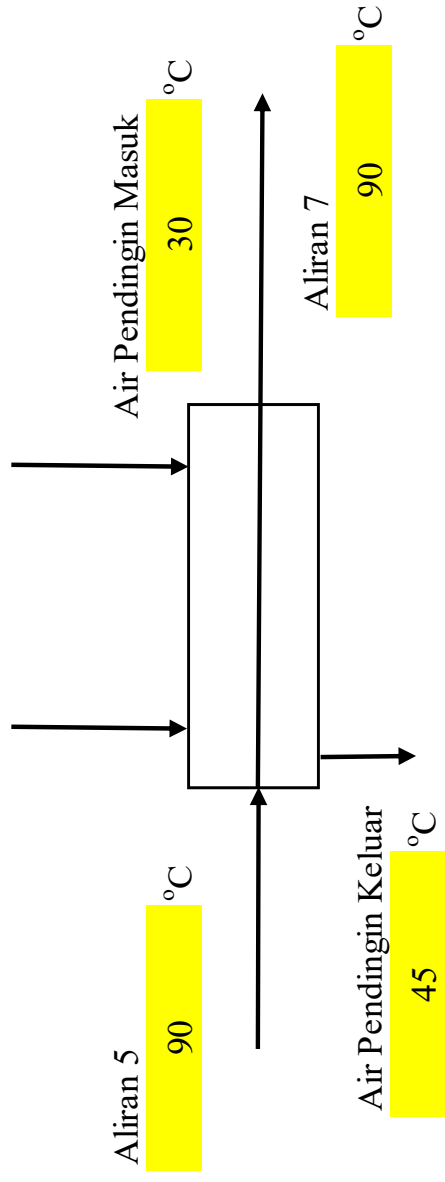
m	=	2.714,01 kg	
Q steam	=	m	X H _v
	=	2.714,01	X 656,94
	=	1.782.931,72 Kkal	

Q Condensat	=	m	X	H _L
	=	2.714,01	X	152,96
	=	415.132,86 Kkal		

	Masuk (kkal/jam)	Keluar (kkal/jam)
Aliran 4 Larutan Pati (C ₆ H ₁₀ O ₅) _{1.000.000}		Aliran 5 Larutan Pati (C ₆ H ₁₀ O ₅) _{1.000.000}
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	16.877,65	Pati (C ₆ H ₁₀ O ₅) _{1.000.000}
Protein	76,41	Protein
Lemak	52,39	Lemak
Serat Kasar	27,94	Serat Kasar
H ₂ O	91.249,40	H ₂ O
		219.409,40
		993,27
		681,10
		363,25
		1.186.242,20

Aliran 4 Larutan Pati ($C_6H_{10}O_5$) _{1.000.000}	Aliran 5 Larutan Pati ($C_6H_{10}O_5$) _{1.000.000}
Pati ($C_6H_{10}O_5$) _{1.000.000}	16.877,65 Pati ($C_6H_{10}O_5$) _{1.000.000}
Protein	76,41 Protein
Lemak	52,39 Lemak
Serat Kasar	27,94 Serat Kasar
H ₂ O	91.249,40 H ₂ O
Ca(OH) ₂	0,29 Ca(OH) ₂
Q steam	1.782.931,72 Q Kondensat
	Q loss
TOTAL	1.891.215,80 TOTAL
	1.891.215,80

2. Neraca Panas Reaktor Liquifikasi /Dekstrinasi



Panas Bahan Masuk		90	°C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal	
Aliran 5							
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	7.850,07	0,43	25	90	65	219.409,40	
Protein	61,12	0,25	25	90	65	993,27	
Lemak	17,46	0,6	25	90	65	681,10	
Serat Kasar	17,46	0,32	25	90	65	363,25	

Komponen	Massa	CP	T1(ref)	T2	ΔT	$Q = M \cdot Cp \cdot \Delta T$
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Serat Kasar	17,46	0,32	25	90	65	363,25
H ₂ O	18.249,88	1	25	90	65	1.186.242,20
Ca(OH) ₂	2,91	0,02	25	90	65	3,78
Total						1.407.692,99

Panas Bahan Masuk 30 °C

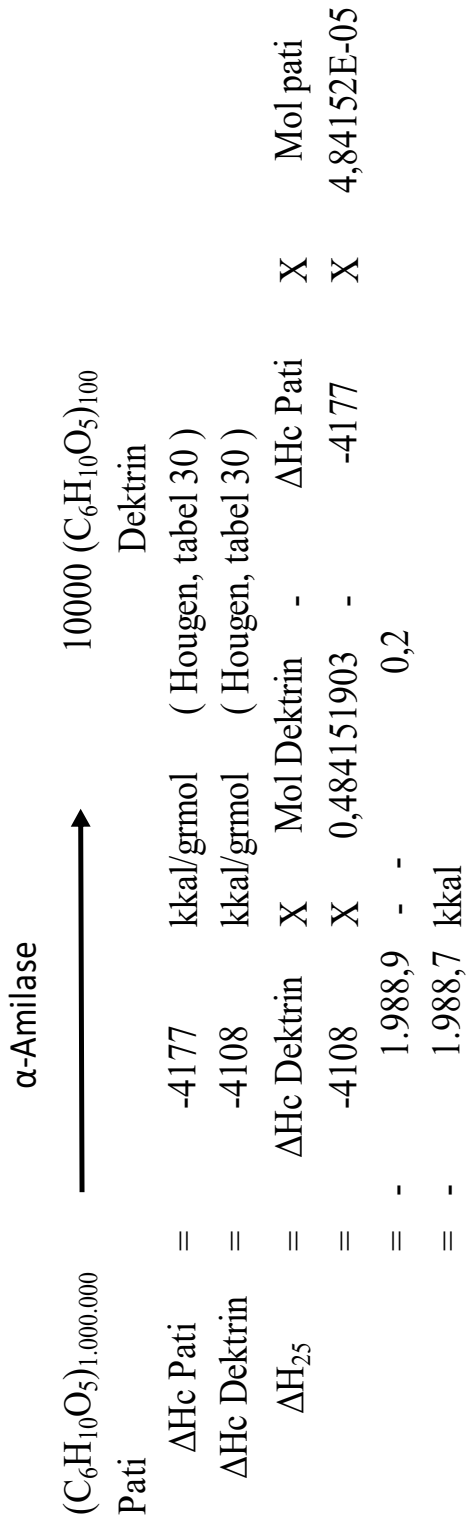
Komponen	Massa	CP	T1(ref)	T2	ΔT	$Q = M \cdot Cp \cdot \Delta T$
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 5						
α -Amilase	8,16	0,44	25	30	5	17,96

Panas Bahan keluar 90 °C

Komponen	Massa	CP	T1(ref)	T2	ΔT	$Q = M \cdot Cp \cdot \Delta T$
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 5						
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.850,07	0,29	25	90	65	147.973,78
Protein	61,12	0,25	25	90	65	993,27

Lemak	17,46	0,6	25	90	65	681,10
Serat Kasar	17,46	0,32	25	90	65	363,25
H ₂ O	18.249,88	1	25	90	65	1.186.242,20
Ca(OH) ₂	2,91	0,02	25	90	65	3,78
α-Amilase	8,16	0,44	25	90	65	233,49
Total						1.336.490,86

Panas Reaksi



$$\Delta H_{\text{Reaktan}} = (m1 \times Cp1) \times (T_{\text{ref}} - T_{\text{reaktan}})$$

Komponen	Massa Kg	CP Kkal/Kg°C	T _{ref} °C	T _{Reaktan} °C	Q Kkal
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	7.850,07	0,43	25	90	- 219.409,40

$$\Delta H_{\text{Produk}} = (m2 \times Cp2) \times (T_{\text{prod}} - T_{\text{Ref}})$$

Komponen	Massa Kg	CP Kkal/Kg°C	T _{Reaktan} °C	T _{ref} °C	Q Kkal
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.850,07	0,29	90	25	147.973,78

$$\begin{aligned} \Delta H_{\text{reaksi}} &= \Delta H_{2,5} & + & \Delta H_{\text{Reaktan}} & + & \Delta H_{\text{Produk}} \\ &= -1.988,69 & + & -219.409,40 & + & 147.973,78 \\ &= -73.424,31 & \text{ kkal} & & & \end{aligned}$$

$$\text{Panas Reaksi Yang Masuk} = 73.424,31 \text{ kkal}$$

Mencari Kebutuhan Air Pendingin

$$\text{Suhu Air Pendingin Masuk} = 30 \text{ } ^\circ\text{C}$$

$$\begin{aligned}
 \text{Suhu Air Pendingin Keluar} &= 45 \text{ } ^\circ\text{C} \\
 \text{Panas Masuk} &= \text{Panas Keluar} \\
 \text{Panas Umpan} + \Delta H_{\text{reaksi}} &= \text{Panas Produk} + \text{Panas Yang Diserap Air Pendingin} \\
 \text{Q Diserap Air Pendingin} &= \text{Panas Umpan} + \Delta H_{\text{reaksi}} - \text{Q Produk} \\
 &= 1.407.710,95 + 73.424,31 - 1.336.490,86 \\
 &= 144.644,40 \text{ kkal}
 \end{aligned}$$

Q Diserap Air Pendingin

Komponen	Massa	CP	T1	T2	ΔT	Q= M.Cp. ΔT
	Kg					
H ₂ O	9.642,96	1	30	45	15	144.644,40

Q_{Ap.in} =

Komponen	Massa	CP	T1	T _{ref}	ΔT	Q= M.Cp. ΔT
	Kg					
H ₂ O	9.642,96	1	30	25	5	48.214,80

QAp.out

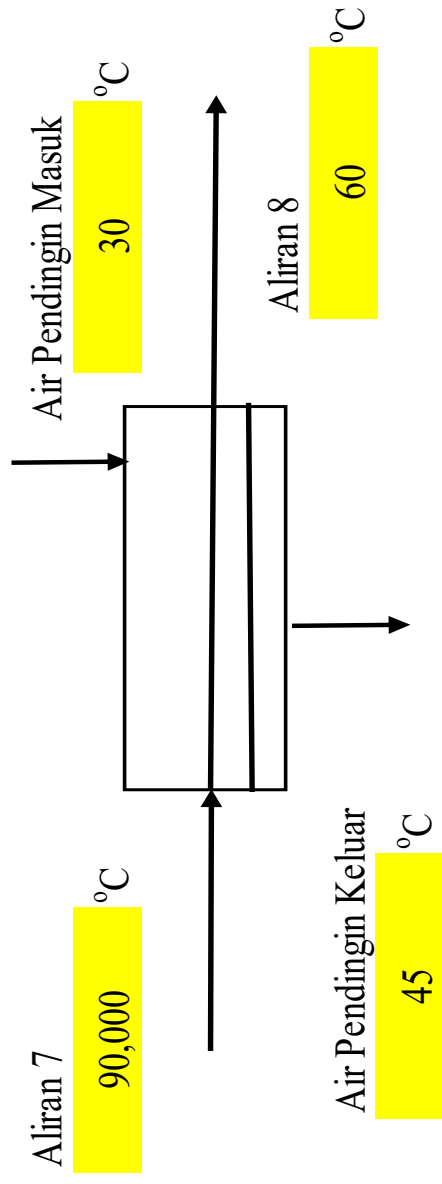
=

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp. ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	9.642,96	1	45	25	20	192.859,20

Masuk (kkal/jam)		Keluar (kkal/jam)	
Aliran 5 Larutan Pati (C ₆ H ₁₀ O ₅) _{1.000.000}		Aliran 7 Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	
Pati (C ₆ H ₁₀ O ₅) _{1.000.000}	219.409,40	Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	147.973,78
Protein	993,27	Protein	993,27
Lemak	681,10	Lemak	681,10
Serat Kasar	363,25	Serat Kasar	363,25
H ₂ O	1.186.242,20	H ₂ O	1.186.242,20
Ca(OH) ₂	3,78	Ca(OH) ₂	3,78
Total	1.407.692,99	α -Amilase	233,49
Aliran 6 α -Amilase		QAp.Out	192.859,20

α -Amilase	17,96	
Total	17,96	
ΔH_{reaksi}	73.424,31	
$Q_{\text{Ap}} \cdot \text{in}$	48.214,80	
Total	121.639,11	
TOTAL	1.529.350,06	1.529.350,06

3. Neraca panas Cooler



$$\begin{aligned} \text{Panas Masuk} &= \text{Dari Reaktor Dektrinasi} \\ &= 1.336.490,86 \text{ kkal} \end{aligned}$$

Panas Bahan Keluar

Panas Bahan keluar		60 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 9						
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.850,07	0,29	25	60	35	79.678,19
Protein	61,12	0,25	25	60	35	534,84
Lemak	17,46	0,6	25	60	35	366,74
Serat Kasar	17,46	0,32	25	60	35	195,60
H ₂ O	18.249,88	1	25	60	35	638.745,80
Ca(OH) ₂	2,91	0,02	25	60	35	2,03
α-Amilase	8,16	0,44	25	60	35	125,73
Total						719.648,93

Air Pendingin yang Dibutuhkan

Mencari Kebutuhan Air Pendingin

Suhu Air Pendingin Masuk = 30 °C

Suhu Air Pendingin Keluar = 45 °C

Panas Masuk = Panas Keluar

Panas Umpan = Panas Produk + Panas Yang Diserap Air Pendingin

Q Diserap Air Pendingin = Q Umpan - Q Produk

= 1.336.490,86 - 719.648,93

= 616.841,94 kkal

Q Diserap Air Pendingin =

Komponen	Massa	CP	T1	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	41.122,80	1	30	45	15	616.841,94

Q_{Ap.in} =

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp.ΔT
	Kg					
H ₂ O	41.122,80	1	30	25	5	205.613,98

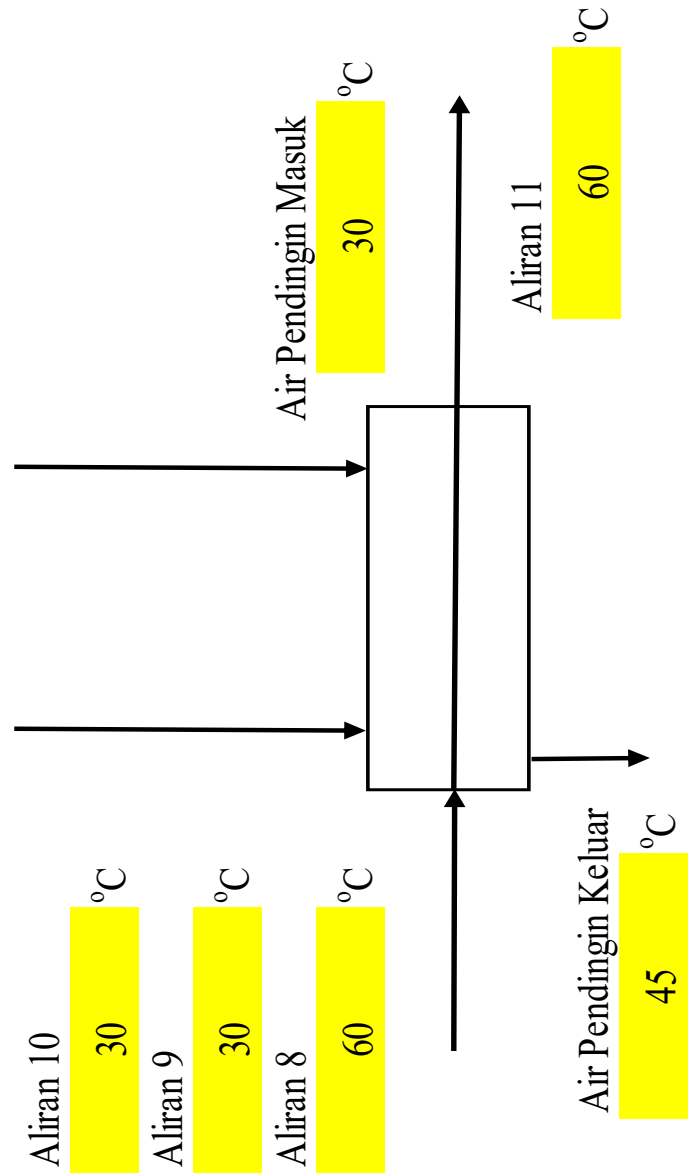
Q_{ap.Out}

Komponen	Massa	CP	T2	Tref	ΔT	Q= M.Cp.ΔT
	Kg					
H ₂ O	41.122,80	1	45	25	20	822.455,92

Masuk (kkal/jam)		Keluar (kkal/jam)	
Aliran 7 Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀		Aliran 8 Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	147.973,78	Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	79.678,19
Protein	993,27	Protein	534,84
Lemak	681,10	Lemak	366,74
Serat Kasar	363,25	Serat Kasar	195,60

Aliran 7 Dekstrin ($C_6H_{10}O_5$) ₁₀₀	Aliran 8 Dekstrin ($C_6H_{10}O_5$) ₁₀₀	
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	147.973,78	Dekstrin ($C_6H_{10}O_5$) ₁₀₀
Protein	993,27	Protein
Lemak	681,10	Lemak
Serat Kasar	363,25	Serat Kasar
H ₂ O	1.186.242,20	H ₂ O
Ca(OH) ₂	3,78	Ca(OH) ₂
α-Amilase	233,49	α-Amilase
QAp _{in}	205.613,98	QAp _{out}
TOTAL	1.542.104,84	TOTAL
		1.542.104,84

4. Neraca Panas Sakarifikasi



Panas Bahan Masuk		60 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 8						
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.850,07	0,29	25	60	35	79.678,19
Protein	61,12	0,25	25	60	35	534,84
Lemak	17,46	0,6	25	60	35	366,74
Serat Kasar	17,46	0,32	25	60	35	195,60
H ₂ O	18.249,88	1	25	60	35	638.745,80
Ca(OH) ₂	2,91	0,02	25	60	35	2,03
α-Amilase	8,16	0,44	25	60	35	125,73

Panas Bahan Masuk		30 °C					
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal	
Aliran 9							
HCl	4,69	0,6	25	30	5	14,08	
H ₂ O	7,99	1	25	30	5	39,94	

Panas Bahan Masuk		30 °C					
Komponen	Massa		CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg		Kkal/K.g°C	°C	°C	°C	Kkal
Aliran 10							
Glukoamilase	8,12		0,44	25	30	5	17,87

Panas Bahan Masuk		30 °C					
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal	
Aliran 10							
Glukoamilase	8,12	0,44	25	30	5	17,87	

Panas Bahan keluar		60 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 11						
Glukosa C ₆ H ₁₂ O ₆	8.460,61	0,29	25	60	35	85.875,22
Maltosa C ₆ H ₂₂ O ₁₁	130,83	0,32	25	60	35	1.465,33
Protein	61,12	0,25	25	60	35	534,84
Lemak	17,46	0,6	25	60	35	366,74
Serat Kasar	17,46	0,32	25	60	35	195,60
H ₂ O	17.360,90	1	25	60	35	607.631,57

Lemak	17,46	0,6	25	60	35	366,74
Serat Kasar	17,46	0,32	25	60	35	195,60
H ₂ O	17.360,90	1	25	60	35	607.631,57
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	157,00	0,29	25	60	35	1.593,56
α-Amilase	8,16	0,44	25	60	35	125,73
HCl	1,83	0,6	25	60	35	38,47
CaCl ₂	4,35	0,17	25	60	35	25,90
Glukoamilase	8,12	0,44	25	60	35	125,12
α-Amilase	8,16	0,44	25	60	35	125,73
Total						698.103,81

Panas Reaksi



Data dari panas pembentukan (ΔH_f)

$$\Delta\text{H}_f \text{ Ca(OH)}_2 = -235,8 \text{ kkal/grmol} \quad (\text{Hougen, tabel 29})$$

ΔH_f	HCl	=	-22,063	kkal/grmol	(Hougen, tabel 29)	
ΔH_f	CaCl_2	=	-190	kkal/grmol	(Hougen, tabel 29)	
ΔH_f	H_2O	=	-68,3174	kkal/grmol	(Hougen, tabel 29)	
Ca(OH)_2	+ 2 HCl	$\longrightarrow$	CaCl_2	+ 2 H_2O		
Ca(OH)_2		$\longrightarrow$	Ca + 1/2 O_2	+ H_2O	ΔH_f	= 235,8
2 HCl		$\longrightarrow$	Cl_2	+ H_2	ΔH_f	= 44,126
Ca + Cl_2		$\longrightarrow$	CaCl_2		ΔH_f	= -190
1/2 O_2 + H_2		$\longrightarrow$	H_2O		ΔH_f	= -68,3174
					ΔH_f	= 21,6086

	Kmol		ΔH_f
Ca(OH)_2	= 0,04	Kmol	= 235,80
HCl	= 0,08	Kmol	= 44,13
CaCl_2	= 0,04	Kmol	= - 190,00

$$\begin{aligned}
 \text{H}_2\text{O} &= & 0,08 \text{ Kmol} &= - & 68,32 \\
 \Delta\text{H}_{25} &= - & 0,10 \text{ Kkal} & &
 \end{aligned}$$

$$\Delta H_{\text{Reaktan}} = (m1 \times Cp1) \times (T_{\text{ref}} - T_{\text{reaktan}})$$

Komponen	Massa	CP	T _{ref}	T _{Reaktan}	Q
	Kg	Kkal/Kg°C	°C	°C	Kkal
Ca(OH)2	2,91	0,02	25	60	2,03
HCl	2,86	0,6	25	60	60,06

$$\Delta H_{\text{Produk}} = (m2 \times Cp2) \times (T_{\text{prod}} - T_{\text{Ref}})$$

Komponen	Massa	CP	T _{Reaktan}	T _{ref}	Q
	Kg	Kkal/Kg°C	°C	°C	Kkal
H ₂ O	1,41	1	60	25	49,46
CaCl ₂	4,35	0,17	60	25	25,90

$$\begin{aligned}
 \Delta H_{25} &= \Delta H_c \text{ Glukosa} \times \text{Mol Glukosa} - \Delta H_c \text{ Dektrin} \times \text{Mol Dektrin} \\
 &= - 3.735,59 \times 46,96 - 4.108,00 \times 0,470 \\
 &= - 175.433,5 - 1.929,2 \\
 &= - 173.504,3 \text{ kkal}
 \end{aligned}$$

$$\Delta H_{\text{Reaktan}} = (m1 \times Cp1) \times (T_{\text{ref}} - T_{\text{reaktan}})$$

Komponen	Massa	CP	T _{ref}	T _{Reaktan}	Q
	Kg	Kkal/Kg°C	°C	°C	Kkal
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.614,57	0,290	25	60	- 77.287,84
H ₂ O	846,05	1	25	60	- 29.611,64

$$\Delta H_{\text{Produk}} = (m2 \times Cp2) \times (T_{\text{prod}} - T_{\text{Ref}})$$

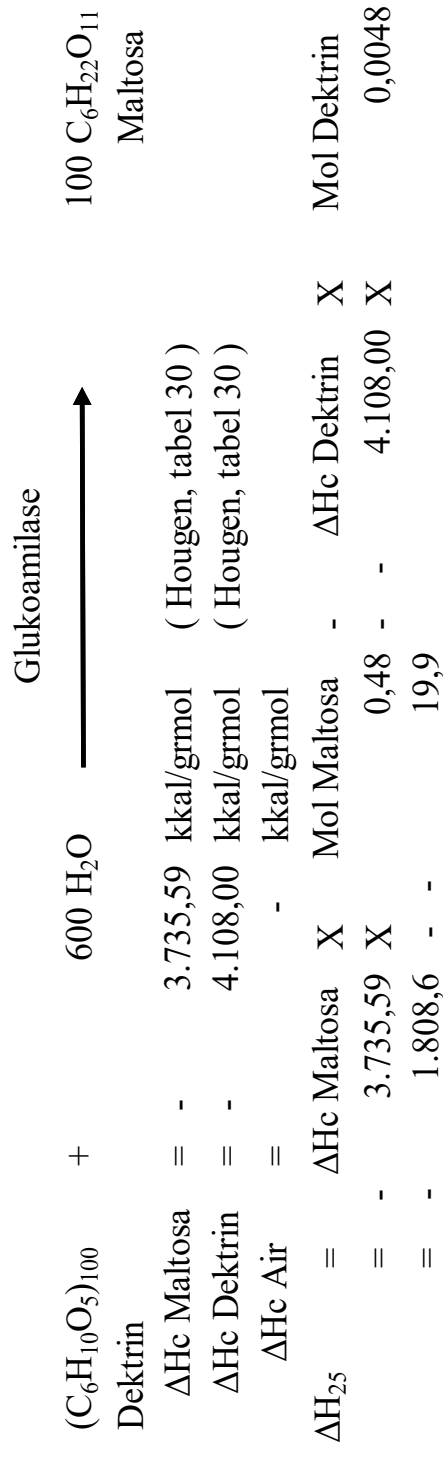
Komponen	Massa	CP	T _{Reaktan}	T _{ref}	Q
	Kg	Kkal/Kg°C	°C	°C	Kkal
Glukosa C ₆ H ₁₂ O ₆	8.460,61	0,290	60	25	85.875,22

$$\begin{aligned}
 \Delta H_{\text{reaksi}} &= \Delta H_{25} + \Delta H_{\text{Reaktan}} + \Delta H_{\text{Produk}} \\
 &= -173.504,31 + -106.899,48 + 85.875,22
 \end{aligned}$$

$$\begin{aligned}
 \Delta H_{\text{reaksi}} &= \Delta H_{25} & + & \Delta H_{\text{Reaktan}} & + & \Delta H_{\text{Produk}} \\
 &= -173.504,31 & + & -106.899,48 & + & 85.875,22 \\
 &= -194.528,57 & & \text{kcal} & &
 \end{aligned}$$

$$\text{Panas Reaksi Yang Masuk} = 194.528,57 \quad \text{kcal}$$

Reaksi 2



$\Delta H_{\text{Reaktan}} = (m1 \times Cp1) \times (T_{\text{ref}} - T_{\text{reaktan}})$						
Komponen	Massa	CP	T _{ref}	T _{Reaktan}	Q	
	Kg	Kkal/Kg°C	°C	°C	Kkal	
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	78,50	0,290	25	60	-	796,78
H ₂ O	52,33	1	25	60	-	1.831,65

$\Delta H_{\text{Produk}} = (m2 \times Cp2) \times (T_{\text{prod}} - T_{\text{Ref}})$						
Komponen	Massa	CP	T _{Reaktan}	T _{ref}	Q	
	Kg	Kkal/Kg°C	°C	°C	Kkal	
Maltosa C ₆ H ₁₂ O ₁₁	130,83	0,320	60	25	1.465,33	

$$\begin{aligned} \Delta H_{\text{reaksi}} &= \Delta H_{25} & + & \Delta H_{\text{Reaktan}} & + & \Delta H_{\text{Produk}} \\ &= -1.788,70 & + & -2.628,43 & + & 1.465,33 \\ &= -2.951,80 & \text{kkal} & & & \end{aligned}$$

$$\text{Panas Reaksi Yang Masuk} = 2.951,80 \text{ kkal}$$

$$\text{Panas Reaksi Yang Masuk} = 197.467,21 \text{ kkal}$$

$$\text{Panas Reaksi Yang Masuk} = 197.467,21 \quad \text{kkal}$$

Mencari Kebutuhan Air Pendingin

$$\text{Suhu Air Pendingin Masuk} = 30 \quad ^\circ\text{C}$$

$$\text{Suhu Air Pendingin Keluar} = 45 \quad ^\circ\text{C}$$

$$\text{Panas Masuk} = \text{Panas Keluar}$$

$$\text{Panas Umpan} + \Delta H_{\text{reaksi}} = \text{Panas Produk} + \text{Panas Yang Diserap Air Pendingin}$$

$$\text{Q Diserap Air Pendingin} = \text{Panas Umpan} + \Delta H_{\text{reaksi}} - \text{Q Produk}$$

$$= 719.720,82 + 197.467,21 - 698.103,81$$

$$= 219.084,22 \quad \text{kkal}$$

$$\text{Q Diserap Air Pendingin} =$$

Komponen	Massa	CP	T1	T2	ΔT	$Q = M \cdot C_p \cdot \Delta T$
	Kg	Kkal/Kg $^\circ\text{C}$	$^\circ\text{C}$	$^\circ\text{C}$	$^\circ\text{C}$	Kkal
H ₂ O	14.605,61	1	30	45	15	219.084,22

QAp.in =

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp. ΔT
	Kg					Kkal
H ₂ O	14.605,61	1	30	25	5	73.028,07

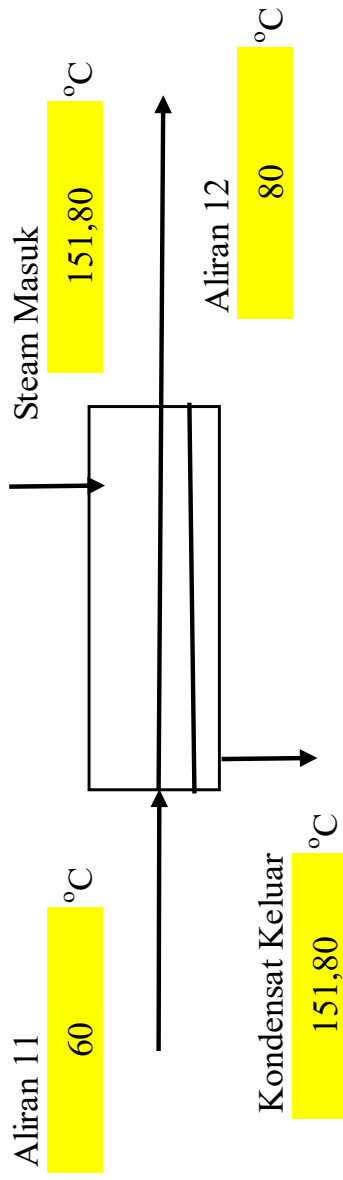
Qap.Out

Komponen	Massa	CP	T2	Tref	ΔT	Q= M.Cp. ΔT
	Kg					Kkal
H ₂ O	14.605,61	1	45	25	20	292.112,30

Masuk (kkal/jam)		Keluar (kkal/jam)	
Aliran 8 Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀		Aliran 11 Glukosa C ₆ H ₁₂ O ₆	
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	79.678,19	Glukosa C ₆ H ₁₂ O ₆	85.875,22
Protein	534,84	Maltosa C ₆ H ₂₂ O ₁₁	1.465,33
Lemak	366,74	Protein	534,84
Serat Kasar	195,60	Lemak	366,74
H ₂ O	638.745,80	Serat Kasar	195,60
Ca(OH) ₂	2,03	H ₂ O	607.631,57
α -Aamilase	125,73	Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	1.593,56

Ca(OH) ₂	2,03	H ₂ O	607.631,57
α-Amilase	125,73	Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	1.593,56
Total	719.648,93	α-Amilase	125,73
Aliran 9 HCl 37 %		HCl	38,47
HCl	14,08	CaCl ₂	25,90
H ₂ O	39,94	Glukoamilase	125,12
Total	54,02	α-Amilase	125,73
Aliran 10 Glukoamilase		QAp.Out	292.112,30
Glukoamilase	17,87		
Total	17,87		
ΔH _{reaksi}	197.467,21		
QAp.in	73.028,07		
TOTAL	990.216,10	TOTAL	990.216,10

5. Neraca Panas Heater



Panas Bahan masuk		60 °C					
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C		Kkal
Aliran 11							
Glukosa C ₆ H ₁₂ O ₆	8.460,61	0,29	25	60	35		85.875,22
Maltosa C ₆ H ₂₂ O ₁₁	130,83	0,32	25	60	35		1.465,33
Protein	61,12	0,25	25	60	35		534,84
Lemak	17,46	0,6	25	60	35		366,74
Serat Kasar	17,46	0,32	25	60	35		195,60
H ₂ O	17.360,90	1	25	60	35		607.631,57
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	157,00	0,29	25	60	35		1.593,56

α -Amilase	8,16	0,44	25	60	35	125,73
HCl	1,83	0,6	25	60	35	38,47
CaCl ₂	4,35	0,17	25	60	35	25,90
Glukoamilase	8,12	0,44	25	60	35	125,12
Total						697.978,08

Panas Bahan keluar		80 °C				
Komponen	Massa	CP	T1 (ref)	T2	ΔT	Q= M.Cp. ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 12						
Glukosa C ₆ H ₁₂ O ₆	8.460,61	0,29	25	80	55	134.946,77
Maltosa C ₆ H ₂₂ O ₁₁	130,83	0,32	25	80	55	2.302,67
Protein	61,12	0,25	25	80	55	840,46
Lemak	17,46	0,6	25	80	55	576,31
Serat Kasar	17,46	0,32	25	80	55	307,37
H ₂ O	17.360,90	1	25	80	55	954.849,61
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	157,00	0,29	25	80	55	2.504,17
α -Amilase	8,16	0,44	25	80	55	197,57

HCl		1,83	0,6	25	80	55	60,45
CaCl ₂		4,35	0,17	25	80	55	40,70
Glukoamilase		8,12	0,44	25	80	55	196,62
Total							1.096.822,70

Asumsi Panas Yang Hilang 5 % dari Panas Steam Yang masuk
 Steam Yang Digunakan adalah saturated steam dengan P 5 bar

P	T	H _L	H _V	λ
Kpa	°C	(kj/kg)	(kj/kg)	(kj/kg)
475,8	150	632,2	2746,5	2114,3
543,1	155	653,84	2752,4	2098,56

Mencari T

500

0,561485	155	-	x	=	x	-	150
87,03016	-	0,561485	x	=	x	-	150
	-	1,561485	x	=	-237,03		

P	T	H _L	H _V	λ
Kpa	°C	(kj/kg)	(kj/kg)	(kj/kg)
475,8	150	632,2	2746,5	2114,3
500	151,7979	639,9814	2748,622	2108,64
543,1	155	653,84	2752,4	2098,56

P	T	H _L	H _V	λ
Kpa	°C	(kkal/kg)	(kkal/kg)	(kkal/kg)
500	151,7979	152,9594	656,937	503,9776

$$\text{Panas Masuk} = \text{Panas Keluar}$$

$$\text{Panas Umpan} + \text{Panas Steam} = \text{Panas Produk} + \text{Panas Kondensat} + \text{Panas Yang Hilang}$$

$$\Delta Q = \text{Panas Produk} - \text{Panas Umpan} + \text{Panas Yang Hilang}$$

$$\Delta Q = 1.096.822,70 - 697.978,08 + 5\% \times \Delta Q$$

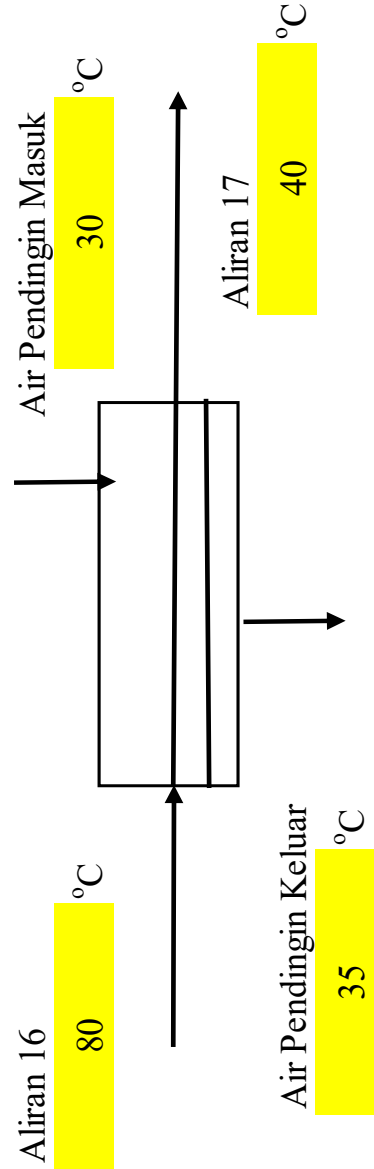
$$0,95 \Delta Q = 398.844,62$$

$$\Delta Q = 419.836,44 \text{ Kkal}$$

$$\text{Panas Yang Hilang} = 20.991,82 \text{ Kkal}$$

α -Amilase	125,73	α -Amilase	197,57
HCl	38,47	HCl	60,45
CaCl ₂	25,90	CaCl ₂	40,70
Glukoamilase	125,12	Glukoamilase	196,62
Q steam	547.258,61	Q Condensat	127.422,17
		Q Loss	20.991,82
TOTAL	1.245.236,69	TOTAL	1.245.236,69

6. Neraca panas Cooler



Panas Masuk dari rotary vakum Filter

Panas Bahan masuk		80 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 16						
Glukosa C ₆ H ₁₂ O ₆	8.206,79	0,29	25	80	55	130.898,37
Maltosa C ₆ H ₂₂ O ₁₁	126,91	0,32	25	80	55	2.233,59
H ₂ O	16.840,07	1	25	80	55	926.204,12
HCl	1,78	0,6	25	80	55	58,64
CaCl ₂	4,22	0,17	25	80	55	39,48
Total						1.059.434,19

Panas Bahan keluar

Panas Bahan keluar		40 °C				
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
Aliran 17						
Glukosa C ₆ H ₁₂ O ₆	8.206,79	0,29	25	40	15	35.699,56
Maltosa C ₆ H ₂₂ O ₁₁	126,91	0,32	25	40	15	609,16

H ₂ O	16.840,07	1	25	40	15	252.601,12
HCl	1,78	0,6	25	40	15	15,99
CaCl ₂	4,22	0,17	25	40	15	10,77
Total						288.936,60

Air Pendingin yang Dibutuhkan
Mencari Kebutuhan Air Pendingin

Suhu Air Pendingin Masuk = 30 °C
Suhu Air Pendingin Keluar = 35 °C

Panas Masuk = Panas Keluar
Panas Umpan = Panas Produk + Panas Yang Diserap Air Pendingin

Q Diserap Air Pendingin = Q Umpan - Q Produk

$$= 1.059.434,19 - 288.936,60$$

$$= 770.497,59 \text{ kkal}$$

Q Diserap Air Pendingin =

Komponen	Massa	CP	T1	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	154.099,52	1	30	35	5	770.497,59

QAp.in =

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp. ΔT
	Kg					Kkal
H ₂ O	154.099,52	1	30	25	5	770.497,59

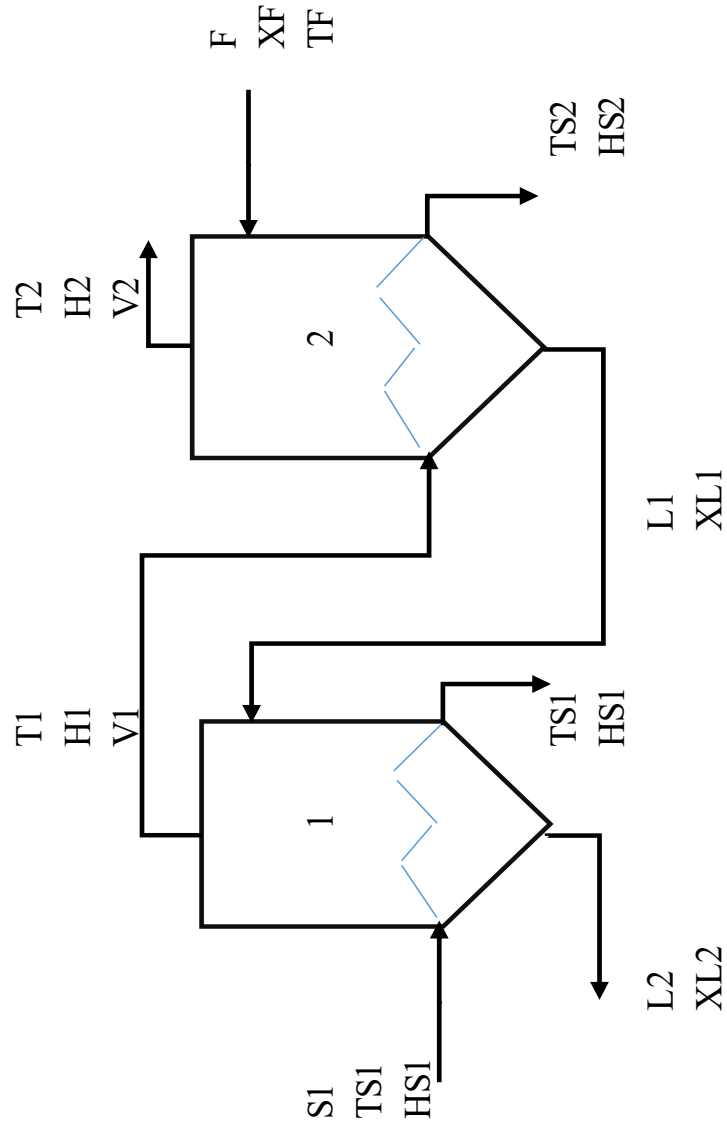
Qap.Out

Komponen	Massa	CP	T2	Tref	ΔT	Q= M.Cp. ΔT
	Kg					Kkal
H ₂ O	154.099,52	1	35	25	10	1.540.995,19

Masuk (kkal/jam)		Keluar (kkal/jam)	
Aliran 16 Glukosa C ₆ H ₁₂ O ₆		Aliran 17 Glukosa C ₆ H ₁₂ O ₆	
Glukosa C ₆ H ₁₂ O ₆	130.898,37	Glukosa C ₆ H ₁₂ O ₆	35.699,56
Maltosa C ₆ H ₂₂ O ₁₁	2.233,59	Maltosa C ₆ H ₂₂ O ₁₁	609,16
H ₂ O	926.204,12	H ₂ O	252.601,12
HCl	58,64	HCl	15,99
CaCl ₂	39,48	CaCl ₂	10,77

$Q_{Ap.in}$	770.497,59	$Q_{Ap.Out}$	1.540.995,19
TOTAL	1.829.931,79	TOTAL	1.829.931,79

7. Neraca panas Evaporator



$$\begin{aligned}
 F &= 25.176,03 \text{ kg/jam} \\
 XF &= 33,1 \% \\
 TF &= 40 \text{ }^{\circ}\text{C} \\
 XL2 &= 70 \% \\
 S1 &= \\
 TS1 &= 115,6 \text{ }^{\circ}\text{C} \\
 HS1 &= \text{ kJ/kg} \\
 U1 &= 2270 \text{ Watt/M}^2 \text{ }^{\circ}\text{K} = \text{ Watt/M}^2 \text{ }^{\circ}\text{C} \\
 U2 &= 1705 \text{ Watt/M}^2 \text{ }^{\circ}\text{K} = \text{ Watt/M}^2 \text{ }^{\circ}\text{C} \\
 cp &= 4,19 - 2,35x \text{ kJ/kg}^{\circ}\text{C} \\
 BPR &= 1,78 x + 6,22 X^2 \\
 P \text{ efect } 2 &= 13,34 \text{ Kpa}
 \end{aligned}$$

langkah 1

Neraca Massa total

$$F = L2 + V1 + V1$$

Asumsi V1 = V2

F	=	L2	+	V
25176,02638	=	L2	+	V
25176,02638	=	11905,2898	+	V
				1)

Neraca Massa Komponen

F	Xf	=	L2	XI2 +	V	yV
25176,02638	0,331017403	=	L2	1 +	V	0
	8333,702858	=	L2	0,7		
	L2	=	11905,2898			

Neraca Massa efek 1

L1	=	L2	+	V1	
L1	=	11905,2898	+	6635,36829	
L1	=	18540,65809			
L1					V1
		X11	=	L2	X12 +
18540,65809		X11	=	11905,2898	1 +
18540,65809		X11	=	8333,702858	+
18540,65809		X11	=	8333,702858	
					V1
					6635,36829
					0
					V1

Neraca Massa efeect 2

$$\begin{aligned}
 F &= L1 + V2 \\
 F &= 18540,65809 + 6635,36829 \\
 F &= 25176,02638 \quad \text{sama}
 \end{aligned}$$

F	Xf	=	L1	Xl1 +	V2	yV
25176,02638	Xf	=	18540,65809	0 +	0	0
25176,02638	Xf	=	8333,702858	+	0	
25176,02638	Xf	=	8333,702858			
	Xf	=	0,331017403	sama		

Menghitung kenaikan titik didih masing-2 effect

$$BPR = 1,78 \times + 6,22 X^2$$

$$Xl1 = 0,449482581$$

$$BPR\ 2 = 1,78 \times 0,4494826 + 6,22 \times 0,2020346 = 2,0567342\ ^\circ C$$

$$Xl2 = 0,7$$

$$BPR\ 1 = 1,78 \times 0,7 + 6,22 \times 0,49 = 4,2938\ ^\circ C$$

$$\Sigma\ BPR = = 6,3505342\ ^\circ C$$

$$\begin{aligned}
 &= 0,428930818 \times 57,80 \\
 &= 24,79305547 \text{ } ^\circ\text{C} \\
 \\
 \text{Effect 2} &= \Delta T2 &= 1/U2 &: 1/U1+1/U2 &\times \Sigma \Delta T \\
 & &0,00058651 &: 0,001027039 &\times 57,80 \\
 & &0,571069182 &\times 57,80 \\
 & &33,00893602 &\text{ } ^\circ\text{C}
 \end{aligned}$$

Kondisi Operasi Masing- Masing Effect

Effect 1	T1	=	Ts1	-	$\Delta T1$	
		=	115,6	-	24,79305547	
		=	90,80694453	$^\circ\text{C}$		
	Ts1	=	115,6	$^\circ\text{C}$		
Effect 2	T2	=	T1	-	BPR1	$\Delta T2$
		=	90,80694453	-	4,2938	33,00893602
		=	53,50420851	$^\circ\text{C}$		
	Ts2	=	T1	-	BPR1	
		=	90,80694453	-	4,2938	
		=	86,51314453	$^\circ\text{C}$		
Condenser	Ts3	=	T2	-	BPR2	

$$= 53,50420851 - 2,056734151$$

$$= 51,44747436 \text{ }^{\circ}\text{C}$$

Profil Suhu Masing - Masing Effect

Effect 1		Effect 2		Condensor	
Ts1	115,6 °C	Ts2	86,51 °C	Ts3	51,45 °C
T1	90,81 °C	T2	53,5 °C		
Menghitung Kapasitas Panas Tiap Effect					
cp	= 4,19 - 2,35x	kj/kg°C			
CP F	= Xf	= 0,33			
	= 4,19 - 2,35	x	0,33	=	3,41
CPL1	= Xl1	= 0,45			
	= 4,19 - 2,35	x	0,449482581	=	3,13
CPL2	= Xl2	= 0,70			
	= 4,19 - 2,35	x	0,7	=	2,55

Menghitung Entalpi H dari berbagai aliran uap relatif terhadap air pada suhu 0 °C sebagai datum diperoleh dari stem tabel

Effect 1	H1	=	HS2	+	1,884	x	BPR1
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Effect 1	H1	=	HS2	+	1,884	X	BPR1
		=	2655,3205	+	1,884	X	2,445
		=	2659,92688	kj/kg			
	λs1	=	HS1	-	hs1		
		=	2699,876	-	485,0276		
		=	2214,8484	kj/kg			
Effect 2		H2	=	HS3	+	1,884	X
		=	2595,496	+	1,884	X	0,469444444
		=	2596,380433	kj/kg			
	λs2	=	H1	-	hs2		
		=	2659,92688	-	217,30586		
		=	2442,62102	kj/kg			
Neraca Energi Tiap- Tiap Effect							
V1	=	L1	-	L2	=	6777,582448	kg/jam
V2	=	F	-	L1	=	6493,154131	kg/jam
Effect 2	=						

dari persamaan Effect 2

Effect 2	=								
F	x	hf	+	V1	x	λs2	=		
L1	x	hl1	+	V2	x	h2			
25.176,03	x	136,4843642	+	L1 - 11905,29	x	2442,62102	=		
L1	x	167,6669907	+	25176,026 - L1		2596,380433			
3436133,952	+	2442,62102	L1	- 29080111,11			=		
167,6669907	L1	+	65366542,27	- 2596,380433	L1				
				4871,334463	L1 =	91010519,43			
					L1 =	18682,87225	kg/jam		

Effect 1								
L1	x	hl1	+	S	x	λs1	=	
L2	x	hl2	+	V1	x	h1		
18682,87225	x	167,6669907	+	S	x	2214,8484	=	
11905,2898	x	231,1036738	+	6777,582448	x	2442,62102		
		3132500,968	+	S	x	2214,8484	=	
		2751356,21		+	16555065,35			
	S	x	2214,8484	=	16173920,6			
	S	=		=	7302,495555	kg/jam		

Menghitung Q pada masing - Masing Effect

Effect 1

Menghitung Q pada masing - Masing Effect

Effect 1

q1	=	s	x	$\lambda s1$
	=	7302,495555	x	2214,8484
	=	16173920,6	kJ/jam	
	=	4492755,757	watt	

Effect 2

q2	=	V1	x	$\lambda s2$
	=	6777,582448	x	2442,62102
	=	16555065,35	kJ/jam	
	=	4598629,301	watt	

Menghitung Luas Area

Effect 1

q1	=	U1	x	A1	x	$\Delta T1$
4492755,757	=	2270	x	A1	x	24,79305547
A1	=	79,82830356	m ²			

Effect 2

q2	=	U2	x	A2	x	$\Delta T2$
----	---	----	---	----	---	-------------

$$4598629,301 = 1705 \times A2 \times 33,00893602$$

$$A2 = 81,70948872 \text{ m}^2$$

$$\begin{aligned} \% \text{ Beda} &= (\frac{A1}{79,82830356} - \frac{A2}{81,70948872}) / \frac{A1}{79,82830356} \times 100,00 \quad X \quad 100\% \\ &= (\frac{-1,88118516}{-0,023565391} \times 100,00) / 100,00 \quad X \quad 100,00 \quad X \quad 100\% \\ &= -2,356539067 \% \end{aligned}$$

std dibawah 10 % (geankoplis)

Effect 2

F	x	hf	+	V1	x	λs2	=
L1	x	hl1	+	V2	x	h2	
25176,02638	x	136,4843642	+	6777,582448	x	2442,62102	=
18682,87225	x	167,6669907	+	6493,154131	x	2596,380433	
3436133,952	+	16555065,35	=	3132500,968	+	16858698,34	
		19991199,3	=	19991199,3			

Effect 1

L1	x	hl1	+	S	x	λs1	=
L2	x	hl2	+	V1	x	h1	
18682,87225	x	167,6669907	+	7302,495555	x	2214,8484	=

$$\begin{array}{rclcl}
 11905,2898 & \times & 231,1036738 & + & 6777,582448 & \times & 2442,62102 \\
 3132500,968 & + & 16173920,6 & = & 2751356,21 & + & 16555065,35 \\
 & & 19306421,56 & = & 19306421,56 & &
 \end{array}$$

EFFECT 1

	Masuk (kkal/jam)	Keluar (kkal/jam)
Q L1	748.667,73	657.574,13
Q STEAM	3.865.567,02	3.956.660,62
TOTAL	4.614.234,75	4.614.234,75

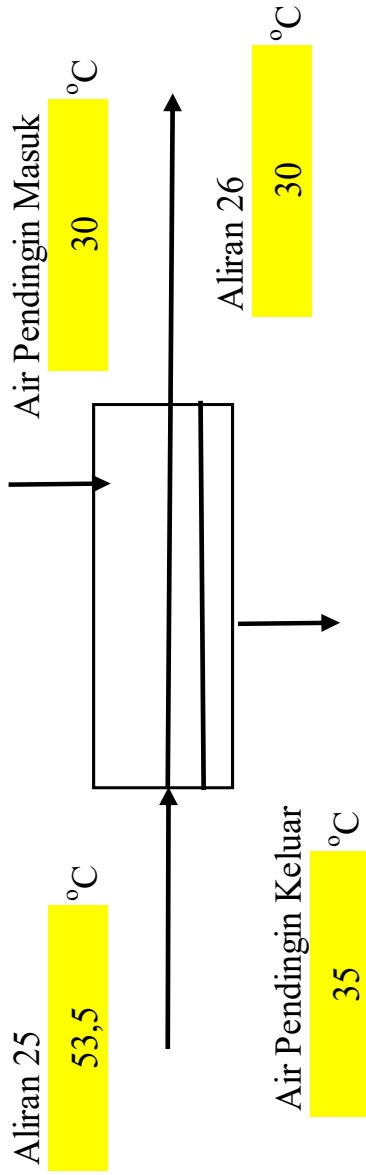
EFFECT 2

	Masuk (kkal/jam)	Keluar (kkal/jam)
Q F	821.236,01	748.667,73
Q V1	3.956.660,62	4.029.228,90
TOTAL	4.777.896,63	4.777.896,63

OVERALL

	Masuk (kkal/jam)	Keluar (kkal/jam)
Q F	821.236,01	657.574,13
Q STEAM	3.865.567,02	4.029.228,90
TOTAL	4.686.803,04	4.686.803,04

8. Neraca panas Cooler



Panas Masuk dari Evaporator

Panas Bahan masuk		53,5 °C					
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal	
Aliran 25							
Glukosa C ₆ H ₁₂ O ₆	8.206,79	0,29	25	53,5	28,5	67.829,16	
Maltosa C ₆ H ₂₂ O ₁₁	126,91	0,32	25	53,5	28,5	1.157,41	
H ₂ O	3.571,59	1	25	53,5	28,5	101.790,23	
Total						170.776,79	

Panas Bahan keluar		30 °C					
Komponen	Massa	CP	T1(ref)	T2	ΔT	Q= M.Cp.ΔT	
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal	
Aliran 26							
Glukosa C ₆ H ₁₂ O ₆	8.206,79	0,29	25	30	5	11.899,85	
Maltosa C ₆ H ₂₂ O ₁₁	126,91	0,32	25	30	5	203,05	
H ₂ O	3.571,59	1	25	30	5	17.857,93	
Total						29.960,84	

Air Pendingin yang Dibutuhkan
Mencari Kebutuhan Air Pendingin

Suhu Air Pendingin Masuk = 30 °C

Suhu Air Pendingin Keluar = 35 °C

Panas Masuk = Panas Keluar

Panas Umpam = Panas Produk + Panas Yang Diserap Air Pendingin

Q Diserap Air Pendingin = Q Umpam - Q Produk

= 170.776,79 - 29.960,84

= 140.815,95 kkal

Q Diserap Air Pendingin =

Komponen	Massa	CP	T1	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	28.163,19	1	30	35	5	140.815,95

Q_{Ap.in} =

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	28.163,19	1	30	25	5	140.815,95

Air Pendingin yang Dibutuhkan
Mencari Kebutuhan Air Pendingin

Suhu Air Pendingin Masuk = 30 °C

Suhu Air Pendingin Keluar = 35 °C

Panas Masuk = Panas Keluar

Panas Umpam = Panas Produk + Panas Yang Diserap Air Pendingin

Q Diserap Air Pendingin = Q Umpam - Q Produk

= 170.776,79 - 29.960,84

= 140.815,95 kkal

Q Diserap Air Pendingin =

Komponen	Massa	CP	T1	T2	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	28.163,19	1	30	35	5	140.815,95

Q_{Ap.in} =

Komponen	Massa	CP	T1	Tref	ΔT	Q= M.Cp.ΔT
	Kg	Kkal/Kg°C	°C	°C	°C	Kkal
H ₂ O	28.163,19	1	30	25	5	140.815,95

Qap.Out

Komponen	Massa	CP	T2	Tref	ΔT	Q= M.Cp. ΔT
	Kg					Kkal
H ₂ O	28.163,19	1	35	25	10	281.631,90

Masuk (kkal/jam)		Keluar (kkal/jam)				
Aliran 25 Glukosa C ₆ H ₁₂ O ₆		Aliran 26 Glukosa C ₆ H ₁₂ O ₆				
Glukosa C ₆ H ₁₂ O ₆	67.829,16	Glukosa C ₆ H ₁₂ O ₆				
Maltosa C ₆ H ₂₂ O ₁₁	1.157,41	Maltosa C ₆ H ₂₂ O ₁₁				
H ₂ O	101.790,23	H ₂ O				
QAp.in	140.815,95	QAp.Out				
TOTAL	311.592,74	TOTAL				
		311.592,74				

LAMPIRAN C
SPEKIFIKASI ALAT

1.Mixing Tank

kondisi operasi

Suhu	:	30	°C	=	86	°F
Tekanan	:	760	mmhg	=	1	atm
Waktu Feeding	:	1	jam	=	1	jam
Waktu Pengadukan	:	1	jam	=	1	jam
Waktu Discharge	:	1	jam	=	1	jam
Jumlah Alat	:	3				

Mixing Tank

Komponen	Masuk			Keluar		
	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)
Pati ($C_6H_{10}O_5$) _{1.000.000}	7.850,07	1,53	5.130,76	7.850,07	1,53	5.130,76
Protein	61,12	0,51	119,85	61,12	0,51	119,85
Lemak	17,46	0,90	19,40	17,46	0,90	19,40
Serat Kasar	17,46	1,30	13,43	17,46	1,30	13,43
H ₂ O	18.249,88	1,00	18.249,88	18.249,88	1,00	18.249,88

Ca(OH) ₂		2,91		2,20	1,32	2,91	2,20	1,32
Total		26.198,91	1,11		23.534,65	26.198,91	1,11	23.534,65

ρ campuran

=

1,113

kg/Liter

=

1.113,21

kg/m³

=

69,495

lbm/ft³

μ Campuran

=

847,03

Cp

=

0,84703

kg/ms

=

0,569

lb/ft.s

Perhitungan Dimensi Tangki

V campuran

=

23.534,653

liter

=

831,1139406

ft³

=

23,5346535

m3

V campuran

=

Volume tangki

X

75

%

Volume tangki

=

831,11

ft³

:

75

%

=

1108,15

ft³

Ls

Hb

=

1,5

D

Hb

=

0,169

D

1,5

D

=

Ls

+

0,169

D

1,331

D

=

Ls

Ls

+

=

14,904742

=

4,54

m

Volume tangki

=

Volume shell

+

Volume tutup Bawah

=

π/4

x

D²

x

Ls

+

0,0847

x

D³

$$\begin{aligned}
&= 0,785 \times D^2 \times Ls + 0,0847 \times D^3 \\
&= 0,785 \times D^2 \times 1,331 + 0,0847 \times D^3 \\
&= 0,785 \times 1,331 + 0,0847 \times D^3 \\
&= 1,04484 + 0,0847 \times D^3 \\
1108,15 &= 1,12954 + D^3 \\
D &= 9,93649 \text{ ft} = 3,03 \text{ m} = 119,24 \text{ in}
\end{aligned}$$

Mencari Tinggi Liquid dalam Shell

$$\begin{aligned}
\text{Volume Liquid} &= \text{Volume Liquid dalam Shell} + \text{Volume Liquid dalam Tutup Bawah} \\
831,1139406 &= \pi/4 \times D^2 \times HI + HI + 0,0847 \times D^3 \\
&= 0,785 \times 98,7339 \times HI + HI + 9,93649466 \\
HI &= 10,595 \text{ ft} = 3,23 \text{ m} = 127,14 \text{ in}
\end{aligned}$$

Menentukan Tekanan Desain (P_d)

Tekanan operasi tangki sama dengan tekanan atmosfer ditambah dengan tekanan parsial bahan

$$\begin{aligned}
PH &= p_H : 144 \\
&= 69,495 \times 10,595 : 144 \\
&= 5,113 \text{ psia} \\
P_{\text{operasi}} &= 1 \text{ atm} = 14,70 \text{ psia} \\
Pd &= 1,1 \times PH + P_{\text{operasi}} \\
&= 1,1 \times 5,113 + 14,70
\end{aligned}$$

$$= 21,790 \text{ psia}$$

$$= 7,094 \text{ psig}$$

Tebal silinder

$$r_i = 60 \text{ in}$$

$$f = 18.750 \text{ psia} \quad \text{allowable stress SA 167 grade 11 type 316}$$

$$E = 0,80 \quad \text{Double welded butt joint}$$

$$P_i = 7,09 \text{ psig}$$

$$C = 0,125 \quad 2 / 16 \text{ factor korosi}$$

$$ts = \frac{P_i \times r_i}{(f \times E) - P_i} + C$$

$$ts = \frac{7,094 \times 59,6}{18.750 \times 0,800 - 7,094} + \frac{2}{16}$$

$$ts = \frac{422,94}{15.000 - 4,256} + \frac{2}{16}$$

$$ts = 0,028 + \frac{1}{16} \text{ in}$$

$$ts = 0,153 \text{ in} \quad 3 \quad 16 \quad 0,1875$$

$$OD = ID + 2 \times ts$$

$$= 119,238 + 2 \times 0,188$$

$$= 119,613 \text{ in} \quad 126 \text{ in}$$

ID baru

$$\begin{aligned}
 ID &= OD - 2 \times ts \\
 &= 126 - 0,375 \\
 &= 125,63 \text{ in} = 3,19 \text{ m} = 10,47 \text{ ft} \\
 &=
 \end{aligned}$$

Tebal tutup (standart dished)

$$\begin{aligned}
 th &= \frac{0,885 \times Pi \times r}{(1 \times E) - 0,1 \times Pi} + C \\
 th &= \frac{0,885 \times 7,094 \times 62,813}{18750,0 \times 0,800 - 0,1 \times 7,094} + 0,125 \\
 th &= \frac{394,3552427}{15000,0 - 0,709} + 0,125 \\
 th &= 0,151 \text{ in} >>>> 3/16 \text{ in} \quad 0,19 \quad 0,48
 \end{aligned}$$

Perhitungan pengaduk

Perhitungan pengaduk

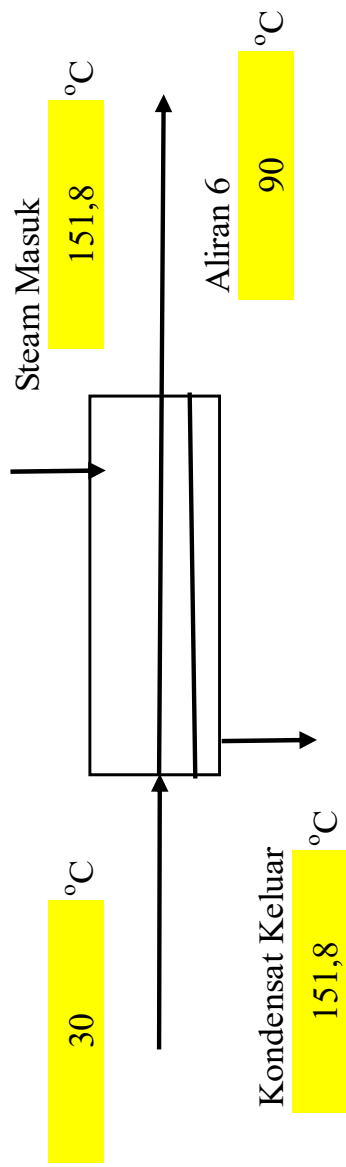
jenis : Pengaduk dengan 6 blade turbin

Dimensi Impeler direncanakan sebagai berikut

Dimeter impeler (Da)	=	0,3	x	ID tangki	
	=	0,3	x	10,47	
	=	3,14078	ft =	0,96	m = 37,69 in
Lebar pengaduk (W)	=	0,2	x	Da	
	=	0,2	x	3,14	
	=	0,62816	ft =	0,19	m = 7,54 in
Digunakan 4 buah baffle dengan lebar					
Lebar baffle (J)	=	0,08333	x	ID tangki	
	=	0,08333	x	10,47	
	=	0,87244	ft =	0,27	m = 10,47 in
Jarak Pengaduk (Dt)	=	0,3	x	10,47	
Kedasar Tangki	=	3,14078	ft =	0,96	m = 37,69 in
RPM	=	100			
RPS	=	1,7			
Nre	=	ρ	x	N	x
	=	1.113,21	x	1,667	x
	=	2.007,39			
				Da ²	/
				0,916	/
				0,84703	
				μ	

$$\begin{aligned}
 N_p &= 4 \\
 P &= N_p \times \rho \times N^3 \times Da^5 \\
 &= 4 \times 1.113,21 \times 4,630^3 \times 0,80 \\
 &= 16.574,8 \text{ Watt} = 22,2 \text{ HP} \\
 \text{Eff Motor} &= 80 \% \\
 \text{Power motor act} &= 28 \text{ Hp} = 30 \text{ Hp} = 22 \text{ kw}
 \end{aligned}$$

2.Heater



1. Heat Balance

$$\begin{array}{rclcl} \text{Panas Umpan} & + & \text{Panas Steam} = & \text{Panas Produk} & + & \text{Panas Kondensat} & + & \text{Panas Yang Hilang} \\ 114841,637 & & 1.890.904 & 1492941,28 & & 440.272,84 & & 72.531,56 \text{ kkal} \end{array}$$

$$\begin{array}{rcl} \text{Panas} & = & 1378099,642 \text{ Kkal/jam} = 5.465.088,41 \text{ btu/jam} \\ \text{Umpan} & = & 27.785,48 \text{ kg/jam} 61.256,43 \text{ lb/jam} \\ \text{M steam} & = & 2.878,36 \text{ kg/jam} 6.345,70 \text{ lb/jam} \end{array}$$

2. LMTD

T1	151,8 °C	305,2362556 °F	t1	30 °C	86 °F	Tbesar adalah hot
T2	151,8 °C	305,2362556 °F	t2	90 °C	194 °F	t kecil adalah cold

Hot Fluid		Cold Fluid	Diff
305,2363	Higher temp	90	215,2 Δt ₂
305,2363	Lower temp	30	275,2 Δt ₁
			-60,0 Δt ₂ - Δt ₁

$$\begin{array}{rcl} \text{LMTD} & = & \Delta t_2 - \Delta t_1 / 2,3 \log(\Delta t_2 / \Delta t_1) \\ & = & -60,0 / -0,245617489 \\ & = & 244,3 \text{ °F} \end{array}$$

3. Caloric temperatur

$$(\mu/\mu_w)^{0,14} = 1$$

$$\begin{aligned} T_{av} &= 305,2 \text{ } ^\circ\text{F} \\ \text{ukurar } 2 \times 11/4 \text{ Sch } 40 \\ D2 &= 2,067 \text{ in} \\ D1 &= 1,66 \text{ in} \\ \text{surface} &= 0,435 \text{ ft}^2/\text{ft} \\ D &= 1,38 \text{ in} \end{aligned}$$

$$= 245,2 \text{ } ^\circ\text{F}$$

tav

Hot fluid di anulus cold fluid di pipa

Hot fluid : anulus, steam

$$\begin{aligned} D2 &= 2,067 \text{ in} = 0,17225 \text{ ft} \\ D1 &= 1,66 \text{ in} = 0,13833 \text{ ft} \\ aa &= \pi/4 \times D2^2 - D1^2 \\ &= 0,785 \times 0,02967 - 0,01914 \\ &= 0,008269 \text{ ft}^2 \\ De &= D2^2 - D1^2 / D1 \\ &= 0,02967 - 0,01914 / 0,13833 \\ &= 0,076149 \text{ ft} \end{aligned}$$

Mas Vel

Cold fluid :inner pipe, Pati

$$\begin{aligned} D &= 1,38 \text{ in} = 0,115 \text{ ft} \\ ap &= \pi/4 \times D^2 \\ &= 0,785 \times 0,01323 \\ &= 0,01038 \text{ ft}^2 \end{aligned}$$

Mas Vel

$$\begin{aligned} Gp &= W / ap \\ &= 61.256,43 / 0,01038 \\ &= 5.900.466,32 \text{ lb/hr.ft}^2 \end{aligned}$$

Ga	=	W	/	aa		tav	=	245,2	°F
	=	6.345,70	/	0,00827		μ	=	0,682	Cp= 1,65044 lb/ft.hr
	=	767.394,21		lb/hr.ft²		Reynold number			
Tav	=	305,2		°F		Rea	=	D	x
μ	=	0,1		Cp= 0,3146 lb/ft.hr			=	0,01038	x
Reynold number							=	37.115	
Rea	=	De	x	Ga	/	JH	=	100	
	=	0,076149	x	767.394,21	/				
	=	185.748							
JH	=	350							
Ho	=	1500		btu/jam					
Tav	=	245,2		°F					
c	=	0,78		Btu/lb°F					
k	=	0,0185		Btu/hr.ft²°F.ft					
(C.μ/k)¹/³	=	23,195							
Hi	=	jH	x	(k/D)	x	C.μ/k)¹	x	(μ/μw)⁰,¹⁴	
	=	100	x	0,16086957	x	#####	x	1	

$$\begin{aligned}
 &= 373 \text{ Btu/hr.ft}^2\text{°F} \\
 \text{Hio} &= \text{Hi} \times \text{ID} / \text{OD} \\
 &= 373,143 \times 0,115 / 0,138 \\
 &= 310,203 \text{ Btu/hr.ft}^2\text{°F} \\
 \text{Clean Overall Coefficient} \\
 \text{Uc} &= \text{Hio} \times \text{Ho} / \text{Hio} + \text{Ho} \\
 &= 310,203 \times 1500 / 310,203 + 1500 \\
 &= 465304,771 / 1810,203 \\
 &= 257,046 \text{ Btu/hr.ft}^2\text{°F} \\
 \text{Design Overall coefsi}>>> \text{RD} &= 0 \\
 1/\text{Ud} &= 1/\text{Uc} + \text{Rd} \\
 &= 0,004 + 0 \\
 &= 0,007 \\
 \text{Ud} &= 145,1 \text{ Btu/hr.ft}^2\text{°F} \\
 \text{Required Surface} \\
 \text{A} &= \text{Q} / \text{Ud} \times \Delta\text{T} \\
 &= 5.465.088,41 / 145,130293 \times \text{##} \\
 &= 154,15 \text{ Ft}^2 \\
 \text{Standart} \\
 \text{Max A} &= 120 \text{ Ft}^2
 \end{aligned}$$

1 Hairpin	=	24	Ft	
		30	Ft	
		40	Ft	

Heater dibuat 2				
masing- masing A	=	77,08	Ft ²	
Kebutuhan Panjang	=	77,08	/	0,44 ft ² /ft
	=	177,19	Ft	
Jumlah Hairpin	=	4,429634709		
	=	5		
Panjang Pipa Baru	=	5	x	40
	=	200	Ft	
Luas Pipa Baru	=	200	x	0,44
	=	87	Ft ²	
untuk 2 Heater	=	174	Ft ²	
Ud	=	Q	/	A ΔT
	=	5.465.088,41	/	174 244,3
	=	128,57		
Rd	=	1/Ud - 1/Uc		
	=	0,01 - 0		

$$= 0,0038872$$

Pressure drop

$$\begin{aligned} \text{De}' &= \text{D2} - \text{D1} \\ &= 0,17225 - 0,13833 \\ &= 0,033917 \text{ ft} \end{aligned}$$

Reynold number

$$\begin{aligned} \text{Rea}' &= \text{De}' \times \text{Ga} / \mu \\ &= 0,033917 \times 383.697,10 / 0,3146 \\ &= 41.366 \end{aligned}$$

menghitung friksi

$$\begin{aligned} f &= 0,0035 + 0,264 / \text{N}_{\text{re}}^{0,42} \\ &= 0,0035 + 0,264 / 87 \\ &= 0,00654 \end{aligned}$$

Mencari ΔP karena panjang anulus

$$\rho = 62,5 \text{ lb/cuft}$$

Δf_a	=	4	x	f	x	G_{an}^2	L
		2	+	g	x	ρ^2	De'
Δf_a	=	4	x	0,00654	x	36.805.866.737,51	200
		2	+	480000000	x	3.906,3	0,03392

$$\begin{aligned}
 &= 1,92515\text{E}+11 \quad / \quad 63.593.750.002 \\
 &= 3,027259501 \quad \text{ft} \\
 V &= \frac{G}{3600} \times \rho \\
 &= \frac{383697,1}{3600} \times 62,5 \\
 &= 1,7 \quad \text{ft/s} \\
 \text{ft} &= \frac{3}{3} \times \frac{V^2}{2,9} \times \frac{g}{32,2} \\
 &= 0,135471 \\
 \Delta p_a &= \frac{\Delta f_a}{3,02726} + \frac{\text{ft}}{0,135471329} \times \rho \\
 &= 1,372713 \quad \text{psi}
 \end{aligned}$$

$$\begin{aligned}
 D &= 0,115 \quad \text{ft} \\
 \text{Rea}' &= \frac{D}{0,115} \times \frac{G_p}{1.966.822,11} \times \frac{\mu}{1,65044} \\
 &= 137.045 \\
 &\text{menghitung friksi} \\
 f &= 0,0035 + \frac{0,264}{0,264} \times \frac{N_{re}^{0,42}}{144}
 \end{aligned}$$

$$\begin{aligned}
 &= 3 \times 2,9 / 2 \times 32,2 \\
 &= 0,135471 \\
 \Delta p_a &= \Delta f_a + \text{ft} \times \rho / 144 \\
 &= 3,02726 + 0,135471329 \times 62,5 / 144 \\
 &= 1,372713 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 D &= 0,115 \text{ ft} \\
 Re_a' &= D \times G_p / \mu \\
 &= 0,115 \times 1.966.822,11 / 1,65044 \\
 &= 137.045
 \end{aligned}$$

menghitung friksi

$$\begin{aligned}
 f &= 0,0035 + 0,264 / N_{re}^{0,42} \\
 &= 0,0035 + 0,264 / 144 \\
 &= 0,00534
 \end{aligned}$$

Mencari ΔP karena panjang Pipa

$$\rho = 69,5 \text{ lb/cuft}$$

Δf_a	=	4	x	f	x	G_p^2	x	L
		2	+	g	x	ρ^2	x	De'
Δf_a	=	4	x	0,00534	x	967.097.299,968,19	x	200
		2	+	480000000	x	4.829,6	x	0,115

$$\begin{aligned}
 &= 4,12916\text{E}+12 \quad / \quad 266.592.919.055,5 \\
 &= 15,48862845 \quad \text{ft} \\
 V &= G \quad / \quad 3600 \quad \times \quad \rho \\
 &= 1.966.822 \quad / \quad 3600 \quad \times \quad 69,5 \\
 &= 7,9 \quad \text{ft/s} \\
 \text{ft} &= 3 \quad \times \quad V^2 \quad / \quad 2 \quad \times \quad g \\
 &= 3 \quad \times \quad 61,8 \quad / \quad 2 \quad \times \quad 32,2 \\
 &= 2,879062 \\
 \Delta p_a &= \Delta f_a \quad + \quad \text{ft} \quad \times \quad \rho \quad / \quad 144 \\
 &= 15,48863 \quad + \quad 2,879061989 \quad \times \quad 69,5 \quad / \quad 144 \\
 &= 8,864349 \quad \text{psi}
 \end{aligned}$$

3. Reaktor dekrinasi/ liquifikasi

Fungsi : Mengkonversi pati menjadi Dekstrin

kondisi operasi

Suhu : 90 °C = 194 °F
 Tekanan : 760 mmhg = 1 atm
 Waktu Feeding : 1 jam = 1 jam
 Waktu Pengadukan : 3 jam = 3 jam
 Waktu Discharge : 1 jam = 1 jam
 Jumlah Alat : 5

Reaktor dekrinasi/ liquifikasi

Komponen	Masuk			Keluar		
	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)
Pati ($C_6H_{10}O_5$) _{1.000.000}	7.850,07	1,53	5.130,76	-		
Protein	61,12	0,51	119,85	61,12	0,51	119,85
Lemak	17,46	0,90	19,40	17,46	0,90	19,40
Serat Kasar	17,46	1,30	13,43	17,46	1,30	13,43
H ₂ O	18.249,88	1,00	18.249,88	18.249,88	1,00	18.249,88
Ca(OH) ₂	2,91	2,20	1,32	2,91	2,20	1,32
α -Amilase	8,16	1,20	6,80	8,16	1,04	7,85
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	-			7.850,07	1,04	7.562,69
Total	26.207,07	1,11	23.541,46	26.207,07	1,01	25.974,43

$$\begin{aligned}
 \rho \text{ campuran} &= 1,009 \text{ kg/Liter} = 1.008,96 \text{ kg/m}^3 &= 62,987 \text{ lbm/ft}^3 \\
 \mu \text{ Campuran} &= 847,03 \text{ Cp} = 0,84703 \text{ kg/ms} &= 0,569 \text{ lb/ft.s} \quad \text{acuan viskositas in}
 \end{aligned}$$

Perhitungan Dimensi Tangki

$$V \text{ campuran} = 25.974,426 \text{ liter} = 917,27323 \text{ ft}^3 = 25,9744261 \text{ m}^3$$

$$V \text{ campuran} = \text{Volume tangki} \times X \quad 75\%$$

$$\text{Volume tangki} = 917,27 \text{ ft}^3 : 75\% = 1223,03 \text{ ft}^3$$

$$L_s + H_b = 1,5 \text{ D}$$

$$H_b = 0,169 \text{ D}$$

$$1,5 \text{ D} = L_s \quad 0,169 \text{ D}$$

$$1,331 \text{ D} = L_s$$

$$L_s + H_b = 15,403$$

$$\text{Volume tangki} = \text{Volume shell} + \text{Volume tutup Bawah}$$

$$\begin{aligned}
 &= \pi/4 \times D^2 \times L_s + 0,0847 \times D^3 \\
 &= 0,785 \times D^2 \times L_s + 0,0847 \times D^3 \\
 &= 0,785 \times D^2 \times 1,33 \text{ D} + 0,0847 \times D^3 \\
 &= 0,785 \times 1,331 \text{ D}^3 + 0,0847 \times D^3 \\
 &= 1,0448 \text{ D}^3 + 0,0847 \times D^3
 \end{aligned}$$

$$\begin{aligned}
 1223,03 &= 1,1295 & D^3 &= \\
 D &= 10,269 \text{ ft} & &= 3,13 & &= 123,22 \text{ in} \\
 Hb &= 1,7354 \text{ ft} & &= 0,53 & &= 20,82 \text{ in} \\
 \text{Total H tangki} &= 15,403 \text{ ft} & &= 4,69 & &= 184,84 \text{ in}
 \end{aligned}$$

Mencari Tinggi Liquid dalam Shell

$$\begin{aligned}
 \text{Volume Liquid} &= \text{Volume Liquid dalam Shell} & \text{Volume Liquid dalam Tutup Bawah} \\
 917,2732302 &= \pi/4 \times D^2 \times HI + 0,0847 \times D^3 \\
 &= 0,785 \times 105,4448 \times HI + 10,26863194 \\
 HI &= 10,958 \text{ ft} & &= 3,34 & &= 131,49 \text{ in}
 \end{aligned}$$

Menentukan Tekanan Desain (P_d)

Tekanan operasi tangki sama dengan tekanan atmosfer ditambah dengan tekanan parsial bahan

$$\begin{aligned}
 PH &= \rho H : 144 \\
 &= 62,987 \times 10,958 : 144 \\
 &= 4,793
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{operasi}} &= 1 & &= 14,70 \text{ psia} \\
 Pd &= 1,1 \times PH + P_{\text{operasi}} \\
 &= 1,1 \times 4,793 + 14,70 \\
 &= 21,438 \text{ psia} \\
 &= 6,742 \text{ psig}
 \end{aligned}$$

Tebal silinder

$$\begin{aligned}
 r_i &= 62 \\
 f &= 18.750 \quad \text{allowable stress SA 167 grade 11 type 316} \\
 E &= 0,80 \quad \text{Double welded butt joint} \\
 P_i &= 6,74 \\
 C &= 0,125 \quad / \quad 16 \text{ factor korosi}
 \end{aligned}$$

$$\begin{aligned}
 t_s &= \frac{\left(\frac{P_i}{f E} \right) - r_i}{C} + C \\
 t_s &= \frac{6,742}{18.750} - \frac{61,6}{0,600} + \frac{2}{16} \\
 t_s &= \frac{415,38}{15.000} + \frac{2}{16} \\
 t_s &= 0,028 \quad \text{in} \\
 t_s &= 0,153 \quad \text{in} \quad 3 \quad 16 \quad 0,1875
 \end{aligned}$$

$$\begin{aligned}
 OD &= ID \quad 2 \quad x \quad t_s \\
 &= 123,224 \quad 2 \quad x \quad 0,188 \\
 &= 123,599 = 132 \quad \text{in} = 3,35 \quad \text{m} = 11,00 \quad \text{ft} \\
 ID \text{ baru} & \\
 ID &= OD \quad 2 \quad x \quad t_s \\
 &= 132 \quad 0,375 \\
 &= 131,63 = 3,34 \quad \text{m} = 10,97 \quad \text{ft}
 \end{aligned}$$

Tebal tutup

$$\begin{aligned}
 \text{th} &= \frac{0,885 \times \left(\frac{\text{Pi} \times \text{r}}{\text{E}} - 0,1 \times \text{Pi} \right) + \text{C}}{18750,0 \times \frac{0,885 \times 6,742 \times 65,813}{0,800 - 0,1 \times 6,742} + 0,125} \\
 &= \frac{392,6727028}{15000,0 - 0,674} + 0,125 \\
 \text{th} &= 0,151 \text{ in} >>>> 3/16 \text{ in} \quad 0,19 \quad 0,48
 \end{aligned}$$

Perhitungan pengaduk

Perhitungan pengaduk

jenis : Pengaduk dengan 6 blade turbin

Dimensi Impeler direncanakan sebagai berikut

$$\begin{aligned}
 \text{Dimeter impeler (Da)} &= 0,3 \times \text{D tangk} \\
 &= 0,3 \times 10,97 \\
 &= 3,29079 \text{ ft} = 1,00 \text{ m} = 39,49 \text{ in} \\
 \text{Lebar pengaduk (W)} &= 0,2 \times \text{Da} \\
 &= 0,2 \times 3,29 \\
 &= 0,65816 \text{ ft} = 0,20 \text{ m} = 7,90 \text{ in}
 \end{aligned}$$

Digunakan 4 buah baffle dengan lebar

$$\begin{aligned} \text{Lebar baffle (J)} &= 0,08333 \times D \text{ tangk} \\ &= 0,08333 \times 10,97 \\ &= 0,91411 \text{ ft} = 0,28 \text{ m} = 10,97 \text{ in} \end{aligned}$$

Jarak Pengaduk (Dt)

Kedasar Tangki

$$\begin{aligned} \text{RPM} &= 100 \\ \text{RPS} &= 1,7 \\ \text{Nre} &= \rho \times N \times Da^2 / \mu \\ &= 1.008,96 \times 1,667 \times 1,006 / 0,84703 \\ &= 1.997,35 \\ \text{Np} &= 4 \\ \text{P} &= \text{Np} \times \rho \times N^3 \times Da^5 \\ &= 4 \times 1.008,96 \times 4,630 \times 1,02 \\ &= 18.969,5 \text{ Watt} = 25,4 \text{ HP} \\ \text{Eff Motor} &= 80 \% \\ \text{Power motor act} &= 32 \text{ Hp} = 40 \text{ Hp} = 30 \text{ kw} \end{aligned}$$

Perhitungan Jacket									
Anullus air pendingin									
ODR	=	11	ft	=	3,35	ft	=	132	in
Spasi Annulus	=	0,10	ft	=	0,03	ft	=	1	in
IDJ	=	ODR	+	2	x	Spasi Annulus			
	=	11,0	+	2	x	0,10			
	=	11,2	ft	=	3,41	ft	=	134	in
ri	=	IDJ	/	2					
	=	11,200	/	2					
	=	5,600	ft	=	1,71	ft	=	67	in
Flow Area (s)	=	$\pi/4$	x	IDJ ²	-	ODR ²			
	=	0,785	x	125,4	-	121			
	=	3,49	ft ²	=	0,32	ft ²	=	207	in ²
D equivalen (De)=		IDJ ²	-	ODR ²	/	ODR			
	=	125,4	-	121	/	11			
	=	0,4	ft	=	0,12	ft	=	5	in
Tebal silinder									
ri	=	67	in						
f	=	18.750	psia			allowwable stress SA 167 grade 11 type 316			
E	=	0,80				Double welded butt joint			
Pi	=	0,40	psig						

$$\begin{aligned}
 C &= 0,125 \quad / \quad 16 \text{ factor korosi} \\
 \text{Rate Air} &= \frac{6.045,37}{\left(\frac{f \times E}{\text{Pi} \times \text{ri}} \right) - 0,600 \times \text{Pi}} \quad \text{kg/jam} \quad 3 \\
 \text{ts} &= \frac{0,404 \times 67,2}{18.750 \times 0,800 - 0,600 \times 0,404} \quad + \quad \frac{C}{2/16} \\
 \text{ts} &= \frac{27,12}{15.000 - 0,242} + \frac{2/16}{0,002 + 1/16} \quad \text{in} \\
 \text{ts} &= \frac{0,127}{3/16} \quad \text{in} \quad 3 \quad 16 \quad 0,1875 \\
 \text{OD} &= \text{ID} + 2 \times \text{ts} \\
 &= 134,400 + 2 \times 0,188 \\
 &= 134,775 \quad \text{in}
 \end{aligned}$$

Kecepatan aliran air

$$\begin{aligned}
 w &= 6.045,4 \text{ kg/jam} = 13.327,7 \text{ lbm/jam} \\
 \theta &= 995,7 \text{ kg/m}^3 = 62 \text{ lbm/ft}^3 \text{ pada } 30^\circ \text{C} \\
 \mu \text{ air} &= \frac{1}{w} \times \frac{C_p}{\theta} = \frac{0,001}{0,001} \times \frac{\text{kg/ms}}{\text{s}} = 0,001 \text{ lb/ft.s} \\
 v &= \frac{13327,7}{61,5} \times \frac{216,7}{0,01709} \text{ ft/s} \\
 \text{Nre} &= \frac{\theta}{De} \times \frac{v}{\mu}
 \end{aligned}$$

	=	62,16	x	0,404	x	0,017	/	0,001
	=	638,03						
Mencari Ho	=							
Nre	=	638,03		>>>>>	J	=	25,00	
k	=	0,36		BTU/hr.ft°C				
c	=	0,9987						
Ho	=	jH		x	(k/De)	x	(C.λ/k) ^{1/3}	x
	=	25,00		x	0,89189189	x	0,7404251	x
	=	16,51		BTU/hr.ft ² °C				(λ/λ _w) ^{0,14} 1
Mencari Hi	=							
Nre	=	1.997,35		>>>>>	J	=	60,00	
k	=	0,36		BTU/hr.ft°C				
c	=	0,9987						
Hi	=	jH		x	(k/De)	x	(C.λ/k) ^{1/3}	x
	=	60,00		x	0,89189189	x	0,7404251	x
	=	39,62		BTU/hr.ft ² °C				(λ/λ _w) ^{0,14} 1
Hio	=	Hi		x	IDR/ODR			
	=	16,51		x	1,00			
	=	16,46		BTU/hr.ft ² °C				

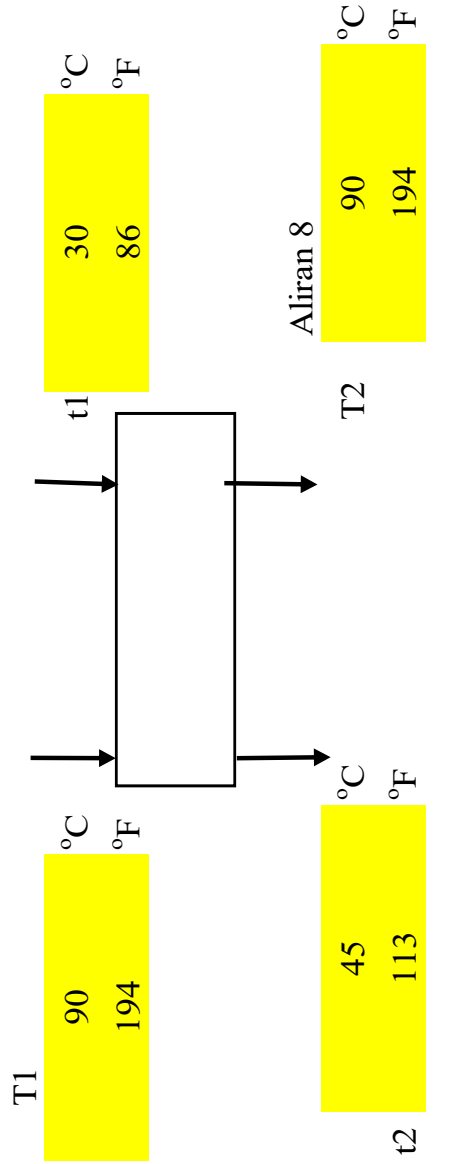
$$U_c = \frac{h_{io} h_{ho}}{271,79} = \frac{h_{io} + h_{ho}}{32,97}$$

$$R_d = \frac{0,003}{8,24}$$

$$\frac{1}{U_d} = \frac{1}{U_c} + R_d = \frac{1}{0,12132} + \frac{1}{0,003}$$

$$U_d = \frac{1}{0,124} = \frac{1}{8,044}$$

Mencari luas perpindahan panas



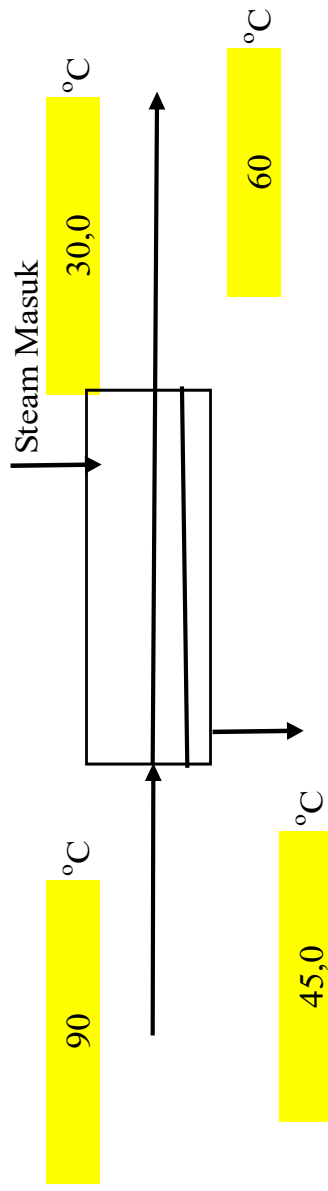
	Hot Fluid	Cold Fluid	Diff
High Temp	194	113	81

	Low Temp	194	86	108
$\Delta LMTD$	=	-27,000 /	-0,288	
	=	93,854 °F		
Q	=	$Ud \times A \times \Delta t$		
Q	=	90.680,56 kkal	=	359.609,19 BTU
A	=	$359.609,19 /$	$8,044 \times$	$93,854$
	=	476,33 ft ²		

Tinggi perpindahan Panas Pada Jacket

A	=	$\pi \times ID \times H$	+	A_{dish}
A_{dish}	=	$6,28 \times Rc \times b$		
	=	$6,28 \times 5,50028 \times 1,7354$		
	=	59,9437 ft ²		
H	=	$A - A_{dish} /$	$\pi \times$	ID
	=	$476,3 - 59,9437 /$	$3,14 \times$	$10,97$
	=	$416,4 /$	$34,4436$	
	=	12,1 ft	VS	Total Tinggi Tangki =
				15,4 ft

4. Cooler
 Fungsi : Menurunkan temperatur dari reaktor liquifikasi



1. Heat Balance

Panas Umpan	+	Panas air masuk	=	Panas Produk	+	Panas keluar
1962591,552	+	218.065,73	=	1308394,368	+	872.262,91

Panas	=	654197,1841	Kkal/jam	=	2.594.330,15	btu/jam
Umpan	=	27.794,14	kg/jam		61.275,52	lb/jam
M air	=	43.613,15	kg/jam		96.150,41	lb/jam
						anulus

2. LMTD

T1	90,0	°C	194	°F	t1	30,0	°C	86	°F	Tbesar adalah hot
T2	60,0	°C	140	°F	t2	45,0	°C	113	°F	t kecil adalah cold

Hot Fluid	Cold Fluid	Diff
194	Higher temp 113	81,0 Δt ₂
140	Lower temp 86	54,0 Δt ₁
		27,0 Δt ₂ .Δt ₁

LMTD = $\Delta t_2 - \Delta t_1$ / 2,3log(Δt2 /Δt1)

= 27,0 / 0,405009896

= 66,7 °F

3. Caloric temperatur

(μ/μw)^{0,14} = 1

Tav = 167,0 °F tav = 67,5

ukuran 3 x 11/4 Sch 40

D2 = 3,068 in

D1 = 1,66 in

surface = 0,345 ft2/ft

D = 1,38 in

Hot fluid di anulus cold fluid di pipa

Hot fluid : anulus, dekstrin

$$\begin{aligned}
 D2 &= 3,068 \quad i= \quad 0,25567 \quad \text{ft} \\
 D1 &= 1,66 \quad i= \quad 0,13833 \quad \text{ft} \\
 aa &= \pi/4 \quad \times \quad D2^2 \quad - \quad D1^2 \\
 &= 0,785 \quad \times \quad 0,0653654 \quad - \quad 0,01914 \\
 &= 0,03629003 \quad \text{ft}^2 \\
 De &= D2^2 \quad - \quad D1^2 \quad / \quad D1 \quad \text{Mas Vel} \\
 &= 0,06536544 \quad - \quad 0,0191361 \quad / \quad 0,13833 \quad \text{Gp} \\
 &= 0,33418795 \quad \text{ft} \\
 \text{Mas Vel} & \\
 Ga &= W \quad / \quad aa \\
 &= 61.275,52 \quad / \quad 0,03629 \\
 &= 1.688.494,69 \quad \text{lb/hr.ft}^2 \\
 Tav &= 167,0 \quad ^\circ\text{F} \\
 \mu &= 2,2 \quad \text{Cps} = \quad 5,324 \quad \text{lb/ft.hr} \\
 \text{Reynold number} & \\
 Rea &= De \quad \times \quad Ga \quad / \quad \mu \\
 &= 0,33418795 \quad \times \quad 1.688.494,69 \quad / \quad 5,3 \\
 &= 105.987
 \end{aligned}$$

Cold fluid :inner pipe, air

$$\begin{aligned}
 D &= 1 \text{ in} = \quad 0,115 \quad \text{ft} \\
 ap &= \tau/2 \times \quad D^2 \\
 &= 1 \times \quad 0,01323 \\
 &= 0 \text{ ft}^2 \\
 & \\
 &= W \quad ap \\
 &= 96.150,4 \quad 0,0104 \\
 &= 9.261.595,66 \quad \text{lb/hr.ft}^2 \\
 tav &= 67,5 \quad ^\circ\text{F} \\
 \mu &= 0,682 \quad C= \quad 1,6498 \quad \text{lb/ft.hr} \\
 \text{Reynold number} & \\
 Rea &= D \quad Gp \quad / \quad \mu \\
 &= 0,0103816 \quad 9.261.595,66 \quad / \quad 1,6498 \\
 &= 58.280 \\
 &= 190 \\
 tav &= 67,5 \quad ^\circ\text{F}
 \end{aligned}$$

JH	=	380						c	=	0,8	Btu/lb°F
								k	=	0	Btu/hr.ft ² °F.ft
Tav	=	167,0	°F					(C.μ/k) ^{1/3}	=	###	
c	=	0,32	Btu/lb°F								
k	=	0,0185	Btu/hr.ft ² °F.ft								
(C.μ/k) ^{1/3}	=	30,697									
		Hi	=	jH	x	(k/D)	x			(C.μ/k) ^{1/3}	μ/μw ^{0,1}
			=	190	x	0,1609	x			23,186	1
			=	709	Btu/hr.ft ² °F						
		Hio	=	Hi	x	ID	/			OD	
			=	708,697	x	0,115	/			0,138	
			=	589,157	Btu/hr.ft ² °F						
Ho	=	jH	x	(k/D)	x	C.μ/k ^{1/4}	x			(μ/μw) ^{0,14}	
	=	380	x	0,05535807	x	30,697	x			1	
	=	646	Btu/hr.ft ² °F								

Clean Overall Coefficient						
Uc	=	Hio	x	Ho	/	Hio + Ho
	=	589,157	x	646	/	589,157 + 646
	=	380444,215		/		1234,900

$$\begin{aligned}
 &= 308,077 \quad \text{Btu/hr.ft}^2\text{°F} \\
 \text{Design Overall coefisien} &>>> \text{RD} = 0 \\
 \frac{1}{\text{Ud}} &= \frac{1}{\text{Uc}} + \text{Rd} \\
 &= 0,00325 + 0,003 \\
 &= 0,00625 \\
 \text{Ud} &= 160,104 \text{ Btu/hr.ft}^2\text{°F} \\
 \text{Required Surface} \\
 \text{A} &= \frac{\text{Q}}{\text{Ud}} \quad \Delta\text{T} \\
 &= \frac{2.594.330,15}{160,103922} \quad 66,7 \\
 &= 243,07 \text{ Ft}^2 \\
 \text{Standart} \\
 \text{Max A} &= 120 \text{ Ft}^2 \\
 \text{1 Hairpin} &= 24 \text{ Ft} \\
 &= 30 \text{ Ft} \\
 &= 40 \text{ Ft} \\
 \text{Heater dibuat 2} \\
 \text{masing- masing A} &= 121,53 \text{ Ft}^2 \\
 \text{Kebutuhan Panjang} &= \frac{121,53}{352,27} \text{ Ft} \\
 &= 0,35 \text{ ft2/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Jumlah Hairpin} &= 8,806757938 \\
 &= 9 \\
 \text{Panjang Pipa Baru} &= 9 \times 40 \\
 &= 360 \text{ Ft} \\
 \text{Luas Pipa Baru} &= 360 \times 0,35 \\
 &= 124,2 \text{ Ft}^2 \\
 \text{untuk 2 Heater} &= 248,4 \text{ Ft}^2 \\
 \text{Ud} &= \frac{Q}{A \times \Delta T} \\
 &= \frac{2.594.330,15}{248 \times 66,7} \\
 &= 156,67 \\
 \text{Rd} &= \frac{1/\text{Ud} - 1/\text{Uc}}{0,006383 - 0,003137} \\
 &= 0,00325 \\
 \text{Pressure drop} & \\
 \text{De}' &= \frac{D2}{D1} \\
 &= \frac{0,25566667}{0,1383333} \\
 &= 0,11733333 \text{ ft} \\
 \text{Reynold number} & \\
 \text{Rea}' &= \frac{\text{De}' \times \text{Ga}}{\mu} \\
 &= \frac{0,11733333 \times 844.247,34}{5,32}
 \end{aligned}$$

$$= 18.606$$

menghitung friksi

$$f = 0,0035 \quad + \quad 0,264 \quad / \quad N_{re}^{0,42}$$

$$= 0,0035 \quad + \quad 0,264 \quad / \quad 62$$

$$= 0,00775$$

Mencari ΔP karena panjang anulus

$$\rho = 62,5 \text{ lb/cuft}$$

Δf_a	=	4	x	f	x	G_{an}^2	x	L
		2	+	g	x	ρ^2	x	De'
Δf_a	=	4	x	0,00775	x	$178.188.394.829$	x	360
		2	+	480000000	x	3.906,3	x	0,117333333
	=	1,98848E+12	/	220.000.000.002,0				
	=	9,038562872	ft					
V	=	G	/	3600	x	ρ		
	=	844247,345	/	3600	x	62,5		
	=	3,8	ft/s					
ft	=	3	x	V^2	/	2	x	g
	=	3	x	14,1	/	2	x	32,2
	=	0,65585791						

$$\begin{aligned}\Delta p_a &= \Delta f_a + \text{ft} \times \rho / 144 \\ &= 9,03856287 + 0,655857906 \times 62,5 / 144 \\ &= 4,20764791 \text{ psi}\end{aligned}$$

$$D = 0,115 \text{ ft}$$

$$\begin{aligned}\text{Rea}' &= D \times G_p / \mu \\ &= 0,115 \times 3.087.198,55 / 1,6498 \\ &= 215.194\end{aligned}$$

menghitung friksi

$$\begin{aligned}f &= 0,0035 + 0,264 / N_{re}^{0,42} \\ &= 0,0035 + 0,264 / 174 \\ &= 0,0050\end{aligned}$$

Mencari ΔP karena panjangPipa

$$\rho = 69,5 \text{ lb/cuft}$$

Δf_a	=	$\frac{4}{2}$	$\times$	f	$\times$	G_p^2	$\times$	L
			+	g	$\times$	ρ^2	$\times$	De'
Δf_a	=	$\frac{4}{2}$	$\times$	$0,00502$	$\times$	$2.382.698.728.268$	$\times$	360
		$\frac{2}{1,72237E+13}$	+	48000000	$\times$	$4.829,6$	$\times$	$0,115$
	=	$1.332.964.595.277,6$						
	=	$12,9 \text{ ft}$						

$$\begin{aligned}
 V &= G / 3600 \times \rho \\
 &= 3.087.198,55 / 3600 \times 69,5 \\
 &= 12,3 \text{ ft/s} \\
 \text{ft} &= 3 \times V^2 / 2 \times \text{g} \\
 &= 3 \times 152,3 / 2 \times 32,2 \\
 &= 7,09333 \\
 \Delta p_a &= \Delta f_a + \rho \times \text{ft} \\
 &= 12,9214 + 69,5 \times 7,093326947 \\
 &= 9,6592 \text{ psi}
 \end{aligned}$$

5. Reaktor sakarifikasi

Fungsi :Mennkonversi dektrin menjadi menjadi glukosa

kondisi operasi

Suhu	:	60	°C	=	140	°F
Tekanan	:	760	mmhg	=	1	atm
Waktu Feeding	:	1	jam	=	1	jam
Waktu Pengadukan	:	72	jam	=	72	jam
Waktu Discharge	:	1	jam	=	1	jam

Jumlah Alat : 74

Reaktor sakarifikasi

Komponen	Masuk			Keluar		
	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)	(Kg/Jam)	ρ (kg/Liter)	(Liter/Jam)
Dekstrin (C ₆ H ₁₀ O ₅) ₁₀₀	7.850,07	1,04	7.562,69	157,00	1,04	151,25
Protein	61,12	0,51	119,85	61,12	0,51	119,85
Lemak	17,46	0,90	19,40	17,46	0,90	19,40
Serat Kasar	17,46	1,30	13,43	17,46	1,30	13,43
H ₂ O	18.257,87	1,00	18.257,87	17.360,90	1,00	17.360,90
Ca(OH) ₂	2,91	2,20	1,32	-	2,20	-
α-Amilase	8,16	1,20	6,80	8,16	1,20	6,80
HCl	4,69	1,27	3,70	1,83	1,27	1,44
Glukoamilase	8,12	1,20	6,77	8,12	1,20	6,77
Glukosa C ₆ H ₁₂ O ₆	-	1,54	-	8.460,61	1,54	5.493,90
Maltosa C ₆ H ₂₂ O ₁₁	-	1,54	-	130,83	1,54	84,96
CaCl ₂	-	1,01		4,35	1,01	4,30
				-		
Total	26.227,87	1,01	25.991,84	26.227,87	1,13	23.263,03

ρ campuran	1,127	kg/Liter	=	1.127,45	kg/m ³	=	70,384	lbm/ft ³
μ Campuran	11,1	Cp	=	0,0111	kg/ms	=	0,007	lb/ft.s

acuan viskositas in

Perhitungan Dimensi Tangki

V campuran	23.263,026	liter	=	821,5215536	ft ³	=	23,26302583	m ³
------------	------------	-------	---	-------------	-----------------	---	-------------	----------------

V campuran	Volume tangki	X		75	%
------------	---------------	---	--	----	---

Volume tangki	821,52	ft ³	:	75	%
---------------	--------	-----------------	---	----	---

	1095,36	ft ³
--	---------	-----------------

$L_s + H_b$	1,5	D
-------------	-----	---

H_b	0,169	D
-------	-------	---

1,5	D	$L_s +$	0,169	D
-----	---	---------	-------	---

1,331	D	L_s
-------	---	-------

Volume tangki	Volume shell	+	Volume tutup Bawah
---------------	--------------	---	--------------------

$\pi/4$	x	D^2	x	$L_s +$	0,0847	x	D^3
0,785	x	D^2	x	$L_s +$	0,0847	x	D^3
0,785	x	D^2	x	1 D	+	0,0847	D^3
0,785	x	1,331	D^3	+	0,0847	x	D^3
1,044835	D^3	+	0,0847	x	D^3		

1095,36	1,129535	D^3	
D	9,898119 ft	=	3,02 in
Hb	1,672782 ft	=	0,51 in
Total H tangki	14,84718 ft	=	4,53 in

Mencari Tinggi Liquid dalam Shell

Volume Liquid	$\pi/4$	x	D^2	x		Volume Liquid dalam Tutup Bawah
821,5215536	0,785	x	97,9728	x		HI+ 0,0847 x D^3
HI	10,55309 ft	=	3,22			HI+ 9,898118952 in

Menentukan Tekanan Desain (P_d)

Tekanan operasi tangki sama dengan tekanan atmosfer ditambah dengan tekanan parsial bahan

PH	=	ρH	:	144
	=	70,384 x	10,553	:
	=	5,158	psia	

P operasi	1 atm	=	14,70	psia
-----------	-------	---	-------	------

Pd	1,1	x	PH	+	P operasi
----	-----	---	----	---	-----------

	1,1	x	5,158	+
--	-----	---	-------	---

	21,839	psia
--	--------	------

	7,144	psig
--	-------	------

Tebal silinder

$$\begin{aligned}
 r_i &= 59 \text{ in} \\
 f &= 18.750 \text{ psia} \quad \text{allowable stress SA 167 grade 11 type 316} \\
 E &= 0,80 \quad \text{Double welded butt joint} \\
 P_i &= 7,14 \text{ psig} \\
 C &= 0,125 \quad / \quad 16 \text{ factor korosi}
 \end{aligned}$$

$$\begin{aligned}
 ts &= \frac{P_i \times r_i}{(f \times E) - P_i} + C \\
 ts &= \frac{7,144 \times 59,4}{(18.750 \times 0,800) - 7,144} + \frac{2}{16} \\
 ts &= \frac{424,25}{15.000 - 4,286} + \frac{2}{16} \\
 ts &= 0,028 + \frac{1}{16} \text{ in} \\
 ts &= 0,153 = \frac{3}{16} \text{ in} \quad 3 \quad 16 \quad 0,1875
 \end{aligned}$$

$$\begin{aligned}
 OD &= ID + 2 \times ts \\
 &= 118,777 + 2 \times 0,188 \\
 &= 119,152 \text{ in}
 \end{aligned}$$

ID baru

$$ID = OD - 2 \times ts$$

ID baru

$$\begin{aligned} \text{ID} &= \text{OD} - \frac{2}{\text{ts}} \\ &= 132 - 0,375 \\ &= 131,63 \text{ in} = 3,34 \text{ m} \\ &= 10,97 \text{ ft} \end{aligned}$$

Tebal tutup

$$\begin{aligned} \text{th} &= \frac{0,885 \times \text{Pi} \times \text{r}}{\text{E} \times \text{C}} + \text{Pi} \\ &= \frac{0,885 \times 7,144 \times 65,813}{18750,0 \times 0,1} + 7,144 \\ &= 0,125 \\ \text{th} &= \frac{416,0692424}{15000,0 - 0,714} + 0,125 \\ &= 0,153 \text{ in} >>>> 3/16 \\ &= 0,47625 \end{aligned}$$

Perhitungan pengaduk
Perhitungan pengaduk
jenis : Pengaduk dengan 6 blade turbin

Dimensi Impeler direncanakan sebagai berikut

Dimeter impeler (Da)	=	0,3	x	ID tangki
	=	0,3	x	10,97

$$= 0,3 \times 10,97$$

# m	=	39,49	in
-----	---	-------	----

Lebar pengaduk (W)	=	0,2	x	Da
----------------------	---	-----	---	----

$$= 0.2 \times 3.29$$

$\#m = 7,90$ in

Digunakan 4 buah baffle dengan lebar

Lebar baffle (J)	=	0,08333	x	ID tangki
------------------	---	---------	---	-----------

$$= 0,08333 \times 10,97$$

$\#m = 10,97$ in

Jarak Pengaduk (Dt)

Kedasar Tangki

# m	=	39,49	in
-----	---	-------	----

$$\text{RPM} = 100$$

$$\text{RPS} = 1.7$$

$$\text{Nre} = \frac{\rho}{N} x$$

$$= 1.127,45 \times 1,667 \times$$

$$= 170.315,24$$

$${}^4\text{Np}$$

3a/	μ
# /	0,01111

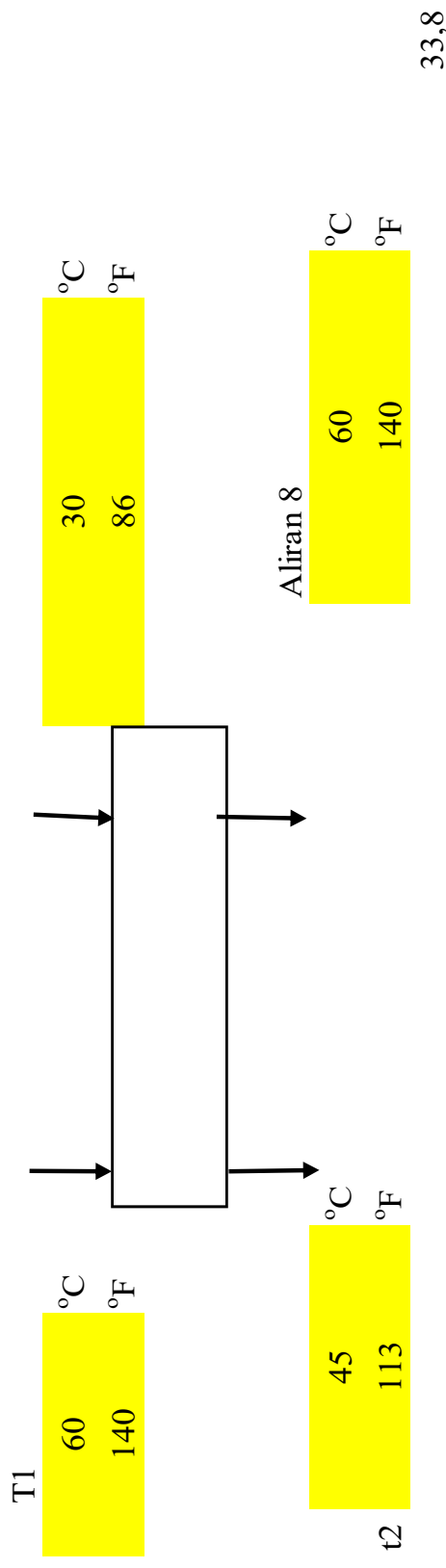
P	=	Np	x	ρ	x	N ³	x	Da ⁵
	=	4	x	1.127,45	x	4,630	x	1,02
Eff Motor	=	21.197,3	Watt	=		28,4	HP	
	=	80	%					
Power motor act	=	36	Hp	=	40	Hp		
Perhitungan Jacket								
Anullus air pendingin								
ODR	=	11	ft	=	3,35	=	132	in
Spasi Annulus	=	1,00	ft	=	0,30	=	12	in
IDJ	=	ODR	+	2	x			
	=	11,0	+	2	x	1,00		
	=	13,0	ft	=	3,96	=	156	in
ri	=	IDJ	/	2				
	=	13,000	/	2				
	=	6,500	ft	=	1,98	=	78	in
Flow Area (s)	=	π/4	x	IDJ ²	-	ODR ²		
	=	0,785	x	169,0	-	121		
	=	37,68	ft ²	=	3,50	=	24196	in ²
D equivalen (De)	=	IDJ ²	-	ODR ²	/	ODR		

$$\begin{aligned}
 &= 169,0 \quad - \quad 121 \quad / \quad 11 \\
 &= 4,4 \quad \text{ft} \quad = \quad 1,33 \quad = \quad 52 \quad \text{in} \\
 \\
 &\text{Tebal silinder} \\
 &\text{ri} = 78 \quad \text{in} \\
 &\text{f} = 18.750 \quad \text{psia} \quad \text{allowwable stress SA 167 grade 11 type 316} \\
 &\text{E} = 0,80 \quad \text{Double welded butt joint} \\
 &\text{Pi} = 4,36 \quad \text{psig} \\
 &\text{C} = 0,125 \quad / \quad 16 \text{ factor korosi} \\
 &\text{Rate Air} = 215,14 \quad \text{kg/jam} \quad 72 \\
 \\
 &\text{ts} = \frac{\left(\frac{\text{Pi} \times \text{ri}}{\text{f} \times \text{E}} \right) - 0,600}{4,364 \times 78,0} \quad \text{Pi} \quad + \quad \text{C} \\
 &\text{ts} = \frac{18.750 \times 0,800 - 0,600}{340,36} \quad 4,364 \quad + \quad 2/16 \\
 &\text{ts} = \frac{15.000 - 2,618}{0,023 + 1/16} \quad \text{in} \\
 &= \frac{0,148 - 3/16}{3} \quad \text{in} \quad 16 \quad 0,1875 \\
 \\
 &\text{OD} = \text{ID} + 2 \times \text{ts} \\
 &= 156,000 + 2 \times 0,188
 \end{aligned}$$

= 156,375 in					
Kecepatan aliran air					
w	=	215,1 kg/jam	=	474,3	
θ	=	995,7 kg/m ³	=	62	
μ air	=	1 Cp	=	0,001	pada 30 °C
v	=	w / θ	x	s	= 0,001
	=	474,3 / 2.342,2			
	=	0,2 ft/jam	=	5,6E-05 ft/s	
Nre	=	θ x De	x	v	/ μ
	=	62,16 x 4,364	x	0,000	/ 0,001
	=	22,71			
Mencari Ho					
Nre	=	22,71	>>>>>	J =	25,00
k	=	0,36		BTU/hr.ft°C	
c	=	0,9987			
Ho	=	jH	x	(k/De)	$(\lambda/\lambda_w)^{0,14}$
	=	25,00	x	0,0825	x 1
	=	1,53		BTU/hr.ft ² °C	
Mencari Hi					
Nre	=	170.315,24	>>>>>	J =	20,00
k	=	0,36		BTU/hr.ft°C	

c	=	0,9987					
Hi	=	jH	x	(k/De)		x	$(\lambda/\lambda_w)^{0,14}$
	=	20,00	x	0,0825		x	1
	=	1,22	BTU/hr.ft ² °C				
Hio	=	Hi	x	IDR/ODR			
	=	1,53	x	1,00			
	=	1,52	BTU/hr.ft ² °C				
Uc	=	hioxho	/	hio+ho			
	=	2,33	/	3,05			
	=	0,76					
Rd	=	0,003					
1/Ud	=	1/Uc +	Rd				
	=	1,31151 +	0,003				
	=	1,315					
Ud	=	0,761					

Mencari luas perpindahan panas



High Temp	140	113	Diff
Low Temp	140	86	27
ΔLMTD =	-27,000 /	-0,693	54
	=	38,953 °F	
Q	=	Ud x A x Δt	
Q	=	3,227,11 kkal	=

$$A = 12.797,64 / 0,761 = 38,953$$

$$= 431,87 \text{ ft}^2$$

Tinggi perpindahan Panas Pada Jacket

$$A = \pi \times ID \times H + A \text{ dish}$$

$$A \text{ dish} = 6,28 \times Rc \times b$$

$$= 6,28 \times 5,48465 \times 1,129535$$

$$= 38,9053 \text{ ft}^2$$

$$H = A - A \text{ dish} / \pi \times ID$$

$$= 431,9 - 38,9053 / 3,14 \times 10,97$$

$$= 393,0 / 34,4436$$

$$= 11,4 \text{ ft} \quad VS \quad \text{Total Tinggi Tangki} = 14,8$$

6.Pompa dari sakarifikasi menuju Tangki karbonasi

Densitas	=	63,0752	Lb/Cuft
Viskositas	=	0,0006	lb/ft.s
Perhitungan			
Rate	=	26.227,9	kg/jam
	=	57.822,5	lb/jam
	=	916,7	cuft/jam
	=	0,25	cuft/s

Diameter Pipa Optimum (ID op)

Asumsi untuk aliran adalah Turbulen sehingga berlaku persamaan

$$ID_{op} = 4 \times Q_f^{0,45} \times \rho^{0,13} \quad (\text{peter \& Timmerhaus hal 525})$$

Keterangan

ID_{op} = inside diameter Optimum pipa, Inch

Q_f = Volumetrik Rate (cuft/s)

ρ = Densitas larutan, lb/cuft

$$ID_{op} = 4 \times 0,54 \times 1,71388478 = 3,61 \text{ in}$$

Pipa yang akan digunakan adalah

	=	4,00 in	Geankoplis, Appendik A-5-1
Sch	=	40,00	
ID Pipa	=	4,03 in	= 0,34 ft

$$A \text{ Pipa} = 0,088 \text{ ft}^2$$

Kecepatan Linier Air

$$V = \frac{Q}{A} = \frac{0,25}{0,09}$$

$$= \frac{2,88}{\text{ft/s}}$$

$$\text{Nre} = \frac{\rho \times D \times V}{\mu} = \frac{63,0752 \times 0,34 \times 2,88}{0,0006} = 101.597,58$$

Nre perhitungan > 2100, maka aliran adalah turbulen sehingga asumsi ID pipa dapat digunakan
Menghitung Friksi Total
menghitung friksi karena panjang pipa lurus

$$Ff = \frac{4}{f} \times L \times \frac{V^2}{D} \times Gc$$

Untuk comersial Stell (geankoplis hal 88)

$$\varepsilon = 4,6\text{E-}05 \text{ m} = 0,00015 \text{ ft}$$

$$\varepsilon/D = 0,00045$$

$$\text{untuk NR} = -$$

$$d = 1,6089 \text{ in} = 0,13408 \text{ ft}$$

$$\varepsilon = 4,6\text{E-}05 \text{ m} = 0,00015 \text{ ft}$$

$$\begin{aligned} \varepsilon/D &= 0,00113 \\ \text{untuk NR} &= 101.598 \text{ di peroleh } f = 0,005 \\ Ff &= 4 \times f \times L \times V^2 / D \times Gc \\ &= 4 \times 0,005 \times 600 \times 8,30 / 0,34 \times 2 \times 32,1212 \\ &= 99,57 / 21,55 \\ &= 121,13 \end{aligned}$$

menghitung friksi karena Fiting dan Valve

$$Hf = Kf \times V^2 / 2 \times Gc$$

Fitting/ Valve	Jumlah	kf	Hf
elbow 90	4	0,75	0,38749533
Globe Valve	2	6	1,54998134
Total			1,93747667

$$\text{total Friksi} = 123,07 \text{ lbf.ft/lb}$$

Perhitungan Power Pompa

$$-Ws = \frac{P2-P1}{\rho} + (Z2-Z1) \times Gc + \frac{V2^2-V1^2}{2a} + \Sigma F$$

$$\begin{aligned}
 \Delta P &= 0 \\
 \Delta Z &= 13,6 \text{ ft} \\
 Gc &= 32,1212 \\
 \Delta V &= 0 \\
 \\
 -Ws &= 0 + 13,6 \times 32,1212 + 0 + 123,07 \\
 &= 436,848 + 123,07 \\
 &= 559,91 \text{ lbf.ft/lbm} \\
 \\
 \text{untuk rate masa} &= 916,7 \text{ cuft/jam} \\
 &= 114,3 \text{ Galon/menit} \\
 \\
 BHP &= \frac{m}{550} \times \frac{-Ws}{\eta} = \frac{114,3 \times 559,91}{550 \times 0,8} \\
 &= 145,4 \text{ HP}
 \end{aligned}$$

7. Tangki Karbonasi

Fungsi : untuk memurnikan larutan glukosa dari pengotor

kondisi operasi

Suhu	:	80 °C	=	176
Tekanan	:	760 mmhg	=	1
Waktu Feeding	:	1 jam	=	0,5
Waktu Pengadukan	:	1 jam	=	0,5
Waktu Discharge	:	1 jam	=	1
Jumlah Alat	:	3		

Komponen	Masuk		Keluar	
	(Kg/Jam)	ρ (kg/Liter)	(Kg/Jam)	ρ (kg/Liter)
Glukosa $C_6H_{12}O_6$	8.460,61	1,54	8.460,61	1,54
Maltosa $C_6H_{22}O_{11}$	130,83	1,54	130,83	1,54
Protein	61,12	0,51	61,12	0,51
Lemak	17,46	0,90	17,46	0,9
Serat Kasar	17,46	1,30	17,46	1,3
H ₂ O	17.360,90	1,00	17.360,90	1
Dekstrin ($C_6H_{10}O_5$) ₁₀₀	157,00	1,04	157,00	1,038
α-Amilase	8,16	1,20	8,16	1,2
HCl	1,83	1,27	1,83	1,268
CaCl ₂	4,35	1,01	4,35	1,012
				4,30

Glukoamilase	8,12	1,20	6,77	8,12	1,2	6,77
Karbon Aktif	135,54	3,51	38,61	135,54	3,51	38,61
Total	17.902,80	1,01	17.807,74	17.902,80	1,01	17.807,74

ρ campuran	= 1,005	kg/Liter	= 1.005,34	= 62,761	lbm/ft ³
μ Campuran	= 11,1	Cp	= 0,0111	= 0,007	lb/ft.s

Perhitungan Dimensi Tangki

V campuran = 17.807,736 liter = 628,870868 m³

V campuran	=	Volume tangki	X	75	%
------------	---	---------------	---	----	---

Volume tangki = 628,87 ft³ : 75 %

$$= 838.49 \text{ ft}^3$$

$$\text{Ls} + \text{Hb} = 1,5 \text{ D}$$

$$\mathrm{Hb} = 0,169 \text{ D}$$

$$1,5 \text{ D} = \text{Ls}^+ \text{ 0,169 D}$$

$$1,331 \text{ D} = \text{Ls}$$

Ls + Hb =	=	13,581824 ft	=	4,14	162,98 in
-----------	---	--------------	---	------	-----------

$$\text{Volume tangki} = \text{Volume shell} + \text{Volume tutup Bawah}$$

$$= \pi/4 \times D^2 \times 0.0847 \times D^3$$

=	0,785	x	D ²	x	D ³
				0,0847	x

$$\begin{aligned}
 &= 0,785 \times D^2 \times D^3 \\
 &= 0,785 \times 1,331 \times D^3 \\
 &= 1,0448 D^3 + D^3 \\
 838,49 &= 1,1295 D^3 \\
 D &= 9,0545 \text{ ft} = 2,76 \text{ m} = 108,65 \text{ in}
 \end{aligned}$$

Mencari Tinggi Liquid dalam Shell

$$\begin{aligned}
 \text{Volume Liquid} &= \text{Volume Liquid dalam Shell} + \text{Volume Liquid dalam Tutup Bawah} \\
 628,870868 &= \pi/4 \times D^2 \times \text{HI} + \text{HI} \times 0,0847 \times D^3 \\
 &= 0,785 \times 81,9849 \times \text{HI} + 9,054549353 \times \text{HI} \\
 \text{HI} &= 9,6307 \text{ ft} = 2,94 \text{ m} = 115,57 \text{ in}
 \end{aligned}$$

Menentukan Tekanan Desain (P_d)

Tekanan operasi tangki sama dengan tekanan atmosfer ditambah dengan tekanan parsial bahan

$$\begin{aligned}
 P_H &= p_H : 144 \\
 &= 62,761 \times 9,631 : 144 \\
 &= 4,197 \text{ psia} \\
 P_{\text{operasi}} &= 1 \text{ atm} = 14,70 \text{ psia} \\
 P_d &= 1,1 \times P_H + P_{\text{operasi}} \\
 &= 1,1 \times 4,197 + 14,70 \\
 &= 20,783 \text{ psia}
 \end{aligned}$$

$$\begin{aligned}
 &= 6,087 \text{ psig} \\
 \text{Tebal silinder} &= 54 \text{ in} \\
 f &= 18.750 \text{ psia} \text{ allowable stress SA 167 grade 11 type 316} \\
 E &= 0,80 \text{ Double welded butt joint} \\
 P_i &= 6,09 \text{ psig} \\
 C &= 0,125 / 16 \text{ factor korosi} \\
 \\
 ts &= \frac{P_i \times r_i}{\left(\frac{f \times E}{3} \right) - P_i} + C \\
 ts &= \frac{6,087 \times 54,3}{\left(\frac{18.750 \times 0,80}{3} \right) - 6,087} + \frac{2}{16} \\
 ts &= \frac{330,68}{15.000 - 3,652} + \frac{2}{16} \\
 ts &= 0,022 + \frac{1}{16} \text{ in} \\
 ts &= 0,147 + \frac{3}{16} \text{ in} \quad 3 \quad 16 \quad 0,1875 \\
 \\
 OD &= ID + 2 \times ts \\
 &= 108,655 + 2 \times 0,188 \\
 &= 109,030 \text{ in} \\
 \text{ID baru} &= OD - 2 \times ts
 \end{aligned}$$

$$\begin{aligned}
 &= 126 - 0,375 \\
 &= 125,63 \text{ i} = 3,19 \text{ m} = 10,47 \text{ ft} \\
 \text{Tebal tutup} \\
 \text{th} &= \frac{0,885 \times \text{Pi} \times \text{r}}{\text{x E} - \text{Pi}} + \text{C} \\
 \text{th} &= \frac{0,885 \times 6,087 \times 62,813}{18750,0 \times 0,800 - 0,1} + 0,125 \\
 \text{th} &= \frac{338,3606348}{15000,0 - 0,609} + 0,125 \\
 \text{th} &= 0,148 \text{ in} >>>> 3/16 \text{ in}
 \end{aligned}$$

Perhitungan pengaduk

jenis : Pengaduk dengan 6 blade turbin

Dimensi Impeler direncanakan sebagai berikut

Dimeter impeler (Da)	=	0,3 x	ID tangki
	=	0,3 x	10,47
	=	3,140785 ft	=
Lebar pengaduk (W)	=	0,2 x	Da
	=	0,2 x	3,14
	=	0,628157 ft	=
		0,96 m	= 37,69 in
		0,19 m	= 7,54 in

Digunakan 4 buah baffle dengan lebar

Lebar baffle (J) = 0,083333 x ID tangki
10,47

0,27 m = 10,47 in

RPM = 100

RPS = 1,7

Nre = $\rho \times N \times$
= 1.005,34 x 1,667 x
= 138.338,88

Da² / μ
0,916 / 0,0111

Np = 4

P = Np x $\rho \times$
= 4 x 1.005,34 x
= 14.968,7 Watt =

N³ x Da⁵
4,630 x 0,80
20,1 HP

Eff Motor

= 80 %

Power motor act =

25 Hp =

30

Hp

22,371