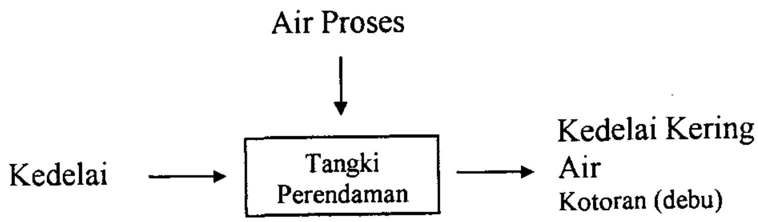
APPENDIX A

NERACA MASSA BASIS

Basis: Kedelai masuk = 3 ton/hari = 3000 kg/hari

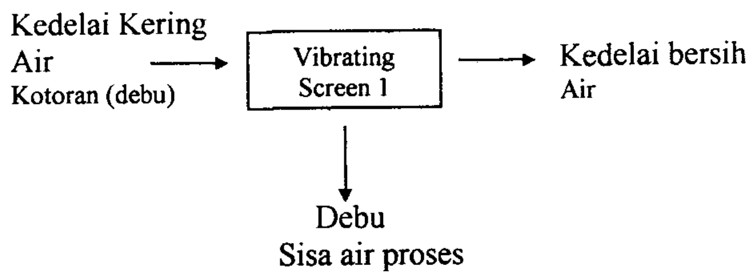
1. TANGKI PERENDAMAN



- Kotoran kedelai = 0,5% . berat kedelai masuk
  = 0,5% . 3000 kg/hari
  = 15 kg/hari
- Perbandingan air proses yang dibutuhkan : kedelai masuk = 2 : 1, sehinggga kebutuhan air proses = 2 . 3000 kg/hari
  = 6000 kg/hari
- Kandungan air dalam kedelai = 7,5% . 3000 kg/hari
  = 225 kg/hari
- Kulit kedelai = 7,3% . berat kedelai
  = 7,3%. 3000 kg/hari
  = 219 kg/hari
- Berat biji kedelai kering tanpa air dan kotoran = (3000 – 225 – 15)kg/hari
  = 2760 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	3000	Kedelai kering	2760
Air proses	6000	Air	6225
		Kotoran	15
Total	9000	Total	9000

2. VIBRATING SCREEN 1



- Kandungan air proses yang terikut perendaman

  = 22% . kedelai kering (tanpa air dan kotoran)

  = 22% . 2760 kg/hari

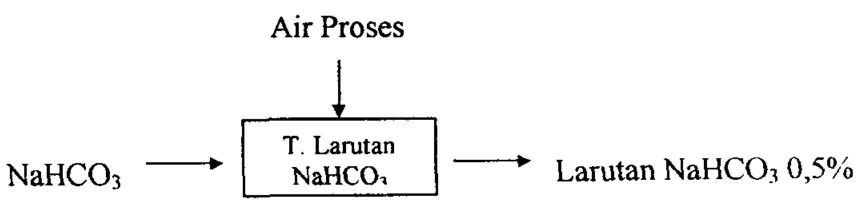
  = 607,2 kg/hari

- Sisa air proses = (6000 – 607,2)kg/hari

  = 5392, 8 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	2760	Kedelai kering	2760
Air	6225	Air	832,2
Kotoran	15	Debu	15
		Sisa air proses	5392, 8
Total	9000	Total	9000

3. TANGKI LARUTAN $NaHCO_3$



- Larutan $NaHCO_3$ yang dibutuhkan = kebutuhan air proses

  = 6000 kg/hari

- $NaHCO_3$ kering yang dibutuhkan untuk membuat larutan $NaHCO_3$ 0,5%

  = 0,5% . 6000 kg/hari

  = 5970 kg/hari

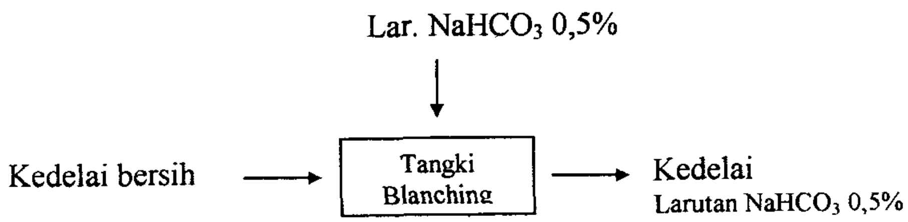
- Air proses yang dibutuhkan untuk melarutkan $NaHCO_3$

  = (6000 – 30)kg/hari

  = 5970 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
$NaHCO_3$	30	Larutan $NaHCO_3$	6000
Air proses	5970		
Total	6000	Total	6000

4. <u>TANGKI BLANCHING</u>



Persamaan reaksi:

$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

n $NaHCO_3$ = 30/ 84 = 0,3571 mol

$NaHCO_3$ yang bereaksi = 99% . 0,3571 . 84

= 29,6964 kg/hari

$NaHCO_3$ yang tidak bereaksi = (30 – 29,6964)kg/hari

= 0,3036 kg/hari

Na_2CO_3 yang terbentuk = ½ . 0,3571

= 0,1786 mol. 106

= 18,9316 kg/hari

CO_2 yang terbentuk = ½ . 0,3571 . 44

= 7,8584 kg/hari

H_2O yang terbentuk = ½ . 0,3571 . 18

= 3,2148 kg/hari

Na_2CO_3 yang terikut kedelai = 10% . 18,9316

$= 1{,}8932$ kg/hari

Sisa Na_2CO_3 $= (18{,}9316 - 1{,}8932)$kg/hari

$= 17{,}0384$ kg/hari

Air yang terikut kedelai $= 20\%\ .\ (H_2O$ yang terbentuk + air proses)

$= 20\%\ .\ (3{,}2148 + 5970)$

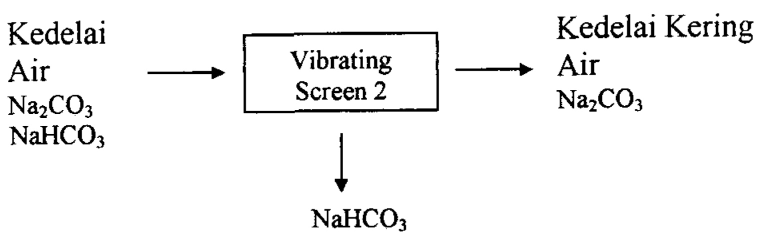
$= 1194{,}643$ kg/hari

Sisa air $= (5970 + 3{,}2148) - 1194{,}643$

$= 4778{,}5718$ kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	2760	Kedelai kering	2760
Air	832,2	Air	2026,843
Larutan $NaHCO_3$ 5%	6000	Na_2CO_3	1,8932
		Sisa $NaHCO_3$	0,3036
		CO_2	7,8584
		Sisa Na_2CO_3	17,0384
		Sisa air proses	4778,5178
Total	9592,2	Total	9592,2

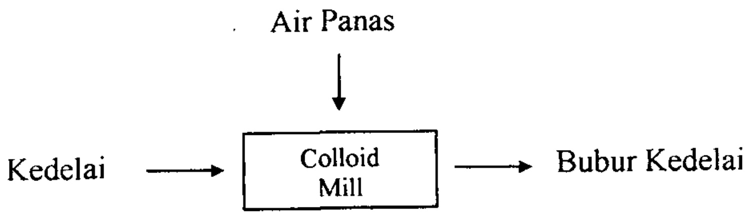
5. VIBRATING SCREEN 2



Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	2760	Kedelai kering	2760
Air	2026,843	Air	2026,843
Na_2CO_3	1,8932	Na_2CO_3	1,8932
Sisa $NaHCO_3$	0,3036	Buangan:	
Sisa Na_2CO_3	17,0384	Sisa $NaHCO_3$	0,3036
Sisa air proses	4778,5178	Sisa Na_2CO_3	17,0384

		Sisa air proses	4778,5178
Total	9584,65	Total	9584,65

6. COLLOID MILL



Perbandingan air panas : kedelai = 4:1

Air panas masuk = 4 . 2760 = 11040 kg/hari

Massa bubur kedelai

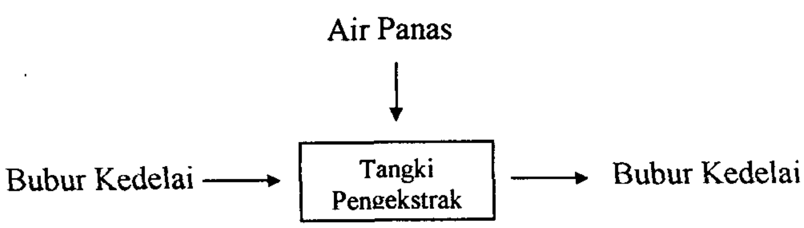
=massa kedelai masuk+massa air masuk+massa Na_2CO_3+ massa air panas

= 2760 + 2026,843 + 1,8932 + 11040

= 15828,7362 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	2760	Bubur kedelai	15828,7362
Air terikut kedelai	2026,843		
Na_2CO_3	1,8932		
Air panas	11040		
Total	15828,7362	Total	15828,7362

7. TANGKI PENGEKSTRAK



Perbandingan air masuk : bubur kedelai = ½ : 1

Air panas yang dibutuhkan = ½ . 15828,7362

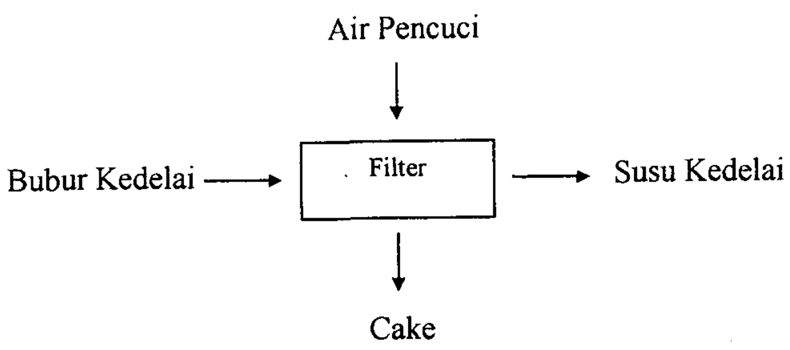
= 7914,3681 kg/hari

Bubur kedelai keluar = 15828,7362 + 7914,3681

= 23743,1043 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	15828,7362	Bubur kedelai	23743,1043
Air panas	7914,3681		
Total	23743,1043	Total	23743,1043

8. FILTER



Dalam bubur kedelai mengandung padatan kedelai

Padatan = (2760/23740,2645) x 100%

= 11,6%

Padatan yang terikut cake = 80% . 2761,8932

= 2209,51456 kg/hari

Padatan yang terikut susu = 20% . 2761,8932

= 552,37864 kg/hari

Air pencucian yang dibutuhkan = 5% . massa bubur kedelai

= 5% . 23743,1043

= 1187,155215 kg/hari

Air dalam bubur = massa bubur – massa kedelai – massa Na_2CO_3

= 23743,1043 – 2760 – 1,8932

=20981,2111 kg/hari

Air yang terikut cake = 20% . 20981,2111

= 4196,24222 kg/hari

Air yang terikut susu = 80% . 20981,2111

= 16784,96888 kg/hari

Air pencuci yang terikut susu = 80% . 1187,155215

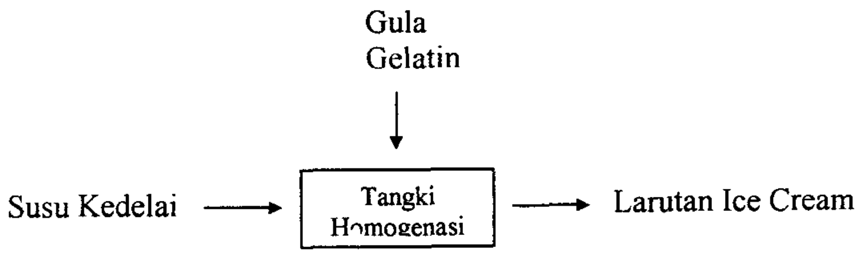
= 947,724172 kg/hari

Air pencuci yang terikut cake = 20% . 1187,155215

= 237,431043 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Bubur kedelai	23743,1043	Susu kedelai:	
Air pencuci	1187,155215	- air	17734,69305
		- padatan	552,37864
		Cake:	
		- air	4433,673263
		- padatan	2209,54156
Total	24930,25052	Total	24930,25052

9. <u>TANGKI HOMOGENASI</u>



Jumlah gelatin yang dibutuhkan = 0,2% . massa susu kedelai

= 0,2% . 18287,07169

= 36,57414 kg/hari

Jumlah gula yang dibutuhkan = 15% . massa kedelai

= 15% . 18287,07169

= 2743,060756 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Susu kedelai	18287,07169	Larutan ice cream	2066,70658
Gelatin	36,57414		
Gula	2743,06075		
Total	2066,70658	Total	2066,70658

10. TANGKI PASTEURISASI

Lar. Ice Cream → Tangki Pasteurisasi → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2066,70658	Larutan ice cream	2066,70658
Total	2066,70658	Total	2066,70658

11. TANGKI PENDINGINAN

Lar. Ice Cream → Tangki Pendinginan → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2066,70658	Larutan ice cream	2066,70658
Total	2066,70658	Total	2066,70658

12. TANGKI PEMBUIHAN

Lar. Ice Cream → Tangki Pembuihan → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2066,70658	Larutan ice cream	2066,70658
Total	2066,70658	Total	2066,70658

13. UNIT PENGEMASAN

Lar. Ice Cream → Tangki Homogenasi → Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2066,70658	Ice cream	2066,70658
Total	2066,70658	Total	2066,70658

14. FREEZER

Ice Cream → Tangki Homogenasi → Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Ice cream	2066,70658	Ice cream	2066,70658
Total	2066,70658	Total	2066,70658

Dari perhitungan neraca massa dengan basis bahan baku kedelai = 3000 kg/hari dapat dihitung neraca massa dengan basis sesuai dengan kapasitas produksi yang dikehendaki.

MENCARI KAPASITAS PRODUKSI

Perkiraan pertumbuhan penduduk 2,5% per tahun.

Tahun 1998 : Jumlah penduduk = 180 000 000 jiwa

Produksi ice cream = 703,339 lt/tahun (data dari BPS, tahun 1998)

Tahun 2004 : Jumlah penduduk = 180 000 000 . $(102,5\%)^6$

= 208 744 815,3 jiwa ≈ 209 000 000 jiwa

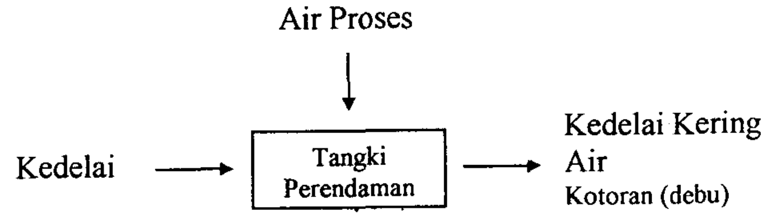
$$\text{Produksi ice cream} = \frac{209.000.000}{180.000.000} x \frac{703.399}{330} = 2.474,9 \approx 2500 lt/hari$$

Kebutuhan kacang kedelai untuk jumlah produksi 2500 kg/hari

NERACA MASSA DENGAN BAHAN BAKU YANG SESUNGGUHNYA

Kedelai masuk = 356,011983 kg/hari

1. TANGKI PERENDAMAN

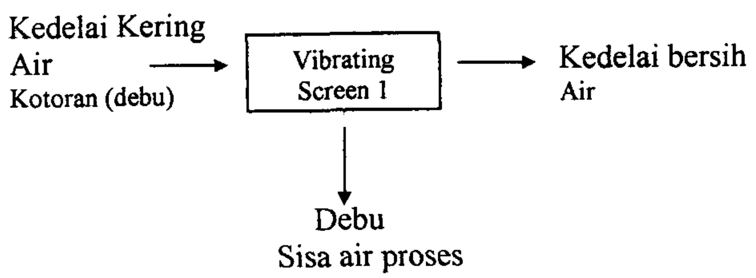


- Kotoran kedelai = 0,5% . berat kedelai masuk
  = 0,5% . 356,011983 kg/hari
  = 1,780059915 kg/hari
- Perbandingan air proses yang dibutuhkan : kedelai masuk = 2 : 1, sehinggga kebutuhan air proses = 2 . 356,011983 kg/hari
  = 712,023966 kg/hari
- Kandungan air dalam kedelai = 7,5% . 356,011983 kg/hari
  = 26,70089873 kg/hari
- Kulit kedelai = 7,3% . berat kedelai
  = 7,3%. 356,011983 kg/hari
  = 25,98887476 kg/hari
- Berat biji kedelai kering tanpa air dan kotoran
  = (3356,011983 – 26,70089873 – 1,780059915)kg/hari
  = 327,5310244 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	356,011983	Kedelai kering	327,5310244
Air proses	712,023966	Air	738,7248647
		Kotoran	1,780059915

Total	1 068,035949	Total	1 068,035949

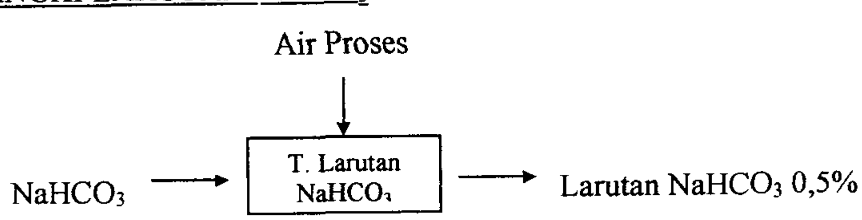
2. VIBRATING SCREEN 1



- Kandungan air proses yang terikut perendaman
  = 22% . kedelai kering (tanpa air dan kotoran)
  = 22% . 327,5310244 kg/hari
  = 72,05682537 kg/hari
- Sisa air proses = (712,023966 – 72,05682537)kg/hari
  = 639,9671406 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	327,5310244	Kedelai kering	327,5310244
Air	738,7248647	Air	98,7577241
Kotoran	1,780059915	Debu	1,780059915
		Sisa air proses	639,9671406
Total	1 068,065949	Total	1 068,065949

3. TANGKI LARUTAN $NaHCO_3$



- Larutan $NaHCO_3$ yang dibutuhkan = kebutuhan air proses
  = 712,023966 kg/hari

- $NaHCO_3$ kering yang dibutuhkan untuk membuat larutan $NaHCO_3$ 0,5%

  = 0,5% . 712,023966 kg/hari

  = 3,56011983 kg/hari

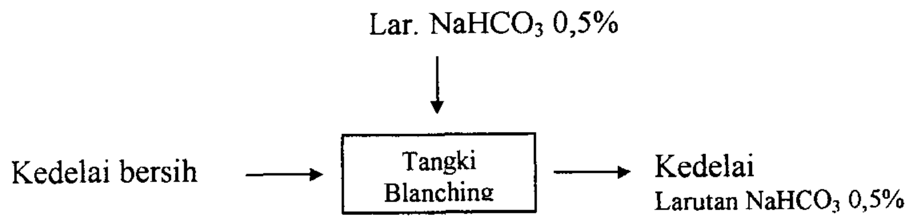
- Air proses yang dibutuhkan untuk melarutkan $NaHCO_3$

  = (712,023966 - 3,56011983)kg/hari

  = 708,4638462 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
$NaHCO_3$	3,56011983	Larutan $NaHCO_3$	712,023966
Air proses	708,4638462		
Total	712,023966	Total	712,023966

4. <u>TANGKI BLANCHING</u>



Persamaan reaksi:

$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

n $NaHCO_3$ = 3,56011983/ 84 = 0,042382378 mol

$NaHCO_3$ yang bereaksi = 99% . 0,042382378 . 84

= 3,524518554 kg/hari

$NaHCO_3$ yang tidak bereaksi = (3,56011983 – 3,524518554)kg/hari

= 0,035601276 kg/hari

Na_2CO_3 yang terbentuk = ½ . 0,042382378

= 0,020979277 mol. 106

= 2,223803362 kg/hari

CO_2 yang terbentuk = ½ . 0,042382378 . 44

= 0,923088188 kg/hari

H_2O yang terbentuk = ½ . 0,042382378 . 18

= 0,377626986 kg/hari

Na_2CO_3 yang terikut kedelai = 10% . 2,223803362

= 0,2223803362 kg/hari

Sisa Na_2CO_3 = (2,223803362 – 0,2223803362)kg/hari

= 2,001423026 kg/hari

Air yang terikut kedelai = 20% . (H_2O yang terbentuk + air proses)

= 20% . (0,377626986 + 708,4638462)

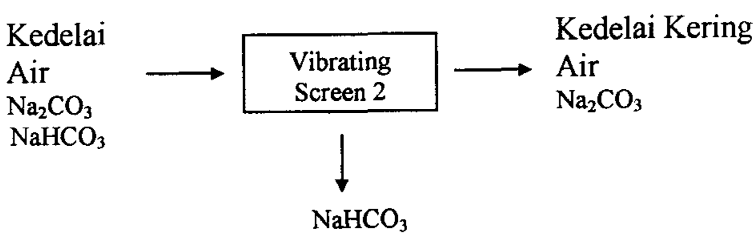
= 141,7682946 kg/hari

Sisa air = (0,377626986 + 708,4638462) – 141,7682946

= 567,0731786 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	327,5310244	Kedelai kering	327,5310244
Air	98,7577241	Air	240,5260187
Larutan $NaHCO_3$ 5%	721,023966	Na_2CO_3	0,2223803362
		Sisa $NaHCO_3$	0,035601276
		CO_2	0,923088188
		Sisa Na_2CO_3	2,001423026
		Sisa air proses	567,0731786
Total	1 138,312715	Total	1 138,312715

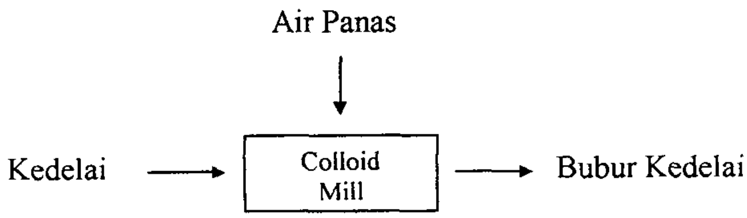
5. <u>VIBRATING SCREEN 2</u>



Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai kering	327,5310244	Kedelai kering	327,5310244
Air	240,5260187	Air	240,5260187
Na_2CO_3	0,2223803362	Na_2CO_3	0,2223803362
Sisa $NaHCO_3$	0,035601276	Sisa $NaHCO_3$	0,035601276
Sisa Na_2CO_3	2,001423026	Sisa Na_2CO_3	2,001423026

Sisa air proses	567,0731786	Sisa air proses	567,0731786
Total	1 137,489626	Total	1 137,489626

6. COLLOID MILL



Perbandingan air panas : kedelai = 4:1

Air panas masuk = 4 . 327,5310244 = 1310,124098 kg/hari

- Massa bubur kedelai

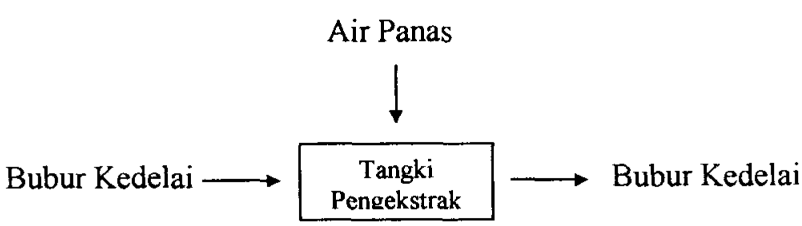
  = massa kedelai masuk+massa air masuk+massa Na_2CO_3+massa air panas

  = 327,5310244 + 240,5260187 + 0,222803362 + 1310,124098

  = 1878,403521 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	327,5310244	Bubur kedelai	1 878,403521
Air terikut kedelai	240,5260187		
Na_2CO_3	0,222803362		
Air panas	1 310,124098		
Total	1 878,403521	Total	1 878,403521

7. TANGKI PENGEKSTRAK



Perbandingan air masuk : bubur kedelai = ½ : 1

Air panas yang dibutuhkan = ½ . 1 878,403521

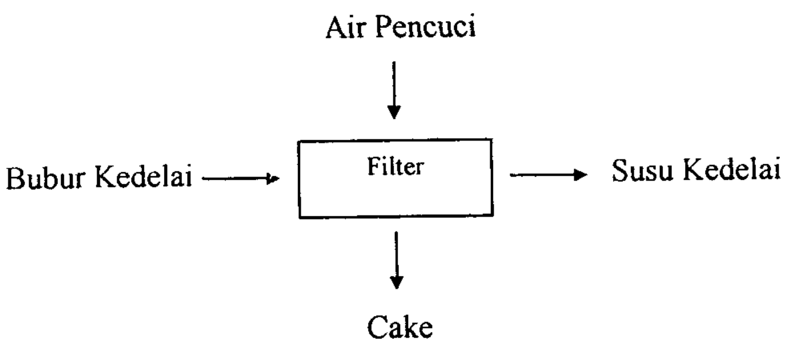
= 939,2017605 kg/hari

Bubur kedelai keluar = 1 878,403521 + 939,2017605

= 2817,605282 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Kedelai	1 878,403521	Bubur kedelai	2 817,605282
Air panas	939,2017605		
Total	2 817,605282	Total	2 817,605282

8. <u>FILTER</u>



Dalam bubur kedelai mengandung padatan kedelai:

Padatan = (327,5310244/ 2917,605282) x 100%

= 11,6%

Padatan yang terikut cake = 80% . 327,5310244

= 262,2027238 kg/hari

Padatan yang terikut susu = 20% . 327,5310244

= 65,55068094 kg/hari

Air pencucian yang dibutuhkan= 5% . massa bubur kedelai

= 5% . 2817,605282

= 140,8802641 kg/hari

Air dalam bubur = massa bubur – massa kedelai – massa Na_2CO_3

= 2817,605282 – 327,5310244 – 0,2229803362

= 2489,629497 kg/hari

Air yang terikut cake = 20% . 2489,629497

= 497,9258994 kg/hari

Air yang terikut susu = 80% . 2489,629497

= 1991,703598 kg/hari

Air pencuci yang terikut susu = 80% . 140,8802641

= 112.7042113,724172 kg/hari

Air pencuci yang terikut cake = 20% . 140,8802641

= 28,17605282 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Bubur kedelai	2817,605282	Susu kedelai:	
Air pencuci	140,8802641	- air	2 104,407809
		- padatan	65,55068094
		Cake:	
		- air	526,1024276
		- padatan	262,2027238
Total	2 958,485546	Total	2 958,485546

9. <u>TANGKI HOMOGENASI</u>

Gula
Gelatin
↓
Susu Kedelai ⟶ [Tangki Homogenasi] ⟶ Larutan Ice Cream

Jumlah gelatin yang dibutuhkan = 0,2% . massa susu kedelai

= 0,2% . 2169,95849

= 4,33991698 kg/hari

Jumlah gula yang dibutuhkan = 15% . massa susu kedelai

= 15% . 2169,95849

= 325,4937735 kg/hari

Masuk (kg/hari)		Keluar (kg/hari)	
Susu kedelai	2 169,95849	Larutan ice cream	2 500,09058
Gelatin	4,33991698		
Gula	325,4937735		
Total	2 500,09058	Total	2 500,09058

10. TANGKI PASTEURISASI

Lar. Ice Cream → Tangki Pasteurisasi → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2 500,09058	Larutan ice cream	2 500,09058
Total	2 500,09058	Total	2 500,09058

11. TANGKI PENDINGINAN

Lar. Ice Cream → Tangki Pendinginan → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2 500,09058	Larutan ice cream	2 500,09058
Total	2 500,09058	Total	2 500,09058

12. TANGKI PEMBUIHAN

Lar. Ice Cream → Tangki Pembuihan → Larutan Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2 500,09058	Larutan ice cream	2 500,09058
Total	2 500,09058	Total	2 500,09058

13. UNIT PENGEMASAN

Lar. Ice Cream → Tangki Homogenasi → Ice Cream

Masuk (kg/hari)		Keluar (kg/hari)	
Larutan ice cream	2 500,09058	Ice cream	2 500,09058
Total	2 500,09058	Total	2 500,09058

14. <u>FREEZER</u>

Ice Cream → $\boxed{\text{Tangki Homogenasi}}$ → Ice Cream

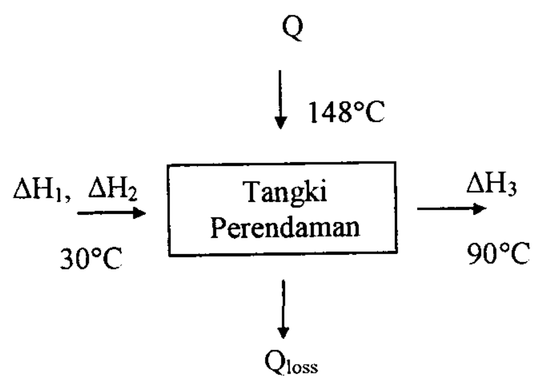
Masuk (kg/hari)		Keluar (kg/hari)	
Ice cream	2 500,09058	Ice cream	2 500,09058
Total	2 500,09058	Total	2 500,09058

APPENDIX B

PERHITUNGAN NERACA MASSA

APPENDIX B
NERACA PANAS

1. <u>TANGKI PERENDAMAN</u>



ΔH_1 = entalpi kedelai masuk

ΔH_2 = entalpi air proses masuk

ΔH_3 = entalpi produk

Steam : T = 148°C $\rightarrow \lambda$ = 2120,448 kj/kg = 506,79 kkal/kg

Q loss diasumsi = 5%.Q = 0,05 Q

Cp kedelai = 2,16 kj/kg K . 1K/1°C

= 0,51624 kkal/kg K . 1K/1°C

Cp air (T =30°C) = 4,181 kj/kg K . 1K/1°C

= 0,9992181 kkal/kg K . 1K/1°C

Cp air (T = 90°C) = 1,0057 kkal/kg K . 1K/1°C

ΔH_1= m . Cp . ΔT

= 356,011983 kg/ hari . 0,51624 kkal/kg K . 1K/1°C . (30 – 0)

= 5513,629 kkal

ΔH_2= m . Cp . ΔT

= 712,023966 kg/hari . 1,0057 kkal/kg K . 1K/1°C . (30 – 0)

$= 21482{,}731$ kkal

Cp campuran = Cp kedelai + Cp air

$$= \left(\frac{356{,}011983}{1068{,}035949} \times 0{,}51624\right) + \left(\frac{712{,}02966}{1068{,}035949} \times 1{,}0057\right)$$

$= 0{,}8429$ kkal/kg K . 1K/1°C

$\Delta H_3 = m \cdot Cp \cdot \Delta T$

$= 1068{,}035949 \cdot 0{,}8429 \cdot (90 - 0)$

$= 81020{,}5352$ kkal

$\Delta H_1 + \Delta H_2 + Q = \Delta H_3 + Q\ loss$

$5513{,}629 + 21482{,}731 + Q = 810520{,}5352 + (5\%.Q)$

$54024{,}1752 = Q\,(1 - 0{,}05)$

$$Q = \frac{54024{,}1752}{1 - 0{,}05}$$

$Q = 56867{,}55284$ kkal/hari

Qloss = 5% . Q

= 5%. 56867,55284 kkal/hari

= 2843,377642 kkal/ hari

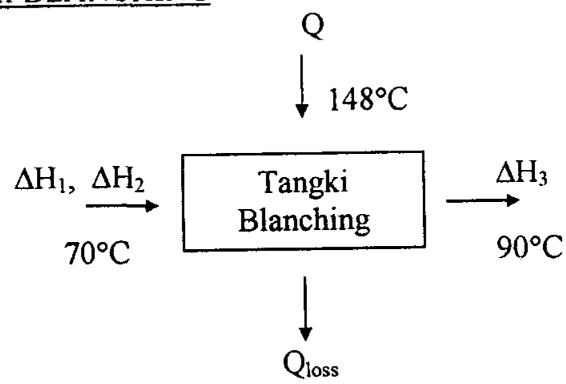
$Q = m_{steam} \cdot \lambda$

$m_{steam} = Q/\lambda$

$$= \frac{56867{,}55284}{506{,}79} = 112{,}21 \text{ kg/hari}$$

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	5513,629	ΔH_3	81020,5352
ΔH_2	21482,732	Qloss	2843,377642
Q	56867,55284		
	83863,91384		83863,91384

2. TANGKI BLANCHING



ΔH_1 = entalpi kedelai + air panas yang terserap kedelai

ΔH_2 = entalpi larutan $NaHCO_3$

ΔH_3 = entalpi produk

Cp campuran = Cp kedelai + Cp air

$$= \left(\frac{327{,}5310244}{420{,}2887485} \times 0{,}51624\right) + \left(\frac{98{,}7577241}{420{,}2887485} \times 1{,}0057\right)$$

$= 0{,}6386$ kkal/kg K . 1K/1°C

Cp $NaHCO_3$ (T = 90°C) = 0,02655 kkal/kg K . 1K/1°C (Himelblaw)

Cp campuran (air + $NaHCO_3$) = (0,995 . 1,0057) + (0,005 . 0,2665)

= 1,001999 kkal/kg K . 1K/1°C

ΔH_1 = m . Cp . ΔT

= 420,2887485 . 0,6386 . (70 – 0)

= 18787,748 kkal/ hari

ΔH_2 = m . Cp . ΔT

= 712,023966 . 1,001999 . (30 – 0)

= 21403,420 kkal/hari

Cp campuran (air+kedelai+$NaHCO_3$)

$$= \left(\frac{327{,}5310244}{1138{,}312715} \cdot 0{,}51624\right) + \left(\frac{98{,}7577241 + 708{,}4638462}{1138{,}312715} \cdot 1{,}0057\right) + \left(\frac{3{,}56011983}{1138{,}312715} \cdot 0{,}2655\right)$$

$= 0{,}8686$ kkal/kg K . 1K/1°C

$\Delta H_3 = m \cdot Cp \cdot \Delta T$

$= 1138{,}312715 \cdot 0{,}826 \cdot (90 - 0)$

$= 88366{,}687$ kkal/ hari

$\Delta H_1 + \Delta H_2 + Q = \Delta H_3 + Q$ loss

$18787{,}748 + 21403{,}420 + Q = 88366{,}687 + (5\%.Q)$

$48175{,}5187 = Q\,(1 - 0{,}05)$

$Q = 50711{,}07232$ kkal/hari

Qloss = 5% . Q

= 5%. 50711,07232 kkal/hari

= 2535,55 kkal/ hari

$Q = m_{steam} \cdot \lambda$

$m_{steam} = Q/\lambda$

$= \dfrac{50711{,}07232}{506{,}79} = 100{,}063$ kg/hari

ΔH_f $NaHCO_3$ = -945,6 kj/gmol = -225,8527 kcal/gmol

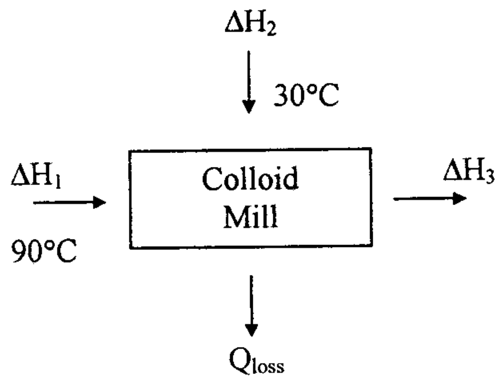
ΔH_f Na_2CO_3 = -1130 kj/gmol = -269,8959 kcal/gmol

ΔH_f CO_2 = -393,51 kj/gmol = -93,9883 kcal/gmol

ΔH_f H_2O = -285,840 kj/gmol = -68,2717 kcal/gmol

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	18787,748	ΔH_3	88366,687
ΔH_2	21403,420	Qloss	2535,55
Q	50711,07232	ΔH_{reaksi}	0,50585617
	90902,240		90902,240

3. COLLOID MILL



ΔH_1 = entalpi kedelai + air

ΔH_2 = entalpi air proses

ΔH_3 = entalpi bubur kedelai

Cp campuran = Cp kedelai + Cp air + Cp Na_2CO_3

$$=\left(\frac{327{,}5310244}{568{,}2794234}\cdot 0{,}51624\right)+\left(\frac{240{,}5260187}{568{,}2794234}\cdot 1{,}0013\right)+\left(\frac{0{,}222380336}{568{,}2794234}\cdot 0{,}273\right)$$

= 0,6386 kkal/kg K . 1K/1°C

ΔH_1= m . Cp . ΔT

= 568,2794234 . 0,7214 . (70 – 0)

= 28722,97123 kkal/ hari

ΔH_2= m . Cp . ΔT

= 1310,124198 . 1,0057 . (30 – 0)

= 39527,754 kkal/hari

$$\Delta H_1 + \Delta H_2 = \Delta H_3 + 5\%(\Delta H_1 + \Delta H_2)$$

$$28722{,}971 + 39527{,}754 = \Delta H_3 + 5\%(28722{,}971 + 39527{,}754)$$

$$\Delta H_3 = 65008{,}814 \text{ kkal/hari}$$

Qloss = 5%(28722,971 + 39527,754)

= 3412,536 kkal/hari

mencari suhu keluar:

Cp campuran = Cp kedelai + Cp air + Cp Na_2CO_3

$$=\left(\frac{327,5310244}{1878,403521}\cdot 0,51624\right)+\left(\frac{240,5260187+1310,124098}{1878,403521}\cdot CpH_2O\right)+\left(\frac{0,222380362}{1878,403521}\cdot 0,273\right)$$

= 0,090015065 + 0,825514911.CpH_2O

ΔH_3= m . Cp . ΔT

65008,814 = 1878,403521 . (0,090015065 + 0,825514911.CpH_2O) . (T – 0)

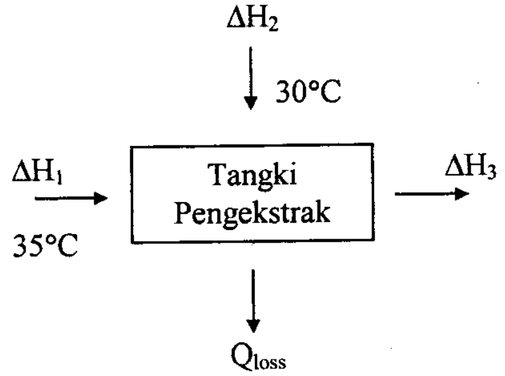
34,609 = (0,090015065 + 0,825514911.CpH_2O) . (T – 0)

dengan trial maka diperoleh:

T = 37,85°C dengan Cp H_2O = 0,9986 kkal/kg K . 1K/1°C

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1 28722,971		ΔH_3	65008,814
ΔH_2 39527,754		Qloss	3412,536
	68421,350		68421,350

4. TANGKI PENGEKSTRAK



ΔH_1 = entalpi kedelai + air

ΔH_2 = entalpi air proses

ΔH_3 = entalpi bubur kedelai

Cp campuran = 0,914 kkal/kg K . 1K/1°C

ΔH_1= m . Cp . ΔT

= 1878,403521 . 0,9145 . (35 – 0)

= 60123,001 kkal/ hari

ΔH_2= m . Cp . ΔT

$= 939{,}2017605 \cdot 0{,}9987 \cdot (30 - 0)$

$= 28139{,}424$ kkal/hari

$$\Delta H_1 + \Delta H_2 = \Delta H_3 + 5\%(\Delta H_1 + \Delta H_2)$$

$$60123{,}001 + 28139{,}424 = \Delta H_3 + 5\%(60123{,}001 + 28139{,}424)$$

$$\Delta H_3 = 83849{,}304 \text{ kkal/hari}$$

Qloss $= 5\%(60123{,}001 + 28139{,}424)$

$= 4413{,}121$ kkal/hari

mencari suhu keluar:

Cp campuran = Cp kedelai + Cp Na_2CO_3 + Cp air

$$= \left(\frac{327{,}5310244}{2817{,}2017605} \cdot 0{,}51624\right) + \left(\frac{0{,}222380362}{2817{,}2017605} \cdot 0{,}273\right) + \left(\frac{2489{,}851877}{2817{,}2017605} \cdot CpH_2O\right)$$

$= 0{,}060040188 + 0{,}883803181 . CpH_2O$

$\Delta H_3 = m \cdot Cp \cdot \Delta T$

$83849{,}304 = 2917{,}2017605 \cdot (0{,}060040188 + 0{,}883803181 . CpH_2O) \cdot (T - 0)$

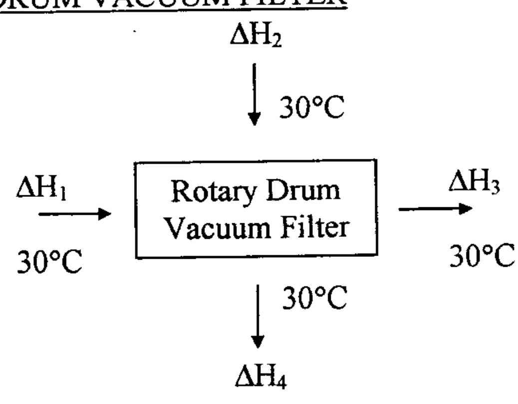
$29{,}763 \quad = (0{,}060040188 + 0{,}883803181 . CpH_2O) \cdot (T - 0)$

dengan trial maka diperoleh:

$T = 31{,}57°C$ dengan Cp $H_2O = 0{,}9987$ kkal/kg K . 1K/1°C

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	60123,001	ΔH_3	83849,304
ΔH_2	28139,424	Qloss	4413,121
	88262,425		88262,425

5. <u>ROTARY DRUM VACUUM FILTER</u>



ΔH_1 = entalpi bubur kedelai

ΔH_2 = entalpi air proses

ΔH_3 = entalpi filtrat

ΔH_4 = entalpi cake

Cp bubur kedelai = 0,060040188 + (0,883803181.CpH$_2$O)

= 0,060040188 + (0,883803181.0,9987)

= 79684,695 kkal/kg K . 1K/1°C

ΔH_1= m . Cp . ΔT

= 2817,605282 . 0,9427 . (30 – 0)

= 79684,695 kkal/ hari

ΔH_2= m . Cp . ΔT

= 140,8802641 . 0,9987 . (30 – 0)

= 4220,914 kkal/hari

Cp campuran di cake = Cp kedelai + Cp Na_2CO_3 + Cp air

$$=\left(\frac{262,2027238}{788,304676}\cdot 0,51624\right)+\left(\frac{0,177904289}{788,304676}\cdot 0,273\right)+\left(\frac{526,1019522}{788,304676}\cdot 0,9987\right)$$

= 0,839 kkal/kg K . 1K/1°C

Cp campuran di filtrat = Cp kedelai + Cp Na_2CO_3 + Cp air

$$=\left(\frac{65,55068094}{2169,95849}\cdot 0,51624\right)+\left(\frac{0,0444767072}{2169,95849}\cdot 0,273\right)+\left(\frac{2104,402809}{2169,95849}\cdot 0,9987\right)$$

= 0,984 kkal/kg K . 1K/1°C

ΔH_3= m . Cp . ΔT

= 2169,95849 . 0,984 . (30 – 0)

= 64057,175 kkal/ hari

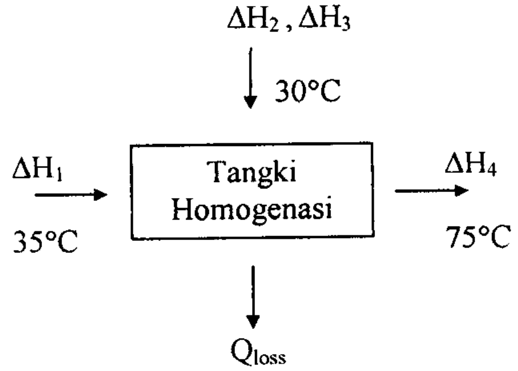
ΔH_4= m . Cp . ΔT

= 788,304676 . 0,839 . (30 – 0)

= 19841,629 kkal/hari

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	79684,695	ΔH_3	64057,175
ΔH_2	4220,914	ΔH_4	19841,629
	83905,609		83905,609

6. TANGKI HOMOGENASI



ΔH_1 = entalpi susu sari kedelai

ΔH_2 = entalpi larutan gula

ΔH_3 = entalpi stabilizer

ΔH_4 = entalpi larutan ice cream

Cp gelatin diasumsi = Cp Protein = 0,351 kkal/kg K . 1K/1°C (TA. Agus David, 2000)

Cp sukrosa = 0,55 kkal/ kg K . 1K/1°C

Cp glukosa = 0,58 kkal/ kg K . 1K/1°C

Cp fruktosa = 0,57 kkal/ kg K . 1K/1°C

ΔH_1 dari rotary drum = 64057,175 kkal

$\Delta H_2 = m \cdot Cp \cdot \Delta T$

$= 325{,}4937735 \cdot 0{,}55 \cdot (30 - 25)$

$= 895{,}108$ kkal/ hari

Sukrosa + $H_2O \rightarrow$ glukosa + fruktosa

$$\text{Mol sukrosa} = \frac{325{,}4937735}{342{,}30} = 0{,}951 mol$$

$\Delta H_{30} = m \cdot Cp \cdot \Delta T$

$= 325{,}4937735 \;.\; 0{,}55 \;.\; (30 - 25)$

$= 895{,}108$ kkal/ hari

$\Delta H_{28} = (\text{mol. } \Delta H_f)_{glukosa} + (\text{mol. } \Delta H_f)_{fruktosa} - (\text{mol. } \Delta H_f)H_2O - (\text{mol. } \Delta H_f)_{sukrosa}$

$= -(0{,}951.-68{,}2717) - (0{,}951.-1{,}319)$

$= 66{,}181$ kkal/ hari

$\Delta H_{27} = m \;.\; Cp \;.\; \Delta T$

$= 325{,}4937735 \;.\; 0{,}55 \;.\; (75 - 25)$

$= 13426{,}61816$ kkal/ hari

$\Delta H_{reaksi} = m \;.\; Cp \;.\; \Delta T$

$= 895{,}108 + 66{,}181 + 13426{,}61816$

$= 14387{,}907$ kkal/ hari

$\Delta H_3 = m \;.\; Cp \;.\; \Delta T$

$= 4{,}33991698 \;.\; 0{,}351 \;.\; (30 - 0)$

$= 45{,}699$ kkal/ hari

Cp campuran larutan ice cream = Cp susu kedelai+Cp gula+Cp stabilizer

$$= \left[\left(\frac{65{,}55068094}{2499{,}792} \cdot 0{,}5164\right) + \left(\frac{0{,}044476072}{2499{,}792} \cdot 0{,}273\right) + \left(\frac{2104{,}402809}{2499{,}792} . 1{,}0021\right)\right] + \left[\left(\frac{325{,}4937735}{2499{,}793} \cdot 0{,}55\right) + \left(\frac{4{,}33991698}{2499{,}792} \cdot 0{,}351\right)\right]$$

$= 0{,}931$ kkal/ kg K . 1K/1°C

$\Delta H_4 = m \;.\; Cp \;.\; \Delta T$

$= 2499{,}792 \;.\; 0{,}931 \;.\; (75 - 0)$

$= 174547{,}976$ kkal/ hari

$\Delta H_1 + \Delta H_2 + \Delta H_3 + Q + \Delta H_R = \Delta H_4 + \text{Qloss}$

$64057{,}175 + 895{,}108 + 45{,}699 + Q + 14387{,}907 = 174547{,}976 + 5\%Q$

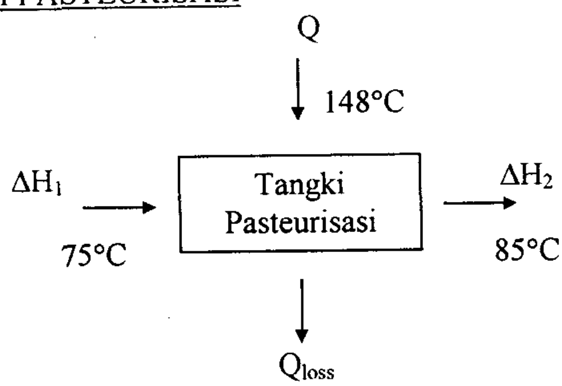
$$Q = \frac{95162{,}017}{1 - 0{,}05} = 1000170{,}6179 \, kkal/hari$$

Qloss $= 5\% \;.\; Q$

$= 5\% \;.\; 100170{,}6179 = 5008{,}531$ kkal/hari

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	64.057,175	ΔH_4	5.008,531
ΔH_2	895,108	Q_{loss}	174.547,976
ΔH_3	45,699		
ΔH_R	14.387,907		
Q	100.170,618		
Total	179.556,507	Total	176.556,507

7. TANGKI PASTEURISASI



ΔH_1 = entalpi larutan ice cream masuk

ΔH_2 = entalpi larutan ice cream keluar

ΔH_1 dari tangki homogenasi = 174547,976 kkal/hari

Cp campuran larutan ice cream pada suhu = 85°C

$$= 0{,}014 + 4{,}857.10^{-6} + \left(\frac{2104{,}402809}{2499{,}792} \cdot 1{,}00395\right) + 0{,}072 + 6{,}094.10^{-4}$$

$= 0{,}9318$ kkal/ kg K . 1K/1°C

$\Delta H_2 = m \cdot Cp \cdot \Delta T$

$= 2499{,}792 \cdot 0{,}9318 \cdot (85 - 0)$

$= 197984{,}790$ kkal/ hari

$\Delta H_1 + Q = \Delta H_2 + Qloss$

$174547{,}976 + Q = 197984{,}790 + 0{,}05\ Q$

$Q = 24670{,}331$ kkal/ hari

Qloss = 5% Q

= 5% . 24670,331 = 1233,517 kkal/hari

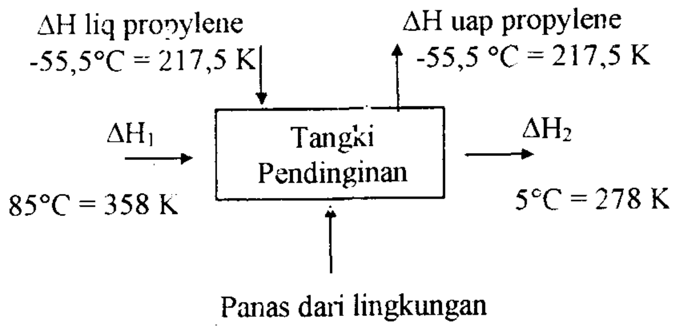
Qloss = 5% Q

= 5% . 24670,331 = 1233,517 kkal/hari

$$m_{steam} = \frac{Q}{\lambda} = \frac{1233{,}517}{506{,}79} = 48{,}68 kkal/hari$$

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	174.547,976	ΔH_2	197.984,790
Q	24.670,331	Q_{loss}	1.233,417
Total	199.218,307	Total	199.218,307

8. TANGKI PENDINGINAN



ΔH_1 dari tangki pasteurisasi = m . Cp . ΔT

= 2499,792 kg/hari . 0,9326 kkal/kg.K . (358-0)

= 833891,614 kkal/hari

Cp larutan ice cream pada suhu = 5°C → 0,9326 kkal/ kg K . 1K/1°C

Cp air (T=5°C) = 1,00495 kkal/ kg K . 1K/1°C

ΔH_2= m . Cp . ΔT

= 2499,792 . 0,9326 . (278 – 0)

= 648103,08 kkal/ hari

λ penguapan propylene = 442,6 kj/kg = 106,224 kkal/kg (Perry, 6^{ed}, p,3-218)

Cp liq propylene = 2,120 kj/kg. K = 0,5067 kkal/kg.K

ΔH liq propylene = m_2 . Cp liq . ΔT

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

Panas dari lingkungan = 5% . λ penguapan propylene (-55,5 °C)]

$= 0{,}05 \;.\; 106{,}224$ kkal/kg = 5,3112 kkal/hari

ΔH_1 + ΔH liq propylene + panas dari lingkungan = ΔH_2 + ΔH uap propylene

833891,614 kkal/hari + m_2 . Cp liq . ΔT + 5,3112 kkal/hari =648103,013 kkal/hari + m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

209106,91 kkal/hari = m_2 . 106,224 kkal/kg

m_2 = 1968,55 kg/hari

Jadi propylene yang dibutuhkan = 1968,55 kg/ hari

ΔH liq propylene = m_2 . Cp liq . ΔT

= m_2 . 0,5067 kkal/kg.K . (217,5 – 0)K

= 1968,55 kg . 0,5067 kkal/kg.K . (217,5 – 0) K

= 216948.48 kkal/hari

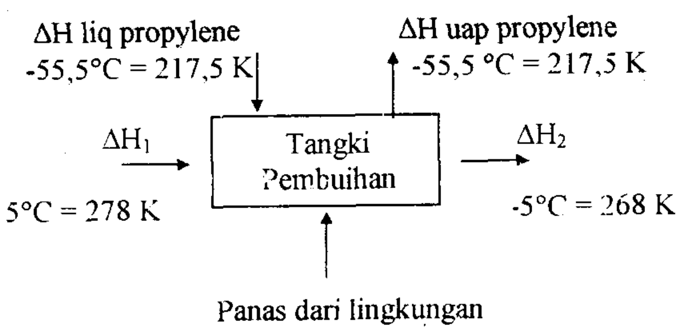
ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

=216948,48kkal/hari+1968,55 kg/hari .106,224 kkal/kg

= 426055,74 kkal/hari

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	833891,614	ΔH_2	648103,013
ΔH_{liq}	216948,482	ΔH_{uap}	426055,74
Panas dari lingk.	5,3112		
Total	1050845,45	Total	1050845,75

9. TANGKI PEMBUIHAN



ΔH_1 dari tangki pendinginan = 648103,013 kkal/hari

ΔH_2= m . Cp . ΔT

= 2499,792 kg . 0,9326 kkal/kg.K. (268 – 0)K

= 628206,73 kkal/ hari

λ penguapan propylene = 442,6 kj/kg = 106,224 kkal/kg (Perry,6[ed],p. 3-218)

Cp liq propylene = 2,120 kj/kg. K = 0,5067 kkal/kg.K

ΔH liq propylene = m_2 . Cp liq . ΔT

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

Panas dari lingkungan = 5% . λ penguapan propylene (-55,5 °C)]

= 0,05 . 106,224 kkal/kg = 5,3112 kkal/hari

ΔH_1 + ΔH liq propylene + panas dari lingkungan = ΔH_2 + ΔH uap propylene

648103,013 kkal/hari + m_2 . Cp liq . ΔT + 5,3112 kkal/hari = 628206,73 kkal/hari + m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

19901,56 kkal/ hari = m_2 . 106,224 kkal/kg

m_2 = 187,36 kg/hari

Jadi propylene yang dibutuhkan = 187,36 kg/ hari

ΔH liq propylene = m_2 . Cp liq . ΔT

= m_2 . 0,5067 kkal/kg.K . (217,5 – 0) K

= 187,36 kg/hari . 0,5067 kkal/kg.K . (217,5 – 0)K

= 20647,94 kkal/hari

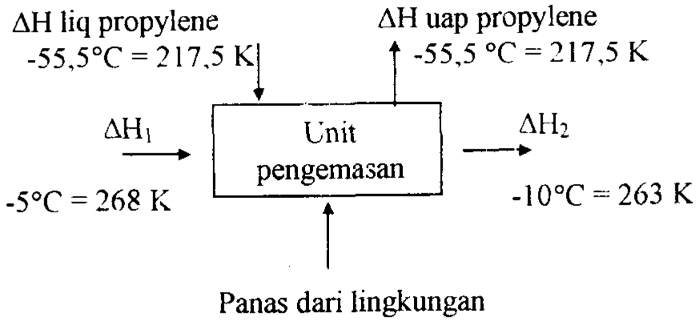
ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= 20647,94 kkal/hari + 187,36 kg/hari .106,224 kkal/kg

= 40550,07 kkal/hari

Masuk (kkal/hari)		**Keluar (kkal/hari)**	
ΔH_1	648103,013	ΔH_2	628206,729
ΔH_{liq}	20647,94	ΔH_{uap}	40550,07
panas dari lingkungan	5,3112		
Total	668756,324	Total	668756,524

10. UNIT PENGEMASAN



ΔH_1 dari tangki pembuihan = 628206,73 kkal/hari

ΔH_2= m . Cp . ΔT

= 2499,792 kg . 0,9377 kkal/kg.K. (263 – 0)K

= 618195,81 kkal/ hari

λ penguapan propylene = 442,6 kj/kg = 106,224 kkal/kg (Perry,6[ed],p. 3-218)

Cp liq propylene = 2,120 kj/kg. K = 0,5067 kkal/kg.K

ΔH liq propylene = m_2 . Cp liq . ΔT

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

Panas dari lingkungan = 5% . λ penguapan propylene (-55,5 °C)]

= 0,05 . 106,224 kkal/kg = 5,3112 kkal/hari

ΔH_1 + ΔH liq propylene + panas dari lingkungan = ΔH_2 + ΔH uap propylene

628206,73 kkal/hari + m_2 . Cp liq . ΔT + 5,3112 kkal/hari = 618195,81 kkal/hari + m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

10016,2312 kkal/hari = m_2 . 106,224 kkal/kg

m_2 = 107,85 kg/hari

Jadi propylene yang dibutuhkan = 107,85 kg/hari

ΔH liq propylene = m_2 . Cp liq . ΔT

= m_2 . 0,5067 kkal/kg.K . (217,5 – 0) K

= 107,85 kg/hari . 0,5067 kkal/kg.K . (217,5 – 0) K

= 11885,95 kkal/hari

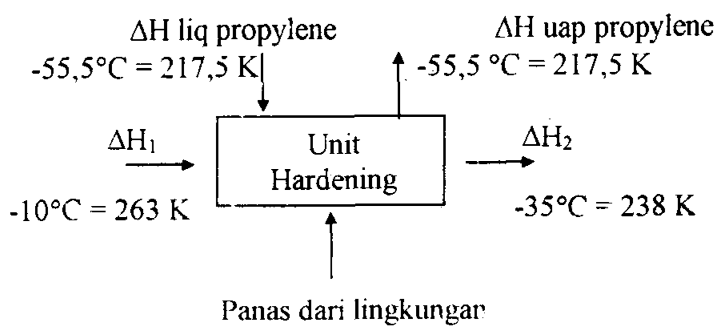
ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= 11885,95 kkal/hari + 107,85kg/hari . 106,224 kkal/kg

= 23342,21 kkal/hari

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	628206,73	ΔH_2	618195,812
ΔH_{liq}	11885,95	ΔH_{uap}	23342,209
panas dari lingkungan	5,3112		
Total	641538,021	Total	641538,021

11. UNIT HARDENING



ΔH_1 dari unit pengemasan = 618195,812 kkal/hari

ΔH_2= m . Cp . ΔT

= 2499,792 kg . 0,9377 kkal/kg.K. (238 – 0)K

= 559431,95 kkal/ hari

λ penguapan propylene = 442,6 kj/kg = 106,224 kkal/kg (Perry,6[ed],p. 3-218)

Cp liq propylene = 2,120 kj/kg. K = 0,5067 kkal/kg.K

ΔH liq propylene = m_2 . Cp liq . ΔT

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

Panas dari lingkungan = 5% . λ penguapan propylene (-55,5 °C)]

= 0,05 . 106,224 kkal/kg = 5,3112 kkal/hari

ΔH_1 + ΔH liq propylene + panas dari lingkungan = ΔH_2 + ΔH uap propylene

618195,812 kkal/hari + m_2 . Cp liq . ΔT + 5,3112 kkal/hari = 559431,95 kkal/hari + m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

58769,17 kkal/hari = m_2 . 106,224 kkal/kg

m_2 = 553,26 kg/hari

Jadi propylene yang dibutuhkan = 553,26 kg/hari

ΔH liq propylene = m_2 . Cp liq . ΔT

= m_2 . 0,5067 kkal/kg.K . (217,5 – 0)K

= 553,26 kg/hari . 0,5067 kkal/kg.K . (217,5 – 0) K

= 60972,93 kkal/hari

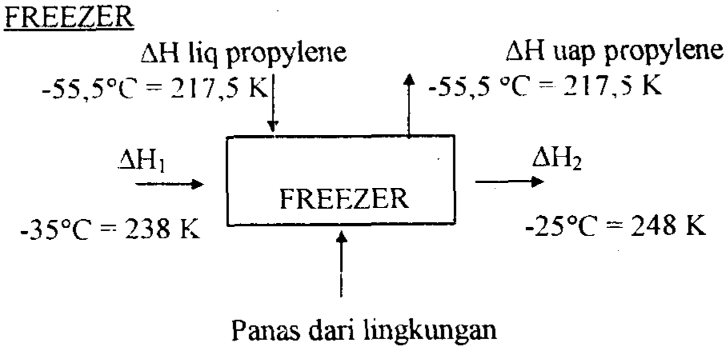
ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= 60972,93 kkal/hari + 553,26 kg/hari . 106,224 kkal/kg

= 119742,42 kkal/hari

Masuk (kkal/hari)		Keluar (kkal/hari)	
ΔH_1	618195,812	ΔH_2	559431,95
ΔH_{liq}	60972,93	ΔH_{uap}	119742,42
panas dari lingkungan	5,3112		
Total	629174,32	Total	679174,32

12. FREEZER



ΔH_1 dari unit hardening = 559431,95 kkal/hari

ΔH_2= m . Cp . ΔT

= 2499,792 kg . 0,9377 kkal/kg.K. (248 – 0)K

= 528163,89 kkal/ hari

λ penguapan propylene = 442,6 kj/kg = 106,224 kkal/kg (Perry,6[ed],p. 3-218)

Cp liq propylene = 2,120 kj/kg. K = 0,5067 kkal/kg.K

ΔH liq propylene = m_2 . Cp liq . ΔT

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

Panas dari lingkungan = 5% . λ penguapan propylene (-55,5 °C)]

= 0,05 . 106,224 kkal/kg = 5,3112 kkal/hari

ΔH_1 + ΔH liq propylene + panas dari lingkungan = ΔH_2 + ΔH uap propylene

559431,95 kkal/hari + m_2 . Cp liq . ΔT + 5,3112 kkal/hari = 528163,89 kkal/hari + m_2 . Cp liq . ΔT + m_2 . 106,224 kkal/kg

18726,63 kkal/hari = m_2 . 106,224 kkal/kg

m_2 = 176,29 kg/hari

Jadi propylene yang dibutuhkan = 176,29 kg/hari

ΔH liq propylene = m_2 . Cp liq . ΔT

= m_2 . 0,5067 kkal/kg.K . (217,5 – 0)K

= 176,29 kg/ hari . 0,5067 kkal/kg.K . (217,5 – 0)K

= 19428,85 kkal/hari

ΔH uap propylene = m_2 [Cp liq . ΔT + λ penguapan propylene (-55,5 °C)]

= 19428,85 kkal/hari + 176,29 kg/hari . 106,224 kkal/kg

= 50708,222 kkal/hari

Masuk (kkal/hari)		**Keluar (kkal/hari)**	
ΔH_1	559431,95	ΔH_2	528163,89
ΔH_{liq}	19428,85	ΔH_{uap}	50702,222
panas dari lingkungan	5,3112		
Total	578866,111	Total	578866,111

APPENDIX C

PERHITUNGAN NERACA PANAS

APPENDIX C
SPESIFIKASI PERALATAN

1. Silo Kedelai (F-110)

Fungsi : menampung bahan baku kedelai selama 1 bulan

Tipe : Konvensional Silo

Dasar Pemilihan: harga lebih murah dibandingkan dengan storage lain serta pemeliharaannya mudah

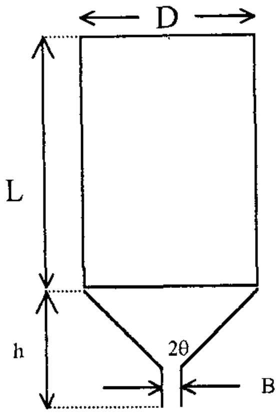
Kondisi operasi : suhu = 30°C

P = 1 atm

Lama penampungan = 1 bulan = 30 hari

Kebutuhan untuk 1 hari proses = 356,011983 kg/ hari

ρ bulk kedelai = 69,96 lbm/ ft^3



Keterangan:

2θ = sudut konis

h = tinggi konis

D = diameter shell

L = tinggi shell

$$\text{Volume padatan} = \frac{356{,}011983 kg/hari . 2{,}025 lbm/kg}{69{,}96 lbm/ft^3} . 30 hari = 309{,}144\, ft^3$$

Vol. Solid = 80% . Vol. silo

$$\text{Vol. Silo 80\% terisi} = \frac{309{,}144}{0{,}8} = 386{,}43\, ft^3$$

Jumlah silo 1 unit:

L = 2.D (T. 4-27, Ulrich, 1984)

B = 0,1.D

$$\sin \alpha_m = \frac{1-K'}{1+K'} (Pers.28-16, McCabe, 1993)$$

dengan:

α_m = angle of internal friction material (15-30°)

K' = konstanta padatan (0,35-0,6)

Diambil K' = 0,5 → α_m = 19,45°

Diperoleh ϕ' = 26°

$$Volume silo = \frac{\pi}{4}.D_i^2.H + \frac{\pi.D_i^3}{24tg\theta'} - \frac{\pi.B^3}{24tg\theta'}$$

$$Volume silo = \frac{\pi}{4}.D_i^2.2D_i + \frac{\pi.D_i^3}{24tg\theta'} - \frac{\pi.(0,1.D_i)^3}{24tg\theta'}$$

$$Volume silo = \frac{\pi}{2}.D_i^3 + \frac{\pi.D_i^3}{24tg\theta'}(1-10^{-3})$$

386,43 ft³ = 1,570796327. D_i^3 + 0,2681157611. D_i^3

D_i^3 = 210,14 → D_i = 5,945 ft = 72 in

L = 144 in

B = 7,2 in

h = tg 45. (1/2 . 72 in) = 36 in

Tinggi silo total = L + h = (12 + 3)ft = 15 ft

Tinggi padatan dalam shell (H):

$$H = \frac{Vol.solid - \frac{\pi}{24tg\vartheta'}(D_i^3 - B^3)}{\frac{\pi}{4}.D^2}$$

$$H = \frac{309{,}144 - \frac{\pi}{24tg26}(6^3 - 0{,}6^3)}{\frac{\pi}{4}.6^2}$$

$$H = 8{,}885 ft$$

$$P_{operasi} = \frac{\rho.H}{144}$$

$$P_{operasi} = \frac{69{,}96.8{,}885}{144} = 4{,}317 psi$$

P_{design} = 1,5 . $P_{operasi}$ = 1,5 . 4,317 = 6,4755 psi

Pemilihan bahan: SS-304

f = 18684 psia

E = 0,8

c = 1/8 in

Tebal shell:

$$t_s = \frac{P.D}{2(f.E - 0{,}6.P)} + c$$

$$t_s = \frac{6{,}4755.72}{2(18684.0{,}8 - 0{,}6.6{,}4755} + \frac{1}{8} = 0{,}14 in \approx 3/16 in$$

Dipakai tebal shell = 3/16 in

Tebal tutup bawah:

$$t_h = \frac{P.D}{2(f.E - 0{,}6.P)\cos\varphi} + c$$

$$t_h = \frac{6{,}4755.72}{2(18684.0{,}8 - 0{,}6.6{,}4755)\cos 45} + \frac{1}{8} = 0{,}14 in \approx 3/16 in$$

Dipakai tebal shell = 3/16 in

Spesifikasi:

Fungsi : menampung bahan baku kedelai selama 1 bulan

Kapasitas : 23496,789 lbm

Bahan konstruksi : SS 304

Dimensi alat : Tinggi shell = 12 ft

Tebal shell = 3/16 in

Diameter shell = 6 ft

Tinggi konis = 3 ft

Tebal konis = 3/16 in

Diameter outlet : ½ in

Bentuk shell : silinder

Tebal sehll : 3/16 in

Jumlah : 1 unit

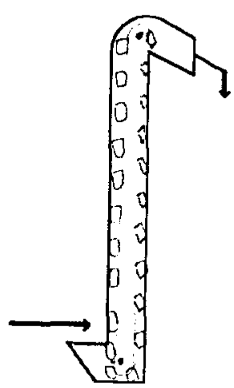
Harga : Rp. 105.865.625,- (App. D)

2. Bucket Elevator (J-111)

Fungsi : memindahkan biji kedelai dari silo ke tangki perendaman

Tipe : Centrifugal Bucket Elevator

Dasar pemilihan : mudah dalam pengoperasian dan sesuai dengan bahan yang akan dipindahkan yang berupa butiran - butiran



Massa kedelai = 356,011983 kg/hari = 98,13 lb/jam = 0,0491 ton/jam

$\rho_{kedelai}$ = 69,96 lb/ft^3

Tinggi bucket = 30 ft

$$Power = \frac{TPH.2.L}{1000}$$ (Perry, ed.3, p.13-49)

di mana:

TPH = kapasitas feed, ton/jam

L = tinggi elevasi bucket

Power = (0,0491 . 2 . 30)/ 1000 = 2,946.10^{-3}HP

Effisiensi = 80% (Peter & Timmerhaus, p.521, gbr.14-38)

HP = 2,946.10^{-3}/0,8 = 3,6825.10^{-3}HP

Dipakai motor dengan power = ½ HP

Spesifikasi:

Tipe	: Centrifugal bucket elevator
Ukuran bucket	: 6 x 4 x 4,5 in
Jarak bucket	: 12 in
Elevator conter	: 30 ft
Kecepatan bucket	: 225 ft/menit
Head shaft	: 43 rpm
Belt width	: 7 in
Bahan konstruksi	: SS-304
Power	: 0,5 HP
Harga	: $ 6700 (Peter & Timmerhaus, 1991)

3. Tangki Perendaman (R-120)

Fungsi : merendam kedelai sehingga kulit kedelai mengelupas dan di samping itu juga menghilangkan bau dan rasa langu.

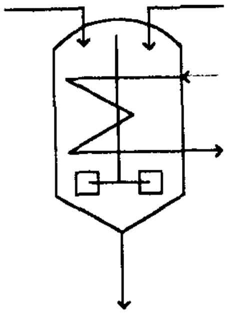
Dimensi : silinder tegak dengan tutup bawah berbentuk konis dengan sudut puncak 30° dan tutup atas berbentuk torispherical dished head.

Dasar Pemilihan : harga murah dan bahan konstruksi cocok untuk industri makanan

Kondisi operasi : $T_{operasi} = 90°C$

$P = 1$ atm

Kondisi : kontinyu



Bahan baku

•	Kedelai	= 356,011983 kg/hari	= 32,63 lb/jam
•	Air	= 712,023966 kg/hari	= 65,26 lb/jam +
•	Total	= 1068,035949 kg/hari	= 97,90 lb/jam

Menentukan dimensi tangki:

ρ kedelai = 919 kg/ m^3 = 57,37 lb/ ft^3

ρ air = 62,4456 lb/ ft^3

$$\rho \text{ campuran} = \frac{1}{\frac{x_A}{\rho_A} + \frac{x_B}{\rho_B}} = \frac{1}{\frac{0,3333}{57,37} + \frac{0,6667}{62,4456}} = 60,68 lb/ft^3$$

$$\text{Volume campuran} = \frac{97,90 lb/jam}{60,68 lb/ft^3}.6\, jam = 9,66 ft^3$$

Diambil: H_s = 1,5 x diameter shell (Ulrich, hal 248)

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.H_s$$

Vol campuran dalam shell $= \frac{\pi}{4}.D_i^2.1{,}5D_i = \frac{\pi}{4}.1{,}5D_i^3$

Dengan:

H_s = tinggi campuran dalam shell

D_i = diameter shell

$$Vol.campurandlmkonis = \left(\frac{1}{3}.\frac{\pi}{4}.D_i^2.H_t\right) - \left(\frac{1}{3}.\frac{\pi}{4}.D_n^2.H_n\right)$$

$$Vol.campurandlmkonis = \left(\frac{1}{3}.\frac{\pi}{4}.D_i^2.\frac{D_i}{2tg\alpha}\right) - \left(\frac{1}{3}.\frac{\pi}{4}.D_n^2.\frac{D_n}{2tg\alpha}\right)$$

$$Vol.campurandlmkonis = \left(\frac{\pi.D_i^3}{24tg\alpha} - \frac{\pi.D_n^3}{24tg\alpha}\right) = \frac{\pi}{24tg\alpha}.\left(D_i^3 - D_n^3\right)$$

dengan:

D_n = diameter lubang pengeluaran campuran

D_i = diameter shell

H_t = tinggi konis

H_n = tinggi shell

Vol. campuran dlm reaktor = vol. campuran dlm shell + vol. campuran dlm konis

Diambil:

Vol tangki perendaman = 1,2 . vol. campuran

D_n = diameter pengeluaran campuran = ½ ft

$$\text{Volume tangki} = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg30}.(D_i^3 - 0{,}5^3)\right)$$

$$11{,}64 = 1{,}178097245.\,D_i^3 + 0{,}2267249205.\ D_i^3 - 0{,}02834061506$$

$$D_i^3 = 8{,}306 \rightarrow D_i = 2{,}025 \text{ ft} \approx 24 \text{ in (diameter shell)}$$

H_s = 1,5. D_i = 1,5 x 2,025 = 3,0375 ft

$$Vol.campurandlmkonis = \frac{\pi}{24tg30.}.(D_i^3 - 0{,}5^3)$$

$$Vol.campurandlmkonis = \frac{\pi}{24tg30.}.(2{,}025^3 - 0{,}5^3) = 1{,}854\,ft^3$$

Vol. campuran dlm shell = (luas alas x tinggi)-(vol. campuran dlm konis)

$$= \frac{\pi}{4}.D_i^2.t - 1{,}854$$

$$tinggicampurandlmshell = \frac{vol.campuran - volcampudlmshell}{\frac{\pi}{4}.D_i^2}$$

$$tinggicampurandlmshell = \frac{9{,}70 - 1{,}854}{\frac{\pi}{4}.2{,}025^2} = 2{,}436 ft = H$$

Tinggi konis (H_c):

$$H_c = \left(\frac{D_i}{2tg\alpha} - \frac{D_u}{2tg\alpha}\right) = \frac{2{,}025 - 0{,}5}{2tg30} = 1{,}321 ft$$

Tinggi campuran dalam tangki = H + H_c = (2,438 + 1,321)ft = 3,759 ft

$$P_{tangki} = \frac{(\rho \times H)}{144} = \frac{(60{,}68 \times 3{,}759)}{144} = 1{,}58 psi$$

P_{design} = 1,3 . P_{tangki}

= 1,3 . 1,58

= 2,054 psi

Tebal tangki:

Bahan plate: SS-304

Dari Brownel & Young Tabel 13.1, didapat:

f = 18684 psi

e = 0,8 (double welded butt joint)

C = 1/8

Perhitungan tebal shell:

$$\text{Tebal shell} = \frac{P.D}{2(f.e - 0{,}6.P)} + C$$

$$= \frac{2{,}054.24{,}30}{2(18684.0{,}8 - 0{,}6.2{,}054)} + \frac{1}{8}$$

= 0,127 in ≈ 3/16 in

dipilih tebal standard =3/16 in

Perhitungan tebal konis:

$$\text{Tebal konis} = \frac{P.D}{2\cos\alpha(f.e - 0{,}6.P)} + C$$

$$= \frac{2{,}054.24{,}30}{2\cos 30(18684.0{,}8 - 0{,}6.2{,}054)} + \frac{1}{8} = 0{,}126 in \approx 3/16 in$$

Pengaduk:

Type impeller: six flat blade turbine

Da = diameter impeller

Di = diameter tangki

H = tinggi liquid dalam shell

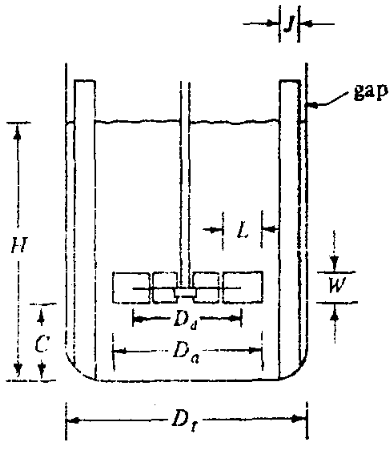
L = panjang blade

W = lebar blade

E = jarak dari dasar tangki ke center impeller

J = lebar baffle

(Mc. Cabe, 4th ed., p. 216)



$\text{Da} = 0{,}3.D_i = 0{,}3.2{,}025 ft = 0{,}608 ft$

$\text{H} = \text{Da} = 0{,}608 \text{ ft}$

$\text{J} = \frac{1}{12} D_i = \frac{1}{12}.2{,}025 ft = 0{,}169 ft$

$\text{E} = \frac{1}{3} D_i = \frac{1}{3}.2{,}025 ft = 0{,}608 ft$

$$W = \frac{1}{5}D_a = \frac{1}{5}.0{,}608\,ft = 0{,}122\,ft$$

$$L = \frac{1}{4}D_i = \frac{1}{4}.0{,}608\,ft = 0{,}152\,ft$$

$$N = k.D_i^{2/3}.\left(\frac{\rho_c - \rho_d}{\rho_c}\right)^{0,26}.\left(\frac{\mu_c}{\rho_c}\right)^{1/9}$$

$$N = 9{,}4.(2{,}025\,ft)^{\frac{2}{3}}\left(\frac{(62{,}4456-57{,}37)lb/ft^3)}{62{,}4456}\right)^{0,26}\left(\frac{6{,}79.10^{-3}}{62{,}4456}\right)^{\frac{1}{9}}$$

N =2,84rpm

μ_{air} = 0,3165.10^{-3}kg/m.s = 0,0002 lb/ft.s

$\mu_{campuran}$ = 0,324 . $\rho^{0,5}$

= 0,324 . $(971{,}969)^{0,5}$

= 10,10 . 2,42 lb/ft.h = 24,445/3600 = 6,79.10^{-3}lb/ft.s

$$N_{re} = \frac{D_a^2.N.\rho_{camp}}{\mu_{camp}}$$

$$= \frac{(0{,}608\,ft)^2.\,{}^{2,84}\!/_{60}.60{,}68\,lb/ft^3}{6{,}79.10^{-3}lb/ft.s} = 843549{,}75(turbulen)$$

Dari gambar 3.4-3 Geankoplis, 3rd edition, p. 145, diperoleh Np = 0,34

$$\text{Jumlah impeller} = \frac{sg.H}{D_i} = \frac{\frac{\rho_{campuran}}{\rho_{air}}.H}{D_i} = \frac{\frac{972kg/m^3}{1000kg/m^3}.0{,}608\,ft}{2{,}025\,ft} = 0{,}29 \approx 1buah$$

$$\text{Power untuk pengaduk} = \frac{N_P.\rho.N^3.D_a^5}{g_c}$$

$$= \frac{0{,}34.60{,}68\,lb/ft^3.\left(\frac{2{,}84rpm}{60\min/s}\right)^3.(0{,}608\,ft)^5}{32{,}174\,ft.lb/lbf.s^2}$$

$$= 5{,}65.10^{-6}\ \text{ft.lb/s} = \frac{5{,}65.10^{-6}\ ft.lb/s}{550Hp/(ft.lb/s)} = 1{,}03.10^{-9}\ Hp$$

Gland Losses = 10%. $1{,}03.10^{-9} = 1{,}03.10^{-10}$ Hp

Power input = $1{,}03.10^{-9} + 1{,}03.10^{-10} = 1{,}133.10^{-9}$ Hp

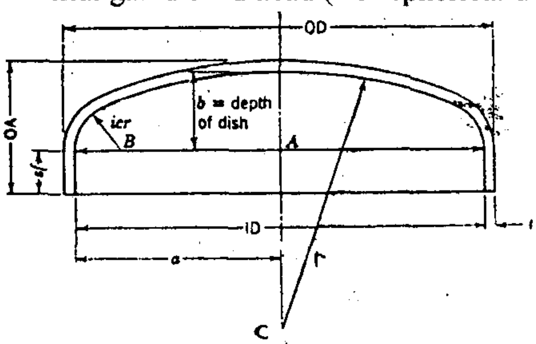
Transmission system losses = 20%. Power input

$= 0.2 \cdot 1{,}133.10^{-9}$

$= 2{,}266.10^{-10}$ Hp

Total power = $1{,}133.10^{-9} + 2{,}266.10^{-10} = 1{,}3596.10^{-9}$ Hp ≈ 0,5 Hp

Perhitungan dished head (Torispherical dished head)



Penentuan tinggi dished head:

$r = D_i = 24$ in = 2,025 ft

Icr = 6% . r = 6%. 24 in = 1,44 in

Dari Brownell & Young, persamaan 7.76:

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{24}{1{,}44}}\right) = 1{,}771$$

AB = D/2 – icr = 24/2 – 1,44 = 10,56 in

BC = r – icr = 24 – 1,44 = 22,56 in

$b = r - (BC^2 - AB^2)^{1/2} = 24 - (22{,}56^2 - 10{,}56^2)^{1/2} = 4{,}064$ in

Penentuan tebal tutup atas:

$$t_d = \frac{P.r_c.W}{2(f.E - 0{,}2.P)} + C$$ (Brownell & Young, pers. 7.77)

dengan:

P_{design} = 2,054 psi

Digunakan tipe sambungan double welded butt joint

Sehingga E = 0,8 (Brownell & Young, Tabel 13.2)

C = 1/8

$$t_d = \frac{2{,}054.24.1{,}771}{2(18684.0{,}8 - 0{,}2.2{,}054)} + \frac{1}{8} = 0{,}128 in$$

Diambil tebal standard 3/16 in

Dipilih panjang straight flange (sf) = 2 in (Brownell & Young, Tabel 5.8)

OA = t + b + sf =3/16 + 4,064 + 2 = 2,762 in = 0,23 ft

Tinggi tangki total = 3 ft + 1,321 ft + 0,23 ft = 4,551 ft

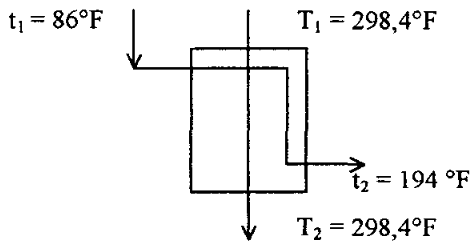
Koil pemanas:

Untuk menaikkan suhu:

$T_{feed\ masuk}$ = 30°C = 86°F

$T_{feed\ keluar}$ = 90°C = 194°F

T_{steam} = 148°C = 298,4°F



1. $$\Delta T_{LMTD} = \frac{(T_1 - t_1) - (T_2 - t_2)}{\ln \frac{T_1 - t_1}{T_2 - t_2}} = \frac{(298{,}4 - 86) - (298{,}4 - 194)}{\ln \frac{298{,}4 - 86}{298{,}4 - 194}} = 152{,}06^\circ F$$

2. Dari Neraca Panas didapat:
   - Q = kalor yang disuplai = 56867,55284 kkal/hari
     = 225521,7038 btu/hari = 9396,7377 btu/jam

- massa steam = 112,21 kg/hari

3. $Tc = 0,5 . (T_1 + T_2) = 0,5 . (298,4 + 298,4) = 298,4°F$

   $tc = 0,5 . (t_1 + t_2) = 0,5 . (86 + 194) = 140°F$

4. Berdasarkan Tabel 11, Kern, Hal. 844

   Diambil pipa koil = ¾ in, sch 40

   OD = 1,05 in

   ID = 0,824 in

   a' = 0,534 in^2/pipe = $3,71.10^{-3}$ ft^2/pipa

   a" =0,275 ft^2/ft

Sisi bejana: fluida dingin	Sisi tube: fluida panas
Nre = 8258,91 (dari impeller) J = 230 SG = 0,972 k = 0,036 Btu/ jam.ft^2.(F/ft) μ = 24,442 lb/ft.jam Cp = 0,8429 Btu/jam.ft^2.F $ho = J.\frac{k}{D}.\left(\frac{Cp.\mu}{k}\right)^{-\frac{1}{3}}.\left(\frac{\mu}{\mu_w}\right)^{0,14}$ $= 230.\frac{0,036}{2,025}.\left(\frac{0,8429.24,442}{0,036}\right)^{-\frac{1}{3}}.(1)^{0,14}$ $= 33,95 Btu/ft^2.h.^{\circ}F$	hoi = 1500 Btu/ft^2.jam.F → steam

$$Uc = \frac{h_c.h_{oi}}{h_c + h_{oi}} = \frac{33,95.1500}{33,95 + 1500} = 33,20 btu / jam.ft^2.F$$

$$Rd = 0,004 \rightarrow hd = \frac{1}{0,004} = 250$$

$$U_D = \frac{U_C.h_d}{U_C + h_d} = \frac{33,20.250}{33,20 + 250} = 29,31 btu / jam.ft^2.F$$

$$A = \frac{Q}{U_D.\Delta t_{LMTD}} = \frac{9396,7377}{29,31.77,51} = 1,16 ft^2$$

$$\text{panjang koil} = \frac{2,11}{0,275} = 7,67 ft$$

$$D_C diambil = 1,25 ft$$

$$N_C = \frac{7,67}{\pi.1,25} = 1,95 \approx 2$$

$$h_c = ((n_c - 1).(d_o + s_c)) + d_o = ((2-1).(1,05+2)) + 1,05 = 4,1 in = 0,34 ft$$

Spesifikasi:

Nama : tangki perendaman

Fungsi : merendam kedelai sehingga kulit kedelai mengelupas dan menghilangkan bau dan rasa langu.

Bentuk tangki : silinder tegak dengan bagian atas terbuka dan tutup bawah berentuk konis dengan sudut puncak 30°.

Kondisi operas : P = 1 atm; $T_{operasi}$ = 90°C

Dimensi tangki :

Diameter shell (Di)	= 2,025 ft
Tinggi shell	= 3 ft
Tebal shell	= 3/16 in
Tinggi konis	= 1,321 ft in
Tebal konis	= 3/16 in
Tinggi tutup atas	= 0,23 ft
Tebal tutup atas	= 3/16 in

Tinggi tangki keseluruhan = 4,551 ft

Bahan konstruksi = Stainless Steel - 304

Pengaduk :

Type impeller = six flate blade turbine

Kecepatan agitator = 2,84 rpm

Jumlah impeller = 1 buah

Total power = 0,5 Hp

Koil pemanas :

dc = 1,25 ft

hc = 0,34 ft

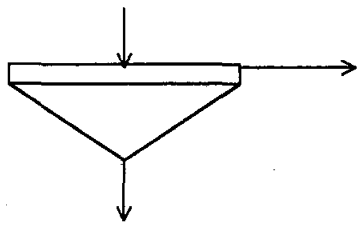
Harga : Rp. 92.632.421,88

4. Vibrating Screen I (H-130)

Fungsi : memisahkan kedelai dengan kotoran dari tangki perendaman

Tipe : Vibrating Screen

Dasar pemilihan : mudah dalam pengoperasian serta biaya operasi lebih murah



Perancangan:

<u>Menghitung Luas Ayakan</u>

Luas ayakan dihitung dengan menggunakan persamaan:

$$A = \frac{0{,}4.C_t}{C_u.F_{oa}.F_s}$$

Dengan:

A : Luas ayakan (ft^2)

C_t : kapasitas (ton/ jam)

C_u : kapasitas unit

F_{oa} : faktor bukaan area $=100\times\left\{\frac{a}{(a+d)}\right\}^2$ (Perry, ed.6, fig.12-16, pers. 21-3)

F_s : faktor slot area

Data-data:

C_t = 1068,066 kg/hari = 41,503 kg/jam = 0,044503 ton/jam

C_u = 0,25 ton/jam.ft^2 (Perry, ed.6, fig. 21-15)

F_s = 1,0

a = bukaan bersih = 0,35 in

d = diameter kawat = 0,2 in

Menentukan Foa:

$$F_{oa}=100\times\left\{\frac{0{,}35}{(0{,}35+0{,}2)}\right\}^2=0{,}40496$$

Menentukan luas ayakan:

$$A=\frac{0{,}4.C_t}{C_u.F_{oa}.F_s}=\frac{0{,}4.0{,}0445}{0{,}25.0{,}40496.1{,}0}=0{,}176\,ft^2=0{,}0164\,m^2$$

Dari Peter & Timmerhaus,edisi 4, Grafik 14-87, hal 567 dipilih ayakan dengan ukuran 1 x 3 ft

Spesifikasi:

Tipe : Vibrating screen single deck

Bentuk saringan : square

Dimensi vibrating screen :

- Kapasitas = 0,0445 ton/jam
- Luas ayakan = 0,176 ft^2 = 0,0164 m^2
- Panjang = 1 ft
- Lebar = 3 ft

Power : 0,5 Hp

Bahan konstruksi : SS-304

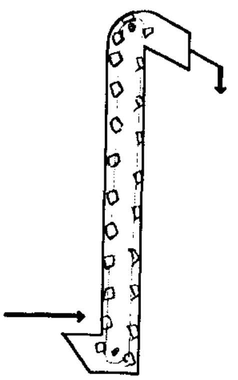
Harga : Rp. 34.406.328,13

5. Bucket Elevator II (J-240)

Fungsi : memindahkan biji kedelai dari vibrating screen I ke tangki blanching

Tipe : Centrifugal Bucket Elevator

Dasar pemilihan : mudah dalam pengoperasian dan sesuai dengan bahan yang akan dipindahkan yang berupa butiran - butiran



Massa kedelai = 327,531 kg/hari = 13,647 kg/jam = 743,7906 lb/jam

$\rho_{kedelai} = 69,96 \text{ lb/ft}^3$

Tinggi bucket = 1,5 ft

$$Power = \frac{TPH.2.L}{1000}$$ (Perry, ed.3, p.13-49)

di mana:

TPH = kapasitas feed, ton/jam

L = tinggi elevasi bucket

$$Power = \frac{0,013647.2.15}{1000} = 4,094.10^{-4}\,HP$$

Effisiensi = 80% (Peter & Timmerhaus, p.521, gbr.14-38)

HP = $4,094.10^{-4}/0,8 = 5,118.10^{-4}$HP

Dipakai motor dengan power = ½ HP

Spesifikasi:

Tipe : Centrifugal bucket elevator

Ukuran bucket : 6 x 4 x 4,5 in

Jarak bucket : 12 in

Elevator conter : 25 ft

Kecepatan bucket : 225 ft/menit

Head shaft : 43 rpm

Belt width : 7 in

Bahan konstruksi : SS-304

Power : 0,5 HP

Harga : $ 6700 (Peter & Timmerhaus, 1991)

6. **Tangki Larutan $NaHCO_3$**

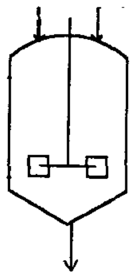
Fungsi : membuat larutan $NaHCO_3$ 0,5%

Bentuk tangki : silinder tegak dengan dasar tangki berbentuk konis dengan sudut 45°

Dasar pemilihan : harga murah dan tidak mudah berkarat sehingga usia alat lebih lama

Kondisi operasi : P = 1 atm

Kondisi : kontinyu



Bahan masuk :

- Air = 708,4638462 kg/hari = 65,09 lb/jam +
- Total = 708,4638462 kg/hari = 65,09 lb/jam

Menentukan dimensi tangki:

Perhitungan diasumsi hanya air saja karena jumlah padatan $NaHCO_3$ sangat kecil.

ρ_{air} = 62,171 lb/ft^3 = (pada T=30°C)

asumsi: $NaHCO_3$ dianggap sangat sedikit sehingga dapat diabaikan.

Lama penampungan = 2 jam

$$\text{Volume campuran} = \frac{1562{,}16\,lb/hari.0{,}083\,hari}{62{,}015\,lb/ft^3} = 2{,}09\,ft^3$$

Diambil: H_s = 1,5 x diameter shell (Ulrich, hal 248)

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.H_s$$

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.1{,}5D_i = \frac{\pi}{4}.1{,}5D_i^3$$

Dengan:

H_s = tinggi campuran dalam shell

D_i = diameter shell

$$Vol.laru\tan dlmkonis = \frac{\pi}{24tg\alpha}.\left(D_i^3 - D_n^3\right)$$

Vol. larutan dlm reaktor = vol. larutan dlm shell + vol. larutan dlm konis

Diambil:

Vol tangki perendaman = 1,2 . vol. larutan

D_n = diameter pengeluaran campuran = ½ ft

Volume tangki = 1,2 . 2,09 ft^3 = 2,508 ft^3

$$\text{Volume tangki} = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg45}.(D_i^3 - 0{,}5^3)\right)$$

$$2{,}508 = 1{,}178097245.D_i^3 + 0{,}1308996939.\ D_i^3 - 0{,}01636246174$$

$$D_i^3 = 1{,}929 \rightarrow D_i = 1{,}25\ ft \approx 15\ in\ \text{(diameter shell)}$$

H_s = 1,5. D_i = 1,5 x 1,25 = 1,875 ft

$$Vol.laru\tan andlmkonis = \frac{\pi}{24tg45.}.(D_i^3 - 0,5^3)$$

$$Vol.laru\tan dlmkonis = \frac{\pi}{24tg45.}.(1,875^3 - 0,5^3) = 0,85 ft^3$$

$$tinggilarutndlmshell = \frac{2,09 - 0,85}{\frac{\pi}{4}.1,25^2} = 1,010 ft = H$$

Tinggi konis (H_c):

$$H_c = \left(\frac{D_i}{2tg\alpha} - \frac{D_n}{2tg\alpha}\right) = \frac{1,25 - 0,5}{2tg45} = 0,375 ft$$

Tinggi larutan dalam tangki = H + Hc = (1,01 + 0,375) ft = 1,385 ft

$$P_{tangki} = \frac{(\rho \times H)}{144} = \frac{(62,171 \times 1,7385)}{144} = 0,60 psi$$

P_{design} = 1,3 . P_{tangki}

= 1,3 . 0,60 = 0,78 psi

Tebal tangki:

Bahan plate: SS-304

Dari Brownell & Young Tabel 13.1, didapat:

f = 18684 psi

e = 0,8 (double welded butt joint)

C = 1/8

Perhitungan tebal shell:

$$\text{Tebal shell} = \frac{P.D}{2(f.e - 0,6.P)} + C$$

$$= \frac{0,78.15}{2(18684.0,8 - 0,6.0,78)} + \frac{1}{8}$$

= 0,125 in ≈ 1/8 in

dipilih tebal standard = 1/8 in

Perhitungan tebal konis:

$$\text{Tebal konis} = \frac{P.D}{2\cos\alpha(f.e - 0{,}6.P)} + C$$

$$= \frac{0{,}78.15}{2\cos 45(18684.0{,}8 - 0{,}6.0{,}78)} + \frac{1}{8} = 0{,}126 in \approx 1/8 in$$

Pengaduk:

Type impeller: six flat blade turbine

Da = diameter impeller

Di = diameter tangki

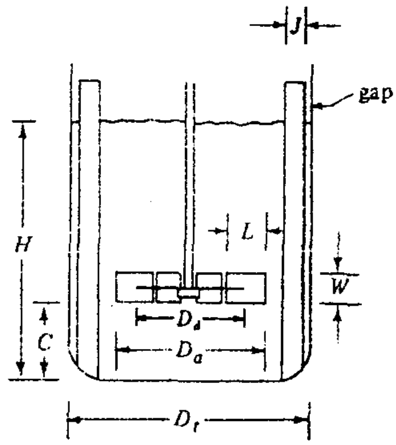
H = tinggi liquid dalam shell

L = panjang blade

W = lebar blade

E = jarak dari dasar tangki ke center impeller

J = lebar baffle



(Mc. Cabe, 4[tn]ed., p. 216)

$$\text{Da} = 0{,}3.D_i = 0{,}3.1{,}25 ft = 0{,}375 ft$$

H = Da = 0,375 ft

$$\text{J} = \frac{1}{12}D_i = \frac{1}{12}.1{,}25 ft = 0{,}104 ft$$

$$\text{E} = \frac{1}{3}D_i = \frac{1}{3}.1{,}25 ft = 0{,}375 ft$$

$$\text{W} = \frac{1}{5}D_a = \frac{1}{5}.0{,}375 ft = 0{,}075 ft$$

$$L = \frac{1}{4}D_i = \frac{1}{4}.0{,}375ft = 0{,}094ft$$

$$N = k.D_i^{2/3}.\left(\frac{\rho_c - \rho_d}{\rho_c}\right)^{0,26}.\left(\frac{\mu_c}{\rho_c}\right)^{1/9}$$

$$N = 9{,}4.(1{,}25ft)^{\frac{2}{3}}\left(\frac{62{,}171}{62{,}171}\right)^{0,26}\left(\frac{0{,}54.10^{-3}}{62{,}171}\right)^{\frac{1}{9}}$$

N = 2,988rpm

μ_{air} = 0,807.10^{-3} kg/m.s = 0,54.10^{-3} lb/ft.s

$$N_{re} = \frac{D_a^2.N.\rho_{camp}}{\mu_{camp}}$$

$$= \frac{(0{,}375ft)^2.\,{}^{2,988}\!/_{60}.62{,}171lb/ft^3}{0{,}54.10^{-3}lb/ft.s} = 806{,}28(la\min er)$$

Dari gambar 3.4-3 Geankoplis, 3rd edition, p. 145, diperoleh Np = 0,32

$$\text{Jumlah impeller} = \frac{sg.H}{D_i} = \frac{\frac{\rho_{campuran}}{\rho_{air}}.H}{D_i} = \frac{\frac{995{,}886kg/m^3}{1000kg/m^3}.0{,}375ft}{1{,}25ft} = 0{,}30 \approx 1buah$$

$$\text{Power untuk pengaduk} = \frac{N_P.\rho.N^3.D_a^5}{g_c}$$

$$= \frac{0{,}32.62{,}171lb/ft^3.\left(\frac{2{,}988rpm}{60\min/s}\right)^3.(0{,}375ft)^5}{32{,}174ft.lb/lbf.s^2}$$

$$= 1{,}47.10^{-9}\text{ ft.lb/s} = \frac{1{,}47.10^{-9}ft.lb/s}{550Hp/(ft.lb/s)} = 2{,}67.10^{-12}Hp$$

Gland Losses = 10%. 2,67.10^{-12} = 2,67.10^{-13} Hp

Power input = 2,67.10^{-12} + 2,67.10^{-13} = 2,937.10^{-12} Hp

Transmission system losses = 20%. Power input

= 0.2 . 2,937.10^{-12}

$= 5{,}874.10^{-13}$ Hp

Total power $= 2{,}937.10^{-12} + 5{,}874.10^{-13} = 3{,}524.10^{-12}$ Hp $\approx 0{,}5$ Hp

Spesifikasi:

Nama : tangki larutan $NaHCO_3$

Fungsi : membuat larutan $NaHCO_3$ 0,5%

Bentuk tangki : silinder tegak dengan bagian atas terbuka dan tutup bawah berbentuk konis dengan sudut puncak 45°.

Kondisi operas : P = 1 atm; $T_{operasi} = 90°C$

Jumlah : 1 unit

Bahan : SS-304

Dimensi tangki :

Diameter shell (Di)	= 1,25 ft
Tinggi shell	= 1,875 ft
Tebal shell	= 1/8 in
Tinggi konis	= 0,375 ft
Tebal Konis	= 1/8 in
Tinggi tangki keseluruhan	= 2,25 ft

Pengaduk :

Type impeller	= six flate blade turbine
Kecepatan agitator	= 2 rpm
Jumlah impeller	= 1 buah
Total power	= 0,5 HP

Harga : Rp 66.166.015,63

7. Tangki Blanching (R-220)

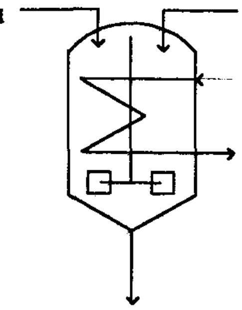
Fungsi : melunakkan biji kedelai dan menghilangkan senyawa antitripsin

Bentuk tangki : silinder tegak dengan tutup atas standar dished head dan tutup bawah berbentuk konis dengan sudut puncak 30°.

Dasar pemilihan : harga murah dan cocok untuk industri makanan

Kondisi operasi : P = 1 atm; $T_{operasi}$ = 90°C

Kondisi : kontinyu



Waktu tinggal kedelai dalam tangki = 3 jam

Bahan masuk :

- Kedelai = 426,289 kg/hari = 939,811 lb/hari
- Lart. $NaHCO_3$ = 721,024 kg/hari = 1589,594 lb/hari +
- Total = 1147,313 kg/hari = 2529,405 lb/hari

Menentukan dimensi tangki:

$\rho_{kedelai}$ = 919 kg/m^3 = 53,37 lb/ft^3

ρ_{air} = 62,4456 lb/ft^3

asumsi: $NaHCO_3$ dianggap sangat sedikit sehingga dapat diabaikan.

$$\rho_{campuran} = \frac{1}{\dfrac{0,372}{57,37} + \dfrac{0,628}{62,4456}} = 60,456 lb/ft^3 = 968,414 kg/m^3$$

$$\text{Volume campuran} = \frac{2529,405 lb/hari . 0,125 hari}{60,456 lb/ft^3} = 5,23 ft^3$$

Diambil: H_s = 1,5 x diameter shell (Ulrich, hal 248)

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.H_s$$

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.1,5D_i^3$$

$$Vol.campurandlmkonis = \frac{\pi}{24tg\alpha}.\left(D_i^3 - D_n^3\right)$$

Vol. campuran dlm reaktor = vol. campuran dlm shell + vol. campuran dlm konis

Diambil:

Vol tangki perendaman = 1,2 . vol. campuran

D_n = diameter pengeluaran campuran = ½ ft

Volume tangki = 1,2 . 5,23 = 6,276 ft^3

$$\text{Volume tangki} = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg30}.(D_i^3 - 0{,}5^3)\right)$$

$$6{,}276 = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg30}.(D_i^3 - 0{,}5^3)\right)$$

$$D_i^3 = 4{,}488 \rightarrow D_i = 1{,}65 \text{ ft} \approx 20 \text{ in (diameter shell)}$$

H_s = 1,5. D_i = 1,5 x 1,65 = 2,475 ft

$$Vol.campurandlmkonis = \frac{\pi}{24tg30.}.(1{,}650^3 - 0{,}5^3) = 0{,}99 ft^3$$

$$tinggicampurandlmshell = \frac{5{,}23 - 0{,}99}{\frac{\pi}{4}.1{,}650^2} = 1{,}980 ft = H$$

Tinggi konis (H_c):

$$H_c = \left(\frac{D_i}{2tg\alpha} - \frac{D_n}{2tg\alpha}\right) = \frac{1{,}650 - 0{,}5}{2tg30} = 0{,}996 ft$$

Tinggi campuran dalam tangki = H + H_c = (1,980 + 0,996)ft = 2,976 ft

$$P_{tangki} = \frac{(\rho \times H)}{144} = \frac{(60{,}456 \times 2{,}976)}{144} = 1{,}25 psi$$

P_{design} = 1,3 . P_{tangki}

= 1,3 . 1,25 = 1,625 psi

Tebal tangki:

Bahan plate: SS-304

Dari Brownell & Young Tabel 13.1, didapat:

f = 18684 psi

e = 0,8 (double welded butt joint)

C = 1/8

Perhitungan tebal shell:

$$\text{Tebal shell} = \frac{P.D}{2(f.e - 0{,}6.P)} + C$$

$$= \frac{1{,}625.20}{2(18684.0{,}8 - 0{,}6.1{,}625)} + \frac{1}{8}$$

$$= 0{,}126 \text{ in} \approx 3/16 \text{ in}$$

dipilih tebal standard = 3/16 in

Perhitungan tebal konis:

$$\text{Tebal konis} = \frac{P.D}{2\cos\alpha(f.e - 0{,}6.P)} + C$$

$$= \frac{1{,}625.20}{2\cos 30(18684.0{,}8 - 0{,}6.21{,}625)} + \frac{1}{8} = 0{,}127 in \approx 3/16 in$$

Dipilih tebal standard = 3/16 in

Pengaduk:

Type impeller: six flat blade turbine

Da = diameter impeller

Di = diameter tangki

H = tinggi liquid dalam shell

L = panjang blade

W = lebar blade

E = jarak dari dasar tangki ke center impeller

J = lebar baffle (Mc. Cabe, 4th ed., p. 216)

$Da = 0{,}3.D_i = 0{,}3.1{,}65 ft = 0{,}495 ft$

H = Da = 0,495 ft

$$J = \frac{1}{12} D_i = \frac{1}{12}.1{,}65 ft = 0{,}138 ft$$

E $= \frac{1}{3} D_i = \frac{1}{3}.1{,}65 ft = 0{,}495 ft$

W $= \frac{1}{5} D_a = \frac{1}{5}.0{,}495 ft = 0{,}099 ft$

L $= \frac{1}{4} D_i = \frac{1}{4}.0{,}495 ft = 0{,}1 ft$

$$N = k.D_i^{2/3}.\left(\frac{\rho_c - \rho_d}{\rho_c}\right)^{0,26}.\left(\frac{\mu_c}{\rho_c}\right)^{1/9}$$

$$N = 9{,}4.(1{,}65 ft)^{\frac{2}{3}}\left(\frac{(62{,}4456 - 57{,}37) lb/ft^3}{62{,}4456}\right)^{0,26}\left(\frac{6{,}778.10^{-3}}{62{,}4456}\right)^{\frac{1}{9}}$$

N =2,48rpm

μ_{air} = 0,3165.10[13]kg/m.s = 0,0002 lb/ft.s

$\mu_{campuran}$ = 0,324 . $\rho^{0,5}$

= 0,324 . $(968{,}414)^{0,5}$

= 10,08 . 2,42 lb/ft.h = 6,778.10^{-3}lb/ft.s

$$N_{re} = \frac{D_a^2.N.\rho_{camp}}{\mu_{camp}}$$

$$= \frac{(0{,}495 ft)^2 . {}^{2,48}\!/_{60} .60{,}456 lb/ft^3}{6{,}778.10^{-3} lb/ft.s} = 90{,}33(la\min er)$$

Dari gambar 3.4-3 Geankoplis, 3rd edition, p. 145, diperoleh Np = 0,57

$$\text{Jumlah impeller} = \frac{sg.H}{D_i} = \frac{\frac{\rho_{campuran}}{\rho_{air}}.H}{D_i} = \frac{\frac{968{,}414 kg/m^3}{1000 kg/m^3}.0{,}495 ft}{1{,}65 ft} = 0{,}30 \approx 1 buah$$

$$\text{Power untuk pengaduk} = \frac{N_P.\rho.N^3.D_a^5}{g_c}$$

$$= \frac{0{,}57.60{,}456 lb/ft^3.\left(\frac{2{,}48 rpm}{60 \min/s}\right)^3.(0{,}495 ft)^5}{32{,}174 ft.lb/lbf.s^2}$$

$$= 2{,}25.10^{-6}\ \text{ft.lb/s} = \frac{2{,}25.10^{-6}\ ft.lb/s}{550 Hp/(ft.lb/s)} = 4{,}1.10^{-9}\ Hp$$

Gland Losses = 10%. $4{,}1.10^{-9} = 4{,}1.10^{-10}$ Hp

Power input = $4{,}1.10^{-9} + 4{,}1.10^{-10} = 4{,}51.10^{-9}$ Hp

Transmission system losses = 20%. Power input

$= 0.2\ .\ 4{,}51.10^{-9} = 9{,}02.10^{-10}$ Hp

Total power = $4{,}51.10^{-9} + 9{,}02.10^{-10} = 5{,}412.10^{-9}$ Hp $\approx$ 0,5 Hp

Perhitungan dished head (Torispherical dished head)

Penentuan tinggi dished head:

r = D_i = 20 in = 1,65 ft

Icr = 6% . r = 6%. 20 in = 1,2 in

Dari Brownell & Young, persamaan 7.76:

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{20}{1{,}2}}\right) = 1{,}771$$

AB = D/2 – icr = 20/2 – 1,2 = 8,8 in

BC = r – icr = 20 – 1,2 = 18,8 in

b = r - $(BC^2 - AB^2)^{1/2}$ = 20 – $(18{,}8^2 - 8{,}8^2)^{1/2}$ = 3,387 in

Penentuan tebal tutup atas:

$$t_d = \frac{P.r_c.W}{2(f.E - 0{,}2.P)} + C$$ (Brownell & Young, pers. 7.77)

dengan:

P_{design} = 1,625 psi

Digunakan tipe sambungan double welded butt joint

Sehingga E = 0,8 (Brownell & Young, Tabel 13.2)

C = 1/8

$$t_d = \frac{1{,}625.20.1{,}771}{2(18684.0{,}8 - 0{,}2.1{,}625)} + \frac{1}{8} = 0{,}127 in$$

Diambil tebal standard 3/16 in

Dipilih panjang straight flange (sf) = 2 in (Brownell & Young, Tabel 5.8)

OA = t + b + sf =3/16 + 3,387 + 2 = 5,5745 in = 0,50 ft

Tinggi tangki total = 1,65 ft + 0,996 ft + 0,50 ft = 3,146 ft

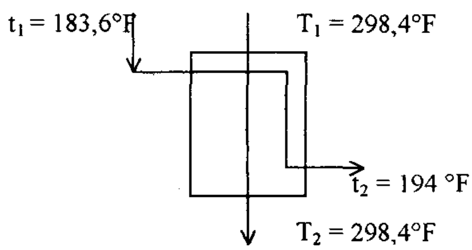
Koil pemanas:

Untuk menaikkan suhu:

$T_{feed\ masuk}$ = 70°C = 183,6°F

$T_{feed\ keluar}$ = 90°C = 194°F

T_{steam} = 148°C = 298,4°F



1. $$\Delta T_{LMTD} = \frac{(T_1 - t_1) - (T_2 - t_2)}{\ln \frac{T_1 - t_1}{T_2 - t_2}} = \frac{(298{,}4 - 183{,}6) - (298{,}4 - 194)}{\ln \frac{298{,}4 - 183{,}6}{298{,}4 - 194}} = 109{,}52^\circ F$$

5. Dari Neraca Panas didapat:
   - Q = kalor yang disuplai = 50711,07232 kkal/hari

     = 20106,73 btu/hari = 8379,450 btu/jam
   - massa steam = 100,063 kg/hari
6. Tc = 0,5 . (T_1 + T_2) = 0,5 . (298,5 + 298,5) = 298,5°F

   tc = 0,5 . (t_1 + t_2) = 0,5 . (183,6 + 194) = 188,8°F
7. Berdasarkan Tabel 11, Kern, Hal. 844

   Diambil pipa koil = ¾ in, sch 40

   OD = 1,05 in

   ID = 0,824 in

a' = 0,534 in^2/pipe = $3,71.10^{-3}$ ft^2/pipa

a" =0,275 ft^2/ft

Sisi bejana: fluida dingin	Sisi tube: fluida panas
Nre = 5463,72 (dari impeller)	hoi = 1500 Btu/ft^2.jam.F → steam
J = 187,5 (Kern, Fig 20.2)	
SG = 0,972	
k = 0,375 Btu/ jam.ft^2.(F/ft)	
μ = 24,393 lb/ft.jam	
Cp = 0,8626 Btu/jam.ft^2.F	
$ho = J.\frac{k}{D}\left(\frac{Cp.\mu}{k}\right)^{-\frac{1}{3}}.\left(\frac{\mu}{\mu_w}\right)^{0,14}$	
$= 187,5.\frac{0,375}{1,65}.\left(\frac{0,8626.24,393}{0,375}\right)^{-\frac{1}{3}}.(1)^{0,14}$	
$= 99,56 Btu/ft^2.h.^\circ F$	

$$Uc = \frac{h_c.h_{oi}}{h_c + h_{oi}} = \frac{99,56.1500}{99,56+1500} = 93,36 btu/jam.ft^2.F$$

$$Rd = 0,004 \rightarrow hd = \frac{1}{0,004} = 250$$

$$U_D = \frac{U_C.h_d}{U_C + h_d} = \frac{93,36.250}{93,36+250} = 67,98 btu/jam.ft^2.F$$

$$A = \frac{Q}{U_D.\Delta t_{LMTD}} = \frac{8379,45}{67,98.109,52} = 1,125 ft^2$$

$$\text{panjang koil} = \frac{1,125}{0,275} = 4,091 ft$$

$$D_C diambil = 1,25 ft$$

$$N_C = \frac{4,091}{\pi.1,25} = 1,04 \approx 1$$

$$h_c = ((n_c - 1).(d_o + s_c)) + d_o = ((1-1).(1,05+2)) + 1,05 = 1,05 in = 0,0875 ft$$

Spesifikasi:

Nama : tangki blanching

Fungsi : merendam kedelai sehingga kulit kedelai mengelupas dan menghilangkan bau dan rasa langu.

Bentuk tangki : silinder tegak dengan bagian atas terbuka dan tutup bawah berbentuk konis dengan sudut puncak 30°.

Bahan konstruksi : SS-304

Jumlah : 1 unit

Kondisi operas : P = 1 atm; $T_{operasi}$ = 90°C

Dimensi tangki :

Diameter shell (Di)	= 1,65 ft
Tinggi shell	= 1,875 ft
Tebal shell	= 3/16 in
Tinggi konis	= 0,996 ft
Tebal konis	= 3/16 in
Tinggi tutup atas	= 0,5 ft
Tebal tutup atas	= 3/16 in
Tinggi tangki keseluruhan	= 3,146 ft

Pengaduk :

Type impeller	= six flate blade turbine
Kecepatan agitator	= 2,48 rpm
Jumlah impeller	= 1 buah
Total power	= 0,5 Hp

Koil pemanas :

dc = 1,25 ft

hc = 1,05 ft

Harga : Rp. 114.694.818,1

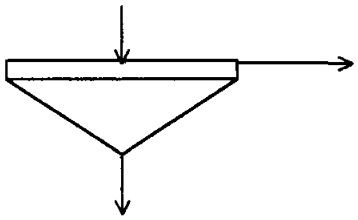
8. Vibrating Screen II (H-230)

Fungsi : memisahkan kedelai dari larutan $NaHCO_3$

Tipe : Vibrating Screen (Perry, 6ed., p.21-15)

Dasar pemilihan : mudah dalam pengoperasian serta biaya operasi lebih murah

Perancangan:



Menghitung Luas Ayakan

Luas ayakan dihitung dengan menggunakan persamaan:

$$A = \frac{0{,}4.C_t}{C_u.F_{oa}.F_s}$$

Di mana :

A : Luas ayakan (ft^2)

C_t : kapasitas (ton/ jam)

C_u : kapasitas unit

F_{oa} : faktor bukaan area $= 100 \times \left\{ \frac{a}{(a+d)} \right\}^2$ (Perry, ed.6, fig.12-16, pers. 21-3)

F_s : faktor slot area

Data-data:

C_t = 1138,31 kg/hari = 47,43 kg/jam = 0,047 ton/jam

C_u = 0,25 ton/jam.ft^2 (Perry, ed.6, fig. 21-15)

F_s = 1,0

a = bukaan bersih = 0,35 in

d = diameter kawat = 0,2 in

Menentukan Foa:

$$F_{oa} = 100 \times \left\{ \frac{0{,}35}{(0{,}35 + 0{,}2)} \right\}^2 = 0{,}40496$$

Menentukan luas ayakan:

$$A = \frac{0{,}4.C_t}{C_u.F_{oa}.F_s} = \frac{0{,}4.0{,}047}{0{,}25.0{,}40496.1{,}0} = 0{,}187 m^2$$

Dari Peter & Timmerhaus, edisi 4, Grafik 14-87, halaman 567 diambil vibrating screen dengan ukuran 1 x 3 ft

Spesifikasi:

Tipe : Vibrating screen single deck

Bentuk saringan : square

Dimensi vibrating screen :

- Kapasitas = 0.047 ton/jam
- Luas ayakan = 0,0173 ft^2 = 0,187 m^2
- Panjang = 1 ft
- Lebar = 3 ft

Bahan konstruksi : SS-304

Power : 0,5 HP

Harga : Rp. 34.406.328,13

9. Bucket Elevator III (J-240)

Fungsi : memindahkan biji kedelai dari vibrating screen 2 ke tangki penampung 1

Dasar pemilihan : sesuai dengan bahan yang akan dipindahkan yang berbentuk butiran-butiran.

Massa kedelai = 4788,7362 kg/hari = 199,530672 kg/jam = 440 lb/jam

$\rho_{kedelai}$ = 69,96 lb/ft^3

Tinggi bucket = 1,5 ft

$$Power = \frac{TPH.2.L}{1000} \qquad \text{(Perry, ed.3, p.13-49)}$$

di mana:

TPH = kapasitas feed, ton/jam

L = tinggi elevasi bucket

$$Power = \frac{440.2.1,5}{1000} = 1,32HP$$

Effisiensi = 80% (Peter & Timmerhaus, p.521, gbr.14-38)

HP = 1,32/0,8 = 1,65HP

Dipakai motor dengan power = ½ HP

Spesifikasi:

Tipe	: Centrifugal bucket elevator
Ukuran bucket	: 6 x 4 x 4,5 in
Jarak bucket	: 12 in
Elevator conter	: 25 ft
Kecepatan bucket	: 225 ft/menit
Head shaft	: 43 rpm
Belt width	: 7 in
Bahan konstruksi	: SS-304
Power	: ½ HP
Harga	: Rp. 70.929.968,77

10. Tangki Penampung I (F-250)

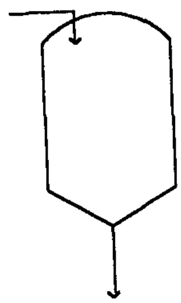
Fungsi : menampung kedelai sebelum masuk ke colloid mill

Bentuk : silinder tegak dengan tutup bawah berbentuk konis dengan sudut puncak 45° dan tutup atas berbentuk torispherical dished head

Dasar pemilihan : harga murah dan bahan serta sesuai untuk industri makanan

Kondisi operasi : P = 1 atm

Kondisi : kontinyu



Bahan masuk :

Waktu tinggal kedelai dalam tangki = 2 jam = 0,083 hari

Bahan masuk :

- Kedelai = 327,5310244 kg/hari = 30,09 lb/jam
- Air = 240,5260187 kg/hari = 22,09 lb/jam +
- Total = 568,0570431kg/hari = 52,18 lb/jam

Menentukan dimensi tangki:

$\rho_{kedelai}$ = 919 kg/m^3 = 57,37 lb/ft^3

ρ_{air} = 61,108 lb/ft^3

asumsi: $NaHCO_3$ dianggap sangat sedikit sehingga dapat diabaikan.

$$\rho_{campuaran} = \frac{1}{\frac{0,577}{57,37}+\frac{0,423}{61,108}} = 58,894 lb/ft^3 = 943,39 kg/m^3$$

$$\text{Volume campuran} = \frac{1252,32 lb/hari.0,083 hari}{58,894 lb/ft^3} = 1,765 ft^3$$

Diambil:

H_s = 1,5 . diameter shell

$$\text{Volume campuran dalam shell} = \frac{\pi}{4}.1,5.D^3$$

$$\text{Volume campuran dalam konis} = \frac{\pi}{24 tg\alpha}(D^3 - D_n^3)$$

Volume campuran dlm reaktor = vol. campuran dlm shell + vol campuran dlm konis

Volume tangki = 1,2 . volume campuran
= 1,2 . 1,765 = 2,118 ft^3

Diambil : Dn = 0,5 ft

$$2{,}118 = \frac{\pi}{4}.1{,}5.D^3 + \left(\frac{\pi}{24tg45}(D^3 - 0{,}5^3)\right)$$

D^3 = 1,63 → D = 1,18 ft = 15 in

H_s = 1,5 . 1,18 = 1,77 ft

$$\text{Volume campuran dalam konis} = \frac{\pi}{24tg45}(1{,}18^3 - 0{,}5^3) = 0{,}20 ft$$

$$\text{Volume campuran dalam shell} = \frac{1{,}765 - 0{,}20}{\frac{\pi}{4}.1{,}18^2} = 1{,}43 ft$$

$$\text{Tinggi konis} = \frac{1{,}18 - 0{,}5}{2tg45} = 0{,}34 ft$$

Tinggi campuran dalam tangki = 1,43 + 0,34 = 1,77 ft

$$P_{operasi} = P_{hidrostatis} = \frac{58{,}894.1{,}77}{144} = 0{,}74 psi$$

P_{design} = 1,3 . $P_{operasi}$ = 1,3 . 0,74 = 0,936 psi

Menghitung tebal shell:

$$t_s = \frac{0{,}936.15}{2(18684.0{,}8 - 0{,}6.0{,}936)} + 1/8 = 0{,}126 in$$

Dipilih tebal standard = 3/16 in

Menghitung tebal konis:

$$t_c = \frac{0{,}936.15}{2\cos 45(18684.9{,}8 - 0{,}6.0{,}936)} + 1/8 = 1{,}27 in$$

Dipilih tebal standard = 3/16 in

Perhitungan dished head (Torispherical dished head)

Penentuan tinggi dished head:

r = D_i = 15 in

Icr = 6% . r = 6%. 15 in = 0,9 in

Dari Brownell & Young, persamaan 7.76:

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{15}{0,9}}\right) = 1,771$$

AB = D/2 – icr = 15/2 – 0,9 = 6,6 in

BC = r – icr = 15 – 0,9 = 14,1 in

b = r - $(BC^2 - AB^2)^{1/2}$ = 15 – $(14,1^2 - 6,6^2)^{1/2}$ = 2,540 in

Penentuan tebal tutup atas:

$$t_d = \frac{P.r_c.W}{2(f.E - 0,2.P)} + C$$ (Brownell & Young, pers. 7.77)

dengan:

P_{design} = 0,936 psi

Digunakan tipe sambungan double welded butt joint

Sehingga E = 0,8 (Brownell & Young, Tabel 13.2)

C = 1/8

$$t_d = \frac{0,936.15.1,771}{2(18684.0,8 - 0,2.0,936)} + \frac{1}{8} = 0,126 in$$

Diambil tebal standard 3/16 in

Dipilih panjang straight flange (sf) = 2 in (Brownell & Young, Tabel 5.8)

OA = t + b + sf =3/16 + 2,540 + 2 = 4,727 in = 0,393 ft

Tinggi tangki total = 1,77 ft + 0,34 ft + 0,393 ft = 2,503 ft

Spesifikasi:

Nama	: tangki penampung I
Fungsi	: menampung kedelai sebelum masuk ke colloid mill

Bentuk : silinder tegak dengan tutup bawah berbentuk konis dengan sudut puncak 45° dan tutup atas berbentuk torispherical dished head

Bahan konstruksi : SS-304

Jumlah : 1 unit

Kondisi operasi : P = 1 atm

Dimensi tangki :

Diameter shell (D_i)	= 1,63 ft = 15 in
Tinggi shell (H_s)	= 1,77 ft
Tebal shell	= 3/16 in
Tinggi konis	= 0,34 ft
Tebal konis	= 3/16 in
Tinggi tutup atas	= 0,393 ft
Tebal tutup atas	= 3/16 in
Tinggi tangki keseluruhan	= 2,503 ft

Harga : Rp. 114.652.471,9

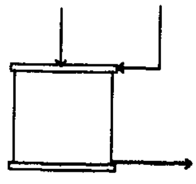
11. Colloid Mill (C-260)

Fungsi : menghancurkan biji kedelai hingga diperoleh bubur kedelai

Tipe : Charlotte mill

Dasar pemilihan : menghasilkan produk yang halus sehingga luas permukaan perpindahan massa untuk proses ekstraksi lebih besar serta sesuai dengan kapasitas yang diinginkan.

Kapasitas alat : 20 – 50 galon/jam



$$\rho_{campuaran} = \frac{1}{\frac{0,577}{57,37} + \frac{0,423}{61,108}} = 58,894 lb/ft^3 = 943,39 kg/m^3$$

Konversi:

- 20 galon/jam = 2,673 ft^3/jam

  2,673 ft^3/jam x 58,894 lb/ft^3 = 157,424 lb/jam = 77,740 kg/jam
- 50 galon/jam = 6,683 ft^3/jam

  6,683 ft^3/jam x 58,894 lb/ft^3 = 393,589 lb/jam = 194,365 kg/jam

Kapasitas : 1878,403521 kg/hari = 158,5 lb/jam

Kapasitas bahan yang akan dihancurkan masuk dalam range kapasitas bahan pada Charlotte mill, sehingga dilih colloid mill tipe Charlotte mill.

Spesifikasi:

Tipe : Charlotte mill

Daya : 3 Hp

Bahan : SS-304

Jumlah : 1 unit

Harga : $ 5500

Kecepatan perputaran rotor : 3600 rpm

12. Tangki Ekstraksi (R-270)

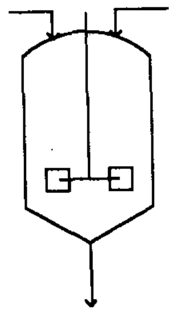
Fungsi : menampung bubur kedelai dari colloid untuk kemudian dialirkan ke rotary drum filter

Bentuk tangki : silinder tegak dengan tutup atas toryspehrical dished head dan tutup bawah berbentuk konis dengan sudut 30°

Dasar pemilihan : harga murah dan cocok untuk digunakan dalam industri makanan

Kondisi operasi : P = 1 atm

Kondisi : kontinyu



Bahan masuk :

- Kedelai = 327,5310244 kg/hari = 30,09 lb/jam
- Air = 1550,650117 kg/hari = 142,47 lb/jam +
- Total = 568,0570431kg/hari = 172,56 lb/jam

Menentukan dimensi tangki:

$\rho_{kedelai}$ = 919 kg/m^3 = 57,37 lb/ft^3

ρ_{air} = 61,1025 lb/ft^3

asumsi: $NaHCO_3$ dianggap sangat sedikit sehingga dapat diabaikan.

$$\rho_{campuaran} = \frac{1}{\frac{0,17}{57,37} + \frac{0,83}{61,025}} = 60,372 lb/ft^3 = 967,069 kg/m^3$$

$$\text{Volume campuran} = \frac{4141,44 lb/hari . 0,042 hari}{60,372 lb/ft^3} = 2,881 ft^3$$

Diambil: H_s = 1,5 x diameter shell (Ulrich, hal 248)

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.H_s$$

$$\text{Vol campuran dalam shell} = \frac{\pi}{4}.D_i^2.1,5D_i = \frac{\pi}{4}.1,5D_i^3$$

Dengan:

H_s = tinggi campuran dalam shell

D_i = diameter shell

$$Vol.campurandlmkonis = \frac{\pi}{24tg\alpha}.\left(D_i^3 - D_n^3\right)$$

Vol. larutan dlm reaktor = vol. larutan dlm shell + vol. larutan dlm konis

Diambil:

Vol tangki perendaman = 1,2 . vol. larutan

D_n = diameter pengeluaran campuran = ½ ft

Volume tangki = 1,2 . 2,881 ft^3 = 3,457 ft^3

$$\text{Volume tangki} = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg\alpha}.(D_i^3 - 0{,}5^3)\right)$$

$$3{,}457 = \frac{\pi}{4}.1{,}5.D_i^3 + \left(\frac{\pi}{24tg30}.(D_i^3 - 0{,}5^3)\right)$$

$$D_i^3 = 2{,}48 \rightarrow D_i = 1{,}35 \text{ ft} \approx 16 \text{ in (diameter shell)}$$

H_s = 1,5. D_i = 1,5 x 1,35 = 2,025 ft

$$Vol.campuranandlmkonis = \frac{\pi}{24tg\alpha.}.(D_i^3 - 0{,}5^3)$$

$$Vol.campurandlmkonis = \frac{\pi}{24tg30.}.(1{,}35^3 - 0{,}5^3) = 0{,}53 ft^3$$

$$tinggicampurandlmshell = \frac{2{,}881 - 0{,}53}{\frac{\pi}{4}.1{,}35^2} = 1{,}642 ft = H$$

Tinggi konis (H_c):

$$H_c = \left(\frac{D_i}{2tg\alpha} - \frac{D_n}{2tg\alpha}\right) = \frac{1{,}35 - 0{,}5}{2tg30} = 0{,}736 ft$$

Tinggi larutan dalam tangki = H + Hc = (1,642 + 0,736) ft = 2,376 ft

$$P_{tangki} = \frac{(\rho \times H)}{144} = \frac{(60{,}372 \times 2{,}376)}{144} = 0{,}996 psi$$

P_{design} = 1,3 . P_{tangki}

= 1,3 . 0,996 = 1,295 psi

Tebal tangki:

Bahan plate: SS-304

Dari Brownell & Young Tabel 13.1, didapat:

f = 18684 psi

e = 0,8 (double welded butt joint)

C = 1/8

Perhitungan tebal shell:

$$\text{Tebal shell} = \frac{P.D}{2(f.e - 0{,}6.P)} + C$$

$$= \frac{1{,}295.16}{2(18684.0{,}8 - 0{,}6.1{,}295)} + \frac{1}{8}$$

$$= 0{,}125 \text{ in} \approx 3/16 \text{ in}$$

dipilih tebal standard = 3/16 in

Perhitungan tebal konis:

$$\text{Tebal konis} = \frac{P.D}{2\cos\alpha(f.e - 0{,}6.P)} + C$$

$$= \frac{1{,}295.16}{2\cos 30(18684.0{,}8 - 0{,}6.1{,}295)} + \frac{1}{8} = 0{,}126 in \approx 3/16 in$$

Pengaduk:

Type impeller: six flat blade turbine

Da = diameter impeller

Di = diameter tangki

H = tinggi liquid dalam shell

L = panjang blade

W = lebar blade

E = jarak dari dasar tangki ke center impeller

J = lebar baffle

(Mc. Cabe, 4^{th}ed., p. 216)

$$Da = 0{,}3.D_i = 0{,}3.1{,}35 ft = 0{,}405 ft$$

$$H = Da = 0{,}405 \text{ ft}$$

$$J = \frac{1}{12} D_i = \frac{1}{12}.1{,}35 ft = 0{,}113 ft$$

$$E = \frac{1}{3}D_i = \frac{1}{3}.1{,}35 ft = 0{,}405 ft$$

$$W = \frac{1}{5}D_a = \frac{1}{5}.0{,}405 ft = 0{,}081 ft$$

$$L = \frac{1}{4}D_i = \frac{1}{4}.0{,}405 ft = 0{,}101 ft$$

$$N = k.D_i^{2/3}.\left(\frac{\rho_c - \rho_d}{\rho_c}\right)^{0,26}.\left(\frac{\mu_c}{\rho_c}\right)^{1/9}$$

$$N = 9{,}4.(1{,}35 ft)^{\frac{2}{3}}\left(\frac{61{,}1025 - 57{,}37}{61{,}1025}\right)^{0,26}\left(\frac{6{,}772.10^{-3}}{61{,}1025}\right)^{\frac{1}{9}}$$

N =2,988rpm

$\mu_{air} = 0{,}807.10^{-3}$ kg/m.s = $0{,}54.10^{-3}$ lb/ft.s

$\mu_{campuran} = 0{,}324 . \rho^{0,5}$

$= 0{,}324 .(967{,}069)^{0,5}$

$= 10{,}075 . 2{,}42$ lb/ft.h = $6{,}772.10^{-3}$ lb/ft.s

$$N_{re} = \frac{D_a^2.N.\rho_{camp}}{\mu_{camp}}$$

$$= \frac{(0{,}405 ft)^2.\,{}^{2,902}\!/_{60}.60{,}372 lb/ft^3}{6{,}772.10^{-3} lb/ft.s} = 49{,}23(laminer)$$

Dari gambar 3.4-3 Geankoplis, 3rd edition, p. 145, diperoleh Np = 0,4

$$\text{Jumlah impeller} = \frac{sg.H}{D_i} = \frac{\frac{\rho_{campuran}}{\rho_{air}}.H}{D_i} = \frac{\frac{967{,}069 kg/m^3}{1000 kg/m^3}.0{,}405 ft}{1{,}35 ft} = 0{,}29 \approx 1 buah$$

$$\text{Power untuk pengaduk} = \frac{N_P.\rho.N^3.D_a^5}{g_c}$$

$$= \frac{0{,}4.60{,}372 lb/ft^3.\left(\frac{2{,}02 rpm}{60 \min/s}\right)^3.(0{,}405 ft)^5}{32{,}17 ft.lb/lbf.s^2}$$

$$= 3{,}12.10^{-7} \text{ ft.lb/s} = \frac{3{,}12.10^{-7} ft.lb/s}{550 Hp/(ft.lb/s)} = 5{,}67.10^{-10} Hp$$

Gland Losses = 10%. $5{,}67.10^{-10} = 5{,}67.10^{-11}$ Hp

Power input = $5{,}67.10^{-10} + 5{,}67.10^{-11} = 6{,}237.10^{-10}$ Hp

Transmission system losses = 20%. Power input

= $0.2 \cdot 6{,}237.10^{-10}$

= $1{,}2474.10^{-10}$ Hp

Total power = $6{,}237.10^{-10} + 1{,}2474.10^{-10} = 7{,}484.10^{-10}$ Hp ≈ 0,5 Hp

Perhitungan dished head (Torispherical dished head)

Penentuan tinggi dished head:

$r = D_i = 16$ in

Icr = 6% . r = 6%. 16 in = 0,96 in

Dari Brownell & Young, persamaan 7.76:

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{16}{0{,}96}}\right) = 1{,}771$$

AB = D/2 – icr = 16/2 – 0,96 = 7,04 in

BC = r – icr = 16 – 0,96 = 15,04 in

$b = r - (BC^2 - AB^2)^{1/2} = 16 - (15{,}04^2 - 7{,}04^2)^{1/2} = 2{,}709$ in

Penentuan tebal tutup atas:

$$t_d = \frac{P.r_c.W}{2(f.E - 0{,}2.P)} + C$$ (Brownell & Young, pers. 7.77)

dengan:

$P_{design} = 1{,}295$ psi

Digunakan tipe sambungan double welded butt joint

Sehingga E = 0,8 (Brownell & Young, Tabel 13.2)

C = 1/8

$$t_d = \frac{1,295.16.1,771}{2(18684.0,8 - 0,2.1,295)} + \frac{1}{8} = 0,126 in$$

Diambil tebal standard 3/16 in

Dipilih panjang straight flange (sf) = 2 in (Brownell & Young, Tabel 5.8)

OA = t + b + sf =3/16 + 2,709 + 2 = 4,897 in = 0,41 ft

Tinggi tangki total = 1,35 ft + 0,736 ft + 0,41 ft = 2,496 ft

Spesifik

Dimensi tangki :

Diameter shell (Di)	= 1,35 ft = 16 in
Tinggi shell	= 2,025 ft
Tebal shell	= 3/16 in
Tinggi konis	= 0,736 ft
Tebal konis	= 3/16 in
Tinggi tutup atas	= 0,41 ft
Tebal tutup atas	= 3/16 in
Tinggi tangki keseluruhan	= 2,496 ft
Bahan konstruksi	= Stainless Steel - 304

Pengaduk :

Type impeller	= six flate blade turbine
Kecepatan agitator	= 2,02 rpm
Jumlah impeller	= 1 buah
Total power	= 0,5 Hp

Harga : Rp. 194.086.943,9

13. Rotary Vacuum Drum Filter (H-280)

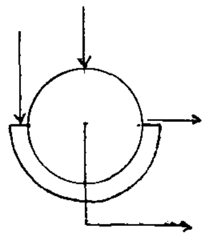
Fungsi : untuk memisahkan sari kedelai dari ampasnya

Tipe : Rotary Vacuum Drum Filter

Dasar pemilihan : dapat memisahkan filtrat dari cake sampai dengan 80%

Bahan masuk:

Air	: 2630,5102370 kg/ hari	= 5800, 275 lb/ hari
Padatan	: 327,7534047 kg/ hari	= 722,701 lb/ hari
Total	:2958,485546 kg/ hari	= 6522,976 lb/hari
Kapasitas	= 2958,485546 kg/ hari	= 123,27 kg/ jam



Menghitung luas filter medium:

$$\psi = \frac{Cv}{A^2.(\Delta Pc)}\left(\frac{(V')^2}{N} + 2.V'.\frac{Ve}{A}.A\right) \qquad \text{(Brown, hal. 214)}$$

A : luas filter medium (ft^2)

V' : kecepatan filtrasi, yaitu volume filtrasi tertampung dibagi waktu filtrasi (cm^3/s)

N : kecepatan putaran drum = 1 rpm

Ve : volume filtrat yang ditampung per satuan luas saring dari cake yang memberikan penahanan sebesar yang diberikan filter cloth dan saluraan-saluran lainnya (cm^3/cm^2)

(ΔPc): Pressure drop filtration, tetap jika cakenya non kompresible (kg/cm^2)

Cv : tetapan untuk filtrasi

ψ : fraksi tercelup drum di dalam feed

Estimasi Tetapan Cv

$$Cv = \frac{\mu.\rho.x}{2.k.(\{\rho s(1-x)(1-X)\} - \rho.x.X)}$$

Permeabilitas = k = $\dfrac{gc.D_p^2.Fre}{32.Ff}$

Fre : f(X,ψ) dari figure 211, Brown

Ff : f(X, ψ) dari figure 212, Brown

gc : 980,665 cm/dt^2

Dp : diameter partikel = 5 μm = 20.10^{-4} in = 5,08.10^{-3} cm

(Perry, ed. 6, hal. 8-45)

X : porosity cake = 0,3954 (Brown, hlm. 215)

ρ : densitas filtrat (gr/cm^3)

ρ_s : densitas solid dalam cake (gr/cm^3)

x : fraksi massa padatan dalam cake

$$x = \frac{berat padatan}{berat slurry} = \frac{29{,}62 lb/jam}{271{,}30 lb/jam} = 0{,}109$$

ψ = 0,4 (Brown, hal.214)

Volume filtrat = (2169,95849 kg/hari x 1000 gr)/ 1,129 gr/cm^3

= 1922018,069 cm^3/hari

= 1922,018 liter/hari = 80,084 liter/hari

= 2,828 ft^3/jam

V' = 1922018,069 cm^3/hari = 22,246 cm^3/detik

$\rho_{filtrat}$ = 62,015 lbm/ft^2 = 0,994 gr/cm^3

$\mu_{filtrat}$ = 0,324 . 62,015

= 2,55 . 2,42 lb/ft.h = 1,714.10^{-3} lb/ft.s = 7,085.10^{-4} gr/cm.s

F_{Re} = 45

F_f = 15500

$$k = \frac{980,665.(5,08.10^{-3})^2.45}{32.15500} = 2,29.10^{-6}\,cm^3/\det^2$$

$$Cv = \frac{7,085.10^{-4}.0,994.0,109}{2.2,29.10^{-6}.(\{1,129(1-0,109)(1-0,3954)\} - 0,994.0,109.0,3954)} = 29,65\,gr.s/cm^4$$

Waktu filtrasi:

t_f = ψ/N = (0,4).(60/1) = 24 detik

$$t_f = \frac{Cv}{(\Delta Pc)}\left[\left(\frac{V}{A}\right)^2 + 2.\left(\frac{V}{A}\right)\left(\frac{Ve}{A}\right)\right]$$

Filtrat keluar = 1922,018 liter/hari = 80,084 liter/jam

Kecepatan volumetric cake keluar = (788,3051508 kg/hari)/ 0,969 kg/liter

= 813,524 liter/hari = 33,90 liter/jam

Tebal cake yang direncanakan = 1 cm

V/A = 80,084 x (1/33,90) = 2,3624 cm^3/cm^2

$$24 = \frac{0,02965.\left(2,3614^2 + \left(2.2,3614.\left(\frac{Ve}{A}\right)\right)\right)}{0,1381}$$

Ve/A = 22,49 cm^3/cm^2

$$0,4 = \frac{0,02965}{A^2.0,1381}.\left[\frac{22,246}{1/60} + (2.22,246.22,49.A)\right]$$

A = 716,2 cm^2 = 23,5 ft^2

Dari Perry, edisi 5, table 19-23 hal 19-77, dipilih rotary drum vacuum filter sebagai berikut:

Diameter : 2 ft = 0,61 m

Panjang drum : 2 ft = 0,61 m

Luas permukaan filter = 62 ft^2 = 5,74 m^2

Perputaran drum : 1 rpm

Power drum : 0,005 HP/ft^2 x 62 ft^2 = 0,31 HP ≈ 0,5 HP

Pompa Vacuum Filter

Dipakai operasi vacuum = 4 inHg

Tekanan udara keluar = 1 atm = 29,92 inHg

Suhu operasi = 30°C = 303 K

Cp udara = 7,055 cal/gmole.K

Cv = Cp – R = 7,055 – 1,987 = 5,068 cal/ gmole

λ = Cp/ Cv = 1,392067866

Dianggap udara sebagai gas ideal, dikompresi secara adiabatic:

$$Ws = \left[\frac{RT}{(\lambda-1)}\right].\left[1-\frac{P1}{P2}^{(\lambda-1)/\lambda}\right]$$ (Smith van Ness, hal. 68)

Ws = 60,83055144 cal/gmole

Volume = (π/4).D^2.L = (π/4).2^3 = 6,28 cuft

Diambil faktor keamanan = 20%

Perputaran drum	: 1 rpm
Volume udara	: 1,2 x 785 = 942 ft^3/menit
ρ_{udara}	: 0,08071 lb/ft^3
BM_{udara}	: 28,84
Berat udara	: 942 x 0,08071 = 76,02882 lb/menit
	= 76,02882 x 453,59 = 34485,91246 gr/menit

= 34485,91246/28,84 = 1195,766729 gmole/menit

Tenaga yang dibutuhkan:

= 60,83 cal/gmole x 1195,76673 gmole/menit x 3,968 Btu/cal

= 288,6289453 Btu/menit x 0,02357 HP/(Btu/menit) = 6,8 HP

Tenaga yang dibutuhkan = 7 HP

Effisiensi motor = 60%

Tenaga motor = 7/0,6 = 11,67 HP = 12 HP

Spesifikasi pompa:

Volume udara = 942 cuft/menit = 26,6754 m^3/menit

Effisiensi motor = 60%

Tenaga pompa = 7 HP

Tenaga motor = 12 HP

Spesifikasi:

Tipe : Rotary Drum Vacuum Filter

Fungsi : memisahkan sari kedelai dari ampasnya

Kapasitas : 123,27 kg/jam

Diameter : 2 ft

Panjang : 2 ft

Luas area : 62 ft^2

Power : 0,5 HP

Bahan konstruksi : SS-316

Harga : Rp. 158.798.437,5

14. Tangki Penampung II (F-290)

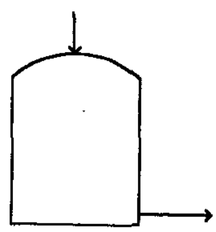
Fungsi : menampung susu kedelai sebelum dialirkan ke tangki homogenasi

Bentuk tangki : silinder tegak dengan tutup atas toryspherical dished head

Dasar pemilihan : harga murah serta sesuai untuk industri makanan

Kondisi operasi : P = 1 atm

Kondisi : kontinyu



Bahan masuk :

- Air = 2104,40780900 kg/hari = 193,34 lb/jam
- Padatan = 65,55068094 kg/hari = 6,02 lb/jam +
- Total = 2169,95849 kg/hari = 199,36 lb/jam

Menentukan dimensi tangki:

$\rho_{kedelai}$ = 919 kg/m^3 = 57,37 lb/ft^3

ρ_{air} = 62,171 lb/ft^3 = (pada T=30°C)

asumsi: $NaHCO_3$ dianggap sangat sedikit sehingga dapat diabaikan.

Lama penampungan = 2 jam = 0,084 hari

$$\rho_{campuaran} = \frac{1}{\frac{0,03}{57,37} + \frac{0,97}{62,171}} = 62,015 lb/ft^3 = 993,387 kg/m^3$$

$$\text{Volume campuran} = \frac{4784,64 lb/hari}{62,0158 lb/ft^3} . 0,084 hari = 6,48 ft^3$$

Diambil: $H_s = D_s$

Volume liquid dalam shell = π/4 . 1,5 . D^3

Volume tangki = 1,2 . volume larutan = 1,2 . 6,48 = 7,776 ft^3

Diambil : Dn = 0,5 ft

Volume tangki $= \pi/4 \cdot D^3$

7,776 $= \pi/4 \cdot D^3$

$D^3 = 9{,}90 \rightarrow D = 2{,}15$ ft $\approx$ 2 ft = 24 in

$H_s = 2$ ft = 24 in

$$\text{Tinggi liquida dalam shell} = \frac{0{,}8.vol.\tan gki}{\frac{\pi}{4}.D^2} = \frac{0{,}8.7{,}776}{\frac{\pi}{4}.2^2} = 1{,}98\,ft$$

$$P_{operasi} = P_{hidrostatis} = \frac{\rho.H}{144} = \frac{62{,}0158.1{,}71}{144} = 0{,}736\,psi$$

$P_{design} = 1{,}3 \cdot 0{,}736 = 0{,}9568$ psi

Menghitung tebal shell:

$$t_s = \frac{0{,}9568.24}{2.(18684.0{,}8 - 0{,}6.0{,}9568)} + 1/8 = 0{,}126 in \approx 3/16 in$$

Dipilih tebal standard = 3/16 in

Menghitung tebal dished head:

$OD = ID + 2 \cdot t_s = 24 + 2 \cdot 1/8 = 24{,}25$ in

Dari Brownell and Young, table 5.7:

OD standard = 24 in

r = 24 in

icr = 1 ½ in

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{r}{icr}}\right)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{24}{1{,}5}}\right) = 1{,}75$$

a = ID/2 = 24,25/2 = 12,125 in

AB = ID/2 – icr = 12,125 – 1,5 = 10,625 in

BC = r – icr = 24 – 1,5 = 22,5 in

b = r – $(BC^2\text{-}AB^2)^{1/2}$ = 24 – $(22{,}5^2 - 10{,}625^2)^{1/2}$ = 4,167 in

$$t_d = \frac{0{,}9568.24.1{,}75}{2.(18684.0{,}8 - 0{,}2.0{,}9568)} + 1/8 = 0{,}126 in$$

Dipilih tebal standard = 3/16 in

Dari Brownell & Young, table 5.8:

Dipilih panjang straight flange (sf) = 2 in

OA = t + b + sf = 3/16 + 4,167 + 2 = 6,355 in = 0,530 ft

Tinggi tangki total = 2 + 0,53 = 2,53 ft

Spesifikasi:

Nama : tangki penampung II

Fungsi : menampung susu kedelai sebelum masuk ke tangki homogenasi

Bentuk : silinder tegak dengan tutup atas berbentuk dished head

Kondisi operasi : P = 1 atm

Dimensi tangki :

Diameter shell (D_i)	= 2 ft
Tinggi shell (H_s)	= 2 ft
Tebal shell	= 3/16 in
Tinggi dishead	= 0,53 ft
Tebal dishead	= 3/16 in
Tinggi tangki keseluruhan	= 2,53 ft

Jumlah : 1 unit

Harga : Rp. 58.967.153,13

15. Tangki Homogenasi (R-310)

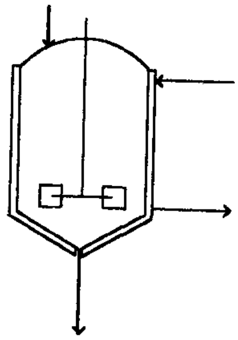
Nama : Tangki homogenasi.

Fungsi : mencampur susu sari kedelai, gula dan stabilizer menjadi larutan ice cream

Dasar pemilihan : Harga murah, dapat digunakan untuk kapasitas besar maupun kecil

Bentuk tangki : silinder tegak dengan bagian atas dished head dan tutup bawah berbentuk konis dengan sudut puncak 30°.

Kondisi operasi : P = 1 atm, Toperasi = 75°C



Bahan masuk :

- Susu kedelai : 2169,958 kg/hari
- Gelatin : 4,340 kg/hari
- Gula : 325,792 kg/hari

Total : 2500,09 kg/hari = 5511,78 lb/hari

Menentukan dimensi tangki :

ρ susu kedelai = 1041 kg/m³ = 64,987 lb/ft³

ρ gelatin = 0,7 gr/cm³ = 43,701 lb/ft³ (Ullman vol. A.12 p.311)

ρ gula (Sukrosa) = 1,5879 g/cm³ = 99,133 lb/ft³

Cp sukrosa = 415,98 j/mol.°K = 99,42 cal/mol.°K (Kirk Orthmer vol. 21 p. 866)

$$\rho campuran = \frac{1}{\frac{0,868}{64,987} + \frac{1,736.10^{-3}}{2,4336.10^{-4}} + \frac{0,130}{99,133}} = 68,020 lb/ft^3 = 1089,5 kg/m^3$$

Waktu tinggal bahan dalam alat = 0,0833 hari

$$\text{vol camp} = \frac{5511,78 lb/hari}{68,020 lb/ft^3} \times 0,0833 hari = 6,711 ft^3$$

V campuran menempati sebesar 80% dari volume tangki

vol tangki (design) = vol liq + vol ruang kosong

V_R = vol liq + 20%. V_R

$V_R = 6{,}711\ ft^3 / 0{,}8 = 8{,}389\ ft^3$

Diasumsikan tinggi shell = diameter shell

vol camp = vol camp dalam shell + vol camp dalam konis

$$volcamp = \pi/_4\, Di^3 + \left[\frac{\pi}{24tg\alpha}\left(Di^3 - Dn^3\right)\right]$$

$$6{,}711 = \pi/_4\, Di^3 + \left[\frac{\pi}{24tg30}\left(Di^3 - 0{,}20575^3\ \right)\right]$$

$Di = 1{,}908\,ft \approx 22{,}9in(diametershell) \rightarrow diambil.Di \approx 24in$

Tekanan tangki :

Tinggi fluida dalam tangki = $H_L + H_C$

= 1,908 ft + ((1,908/2tg30) – (0,20575/2tg30)

= 3,382 ft

Tekanan hidrostatis pada dasar tangki :

P tangki = ρ x (H / 144) = 68,020 x (3,382/144) = 1,598 psi

Pdesign = 1,2 x P tangki = 1,2 x 1,598 =1,917 psi

Tebal tangki :

Bahan plate : stainles steel –304

Suhu operasi < 150°F

Dari Brownell & Young didapat :

f = 20000 psi

e = 0,8 (double welded butt joint) → (Tabel 13.2, Brownell & Young)

c = 1/8 in

Perhitungan tebal shell :

$$\text{Tebal shell} = \frac{P.D}{2.(f.e - 0{,}6.P)} + C(B \& Y, pers13)$$

$$= \frac{1{,}917.22{,}9}{2(20000.0{,}8 - 0{,}6.1{,}917)} + 1/_8 = 0{,}126in$$

Dipilih tebal standart = 3/16 in

Perhitungan tebal tutup bawah :

Tebal konis $= \dfrac{P.D}{2.\cos\alpha(f.e - 0{,}6.P)} + C(B \& Y, pers 13.2)$

$$= \frac{1{,}917.22{,}9}{2\cos 30(20000.0{,}8 - 0{,}6.1{,}917)} + \tfrac{1}{8} = 0{,}127 in$$

Dipilih tebal standart = 3/16 in

tinggi tangki :

- tinggi konis = $H_L + H_n$

$$= \frac{D}{2.tg\alpha} - \frac{Dn}{2.tg\alpha} = \frac{1{,}908}{2.tg30} - \frac{0{,}2575}{2.tg30}$$

$$= 1{,}429 \text{ ft}$$

- tinggi shell = 1,908 ft

Pengaduk :

Type impeller : six flat blade turbine

Dimensi – dimensi standart dari tangki pengaduk

Dimana :

Da = diameter impeller

Di = diameter tangki

L = panjang blade

W = lebar blade

E = jarak dasar tangki ke center impeller

Da = 1/3 Di = 1/3 . 1,908 = 0,636 ft
H = Da = 0,636 ft

E = 1/3 . Di = 1/3 . 1,908 = 0,636 ft

W = 1/5 . Da = 1/5 .0,636 = 0,1272 ft

L = ¼ . Di = ¼ . 1,908 = 0,477 ft

Kecepatan pengadukan dihitung dengan pers :

$$N = k.Di^{\frac{2}{3}}\left(\frac{\rho c - \rho d}{\rho c}\right)^{0,26}.\left(\frac{\mu c}{\rho c}\right)^{\frac{1}{9}} .....(Nagata, 1975)$$

$$= 9,4.1,908^{\frac{2}{3}}\left(\frac{64,987 - 43,701}{64,987}\right)^{0,26}\left(\frac{0,0002}{64,987}\right)^{\frac{1}{9}}$$

$$= 2,641 rpm \approx 3 rpm$$

μ camp = 0,324 . $\rho^{0,5}$ (Perry, 5th ed, p.3-246)

= 0,324 $(1089,5.10^{-3})^{0,5}$ gr/cm^3

= 0,3382 cp . 2,42

= 24,881lb/ft.h/3600 (h/s) = 6,911 . 10^{-3} lb/ft.s

$$N_{RE} = \frac{Da^2.N.\rho camp}{\mu camp} = \frac{0,636 ft^2.3.68,020 lb/ft^3.}{6,911.10^{-3} lb/ft.s} = 107491,40(turbulen)$$

Dari gambar 3.4-1 Geankopils 3ed.p.145 diperoleh Np = 6

$$Jumlahimpeller = \frac{Sg.H}{Di} = \frac{\frac{\rho camp}{\rho air}.H}{Di} = \frac{\frac{993,467}{1000}.0,636}{1,908} = 0,3331 \approx 1$$

$$Powerpengaduk = \frac{Np.\rho.N^3.Da^5}{gc} = \frac{6.68,020.\left(\frac{3}{60}\right)^3.0,636^5}{32,174}$$

$$= 1,650.10^{-4} ft.lb/s$$

$$= 1,650.10^{-4} ft.lb/s/1Hp/550(ft.lb/s)$$

$$= 3.10^{-7} Hp$$

Gland losses = 10%.3.10^{-7} = 3.10^{-8} Hp

Power input = 3.10^{-7} + 3.10^{-8} = 3,3.10^{-7} Hp

Transmission system losses = 20% dr power input = 0,2 . 3,3.10^{-7}

= 6,6.10^{-8} Hp

total power = 3,3.10^{-7} + 6,6.10^{-8} = 3,96.10^{-7} Hp ≈ 0,5 Hp

Perhitungan dished head (Torispherical dishead)

Penentuan tinggi dishead :

R = d = 22,9 in

Icr = 6% . r = 6% . 22,9 = 1,374 in

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right) \ldots (Brownell \,\&\, Young, pers 7.76)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{22,9}{1,374}}\right) = 1,771$$

AB = D/2 – icr = 22,9/2 – 1,374 = 10,076 in

BC = r – icr = 22,9 – 1,374 = 21,526 in

b = r – $(BC^2\text{-}AB^2)^{1/2}$ = 22,9 – $(21,526^2 - 10,076^2)^{1/2}$ = 3,878 in

Penentuan tebal tutup atas :

$$td = \frac{P.rc.W}{2(f.E - 0,2.P)} (B \,\&\, Y, pers 7.77)$$

dimana:

P design = 1,917 psi

Digunakan type sambungan double welded butt joint

Sehingga E = 0,8 (B&Y, tabel 13.2)

C = 1/8 in

$$td = \frac{1,917.22,9.1,771}{2(20000.0,8 - 0,2.1,917)} + \frac{1}{8} = 0,127$$

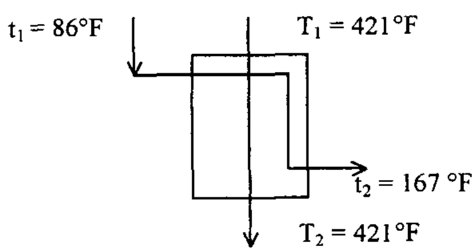
dipilih tebal dish standart = 3/16 in (B&Y, tabel 5.7)

Jaket pemanas :

T feed masuk = 30°C = 86°F

T produk keluar = 75°C = 167°F

T steam = 148°C = 298,4°F



$$\Delta T_{LMTD} = \frac{(T1-t2)-(T2-t1)}{\ln\left(\frac{T1-t2}{T2-t1}\right)} = \frac{(298{,}4-167)-(298{,}4-86)}{\ln\left(\frac{298{,}4-167}{298{,}4-86}\right)} = 168{,}67°F$$

T_c = 0,5 (298,4 + 298,4) = 298,4°F

Tc = 0,5 (167 + 86) = 126,5°F

Pada suhu 298°F;λ steam = 851,6 btu/lb (Geankoplis,1993)

Kalor yang dilepas oleh steam = panas untuk menaikkan suhu

ms . λ . = m feed . Cp . ΔT

$$ms = \frac{5512{,}69845 lb/hari . 0{,}931 btu/lb.°F . 168{,}67°F}{851{,}6 btu/lb}$$

$= 488{,}16 lb/hari = 20{,}34 lb/jam$

Kalor yang dilepas = ms . λ

= 20,34lb/jam . 851,6 btu/lb

= 17321,54 btu/jam

Nre = 107491,40

Sg = 0,993

K = 2,25 w/m.k = 0,396 btu/h.ft^2,k

μ = 24,714 lb/ft.hr

Cp = 0,931 kkal/kg.°K = 3,692 btu

Spasi jaket diambil 1 in, maka :

DO = OD tangki + (2 x spasi jaket)

= 22,9 + (2.1)

= 23,2 in = 1,933 ft

J = 1500 (Kern, fig 20.2)

$$hi = J.\frac{k}{dijaket}.\left(\frac{Cp.\mu}{k}\right)^{1/3}.\left(\frac{\mu}{\mu w}\right)^{1/4}$$

$$hi = 1500.\frac{0{,}396}{1{,}933}\left(\frac{3{,}692.24{,}714}{0{,}396}\right)^{1/3}.(1)^{1/4} = 1884{,}410 btu/ft^2.°F$$

$$hio = hi.\frac{Di}{Do} = 1884,41 btu/ft^2.°F.\frac{1,908 ft}{1,933 ft} = 1860,0238 btu/ft^2.°F$$

ho untuk steam = 1500 btu/jam. Ft^2.°F

$$Uc = \frac{ho.hio}{ho+hio} = \frac{1500.1860,0238}{1500+1860,0238} = 830,362 btu/jam.ft^2.°F$$

$Rd.larutan\ icecream = 0,004$.............(kern, tabel 20.5)

$Rd.steam = 0,001$.............................(kern, tabel 20.5)

$Rd.gabungan = 0.005$

$$hd = \frac{1}{Rd} = \frac{1}{0,005} = 200$$

$$Ud = \frac{1}{Rd + \frac{1}{Uc}} = \frac{1}{0,005 + \frac{1}{830,362}} = 161,179 btu/jam.ft^2.°F$$

$$A = \frac{Q}{Ud.\Delta t} = \frac{196135,011}{161,179.168,671} = 7,215 ft^2$$

A = 7,215 ft^2 merupakan luas perpindahan panas yang dibutuhkan.

Tinggi jaket diambil lebih tinggi dari tinggi cairan dalam tangki = 3,5 ft

A yang tersedia = π . Do.h jaket + luas konis

= π . 1,993 ft . 3,5 ft + π . (1/2 . 1,908)

= 24,911 ft^2

Karena A untuk perpindahan panas < A yang tersedia maka memenuhi syarat

Spesifikasi :

Nama : tangki homogenasi

Fungsi : Mencampur susu sari kedelai, larutan gula dan stabilizier menjadi larutan ice cream.

Bentuk tangki : silinder tegak dengan bagian atas dished head dan tutup bawah berbentuk konis dengan sudut puncak 30°.

Kondisi operasi : P = 1 atm; T operasi = 90°C

Dimensi tangki :

Diameter shell (Di) = 1,908 ft = 24in

Tinggi shell (Hs) = 1,908 ft = 24 in

Tebal shell = 3/16 in

Tinggi konis = 1,429 ft

Tebal konis = 3/16 in

Bahan : stainless stell - 304

Pengaduk :

Type impeler : six flate blade turbine

Kecepatan agitator : 3 rpm

Jumlah impeler : 1 buah

Total power : 0,5 HP

Harga : Rp. 190.558.125,-

16. Tangki Pasteurisasi (R-320)

Nama : tangki pasteurisasi

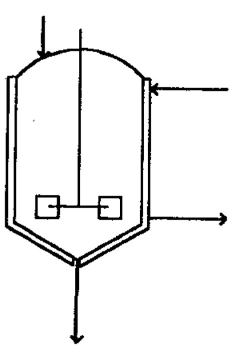
Fungsi : mensterilisasi larutan ice cream

Dasar pemilihan : murah, dapat digunakan untuk kapasitas besar maupun kecil.

Bentuk tangki : silinder tegak dengan bagian atas tertutup dan bagian bawah berbentuk konis dengan sudut 30°

Kondisi opeasi : P = 1 atm, T operasi = 85°C

Kondisi : kontinyu



Bahan masuk :

- larutan ice cream = 2500,09 kg/hari =5511,78 lb/hari

Waktu tinggal dalam tangki pasteurisasi = 2 jam = 0,0833 hari

Menentukan dimensi tangki :

ρ campuran = 68,02 lb/ft^3 = 1089,5 kg/m^3

$$\text{vol camp} = \frac{5511{,}78 lb/hari}{68{,}020 lb/ft^3} \times 0{,}0833 hari = 6{,}711 ft^3$$

V campuran menempati sebesar 80% dari volume tangki

V tangki = V campuran

vol tangki (design) = vol liq + vol ruang kosong

V_R = vol liq + 20%. V_R

V_R = 6,711 ft^3 / 0,8 = 8,389 ft^3

Diasumsikan tinggi shell = diameter shell

vol camp = vol camp dalam shell + vol camp dalam konis

$$volcamp = \pi/_4\, Di^3 + \left[\frac{\pi}{24 tg\alpha}\left(Di^3 - Dn^3\right)\right]$$

$$6{,}711 = \pi/_4\, Di^3 + \left[\frac{\pi}{24 tg 30}\left(Di^3 - 0{,}20575^3\right)\right]$$

$$Di = 1{,}908 ft \approx 22{,}9 in (diametershell) \rightarrow diambil.24 in$$

Tekanan tangki :

Tinggi fluida dalam tangki = $H_L + H_C$

= 1,908 ft + ((1,908/2tg30) – (0,20575/2tg30)

= 3,382 ft

P tangki = ρ x (H / 144) = 68,020 x (3,382/144) = 1,598 psi

Pdesign = 1,2 x P tangki = 1,2 x 1,598 =1,917 psi

Tebal tangki :

Bahan plate : stainles steel –304

Suhu operasi < 150°F

Dari Brownell & Young didapat :

f = 20000 psi

e = 0,8 (double welded butt joint)......(Tabel 13.2, Brownell & Young)

c = 1/8 in

Perhitungan tebal shell :

$$\text{Tebal shell} = \frac{P.D}{2.(f.e - 0{,}6.P)} + C(B\,\&\,Y, pers13)$$

$$= \frac{1{,}917.22{,}9}{2(20000.0{,}8 - 0{,}6.1{,}917)} + \tfrac{1}{8} = 0{,}126 in$$

Dipilih tebal standart = 3/16 in

Perhitungan tebal tutup bawah :

$$\text{Tebal konis} = \frac{P.D}{2.\cos\alpha(f.e - 0{,}6.P)} + C(B\,\&\,Y, pers13.2)$$

$$= \frac{1{,}917.22{,}9}{2\cos 30(20000.0{,}8 - 0{,}6.1{,}917)} + \tfrac{1}{8} = 0{,}127 in$$

dipilih tebal standart = 3/16 in

tinggi tangki :

- tinggi konis = $H_L + H_n$

$$= \frac{D}{2.tg\alpha} - \frac{Dn}{2.tg\alpha} = \frac{1{,}908}{2.tg30} - \frac{0{,}2575}{2.tg30}$$

$= 1{,}429$ ft

- tinggi shell = 1,908 ft

Pengaduk :

Type impeller : six flat blade turbine

Dimensi – dimensi standart dari tangki pengaduk

Dimana :

Da = diameter impeller

Di = diameter tangki

L = panjang blade

W = lebar blade

E = jarak dasar tangki ke center impeller

Da = 1/3 Di = 1/3 . 1,908 = 0,636 ft

H = Da = 0,636 ft

E = 1/3 . Di = 1/3 . 1,908 = 0,636 ft

W = 1/5 . Da = 1/5 .0,636 = 0,1272 ft

L = ¼ . Di = ¼ . 1,908 = 0,477 ft

Kecepatan pengadukan dihitung dengan persamaan : (Nagata, 1975)

$$N = k.Di^{\frac{2}{3}}\left(\frac{\rho c-\rho d}{\rho c}\right)^{0,26}\cdot\left(\frac{\mu c}{\rho c}\right)^{\frac{1}{9}},$$

$$dengan: \rho c = \rho susu.sari.kedelai, \rho d = \rho gelatin$$

$$= 9,4.1,908^{\frac{2}{3}}\left(\frac{64,987-43,701}{64,987}\right)^{0,26}\left(\frac{0,0002}{64,987}\right)^{\frac{1}{9}}$$

$$= 2,641 rpm \approx 3 rpm$$

μ camp = 0,324 . $\rho^{0,5}$ (Perry, 5th ed, p.3-246)

= 0,324 $(1089,5.10^{-3})^{0,5}$ gr/cm^3

= 0,3382 cp . 2,42

= 24,881lb/ft.h/3600 (h/s) = 6,911 . 10^{-3} lb/ft.s

$$N_{RE} = \frac{Da^2.N.\rho camp}{\mu camp} = \frac{0,636 ft^2.3.68,020 lb/ft^3.}{6,911.10^{-3} lb/ft.s} = 107491,40 (turbulen)$$

Dari gambar 3.4-1 Geankopils 3^{ed}.p.145 diperoleh Np = 6

$$Jumlahimpeller = \frac{Sg.H}{Di} = \frac{\frac{\rho camp}{\rho air}.H}{Di} = \frac{\frac{993,467}{1000}.0,636}{1,908} = 0,3331 \approx 1$$

$$Powerpengaduk = \frac{Np.\rho.N^3.Da^5}{gc} = \frac{6.68,020.\left(\frac{3}{60}\right)^3.0,636^5}{32,174}$$

$$= 1,650.10^{-4} ft.lb/s$$

$$= 1,650.10^{-4} ft.lb/s / 1Hp/550(ft.lb/s)$$

$$= 3.10^{-7} Hp$$

Gland losses = 10%.3.10^{-7} = 3.10^{-8} Hp

Power input = 3.10^{-7} + 3.10^{-8} = 3,3.10^{-7} Hp

Transmission system losses = 20% dr power input = 0,2 . 3,3.10^{-7}

$= 6{,}6.10^{-8}$ Hp

total power = $3{,}3.10^{-7} + 6{,}6.10^{-8} = 3{,}96.10^{-7}$ Hp ≈ 0,5 Hp

Perhitungan dishead (Torispherical dishead)

Penentuan tinggi dishead:

R = d = 22,9 in

Icr = 6% . r = 6% . 22,9 = 1,374 in

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{rc}{icr}}\right) \text{....}(Brownell \,\&\, Young, pers 7.76)$$

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{22{,}9}{1{,}374}}\right) = 1{,}771$$

AB = D/2 – icr = 22,9/2 – 1,374 = 10,076 in

BC = r – icr = 22,9 – 1,374 = 21,526 in

b = r – $(BC^2\text{-}AB^2)^{1/2}$ = 22,9 – $(21{,}526^2 - 10{,}076^2)^{1/2}$ = 3,878 in

Penentuan tebal tutup atas :

$$td = \frac{P.rc.W}{2(f.E - 0{,}2.P)} (B \,\&\, Y, pers 7.77)$$

dimana:

P design = 1,917 psi

Digunakan type sambungan double welded butt joint

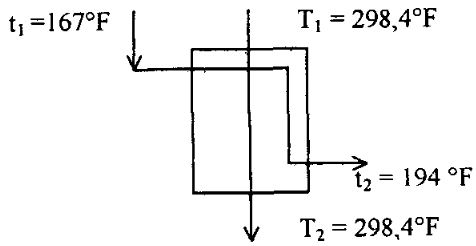
Sehingga E = 0,8 (B&Y, tabel 13.2)

C = 1/8 in

$$td = \frac{1{,}917.22{,}9.1{,}771}{2(20000.0{,}8 - 0{,}2.1{,}917)} + \frac{1}{8} = 0{,}127$$

dipilih tebal dish standart = 3/16 in (B&Y, tabel 5.7)

Jaket pemanas :



T larutan ice cream masuk = 75°C = 167°F

T larutan ice cream keluar = 85°C = 185°F

T steam = 148°C = 298,4°F

$$\Delta T_{LMTD} = \frac{(T1-t2)-(T2-t1)}{\ln\left(\dfrac{T1-t2}{T2-t1}\right)} = \frac{(298{,}4-185)-(298{,}4-167)}{\ln\left(\dfrac{298{,}4-185}{298{,}4-167}\right)} = 122{,}179°F$$

T_c = 0,5 (298,4+298,4) = 298,4°F

Tc = 0,5 (185 + 167) = 176°F

Pada suhu steam 298,4°F , λ steam = 851,6 btu/lb (Geankoplis,1993)

Kalor yang dilepas oleh steam = panas untuk menaikkan suhu

ms . λ .= m feed . Cp . ΔT

$$ms = \frac{5512{,}69845 lb/hari . 0{,}931 btu/lb.°F . 122{,}179°F}{851{,}6 btu/lb}$$

$= 736{,}33 lb/hari = 30{,}68 lb/jam$

Kalor yang dilepas = ms . λ

= 30,68 lb/jam . 851,6 btu/lb

= 26127,58 btu/jam

Nre = 107491,40 (turbulen)

Dari Perry, 6th edition, table 3-274, p.3-21 didapatkan :

K = 0,395 btu/h.ft.K

μ = 0,20 lb/ft.hr

Cp = 0,931 kkal/kg°K = 3,692 btu

J = 1500 (Kern, fig 20.2)

Spasi jaket diambil 1 in, maka :

DO = OD tangki + (2 x spasi jaket)

= 22,9 + (2.1)

= 23,2 in = 1,933 ft

$$hi = J.\frac{k}{dijaket}.\left(\frac{Cp.\mu}{k}\right)^{1/3}.\left(\frac{\mu}{\mu w}\right)^{1/4}$$

$$hi = 1500.\frac{0,395}{1,933}\left(\frac{3,692.0,2}{0,395}\right)^{1/3}.(1)^{1/4} = 377,591 btu/jam.ft^2.°F$$

ho untuk steam = 1500 btu/jam. Ft^2.°F

$$hio = hi.\frac{Di}{Do} = 377,591 btu/jam.ft^2.°F.\frac{1,908 ft}{1,933 ft} = 372,708 btu/jam.ft^2.°F$$

$$Uc = \frac{ho.hio}{ho+hio} = \frac{1500.372,708}{1500+372,708} = 298,531 btu/jam.ft^2.°F$$

$Rd.larutan\ icecream = 0,004$.........(kern, tabel 20.5)

$Rd.steam = 0,001$..........................(kern, tabel 20.5)

$Rd.gabungan = 0.005$

$$hd = \frac{1}{Rd} = \frac{1}{0,005} = 200$$

$$Ud = \frac{1}{Rd + \frac{1}{Uc}} = \frac{1}{0,005 + \frac{1}{298,531}} = 119,764 btu/jam.ft^2.°F$$

$$A = \frac{Q}{Ud.\Delta t} = \frac{196135,011}{119,764.122,179} = 13,404 ft^2$$

A= 13,404 ft^2 merupakan luas perpindahan panas yang dibutuhkan.

Tinggi jaket diambil lebih tinggi dari tinggi cairan dalam tangki = 3,5 ft

A yang tersedia = π . Do.h jaket + luas konis

= π . 1,993 ft . 3,5 ft + π . (1/2 . 1,908)

= 24,911 ft^2

Karena A untuk perpindahan panas < A yang tersedia maka memenuhi syarat

Spesifikasi :

Nama : tangki pasteurisasi

Fungsi : Mensterilkan larutan ice cream

Bentuk tangki : silinder tegak dengan bagian atas dished head dan tutup bawah berbentuk konis dengan sudut puncak 60°.

Kondisi operasi : P = 1 atm; T operasi = 85°C

Dimensi tangki :

Diameter shell (Di) = 1,908 ft = 24in

Tinggi shell (Hs) = 1,908 ft = 24 in

Tebal shell = 3/16 in

Tinggi konis = 1,429 ft

Tebal konis = 3/16 in

Bahan stainless stell - 304

Pengaduk :

Type impeler : six flate blade turbine

Kecepatan agitator : 3 rpm

Jumlah impeler : 1 buah

Total power : 0,5 HP

Jaket pemanas :

Spasi jaket : 1 in

Harga : Rp. 190.558.125,-

17. Tangki Pendinginan (R-330)

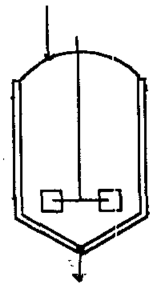
Fungsi : mendinginkan larutan ice cream sampai 5°C

Dasar pemilihan : harganya murah, dapat digunakan untuk kapasitas besar maupun kecil

Bentuk tangki : silinder tegak dengan bagian atas diskhead dan tutup bawah berbentuk konis dengan sudut puncak 60°C

Kondisi operasi : P = 1 atm , T operasi = 5°C

Kondisi : kontinyu



Bahan masuk :

- larutan ice cream = 2500,09 kg/hari = 5511,78 lb/hari

Menentukan dimensi tangki :

ρ campuran = 68,02 lb/ft^3 = 1089,5 kg/m^3

$$\text{vol camp} = \frac{5511{,}78 lb/hari}{68{,}020 lb/ft^3} \times 0{,}0833 hari = 6{,}711 ft^3$$

V campuran menempati sebesar 80% dari volume tangki

vol tangki (design) = vol liq + vol ruang kosong

V_R = vol liq + 20%. V_R

V_R = 6,711 ft^3 / 0,8 = 8,389 ft^3

Diasumsikan tinggi shell = diameter shell

vol camp = vol camp dalam shell + vol camp dalam konis

$$volcamp = \pi/_4\, Di^3 + \left[\frac{\pi}{24 tg\alpha}\left(Di^3 - Dn^3\right)\right]$$

$$6{,}711 = \pi/_4\, Di^3 + \left[\frac{\pi}{24 tg30}\left(Di^3 - 0{,}20575^3\right)\right]$$

$$Di = 1{,}908 ft \approx 22{,}9 in (diameter shell) \rightarrow diambil. 24 in$$

Tekanan tangki :

Tinggi fluida dalam tangki = $H_L + H_C$

= 1,908 ft + ((1,908/2tg30) – (0,20575/2tg30)

= 3,382 ft

Tekanan hidrostatik pada dasar tangki:

P tangki = ρ x (H / 144) = 68,020 x (3,382/144) = 1,598 psi

Pdesign = 1,2 x P tangki = 1,2 x 1,598 =1,917 psi

Tebal tangki :

Bahan plate : stainles steel –304

Suhu operasi < 150°F

Dari Brownell & Young didapat :

f = 20000 psi

e = 0,8 (double welded butt joint)......(Tabel 13.2, Brownell & Young)

c = 1/8

Perhitungan tebal shell :

$$\text{Tebal shell} = \frac{P.D}{2.(f.e - 0{,}6.P)} + C(B\,\&\,Y, pers13)$$

$$= \frac{1{,}917.22{,}9}{2(20000.0{,}8 - 0{,}6.1{,}917)} + \frac{1}{8} = 0{,}126 in$$

Dipilih tebal standart = 3/16 in

Perhitungan tebal tutup bawah :

$$\text{Tebal konis } = \frac{P.D}{2.\cos\alpha(f.e - 0{,}6.P)} + C(B\,\&\,Y, pers13.2)$$

$$= \frac{1{,}917.22{,}9}{2\cos 30(20000.0{,}8 - 0{,}6.1{,}917)} + \frac{1}{8} = 0{,}127 in$$

Dipilih tebal standart = 3/16 in

Tinggi tangki :

- tinggi konis = $H_L + H_n$

$$= \frac{D}{2.tg\alpha} - \frac{Dn}{2.tg\alpha} = \frac{1{,}908}{2.tg30} - \frac{0{,}2575}{2.tg30}$$

= 1,429 ft

- tinggi shell = 1,908 ft

Pengaduk :

Type impeller : six flate blade turbine

Dimensi – dimensi standart dari tangki pengaduk

Dimana :

Da = diameter impeller

Di = diameter tangki

L = panjang blade

W = lebar blade

E = jarak dasar tangki ke center impeller

Da = 1/3 Di = 1/3 . 1,908 = 0,636 ft

H = Da = 0,636 ft

E = 1/3 . Di = 1/3 . 1,908 = 0,636 ft

W = 1/5 . Da = 1/5 .0,636 = 0,1272 ft

L = ¼ . Di = ¼ . 1,908 = 0,477 ft

Kecepatan pengadukan dihitung dengan persamaan : (Nagata, 1975)

$$N = k.Di^{\frac{2}{3}}\left(\frac{\rho c - \rho d}{\rho c}\right)^{0,26}.\left(\frac{\mu c}{\rho c}\right)^{\frac{1}{9}},$$

$dengan : \rho c = \rho susu.sari.kedelai, \rho d = \rho gelatin$

$$= 9,4.1,908^{\frac{2}{3}}\left(\frac{64,987 - 43,701}{64,987}\right)^{0,26}\left(\frac{0,0002}{64,987}\right)^{\frac{1}{9}}$$

$$= 2,641 rpm \approx 3 rpm$$

μ camp = 0,324 . $\rho^{0,5}$ (Perry, 5th ed, p.3-246)

= 0,324 (1089,5.10^{-3})^{0,5} gr/cm^3

= 0,3382 cp . 2,42

= 24,881lb/ft.h/3600 (h/s) = 6,911 . 10^{-3} lb/ft.s

$$N_{RE} = \frac{Da^2.N.\rho camp}{\mu camp} = \frac{0,636 ft^2.3.68,020 lb/ft^3.}{6,911.10^{-3} lb/ft.s} = 107491,40(turbulen)$$

Dari gambar 3.4-1 Geankopils 3^{ed}.p.145 diperoleh Np = 6

$$Jumlahimpeller = \frac{Sg.H}{Di} = \frac{\frac{\rho camp}{\rho air}.H}{Di} = \frac{\frac{993,467}{1000}.0,636}{1,908} = 0,3331 \approx 1$$

$$Powerpengaduk = \frac{Np.\rho.N^3.Da^5}{gc} = \frac{6.68,020.\left(\frac{3}{60}\right)^3.0,636^5}{32,174}$$

$= 1,650.10^{-4}\, ft.lb/s$

$= 1,650.10^{-4}\, ft.lb/s / 1Hp/550(ft.lb/s)$

$= 3.10^{-7}\, Hp$

Gland losses = $10\%.3.10^{-7} = 3.10^{-8}$ Hp

Power input = $3.10^{-7} + 3.10^{-8} = 3{,}3.10^{-7}$ Hp

Transmission system losses = 20% dr power input = $0{,}2 \,.\, 3{,}3.10^{-7}$

$= 6{,}6.10^{-8}$ Hp

total power = $3{,}3.10^{-7} + 6{,}6.10^{-8} = 3{,}96.10^{-7}$ Hp $\approx$ 0,5 Hp

Perhitungan dishead (Torispherical dishead)

Penentuan tinggi dishead:

R = d = 22,9 in

Icr = 6% . r = 6% . 22,9 = 1,374 in

$$W = \frac{1}{4}.\left(3 + \sqrt{\frac{rc}{icr}}\right) ....(Brownell \,\&\, Young, pers 7.76)$$

$$W = \frac{1}{4}.\left(3 + \sqrt{\frac{22,9}{1,374}}\right) = 1,771$$

AB = D/2 – icr = 22,9/2 – 1,374 = 10,076 in

BC = r – icr = 22,9 – 1,374 = 21,526 in

b = r – $(BC^2 - AB^2)^{1/2}$ = 22,9 – $(21{,}526^2 - 10{,}076^2)^{1/2}$ = 3,878 in

Penentuan tebal tutup atas :

$$td = \frac{P.rc.W}{2(f.E - 0{,}2.P)} (B \,\&\, Y, pers 7.77)$$

dimana:

P design = 1,917 psi

Digunakan type sambungan double welded butt joint

Sehingga E = 0,8 (B&Y, tabel 13.2)

C = 1/8 in

$$td = \frac{1{,}917.22{,}9.1{,}771}{2(20000.0{,}8 - 0{,}2.1{,}917)} + \frac{1}{8} = 0{,}127$$

dipilih tebal dish standart = 3/16 in (B&Y, tabel 5.7)

Jaket pendingin :

T feed masuk = 85°C = 185°F = 645 °R

T produk keluar = 5°C = 41°F =501°R

T pendingin = -55,5°C = -67,9°F = 392,1°R

$$\Delta T_{LMTD} = \frac{(T1 - t2) - (T2 - t1)}{\ln\left(\frac{T1 - t2}{T2 - t1}\right)} = \frac{(645 - 392{,}1) - (501 - 392{,}1)}{\ln\left(\frac{645 - 392{,}1}{501 - 392{,}1}\right)} = 170{,}906°F$$

T_c = 0,5 (-67,9 – 67,9) = -67,9°F

Tc = 0,5 (41 + 185) = 113°F

λ Propylene = 421,706 btu/lb (perry 5th ed,p.3-218)

mp . λ = m feed . Cp . ΔT

$$mp = \frac{5512{,}69845 lb/hari . 0{,}931 bu/lb°F . 170{,}906°F}{421{,}706 btu/lb}$$

$$= 2079{,}99 lb/hari = 86{,}67 lb/jam$$

Dingin yang dilepas = mp . λ

= 86,67lb/jam . 421,706btu/lb

= 36547,694 btu/jam

Jaket Pendingin :

Nre = 107491,40

J = 1500 (Kern, fig 20.2)

Sg = 0,993

Dari Perry, 6th edition, table 3-274, p.3-21 didapatkan :

K = 2,25 w/m.k = 0,396 btu/j.ft^2 °F

μ = 24,714 lb/ft.hr

Cp = 0,931 kkal/kg.°K = 3,692 btu

$$hi = J.\frac{k}{dijaket}.\left(\frac{Cp.\mu}{k}\right)^{1/3}.\left(\frac{\mu}{\mu w}\right)^{1/4}$$

$$hi = 1500.\frac{0,396}{1,933}\left(\frac{24,714.3,692}{0,396}\right)^{1/3}.(1)^{1/4} = 1883,900 btu/jam.ft^2.°F$$

$$hio = hi.\frac{ID.jaket}{OD.jaket} = 1883,900.\frac{1,933}{1,975} = 1843,837 btu/jam.ft^2.°F$$

h = 4000/ ($L^{1/4}$. $\Delta t_f^{1/4}$) (Kern, Pers. 12-44b, hal. 266)

h = 4000/ ($3,5^{1/4}$. $170,906^{1/4}$) = 808,823 btu/jam.ft^2.F

$$Uc = \frac{ho.hoi}{ho + hoi} = \frac{808,823.1843,837}{808,823 + 1843,837} = 562,205 btu/jam.ft^2.°F$$

$Rd.larutan\ icecream = 0,004(kern, tabel 20.5)$

$Rd.steam = 0,001(kern, tabel 20.5)$

$Rd.gabungan = 0.005$

$$hd = 1/_{Rd} = 1/_{0,005} = 200$$

$$Ud = \frac{1}{Rd + 1/_{Uc}} = \frac{1}{0,005 + 1/_{562,205}} = 147,521 btu/jam.ft^2.°F$$

$$A = \frac{Q}{Ud.\Delta t} = \frac{196135,011}{147,52.170,906} = 7,779 ft^2$$

Tinggi jaket diambil lebih tinggi dari tinggi cairan dalam tangki = 3,5 ft

A yang tersedia = π . Do.h jaket + luas konis

= π . 1,993 ft . 3,5 ft + π . (1/2 . 1,908)

= 24,911 ft^2

Karena A untuk perpindahan panas < A yang tersedia maka memenuhi syarat

Spesifikasi :

Nama : tangki pendingin

Fungsi : Mendinginkan larutan ice cream sampai suhu 5°C

Bentuk tangki : silinder tegak dengan bagian atas dished head dan tutup bawah berbentuk konis dengan sudut puncak 60°.

Kondisi operasi : P = 1 atm; T operasi = 5°C

Dimensi tangki :

Diameter shell (Di) = 1,908 ft = 24in

Tinggi shell (Hs) = 1,908 ft = 24 in

Tebal shell = 3/16 in

Tinggi konis = 1,429 ft

Tebal konis = 3/16 in

Bahan : stainless stell - 304

Pengaduk :

Type impeler : six flate blade turbine

Kecepatan agitator : 282 rpm

Jumlah impeler : 1 buah

Total power : 0,5 HP

Jaket pemanas :

Spasi jaket : 1 in

Harga : Rp. 190.558.125,-

18. Tangki Pembuihan (R-304)

Nama : Tangki Pembuihan

Fungsi :mengembangkan larutan ice cream

Dasar pemilihan : Harga murah, dapat digunakan untuk kapasitas besar maupun kecil

Bentuk : silinder tegak dengan bagian atas diskhead dan tutup bagian bawah berbentuk konis dengan sudut puncak 30°

Kondisi operasi : P = 1 atm, T operasi = -5°C

Kondisi : kontinyu

Bahan masuk :

- larutan ice cream = 2500,09 kg/hari = 5511,78 lb/hari

Menentukan dimensi tangki :

$$\text{vol camp} = \frac{5511{,}78 lb/hari}{68{,}020 lb/ft^3} \times 0{,}167 hari = 13{,}532 ft^3$$

Volume campuran mengembang sebesar 80%, maka:

Volume udara = 80%. Volume campuran = 10,825 ft^3

$$\text{Massa}_{\text{udara}} = \frac{Vol._{udara}}{\rho_{udara}} = \frac{10{,}826}{0{,}487} 0{,}487 = 5{,}275 lb$$

V campuran menempati sebesar 80% dari volume tangki

V tangki = V campuran + V udara

vol tangki (design) = vol liq + vol ruang kosong

V_R = vol liq + 20%. V_R

V_R = 24,358 ft^3 / 0,8 = 30,4475 ft^3

Diasumsikan tinggi shell = diameter shell

vol camp = vol camp dalam shell + vol camp dalam konis

$$volcamp = \pi/4\, Di^3 + \left[\frac{\pi}{24 tg\alpha}\left(Di^3 - Dn^3\right)\right]$$

$$24{,}358 = \pi/4\, Di^3 + \left[\frac{\pi}{24 tg 30}\left(Di^3 - 0{,}20575^3\right)\right]$$

$$Di = 2{,}886 ft \approx 36 in (diametershell)$$

Tekanan tangki :

Tinggi fluida dalam tangki = $H_L + H_C$

= 2,886 ft + ((2,886/2tg30) – (0,20575/2tg30)

= 5,207 ft

P tangki = ρ x (H / 144) = 68,020 x (5,207/144) = 2,460 psi

Pdesign = 1,2 x P tangki = 1,2 x 2,460 =2,952 psi

Tebal tangki :

Bahan plate : stainles steel –304

Suhu operasi < 150°F

Dari Brownell & Young didapat :

f = 20000 psi

e = 0,8 (double welded butt joint)

c = 1/8 in

Perhitungan tebal shell :

$$\text{Tebal shell} = \frac{P.D}{2.(f.e - 0{,}6.P)} + C(B \& Y, pers13)$$

$$= \frac{2{,}952.36}{2(20000.0{,}8 - 0{,}6.2{,}952)} + \frac{1}{8} = 0{,}128 in$$

Dipilih tebal standart = 3/16 in

Perhitungan tebal tutup bawah :

$$\text{Tebal konis} = \frac{P.D}{2.\cos\alpha(f.e - 0{,}6.P)} + C(B \& Y, pers13.2)$$

$$= \frac{2{,}952.36}{2\cos 30(20000.0{,}8 - 0{,}6.2{,}952)} + \frac{1}{8} = 0{,}129 in$$

Dipilih tebal standart = 3/16 in

Tinggi tangki :

- tinggi konis = $H_L + H_n$

$$= \frac{D}{2.tg\alpha} - \frac{Dn}{2.tg\alpha} = \frac{2{,}886}{2.tg30} - \frac{0{,}2575}{2.tg30}$$

= 2,276 ft

- tinggi shell = 1,908 ft

Pengaduk :

Type impeller : enam flat turbine dengan disk

Dimensi – dimensi standart dari tangki pengaduk

Dimana :

Da = diameter impeller

Di = diameter tangki

L = panjang blade

W = lebar blade

E = jarak dasar tangki ke center impeller

Da = 1/3 Di = 1/3 . 2,886 = 0,962ft

H = Da = 0,962 ft

E = 1/3 . Di = 1/3 . 2,886 = 0,962 ft

W = 1/5 . Da = 1/5 .0,962 = 0,1924 ft

L = ¼ . Di = ¼ . 2,886 = 0,7215 ft

Kecepatan pengadukan dihitung dengan persamaan : (Nagata, 1975)

$$N = k.Di^{\frac{2}{3}}\left(\frac{\rho c-\rho d}{\rho c}\right)^{0.26}\cdot\left(\frac{\mu c}{\rho c}\right)^{\frac{1}{9}},$$

$$dengan: \rho c = \rho susu.sari.kedelai, \rho d = \rho gelatin$$

$$= 9{,}4.2{,}886^{\frac{2}{3}}\left(\frac{64{,}987-43{,}701}{64{,}987}\right)^{0.26}\left(\frac{0{,}0002}{64{,}987}\right)^{\frac{1}{9}}$$

$$= 3{,}415rpm \approx 4rpm$$

Untuk kecepatan pengadukan 4 rpm tidak dapat diterapkn pada proses ini, karena pada proses pembuihan dibutuhkan pengadukan cepat supaya udara dapat membentu penambahan volume campuran, sehingga digunakan kecepatan pengadukan sebesar 120 rpm.

μ camp = 0,324 . $\rho^{0,5}$ (Perry, 5th ed, p.3-246)

$= 0,324 \ (1089,5.10^{-3})^{0,5}$ gr/cm^3

= 0,3382 cp . 2,42

= 24,881lb/ft.h/3600 (h/s) = 6,911 . 10^{-3} lb/ft.s

$$N_{RE} = \frac{Da^2.N.\rho camp}{\mu camp} = \frac{0,962 ft^2.120.68,020 lb/ft^3.}{6,911.10^{-3} lb/ft.s} = 1093017,524 (turbulen)$$

Dari gambar 3.4-1 Geankopils 3^{ed}.p.145 diperoleh Np = 6

$$Jumlahimpeller = \frac{Sg.H}{Di} = \frac{\frac{\rho camp}{\rho air}.H}{Di} = \frac{\frac{993,467}{1000}.0,962}{2,886} = 0,3331 \approx 1$$

$$Powerpengaduk = \frac{Np.\rho.N^3.Da^5}{gc} = \frac{6.68,020.\left(\frac{12}{60}\right)^3.0,962^5}{32,174}$$

$= 10,650 ft.lb/s$

$= 10,650 ft.lb/s / 1Hp / 550(ft.lb/s)$

$= 0,0192 Hp$

Gland losses = 10%.0,0192 = 1,92.10^{-3} Hp

Power input = 0,0192+ 1,92.10^{-3} = 0,0211 Hp

Transmission system losses = 20% dr power input = 0,2 .0,0211

= 4,224.10^{-3} Hp

Total power = 0,0211 + 4,224.10^{-3} = 0,025 Hp ≈ 0,5 Hp

Perhitungan dishead (Torispherical dishead)

Penentuan tinggi dishead:

R = d = 36 in

Icr = 6% . r = 6% . 36 = 2,16 in

$$W = \frac{1}{4}.\left(3 + \sqrt{\frac{rc}{icr}}\right) ....(Brownell \& Young, pers 7.76)$$

$$W = \frac{1}{4}.\left(3 + \sqrt{\frac{36}{2,16}}\right) = 1,771$$

AB = D/2 – icr = 36/2 – 2,16 = 15,84 in

BC = r – icr = 36 – 2,16 = 33,84 in

b = r – $(BC^2\text{-}AB^2)^{1/2}$ = 36 – $(33{,}84^2 - 15{,}84^2)^{1/2}$ = 6,096 in

Penentuan tebal tutup atas :

$$td = \frac{P.rc.W}{2(f.E - 0{,}2.P)} (B \& Y, pers 7.77)$$

dimana:

P design = 2,952 psi

Digunakan type sambungan double welded butt joint

Sehingga E = 0,8 (B&Y, tabel 13.2)

C = 1/8 in

$$td = \frac{2{,}952.36.1{,}771}{2(20000.0{,}8 - 0{,}2.2{,}952)} + \frac{1}{8} = 0{,}131$$

dipilih tebal dish standart = 3/16 in (B&Y, tabel 5.7)

Jaket pendingin :

T feed masuk = 5°C = 501°R

T feed keluar = -5°C = 483°R

T pendingin = -55,5°C = 392,1°R

$$\Delta T_{LMTD} = \frac{(T1 - t2) - (T2 - t1)}{\ln\left(\frac{T1 - t2}{T2 - t1}\right)} = \frac{(501 - 392{,}1) - (483 - 392{,}1)}{\ln\left(\frac{501 - 392{,}1}{483 - 392{,}1}\right)} = 99{,}6312°R$$

T_c = 0,5 (392,1 – 392,1) = 392,1 °R

Tc = 0,5 (483+501) = 492 °R

λ Propylene = 421,706 btu / lb

$$mp . \lambda = m\ feed . Cp . \Delta T$$

$$mp = \frac{5517{,}052 lb/hari . 0{,}931 btu/lb.°F . 44{,}44°F}{421{,}706 btu/lb}$$

$= 541{,}28 lb/hari = 22{,}553 lb/jam$

Dingin yang dilepas = mp . λ

= 22,553lb/jam . 421,706btu/lb

= 9510,855 btu/jam

Nre = 107491,40

J = 1500 (Kern, fig 20.2)

Dari Perry, 6th edition, table 3-274, p.3-21 didapatkan :

Sg = 0,993

K = 2,25 w/m.k = 0,396 btu/h.ft^2,k

μ = 24,714 lb/ft.hr

Cp = 0,931 kkal/kg.°K = 3,692 btu

$$hi = J.\frac{k}{dijaket}.\left(\frac{Cp.\mu}{k}\right)^{1/3}.\left(\frac{\mu}{\mu w}\right)^{1/4}$$

$$hi = 1500.\frac{0,396}{3,33}\left(\frac{24,714.3,692}{0,396}\right)^{1/3}.(1)^{1/4} = 1093,567 btu/jam.ft^2.°F$$

$$hio = hi.\frac{ID.jaket}{OD.jaket} = 1093,567.\frac{3,33}{1,975} = 1087,038 btu/jam.ft^2.°F$$

h = 4000/ ($L^{1/4}$. $\Delta t_f^{1/4}$) (Kern, Pers. 12-44b, hal. 266)

h = 4000/ ($5,5^{1/4}$. $99,63^{1/4}$) = 826,745 btu/jam.ft^2.F

Uc = 616,269 btu/jam.ft^2.F

$$Uc = \frac{hi.hoi}{hi + hoi} = \frac{826,745.1087,038}{826,745 + 1087,038} = 796,529 btu/jam.ft^2.°F$$

$$Rd.larutan\ icecream = 0,004(kern, tabel 20.5)$$

$$Rd.steam = 0,001(kern, tabel 20.5)$$

$$Rd.gabungan = 0.005$$

$$hd = 1/Rd = 1/0,005 = 200$$

$$Ud = \frac{1}{Rd + 1/Uc} = \frac{1}{0,005 + 1/796,529} = 159,861 btu/jam.ft^2.°F$$

$$A = \frac{Q}{Ud.\Delta t} = \frac{3414,065}{159,861.99,6312} = 0.215 ft^2$$

Tinggi jaket diambil lebih tinggi dari tinggi cairan dalam tangki = 5,5 ft

A yang tersedia = π . Do.h jaket + luas konis

$= \pi \,.\, 3{,}333 \text{ ft} \,.\, 5{,}5 \text{ ft} + \pi \,.\, (1/2 \,.\, 3{,}33)$

$= 62{,}769 \text{ ft}^2$

Karena A untuk perpindahan panas < A yang tersedia maka memenuhi syarat.

Spesifikasi :

Nama : tangki pembuihan

Fungsi : Mengembangkan larutan ice cream.

Bentuk tangki : silinder tegak dengan bagian atas dished head dan tutup bawah berbentuk konis dengan sudut puncak 30°.

Kondisi operasi : P = 1 atm; T operasi = -5°C

Dimensi tangki :

Diameter shell (Di) = 2,886 ft = 36 in

Tinggi shell (Hs) = 2,886 ft = 36 in

Tebal shell = 3/16 in

Tinggi konis = 2,276 ft

Tebal konis = 3/16 in

Bahan : stainless stell - 304

Pengaduk :

Type impeler : six flate blade turbine

Kecepatan agitator : 120 rpm

Jumlah impeler : 1 buah

Total power : 0,5 HP

Jaket pendingin :

Spasi jaket : 1 in

Harga :Rp. 190.558.125

20. Unit Pengemasan (P-410)

Nama : unit pengemasan

Fungsi : mengisikan ice cream kedalam cup – cup kecil yang berukuran 60 ml selanjutnya menuju ke freezer

Dasar pemilihan: Dapat digunakan untuk kapasitas besar maupun kecil

Type alat : Dosage filling machines

Bentuk : persegi panjang yang dilengkapi dengan valve

Cara kerja : di dalam alat tersebut terdapat belt convenyor yang di atasnya terdapat cup-cup yang siap untuk diisi ice cream sejumlah tertentu kemudian akan menuju ke hardening

$$\text{Kecepatan pengisian} = \frac{2500{,}09\, liter/hari}{\frac{60}{1000} liter} = 41668{,}167\, cup/hari \approx 41669\, cup/hari$$

Jumlah : 1 unit

Harga : $ 133 000 (Perry, ed.6, 1984)

21. Hardening (P-420)

Fungsi : mengeraskan ice cream yang sudah di kemas

Dasar pemilihan : Dapat digunakan untuk kapasitas besar maupun kecil

Type : paralellepipedum / peti

Kapasitas = 2502,518 kg/hari ×3hari

= 7507,554 kg = 16551,153 lb

Dibuat seperti rak, 1 rak terdiri dari 5 tray, dimensi ukuran tray diambil :

Panjang = 3 m ;

Lebar = 1 m ;

Tinggi = 0,3 m

Jarak antar tray = 30 cm

Jadi volume untuk 1 rak = (3 . 1 . 0,3) . 3 = 2,7 m^3

Data operasi :

- Suhu ruang refrigerator = -35 °C
- Refrigerant = Propylene

$\rho_{ice\ cream}$ = 68,020 lb/cuft

Jumlah rak yang dibutuhkan $= \frac{6,89}{2,7} = 2,55 buah \approx 3 buah$

Jarak antar rak = 1 m, jadi dimensi hardening :

Lebar = (1 . 1) + 8 = 8 m

Panjang = (4 . 3) + 6 = 18 m

Tinggi = 2,5 m = 8,20 ft

Mencari tebal isolasi :

Suhu permukaan luar = 35 °C

Suhu permukaan dalam = -35 °C

$k_{aluminium}$ = 206 W/m.°K = 177,2448 kkal/jam.m.°C

k_{copper} = 377 W/m.°K = 324,375 kkal/jam.m.°C

Tebal aluminium = 10 cm = 0,1 m

Q konduksi = Q konveksi

$$k \cdot A \cdot \frac{\Delta T}{\Delta x} = h \cdot A \cdot \Delta T$$

$$206 \cdot \left(\frac{25 - T2}{0,1}\right) = 8,5175 \cdot (30\text{-}25)$$

$$T2 = 24,98\ °C$$

Q konduksi (aluminium) = Q konduksi (copper)

$$k \cdot A \cdot \frac{\Delta T}{\Delta x} = k \cdot A \cdot \frac{\Delta T}{\Delta x}$$

$$206 \cdot \left(\frac{25 - 24,98}{0,1}\right) = 377 \cdot \left(\frac{24,98 - (-35)}{\Delta x}\right)$$

$$\Delta x = 1,88 \cdot 10^{-3}\ m$$

Jadi dimensi hardening termasuk isolasi :

Panjang = $18 + 2.(1,88 \cdot 10^{-3}) = 18,004$ m

Lebar = $8 + 2.(1,88 \cdot 10^{-3}) = 8,004$ m

Tinggi = $2,5 + 1,88 \cdot 10^{-3} = 2,50188$ m

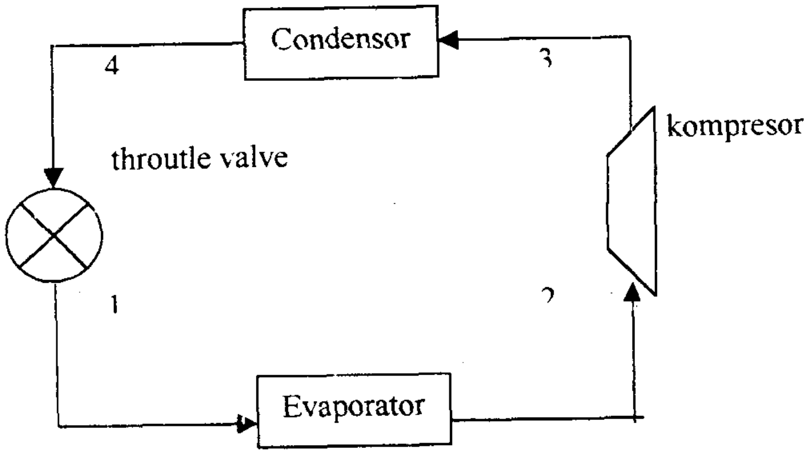
$A = (2 \cdot p \cdot l) + (2 \cdot p \cdot t) + (2 \cdot l \cdot t)$

$= (2 \cdot 18,004 \cdot 8,004) + (2 \cdot 18,004 \cdot 2,50188) + (2 \cdot 8,004 \cdot 2,50188)$

$= 418,346\ m^3$

Menentukan kecepatan propylene:

Pendingin yang dipakai : Propylene



Proses perubahan :

1 → 2 : suhu tetap, fasa berubah

2 → 3 : suhu berubah, tekanan berubah, volume berubah

3 → 4 : suhu tetap, fasa berubah

4 → 1 : suhu berubah, tekanan berubah

Titik 1

Dari Perry, 6th edition, Fig 3-32, p.3-219, didapatkan :

Pada T_1 = -55,5°C = -31°F : H_2 = 100,1099 btu/lb

P_2 = 29,7038 psia

Titik 2

Dari Perry, 6th edition, table 3-274, p.3-21 didapatkan :

Pada T_2 = -55,5 °C = -31°F : H_2 = 150,473 btu/lb

P_2 = 29,7038 psia

Titik 3

Dari Perry, 6th edition, fig 3-32, p. 3-219 didapatkan :

Pada T_3 = 90 °C : H_3 = 286,615 btu/lb

P_3 = 145,038 psia

Titik 4

Dari Perry, 6th edition, fig 3-32, p. 3-219 didapatkan :

T_4 = 90 °C : H_4 = 250,788 btu/lb

P_4 = 145,038 psia

Maka jumlah Propylene yang diperlukan :

$$m = \frac{Q}{H2 - H1}$$

$$= \frac{241802{,}546 \text{ btu/hari}}{150{,}473 \text{ btu/lb} - 100{,}1099 \text{ btu/lb}}$$

$$= 4801{,}185 \text{ lb/hari} = 200{,}049 \text{ lb/jam} = 90{,}74 \text{ kg/jam}$$

$$P = m\,(H_3 - H_2) = 200{,}49 \text{ lb/jam } (286{,}615 - 150{,}473) \text{ btu/lb}$$

$$= 12353{,}77 \text{ btu/jam} = 4{,}855 \text{ Hp}$$

Effisiensi kompresor = 80%

Power yang dibutuhkan $= \dfrac{P}{0,8} = \dfrac{4,855}{0,8}$

$= 6,069$ Hp $\approx$ 7 Hp

Menentukan jumlah air pendingin yang dipakai pada kondensor :

Titik 3 :

$T_3 = 90$ °C, $H_3 = 286,615$ btu/lb, $P_3 = 145,038$ psia

$T_4 = 90$ °C, $H_4 = 250,788$ btu/lb, $P_4 = 145,038$ psia

Air pendingin masuk kondensor pada suhu 86 °F (H = 54,068 btu/lb) dan keluar pada suhu 90°F (H = 58,07 btu/lb)

Panas masuk kondensor = panas keluar kondensor

H3 + H air pendingin masuk = H4 + H air pendingin keluar

(4801,185 lb/hari . 286,615 btu/lb) + (m air . 54,068 btu/lb) = (4801,185 lb/hari . 250,788 btu/lb) + (m air . 58,07 btu/lb)

m air = 42981,523 lb/hari

= 1790 lb/jam = 812 kg/jam

Spesifikasi:

Nama alat : Hardening

Type : paralellepipedum

Kapasitas : 2502,518 kg/hari

Dimensi :

- Panjang : 18,004 m
- Lebar : 8,004 m
- Tinggi : 2,50188 m

Kecepatan pendingin propylene : 200,049 lb/jam = 90,74 kg/jam

Kecepatan pendingin air : 812 kg/jam

Power : 7 Hp

Jumlah : 1 unit

Harga : $ 133 000 (Perry, ed 6, 1984)

22. Freezer (P-430)

Fungsi : menyimpan ice cream

Dasar pemilihan : dapat digunakan untuk kapasitas besar maupun kecil

Type : persegi panjang

Kapasitas = 2502,518 kg/hari ×3hari

= 7507,554 kg = 16551,153 lb

Data operasi :

- Suhu ruang refrigerator = -25°C

Refrigerant = Propyllene

$\rho_{ice\ cream}$ = 68,020 lb/cuft

Dibuat seperti rak, 1 rak terdiri dari 5 tray, dimensi ukuran tray diambil :

Panjang = 3 m ;

Lebar = 1 m ;

Tinggi = 0,3 m

Jarak antar tray = 30 cm

Jadi volume untuk 1 rak = (3 . 1 . 0,3) . 3 = 2,7 m^3

$$\text{Jumlah rak yang dibutuhkan} = \frac{6,89}{2,7} = 2,55 buah \approx 3 buah$$

Jarak antar rak = 1 m, jadi dimensi hardening :

Lebar = (1 . 1) + 8 = 8 m

Panjang = (4 . 3) + 6 = 18 m

Tinggi = 2,5 m = 8,20 ft

Mencari tebal isolasi :

Suhu permukaan luar = 35 °C

Suhu permukaan dalam = -35 °C

$k_{aluminium}$ = 206 W/m.°K = 177,2448 kkal/jam.m.°C

k_{copper} = 377 W/m.°K = 324,375 kkal/jam.m.°C

Tebal aluminium = 10 cm = 0,1 m

Q konduksi = Q konveksi

$$k \,.\, A \,.\, \frac{\Delta T}{\Delta x} = h \,.\, A \,.\, \Delta T$$

$$206 \,.\, \left(\frac{25 - T2}{0{,}1}\right) = 8{,}5175 \,.\, (30\text{-}25)$$

$$T2 = 24{,}98\ °C$$

Q konduksi (aluminium) = Q konduksi (copper)

$$k \,.\, A \,.\, \frac{\Delta T}{\Delta x} = k \,.\, A \,.\, \frac{\Delta T}{\Delta x}$$

$$206 \,.\, \left(\frac{25 - 24{,}98}{0{,}1}\right) = 377 \,.\, \left(\frac{24{,}98 - (-25)}{\Delta x}\right)$$

$$\Delta x = 1{,}82 \,.\, 10^{-3}\ m$$

Jadi dimensi hardening termasuk isolasi :

Panjang = $18 + 2.(1{,}82 \,.\, 10^{-3}) = 18{,}004$ m

Lebar = $8 + 2.\,(1{,}8 \,.\, 10^{-3}) = 8{,}004$ m

Tinggi = $2{,}5 + 1{,}82 \,.\, 10^{-3} = 2{,}50188$ m

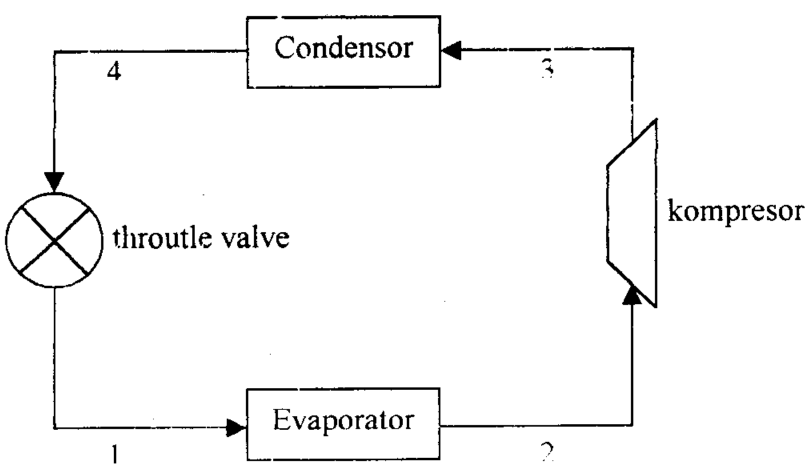
$A = (2 \,.\, p \,.\, l) + (2 \,.\, p \,.\, t) + (2 \,.\, l \,.\, t)$

$= (2 \,.\, 18{,}004 \,.\, 8{,}004) + (2 \,.\, 18{,}004 \,.\, 2{,}50188) + (2 \,.\, 8{,}004 \,.\, 2{,}50188)$

$= 418{,}346\ m^3$

Menentukan kecepatan Propylene :

Pendingin yang dipakai : Propylene



Proses perubahan :

$1 \rightarrow 2$: suhu tetap, fasa berubah

$2 \rightarrow 3$: suhu berubah, tekanan berubah, volume berubah

$3 \rightarrow 4$: suhu tetap, fasa berubah

$4 \rightarrow 1$:suhu berubah, tekanan berubah

Titik 1

Dari Perry, 6th edition, Fig 3-32, p.3-219, didapatkan :

Pada $T_1 = -55{,}5°C$: $H_2 = 98{,}4138$ btu/lb

$P_2 = 37{,}188$ psia

Titik 2

Dari Perry, 6th edition, table 3-274, p.3-21 didapatkan :

Pada $T_2 = -55{,}5\ °C$: $H_2 = 155{,}250$ btu/lb

$P_2 = 37{,}188$ psia

Titik 3

Dari Perry, 6th edition, Fig 3-32, p. 3-219 didapatkan :

Pada $T_3 = 90\ °C$: $H_3 = 281{,}838$ btu/lb

$P_3 = 145{,}038$ psia

Titik 4

Dari Perry, 6th edition, Fig 3-32, p. 3-219 didapatkan :

$T_4 = 90\ °C$: $H_4 = 272{,}284$ btu/lb

$P_4 = 145{,}038$ psia

Maka jumlah Propylene yang diperlukan :

$$m = \frac{Q}{H2 - H1}$$

$$= \frac{77049{,}691\ \text{btu/hari}}{155{,}250\ \text{btu/lb} - 98{,}4138\ \text{btu/lb}}$$

$$= 1355{,}644\ \text{lb/hari} = 56{,}485\ \text{lb/jam} = 25{,}6215\ \text{kg/jam}$$

$$P = m\,(H_3 - H_2) = 56{,}485\ \text{lb/jam}\ (281{,}838 - 155{,}250)\ \text{btu/lb}$$

$$= 7150{,}323\ \text{btu/lb} = 2{,}81\ \text{Hp}$$

Effisiensi kompresor = 80%

Power yang dibutuhkan $= \dfrac{P}{0,8} = \dfrac{2,81}{0,8}$

$= 3,51$ Hp ≈ 4 Hp

Menentukan jumlah air pendingin yang dipakai pada kondensor :

Titik 3 :

$T_3 = 90$ °C, $H_3 = 281,838$ btu/lb, $P_3 = 145,038$ psia

$T_4 = 90$ °C, $H_4 = 272,284$ btu/lb, $P_4 = 145,038$ psia

Air pendingin masuk kondensor pada suhu 86 °F (H = 54,068 btu/lb) dan keluar pada suhu 90°F (H = 58,07 btu/lb)

Panas masuk kondensor = panas keluar kondensor

H3 + H air pendingin masuk = H4 + H air pendingin keluar

(1355,644 lb/hari . 281,838 btu/lb) + (m air . 54,068 btu/lb) = (1355,644 lb/hari . 250,788 btu/lb) + (m air . 58,07 btu/lb)

m air = 10549,55 lb/hari

= 439,56516 lb/jam = 199,385 kg/jam

Spesifikasi:

Nama alat : Freezer

Type : persegi panjang

Kapasitas : 2502,518 kg/hari

Dimensi :

- Panjang : 18,004 m
- Lebar : 8,004 m
- Tinggi : 2,50188 m

Kecepatan pendingin Propylene : 25,6215 kg/jam

Kecepatan air pendingin : 1994,385 kg/jam

Power : 4 Hp

Jumlah : 1 unit

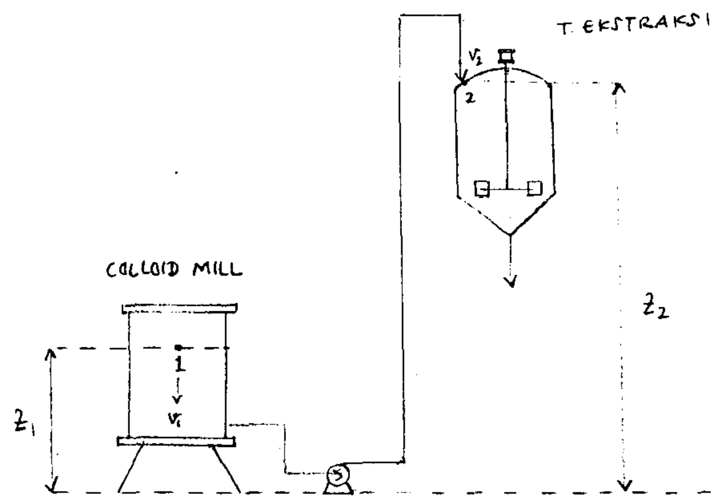
Harga : $ 133 000 (Perry, ed. 6, 1984)

22. Pompa 1 (L-261)

Fungsi : mengalirkan bubur kedelai dari colloid mill ke tangki pengekstrak

Type : Centrifugal Pump

Dasar pemilihan : biaya operasi dan instalasi lebih murah



Kapasitas = 1878,40351 kg/hari = 4141,88 lb/hari = 0,048lb/det

$\rho_{kedelai}$ = 57,37 lb/ft^3

ρ_{air} (pada T=30°C) = 61,1025 lb/ft^3

$$\rho_{campuran} = \frac{1}{\frac{0,577}{57,37} + \frac{0,423}{61,108}} = 58,894 lb/ft^3 = 943,39 kg/m^3$$

$\mu_{campuran}$ = 6,772.10^{-3}lb/ft.det = 10,08 cp

$$q_f = \frac{0,048}{58,894} = 8,15.10^{-4} ft^3/\text{det} = 6,10.10^{-3} gal/\text{det} = 0,366 gal/mnt$$

$H_{colloid\ mill}$ = 1,5 . diameter shell

Volume campuran dalam colloid mill = π/4 . Di^2. Hs

= π/4 . 1,5 . Di^3

Volume colloid mill = 1,2 . volume campuran

= 1,2 .0,048 ft^3/menit = 0,059 ft^3/det

Volume colloid mill $= \pi/4 \;.\; 1{,}5 \;.\; Di^3$

$0{,}059 = \pi/4 \;.\; 1{,}5 \;.\; Di^3$

$Di^3 = 0{,}05$

$Di = 0{,}36$ ft

$H_{colloid\ mill} = 1{,}5 \;.\; 0{,}36$ ft $= 0{,}54$ ft

$H_{campuran} = 80\%.\ 0{,}54$ ft $= 0{,}432$ ft

Asumsi aliran fluida merupakan aliran viscous, sehingga

$D_{i,opt} = 3{,}0.q_f^{0,36}.\mu_{campuran}^{0,18}$ (Peter and Timmerhaus, hal. 496)

$= 3{,}0.(8{,}15.10^{-4})^{0,36}.(10{,}08)^{0,18}$

$= 0{,}35$ in

Dipilih stainless steel 3/8 in, sched 40 didapatkan:

ID $= 0{,}493$ in $= 0{,}041$ ft

OD $= 0{,}675$ in $= 0{,}056$ ft

A $= 0{,}191\ in^2 = 1{,}33.10^{-3}\ ft^2$

$$v = \frac{q_f}{A} = \frac{8{,}15.10^{-4}}{1{,}33.10^{-3}} = 0{,}61 ft/\det$$

$$N_{re} = \frac{D.v.\rho}{\mu} = \frac{0{,}041 ft.0{,}61 ft/\det.58{,}894 lb/ft^3}{6{,}772.10^{-3} lb/ft.\det} = 217{,}50$$

(aliran viscous, sehingga memenuhi)

Dari persamaan Neraca Energi:

$$W_s = -\frac{1}{2.\alpha.g_c}\left(v_2^2 - v_1^2\right) - \frac{g}{g_c}\left(z_2 - z_1\right) - \frac{P_2 - P_1}{\rho} - \Sigma F$$ (Geankoplis, 3rd ed, hal. 64)

Di mana ΣF merupakan total friksional losses yang meliputi:

1. Losses karena kontraksi pada outlet tangki, h_c.
2. Losses karena friksi pada pipa lurus, k_f.
3. Losses karena friksi pada elbow dan valve, h_f.
4. Losses karena ekspansi pada inlet tangki, h_{ex}.
5. Losses karena pressure drop.

Perhitungan mencari ΣF:

1. Friksi karena kontraksi, h_c

$$K_c = 0{,}55.\left(1 - \frac{A_2}{A_1}\right)$$

Karena A_2 <<<< A_1 maka $\frac{A_2}{A_1} = 0$

$K_c = 0{,}55 \,.\, (1 - 0) = 0{,}55$

$$h_c = K_c.\left(\frac{v^2}{2.\alpha.g_c}\right) = 0{,}55.\left(\frac{0{,}61^2}{2.1.32{,}174}\right) = 3{,}08.10^{-3}\,ft\frac{lbf}{lbm}$$

2. Losses karena friksi pada pipa lurus, k_f

Penafsiran panjang pipa lurus = 8,762 m = 28,74 ft

Digunakan pipa commercial steel, $\varepsilon = 4{,}6.10^{-5}$ m = $1{,}5.10^{-4}$ ft

$$\frac{\varepsilon}{ID} = \frac{1{,}5.10^{-4}}{0{,}041} = 3{,}65.10^{-3}$$

dari Geankoplis, 3rd ed, fig 2.10-3, hal. 88 diperoleh:

f = 0,021

$$h_f = 4.f.\frac{\Delta L}{D}.\frac{v^2}{2.g_c}$$

$$= 4.0{,}021.\frac{28{,}74}{0{,}041}.\frac{(0{,}61)^2}{2.32{,}174} = 0{,}341\,ft\frac{lbf}{lbm}$$

3. Losses karena friksi pada elbow dan valve, H_f

Terdapat 5 elbow 90° dan 1 globe valve

Dari Geankoplis, 3rd ed, tabel 2.10-1, hal 93, diperoleh:

$K_{f\,\text{elbow }90°} = 0{,}75$ dan $K_{f\,\text{globe valve}} = 6$

$K_{f\,\text{total}} = (5 \times 0{,}75) + (1 \times 6) = 9{,}75$

$$H_f = K_f.\frac{v^2}{2.\alpha..g_c} = 9{,}75.\frac{0{,}61^2}{2.1.32{,}174} = 0{,}056\,ft\frac{lbf}{lbm}$$

4. Losses karena ekspansi pada inlet tangki eksrtaksi, h_{ex}

Di mana: A_1 = luas penampang pipa

A_2 = luas penampang tangki

A_1 <<<< A_2 sehingga $\frac{A_1}{A_2} = 0$

$$K_{ex} = 1 - \frac{A_1}{A_2} = 1 - 0 = 1$$

$$h_{ex} = K_{ex}.\left(\frac{v^2}{2.g_c}\right) = 1.\left(\frac{0{,}61^2}{2.32{,}174}\right) = 5{,}59.10^{-3}\ ft\frac{lbf}{lbm}$$

5. Losses karena pressure drop, ΔP

$\Delta P = 0$

$\Sigma F = 3{,}08.10^{-3} + 0{,}341 + 0{,}047 + 5{,}59.10^{-3} + 0 = 0{,}406$ ft lbf/lbm

$(z_2 - z_1) = (17{,}26 - 3{,}712)$ ft = 13,548 ft

$$W_s = -\frac{1}{2.1.32{,}174}.(0{,}61^2 - 0^2) - \frac{32{,}808}{32{,}174}.13{,}548 - 0{,}406 = -14{,}227\ ft\frac{lbf}{lbm}$$

Effisiensi pompa η = 10% (Peter and Timerhaus, fig 14-38, hal 520)

$$\text{Brake Hp} = \frac{-W_s.m}{\eta.550} = \frac{14{,}227.0{,}048}{0{,}1.550} = 0{,}012Hp$$

Effisiensi motor = 77,5% (Peter and Timmerhaus, 4th ed, fig 14-38, hal 521)

$$\text{Sehingga dipakai pompa dg power motor} = \frac{0{,}012}{0{,}775} = 0{,}016Hp \approx 0{,}5Hp$$

Spesifikasi:

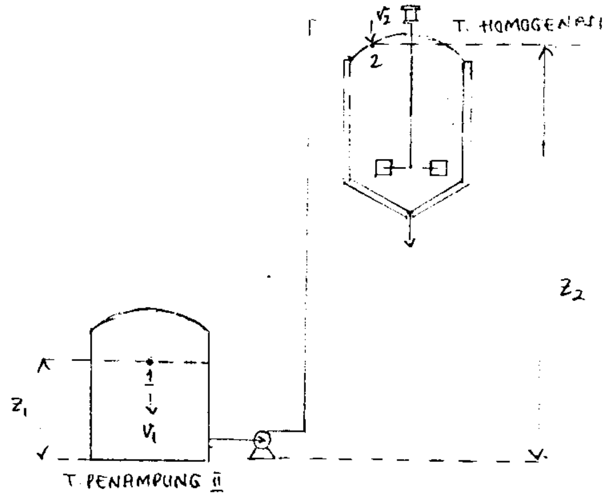
Type	: centrifugal pump
Rate	: $7{,}95.10^{-4}$ ft^3/det
Power	: 0,5 Hp
Jumlah	: 1 unit
Bahan	: SS-316
Harga	: $ 272 (Peter and Timmerhaus, 1991)

23. Pompa 2 (L-291)

Fungsi : mengalirkan susu kedelai dari tangki penampung II ke tangki homogenasi

Type : Centrifugal Pump

Dasar pemilihan : Biaya operasi dan instalasi lebih murah



Kapasitas = 2169,95849 kg/hari = 4784,76 lb/hari = 0,055 lb/det

$\rho_{campuran}$ = 62,015 lb/ft^3

$\mu_{campuran}$ = 6,865.10^{-3}lb/ft.det = 10,22 cp

$$q_f = \frac{0{,}055}{62{,}015} = 8{,}87.10^{-4}\, ft^3/\det = 6{,}64.10^{-3}\, gal/\det = 0{,}398\, gal/mnt$$

Asumsi aliran fluida merupakan aliran viscous, sehingga

$D_{i,opt} = 3{,}0.q_f^{0,36}.\mu_{campuran}^{0,18}$ (Peter and Timmerhaus, hal. 496)

$= 3{,}0.(8{,}87.10^{-4})^{0,36}.(10{,}22)^{0,18}$

$= 0{,}36$ in

Dipilih stainless steel 3/8 in, sched 40 didapatkan:

ID = 0,493 in = 0,041 ft

OD = 0,675 in = 0,056 ft

A = 0,191 in^2 = 1,33.10^{-3} ft^2

$$v = \frac{q_f}{A} = \frac{8{,}87.10^{-4}}{1{,}33.10^{-3}} = 0{,}67\,ft/\det$$

$$N_{re} = \frac{D.v.\rho}{\mu} = \frac{0{,}041 ft.0{,}67 ft/\det.62{,}015 lb/ft^3}{6{,}865.10^{-3} lb/ft.\det} = 251{,}78$$

(aliran viscous, sehingga memenuhi)

Dari persamaan Neraca Energi:

$$W_s = -\frac{1}{2.\alpha.g_c}\left(v_2^2 - v_1^2\right) - \frac{g}{g_c}\left(z_2 - z_1\right) - \frac{P_2 - P_1}{\rho} - \sum F$$ (Geankoplis, 3[rd]ed, hal. 64)

Perhitungan mencari ΣF:

1. Friksi karena kontraksi, h_c

$$K_c = 0{,}55.\left(1 - \frac{A_2}{A_1}\right)$$

Karena A_2 <<<< A_1 maka $\frac{A_2}{A_1} = 0$

K_c = 0,55 . (1 - 0) = 0,55

$$h_c = K_c.\left(\frac{v^2}{2.\alpha.g_c}\right) = 0{,}55.\left(\frac{0{,}67^2}{2.1.32{,}174}\right) = 3{,}84.10^{-3}\,ft\frac{lbf}{lbm}$$

2. Losses karena friksi pada pipa lurus, k_f

Penafsiran panjang pipa lurus = 13,7 m = 44,936 ft

Digunakan pipa commercial steel, $\varepsilon = 4{,}6.10^{-5}$ m = $1{,}5.10^{-4}$ ft

$$\frac{\varepsilon}{ID} = \frac{1{,}5.10^{-4}}{0{,}041} = 3{,}65.10^{-3}$$

dari Geankoplis, 3[rd] ed, fig 2.10-3, hal. 88 diperoleh:

f = 0,021

$$k_f = 4.f.\frac{\Delta L}{D}.\frac{v^2}{2.g_c}$$

$$= 4.0{,}021.\frac{44{,}936}{0{,}041}.\frac{0{,}67^2}{2.32{,}174} = 0{,}64\,ft\frac{lbf}{lbm}$$

3. Losses karena friksi pada elbow dan valve, H_f

   Terdapat 3 elbow dan 1 globe valve

   Dari Geankoplis, 3rd ed, tabel 2.10-1, hal 93, diperoleh:

   $K_{f\ elbow\ 90°} = 0{,}75$ dan $K_{f\ globe\ valve} = 6$

   $K_{f\ total} = (3 \times 0{,}75) + (1 \times 6) = 8{,}25$

   $$H_f = K_f.\frac{v^2}{2.\alpha..g_c} = 8{,}25.\frac{0{,}67^2}{2.1.32{,}174} = 0{,}058\,ft\frac{lbf}{lbm}$$

4. Losses karena ekspansi pada inlet tangki ekstraksi, h_{ex}

   Di mana: A_1 = luas penampang pipa

   A_2 = luas penampang tangki

   $A_1 <<<< A_2$ sehingga $\frac{A_1}{A_2} = 0$

   $$K_{ex} = 1 - \frac{A_1}{A_2} = 1 - 0 = 1$$

   $$h_{ex} = K_{ex}.\left(\frac{v^2}{2.g_c}\right) = 1.\left(\frac{0{,}67^2}{2.32{,}174}\right) = 6{,}98.10^{-3}\,ft\frac{lbf}{lbm}$$

5. Losses karena pressure drop, ΔP

   $\Delta P = 0$

$\Sigma F = 3{,}84.10^{-3} + 0{,}64 + 0{,}058 + 6{,}98.10^{-3} + 0 = 0{,}709$ ft lbf/lbm

$(z_2 - z_1) = (29{,}788 - 1{,}98)$ ft $= 27{,}808$ ft

$$W_s = -\frac{1}{2.1.32{,}174}.(0{,}67^2 - 0^2) - \frac{32{,}808}{32{,}174}.27{,}808 - 0{,}709 = -29{,}072\,ft\frac{lbf}{lbm}$$

Effisiensi pompa η = 10% (Peter and Timerhaus, fig 14-38, hal 520)

$$\text{Brake Hp} = \frac{-W_s.m}{\eta.550} = \frac{29{,}072.0{,}055}{0{,}1.550} = 0{,}03Hp$$

Effisiensi motor = 77,5% (Peter and Timmerhaus, 4th ed, fig 14-38, hal 521)

$$\text{Sehingga dipakai pompa dg power motor} = \frac{0{,}03}{0{,}775} = 0{,}04Hp \approx 0{,}5Hp$$

Spesifikasi:

Type : centrifugal pump

Rate : 8,87.10^{-4} ft^3/det

Power : 0,5 Hp

Jumlah : 1 unit

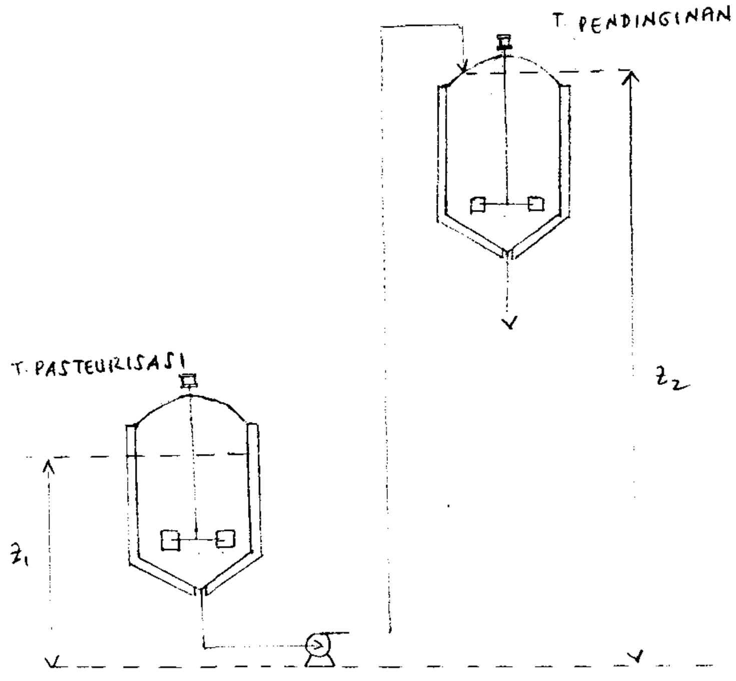
Harga : $ 282,93 (Peter and Timmerhaus, 1991)

24. Pompa 3 (L-321)

Fungsi : mengalirkan larutan ice cream dari tangki pasteurisasi ke tangki pendinginan

Type : Centrifugal Pump

Dasar pemilihan : Biaya operasi dan instalasi lebih murah



Kapasitas = 2500,09058 kg/hari = 5512,70 lb/hari = 0,064 lb/det

$\rho_{campuran}$ = 68,020 lb/ft^3

$\mu_{campuran}$ = 6,865.10^{-3}lb/ft.det = 10,22 cp

$$q_f = \frac{0{,}064}{62{,}020} = 1{,}032.10^{-3}\, ft^3/\det = 7{,}72.10^{-3}\, gal/\det = 0{,}463 gal/mnt$$

Asumsi aliran fluida merupakan aliran viscous, sehingga

$D_{i,opt} = 3{,}0.q_f^{0,36}.\mu_{campuran}^{0,18}$ (Peter and Timmerhaus, hal. 496)

$= 3{,}0.(1{,}032.10^{-3})^{0,36}.(10{,}22)^{0,18}$

$= 0{,}38$ in

Dipilih stainless steel 1/2 in, sched 40 didapatkan:

ID = 0,622 in = 0,051 ft

OD = 0,840 in = 0,070 ft

A = 0,304 in^2 = 2,11.10^{-3} ft^2

$$v = \frac{q_f}{A} = \frac{1{,}032.10^{-3}}{2{,}11.10^{-3}} = 0{,}49\, ft/\det$$

$$N_{re} = \frac{D.v.\rho}{\mu} = \frac{0{,}051 ft.0{,}49 ft/\det.62{,}020 lb/ft^3}{6{,}865.10^{-3} lb/ft.\det} = 225{,}77$$

(aliran viscous, sehhingga memenuhi)

Dari persamaan Kesetimbangan Energi:

$W_s = -\frac{1}{2.\alpha.g_c}(v_2^2 - v_1^2) - \frac{g}{g_c}(z_2 - z_1) - \frac{P_2 - P_1}{\rho} - \sum F$ (Geankoplis, 3rd ed, hal. 64)

Perhitungan mencari ΣF:

1. Friksi karena kontraksi, h_c

$$K_c = 0{,}55.\left(1 - \frac{A_2}{A_1}\right)$$

Karena $A_2 <<<< A_1$ maka $\frac{A_2}{A_1} = 0$

$K_c = 0{,}55 . (1 - 0) = 0{,}55$

$$h_c = K_c.\left(\frac{v^2}{2.\alpha.g_c}\right) = 0{,}55.\left(\frac{0{,}49^2}{2.1.32{,}174}\right) = 2{,}05.10^{-3}\, ft\frac{lbf}{lbm}$$

2. Losses karena friksi pada pipa lurus, k_f

   Penafsiran panjang pipa lurus = 7,7 m = 25,256 ft

   Digunakan pipa commercial steel, ε = $4,6.10^{-5}$ m = $1,5.10^{-4}$ ft

   $$\frac{\varepsilon}{ID} = \frac{1,5.10^{-4}}{0,051} = 2,90.10^{-3}$$

   dari Geankoplis, 3rd ed, fig 2.10-3, hal. 88 diperoleh:

   f = 0,018

   $$k_f = 4.f.\frac{\Delta L}{D}.\frac{v^2}{2.g_c}$$

   $$= 4.0,018.\frac{25,256}{0,051}.\frac{0,49^2}{2.32,174} = 0,13\,ft\frac{lbf}{lbm}$$

3. Losses karena friksi pada elbow dan valve, H_f

   Terdapat 4 elbow dan 1 globe valve

   Dari Geankoplis, 3rd ed, tabel 2.10-1, hal 93, diperoleh:

   $K_{f\ elbow\ 90°} = 0,75$ dan $K_{f\ globe\ valve} = 6$

   $K_{f\ total} = (4 \times 0,75) + (1 \times 6) = 9$

   $$H_f = K_f.\frac{v^2}{2.\alpha..g_c} = 9.\frac{0,49^2}{2.1.32,174} = 0,034\,ft\frac{lbf}{lbm}$$

4. Losses karena ekspansi pada inlet tangki eksrtaksi, h_{ex}

   Di mana: A_1 = luas penampang pipa

   A_2 = luas penampang tangki

   A_1 <<<< A_2 sehingga $\frac{A_1}{A_2} = 0$

   $$K_{ex} = 1 - \frac{A_1}{A_2} = 1 - 0 = 1$$

   $$h_{ex} = K_{ex}.\left(\frac{v^2}{2.g_c}\right) = 1.\left(\frac{0,49^2}{2.32,174}\right) = 3,73.10^{-3}\,ft\frac{lbf}{lbm}$$

5. Losses karena pressure drop, ΔP

$\Delta P = 0$

$\Sigma F = 2{,}05.10^{-3} + 0{,}13 + 0{,}034 + 3{,}73.10^{-3} + 0 = 0{,}167$ ft lbf/lbm3

$(z_2 - z_1) = (18{,}308 - 6{,}828)$ ft $= 11{,}480$ ft

$$W_s = -\frac{1}{2.1.32{,}174}.(0{,}49^2 - 0^2) - \frac{32{,}808}{32{,}174}.11{,}480 - 0{,}167 = -11{,}870 ft\frac{lbf}{lbm}$$

Effisiensi pompa η = 10% (Peter and Timerhaus, fig 14-38, hal 520)

$$\text{Brake Hp} = \frac{-W_s.m}{\eta.550} = \frac{11{,}870.0{,}064}{0{,}1.550} = 0{,}014Hp$$

Effisiensi motor = 77,5% (Peter and Timmerhaus, 4th ed, fig 14-38, hal 521)

$$\text{Sehingga dipakai pompa dg power motor} = \frac{0{,}014}{0{,}775} = 0{,}02Hp \approx 0{,}5Hp$$

Spesifikasi:

Type	: centrifugal pump
Rate	: $1{,}032.10^{-3}$ ft^3/det
Power	: 0,5 Hp
Jumlah	: 1 unit
Bahan	: SS-316
Harga	: $ 297,34 (Peter and Timmerhaus, 1991)

APPENDIX D

PERHITUNGAN SPESIFIKASI ALAT

APPENDIX D
PERHITUNGAN ANALISA EKONOMI

1. Metode Penafsiran Harga-harga

Harga alat akan berubah setiap saat tergantung dari kondisi ekonomi dan politik. Untuk itu dibutuhkan suatu metode yang dapat mengkonversikan harga dari alat beberapa tahun yang lalu, agar dapat diperoleh harga alat yang ekuivalen pada saat ini. Ekuivalensi itu dihitung dengan menggunakan persamaan :

$$\text{Harga alat saat ini} = \frac{\text{indeks harga saat ini}}{\text{indeks harga tahun A}} \times \text{harga alat tahun A}$$

Harga alat pada tahun A diperoleh dari literature Peters & Timmerhaus dan Ulrich, 1984. Sedangkan indeks harga didapatkan dari :

- Marshall & Shift Equitment Cost Index, tahun A (Januari, 1990) 904 (tabel 3 Peters 4ed.p.13).
- Marshall & Shift Equitment Cost Index, saat ini (Agustus,2002) 1073,5 (Chemical Enginering) Agustus, 2002.
- Chemical Plant Cost Index, tahun A (Mid, 1982) 315 (Ulrich, fig 5-1)
- Chemical Plant Cost Index, saat ini (Mid, 2002) 394,3 (Chemical Enginering, Mei, 2002).

Harga peralatan yang tidak ada pada gambar, dikonversikan terlebih dahulu dengan persamaan berikut :

$$\text{Cost A} = \text{Cost B} \cdot \left(\frac{sizeA}{sizeB}\right)^{0.6} \qquad \text{(B \& Y, pers 12)}$$

Dengan : Cos A = harga alat A

Cos B = harga alat B

Size A = ukuran alat A

2. Harga Peralatan

Harga alat-alat yang digunakan dihitung berdasarkan persamaan umum.
Harga saat ini = (indeks harga saat ini / indeks harga tahun lalu) x harga tahun A.

Berikut ini diberikan contoh perhitungan untuk menentukan harga alat pada tahun 2002.

Bucket elevator

Jumlah = 1 buah

Dari pustaka Peters & Timmerhaus Fig 14.91.p 570 diperoleh harga : $ 6.700.

Kurs Dollar : 1 US $: Rp. 8.915,- (Harian Jawa Pos, tanggal 3-1-2003)

Indeks harga tahun A = 904

Indek harga tahun 2003 = 1073,5

Harga saat ini : (1073.5 / 904 x S 6.700 x 8.915 = Rp. 70.929.968,75

Selanjutnya melalui cara yang serupa ditaksir harga-harga alat yang lain dan ditabelkan sbb :

No	Nama Peralataan	Jml	Harga satuan Th 1991($)	Harga Th 2003 (Rp)
1.	Silo (F-110)	1	10.000	105.865.625
2	Bucket (J-111, J-210, J-240)	3	6.700	212.789.906,30
3	Vibrating screen (H-130, H-230)	2	6.500	68.812.656,25
4	Colloid mill (C-260)	1	5.500	58.226.093,75
5	T. Lar NaHCO3 (R-221)	1	6.250	66.166.015,63
6	T. blanching (R-220)	1	10.834	114.694.818,1
7	T. Penampung I (F-250)	1	10.830	114.652.471,9
8	T. Pengekstrak (R-270)	1	18.333,33	194.086.943,9
9	T. Penampung II (F-290)	1	5.570	58.967.153,13
10	Rotary drum filter (H-280)	1	15.000	158.798.437,5
11	T. Homogenesis (R-310)	1	18.000	190.558.125
12	T. Pasteurisasi (R-320)	1	18.000	190.558.125
13	T. Pembuihan (R-330)	1	18.000	190.558.125
14	T. Pendinginan (R-340)	1	18.000	190.558.125
15	Pengemasan (P-410)	1	133.000	1.408.012.813
16	Hardening (P-420)	1	133.000	1.408.012.813
17	Freezer (P-430)	1	133.000	1.408.012.813
18	Rak	8	4375	32.000.000
19	Pompa 1 (L-261)	1	272	2.879.545
20	Pompa 2 (L-291)	1	282,93	2.995.256,125
21	Pompa 3 (L-321)	1	297,34	3.147.808,494
	Total			6.074.593.911,-

Harga Peralatan utilitas

No.	Nama	Harga (Rp)
1.	Boiler	127.185.142
2.	Pompa air dari sumur	2.879.545
3.	Bak penampung air sumur	2.500.000

4.	Pompa air ke clarifier	2.785.652
5.	Clarifier (2 buah)	37.970.652
6.	Bak penampung air jernih	2.850.000
7.	Sand filter (2 buah)	25.714.822,38
8.	Bak penampung filtrat	3.500.000
9.	T. Demineralisasi 1	57.462.389,72
10.	T. Demineralisasi 2	57.462.389,72
11.	Bak penampung air demineralisasi	2.950.000
12.	Pompa air untuk steam ke peralatan	2.895.362
13.	Bak air pendingin	3.250.000
14.	Bak penampung air sanitasi	3.250.000
15.	Generator	4.643.623
16.	Cooling tower	12.196.729,11
17.	Pompa air untuk pendingin	3.214.000
	Total	372.710.306,9,-

Total harga peralatan = Rp . 6.447.304.218,-

3. Harga bahan baku dan harga pembantu

a. Harga bahan baku

1) Kedelai (dibeli dari Banyuwangi)

Kebutuhan = 356,00983 kg/hari

Harga = Rp 2.500 / kg

Harga pertahun = 356,011983 kg/hari x Rp 2.500 / kg x 3330 hari

= Rp 293.709.886,-

2) $NaHCO_3$

Kebutuhan = 3,56011983 kg/hari

Harga = Rp 15.000 / kg

Harga pertahun = 3,56011983 kg/hari x Rp 15.000 / kg x 330 hari

= Rp 17.622.593,16

3) Gelatin

Kebutuhan = 4,33991698 kg/hari

Harga = Rp 75.000 / kg

Harga pertahun = 4,33991698 kg/hari x Rp 75.000 / kg x 330 hari

= Rp 107.412.945,3

4) Sukrosa

Kebutuhan = 325,4937735 kg/hari

Harga = Rp 3.000 / kg

Harga pertahun = 325,4937735 kg/hari x Rp 3.000 / kg x 330 hari

= Rp 322.238.835,8

b. Harga bahan pembantu

1) Cup

Kebutuhan = 41669 cup/hari

Harga = Rp 35,- / cup

Harga per tahun = 41669 cup/hari x Rp 35 / cup x 330 hari

= Rp 481.276.950

2) Na_2Z

Kebutuhan = 1232,944 kg/tahun x 1 tahun

Harga = Rp. 650,-/kg

Harga per tahun = Rp. 801.413,60

3) Propylene

Propylene yang didistribusikan dalam unit pendingin, pada dasarnya mirip dengan refrigerant yang disirkulasikan pada alat kulkas/ freezer.

Dianggap bahwa:

a. Propylene tersebut harus diganti dengan propylene yang baru setiap tahun sekali.

b. Dianggap waktu tinggal propylene dalam alat condenser selam 3 jam.

Dari data tersebut, maka:

Kebutuhan propylene = 1896,79 kg/jam x 3 jam = 5690,38 kg

Harga = Rp. 1200,-/kg

Harga per tahun = Rp. 6.633.712,5

Total harga bahan baku dan bahan pembantu = Rp 1.229.696.337,-

4. Harga jual produk :

a. Produk Utama

Ice cream : 2.500 kg/hari	= 2.500 L/hari
Harga per cup (60ml)	= Rp 1.750,-
Produk	= 41.669 cup/hari
Harga per tahun	= 41.669 cup/hari x Rp 1.750 /cup x 330 hari
	= Rp 24.063.847.500,-

b. Produk Samping

Ampas kedelai	= 262,2027238 kg/hari
Harga	= Rp 500
Harga per tahun	= 262,2027238 kg/hari x Rp.500/kg x 330 hr
	= Rp 43.263.449,43

Total produk = Rp24.107.770.950,-

No	Gaji karyawan		Upah/bln (Rp)	Total (Rp)
1	Direk. Utama	1	5.000.000	5.000.000
2	Direk. Teknik	1	3.000.000	3.000.000
3	Direk. Administrasi	1	3.000.000	3.000.000
4	Sekt. Direktur	3	1.500.000	4.500.000
5	Kabag.	6	2.000.000	12.000.000
6	Kary. Shift.	88	800.000	68.800.000
7	Kary. Pembukuan	2	800.000	1.600.000
8	Kary. Personalia	2	800.000	1.600.000
9	Keamanan	20	500.000	10.000.000
10	Rumah tangga	6	500.000	3.000.000
11	Kebersihan	10	500.000	5.000.000
12	Sopir + lain-lain	5	500.000	2.900.000
	Jumlah tenaga kerja	**145**		**120.000.000**

Untuk 1 tahun gaji karyawan + 1 kali gaji untuk THR = Rp 1.560.000.000

5. Biaya Utilitas

a. Pengolahan air

Biaya rata-rata pengolahan air = Rp 1.500.000/hari

Kebutuhan = 963.918 m^3/hari

Biaya / th = Rp 1.500.000 x 365

= Rp 495.000.000

b. Biaya bahan bakar

Generator dan boiler menggunakan bahan bakar IDO yang setara dengan bahan bakar jenis solar sebanyak 4.063.716 L/th

Harga solar = Rp 1.890,-/L

Biaya bahan bakar untuk 1 th = Rp 1.890,-/L x 4.063.716 L/th

= Rp 7.680.423.240,-

c. Listrik

Kebutuhan listrik pabrik = 253 kw

= 253 kva (1w = 1v . 1A . Cos φ)

dimana : Cos φ = 1,0

Beban listrik terpasang : 253 kva

Biaya beban listrik perbulan = Rp 18.000 /kva per bulan

Biaya beban /tahun = Rp 18.000 . 253 . 12

= Rp 54.648.000,-

Listrik terpakai = 253 kva

Biaya listrik WBP = Rp 260/kwh (18.00 – 22.00)

LWBP = Rp 105/kwh (22.00 – 08.00)

Biaya listrik terpakai / tahun :

(4 jam x 253 kva x Rp 260)+(20jam x 253 kva.Rp 105)x365 hr/th

= Rp 289.963.300,-

Biaya listrik & total = biaya beban + biaya listrik terpakai

= Rp 54.648.000,- + Rp 289.963.300,-

= Rp 344.611.300,-

Total biaya utilitas = Rp 8.520.034.540,-

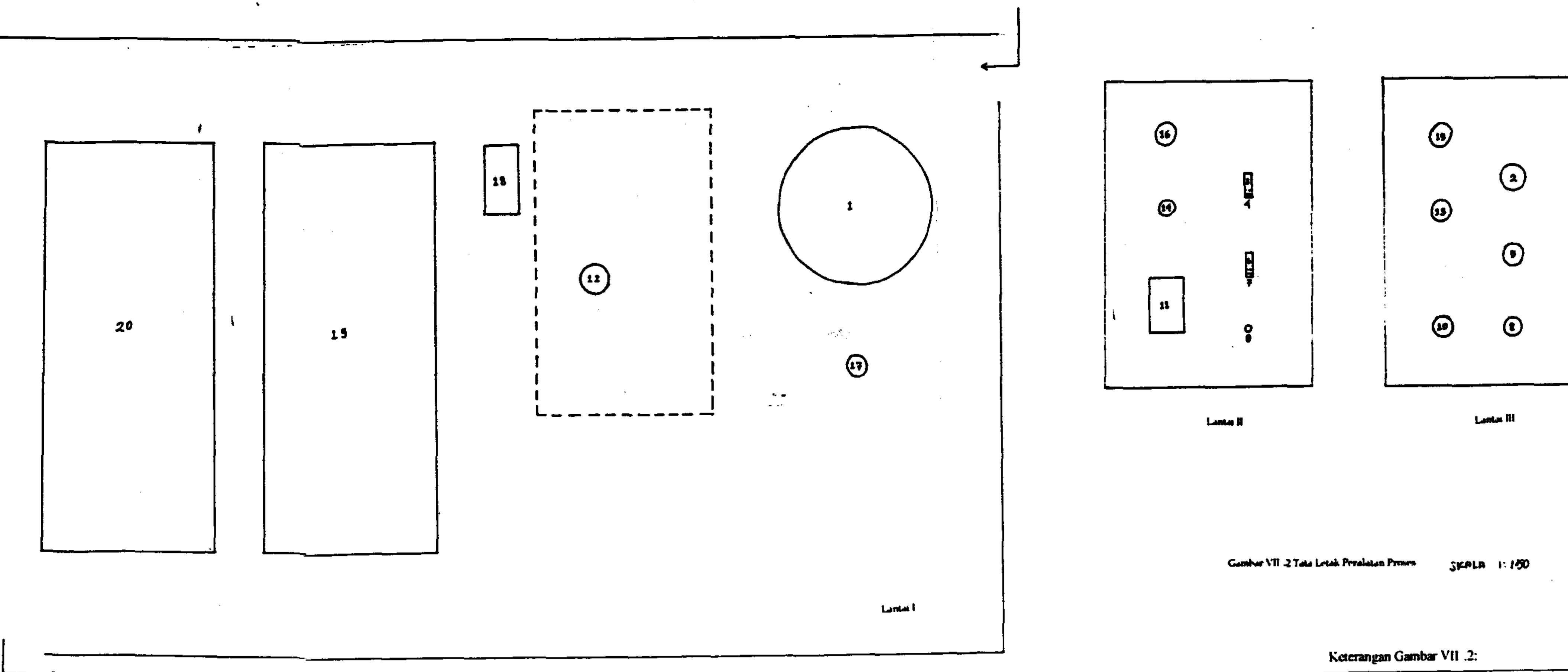
6. Harga tanah = bangunan

Luas tanah	= 6618,5 m^2
Luas bangunan	= 6179 m^2
Harga bangunan	= Rp 300.000
Harga tanah	= Rp 250.000
Total harga bangunan	= Rp 300.000 x 6179 = Rp 1.151.600.000
Total harga tanah	= Rp 250.000 x 6618,5 = Rp 1.654.625.000
Total harga tanah + bangunan	= Rp 2.806.225.000

APPENDIX E

PERHITUNGAN ANALISA EKONOMI

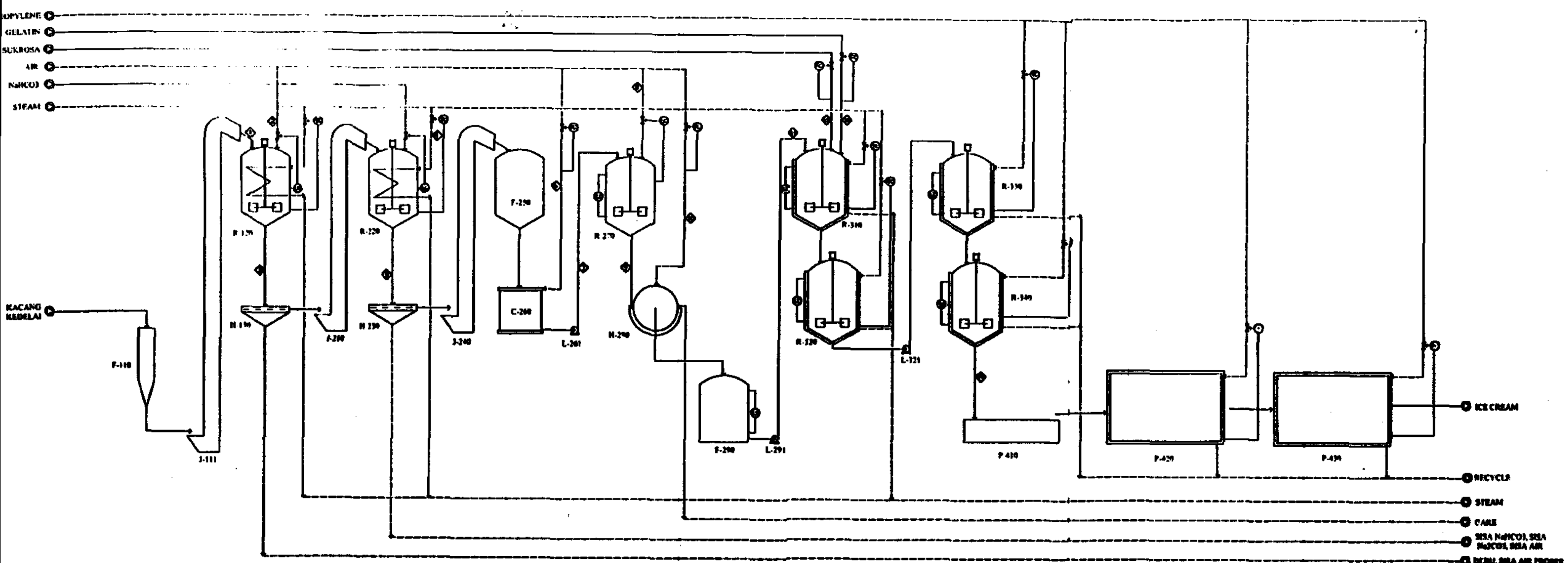
PRA RENCANA PABRIK ICE CREAM
DARI KACANG KEDELAI
KAPASITAS : 2500kg/Hari
OLEH :
YULIATY YOLORINA (5203097025)
PANNY (5203097026)



Gambar VII .2 Tata Letak Peralatan Proses SKALA 1 : 150

Keterangan Gambar VII .2:

1. Silo	11. Rotary vacuum filter
2. Tangki Perendaman	12. Tangki penampungan II
3. Vibrating screen I	13. Tangki homogenasi
4. Bucket elevator I	14. Tangki pasteurisasi
5. Tangki blanching	15. Tangki pendinginan
6. Vibrating screen II	16. Tangki pembuihan
7. Bucket elevator II	17. Tangki larutan $NaHCO_3$
8. Tangki penampungan I	18. Unit pengemasan
9. Colloid mill	19. Unit hardening
10. Tangki ekstraksi	20. Frezeer



BAHAN/SENYAWA	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	KG/HARI													
KEDELAI	32,72		327,5		327,5									
LAR. NaHCO3				712,0	712,0									
AIR	26,7	712,0	710,7		712,0	1390,1		996,2		168,5				
BUBUR KEDELAI							1870,8		2017,6					
SUSU KEDELAI											2078,6			
SUKROSA												325,7		
GELATIN													4,3	
ICE CREAM														2500
KOTORAN	1,6		1,6											
TOTAL	356	712,0	[illegible]	712,0	1751,5	1390,1	1870,8	996,2	2017,6	168,5	2078,6	325,7	4,3	2500

NO	KODE	NAMA ALAT	JUMLAH	KET
23	P-430	FREZEER	1	
22	P-420	HARDENING	1	
21	P-410	FILLER	1	
20	R-340	TANGKI PEMBUIHAN	1	
19	R-330	TANGKI PENDINGINAN	1	
18	L-321	POMPA-3	1	
17	R-320	TANGKI PASTEURISASI	1	
16	R-300	TANGKI HOMOGENASI	1	
15	L-291	POMPA-2	1	
14	F-290	TANGKI PENAMPUNG-2	1	
13	H-280	ROTARY VACUUM FILTER	1	
12	R-270	TANGKI EKSTRAKSI	1	
11	L-261	POMPA-1	1	
10	C-260	COLLOID MILL	1	
9	F-250	TANGKI PENAMPUNG-1	1	
8	J-240	BUCKET ELEVATOR-3	1	
7	H-230	VIBRATING SCREEN-2	1	
6	R-220	TANGKI BLANCHING	1	
5	J-200	BUCKET ELEVATOR-2	1	
4	H-130	VIBRATING SCREEN-1	1	
3	R-120	TANGKI PERENDAMAN	1	
2	J-111	BUCKET ELEVATOR-1	1	
1	F-110	SILO	1	

FLOW SHEET

PABRIK ICE CREAM DARI KEDELAI

KAPASITAS

2500 KG/HARI

DIPERIKSA :
Ir. SURATNO L., MS

OLEH :
WENI Y./ 5203097025
FANNY/ 5203097026

JURUSAN TEKNIK KIMIA
FAKULTAS TEKNIK
UNIVERSITAS KATOLIK WIDYA MANDALA

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