BAB IX
TUGAS KHUSUS

IX.1 Perhitungan Neraca Massa

IX.1.1 Neraca Massa Stasiun Gilingan

Kapasitas Produksi = 99,8 ton/jam

Imbibisi tebu = 25% x 99,8 ton/jam

= 24,95 ton/jam

Imbibisi % Nira

Gilingan IV = 10 % x 24,95 ton/jam

= 2,50 ton/jam

Gilingan V = 90 % x 24,95 ton/jam

= 22,46 ton/jam

Nira mentah (NM) % tebu = 108,7% x 99,8 ton/jam

= 108,48 ton/jam

Sabut % tebu = 9 %

Ampas = Tebu + Imbibisi - NM

= 99,8 ton/jam + (2,50 + 22,46) ton/jam

- 108,48 ton/jam

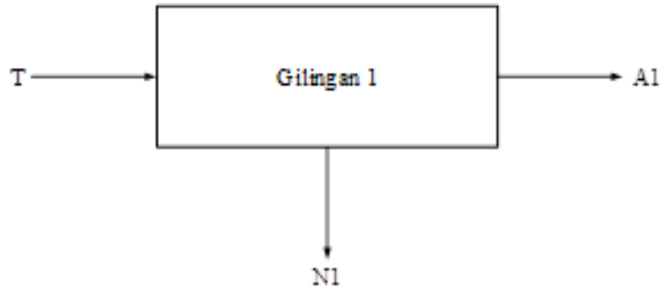
= 16,27 ton/jam

Data Analisa :

No	Uraian	% Brix	% Pol
1.	Tebu	16,34	10,26
2.	Nira Gilingan ke-1	15	11,29
3.	Nira Gilingan ke-2	8,34	6,4
4.	Nira Gilingan ke-3	6,52	4,59
5.	Nira Gilingan ke-4	4,4	2,96
6.	Nira Gilingan ke-5	2,36	1,53
7.	Nira Mentah 1	12,34	9,05

8.	Nira Mentah 2	12,1	8,85
9.	Nira Tapisan	8,38	5,5
10.	Nira Encer	12,7	9,2

a. Neraca Massa Gilingan I



- $N_1 = NM\ x \frac{b_{NM} - b_{N2}}{b_{N1} - b_{N2}}$

  $N_1 = 108{,}48 \frac{ton}{jam} x \frac{12{,}34 - 8{,}34}{15 - 8{,}34}$

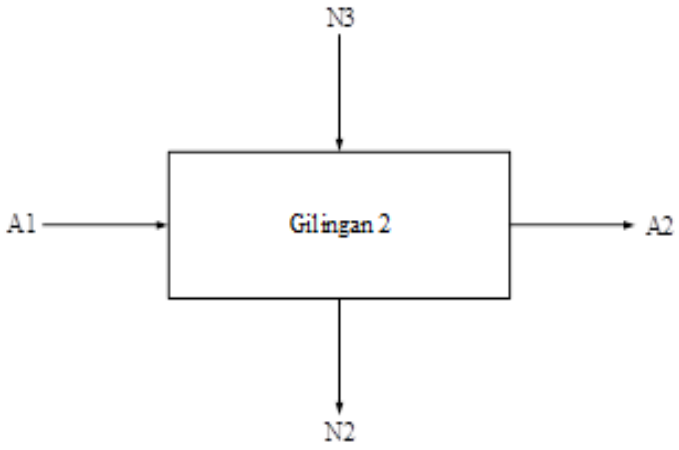
  $N_1 = 65{,}15 \frac{ton}{jam}$

- $A_1 = N_2 + A_2 - N_3$

  $A_1 = 43{,}3 \frac{ton}{jam} + 25{,}35 \frac{ton}{jam} - 34{,}03 \frac{ton}{jam}$

  $A_1 = 34{,}65 \frac{ton}{jam}$

b. Neraca Massa Gilingan II



- NM = $N_1 + N_2$

  $N_2 = NM - N1$

  $N_2 = 108{,}48\,\frac{ton}{jam} - 65{,}15\,\frac{ton}{jam}$

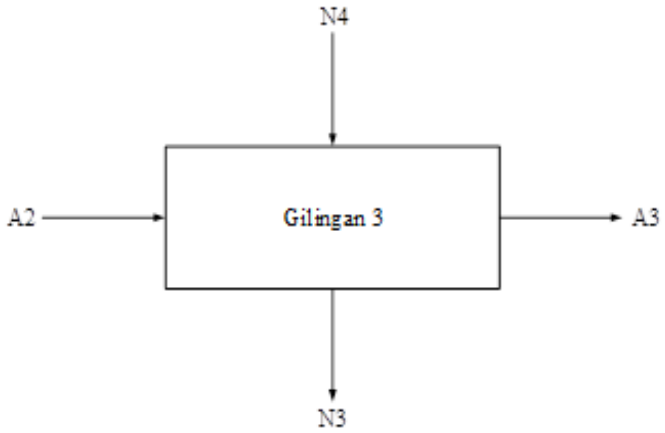
  $N_2 = 43{,}33\,\frac{ton}{jam}$

- $A_2 = A_3 + N_3 - N_4$

  $A_2 = 18{,}54\,\frac{ton}{jam} + 34{,}03\,\frac{ton}{jam} - 27{,}22\,\frac{ton}{jam}$

  $A_2 = 25{,}35\,\frac{ton}{jam}$

c. Neraca Massa Gilingan III



- $N_3 = N_2\ x\ \frac{b_{N1} - bN_2}{b_{N1} - b_{N3}}$

  $N_3 = 43{,}33\,\frac{ton}{jam}\ x\ \frac{15-8{,}34}{15-6{,}52}$

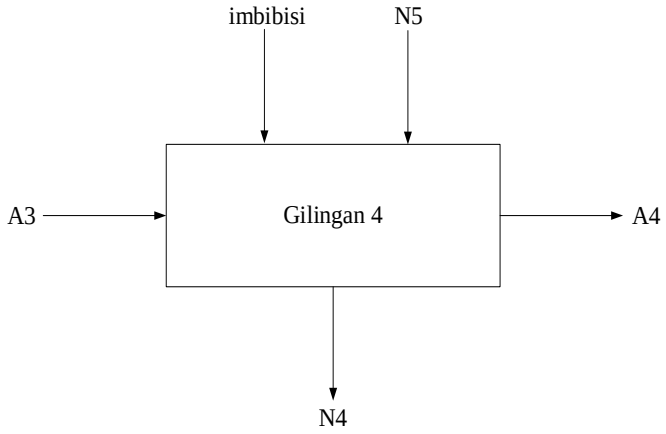
  $N_3 = 34{,}03\,\frac{ton}{jam}$

- $A_3 = N_4 + A_4 - N_5 - Imbibisi\ \%\ Nira\ Gilingan\ IV$

  $A_3 = 27{,}22\,\frac{ton}{jam} + 16{,}64\,\frac{ton}{jam} - 22{,}83\,\frac{ton}{jam} - 2{,}50\,\frac{ton}{jam}$

  $A_3 = 18{,}54\,\frac{ton}{jam}$

d. Neraca Massa Gilingan IV



- $N_4 = N_3 \, x \, \frac{b_{N1} - bN_3}{b_{N1} - b_{N4}}$

  $N_4 = 34{,}03 \, \frac{ton}{jam} \, x \, \frac{15 - 6{,}52}{15 - 4{,}4}$

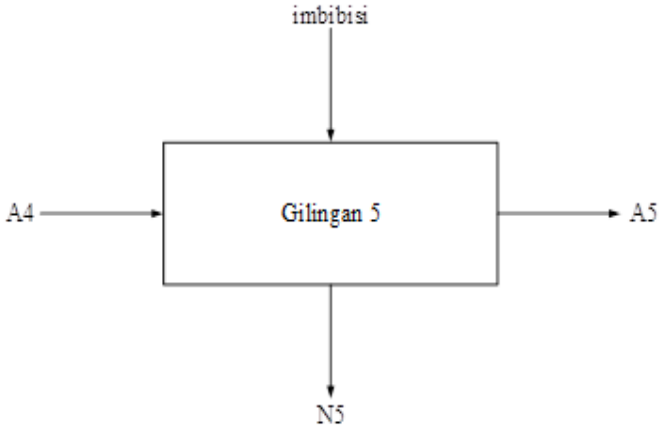
  $N_4 = 27{,}22 \, \frac{ton}{jam}$

- $A_4 = A_5 + N_5 - Imbibisi \, \% \, Nira \, Gilingan \, V$

  $A_4 = \ 16{,}27 \, \frac{ton}{jam} - 22{,}83 \, \frac{ton}{jam} - 22{,}46 \, \frac{ton}{jam}$

  $A_4 = 16{,}64 \, \frac{ton}{jam}$

e. Neraca Massa Gilingan V



- $N_5 = N_4 \, x \, \frac{b_{N1} - bN_4}{b_{N1} - b_{N5}}$

  $N_5 = 27{,}22 \, \frac{ton}{jam} \, x \, \frac{15 - 4{,}4}{15 - 2{,}36}$

$N_5 = 22{,}85 \frac{ton}{jam}$

- $A_5 = Ampas$

$A_5 = 16{,}27 \frac{ton}{jam}$

Masuk		Keluar	
Komponen	Massa (Ton/Jam)	Komponen	Massa (Ton/jam)
Tebu	99,8	NM	108,48
Imbibisi	24,95	Ampas	16,27
Total	124,75	Total	124,75

IX.1.2 Neraca Massa Stasiun Pemurnian

Data Analisa :

No.	Uraian	% Brix	% Pol	Densitas ($\frac{kg}{l}$)
1.	Nira Mentah 1	12,34	9,05	1,04558
2	Nira Mentah 2	12,1	8,85	1,04475
3	Nira Encer	12,7	9,2	1,04725
4	Nira Tapis	8,38	5,5	1,02015
5	Blotong		3,05	

a. Neraca Massa Pre-Liming

1. Massa Masuk

a) NM

Massa NM 1 = $108{,}48 \frac{ton}{jam}$

$= \frac{108{,}48 \frac{ton}{jam}}{1{,}04558 \frac{kg}{l}} \; x \; 1000$

$= 103753{,}5 \frac{l}{jam}$

b) Susu Kapur

pH Nira Mentah sebelum $= 4{,}9\ [H+]$

$= 10^{-4{,}9}$

$= 1{,}2589\ x\ 10^{-5}\ M$

pH Nira Mentah diinginkan $= 6{,}2\ [H+]$

$= 10^{-6{,}2}$

$= 6{,}3096\ x\ 10^{-7}\ M$

$\Delta[H^+] = 1{,}2589\ x\ 10^{-5}M - 6{,}3096\ x\ 10^{-7}M$

$= 1{,}1958X10^{-5}\ M$

Menghitung kebutuhan $Ca(OH)_2$

$\Delta[H^+]\ x\ volume = 1{,}1958X10^{-5}\ M\ x\ 103753{,}5\ \frac{l}{jam}$

$= 1{,}24072\ mol$

Karena 1 mol $Ca(OH)_2$ dapat menetralisir 2 mol H^+, maka :

Mol $Ca(OH)_2 = \frac{1{,}24072\ mol}{2}$

$= 0{,}6203577\ mol$

Massa $Ca(OH)_2 = \frac{0{,}6203577\ mol}{74}$

$= 45{,}9064669\ \frac{gram}{jam}$

Kebutuhan $Ca(OH)_2 = \frac{45{,}9064669\ \frac{gram}{jam}}{1000000}$

$= 4{,}5906\ x\ 10^{-5}\ \frac{ton}{jam}$

Kemurnian CaO $= Kemurnian\ CaO\ x\ Pemakaian\ Ca(OH)_2$

$= \frac{82\ ton}{100\ jam}\ x\ 4{,}5906\ x\ 10^{-5}\ \frac{ton}{jam}$

$= 3{,}7643\ x\ 10^{-5}\ \frac{ton}{jam}$

Volume $Ca(OH)_2 = \frac{Kemurnian\ CaO}{Kelarutan\ CaO}\ x\ 1000000\ \frac{ton}{jam}$

$= \frac{3{,}7643\ x\ 10^{-5}\ \frac{ton}{jam}}{55{,}6}\ x\ 1000000\ \frac{ton}{jam}$

$= 0{,}67703782\ \frac{l}{jam}$

Densitas $Ca(OH)_2 = 22{,}4\,\frac{kg}{l}$

Berat $Ca(OH)_2 = \frac{Densitas\ Ca(OH)_2}{1000}\ x\ Volume\ Ca(OH)_2$

$= \frac{22{,}4\frac{kg}{l}}{1000}\ x\ 0{,}67703782\,\frac{l}{jam}$

$= 0{,}00151656\,\frac{ton}{jam}$

2. Massa Keluar

a) Nira Mentah 1 $= 108{,}48\,\frac{ton}{jam}$

b. Neraca Massa pada Peti Nira

1. Massa Masuk

NM $= 108{,}48\,\frac{ton}{jam}$

NT $= 15\ \%\ Tebu$

$= 15\ \%\ x\ \ 108{,}48\,\frac{ton}{jam}$

$= 18{,}962\,\frac{ton}{jam}$

$H_3PO_4 = H_3PO_4\ tiap\ 100\ ton\ tebu\ (Kg)\ x\ Kapasitas\ Giling$

$= \frac{11{,}25}{100}\ x\ \frac{99{,}8}{100}$

$= 0{,}011\ \frac{ton}{jam}$

2. Massa Keluar

NM 2 $= NM + H_3PO_4 + \ NT$

$= 108{,}48\,\frac{ton}{jam} + 0{,}009\ \frac{ton}{jam}\ + 9{,}36\,\frac{ton}{jam}$

$= 127{,}4573\,\frac{ton}{jam}$

Brix $= 12{,}1\ \%$

Massa Brix $= 12{,}1\ \%\ x\ 127{,}4573\,\frac{ton}{jam}$

$= 15{,}4223\,\frac{ton}{jam}$

Massa Air $= 127{,}4573\,\frac{ton}{jam} - 15{,}4223\,\frac{ton}{jam}$

$= 112{,}0350\,\frac{ton}{jam}$

c. Neraca Massa pada Juice Reaktor dan Flash Tank

1. Massa Masuk

a) NM 2 $= 127{,}4573 \frac{ton}{jam}$

Brix $= 12{,}1\ \%$

Massa Brix $= 12{,}1\ \% \ x\ 127{,}4573 \frac{ton}{jam}$

$= 15{,}4223 \frac{ton}{jam}$

Massa Air $= 127{,}4573 \frac{ton}{jam} - 15{,}4223 \frac{ton}{jam}$

$= 112{,}0350 \frac{ton}{jam}$

b) Pemakaian $Ca(OH)_2 = \ Pemakaian\ CaO\ x\ Kapasitas\ Giling$

$= \frac{0{,}1\ ton}{100\ jam}\ x\ 99{,}8 \frac{ton}{jam}$

$= 0{,}0998 \frac{ton}{jam}$

Kemurnian CaO $= \ Kemurnian\ CaO\ x\ Pemakaian\ Ca(OH)_2$

$= \frac{82\ ton}{100\ jam}\ x\ 0{,}0998 \frac{ton}{jam}$

$= 0{,}081836 \frac{ton}{jam}$

Kebutuhan Ca(OH)2 untuk tangki defekator adalah 6 Be° (Tabel 24.1 E. Hugot, 1986).

Kelarutan CaO dalam susu kapur = 55,6 g/l (Tabel 24.1 E. Hugot, 1986).

Volume $Ca(OH)_2 = \frac{Kemurnian\ CaO}{Kelarutan\ CaO}\ x\ 1000000 \frac{ton}{jam}$

$= \frac{0{,}081836 \frac{ton}{jam}}{55{,}6}\ x\ 1000000 \frac{ton}{jam}$

$= 1471{,}8705 \frac{l}{jam}$

Densitas $Ca(OH)_2 = 22{,}4 \frac{kg}{l}$

Berat $Ca(OH)_2 = \frac{Densitas\ Ca(OH)_2}{1000}\ x\ Volume\ Ca(OH)_2$

$= \frac{22{,}4 \frac{kg}{l}}{1000}\ x\ 1471{,}8705 \frac{l}{jam}$

$$= 3{,}30\,\frac{ton}{jam}$$

%CaO dalam $Ca(OH)_2 = 5{,}292\ \%$

Berat air dalam $Ca(OH)_2 = \frac{100-\%CaO}{100}\ x\ Berat\ Ca(OH)_2$

$$= \frac{100-5{,}292\ \%}{100}\ x\ 3{,}30\,\frac{ton}{jam}$$

$$= 3{,}12\,\frac{ton}{jam}$$

c) Pemakaian Belerang (S)

$$S = \frac{Pemakaian\ S\ untuk\ NM}{100}\ x\ \frac{Kapasitas\ Giling}{1000}$$

$$= \frac{42}{100}\ x\ \frac{99{,}8}{1000}$$

$$= 0{,}04\,\frac{ton}{jam}$$

Dengan kemurnian belerang (S) = 100%, maka jumlah S yang terpakai adalah 0.04 ton/jam

$$Jumlah\ SO_2 = \frac{Mr\ SO_2}{Mr\ O_2}\ x\ Jumlah\ S$$

$$= \frac{64}{32}\ x\ 0{,}04$$

$$= 0{,}083832$$

Komponen	BM	Produk	
		Kmol	ton
Brix Nira Mentah			15,4223
H2O	18	6224,1670	112,0350
Ca(OH)2	74	44,5539	3,30
SO2	64	1,3099	0,083832
Total			130,8382

Reaksi 1

	SO2	+	H2O	→	H2SO3
m	1,3099		6224,1670		
r	0,9169		0,9169		0,9169
s	0,3930		6223,2501		0,9169

Reaksi 2

	H2SO3	+ Ca(OH)2	→ CaSO3	+ 2H2O
M	0,9169	44,5539	-	-
r	0,9169	0,9169	0,9169	1,8338
s	0	43,64	0,9169	1,8338

d. Neraca Massa pada Flash Tank

1. Massa Masuk

Komponen	BM	Produk	
		Kmol	ton
Brix Nira Mentah			15,4223
H2O	18	6225,0839	112,0515099
SO2	64	0,3930	0,0251496
Ca(OH)2	74	43,6370	3,229138403
CaSO3	120	0,9169	0,1100295
Total			130,8382

2. Massa Keluar

a) Asumsi jumlah SO_2 yang terserap = 70 %

SO_2 Out $= 30\ \% \ SO_2 in$

$= 30\ \% \ x\ 0{,}083832$

$= 0{,}0251496\ \frac{ton}{jam}$

NM2 + SO_2In + Susu Kapur = NJR + SO_2Out

$127{,}4573 + \ 0{,}083832 + 3{,}30 = NJR + 0{,}0251496$

$NJR = 130{,}8130\ \frac{ton}{jam}$

Komponen	BM	Produk	
		Kmol	ton
Brix Nira Mentah			15,4223
H2O	18	6225,083881	112,0515
Ca(OH)2	74	43,63700545	3,2291
CaSO3	120	0,9169125	0,1100
Total			130,8130

e. Neraca Massa pada Snow Boiling Tank

1. Massa Masuk

a) NJR

Massa NJR $= 130{,}8130 \frac{ton}{jam}$

b) Flokulan

$$\text{Berat Flokulan} = \frac{Pemakaian\ Flokulan\ (kg)}{100}\ x\ \frac{Kapasitas\ Giling}{1000}$$

$$= \frac{0{,}21}{100}\ x\ \frac{99{,}8}{1000}$$

$$= 0{,}00020958 \frac{ton}{jam}$$

Kadar flokulan dalam larutan adalah 0.1%

$$Jumlah\ Flokulan = \frac{Berat\ Flokulan}{Kadar\ Flokulan}\ x\ 100 \frac{ton}{jam}$$

$$= \frac{0{,}00020958 \frac{ton}{jam}}{0.1\%}\ x\ 100 \frac{ton}{jam}$$

$$= 0{,}20958 \frac{ton}{jam}$$

2. Massa Keluar

a) NSB = NJR + Flokulan

$$= 130{,}8130 \frac{ton}{jam} + 0{,}20958 \frac{ton}{jam}$$

$$= 131{,}022596 \frac{ton}{jam}$$

f. Neraca Massa pada Door Clarifier

1. Massa Masuk

a) NSB

Massa NSB $= 131{,}02 \frac{ton}{jam}$

Brix $= 12{,}1\ \%$

Massa Brix $= 12{,}1\ \%\ x\ 131{,}02 \frac{ton}{jam}$

$$= 15{,}85 \frac{ton}{jam}$$

Massa Air $= 131{,}02 \frac{ton}{jam} - 15{,}85 \frac{ton}{jam}$

$$= 115{,}17 \frac{ton}{jam}$$

2. Massa Keluar

a) Nira Encer $= 108{,}7\ \%$

Massa NE $= 108{,}7\ \%\ x\ 99{,}8 \frac{ton}{jam}$

$$= 108{,}4826\,\frac{ton}{jam}$$

Brix = 12,7 %

Massa Brix = $12{,}7\ \%\ x\ 108{,}4826\,\frac{ton}{jam}$

$$= 13{,}7772902\,\frac{ton}{jam}$$

Massa Air = $108{,}4826\,\frac{ton}{jam} - 13{,}7772902\,\frac{ton}{jam}$

$$= 94{,}705309\,\frac{ton}{jam}$$

b) Nira Kotor

Massa NK = $Massa\ NSB\ - Massa\ NE$

$$= 131{,}02\,\frac{ton}{jam} - 108{,}4826\,\frac{ton}{jam}$$

$$= 22{,}54\,\frac{ton}{jam}$$

g. Neraca Massa pada Rotary Vacuum Filter

1. Massa Masuk

a) Nira Kotor

Massa Nira Kotor = $22{,}54\,\frac{ton}{jam}$

b) Air Siraman

Jumlah Air Siraman di RVF = $\frac{Air\ Siraman\ \%\ Tebu}{100}\ x\ Kapasitas$

$$= \frac{2}{100}\,x\ 99{,}8\,\frac{ton}{jam}$$

$$= 1{,}996\,\frac{ton}{jam}$$

2. Massa Keluar

a) Nira Tapis

Nira Tapis = $19\ \%\ Tebu$

$$= 19\ 5\ x\ 99{,}8\,\frac{ton}{jam}$$

$$= 18{,}96\,\frac{ton}{jam}$$

b) Blotong

Berat Blotong = $NK + Air\ Siraman - NT$

$$= 22{,}54\,\frac{ton}{jam} + 1{,}996\,\frac{ton}{jam} - 5{,}574\,\frac{ton}{jam}$$

$$= 5{,}574\,\frac{ton}{jam}$$

IX.1.3 Neraca Massa Stasiun Penguapan

Untuk menentukan nilai air yang diuapkan tiap evaporator dapat dihitung menggunakan rumus persamaan jumlah air yang akan diuapkan (E).

$vessel\ 5$	$=$	x
$vessel\ 4$	$=$	x
$vessel\ 3$	$=$	x
$vessel\ 2$	$=$	$x + P1$
$vessel\ 1$	$=$	$x + P1 + P2 + P3$
E	$=$	$5x + 2P1 + P2 + P3$

a. Menentukan Jumlah Air yang Menguap

Menurut Hugot (1960), dalam menentukan jumlah air yang menguap pada stasiun evaporator dapat ditentukan dengan rumus berikut:

$$E = J(1 - \frac{Bj}{Bs})$$

Keterangan:

E = Jumlah air yang menguap

J = Massa nira encer

Bj = %Brix nira encer

Bs = %Brix nira kental

a) Air yang Menguap

$$E = J(1 - \tfrac{Bj}{Bs})$$

$$= 108{,}4826\,\frac{ton}{jam}\,x\,(1 - \tfrac{0{,}127}{0{,}6285})$$

$$= 86{,}5617\,\frac{ton}{jam}$$

b) Massa Nira Kental $= massa\ nira\ encer - air\ yang\ menguap$

$$= 108{,}4826\,\frac{ton}{jam} - 86{,}5617\,\frac{ton}{jam}$$

$$= 21{,}9209\,\frac{ton}{jam}$$

b. Menentukan Jumlah Uap Bleeding

Uap nira dari vessel (badan pemanas) I akan di bleed ke stasiun masakan (Vacuum pan) dan ke pemanas pendahuluan (PP)II.

1. Menghitung Kebutuhan Uap Stasiun Masakan (Vacuum Pan) (P3)

   Menurut Tromp (1938), kebutuhan uap pada stasiun masakan adalah 1.74 dari air yang harus diuapkan. %Brix masuk stasiun masakan diketahui = 62.85% dan keluar stasiun masakan = 94.2%. Untuk menentukan kebutuhan uap pada stasiun masakan, maka digunakan rumus berikut:

$$E = J(1 - \frac{Bj}{Bs})$$

   1. Uap Bleeding

$$E = J(1 - \frac{Bj}{Bs})$$

$$= 21{,}9209 \frac{ton}{jam} x\ (1 - \frac{0{,}6285}{0{,}942})$$

$$= 7{,}2953 \frac{ton}{jam}$$

   2. Massa Bleed Vacuum Pan

      Asumsi uap nira yang akan di bleed ke stasiun masakan adalah 80%, maka:

$$\text{Massa Bleed Vacuum Pan} = 80\%\ x\ 1{,}74\ x\ 7{,}2953 \frac{ton}{jam}$$

$$= 10{,}1551 \frac{ton}{jam}$$

2. Menghitung Kebutuhan Uap PP II (P2)

   Nira yang masuk ke PP II adalah nira hasil sulfitasi yaitu nira mentah terkapur, maka input PP II yaitu 130.8382 ton/jam. Untuk menghitung kebutuhan masing - masing alat yang akan di bleed digunakan perhitungan seperti dibawah ini:

$$P\ (m\ bleed\ PP\ II) = \frac{\dot{m} \times Cp \times \Delta T}{r}$$

   Keterangan:

   P = Kebutuhan uap (ton/jam)

   m = Laju alir nira terkapur (ton/jam)

   Cp = Kapasitas panas(kcal.kg.k)

T = Perbedaan temperatur (k)

r = Kalor laten pada suhu uap bleed (kcal/kg)

Kalor laten adalah jumlah panas untuk mengubah air menjadi uap pada temperatur yang sama. Kapasitas panas dapat dihitung berdasarlan %brix dengan rumus:

$$Cp = (1 - 0{,}0056B)$$

Sehingga :

$$\text{Cp} = (1 - 0{,}0056B)$$
$$= (1 - 0{,}0056\ x\ 12{,}7))$$
$$= 0{,}92888\,\frac{kcal}{kg.K}$$

$$\text{P} = \frac{\dot{m} \times Cp \times \Delta T}{r}$$
$$= \frac{130{,}8382\frac{ton}{jam}\ x\ 0{,}92888\frac{kcal}{kg.K}\ x\ (378-348)}{532}$$
$$= 6{,}8436\,\frac{ton}{jam}$$

Uap nira dari PP II dibleed untuk PP I. Pada PP I diolah nira mentah dan nira tapis, maka jumlah nira yang masuk PP I:

Massa nira masuk PP I $= 127{,}4573\,\frac{ton}{jam}$

3. Menghitung Kebutuhan Uap PP I

$$P\ (m\ bleed\ PP\ II) = \frac{\dot{m} \times Cp \times \Delta T}{r}$$
$$= \frac{127{,}4573\frac{ton}{jam} \times 0{,}92888\frac{kcal}{kg.K} \times (348-303)}{553{,}781}$$
$$= 9{,}62053\,\frac{ton}{jam}$$

Air yang diuapkan tiap badan:

$$\text{E} = 5x + 2P1 + P2 + P3$$
$$86{,}5617\,\frac{ton}{jam} = 5x + \left(2\ (9{,}62053\,\frac{ton}{jam})\right) + 6{,}8436\,\frac{ton}{jam} + 10{,}1551\,\frac{ton}{jam}$$
$$x = 10{,}0644\,\frac{ton}{jam}$$

Sehingga, air yang diuapkan tiap bulan:

Vesel 5 $= 10{,}0644\,\frac{ton}{jam}$

$$\text{Vesel 4} = 10{,}0644\,\frac{ton}{jam}$$

$$\text{Vesel 3} = 10{,}0644\,\frac{ton}{jam}$$

$$\text{Vesel 2} = 9{,}62053\,\frac{ton}{jam} + 10{,}0644\,\frac{ton}{jam}$$

$$= 19{,}6849\,\frac{ton}{jam}$$

$$\text{Vesel 1} = 9{,}62053\,\frac{ton}{jam} + 10{,}0644\,\frac{ton}{jam} + 6{,}8436\,\frac{ton}{jam} + 10{,}551\,\frac{ton}{jam}$$

$$= 36{,}6836\,\frac{ton}{jam}$$

c. Menentukan % Brix Tiap Badan Penguapan

Digunakan rumus berikut: (Hug.601)

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer\ - E}$$

Keterangan:

Bi = Brix masuk vessel

B0 = Brix keluar vessel

m encer = Banyaknya nira encer yang masuk BP (ton/jam)

E = Banyaknya air yang diuapkan (ton/jam)

1. Badan Pemanas I

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer - E}$$

$$= 12{,}7 \times \frac{108{,}4826\frac{ton}{jam}}{108{,}4826\frac{ton}{jam} - 36{,}6836\frac{ton}{jam}}$$

$$= 19{,}189\%$$

2. Badan Pemanas II

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer - E}$$

$$= 19{,}159\% \times \frac{71{,}799\frac{ton}{jam}}{71{,}799\frac{ton}{jam} - 19{,}6849\frac{ton}{jam}}$$

$$= 26{,}437\%$$

3. Badan Pemanas III

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer - E}$$

$$= 26{,}437\% \times \frac{52{,}114\frac{ton}{jam}}{52{,}114\frac{ton}{jam} - 10{,}0644\frac{ton}{jam}}$$

$$= 32{,}7643\%$$

4. Badan Pemanas IV

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer - E}$$

$$= 32{,}7643\% \times \frac{42{,}0497\frac{ton}{jam}}{42{,}0497\frac{ton}{jam} - 10{,}0644\frac{ton}{jam}}$$

$$= 43{,}0738\%$$

5. Badan Pemanas V

$$\%B_0 = \%B_i \times \frac{m\ encer}{m\ encer - E}$$

$$= 43{,}0738\% \times \frac{31{,}9853\frac{ton}{jam}}{31{,}9853\frac{ton}{jam} - 10{,}0644\frac{ton}{jam}}$$

$$= 62{,}85\%$$

d. Menentukan Neraca Massa Badan Penguapan

1. Badan Penguapan I

a) Massa Masuk

1) Nira Encer

Brix = 12,7 %

Massa Brix = $12{,}7\%\ x\ Massa\ nira\ encer$

$$= 12{,}7\%\ x\ 108{,}483\ \frac{ton}{jam}$$

$$= 13{,}7773\ \frac{ton}{jam}$$

Massa Air = $108{,}483\ \frac{ton}{jam} - 13{,}7773\ \frac{ton}{jam}$

$$= 94{,}70531\ \frac{ton}{jam}$$

b) Massa Keluar

1) Uap Air = $\dot{m}_{encer} \times \left(1 - \frac{\%brix\ nira\ encer}{\%brix\ nira\ kental\ BP1}\right)$

$$= 108{,}483\ \frac{ton}{jam} \times \left(1 - \frac{12{,}7\%}{19{,}189\%}\right)$$

$$= 36{,}6836\ \frac{ton}{jam}$$

2) Nira Kental BP I

Massa NK BP I $= massa\ nira\ encer - uap\ air$

$= 108{,}483\,\frac{ton}{jam} - 36{,}6836\,\frac{ton}{jam}$

$= 71{,}799\,\frac{ton}{jam}$

Brix BP I $= 19{,}159\%$

Massa Brix $= \%BP\ I\ x\ Massa\ NK\ BP\ I$

$= 19{,}189\%\ x\ 71{,}799\,\frac{ton}{jam}$

$= 13{,}7773\,\frac{ton}{jam}$

Massa Air $= 71{,}9110\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$

$= 58{,}0217\,\frac{ton}{jam}$

2. Badan Penguapan II

a) Massa Masuk

1) Nira BP I

Brix $= 19{,}19\%$

Massa Brix $= 19{,}19\%\ x\ Massa\ nira\ encer$

$= 19{,}19\%\ x\ 71{,}799\,\frac{ton}{jam}$

$= 13{,}7773\,\frac{ton}{jam}$

Massa Air $= 71{,}7990\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$

$= 58{,}0217\,\frac{ton}{jam}$

b) Massa Keluar

1) Uap Air $= \dot{m}_{BP1} \times \left(1 - \frac{\%brix\ nira\ Kental\ BP\ 1}{\%brix\ nira\ kental\ BP2}\right)$

$= 71{,}799\,\frac{ton}{jam} \times \left(1 - \frac{19{,}189\%}{26{,}437\%}\right)$

$= 19{,}6849\,\frac{ton}{jam}$

2) Nira Kental BP II

Massa NK BP II $= massa\ NK\ BP\ I - uap\ air$

$$= 71{,}799\,\frac{ton}{jam} - 19{,}6849\,\frac{ton}{jam}$$

$$= 52{,}1141\,\frac{ton}{jam}$$

Brix BP II $= 26{,}437\%$

Massa Brix $= \%BP\ II\ x\ Massa\ NK\ BP\ II$

$$= 26{,}437\%\ x\ 52{,}1141\,\frac{ton}{jam}$$

$$= 13{,}7773\,\frac{ton}{jam}$$

Massa Air $= 52{,}1141\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$

$$= 38{,}3368\,\frac{ton}{jam}$$

3. Badan Penguapan III
   a) Massa Masuk
      1) Nira BP II

Brix $= 26{,}44\ \%$

Massa Brix $= 26{,}44\ \%\ x\ Massa\ nira\ BP\ II$

$$= 26{,}44\ \%\ x\ 52{,}1141\,\frac{ton}{jam}$$

$$= 13{,}7773\,\frac{ton}{jam}$$

Massa Air $= 52{,}1141\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$

$$= 38{,}3368\,\frac{ton}{jam}$$

   b) Massa Keluar
      1) Uap Air $= \dot{m}_{BP2} \times \left(1 - \frac{\%brix\ nira\ Kental\ BP\ 2}{\%brix\ nira\ kental\ BP3}\right)$

$$= 52{,}3253\,\frac{ton}{jam} \times \left(1 - \frac{26{,}330\ \%}{32{,}5241\%}\right)$$

$$= 10{,}0644\,\frac{ton}{jam}$$

      2) Nira Kental BP III

Massa NK BP III $= massa\ BP\ II - uap\ air$

$$= 52{,}1141\,\frac{ton}{jam} - 10{,}0644\,\frac{ton}{jam}$$

$$= 42{,}0497\,\frac{ton}{jam}$$

Brix BP III = 32,764%

Massa Brix = $\%BP\ III\ x\ Massa\ NK\ BP\ III$

$= 32{,}764\%\ \ x\ 42{,}0497\ \frac{ton}{jam}$

$= 13{,}7773\ \frac{ton}{jam}$

Massa Air = $42{,}0497\ \frac{ton}{jam} - 13{,}7773\ \frac{ton}{jam}$

$= 28{,}2724\ \frac{ton}{jam}$

4. Badan Penguapan IV

a) Massa Masuk

1) Nira BP III

Brix = 32,76%

Massa Brix = $32{,}76\%\ x\ Massa\ NK\ BP\ III$

$= 32{,}76\%\ x\ 42{,}0497\ \frac{ton}{jam}$

$= 13{,}7773\ \frac{ton}{jam}$

Massa Air = $42{,}0497\ \frac{ton}{jam} - 13{,}7773\ \frac{ton}{jam}$

$= 28{,}2724\ \frac{ton}{jam}$

b) Massa Keluar

1) Uap Air = $\dot{m}_{BP3} \times \left(1 - \frac{\%brix\ nira\ Kental\ BP\ 3}{\%brix\ nira\ kental\ BP4}\right)$

$= 42{,}0497\ \frac{ton}{jam} \times \left(1 - \frac{32{,}7643\%}{43{,}0738\%}\right)$

$= 10{,}0644\ \frac{ton}{jam}$

2) Nira Kental BP IV

Massa NK BP IV = $massa\ NK\ BP\ III - uap\ air$

$= 42{,}0497\ \frac{ton}{jam} - 10{,}0644\ \frac{ton}{jam}$

$= 31{,}9853\ \frac{ton}{jam}$

Brix BP IV = 43,074%

Massa Brix = $\%BP\ IV\ x\ Massa\ NK\ BP\ IV$

$$= 43{,}074\%\ x\ 31{,}9853\,\frac{ton}{jam}$$

$$= 13{,}7773\,\frac{ton}{jam}$$

$$\text{Massa Air} = 31{,}9853\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$$

$$= 18{,}2080\,\frac{ton}{jam}$$

5. Badan Penguapan V

a) Massa Masuk

1) NK BP IV

Brix = 43,07%

$$\text{Massa Brix} = 43{,}07\ \%\ x\ Massa\ NK\ BP\ IV$$

$$= 43{,}07\ \%\ x\ 31{,}9853\,\frac{ton}{jam}$$

$$= 13{,}7773\,\frac{ton}{jam}$$

$$\text{Massa Air} = 31{,}9853\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$$

$$= 18{,}208\,\frac{ton}{jam}$$

b) Massa Keluar

1) $\text{Uap Air} = \dot{m}_{BP4} \times \left(1 - \frac{\%brix\ nira\ Kental\ BP\ 4}{\%brix\ nira\ kental\ BP5}\right)$

$$= 31{,}9853\,\frac{ton}{jam} \times \left(1 - \frac{43{,}0738\%}{62{,}85\%}\right)$$

$$= 10{,}0644\,\frac{ton}{jam}$$

2) Nira Kental BP V

$$\text{Massa NK BP V} = massa\ NK\ BP\ IV - uap\ air$$

$$= 31{,}9853\,\frac{ton}{jam} - 10{,}0644\,\frac{ton}{jam}$$

$$= 21{,}9209\,\frac{ton}{jam}$$

Brix BP V = 62,85%

$$\text{Massa Brix} = \%BP\ V\ x\ Massa\ NK\ BP\ V$$

$$= 62{,}85\%\ \ x\ 21{,}9209\,\frac{ton}{jam}$$

$$= 13{,}7773\,\frac{ton}{jam}$$

$$\text{Massa Air} = 21{,}9209\,\frac{ton}{jam} - 13{,}7773\,\frac{ton}{jam}$$

$$= 8{,}1436\,\frac{ton}{jam}$$

e. Menentukan Neraca Massa Tangki Sulfitasi

1. Massa Masuk

a) Nira Kental

Massa Nira Kental $= 21{,}9209\,\frac{ton}{jam}$

Massa Brix $= 13{,}7773\,\frac{ton}{jam}$

Massa air $= 8{,}1436\,\frac{ton}{jam}$

b) Belerang

$$S = \frac{Pemakaian\ S\ untuk\ NM}{100}\ x\ \frac{Kapasitas\ Giling}{1000}$$

$$= \frac{28}{100}\ x\ \frac{99{,}8}{1000}$$

$$= 0{,}03\,\frac{ton}{jam}$$

Dengan kemurnian belerang (S) = 100%, maka jumlah S yang terpakai adalah 0.04 ton/jam

$$\text{Jumlah } SO_2 = \frac{Mr\ SO_2}{Mr\ O_2}\ x\ Jumlah\ S$$

$$= \frac{64}{32}\ x\ 0{,}03\,\frac{ton}{jam}$$

$$= 0{,}05589\,\frac{ton}{jam}$$

2. Massa Keluar

Asumsi jumlah SO_2 yang terserap $= 70\ \%$

SO_2 Out $= 30\ \%\ SO_2in$

$$= 30\ \%\ x\ 0{,}083832$$

$$= 0{,}0251496\ \frac{ton}{jam}$$

NM2 + SO_2In + Klare SHS = NKsulf + SO_2Out

$$21{,}9209 + 0{,}05589 + 3{,}4423 = NKsulf + 0{,}01677$$

$$NJR = 25{,}4023\,\frac{ton}{jam}$$

IX.1.4 Neraca Massa Stasiun Pemasakan dan Puteran

Kapasitas	=	99.8	ton/jam
Nksulf	=	25.91139314	ton/jam

Data analisa:

NO	Bahan	%Brix	%Pol	HK	Densitas
1	NK sulf	62.85	48.16	76.63	1.29928
2	Klare D	74.9	38.3	51.13	1.3742
3	Tetes	89.6	30.1	33.59	1.4726
4	Bibit D	90.1	84.7	94.01	1.4761
5	Gula D1	93.23	77.8	83.45	1.4979
6	Gula D2	97.23	93.9	96.58	1.5266
7	Masakan D	97.61	59.6	61.06	1.5293
8	Stroop C	74.2	39.5	53.23	1.3697
9	Bibit C	89.45	83.95	93.85	1.4712
10	Gula C	98.23	94.2	95.90	1.5339
11	Masakan C	96.61	68.7	71.11	1.5223
12	Stroop A	85.4	54.7	64.05	1.4437
13	Klare SHS	75.4	59.3	78.65	1.3774
14	Masakan A	94.2	75.7	80.36	1.5051
15	Gula A	99.4	97.4	97.99	1.5425
16	GKP/SHS	99.97	99.75	99.78	1.5463

1. Vacuum Pan C Bibitan

Masuk

a. Nksulf

%Brix = 62,85%

Massa Nksulf dibutuhkan = 25,4023 ton/jam

Volume Nksulf dibutuhkan = $\frac{25,4023}{1,29928} \times 10$

= 195,5HL

Massa brix = $62,85\% \times 25,4023$

= 15,9654 ton/jam

Massa air = 25,4023 – 15,9654

= 9,4370 ton/jam

b. Fondan

Volume yang dibutuhkan = 200ml

Massa fondan = 200ml × 1,3 gr/ml

= 260 gram

c. Air

Volume yang dibutuhkan = 250 HL – 195,5 HL

= 54,5 HL

Massa air = $54{,}5HL \times \frac{1kg}{L} \times 100\frac{L}{HL} \times \frac{ton}{1000kg}$

= 5,4489 ton/jam

Keluar

a. Masakan C

%Brix = 96,61%

Volume masakan C = 195,5 HL + 54,5 HL

= 250 HL

Massa brix = 15,9654 ton/jam

Massa masakan C = $15{,}9654 \times \frac{100\%}{96{,}61\%}$

= 16,5256 ton/jam

b. Uap air

Massa uap air = Massa Nksulf + Massa fondan +Massa air – Massa masakan C

= 14,3529 ton/jam

2. LGF C

Masuk

a. Masakan C

%Brix = 96,61%

Volume masakan C = 250 HL

Massa brix = 15,9654 ton/jam

Massa masakan C = 16,5256 ton/jam

Massa air = 0,5602 ton/jam

b. Air

Air yang dibutuhkan = 3% masakan C
= 0,4958 ton/jam

Keluar

a. Gula C

Brix = 98,23%

$$Massa\ Gula\ C\ (Qs) = Qm \times \frac{BM}{BS} \times \frac{PM-PC}{PS-PC}$$

Keterangan:

Qm = Weight of massecuite
Qs = Weight of sugar
Bm = Weight of dry substance % massecuite
Bs = Weight of dry substance % sugar
Pm = Purity of massecuite
Pc = Purity of mollases
Ps = Purity of sugar

Massa gula C (Qs) $= 16{,}5256 \times \frac{96{,}61}{98{,}23} \times \frac{71{,}11-53{,}23}{95{,}9-53{,}23}$
= 6,8102 ton/jam
Massa brix = 6,6896 ton/jam
Massa air = 0,1206 ton/jam

Bibitan C
Brix = 89,45%
Massa bibitan C = 6,8102 ton/jam
Volume = 46,2899HL
Massa brix = 6,0917 ton/jam
Massa air = 2,6345 ton/jam

b. Stroop C

Brix = 74,2%
Massa stroop C = Massa masakan C + Massa Air – Massa Gula C

= 10,2112 ton/jam

Volume = 74,55HL

Massa brix = 7,5767 ton/jam

Massa air = 2,6344 ton/jam

3. Vacuum Pan A4

Masuk

a. Bibitan C

%Brix = 89,45%

Massa bibitan C = 6,8102 ton/jam

Volume = 46 HL

Massa brix = 6,0917 ton/jam

Massa air = 0,7185 ton/jam

b. Nksulf

%Brix = 62,85%

Volume Nksulf dibutuhkan = 250HL-46HL

= 204 HL

Massa Nksulf dibutuhkan = 26,4676 ton/jam

Massa brix = 16,6349 ton/jam

Massa air = 9,8327 ton/jam

c. Bibitan D

%brix = 90,1%

Volume yang dibutuhkan = 50HL

Massa yang dibtuhkan = 7,3805 ton/jam

Massa brix = 6,6498 ton/jam

Massa air = 0,7307 ton/jam

Keluar

a. NK A4

Asumsi brix yang dihasilkan = 90%

Volume = 300 HL

Massa brix = 29,3764 ton/jam

Massa NK A4 = 32,6405 ton/jam

Massa air = 3,2640 ton/jam

b. Uap air

Massa uap air = 8,0178 ton/jam

4. Vacuum Pan A2-1

Masuk

a. NK A4

Asumsi brix yang dihasilkan = 90%

Volume = $\frac{300}{2}$HL

= 150 HL

Massa brix = 14,6882 ton/jam

Massa NK A4 = 16,3202 ton/jam

Massa air = 1,632 ton/jam

b. NK sulf

%brix = 62,85%

Volume Nksulf dibutuhkan = 100 HL

Massa Nksulf dibutuhkan = 12,9928 ton/jam

Massa brix = 8,166 ton/jam

Massa air = 4,8268 ton/jam

Keluar

a. NK A2-1

Asumsi brix yang dihasilkan = 93,4%

Volume = 250 HL

Massa brix = 22,8542 ton/jam

Massa NK A2-1 = 24,4692 ton/jam

Massa air = 1,615 ton/jam

b. Uap air

Massa uap air = 4,8439 ton/jam

5. Vacuum Pan A2-2

Masuk

a. NK A4

Asumsi brix yang dihasilkan	= 90%
Volume	= $\frac{300}{2}$HL
	= 150 HL
Massa brix	= 14,6882 ton/jam
Massa NK A4	= 16,3202 ton/jam
Massa air	= 1,632 ton/jam

b. NK sulf

%brix	= 62,85%
Volume Nksulf dibutuhkan	= 100 HL
Massa Nksulf dibutuhkan	= 12,9928 ton/jam
Massa brix	= 8,166 ton/jam
Massa air	= 4,8268 ton/jam

Keluar

a. NK A2-2

Asumsi brix yang dihasilkan	= 93,4%
Volume	= 250 HL
Massa brix	= 22,8542 ton/jam
Massa NK A2-2	= 24,4692 ton/jam
Massa air	= 1,615 ton/jam

b. Uap air

Massa uap air	= 4,8439 ton/jam

6. Vacuum Pan A1-1

Masuk

a. NK A2-1

Asumsi brix yang dihasilkan	= 93,4%
Volume	= 250 HL
Massa brix	= 22,8542 ton/jam
Massa NK A2-1	= 24,4692 ton/jam
Massa air	= 1,615 ton/jam

b. NK sulf

%brix	= 62,85%
Volume Nksulf dibutuhkan	= 50 HL
Massa Nksulf dibutuhkan	= 6,4962 ton/jam
Massa brix	= 4,083 ton/jam
Massa air	= 2,4134 ton/jam

Keluar

a. Masakan A

Brix	= 94,2%
Volume	= 300 HL
Massa brix	= 26,9372 ton/jam
Massa NK A2-1	= 28,5957 ton/jam
Massa air	= 1,6586 ton/jam

b. Uap air

Massa uap air	= 2,3698 ton/jam

7. Vacuum Pan A1-2

Masuk

a. NK A2-1

Asumsi brix yang dihasilkan	= 93,4%
Volume	= 250 HL
Massa brix	= 22,8542 ton/jam
Massa NK A2-1	= 24,4692 ton/jam
Massa air	= 1,615 ton/jam

b. NK sulf

%brix	= 62,85%
Volume Nksulf dibutuhkan	= 50 HL
Massa Nksulf dibutuhkan	= 6,4962 ton/jam
Massa brix	= 4,083 ton/jam
Massa air	= 2,4134 ton/jam

Keluar

a. Masakan A

Brix	= 94,2%
Volume	= 300 HL
Massa brix	= 26,9372 ton/jam
Massa NK A2-1	= 28,5957 ton/jam
Massa air	= 1,6586 ton/jam

b. Uap air

Massa uap air	= 2,3698 ton/jam

TOTAL MASAKAN A

Brix	= 94,2%
Massa masakan A	= 57,1915 ton/jam
Massa brix`	= 53,8744 ton/jam
Massa air	= 3,3171 ton/jam

8. HGF A

Masuk

a. Masakan A

Brix	= 94,2%
Massa masakan A	= 57,1915 ton/jam
Massa brix	= 54,8744 ton/jam
Massa air	= 3,3171 ton/jam

b. Air

Air yang dibutuhkan	= 0,5% masakan A
	= 0,286 ton/jam

Keluar

a. Gula A

Brix	= 99,4%
Massa gula A(Qs)	= 26,0476 ton/jam
Massa brix	= 25,8913 ton/jam
Massa air	= 0,1563 ton/jam

b. Stroop A

Brix	= 85,4%
Massa stroop A	= 31,4298 ton/jam
Massa brix	= 26,841 ton/jam
Massa air	= 4,5888 ton/jam

9. HGF SHS

Masuk

a. Gula A

Brix	= 99,4%
Massa masakan A	= 26,0476 ton/jam
Massa brix	= 25,8913 ton/jam
Massa air	= 0,1563 ton/jam

b. Air

Air yang dibutuhkan	= 0,5% Gula A
	= 0,1302 ton/jam

Keluar

a. Gula SHS

Brix	= 99,97%
Massa gula SHS(Qs)	= 23,7029 ton/jam
Massa brix	= 23,6958 ton/jam
Massa air	= 0,0071 ton/jam

b. Klare SHS

Brix	= 75,4%
Massa klare SHS	= 2,4749 ton/jam
Massa brix	= 1,8661 ton/jam
Massa air	= 0,6088 ton/jam

10. Vacuum Pan D2

Masuk

a. Nksulf

Brix	= 62,85%
Volume yang dibutuhkan	= 30 HL
Massa yang dibutuhkan	= 3,8978 ton/jam

Massa brix = 2,4498 ton/jam

Massa air = 1,448 ton/jam

b. Foundant

Volume yang dibutuhkan = 200 ml

Massa foundant = 260 gram

= 0,00026 ton/jam

c. Stroop A

Brix = 85,4%

Volume yang dibutuhkan = 170 HL

Massa yang dibutuhkan = 24,5429 ton/jam

Massa brix = 20,9596 ton/jam

Massa air = 3,5833 ton/jam

Keluar

a. Masakan D2

Asumsi brix masakan D2 = 93,8%

Volume = 200 HL

Massa Masakan D2 = 24,9567 ton/jam

Massa brix = 23,4094 ton/jam

Massa air = 1,5473 ton/jam

b. Uap air

Massa uap air = 3,4843 ton/jam

11. Vacuum Pan D1-1

Masuk

a. Masakan D2

Asumsi brix masakan D2 = 93,8%

Volume = $\frac{200}{2} HL$

= 100 HL

Massa masakan D2 = 12,4784 ton/jam

Massa brix = 11,7047 ton/jam

Massa air = 0,7737 ton/jam

b. Klare D

Brix	= 74,9%
Volume	= 40 HL
Massa yang dibutuhkan	= 5,4968 ton/jam
Massa brix	= 4,1171 ton/jam
Massa air	= 1,3797 ton/jam

c. Stroop C

Brix	= 74,2%
Volume yang dibutuhkan	= 40 HL
Massa yang dibutuhkan	= 5,4788 ton/jam
Massa brix	= 4,0623 ton/jam
Massa air	= 1,4135 ton/jam

Keluar

a. Masakan D

Brix	= 97,61%
Volume masakan D	= 180 HL
Massa brix	= 19,8871 ton/jam
Massa masakan D	= 20,3740 ton/jam
Massa air	= 0,4869 ton/jam

b. Uap air

Massa uap air	= 3,0799 ton/jam

12. Vacuum Pan D1-2

Masuk

a. Masakan D2

Asumsi brix masakan D2	= 93,8%
Volume	$= \frac{200}{2} HL$
	= 100 HL
Massa masakan D2	= 12,4784 ton/jam
Massa brix	= 11,7047 ton/jam
Massa air	= 0,7737 ton/jam

b. Klare D

Brix	= 74,9%
Volume	= 40 HL
Massa yang dibutuhkan	= 5,4968 ton/jam
Massa brix	= 4,1171 ton/jam
Massa air	= 1,3797 ton/jam

c. Stroop C

Brix	= 74,2%
Volume yang dibutuhkan	= 40 HL
Massa yang dibutuhkan	= 5,4788 ton/jam
Massa brix	= 4,0623 ton/jam
Massa air	= 1,4135 ton/jam

Keluar

a. Masakan D

Brix	= 97,61%
Volume masakan D	= 180 HL
Massa brix	= 19,8871 ton/jam
Massa masakan D	= 20,3740 ton/jam
Massa air	= 0,4869 ton/jam

b. Uap air

Massa uap air	= 3,0799 ton/jam

13. LGF D1

Masuk

a. Masakan D

%Brix	= 97,61%
Volume masakan C	= 360 HL
Massa brix	= 39,7742 ton/jam
Massa masakan C	= 40,7481 ton/jam

b. Air

Air yang dibutuhkan	= 2% masakan D
	= 0,815 ton/jam

Keluar

a. Gula D1

Brix	= 93,23%
Massa gula D1(Qs)	= 23,5027 ton/jam
Massa brix	= 21,9116 ton/jam
Massa air	= 1,5911 ton/jam

b. Tetes

Brix	= 89,6%
Massa tetes	= 18,0603 ton/jam
Volume	= 122,6421 HL
Massa brix	= 16,1820 ton/jam
Massa air	= 1,8783 ton/jam

14. LGF D2

Masuk

a. Gula D1

%Brix	= 93,23%
Massa brix	= 21,9116 ton/jam
Massa Gula D1	= 23,5027 ton/jam
Massa air	= 1,5911 ton/jam

b. Air

Air yang dibutuhkan	= 2% Gula D1
	= 0,4701 ton/jam

Keluar

a. Gula D2

Brix	= 97,23%
Massa gula D2(Qs)	= 16,0263 ton/jam
Massa brix	= 15,5824 ton/jam
Massa air	= 0,4439 ton/jam

Bibitan D

Brix	= 90,1%

Massa bibitan D = 16,3468 ton/jam
Volume = 110,7432 HL
Massa brix = 14,7285 ton/jam
Massa air = 1,6183 ton/jam

b. Klare D

Brix = 74,9%
Massa tetes = 7,9465 ton/jam
Volume = 57,8265 HL
Massa brix = 5,9519 ton/jam
Massa air = 1,9946 ton/jam

IX.2 Perhitungan Neraca Panas

IX.2.1 Neraca Panas Stasiun Pemurnian

a. Neraca Panas TJH 1

1. Massa Masuk

a) NM 2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 80^{\circ}C = 353{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573 \frac{ton}{jam}$

Massa Brix = $\%Brix \times Massa\ NM$

Massa Brix $= 15{,}4223 \frac{ton}{jam}$

$Cp = (1 - 0.0056B)$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$

$= 0{,}9993224 \frac{kcal}{kg.K}$

HNM = $m \times Cp \times \Delta T$

HNM2-1 $= 15{,}4223 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9993224 \frac{ton}{jam}\ x$

$(303{,}15\ K - 298{,}15\ K)$

$$= 77059{,}44228 \frac{kcal}{jam}$$

b) H_2O NM 2

Massa Air $= 112{,}0305 \frac{ton}{jam}$

$C_{pair30} = \int_{298.15}^{303.15} Cp\, dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 376738{,}0481 \frac{J}{kmol}$

Hair $= n\ air\ x$ Cpair30

$= \frac{112{,}0305 \frac{ton}{jam}}{18 gr/mol} \times 376738{,}0481 \frac{J}{kmol} \times 0{,}00024 \frac{kkal}{J} \times \frac{1000 kg}{ton}$

$= 562771{,}3236 \frac{kcal}{jam}$

Total H masuk $= 77059{,}44228 \frac{kcal}{jam} + 562771{,}3236 \frac{kcal}{jam}$

$= 639830{,}7659 \frac{kcal}{jam}$

2. Massa Keluar

a) NM 2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 80^{\circ}C = 353{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573 \frac{ton}{jam}$

Massa Brix $= 15{,}4223 \frac{ton}{jam}$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$

$= 0{,}9993224 \frac{kcal}{kg.K}$

HNM2-2 $= 15{,}4223 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9993224 \frac{ton}{jam}\ x$

$$(353{,}15\ K - 298{,}15\ K)$$

$$= 847653{,}865 \frac{kcal}{jam}$$

b) H_2O NM 2

Massa Air $= 112{,}0305 \frac{ton}{jam}$

$C_{pair30} = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 4143297{,}551 \frac{J}{mol}$

Hair $= n\ air\ x$ Cpair30

$= \frac{112{,}0305 \frac{ton}{jam}}{18 kg/kmol} \times 4143297{,}551 \frac{J}{kmol} \times 0{,}00024 \times 1000 \frac{kg}{ton}$

$= 6189258{,}182 \frac{kcal}{jam}$

Total H masuk $= 847653{,}865 \frac{kcal}{jam} + 6189258{,}182 \frac{kcal}{jam}$

$= 7036912{,}047 \frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$639830{,}766 \frac{kcal}{jam} + Qsupply = 7036912{,}047 \frac{kcal}{jam} + 0{,}05\ Qsupply$

$0{,}95\ Qsupply = 6397081{,}281 \frac{kcal}{jam}$

$Qsupply = 6733769{,}77 \frac{kcal}{jam}$

$Qloss = 0{,}05\ Qsupply$

$= 0{,}05\ x\ 6733769{,}77 \frac{kcal}{jam}$

$= 336688{,}4885 \frac{kcal}{jam}$

Masuk		Keluar	
HNM2-1	77059,44	HNM2-2	847653,87
Hair30	562771,32	Hair80	6189258,18

Qsupply	6733769,77	Qloss	336688,49
Total	7373600,54	Total	7373600,54

b. Neraca Panas Juice Reaktor

a) NM 2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 80^{\circ}C = 353{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573\ \frac{ton}{jam}$

Massa Brix $= 15{,}4223\ \frac{ton}{jam}$

Massa Air $= 112{,}0305\ \frac{ton}{jam}$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$

$= 0{,}9993224\ \frac{kcal}{kg.K}$

HNM2-2 $= 15{,}4223\ \frac{ton}{jam}\ x\ 1000\ \frac{kg}{ton}\ x\ 0{,}9993224\ \frac{kcal}{kg.K}\ x$
$(353{,}15\ K - 298{,}15\ K)$

$= 847653{,}865\ \frac{kcal}{jam}$

$C_{pair80} = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 4143297{,}551\ \frac{J}{kmol}$

Hair $= n\ air\ x$ Cpair80

$= \frac{112{,}0305 \frac{ton}{jam}}{18 kg/mol}\ x\ 4143297{,}551\ \frac{J}{mol}\ x\ 0{,}00024\ \frac{kcal}{J} \times 1000\ \frac{kg}{ton}$

$= 6189258{,}182\ \frac{kcal}{jam}$

b) $Ca(OH)_2$

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 80^{\circ}C = 353{,}15\ K$

Massa $Ca(OH)_2 = 3{,}30\ \frac{ton}{jam}$

$Cp_{Ca(OH)2} = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (9.957 + 5.435 \times 10^{3}T)dT$

$= 97345473{,}89\ \frac{J}{\boldsymbol{mol}}$

H $Ca(OH)_2 = n\ Ca(0H)_2\ x\ Cp Ca(0H)_2$

$= \frac{3{,}30 \frac{ton}{jam}}{74 gr/mol} \times 97345473{,}89\ \frac{J}{mol} \times 0{,}00024\ \frac{kcal}{J} \times 1000000\ \frac{gr}{ton}$

$= 1203551426\ \frac{kcal}{jam}$

c) SO_2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 80^{\circ}C = 353{,}15\ K$

Massa $SO_2 = 0{,}083832\ \frac{ton}{jam}$

$CpSO_2 = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (5.699 + 0.801 \times 10^{3}T - 1.015 \times 10^{-5}T^{-2})dT$

$= 14346824{,}2\ \frac{J}{mol}$

$HSO_2 = n\ SO_2\ x\ Cp SO_2$

$= \frac{0{,}083832 \frac{ton}{jam}}{64 gr/mol}\ x\ 14346824{,}2\ \frac{J}{mol}\ x\ 0{,}00024\ \frac{kcal}{J} \times 1000000\ \frac{gr}{ton}$

$= 4510211{,}122\ \frac{kcal}{jam}$

Total H Masuk $= 847653{,}865\ \frac{kcal}{jam} + 6189258{,}182\ \frac{kcal}{jam} + 1203551426\ \frac{kcal}{jam} + 4510211{,}122\ \frac{kcal}{jam}$

$= 7398167473\ \frac{kcal}{jam}$

d) Mengitung Panas Reaksi pada Reaktor

Reaksi 1

	SO_2	+	H_2O	→	H_2SO_3
m	1,3099		6224,1670		-
r	0,9169		0,9169		0,9169
s	0,3930		6223,2501		0,9169

	SO_2	H_2O	H_2SO_3
ΔH_{f298}	-296830	-285830	-608100
n (kmol)	0,3930	6223,2501	0,9169
$n.\Delta H_{f298}$	-116643058,9	-1,77879E+12	-557574491,3
ΔH_{rx}	1,77835E+12 Joule		
ΔH_{rx}	426804151,7 kkal		

Reaksi 2

	H_2SO_3	+	$Ca(OH)_2$	→	$CaSO_3$	+	$2H_2O$
m	0,9169		44,5539		-		-
r	0,9169		0,9169		0,9169		1,8338
s	0		43,64		0,9169		1,8338

	H_2SO_3	$Ca(OH)_2$	$CaSO_3$	H_2O
ΔH_{f298}	-608100	-986000	-1434500	-285830
n (kmol)	0	43,6370	0,9169	1,8338
$n.\Delta H_{f298}$	0	-43026087370	-1315310981	-524162199,8
ΔH_{rx}	41186614189 Joule			
ΔH_{rx}	9884787,405 kkal			

$$\Delta H_{rx} = 426804151{,}7 \text{ kkal} + 9884787{,}405 \text{ kkal}$$
$$= 436688939{,}1 \text{ kkal}$$

e) Enthalpy Keluar Reaktor

b. NM 2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 80^{\circ}C = 353{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573\ \frac{ton}{jam}$

Massa Brix $= 15{,}4223\ \frac{ton}{jam}$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$

$= 0{,}9993224\ \frac{kcal}{kg.K}$

HNM2-2 $= 15{,}4223\ \frac{ton}{jam} \times 1000\ \frac{kg}{ton} \times 0{,}9993224\ \frac{kcal}{kg.K} \times (353{,}15\ K - 298{,}15\ K)$

$= 847653{,}865\ \frac{kcal}{jam}$

b. H2O NM2

Massa Air $= 112{,}0305\ \frac{ton}{jam}$

$C_{pair80} = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 4143297{,}551\ \frac{J}{kmol}$

Hair $= n\ air\ x$ Cpair80

$= \frac{112{,}0305 \frac{ton}{jam}}{18 kg/kmol}\ x\ 4143297{,}551\ \frac{J}{kmol}\ x\ 0{,}00024\ \frac{kcal}{J}$

$= 6190169{,}952\ \frac{kcal}{jam}$

c. SO_2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 80^{\circ}C = 353{,}15\ K$

Massa $SO_2 = 0{,}083832\ \frac{ton}{jam}$

$$\text{CpSO}_2 = \int_{298.15}^{353.15} \text{Cp dT} = \int_{298.15}^{353.15} (5.699 + 0.801 \times 10^3 \text{T} - 1.015 \times 10^{-5} \text{T}^{-2}) \text{dT}$$

$$= 14346824{,}2 \frac{J}{mol}$$

$$\text{HSO}_2 = n\,SO_2\ x\ \text{Cp}SO_2$$

$$= 0.3930 kmol \times 14346824{,}2 \frac{J}{mol} \times 0{,}00024 \frac{kcal}{J} \times 1000 \frac{mol}{kmol}$$

$$= 1353036{,}337 \frac{kcal}{jam}$$

d. $Ca(OH)_2$

Tref = $\mathbf{25^{\circ}C = 298{,}15\ K}$

$T_1 = \mathbf{80^{\circ}C = 353{,}15\ K}$

Massa $Ca(OH)_2 = \mathbf{3{,}30 \frac{ton}{jam}}$

$$\text{Cp}_{Ca(OH)2} = \int_{298.15}^{353.15} \boldsymbol{Cp\ dT} = \int_{298.15}^{353.15} (\mathbf{9.957 + 5.435 \times 10^3 T}) \boldsymbol{dT}$$

$$= \mathbf{97345473{,}89} \frac{J}{mol}$$

$$\text{H Ca(OH)}_2 = \boldsymbol{n\ Ca(0H)_2\ x\ \text{Cp}Ca(0H)_2}$$

$$= \mathbf{43{,}6370 kmol} \times \mathbf{97345473{,}89} \frac{J}{mol} \times \mathbf{0{,}00024} \frac{kcal}{J} \times \mathbf{1000} \frac{mol}{kmol}$$

$$= \mathbf{1019487594} \frac{kcal}{jam}$$

$CaSO_3$

Tref = $25^{\circ}C = 298{,}15\ K$

$T_1 = 80^{\circ}C = 353{,}15\ K$

Massa $CaSO_3 = 0{,}11 \frac{ton}{jam}$

Cp $CaSO_3 = 99{,}7 \frac{J}{mol.K}$

$$\text{H CaSO}_3 = n\ CaSO_3\ x\ \text{Cp}CaSO_3\ x\ \Delta T$$

$$= 0{,}9169 kmol \times 99{,}7 \frac{J}{mol.K} \times (353{,}15\ K -$$

$$298{,}15\ K) \times 0.00024 \frac{kcal}{J} \times 1000 \frac{mol}{kmol}$$

$$= 1206{,}693527 \frac{kkal}{jam}$$

$$\text{TotalHKeluar} = 847653{,}865 \frac{kcal}{jam} + 6190169{,}952 \frac{kcal}{jam} +$$

$$1353036{,}337 \frac{kcal}{jam} + 1019487594 \frac{kcal}{jam} +$$

$$1206{,}693527 \frac{kkal}{jam}$$

$$= 1027878481 \frac{kkal}{jam}$$

Neraca Panas Total

$$Total\ H\ masuk + Q\ serap = Total\ H\ keluar + H\ reaksi$$

$$1215098549 \frac{kcal}{jam} + Q\ serap = 1027878481 \frac{kkal}{jam} + 436688939{,}1 \text{ kkal}$$

$$Q\ serap = 249468870{,}9 kkal$$

$$\text{Tekanan} = 7{,}65 \frac{kg}{cm^2} = 750\ kPa$$

$$\text{Temperatur} = 175\ ^\circ C$$

Dari Tabel

$$\text{Hsteam} = 2782{,}5\ x\ 1000\ x\ 10$$

$$= 27825000 \frac{J}{kg}$$

$$\text{Maka Steam yang dibutuhkan} = \frac{Qserap}{Hsteam}$$

$$= \frac{249468870{,}9\ kkal}{27825000 \frac{J}{kg}}$$

$$= 37512{,}22841\ kg$$

$$= 37{,}5122\ ton$$

c. Neraca Panas TJH 2

a) Enthalpy Masuk

a. NM 2

$\text{Tref} = 25^\circ C = 298{,}15\ K$

$T_1 = 30^\circ C = 303{,}15\ K$

$T_2 = 80^{\circ}C = 353{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573\ \frac{ton}{jam}$

Massa Brix $= 15{,}4223\ \frac{ton}{jam}$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$

$= 0{,}9993224\ \frac{kcal}{kg.K}$

HNM2-2 $= 15{,}4223\ \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9993224\ \frac{ton}{jam}\ x$
$(353{,}15\ K - 298{,}15\ K)$

$= 847653{,}865\ \frac{kcal}{jam}$

b. H2O NM2

Massa Air $= 112{,}0515099\ \frac{ton}{jam}$

$C_{pair80} = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 4143297{,}551\ \frac{J}{mol}$

Hair $= n\ air\ x$ Cpair80

$= \frac{112{,}0305 \frac{ton}{jam}}{18 kg/kmol}\ x\ 4143297{,}551\ \frac{J}{kmol}\ x\ 0{,}00024\ \frac{kcal}{J} \times 1000\ \frac{kg}{ton}$

$= 6190169{,}952\ \frac{kcal}{jam}$

c. SO_2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 80^{\circ}C = 353{,}15\ K$

Massa $SO_2 = 0{,}083832\ \frac{ton}{jam}$

$CpSO_2 = \int_{298.15}^{353.15} Cp\ dT = \int_{298.15}^{353.15} (5.699 + 0.801 \times 10^3 T - 1.015 \times 10^{-5} T^{-2}) dT$

$$= 14346824{,}2\,\frac{J}{mol}$$

$HSO_2 = n\,SO_2\;x\;\mathrm{Cp}SO_2$

$$= 0.3930kmol\;\times 14346824{,}2\,\frac{J}{mol}\;\times$$

$$0{,}00024\,\frac{kcal}{J}\times 1000\,\frac{mol}{kmol}$$

$$= 1353036{,}337\,\frac{kcal}{jam}$$

d. $Ca(OH)_2$

Tref $= \mathbf{25^{\circ}C = 298{,}15\;K}$

$T_1 = \mathbf{80^{\circ}C = 353{,}15\;K}$

Massa $Ca(OH)_2 = \mathbf{3{,}30\,\frac{ton}{jam}}$

$Cp_{Ca(OH)2} = \int_{298.15}^{353.15} \boldsymbol{Cp\;dT} = \int_{298.15}^{353.15} (\mathbf{9.957 + 5.435 \times 10^3 T})\boldsymbol{dT}$

$$= \mathbf{97345473{,}89\,\frac{J}{mol}}$$

H $Ca(OH)_2 = \boldsymbol{n\;Ca(0H)_2\;x\;\mathrm{Cp}Ca(0H)_2}$

$$= \mathbf{43{,}6370kmol}\;\times\;\mathbf{97345473{,}89}\,\frac{J}{mol}\;\times$$

$$\mathbf{0{,}00024}\,\frac{kcal}{J}\times\mathbf{1000}\,\frac{mol}{kmol}$$

$$= \mathbf{1019487594}\,\frac{kcal}{jam}$$

e. $CaSO_3$

Tref $= 25^{\circ}C = 298{,}15\;K$

$T_1 = 80^{\circ}C = 353{,}15\;K$

Massa $CaSO_3 = 0{,}11\,\frac{ton}{jam}$

Cp $CaSO_3 = 99{,}7\,\frac{J}{mol.K}$

H $CaSO_3 = n\;CaSO_3\;x\;\mathrm{Cp}CaSO_3\;x\;\Delta T$

$$= 0{,}9169kmol \times 99{,}7\,\frac{J}{mol.K}\times(353{,}15\;K -$$

$$298{,}15\;K)\times 0.00024\,\frac{kcal}{J}\times 1000\,\frac{mol}{kmol}$$

$$= 1206{,}693527\,\frac{kkal}{jam}$$

Total Enthalpy masuk = $847653{,}865\frac{kcal}{jam} + 6190169{,}95\frac{kcal}{jam} +$
$1353036{,}337\frac{kcal}{jam} + 1019487594\frac{kcal}{jam} +$
$1206{,}693527\frac{kkal}{jam}$
$= 1027879688\frac{kkal}{jam}$

b) Enthalpy Keluar

1. NM 2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 100^{\circ}C = 373{,}15\ K$

Brix $= 12{,}1\ \%$

Massa NM 2 $= 127{,}4573\frac{ton}{jam}$

Massa Brix $= 15{,}4223\frac{ton}{jam}$

Cp NM 2 $= 1 - 0{,}0056\ x\ 12{,}1\ \%$
$= 0{,}9993224\frac{kcal}{kg.K}$

HNM2-2 $= 15{,}4223\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9993224\frac{kcal}{kg.K}\ x$
$(373{,}15\ K - 298{,}15\ K)$
$= 1155891{,}63\frac{kcal}{jam}$

2. H2O NM2

Massa Air $= 112{,}0515099\frac{ton}{jam}$

$C_{pair80} = \int_{298.15}^{373.15} Cp\ dT = \int_{298.15}^{373.15} (2.7637 \times 10^5 -$
$2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 +$
$9.3701 \times 10^{-6}T^4)dT$
$= 5659107{,}53\frac{J}{mol}$

Hair $= n\ air\ x$ Cpair80
$= 6225{,}0839\ kmol \times 5659107{,}53\frac{J}{mol} \times$
$0{,}00024\frac{kcal}{J} \times 1000\frac{mol}{kmol}$

$$= 8454820573 \frac{kcal}{jam}$$

3. SO_2

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 100^{\circ}C = 373{,}15\ K$

Massa $SO_2 = 0{,}0251496 \frac{ton}{jam}$

$CpSO_2 = \int_{298.15}^{373.15} Cp\ dT = \int_{298.15}^{373.15} (5.699 + 0.801 \times 10^3 T - 1.015 \times 10^{-5} T^{-2}) dT$

$= 20164601{,}2 \frac{J}{mol}$

$HSO_2 = n\ SO_2\ x\ CpSO_2$

$= 0.393 kmol \times 20164601{,}2 \frac{J}{mol} \times 0{,}00024 \frac{kcal}{J} \times 1000 \frac{mol}{kmol}$

$= 1901743{,}7 \frac{kcal}{jam}$

4. $Ca(OH)_2$

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 100^{\circ}C = 373{,}15\ K$

Massa $Ca(OH)_2 = 3{,}23 \frac{ton}{jam}$

$Cp_{Ca(OH)2} = \int_{298.15}^{373.15} Cp\ dT = \int_{298.15}^{373.15} (9.957 + 5.435x10^3 T) dT$

$= 136820078 \frac{J}{mol}$

$H\ Ca(OH)_2 = n\ Ca(0H)_2\ x\ CpCa(0H)_2$

$= 43{,}637 kmol \times 136820078 \frac{J}{mol} \times 0{,}00024 \frac{kcal}{J} \times 1000 \frac{mol}{kmol}$

$= 1432900438 \frac{kcal}{jam}$

5. $CaSO_3$

Tref $= 25^{\circ}C = 298{,}15\ K$

$T_1 = 100^{\circ}C = 373{,}15\ K$

Massa $CaSO_3 = 0{,}11 \frac{ton}{jam}$

Cp $CaSO_3 = 99{,}7 \frac{J}{mol.K}$

H $CaSO_3 = n\ CaSO_3\ x\ \text{Cp}CaSO_3\ x\ \Delta T$

$= 0{,}9169 kmol\ x\ 99{,}7 \frac{J}{mol.K}\ x\ (373{,}15\ K - 298{,}15\ K)$

$= 6856213{,}2188 \frac{J}{jam}$

$= 1645{,}491173 \frac{kkal}{jam}$

Total Enthalpy masuk $= 1155891{,}63 \frac{kcal}{jam} + 8454820573 \frac{kcal}{jam} +$
$1901743{,}7 \frac{kcal}{jam} + 1432900438 \frac{kcal}{jam} +$
$1645{,}491173 \frac{kkal}{jam}$
$= 9890780291{,}40 \frac{kkal}{jam}$

Neraca Panas Total

H masuk = H keluar

$1027879688 \frac{kkal}{jam} + Qsupply = 9890780291{,}40 \frac{kkal}{jam} + 0{,}05\ Qsupply$

$0{,}95\ Qsupply = 8862900604 \frac{kkal}{jam}$

$Qsupply = 9329369057 \frac{kkal}{jam}$

$Qloss = 0{,}05\ Qsupply$
$= 0{,}05\ x\ 9329369057 \frac{kkal}{jam}$
$= 466468452{,}8 \frac{kkal}{jam}$

Masuk		Keluar	
HNM2-1	847653,87	HNM2-2	1155891,63
Hair80	6190169,95	Hair100	8454820572,97
SO_2	1353063,34	SO_2	1901743,70
$Ca(OH)_2$	1019487593,79	$Ca(OH)_2$	1432900437,60
$CaSO_3$	1206,69	$CaSO_3$	1645,49
Qsupply	9329369056,59	Qloss	466468452,83
Total	**10357248744,23**	**Total**	**10357248744,23**

d. Neraca Panas TJH 3

a) Enthalpy Masuk

1. Nira Encer = 108,7 %

Tref = $25^{\circ}C = 298{,}15\ K$

$T_1 = 30^{\circ}C = 303{,}15\ K$

$T_2 = 100^{\circ}C = 373{,}15\ K$

Brix = 12,70 %

Massa NE = $108{,}4826\ \frac{ton}{jam}$

Massa Brix = $12{,}70\ \%\ x\ 108{,}4826\ \frac{ton}{jam}$

$= 13{,}7772902\ \frac{ton}{jam}$

Cp NE = $1 - 0{,}0056\ x\ 12{,}70\ \%$

$= 0{,}9992888\ \frac{kcal}{kg.K}$

HNE = $13{,}7772902\ \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9992888\ \frac{kcal}{kg.K}\ x$

$(303{,}15\ K - 298{,}15\ K)$

$= 68837{,}45896\ \frac{kcal}{jam}$

2. H2O NE

Massa Air = $94{,}7053098\ \frac{ton}{jam}$

$C_{pair30} = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{353.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 376738{,}0481\ \frac{J}{mol}$

Hair = $n\ air\ x$ Cpair30

$= \frac{94{,}7053098 \frac{ton}{jam}}{18 gr/mol}\ x\ 376738{,}0481\ \frac{J}{mol}\ x\ 0{,}00024\ \frac{kcal}{J} \times 1000000\ \frac{gr}{ton}$

$= 475721247{,}5\ \frac{kcal}{jam}$

Total Enthalpy masuk = $68837{,}45896\ \frac{kcal}{jam} + 475721247{,}5\ \frac{kcal}{jam}$

$$= 475790085 \frac{kkal}{jam}$$

c) Enthalpy Keluar

1. Nira Encer = 108,7 %

   Tref = $25^{\circ}C = 298{,}15\ K$

   $T_1 = 30^{\circ}C = 303{,}15\ K$

   $T_2 = 100^{\circ}C = 373{,}15\ K$

   Brix = 12,70 %

   Massa NE = $108{,}4826 \frac{ton}{jam}$

   Massa Brix = $12{,}70\ \%\ x\ 108{,}4826 \frac{ton}{jam}$

   $= 13{,}7772902 \frac{ton}{jam}$

   Cp NE = $1 - 0{,}0056\ x\ 12{,}70\ \%$

   $= 0{,}9992888 \frac{kcal}{kg.K}$

   HNE = $13{,}7772902 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9992888 \frac{kcal}{kg.K}\ x$ $(373{,}15\ K - 298{,}15\ K)$

   $= 1032561{,}884 \frac{kcal}{jam}$

2. H2O NE

   Massa Air = $94{,}7053098 \frac{ton}{jam}$

   $C_{pair30} = \int_{298.15}^{373.15} Cp\ dT = \int_{298.15}^{373.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

   $= 5659107{,}528 \frac{J}{mol}$

   Hair $= n\ air\ x$ Cpair30

   $= \frac{94{,}7053098 \frac{ton}{jam}}{18 gr/mol} x\ 35659107{,}528 \frac{J}{mol}\ x\ 0{,}00024 \frac{kcal}{J} \times 1000000 \frac{kg}{ton}$

   $= 7145967089 \frac{kcal}{jam}$

$$\text{Total Enthalpy Keluar} = 1032561{,}884\,\frac{kcal}{jam} + 7145967089\,\frac{kcal}{jam}$$

$$= 7146999650\,\frac{kkal}{jam}$$

Neraca Panas Total

H masuk = H keluar

$$475790085\,\frac{kkal}{jam} + Qsupply = 7146999650\,\frac{kkal}{jam} + 0{,}05\;Qsupply$$

$$0{,}95\;Qsupply = 6671209565\,\frac{kkal}{jam}$$

$$Qsupply = 7022325858\,\frac{kkal}{jam}$$

$$Qloss = 0{,}05\;Qsupply$$

$$= 0{,}05\;x\;7022325858\,\frac{kkal}{jam}$$

$$= 351116292{,}9\,\frac{kkal}{jam}$$

Masuk		Keluar	
HNM2-1	68837,46	HNM2-2	1032561,88
Hair30	475721247,49	Hair80	7145967088,55
Qsupply	7022325858,40	Qloss	351116292,92
Total	**7498115943,35**	**Total**	**7498115943,35**

IX.2.2 Neraca Panas Stasiun Penguapan

Komponen Nira yang Masuk

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	12,70%
H2O	94,7053	87,300%

Effect 1

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	19,19%
H2O	58,0217	80,811%

Effect 2

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	26,44%
H2O	38,3368	73,563%

Effect 3

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	32,76%
H2O	28,2724	67,236%

Effect 4

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	43,07%
H2O	18,2080	56,926%

Effect 5

Komponen	Massa(Ton/jam)	%
Brix nira	13,7773	62,85%
H2O	8,1436	37,150%

Diketahui :

T_{s1} = 125˚C

T_1 = 111˚C

T_2 = 107˚C

T_3 = 90˚C

T_4 = 80˚C

T_5 = 54˚C

a. Perhitungan BPR (*Boiling Point Rise*)

$$BPR = 1{,}73X + 6{,}22X^2$$

$$BPR\ 1 = 1{,}73(19{,}19) + 6{,}22(19{,}19)^2$$
$$= 0{,}570583^{\circ}C$$
$$= 273{,}720K$$

$$BPR\ 2 = 1{,}73(26{,}44) + 6{,}22(26{,}44)^2$$
$$= 0{,}905293^{\circ}C$$
$$= 274{,}055K$$

$$BPR\ 3 = 1{,}73(32{,}76) + 6{,}22(32{,}76)^2$$
$$= 1{,}250922^{\circ}C$$
$$= 274{,}400K$$

$$BPR\ 4 = 1{,}73(43{,}07) + 6{,}22(43{,}07)^2$$
$$= 1{,}920745^{\circ}C$$
$$= 275{,}070K$$

$$BPR\ 5 = 1{,}73(62{,}85) + 6{,}22(62{,}85)^2$$
$$= 3{,}575706^{\circ}C$$
$$= 276{,}725K$$

$T_{s1} = 125^{\circ}C$

$T_{s2} = 111^{\circ}C - 0{,}570583^{\circ}C$

$= 110{,}43^{\circ}C$

$T_{s3} = 107^{\circ}C - 0{,}905293^{\circ}C$

$= 106{,}09^{\circ}C$

$T_{s4} = 90^{\circ}C - 1{,}250922^{\circ}C$

$= 88{,}749^{\circ}C$

$T_{s5} = 80^{\circ}C - 1{,}920745^{\circ}C$

$= 78{,}079^{\circ}C$

$T_{s6} = 51^{\circ}C$

Kapasitas Panas $Cp = (1 - 0.0056B)$

$F = 1 - 0{,}0056(12{,}70)$

$= 0{,}9993 \frac{kcal}{kg.K}$

$L_1 = 1 - 0{,}0056(19{,}19)$

$= 0{,}9989 \frac{kcal}{kg.K}$

$L_2 = 1 - 0{,}0056(26{,}44)$

$= 0{,}9985 \frac{kcal}{kg.K}$

$L_3 = 1 - 0{,}0056(32{,}76)$

$= 0{,}9982 \frac{kcal}{kg.K}$

$L_4 = 1 - 0{,}0056(43{,}07)$

$= 0{,}9976 \frac{kcal}{kg.K}$

$L_5 = 1 - 0{,}0056(62{,}85)$

$= 0{,}9965 \frac{kcal}{kg.K}$

b. Nilai Enthalphy (H)

1. Effect 1

$HS2 = 2691{,}3 \frac{kJ}{kg}$

$= 645{,}912 \frac{kcal}{kg}$

$HS1 = 2714{,}4 \frac{kJ}{kg}$

$= 651{,}456 \frac{kcal}{kg}$

$$\text{hs1} = 529{,}2\,\frac{kJ}{kg}$$
$$= 127{,}008\,\frac{kcal}{kg}$$
$$\text{H1} = Hs_2 + 1{,}884(BPR\ 1)$$
$$= 2691{,}3\,\frac{kJ}{kg} + 1{,}884(0{,}570583^{\circ}C)$$
$$= 2692{,}4\,\frac{kJ}{kg}$$
$$= 646{,}17\,\frac{kcal}{kg}$$
$$\lambda s_1 = Hs_1 - hs_1$$
$$= 529{,}2\,\frac{kJ}{kg} - 529{,}2\,\frac{kJ}{kg}$$
$$= 2185{,}2\,\frac{kJ}{kg}$$
$$= 524{,}448\,\frac{kcal}{kg}$$

2. Effect 2

$$\text{HS3} = 2685{,}3\,\frac{kJ}{kg}$$
$$= 644{,}472\,\frac{kcal}{kg}$$
$$\text{HS2} = 451{,}3\,\frac{kJ}{kg}$$
$$= 110{,}712\,\frac{kcal}{kg}$$
$$\text{H2} = Hs_3 + 1{,}884(BPR\ 2)$$
$$= 2685{,}3\,\frac{kJ}{kg} + 1{,}884(0{,}905293^{\circ}C)$$
$$= 2687{,}01\,\frac{kJ}{kg}$$
$$= 644{,}881\,\frac{kcal}{kg}$$
$$\lambda s_2 = Hs_1 - hs_2$$
$$= 529{,}2\,\frac{kJ}{kg} - 451{,}3\,\frac{kJ}{kg}$$
$$= 2231{,}07\,\frac{kJ}{kg}$$
$$= 535{,}458\,\frac{kcal}{kg}$$

3. Effect 3

$$\text{HS4} = 2658{,}5\,\frac{kJ}{kg}$$
$$= 638{,}04\,\frac{kcal}{kg}$$
$$\text{HS3} = 444{,}4\,\frac{kJ}{kg}$$
$$= 106{,}656\,\frac{kcal}{kg}$$
$$\text{H3} = Hs_4 + 1{,}884(BPR\ 3)$$
$$= 2658{,}5\,\frac{kJ}{kg} + 1{,}884(1{,}250922^{\circ}C)$$

$= 2660{,}86 \frac{kJ}{kg}$

$= 638{,}606 \frac{kcal}{kg}$

$\lambda s_3 = Hs_1 - hs_3$

$= 529{,}2 \frac{kJ}{kg} - 444{,}4 \frac{kJ}{kg}$

$= 2247{,}97 \frac{kJ}{kg}$

$= 539{,}514 \frac{kcal}{kg}$

4. Effect 4

HS5 $= 2640{,}4 \frac{kJ}{kg}$

$= 633{,}696 \frac{kcal}{kg}$

HS4 $= 372{,}7 \frac{kJ}{kg}$

$= 89{,}448 \frac{kcal}{kg}$

H4 $= Hs_5 + 1{,}884(BPR\ 4)$

$= 2640{,}4 \frac{kJ}{kg} + 1{,}884(1{,}920745^{\circ}C)$

$= 2644{,}02 \frac{kJ}{kg}$

$= 634{,}564 \frac{kcal}{kg}$

$\lambda s_4 = Hs_1 - hs_4$

$= 529{,}2 \frac{kJ}{kg} - 372{,}7 \frac{kJ}{kg}$

$= 2319{,}67 \frac{kJ}{kg}$

$= 556{,}722 \frac{kcal}{kg}$

5. Effect 5

HS6 $= 2593{,}9 \frac{kJ}{kg}$

$= 622{,}536 \frac{kcal}{kg}$

HS5 $= 326{,}5 \frac{kJ}{kg}$

$= 78{,}36 \frac{kcal}{kg}$

H5 $= Hs_6 + 1{,}884(BPR\ 5)$

$= 2593{,}9 \frac{kJ}{kg} + 1{,}884(3{,}575706^{\circ}C)$

$= 2600{,}64 \frac{kJ}{kg}$

$= 624{,}153 \frac{kcal}{kg}$

$\lambda s_5 = Hs_1 - hs_5$

$= 529{,}2 \frac{kJ}{kg} - 326{,}5 \frac{kJ}{kg}$

$$= 2365{,}64\,\frac{kJ}{kg}$$
$$= 567{,}810\,\frac{kcal}{kg}$$

c. Neraca Energi

Mencari laju steam

$$F\ x\ Cp\ x\ dT + S\ x\ \lambda 1 = L1\ x\ Cp\ x\ dT + V1\ X\ H1$$

$$108482{,}6\ x\ 0{,}9993\,\frac{kcal}{kg.K}\ x\ 383 + S\ x\ 524{,}448\,\frac{kcal}{kg} =$$
$$71798{,}9860\ x\ 0{,}9989\,\frac{kcal}{kg.K}\ x\ 383 + 36683{,}6\ x\ 646{,}17\,\frac{kcal}{kg}$$

$$S = 18407{,}977\,\frac{kg}{jam}$$
$$= 18{,}408\,\frac{ton}{jam}$$

IX.2.3 Neraca Panas Stasiun Pemasakan

1. Vacuum Pan C

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$
Pvacuum $= 63\ cmHg$
Patmosfer $= 76\ cmHg$
Pabs $= 13\ cmHg$
$= 17{,}29\ kPa$

Tuap air dari tabel yang didapatkan
T uap air $= 57^{\circ}C = 330{,}15\ K$

a. Masuk
   a) Nk sulf

% Brix $= 62{,}85$
Volume NK Sulf dibutuhkan $= 195{,}5108\ HL$
Massa NK sulf dibutuhkan $= 25{,}4023\,\frac{ton}{jam}$
Massa Brix $= 15{,}9654\,\frac{ton}{jam}$
Cp brix NKsulf $= 0{,}9965\,\frac{kcal}{kg.K}$
HNKsulf $= m\ x\ Cp\ x\ dT$
$= 15{,}9654\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9965\,\frac{kcal}{kg.K}\ x\ 5$
$= 79545{,}8599\,\frac{kcal}{jam}$
Massa air $= 9{,}4370\,\frac{ton}{jam}$

$$\text{Cpair 30} = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 376738{,}0481 \frac{J}{mol}$$

$$\text{Hair} = n\ air\ x\ Cp\ air$$

$$= \left(\frac{9{,}4370 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol} x\ 0{,}00024$$

$$= 47403517{,}81 \frac{kcal}{jam}$$

b) Fondant

Volume yang dibutuhkan $= 200\ ml$

Massa fondant $= 260\ gram = 0{,}0003 \frac{ton}{jam}$

c) Air

Volume yang dibutuhkan $= 54{,}4892\ HL$

Massa air $= 5{,}4489 \frac{ton}{jam}$

$$\text{Cpair 30} = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 376738{,}0481 \frac{J}{mol}$$

$$\text{Hair} = n\ air\ x\ Cp\ air$$

$$= \left(\frac{5{,}4489 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol} x\ 0{,}00024$$

$$= 27370866{,}88 \frac{kcal}{jam}$$

$$\text{Total H masuk} = 79545{,}8599 \frac{kcal}{jam} + 47403517{,}81 \frac{kcal}{jam} + 27370866{,}88 \frac{kcal}{jam}$$

$$= 74853930{,}5594 \frac{kcal}{jam}$$

b. Keluar

a) Masakan C

% Brix $= 96{,}61\%$

Volume masakan C $= 250 HL$

Massa masakan C $= 16{,}5256 \frac{ton}{jam}$

Massa Brix $= 15{,}9654 \frac{ton}{jam}$

Cp brix masC $= 0{,}9946 \frac{kcal}{kg.K}$

HmasC $= m\ x\ Cp\ x\ dT$

$= 16{,}5256 \frac{ton}{jam} x\ 1000\ x 0{,}9946 \frac{kcal}{kg.K}\ x\ 25$

$= 396974{,}7126 \frac{kcal}{jam}$

Massa air $= 0{,}5602 \frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 1881842{,}357 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{0{,}5602 \frac{ton}{jam} * 1000000}{18} \right) x\ 1881842{,}357 \frac{J}{mol}\ x\ 0{,}00024$

$= 14056539{,}2 \frac{kcal}{jam}$

b) Uap Air

Massa uap air $= 14{,}3259 \frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{330.15} Cp\ dT = \int_{298.15}^{330.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 2408687{,}031 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{14{,}3259 \frac{ton}{jam} * 1000000}{18} \right) x 2408687{,}031 \frac{J}{mol} x\ 0{,}00024$

$= 460088985{,}6 \frac{kcal}{jam}$

Total H keluar $= 396974{,}7126 \frac{kcal}{jam} + 14056539{,}2 \frac{kcal}{jam} + 460088985{,}6 \frac{kcal}{jam}$

$= 474542499{,}4878 \frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$$74853930{,}5594\,\frac{kcal}{jam} + Qsupply = 474542499{,}4878\,\frac{kcal}{jam} + 0{,}05\ Qsupply$$

$$0{,}95\ Qsupply = 399688568{,}9\,\frac{kcal}{jam}$$

$$Qsupply = 420724809{,}4\,\frac{kcal}{jam}$$

$$Qloss = 0{,}05\ Qsupply$$

$$= 0{,}05\ x\ 420724809{,}4\,\frac{kcal}{jam}$$

$$= 21036240{,}47\,\frac{kcal}{jam}$$

Masuk		Keluar	
HNKsulf	79545,86	HmasC	396974,71
HairNk	47403517,81	Hair50	14056539,20
H air	27370866,88	Huapair	460088985,57
Qsupply	420724809,40	Qloss	21036240,47
Total	**495578739,96**	**Total**	**495578739,96**

2. Vacuum Pan A4

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$

a. Masuk

a) Bibitan C

% Brix $= 89{,}45\%$

Volume bibitan C $= 46{,}28995351\ HL$

Massa bibitan C $= 6{,}810177975\,\frac{ton}{jam}$

Massa Brix $= 6{,}091704199\,\frac{ton}{jam}$

Cp brix bitC $= 0{,}9950\,\frac{kcal}{kg.K}$

HbitC $= m\ x\ Cp\ x\ dT$

$= 6{,}091704199\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9950\,\frac{kcal}{kg.K}\ x\ 5$

$= 30305{,}9482\,\frac{kcal}{jam}$

Massa air $= 0{,}718473776\,\frac{ton}{jam}$

$$\text{Cpair 30} = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 376738{,}0481 \frac{J}{mol}$$

$$\text{Hair} = n\ air\ x\ Cp\ air$$

$$= \left(\frac{0{,}718473776 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol}\ x\ 0{,}00024$$

$$= 3609018{,}775 \frac{kcal}{jam}$$

b) Nk sulf

% Brix = 62,85%

Volume NK Sulf dibutuhkan = 203,7100464 HL

Massa NK sulf dibutuhkan = $26{,}4676 \frac{ton}{jam}$

Massa Brix = $16{,}6349 \frac{ton}{jam}$

Cp brix NKsulf = $0{,}9965 \frac{kcal}{kg.K}$

$$\text{HNKsulf} = m\ x\ Cp\ x\ dT$$

$$= 16{,}6349 \frac{ton}{jam} x\ 1000\ x\ 0{,}9965 \frac{kcal}{kg.K}\ x\ 5$$

$$= 82881{,}8141 \frac{kcal}{jam}$$

Massa air = $9{,}8327 \frac{ton}{jam}$

$$\text{Cpair 30} = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 376738{,}0481 \frac{J}{mol}$$

$$\text{Hair} = n\ air\ x\ Cp\ air$$

$$= \left(\frac{9{,}8327 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol} x\ 0{,}00024$$

$$= 49391502{,}66 \frac{kcal}{jam}$$

c) Bibitan D

% Brix = 90,1%

Volume bibitan D= 50 HL

Massa bibitan D = $7{,}3805 \frac{ton}{jam}$

Massa Brix $= 6{,}6498\,\frac{ton}{jam}$

Cp brix bitD$= 0{,}9950\,\frac{kcal}{kg.K}$

HbitD $= m\ x\ Cp\ x\ dT$

$= 6{,}6498\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9950\,\frac{kcal}{kg.K}\ x\ 5$

$= 33081{,}3906\,\frac{kcal}{jam}$

Massa air $= 0{,}7303\,\frac{ton}{jam}$

Cpair 30 $= \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 376738{,}0481\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{0{,}7307\frac{ton}{jam} * 1000000}{18}\right) x\ 376738{,}0481\,\frac{J}{mol}\ x\ 0{,}00024$

$= 3670280{,}017\,\frac{kcal}{jam}$

Total H masuk $= 30305{,}9482\,\frac{kcal}{jam} + 3609018{,}775\,\frac{kcal}{jam} + 82881{,}8141\,\frac{kcal}{jam} + 49391502{,}66\,\frac{kcal}{jam} + 33081{,}3906\,\frac{kcal}{jam} + 3670280{,}017\,\frac{kcal}{jam}$

$= 202939{,}9543\,\frac{kcal}{jam}$

b. Keluar
   a) NK A4
      % Brix $= 92{,}5\%$
      Volume $= 300\ HL$
      Massa $= 32{,}6405\,\frac{ton}{jam}$
      Massa Brix $= 29{,}3764\,\frac{ton}{jam}$
      Cp brix NK A4 $= 0{,}9948\,\frac{kcal}{kg.K}$
      HNK A4 $= m\ x\ Cp\ x\ dT$

      $= 29{,}3764\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9948\,\frac{kcal}{kg.K}\ x\ 25$

      $= 730606{,}8941\,\frac{kcal}{jam}$

Massa air $= 3{,}2640\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\,dT = \int_{298.15}^{323.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 1881842{,}357\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{3{,}2640\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{mol}\ x\ 0{,}00024$

$= 81899{,}02212\,\frac{kcal}{jam}$

b) Uap Air

Massa uap air $= 8{,}01782\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{330.15} Cp\,dT = \int_{298.15}^{330.15}(3.47 + 1.45 \times 10^3 T + 0.121 \times 10^{-2}T^3)dT$

$= 14576671{,}04\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{8{,}01782\frac{ton}{jam} * 1000000}{18}\right) x\ 4576671{,}04\,\frac{J}{mol} x\ 0{,}00024$

$= 1558308{,}639\,\frac{kcal}{jam}$

Total H keluar $= 730606{,}8941\,\frac{kcal}{jam} + 81899{,}02212\,\frac{kcal}{jam} + 1558308{,}639\,\frac{kcal}{jam}$

$= 2370814{,}5556\,\frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$202939{,}9543\,\frac{kcal}{jam} + Qsupply = 2370814{,}5556\,\frac{kcal}{jam} + 0{,}05\ Qsupply$

$0{,}95\ Qsupply = 2167874{,}601\,\frac{kcal}{jam}$

$Qsupply = 2281973{,}265\,\frac{kcal}{jam}$

$Qloss = 0{,}05\ Qsupply$

$= 0{,}05\ x\ 2281973{,}265\,\frac{kcal}{jam}$

$$= 114098{,}6632 \frac{kcal}{jam}$$

Masuk		Keluar	
HbitC	30305,95	HNKA4	730606,89
HairbitC	3609,02	HairNKA4	81899,02
HNKsulf	82881,81	Huapair	1558308,64
HairNKsulf	49391,50	Qloss	114098,66
HbitD	33081,39		
HairbitD	3670,28		
Qsupply	2281973,26		
Total	**2484913,22**	**Total**	**2484913,22**

3. Vacuum Pan A2

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$

a. Masuk

a) NK A4

% Brix $= 92{,}5\%$

Volume $= 150HL$

Massa $= 16{,}3202 \frac{ton}{jam}$

Massa Brix $= 14{,}6882 \frac{ton}{jam}$

Cp brix NK A4 $= 0{,}9948 \frac{kcal}{kg.K}$

HNK A4 $= m\ x\ Cp\ x\ dT$

$= 14{,}6882 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9948 \frac{kcal}{kg.K}\ x\ 25$

$= 365303{,}4470 \frac{kcal}{jam}$

Massa air $= 1{,}6320 \frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 1881842{,}357 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$$= \left(\frac{1{,}6320\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\frac{J}{mol}\ x\ 0{,}00024$$

$$= 40949{,}51106\frac{kcal}{jam}$$

b) Nk sulf

% Brix = 62,85%

Volume NK Sulf dibutuhkan = 100 HL

Massa NK sulf dibutuhkan = $12{,}9928\frac{ton}{jam}$

Massa Brix = $8{,}1660\frac{ton}{jam}$

Cp brix NKsulf = $0{,}9965\frac{kcal}{kg.K}$

HNKsulf = $m\ x\ Cp\ x\ dT$

$$= 8{,}1660\frac{ton}{jam}\ x\ 0{,}9965\frac{kcal}{kg.K}\ x\ 5$$

$$= 40686{,}1692\frac{kcal}{jam}$$

Massa air = $4{,}8268\frac{ton}{jam}$

Cpair 30 = $\int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$$= 376738{,}0481\frac{J}{mol}$$

Hair = $n\ air\ x\ Cp\ air$

$$= \left(\frac{4{,}8268\frac{ton}{jam} * 1000000}{18}\right) x\ 376738{,}0481\frac{J}{mol} x\ 0{,}00024$$

$$= 24245{,}98273\frac{kcal}{jam}$$

Total H masuk = $365303{,}4470\frac{kcal}{jam} + 40949{,}51106\frac{kcal}{jam} + 40686{,}1692\frac{kcal}{jam} + 24245{,}98273\frac{kcal}{jam} +$

$$= 471185{,}1100\frac{kcal}{jam}$$

b. Keluar

a) NK A2-1

Asumsi Brix yang dihasilkan = 93,40%

Volume = 250 HL

Massa = $24{,}4692\frac{ton}{jam}$

Massa Brix = $22{,}8542\frac{ton}{jam}$

Cp brix NK A2-1 $= 0{,}9948 \frac{kcal}{kg.K}$

HNK A4 $= m\ x\ Cp\ x\ dT$

$= 22{,}8542 \frac{ton}{jam} x\ 1000\ x\ 0{,}9948 \frac{kcal}{kg.K}\ x\ 25$

$= 113673{,}3054 \frac{kcal}{jam}$

Massa air $= 1{,}6150 \frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 1881842{,}357 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{1{,}6150 \frac{ton}{jam} * 1000000}{18} \right) x\ 1881842{,}357 \frac{J}{mol}\ x\ 0{,}00024$

$= 40521{,}4535 \frac{kcal}{jam}$

b) Uap Air

Massa uap air $= 4{,}8439 \frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{330.15} Cp\ dT = \int_{298.15}^{330.15} (3.47 + 1.45 \times 10^3 T + 0.121 \times 10^{-2} T^3) dT$

$= 14576671{,}04 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{4{,}8439 \frac{ton}{jam} * 1000000}{18} \right) x\ 14576671{,}04 \frac{J}{mol} x\ 0{,}00024$

$= 941436{,}2905 \frac{kcal}{jam}$

Total H keluar $= 113673{,}3054 \frac{kcal}{jam} + 40521{,}4535 \frac{kcal}{jam} + 40521{,}4535 \frac{kcal}{jam}$

$= 1095631{,}0494 \frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$471185{,}1100 \frac{kcal}{jam} + Qsupply = 1095631{,}0494 \frac{kcal}{jam} + 0{,}05\ Qsupply$

$$0{,}95\ Qsupply = 624445{,}9394\ \frac{kcal}{jam}$$

$$Qsupply = 657311{,}5151\ \frac{kcal}{jam}$$

$$Qloss = 0{,}05\ Qsupply$$

$$= 0{,}05\ x\ 657311{,}5151\ \frac{kcal}{jam}$$

$$= 32865{,}57576\ \frac{kcal}{jam}$$

Masuk		Keluar	
HNKA4	365303,45	HNK2	113673,31
HairNKA4	40949,51	HairNK2	40521,45
HNKsulf	40686,17	Huapair	941436,29
HairNksulf	24245,98	Qloss	32865,58
Qsupply	657311,52		
Total	**1128496,63**	**Total**	**1128496,63**

4. Vacuum Pan A1

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$

a. Masuk
   a) NK A2

% Brix $= 93{,}4\%$
Volume $= 250HL$
Massa $= 24{,}4692\ \frac{ton}{jam}$
Massa Brix $= 22{,}8542\ \frac{ton}{jam}$
Cp brix NK A2 $= 0{,}9948\ \frac{kcal}{kg.K}$
HNK A4 $= m\ x\ Cp\ x\ dT$

$$= 22{,}8542\ \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9948\ \frac{kcal}{kg.K}\ x\ 25$$

$$= 568366{,}5270\ \frac{kcal}{jam}$$

Massa air $= 1{,}6150\ \frac{ton}{jam}$

$$\text{Cpair } 50 = \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 1881842{,}357\,\frac{J}{mol}$$

Hair $= n\ air\ x\ Cp\ air$

$$= \left(\frac{1{,}6150\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{mol}\ x\ 0{,}00024$$

$$= 40521{,}4535\,\frac{kcal}{jam}$$

b) Nk sulf

% Brix $= 62{,}85\%$

Volume NK Sulf dibutuhkan $= 50\ HL$

Massa NK sulf dibutuhkan $= 6{,}4964\,\frac{ton}{jam}$

Massa Brix $= 4{,}0830\,\frac{ton}{jam}$

Cp brix NKsulf $= 0{,}9965\,\frac{kcal}{kg.K}$

HNKsulf $= m\ x\ Cp\ x\ dT$

$$= 4{,}0830\,\frac{ton}{jam} x\ 1000\ x\ 0{,}9965\,\frac{kcal}{kg.K}\ x\ 5$$

$$= 20343{,}0846\,\frac{kcal}{jam}$$

Massa air $= 2{,}4134\,\frac{ton}{jam}$

$$\text{Cpair } 50 = \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$$

$$= 376738{,}0481\,\frac{J}{mol}$$

Hair $= n\ air\ x\ Cp\ air$

$$= \left(\frac{2{,}4134\frac{ton}{jam} * 1000000}{18}\right) x\ 376738{,}0481\,\frac{J}{mol} x\ 0{,}00024$$

$$= 12122{,}99136\,\frac{kcal}{jam}$$

$$\text{Total H masuk} = 568366{,}5270\,\frac{kcal}{jam} + 40521{,}4535\,\frac{kcal}{jam} + 20343{,}0846\,\frac{kcal}{jam} + 12122{,}99136\,\frac{kcal}{jam}$$

$$= 641354{,}0565\,\frac{kcal}{jam}$$

b. Keluar

a) Masakan A

Brix yang dihasilkan $= 94{,}20\%$

Volume $= 300\ HL$

Massa $= 28{,}5957\,\frac{ton}{jam}$

Massa Brix $= 26{,}9372\,\frac{ton}{jam}$

Cp brix NK A2-1 $= 0{,}9947\,\frac{kcal}{kg.K}$

HNK A4 $= m\ x\ Cp\ x\ dT$

$= 22{,}8542\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9948\,\frac{kcal}{kg.K}\ x\ 25$

$= 669877{,}1509\,\frac{kcal}{jam}$

Massa air $= 1{,}6586\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 1881842{,}357\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{1{,}6586\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{mol}\ x\ 0{,}00024$

$= 4165{,}13206\,\frac{kcal}{jam}$

c) Uap Air

Massa uap air $= 2{,}3698\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{330.15} Cp\ dT = \int_{298.15}^{330.15}(3.47 + 1.45 \times 10^3 T + 0.121 \times 10^{-2}T^3)dT$

$= 14576671{,}04\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{2{,}3698\frac{ton}{jam} * 1000000}{18}\right) x\ 4576671{,}04\,\frac{J}{mol} x\ 0{,}00024$

$= 460588{,}6996\,\frac{kcal}{jam}$

Total H keluar $= 669877{,}1509\,\frac{kcal}{jam} + 4165{,}13206\,\frac{kcal}{jam} + 460588{,}6996\,\frac{kcal}{jam}$

$= 1172080{,}9826\,\frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$$641354{,}0565\,\frac{kcal}{jam} + Qsupply = 1172080{,}9826\,\frac{kcal}{jam} + 0{,}05\ Qsupply$$

$$0{,}95\ Qsupply = 530726{,}9261\,\frac{kcal}{jam}$$

$$Qsupply = 558659{,}9223\,\frac{kcal}{jam}$$

$$Qloss = 0{,}05\ Qsupply$$

$$= 0{,}05\ x\ 558659{,}9223\,\frac{kcal}{jam}$$

$$= 27932{,}99611\,\frac{kcal}{jam}$$

Masuk		Keluar	
HNKA2	568366,53	Hmas A	669877,15
HairNKA2	40521,45	HairmasA	41615,13
HNKsulf	20343,08	Huapair	460588,70
HairNksulf	12122,99	Qloss	27933,00
Qsupply	558659,92		
Total	**1200013,98**	**Total**	**1200013,98**

5. Vacuum Pan D2

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$

a. Masuk
   a) Nk sulf

% Brix $= 62{,}85$
Volume NK Sulf dibutuhkan $= 30\ HL$
Massa NK sulf dibutuhkan $= 3{,}8978\,\frac{ton}{jam}$
Massa Brix $= 2{,}4498\,\frac{ton}{jam}$
Cp brix NKsulf $= 0{,}9965\,\frac{kcal}{kg.K}$
HNKsulf $= m\ x\ Cp\ x\ dT$

$$= 2{,}4498\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9965\,\frac{kcal}{kg.K}\ x\ 5$$

$$= 12205{,}8508\,\frac{kcal}{jam}$$

Massa air $= 1{,}4480\,\frac{ton}{jam}$

Cpair 30 $= \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 376738{,}0481 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{1{,}4480 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol} x\ 0{,}00024$

$= 7273{,}794818 \frac{kcal}{jam}$

b) Fondant

Volume yang dibutuhkan $= 200\ ml$

Massa fondant $= 260\ gram = 0{,}00026 \frac{ton}{jam}$

c) Stroop A

Brix $= 85{,}4\%$

Volume yang dibutuhkan $= 170\ HL$

Massa yang dibutuhkan $= 24{,}5429 \frac{ton}{jam}$

Massa Brix $= 20{,}9596 \frac{ton}{jam}$

Cp brix $= 0{,}9952 \frac{kcal}{kg.K}$

Hstr A$= m\ x\ Cp\ x\ dT$

$= 20{,}9596 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9948 \frac{kcal}{kg.K}\ x\ 25$

$= 104296{,}9962 \frac{kcal}{jam}$

Massa air $= 3{,}5883 \frac{ton}{jam}$

Cpair 30 $= \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 376738{,}0481 \frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{3{,}5883 \frac{ton}{jam} * 1000000}{18} \right) x\ 1881842{,}357 \frac{J}{mol}\ x\ 0{,}00024$

$= 17999{,}35546 \frac{kcal}{jam}$

$$\text{Total H masuk} = 12205{,}8508\,\frac{kcal}{jam} + 7273{,}794818\,\frac{kcal}{jam} + 104296{,}9962\,\frac{kcal}{jam} + 17999{,}35546\,\frac{kcal}{jam}$$

$$= 141775{,}9972\,\frac{kcal}{jam}$$

b. Keluar

a) Masakan D2

Asumsi Brix = 93,8%

Volume masakan D2 = 200 HL

Massa masakan D2 = $24{,}9567\,\frac{ton}{jam}$

Massa Brix = $23{,}4094\,\frac{ton}{jam}$

Cp brix masD2 = $0{,}9947\,\frac{kcal}{kg.K}$

HmasD2 = $m\ x\ Cp\ x\ dT$

$$= 23{,}4094\,\frac{ton}{jam}\ x1000\ X\ 0{,}9946\,\frac{kcal}{kg.K}\ x\ 25$$

$$= 582161{,}5998\,\frac{kcal}{jam}$$

Massa air = $1{,}5473\,\frac{ton}{jam}$

Cpair 50 = $\int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 1881842{,}357\,\frac{J}{mol}$

Hair = $n\ air\ x\ Cp\ air$

$$= \left(\frac{1{,}5473\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{mol}\ x\ 0{,}00024$$

$$= 38824{,}1225\,\frac{kcal}{jam}$$

b) Uap Air

Massa uap air = $3{,}4843\,\frac{ton}{jam}$

Cpair 50 = $\int_{298.15}^{330.15} Cp\ dT = \int_{298.15}^{330.15}(3.47 + 1.45 \times 10^3 T + 0.121 \times 10^{-2}T^3)dT$

$= 14576671{,}04\,\frac{J}{mol}$

Hair = $n\ air\ x\ Cp\ air$

$$= \left(\frac{3{,}4843\frac{ton}{jam} * 1000000}{18}\right) x2408687{,}031\,\frac{J}{mol}\,x\ 0{,}00024$$

$$= 677184{,}0573\,\frac{kcal}{jam}$$

$$\text{Total H keluar} = 582161{,}5998\,\frac{kcal}{jam} + 38824{,}1225\,\frac{kcal}{jam} + 677184{,}0573\,\frac{kcal}{jam}$$

$$= 1298169{,}7796\,\frac{kcal}{jam}$$

Neraca Panas Total

H masuk = H keluar

$$141775{,}9972\,\frac{kcal}{jam} + Qsupply = 1298169{,}7796\,\frac{kcal}{jam} + 0{,}05\,Qsupply$$

$$0{,}95\,Qsupply = 1156393{,}7824\,\frac{kcal}{jam}$$

$$Qsupply = 1217256{,}613\,\frac{kcal}{jam}$$

$$Qloss = 0{,}05\,Qsupply$$

$$= 0{,}05\ x\ 1217256{,}613\,\frac{kcal}{jam}$$

$$= 60862{,}83065\,\frac{kcal}{jam}$$

Masuk		Keluar	
HNKsulf	12205,85	HmasD2	582161,60
HairNKsulf	7273,79	HairmasD2	38824,12
HstroopA	104297,00	Huapair	677184,06
HairstroopA	17999,36	Qloss	60862,83
Qsupply	1217256,61		
Total	**1359032,61**	**Total**	**1359032,61**

6. Vacuum Pan D1

Tref $= 25^{\circ}C = 298{,}15\ K$
T1 $= 30^{\circ}C = 303{,}15\ K$
T2 $= 50^{\circ}C = 323{,}15\ K$

a. Masuk
   a) Masakan D2
      Asumsi Brix = 93,8%
      Volume $= 100\ HL$
      Massa masakan D2 $= 12{,}4784\,\frac{ton}{jam}$

Massa Brix $= 11{,}7047\,\frac{ton}{jam}$

Cp brix $= 0{,}9947\,\frac{kcal}{kg.K}$

HmasD2 $= m\ x\ Cp\ x\ dT$

$= 11{,}7047\,\frac{ton}{jam}\ x\ 1000\ x\ 0{,}9950\,\frac{kcal}{kg.K}\ x\ 25$

$= 291080{,}7999\,\frac{kcal}{jam}$

Massa air $= 0{,}7737\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 1881842{,}357\,\frac{J}{kmol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{0{,}7737\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{kmol}\ x\ 0{,}00024$

$= 19412{,}06125\,\frac{kcal}{jam}$

b) Klare D

% Brix $= 74{,}9\%$

Volume $= 40\ HL$

Massa $= 5{,}4968\,\frac{ton}{jam}$

Massa Brix $= 4{,}1171\,\frac{ton}{jam}$

Cp brix $= 0{,}9958\,\frac{kcal}{kg.K}$

HklrD $= m\ x\ Cp\ x\ dT$

$= 0{,}9958\,\frac{kcal}{kg.K}\ x\ 1000\ x\ 0{,}9958\,\frac{kcal}{kg.K}\ x\ 5$

$= 20499{,}1721\,\frac{kcal}{jam}$

Massa air $= 1{,}3797\,\frac{ton}{jam}$

Cpair 30 $= \int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 376738{,}0481\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{1{,}3797\frac{ton}{jam} * 1000000}{18}\right) x\ 376738{,}0481\,\frac{J}{mol} x\ 0{,}00024$

$$= 6930{,}457059 \frac{kcal}{jam}$$

c) Stroop C

% Brix = 74,2%

Volume stroop C= 40 HL

Massa stroop C = $5{,}4788 \frac{ton}{jam}$

Massa Brix = $4{,}0653 \frac{ton}{jam}$

Cp brix str C= $0{,}9958 \frac{kcal}{kg.K}$

HstrC = $m\ x\ Cp\ x\ dT$

$= 4{,}0653 \frac{ton}{jam}\ x\ 1000\ x\ 0{,}9950 \frac{kcal}{kg.K}\ x\ 5$

$= 20241{,}8880 \frac{kcal}{jam}$

Massa air = $1{,}4135 \frac{ton}{jam}$

Cpair 30 = $\int_{298.15}^{303.15} Cp\ dT = \int_{298.15}^{303.15} (2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125 T^2 - 1.4116 \times 10^{-2} T^3 + 9.3701 \times 10^{-6} T^4) dT$

$= 376738{,}0481 \frac{J}{mol}$

Hair = $n\ air\ x\ Cp\ air$

$= \left(\frac{1{,}4135 \frac{ton}{jam} * 1000000}{18} \right) x\ 376738{,}0481 \frac{J}{mol} x\ 0{,}00024$

$= 7100{,}409118 \frac{kcal}{jam}$

Total H masuk = $291080{,}7999 \frac{kcal}{jam} + 19412{,}06125 \frac{kcal}{jam} + 20499{,}1721 \frac{kcal}{jam} + 6930{,}457059 \frac{kcal}{jam} + 20241{,}8880 \frac{kcal}{jam} + 7100{,}409118 \frac{kcal}{jam}$

$= 365264{,}7874 \frac{kcal}{jam}$

b. Keluar

a) Masakan D

% Brix = 97,61%

Volume = 180 HL

Massa = $20{,}3740 \frac{ton}{jam}$

Massa Brix = $19{,}8871 \frac{ton}{jam}$

Cp brix = $0{,}9945 \frac{kcal}{kg.K}$

HmskD $= m\ x\ Cp\ x\ dT$

$= 19{,}8871\,\frac{ton}{jam}\,x\ 1000\ x\ 0{,}9948\,\frac{kcal}{kg.K}\ x\ 25$

$= 494459{,}5330\,\frac{kcal}{jam}$

Massa air $= 0{,}4869\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{323.15} Cp\ dT = \int_{298.15}^{323.15}(2.7637 \times 10^5 - 2.0901 \times 10^3 T + 8.125T^2 - 1.4116 \times 10^{-2}T^3 + 9.3701 \times 10^{-6}T^4)dT$

$= 1881842{,}357\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{0{,}4869\frac{ton}{jam} * 1000000}{18}\right) x\ 1881842{,}357\,\frac{J}{mol}\ x\ 0{,}00024$

$= 12217{,}90503\,\frac{kcal}{jam}$

c) Uap Air

Massa uap air $= 3{,}0799\,\frac{ton}{jam}$

Cpair 50 $= \int_{298.15}^{330.15} Cp\ dT = \int_{298.15}^{330.15}(3.47 + 1.45 \times 10^3 T + 0.121 \times 10^{-2}T^3)dT$

$= 14576671{,}04\,\frac{J}{mol}$

Hair $= n\ air\ x\ Cp\ air$

$= \left(\frac{3{,}0799\frac{ton}{jam} * 1000000}{18}\right) x\ 14576671{,}04\,\frac{J}{mol} x\ 0{,}00024$

$= 598605{,}0159\,\frac{kcal}{jam}$

Total H keluar $= 494459{,}5330\,\frac{kcal}{jam} + 12217{,}90503\,\frac{kcal}{jam} + 598605{,}0159\,\frac{kcal}{jam}$

$= 110582{,}4539\,\frac{kcal}{jam}$

Neraca Panas Total

H masuk = H keluar

$365264{,}7874\,\frac{kcal}{jam} + Qsupply = 110582{,}4539\,\frac{kcal}{jam} + 0{,}05\ Qsupply$

$0{,}95\ Qsupply = 740017{,}6665\,\frac{kcal}{jam}$

$$Qsupply = 778965{,}9648\,\frac{kcal}{jam}$$

$$Qloss = 0{,}05\ Qsupply$$

$$= 0{,}05\ x\ 778965{,}9648\,\frac{kcal}{jam}$$

$$= 38948{,}29824\,\frac{kcal}{jam}$$

Masuk		Keluar	
HmasD2	291080,80	HmasD	494459,53
HairmasD2	19412,06	HairmasD	12217,91
HklareD	20499,17	Huapair	598605,02
Haiklare D	6930,46	Qloss	38948,30
HstroopC	20241,89		
HairstpC	7100,41		
Qsupply	778965,96		
Total	**1144230,75**	**Total**	**1144230,75**