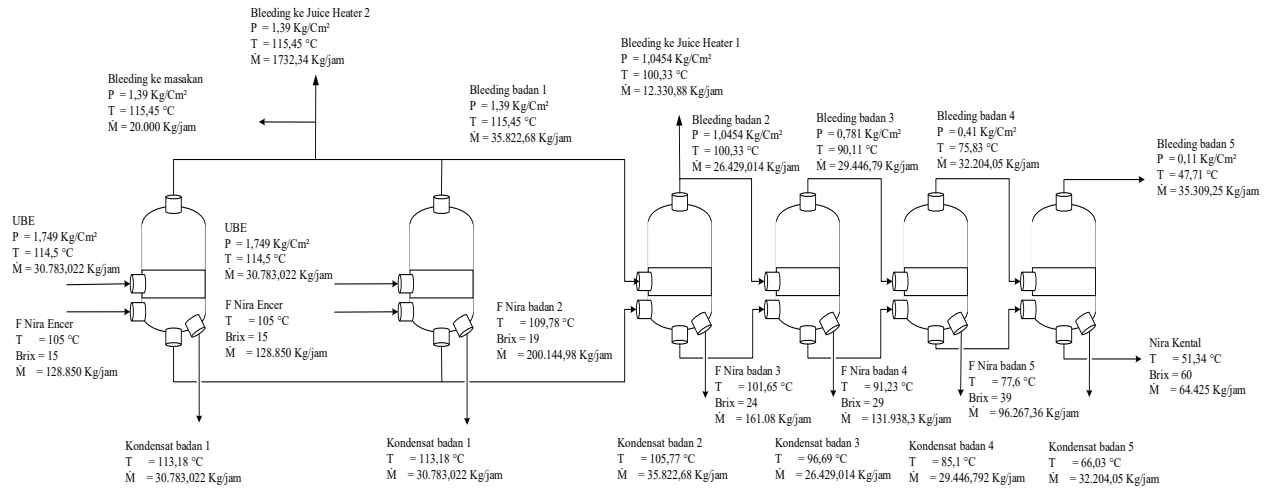


BAB IX

URAIAN TUGAS KHUSUS



Gambar IX. 1 Diagram alir *Quintuple effect evaporator*

A. Perhitungan Manual

Neraca Massa

Kapasitas giling = 6000 TCD = 250000 Kg/jam

% nira mentah = 105%

%blotong = 1,92%

Brix nira encer (bne) = 15%

Brix nira kental (bnk) = 60%

Brix nira mentah = 13%

Perhitungan Neraca Massa Overall

Nira mentah (Fo) = m. tebu masuk x %nira mentah

$$= 250000 \frac{\text{kg}}{\text{jam}} \times 105\%$$

$$= 262500 \frac{\text{kg}}{\text{jam}}$$

Nira encer (kg/jam) = m. nira mentah – (%blotong × m. tebu masuk)

$$= 262500 \frac{\text{kg}}{\text{jam}} - \left(1,92\% \times 250000 \frac{\text{kg}}{\text{jam}} \right)$$

$$= 257700 \text{ kg/jam}$$

$$\begin{aligned}\text{Total air yang teruapkan (V)} &= nira\ encer \times \left(1 - \frac{bne}{bnk}\right) \\ &= 257700 \frac{kg}{jam} \times \left(1 - \frac{0,15}{0,60}\right) \\ &= 193275 \text{ kg/jam}\end{aligned}$$

$$\begin{aligned}\text{Aliran badan 5 (L)} &= F - V \\ &= 257700 \text{ kg/jam} - 193275 \text{ kg/jam} \\ &= 64425 \text{ kg/jam}\end{aligned}$$

Perhitungan Air yang Teruapkan Setiap Badan secara Teoritis

Badan 1	X	+ kebutuhan uap di JH2	+ kebutuhan masakan
Badan 2	X	+ kebutuhannya uap di JH1	
Badan 3	X		
Badan 4	X		
Badan 5	X		
Total	5X	+ kebutuhan uap (JH1+JH2)	+ kebutuhan masakan

$$T_{\text{out JH1}} = 75^{\circ}\text{C}$$

$$T_{\text{out JH2}} = 105^{\circ}\text{C}$$

evaporator	dP
Badan 1	0,22
Badan 2	0,21
Badan 3	0,2
Badan 4	0,19
Badan 5	0,18

$$\begin{aligned}P_{\text{badan 5}} &= -67,75 \text{ CmHg} + 76 \text{ CmHg} = 8,24 \text{ CmHg} \\ &= 0,1122 \frac{Kg}{cm^2}\end{aligned}$$

$$P_{\text{UBE}} = 0,7163 \frac{Kg}{cm^2} + 1,0332 \frac{kg}{cm^2} = 1,7495 \frac{kg}{cm^2}$$

$$dP_{\text{total}} = 1,7495 \frac{kg}{cm^2} - 0,1122 \frac{kg}{cm^2} = 1,6373 \frac{Kg}{cm^2}$$

$$\begin{aligned} P \text{ uap badan 1} &= P_{UBE} - (dP \text{ badan 1} \times dP \text{ total}) \\ &= 1,7495 \frac{\text{kg}}{\text{cm}^2} - (0,22 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 1,3893 \frac{\text{kg}}{\text{cm}^2} \end{aligned}$$

$$\begin{aligned} P \text{ uap badan 2} &= P_{UBE} - (dP \text{ badan 2} \times dP \text{ total}) \\ &= 1,3893 \frac{\text{kg}}{\text{cm}^2} - (0,21 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 1,0454 \frac{\text{kg}}{\text{cm}^2} \end{aligned}$$

Berdasarkan buku Hugot

$$T \text{ uap dari badan 1} = 108,522^\circ\text{C}$$

$$T \text{ uap dari badan 2} = 100,3253^\circ\text{C}$$

$$P. \text{ latent JH1 } (100,3253^\circ\text{C}) = 538,705 \frac{\text{Kcal}}{\text{kg}}$$

$$P. \text{ latent JH2 } (108,522^\circ\text{C}) = 533,2688 \frac{\text{Kcal}}{\text{kg}}$$

$$\begin{aligned} C_p \text{ nira mentah} &= 1 - (0,006 \text{ Brix nira mentah}) \\ &= 1 - (0,006 \times 0,13) \\ &= 0,99922 \frac{\text{Kcal}}{\text{kg}^\circ\text{C}} \end{aligned}$$

$$\begin{aligned} \text{Kebutuhan uap JH1} &= F_o \times C_p \text{ NM} \times \frac{T_{in} - T_{out}}{P \text{ latent}} \\ &= 241450 \frac{\text{kg}}{\text{jam}} \times 0,99922 \frac{\text{Kcal}}{\text{kg}^\circ\text{C}} \times \frac{100,3253^\circ\text{C} - 75^\circ\text{C}}{538,705 \frac{\text{Kcal}}{\text{kg}}} \\ &= 12330,8785 \frac{\text{kg}}{\text{jam}} \end{aligned}$$

$$\begin{aligned} \text{Kebutuhan uap JH2} &= F_o \times C_p \text{ NM} \times \frac{T_{in} - T_{out}}{P \text{ latent}} \\ &= 241450 \frac{\text{kg}}{\text{jam}} \times 0,99922 \frac{\text{Kcal}}{\text{kg}^\circ\text{C}} \times \frac{108,522^\circ\text{C} - 105^\circ\text{C}}{533,2688 \frac{\text{Kcal}}{\text{kg}}} \\ &= 1732,3419 \frac{\text{kg}}{\text{jam}} \end{aligned}$$

$$\begin{aligned} \text{Nilai X} &= \frac{\text{total air yang teruapkan} - \text{total kebutuhan uap JH}}{5} \\ &= \frac{1933275 \frac{\text{kg}}{\text{jam}} - (1732,3419 + 12330,8785) \frac{\text{kg}}{\text{jam}} - 20000 \frac{\text{kg}}{\text{jam}}}{5} \\ &= 31842,3559 \text{ Kg/jam} \end{aligned}$$

Perhitungan nilai Brix setiap badan secara teoritis

$$\% \text{pol nira encer} = 10\%$$

$$\begin{aligned} \text{Massa sukrosa} &= m. \text{nira encer} \times \% \text{pol nira encer} \\ &= 257700 \frac{\text{kg}}{\text{jam}} \times 0,1 \\ &= 25770 \frac{\text{kg}}{\text{jam}} \end{aligned}$$

$$\begin{aligned} \text{Massa zat lain} &= M. \text{nira encer} \times bne - m. \text{sukrosa} \\ &= 257700 \frac{\text{kg}}{\text{jam}} \times 0,15 - 25770 \\ &= 12885 \frac{\text{kg}}{\text{jam}} \end{aligned}$$

$$\begin{aligned} \text{Total air dalam nira} &= m \text{ Nira encer} - (m. \text{sukrosa} + m. \text{zat lain}) \\ &= 257700 \frac{\text{kg}}{\text{jam}} - \left(25770 \frac{\text{kg}}{\text{jam}} + 12885 \frac{\text{kg}}{\text{jam}} \right) \\ &= 219045 \frac{\text{kg}}{\text{jam}} \end{aligned}$$

Evaporator Badan 1

$$\text{Berat masuk} = 257700 \frac{\text{kg}}{\text{jam}}$$

$$\text{Berat air yang teruapkan} = 53574,6978 \frac{\text{kg}}{\text{jam}}$$

$$\text{Brix masuk} = 15\%$$

$$\begin{aligned} \text{Brix keluar} &= \frac{m. \text{NE} \times bne}{\text{berat masuk} - \text{air yang teruapkan}} \\ &= 19\% \end{aligned}$$

Evaporator Badan 2

$$\text{Berat masuk} = 204125,3022 \frac{\text{kg}}{\text{jam}}$$

$$\text{Berat air yang teruapkan} = 444173,23441 \frac{\text{kg}}{\text{jam}}$$

$$\text{Brix masuk} = 19\%$$

$$\begin{aligned} \text{Brix keluar} &= \frac{m. \text{NE} \times bne}{\text{berat masuk} - \text{air yang teruapkan}} \\ &= 24\% \end{aligned}$$

Evaporator Badan 3

$$\text{Berat masuk} = 159952,0678 \frac{\text{kg}}{\text{jam}}$$

$$\begin{aligned}\text{Berat air yang teruapkan} &= 31842,3559 \frac{\text{kg}}{\text{jam}} \\ \text{Brix masuk} &= 24\% \\ \text{Brix keluar} &= \frac{m.NE \times bne}{\text{berat masuk-air yang teruapkan}} \\ &= 30\%\end{aligned}$$

Evaporator Badan 4

$$\begin{aligned}\text{Berat masuk} &= 128109,7119 \frac{\text{kg}}{\text{jam}} \\ \text{Berat air yang teruapkan} &= 31842,3559 \frac{\text{kg}}{\text{jam}} \\ \text{Brix masuk} &= 30\% \\ \text{Brix keluar} &= \frac{m.NE \times bne}{\text{berat masuk-air yang teruapkan}} \\ &= 40\%\end{aligned}$$

Evaporator Badan 5

$$\begin{aligned}\text{Berat masuk} &= 96267,3559 \frac{\text{kg}}{\text{jam}} \\ \text{Berat air yang teruapkan} &= 31842,3559 \frac{\text{kg}}{\text{jam}} \\ \text{Brix masuk} &= 40\% \\ \text{Brix keluar} &= \frac{m.NE \times bne}{\text{berat masuk-air yang teruapkan}} \\ &= 60\%\end{aligned}$$

Neraca Panas

Evaporator Badan 1

$$\begin{aligned}\text{P UBE gauge} &= 0,7163 \frac{\text{Kg}}{\text{cm}^2} \\ \text{P UBE abs} &= 1,7495 \frac{\text{Kg}}{\text{cm}^2} \\ \text{P uap badan 1} &= \text{P UBE} - (\text{dP badan 1} \times \text{dP total}) \\ &= 1,7495 \frac{\text{kg}}{\text{cm}^2} - (0,22 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 1,3893 \frac{\text{kg}}{\text{cm}^2}\end{aligned}$$

Berdasarkan buku Hugot hal 1034

$$\text{T UBE} = 115,45^\circ\text{C}$$

T uap badan 1	= 108,522°C
Panas latent UBE	= 529,1 $\frac{\text{Kcal}}{\text{kg}}$
Panas latent uap	= 533,2868 $\frac{\text{Kcal}}{\text{kg}}$
KTD P hidrostatik	= 1,2593
T nira keluar badan	= $T \text{ uap badan} + KTD$ = 109,7813°C
T nira masuk	= 105°C
Nira masuk	= 257700 $\frac{\text{kg}}{\text{jam}}$
Air yang teruapkan	= 57555,0245 $\frac{\text{kg}}{\text{jam}}$
Nira keluar	= 200144,9755 $\frac{\text{kg}}{\text{jam}}$
T kondensat	= $t_v - 0,4 (t_v - t_f)$ = 113,1825°C
Brix masuk	= 15%
Brix keluar	= 19%
Cp masuk	= 1 – (0,006 Brix masuk) = 0,9991 Kcal/kg°C
Cp keluar	= 0,998863786 Kcal/kg°C

Perhitungan Panas masuk

Nira masuk	= nira masuk $\times$ cp brix masuk $\times$ T masuk = 27034147,35 $\frac{\text{Kcal}}{\text{jam}}$
UBE	= y $\times$ panas latent UBE = 529,1 y $\frac{\text{Kcal}}{\text{jam}}$

Perhitungan Panas keluar

Nira keluar	= nira keluar $\times$ cp brix keluar $\times$ T keluar = 21947206,6 $\frac{\text{Kcal}}{\text{jam}}$
Uap	= y $\times$ panas latent Uap

$$= 30693334,85 \frac{\text{Kcal}}{\text{jam}}$$

$$\begin{aligned}\text{Kondensat} &= y \times \text{panas latent} \\ &= 113,1825 y \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

Panas masuk = panas keluar

$$y = 61566,0434 \frac{\text{Kg}}{\text{jam}}$$

➤ Evaporator Badan 2

$$P \text{ bleeding} = 1,3893$$

$$\begin{aligned}P \text{ uap badan 2} &= P \text{ bleeding} - (dP \text{ badan 2} \times dP \text{ total}) \\ &= 1,3893 \frac{\text{kg}}{\text{cm}^2} - (0,21 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 1,0454 \frac{\text{kg}}{\text{cm}^2}\end{aligned}$$

Berdasarkan buku Hugot hal 1034

$$T \text{ bleeding} = 108,522^\circ\text{C}$$

$$T \text{ uap badan 2} = 100,3253^\circ\text{C}$$

$$\text{Panas latent bleeding} = 533,2868 \frac{\text{Kcal}}{\text{kg}}$$

$$\text{Panas latent uap} = 538,705 \frac{\text{Kcal}}{\text{kg}}$$

$$\text{KTD P hidrostatik} = 1,3289$$

$$\begin{aligned}T \text{ nira keluar badan} &= T \text{ uap badan} + \text{KTD} \\ &= 101,6542^\circ\text{C}\end{aligned}$$

$$T \text{ nira masuk} = 109,7813^\circ\text{C}$$

$$\text{Nira masuk} = 200144,9755 \frac{\text{kg}}{\text{jam}}$$

$$\begin{aligned}T \text{ kondensat} &= t_v - 0,4 (t_v - t_f) \\ &= 105,7749^\circ\text{C}\end{aligned}$$

$$\text{Brix masuk} = 19\%$$

$$\text{Brix keluar} = 24\%$$

$$\begin{aligned}C_p \text{ masuk} &= 1 - (0,006 \text{ Brix masuk}) \\&= 0,998863786 \text{ Kcal/kg}^\circ\text{C} \\C_p \text{ keluar} &= 0,998550003 \text{ Kcal/kg}^\circ\text{C}\end{aligned}$$

Perhitungan Panas masuk

$$\begin{aligned}\text{Nira masuk} &= \text{nira masuk} \times c_p \text{ brix masuk} \times T \text{ masuk} \\&= 21947206,6 \frac{\text{Kcal}}{\text{jam}} \\ \text{bleeding} &= (y - JH 2 - \text{masakan}) \times \text{panas latent bleeding} \\&= 19103763,8 \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

Perhitungan Panas keluar

$$\begin{aligned}\text{Nira keluar} &= (\text{nira masuk} - \text{uap keluar}) \times \\&\quad c_p \text{ brix keluar} \times T \text{ keluar} \\&= 20316075,31 - 101,5068 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Uap} &= y \times \text{panas latent Uap} \\&= 538,705 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Kondensat} &= (y - JH 2 - \text{masakan}) \times \text{suhu kondensat} \\&= 3789139,884 \frac{\text{Kcal}}{\text{jam}} \\ \text{Panas masuk} &= \text{panas keluar} \\ y &= 38759,8921 \frac{\text{Kg}}{\text{jam}}\end{aligned}$$

➤ Evaporator Badan 3

$$\begin{aligned}P \text{ bleeding} &= 1,0454 \\ P \text{ uap badan 3} &= P \text{ bleeding} - (dP \text{ badan 3} \times dP \text{ total}) \\&= 1,0454 \frac{\text{kg}}{\text{cm}^2} - (0,2 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\&= 0,7180 \frac{\text{kg}}{\text{cm}^2}\end{aligned}$$

Berdasarkan buku Hugot hal 1034

$$T \text{ bleeding} = 100,3253^\circ\text{C}$$

$$\begin{aligned}T_{\text{uap badan 3}} &= 90,1123^{\circ}\text{C} \\ \text{Panas latent bleeding} &= 538,705 \frac{\text{Kcal}}{\text{kg}} \\ \text{Panas latent uap} &= 545,0326 \frac{\text{Kcal}}{\text{kg}} \\ \text{KTD P hidrostatik} &= 1,1133 \\ T_{\text{nira keluar badan}} &= T_{\text{uap badan}} + \text{KTD} \\ &= 91,2256^{\circ}\text{C} \\ T_{\text{nira masuk}} &= 101,6542^{\circ}\text{C} \\ \text{Nira masuk} &= 161385,0833 \frac{\text{kg}}{\text{jam}} \\ T_{\text{kondensat}} &= t_v - 0,4 (t_v - t_f) \\ &= 96,6854^{\circ}\text{C} \\ \text{Brix masuk} &= 24\% \\ \text{Brix keluar} &= 30\% \\ C_p \text{ masuk} &= 1 - (0,006 \text{ Brix masuk}) \\ &= 0,998550003 \text{ Kcal/kg}^{\circ}\text{C} \\ C_p \text{ keluar} &= 0,998189599 \text{ Kcal/kg}^{\circ}\text{C}\end{aligned}$$

Perhitungan Panas masuk

$$\begin{aligned}\text{Nira masuk} &= \text{nira masuk} \times c_p \text{ brix masuk} \times T_{\text{masuk}} \\ &= 16381682,82 \frac{\text{Kcal}}{\text{jam}} \\ \text{bleeding} &= (y - JH 1) \times \text{panas latent UBE} \\ &= 14237441,8 \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

Perhitungan Panas keluar

$$\begin{aligned}\text{Nira keluar} &= (\text{nira masuk} - \text{uap keluar}) \times \\ &\quad c_p \text{ brix keluar} \times T_{\text{keluar}} \\ &= 14695803,37 - 91,0605 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Uap} &= y \times \text{panas latent Uap} \\ &= 545,0326 y \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

$$\begin{aligned}\text{Kondensat} &= y \times \text{panas latent} \\ &= 2555300,6694 \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

$$\text{Panas masuk} = \text{panas keluar}$$

$$y = 29446,7877 \frac{\text{Kg}}{\text{jam}}$$

➤ Evaporator Badan 4

$$P \text{ bleeding} = 0,7180 \frac{\text{kg}}{\text{cm}^2}$$

$$\begin{aligned}P \text{ uap badan 4} &= P \text{ bleeding} - (dP \text{ badan 4} \times dP \text{ total}) \\ &= 0,7180 \frac{\text{kg}}{\text{cm}^2} - (0,2 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 0,4069 \frac{\text{kg}}{\text{cm}^2}\end{aligned}$$

Berdasarkan buku Hugot hal 1034

$$T \text{ bleeding} = 90,1123^\circ\text{C}$$

$$T \text{ uap badan 4} = 75,8264^\circ\text{C}$$

$$\text{Panas latent bleeding} = 545,0326 \frac{\text{Kcal}}{\text{kg}}$$

$$\text{Panas latent uap} = 553,9042 \frac{\text{Kcal}}{\text{kg}}$$

$$KTD \text{ P hidrostatik} = 1,7646$$

$$\begin{aligned}T \text{ nira keluar badan} &= T \text{ uap badan} + KTD \\ &= 77,5910^\circ\text{C}\end{aligned}$$

$$T \text{ nira masuk} = 91,2256^\circ\text{C}$$

$$\text{Nira masuk} = 131938,2957 \frac{\text{kg}}{\text{jam}}$$

$$\text{Air yang teruapkan} = 31842,3559 \frac{\text{kg}}{\text{jam}}$$

$$\begin{aligned}T \text{ kondensat} &= t_v - 0,4 (t_v - t_f) \\ &= 85,1038^\circ\text{C}\end{aligned}$$

$$\text{Brix masuk} = 30\%$$

$$\text{Brix keluar} = 40\%$$

$$\begin{aligned}\text{Cp masuk} &= 1 - (0,006 \text{ Brix masuk}) \\ &= 0,998189599 \text{ Kcal/kg}^\circ\text{C}\end{aligned}$$

$$\text{Cp keluar} = 0,997590772 \text{ Kcal/kg}^\circ\text{C}$$

Perhitungan Panas masuk

$$\begin{aligned}\text{Nira masuk} &= \text{nira masuk} \times \text{cp brix masuk} \times T \text{ masuk} \\ &= 12014364,71 \frac{\text{Kcal}}{\text{jam}} \\ \text{bleeding} &= y \times \text{panas latent bleeding} \\ &= 16049459,24 \frac{\text{Kcal}}{\text{jam}}\end{aligned}$$

Perhitungan Panas keluar

$$\begin{aligned}\text{Nira keluar} &= (\text{nira masuk} - \text{uap keluar}) \times \\ &\quad \text{cp brix keluar} \times T \text{ keluar} \\ &= 10212558,04 - 77,4041 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Uap} &= y \times \text{panas latent Uap} \\ &= 553,9042 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Kondensat} &= y \times \text{panas latent} \\ &= 2506032,718 \frac{\text{Kcal}}{\text{jam}} \\ \text{Panas masuk} &= \text{panas keluar} \\ y &= 32204,0467 \frac{\text{Kg}}{\text{jam}}\end{aligned}$$

➤ Evaporator Badan 5

$$\begin{aligned}\text{P bleeding} &= 0,4069 \frac{\text{kg}}{\text{cm}^2} \\ \text{P uap badan 5} &= P \text{ bleeding} - (dP \text{ badan 5} \times dP \text{ total}) \\ &= 0,4069 \frac{\text{kg}}{\text{cm}^2} - (0,19 \times 1,6373 \frac{\text{kg}}{\text{cm}^2}) \\ &= 0,1122 \frac{\text{kg}}{\text{cm}^2}\end{aligned}$$

Berdasarkan buku Hugot hal 1034

$$\begin{aligned}T \text{ bleeding} &= 75,8264 \text{ }^{\circ}\text{C} \\ T \text{ uap badan 5} &= 47,7075 \text{ }^{\circ}\text{C} \\ \text{Panas latent bleeding} &= 553,9042 \frac{\text{Kcal}}{\text{kg}} \\ \text{Panas latent uap} &= 570,2755 \frac{\text{Kcal}}{\text{kg}}\end{aligned}$$

$$\begin{aligned} \text{KTD P hidrostatik} &= 3,6277 \\ \text{T nira keluar badan} &= T_{\text{uap badan}} + \text{KTD} \\ &= 51,3352 \text{ }^{\circ}\text{C} \\ \text{T nira masuk} &= 77,5910^{\circ}\text{C} \\ \text{Nira masuk} &= 99734,2490 \frac{\text{kg}}{\text{jam}} \\ \text{T kondensat} &= t_v - 0,4 (t_v - t_f) \\ &= 66,0299 \text{ }^{\circ}\text{C} \\ \text{Brix masuk} &= 40\% \\ \text{Brix keluar} &= 60\% \\ \text{Cp masuk} &= 1 - (0,006 \text{ Brix masuk}) \\ &= 0,997590772 \text{ Kcal/kg}^{\circ}\text{C} \\ \text{Cp keluar} &= 0,9964 \text{ Kcal/kg}^{\circ}\text{C} \end{aligned}$$

Perhitungan Panas masuk

$$\begin{aligned} \text{Nira masuk} &= \text{nira masuk} \times \text{cp brix masuk} \times T_{\text{masuk}} \\ &= 7719834,491 \frac{\text{Kcal}}{\text{jam}} \\ \text{bleeding} &= y \times \text{panas latent bleeding} \\ &= 17837956,74 \frac{\text{Kcal}}{\text{jam}} \end{aligned}$$

Perhitungan Panas keluar

$$\begin{aligned} \text{Nira keluar} &= (\text{nira masuk} - \text{uap keluar}) \times \\ &\quad \text{cp brix keluar} \times T_{\text{keluar}} \\ &= 5101442,073 - 51,1504 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Uap} &= y \times \text{panas latent Uap} \\ &= 570,2755 y \frac{\text{Kcal}}{\text{jam}} \\ \text{Kondensat} &= y \times \text{panas latent} \\ &= 2126430,1128 \frac{\text{Kcal}}{\text{jam}} \end{aligned}$$

Panas masuk = panas keluar

$$y = 35309,2489 \frac{kg}{jam}$$

Perhitungan Nilai Brix Setiap Badan secara Riil

➤ Evaporator Badan 1

$$\text{Berat masuk} = 257700 \frac{kg}{jam}$$

$$\text{Berat air yang teruapkan} = 69143,7395 \frac{kg}{jam}$$

$$\text{Brix masuk} = 15\%$$

$$\text{Brix keluar} = \frac{m.NE \times bne}{\text{berat masuk} - \text{air yang teruapkan}} = 21\%$$

➤ Evaporator Badan 2

$$\text{Berat masuk} = 188556,2605 \frac{kg}{jam}$$

$$\text{Berat air yang teruapkan} = 44259,6401 \frac{kg}{jam}$$

$$\text{Brix masuk} = 21\%$$

$$\text{Brix keluar} = \frac{m.NE \times bne}{\text{berat masuk} - \text{air yang teruapkan}} = 27\%$$

➤ Evaporator Badan 3

$$\text{Berat masuk} = 144296,6204 \frac{kg}{jam}$$

$$\text{Berat air yang teruapkan} = 24257,0196 \frac{kg}{jam}$$

$$\text{Brix masuk} = 27\%$$

$$\text{Brix keluar} = \frac{m.NE \times bne}{\text{berat masuk} - \text{air yang teruapkan}} = 32\%$$

➤ Evaporator Badan 4

$$\text{Berat masuk} = 120039,6007 \frac{kg}{jam}$$

$$\text{Berat air yang teruapkan} = 26528,3332 \frac{kg}{jam}$$

$$\text{Brix masuk} = 32\%$$

$$\text{Brix keluar} = \frac{m.NE \times bne}{\text{berat masuk} - \text{air yang teruapkan}} = 41\%$$

➤ Evaporator Badan 5

$$\begin{aligned} \text{Berat masuk} &= 93511,2676 \frac{\text{kg}}{\text{jam}} \\ \text{Berat air yang teruapkan} &= 29086,2676 \frac{\text{kg}}{\text{jam}} \\ \text{Brix masuk} &= 41\% \\ \text{Brix keluar} &= \frac{m.NE \times bne}{\text{berat masuk} - \text{air yang teruapkan}} \\ &= 60\% \end{aligned}$$

Tabel VIII. 1 Perhitungan Neraca Massa

NERACA MASSA					
EVAPORATOR BADAN 1					
Senyawa	Inlet		Outlet		
	Aliran F (Kg/jam)	Brix	Aliran L (Kg/jam)	Aliran V (Kg/jam)	Brix
Sukrosa	25770	15	25770	0	19
H2O	219045		161489,9755	57555,0245	
zat lainnya	12885		12885,0000	0	
TOTAL	257700		200144,9755	57555,0245	
			257700		
EVAPORATOR BADAN 2					
Senyawa	Inlet		Outlet		
	Aliran F (Kg/jam)	Brix	Aliran L (Kg/jam)	Aliran V (Kg/jam)	Brix
Sukrosa	25770	19	25770	0	24
H2O	161489,9755		122730,0833	38759,8921	
zat lainnya	12885,0000		12885,0000	0	
TOTAL	200144,9755		161385,0833	38759,8921	
			200144,9755		
EVAPORATOR BADAN 3					
Senyawa	inlet		Outlet		
	Aliran F (Kg/jam)	Brix	Aliran L (Kg/jam)	Aliran V (Kg/jam)	Brix
Sukrosa	25770	24	25770	0	29
H2O	122730.0833		93283.29569	29446.7877	

zat lainnya	12885,0000		12885,0000	0	
TOTAL	161385,0833		131938,2957	29446,7877	
			161385,0833		
EVAPORATOR BADAN 4					
Senyawa	Inlet		Outlet		
	Aliran F (Kg/jam)	Brix	Aliran L (Kg/jam)	Aliran V (Kg/jam)	Brix
Sukrosa	25770	29	25770	0	39
H2O	93283,29569		61079,24896	32204,0467	
zat lainnya	12885,0000		12885,0000	0	
TOTAL	131938,2957		99734,2490	32204,0467	
			131938,2957		
EVAPORATOR BADAN 5					
Senyawa	Inlet		Outlet		
	Aliran F (Kg/jam)	Brix	Aliran L (Kg/jam)	Aliran V (Kg/jam)	Brix
Sukrosa	25770	39	25770	0	60
H2O	61079,24896		25770	35309,2490	
zat lainnya	12885,0000		12885,0000	0	
TOTAL	99734,2490		64425	35309,2490	
			99734,2490		

Tabel VIII. 2 Perhitungan Neraca Panas

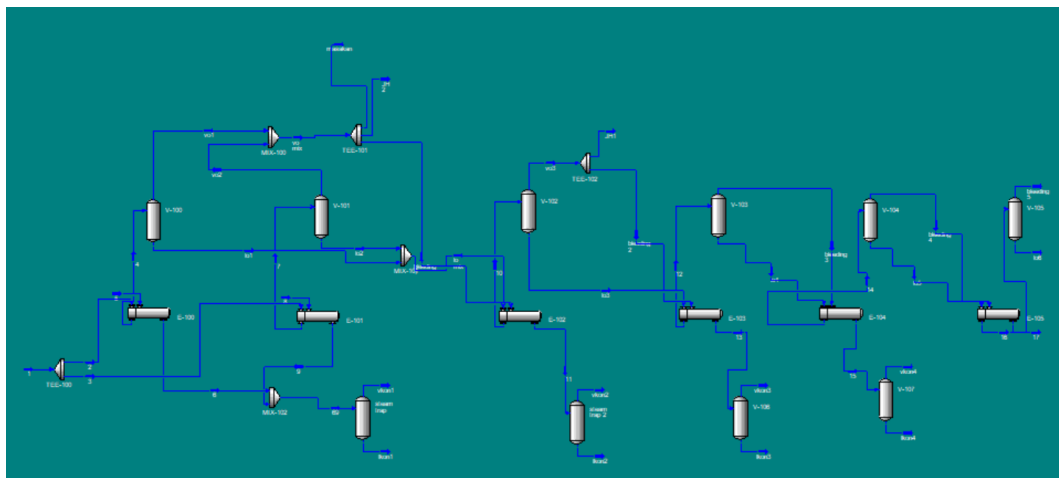
NERACA PANAS						
EVAPORATOR BADAN 1						
Komponen	Inlet			Outlet		
	Suhu (°C)	Brix	Aliran In (Kcal/jam)	Suhu (°C)	Brix	Aliran Out (Kcal/jam)
Nira	105	15	27034147,3500	109,7813	19	21947206,6014
UBE	115,45		32574593,5568	113,1825		6968199,4561
Uap badan				108,522		30693334,85
TOTAL			59608740,9068			59608740,9068
EVAPORATOR BADAN 2						



Komponen	Inlet			Outlet		
	Suhu (°C)	Bri x	Aliran In (Kcal/jam)	Suhu (°C)	Bri x	Aliran Out (Kcal/jam)
Nira	110	19	21947206,60	101,654 2	24	16381682,820 6
bleeding	108,52 2		19103763,796 6	105,774 9		3789139,8840
Uap badan				100,325 3		20880147,693 4
TOTAL			41050970,398 0			41050970,398 0
EVAPORATOR BADAN 3						
Komponen	Inlet			Outlet		
	Suhu (°C)	Bri x	Aliran In (Kcal/jam)	Suhu (°C)	Bri x	Aliran Out (Kcal/jam)
Nira	101,7	24	16381682,820 6	91,2256	29	12014364,712 9
bleeding	100,32 5		14237441,798 6	96,6854		2555300,6694
Uap badan				90,1123		16049459,236 9
TOTAL			30619124,619 2			30619124,619 2
EVAPORATOR BADAN 4						
Komponen	Inlet			Outlet		
	Suhu (°C)	Bri x	Aliran In (Kcal/jam)	Suhu (°C)	Bri x	Aliran Out (Kcal/jam)
Nira	91,226	29	12014364,712 9	77,5910	39	7719834,4907
bleeding	90,112		16049459,236 9	85,1038		2506032,7183
Uap badan				75,8264		17837956,740 9
TOTAL			28063823,949 8			28063823,949 8
EVAPORATOR BADAN 5						
Komponen	Inlet			Outlet		
	Suhu (°C)	Bri x	Aliran In (Kcal/jam)	Suhu (°C)	Bri x	Aliran Out (Kcal/jam)

Nira	77,591	39	7719834,4907	51,3352	60	3295361,5131
bleeding	75,826		17837956,7409	66,0299		2126430,1128
Uap badan				47,7075		20135999,6057
TOTAL			25557791,2316			25557791,2316

B. Simulasi Proses



Gambar IX. 2 PFD Simulasi Proses pada Stasiun Penguapan

Name	1	2	3	4	5	6
Vapour Fraction	0,0000	0,0000	0,0000	0,2580	1,0000	1,0000
Temperature [C]	105,0	105,0	105,0	104,4	121,0	119,0
Pressure [kPa]	117,1	117,1	117,1	115,1	166,7	141,7
Molar Flow [kgmole/h]	1,231e+004	6153	6153	6153	3290	3290
Mass Flow [kg/h]	2,577e+005	1,288e+005	1,288e+005	1,288e+005	5,928e+004	5,928e+004
Liquid Volume Flow [m3/h]	242,9	121,4	121,4	121,4	59,28	59,28
Heat Flow [kJ/h]	1,493e+008	7,463e+007	7,463e+007	7,599e+007	5,428e+007	5,292e+007
Name	vo1	lo1	7	8	9	vo2
Vapour Fraction	1,0000	0,0000	0,2580	1,0000	1,0000	1,0000
Temperature [C]	104,4	104,4	104,4	121,0	119,0	104,4
Pressure [kPa]	115,1	115,1	115,1	166,7	141,7	115,1
Molar Flow [kgmole/h]	1589	4564	6153	3291	3291	1587
Mass Flow [kg/h]	2,862e+004	1,002e+005	1,288e+005	5,928e+004	5,928e+004	2,860e+004
Liquid Volume Flow [m3/h]	28,62	92,82	121,4	59,28	59,28	28,60
Heat Flow [kJ/h]	2,100e+007	5,500e+007	7,599e+007	5,428e+007	5,292e+007	2,098e+007

Material Streams Compositions Energy Streams Unit Ops

1	2	3
Temperature	105,0 C	105,0 C
Pressure	117,1 kPa	117,1 kPa
Molar Flow	1,231e+004 kgmole/h	6153 kgmole/h
Master Comp Mass Flow (water*)	2,1905e+005 kg/h	1,0952e+005 kg/h
Master Comp Mass Flow (zat lainnya *)	12885 kg/h	6442,5 kg/h
Master Comp Mass Flow (sukrosa*)	25770 kg/h	12885 kg/h
4	5	6
Temperature	104,4 C	121,0 C
Pressure	115,1 kPa	166,7 kPa
Molar Flow	6153 kgmole/h	3290 kgmole/h
Master Comp Mass Flow (water*)	1,0952e+005 kg/h	59276 kg/h
Master Comp Mass Flow (zat lainnya *)	6442,5 kg/h	0,00000 kg/h
Master Comp Mass Flow (sukrosa*)	12885 kg/h	0,00000 kg/h

vo1			lo1			7		
Temperature	104,4	C	Temperature	104,4	C	Temperature	104,4	C
Pressure	115,1	kPa	Pressure	115,1	kPa	Pressure	115,1	kPa
Molar Flow	1589	kgmole/h	Molar Flow	4564	kgmole/h	Molar Flow	6153	kgmole/h
Master Comp Mass Flow (water*)	28619	kg/h	Master Comp Mass Flow (water*)	80904	kg/h	Master Comp Mass Flow (water*)	1,0852e+005	kg/h
Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	6442,5	kg/h	Master Comp Mass Flow (zat lainnya *)	6442,5	kg/h
Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	12885	kg/h	Master Comp Mass Flow (sukrosa*)	12885	kg/h

8			9			vo2		
Temperature	121,0	C	Temperature	119,0	C	Temperature	104,4	C
Pressure	166,7	kPa	Pressure	141,7	kPa	Pressure	115,1	kPa
Molar Flow	3291	kgmole/h	Molar Flow	3291	kgmole/h	Molar Flow	1587	kgmole/h
Master Comp Mass Flow (water*)	59280	kg/h	Master Comp Mass Flow (water*)	59280	kg/h	Master Comp Mass Flow (water*)	28598	kg/h
Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h
Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h

Name	lo2	vo mix	masakan	JH 2	bleeding 1	lo mix
Vapour Fraction	0,0000	0,9997	0,9997	0,9997	0,9997	0,0000
Temperature [C]	104,4	104,4	104,4	104,4	104,4	104,4
Pressure [kPa]	115,1	115,1	115,1	115,1	115,1	115,1
Molar Flow [kgmole/h]	4565	3176	1110	96,16	1970	9130
Mass Flow [kg/h]	1,003e+005	5,722e+004	2,000e+004	1732	3,548e+004	2,005e+005
Liquid Volume Flow [m3/h]	92,84	57,22	20,00	1,732	35,48	185,7
Heat Flow [kJ/h]	5,501e+007	4,198e+007	1,467e+007	1,271e+006	2,603e+007	1,100e+008

Name	10	vo3	lo3	JH1	bleeding 2
Vapour Fraction	0,2310	0,0000	1,0000	0,0000	1,0000
Temperature [C]	103,8	106,7	103,8	103,8	103,8
Pressure [kPa]	113,1	165,1	113,1	113,1	113,1
Molar Flow [kgmole/h]	9130	1970	2111	7019	684,5
Mass Flow [kg/h]	2,005e+005	3,548e+004	3,802e+004	1,625e+005	1,233e+004
Liquid Volume Flow [m3/h]	185,7	35,48	38,02	147,6	12,33
Heat Flow [kJ/h]	1,117e+008	2,435e+007	2,765e+007	8,404e+007	8,966e+006

Material Streams Compositions Energy Streams Unit Ops

lo2			vo mix			masakan		
Temperature	104,4	C	Temperature	104,4	C	Temperature	104,4	C
Pressure	115,1	kPa	Pressure	115,1	kPa	Pressure	115,1	kPa
Molar Flow	4565	kgmole/h	Molar Flow	3176	kgmole/h	Molar Flow	1110	kgmole/h
Master Comp Mass Flow (water*)	80925	kg/h	Master Comp Mass Flow (water*)	57217	kg/h	Master Comp Mass Flow (water*)	20000	kg/h
Master Comp Mass Flow (zat lainnya *)	6442,5	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h
Master Comp Mass Flow (sukrosa*)	12885	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h

JH 2			bleeding 1			lo mix		
Temperature	104,4	C	Temperature	104,4	C	Temperature	104,4	C
Pressure	115,1	kPa	Pressure	115,1	kPa	Pressure	115,1	kPa
Molar Flow	96,16	kgmole/h	Molar Flow	1970	kgmole/h	Molar Flow	9130	kgmole/h
Master Comp Mass Flow (water*)	1732,3	kg/h	Master Comp Mass Flow (water*)	35484	kg/h	Master Comp Mass Flow (water*)	1,6183e+005	kg/h
Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	12885	kg/h
Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	25770	kg/h

10			11			vo3		
Temperature	103,8	C	Temperature	106,7	C	Temperature	103,8	C
Pressure	113,1	kPa	Pressure	165,1	kPa	Pressure	113,1	kPa
Molar Flow	9130	kgmole/h	Molar Flow	1970	kgmole/h	Molar Flow	2111	kgmole/h
Master Comp Mass Flow (water*)	1,6183e+005	kg/h	Master Comp Mass Flow (water*)	35484	kg/h	Master Comp Mass Flow (water*)	38025	kg/h
Master Comp Mass Flow (zat lainnya *)	12885	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h
Master Comp Mass Flow (sukrosa*)	25770	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h

lo3			JH1			bleeding 2		
Temperature	103,8	C	Temperature	103,8	C	Temperature	103,8	C
Pressure	113,1	kPa	Pressure	113,1	kPa	Pressure	113,1	kPa
Molar Flow	7019	kgmole/h	Molar Flow	684,5	kgmole/h	Molar Flow	1426	kgmole/h
Master Comp Mass Flow (water*)	1,2380e+005	kg/h	Master Comp Mass Flow (water*)	12331	kg/h	Master Comp Mass Flow (water*)	25694	kg/h
Master Comp Mass Flow (zat lainnya *)	12885	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h
Master Comp Mass Flow (sukrosa*)	25770	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h

Name	12	13	bleeding 3	lo4	14	15
Vapour Fraction	0,2305	0,0000	1,0000	0,0000	0,3339	0,0000
Temperature [C]	103,2	105,9	103,2	103,2	102,2	105,6
Pressure [kPa]	111,1	158,1	111,1	111,1	108,1	151,1
Molar Flow [kgmole/h]	7019	1426	1619	5400	5400	1619
Mass Flow [kg/h]	1,625e+005	2,569e+004	2,917e+004	1,333e+005	1,333e+005	2,917e+004
Liquid Volume Flow [m3/h]	147,6	25,69	29,17	118,5	118,5	29,17
Heat Flow [kJ/h]	8,532e+007	1,740e+007	2,102e+007	6,430e+007	6,568e+007	1,964e+007
Name	bleeding 4	lo5	17	bleeding 5	lo6	69
Vapour Fraction	1,0000	0,0000	0,0000	1,0000	0,0000	1,0000
Temperature [C]	102,2	102,2	103,5	101,6	101,6	119,0
Pressure [kPa]	108,1	108,1	143,1	106,1	106,1	141,7
Molar Flow [kgmole/h]	1801	3599	1801	1798	1800	6581
Mass Flow [kg/h]	3,245e+004	1,008e+005	3,245e+004	3,240e+004	6,844e+004	1,186e+005
Liquid Volume Flow [m3/h]	32,45	86,02	32,45	32,40	53,62	118,6
Heat Flow [kJ/h]	2,305e+007	4,263e+007	2,114e+007	2,280e+007	2,174e+007	1,058e+008

Material Streams Compositions Energy Streams Unit Ops

12		13		bleeding 3	
Temperature	103,2 C	Temperature	105,9 C	Temperature	103,2 C
Pressure	111,1 kPa	Pressure	158,1 kPa	Pressure	111,1 kPa
Molar Flow	7019 kgmole/h	Molar Flow	1426 kgmole/h	Molar Flow	1619 kgmole/h
Master Comp Mass Flow (water*)	1,2380e+005 kg/h	Master Comp Mass Flow (water*)	25694 kg/h	Master Comp Mass Flow (water*)	29171 kg/h
Master Comp Mass Flow (zat lainnya *)	12885 kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h
Master Comp Mass Flow (sukrosa*)	25770 kg/h	Master Comp Mass Flow (sukrosa*)	0,00000 kg/h	Master Comp Mass Flow (sukrosa*)	0,00000 kg/h

14		15	
Temperature	103,2 C	Temperature	105,6 C
Pressure	111,1 kPa	Pressure	151,1 kPa
Molar Flow	5400 kgmole/h	Molar Flow	1619 kgmole/h
Master Comp Mass Flow (water*)	94633 kg/h	Master Comp Mass Flow (water*)	29171 kg/h
Master Comp Mass Flow (zat lainnya *)	12885 kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h
Master Comp Mass Flow (sukrosa*)	25770 kg/h	Master Comp Mass Flow (sukrosa*)	0,00000 kg/h

bleeding 4		lo5		17	
Temperature	102,2 C	Temperature	102,2 C	Temperature	103,5 C
Pressure	108,1 kPa	Pressure	108,1 kPa	Pressure	143,1 kPa
Molar Flow	1801 kgmole/h	Molar Flow	3599 kgmole/h	Molar Flow	1801 kgmole/h
Master Comp Mass Flow (water*)	32447 kg/h	Master Comp Mass Flow (water*)	62185 kg/h	Master Comp Mass Flow (water*)	32447 kg/h
Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h	Master Comp Mass Flow (zat lainnya *)	12885 kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h
Master Comp Mass Flow (sukrosa*)	0,00000 kg/h	Master Comp Mass Flow (sukrosa*)	25770 kg/h	Master Comp Mass Flow (sukrosa*)	0,00000 kg/h

bleeding 5		lo6		69	
Temperature	101,6 C	Temperature	101,6 C	Temperature	119,0 C
Pressure	106,1 kPa	Pressure	106,1 kPa	Pressure	141,7 kPa
Molar Flow	1798 kgmole/h	Molar Flow	1800 kgmole/h	Molar Flow	6581 kgmole/h
Master Comp Mass Flow (water*)	32388 kg/h	Master Comp Mass Flow (water*)	29787 kg/h	Master Comp Mass Flow (water*)	1,1856e+005 kg/h
Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h	Master Comp Mass Flow (zat lainnya *)	12885 kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000 kg/h
Master Comp Mass Flow (sukrosa*)	0,00000 kg/h	Master Comp Mass Flow (sukrosa*)	25770 kg/h	Master Comp Mass Flow (sukrosa*)	0,00000 kg/h

Name	lkon1	vkou1	vkou2	lkon2	16	vkou3
Vapour Fraction	0,0000	1,0000	1,0000	0,0000	0,5000	1,0000
Temperature [C]	119,0	119,0	106,7	106,7	101,6	105,9
Pressure [kPa]	141,7	141,7	140,1	140,1	106,1	158,1
Molar Flow [kgmole/h]	0,0000	6581	0,0000	1970	3599	0,0000
Mass Flow [kg/h]	0,0000	1,186e+005	0,0000	3,548e+004	1,008e+005	0,0000
Liquid Volume Flow [m3/h]	0,0000	118,6	0,0000	35,48	86,02	0,0000
Heat Flow [kJ/h]	0,0000	1,058e+008	0,0000	2,435e+007	4,454e+007	0,0000
Name	lkon3	vkou4	lkon4	** New **		
Vapour Fraction	0,0000	1,0000	0,0000			
Temperature [C]	105,9	105,6	105,6			
Pressure [kPa]	158,1	151,1	151,1			
Molar Flow [kgmole/h]	1426	0,0000	1619			
Mass Flow [kg/h]	2,569e+004	0,0000	2,917e+004			
Liquid Volume Flow [m3/h]	25,69	0,0000	29,17			
Heat Flow [kJ/h]	1,740e+007	0,0000	1,964e+007			

Material Streams Compositions Energy Streams Unit Ops

<table> <tr><td>Temperature</td><td>119,0</td><td>C</td></tr> <tr><td>Pressure</td><td>141,7</td><td>kPa</td></tr> <tr><td>Molar Flow</td><td>0,0000</td><td>kgmole/h</td></tr> <tr><td>Master Comp Mass Flow (water*)</td><td>0,00000</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (zat lainnya *)</td><td>0,00000</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (sukrosa*)</td><td>0,00000</td><td>kg/h</td></tr> </table>	Temperature	119,0	C	Pressure	141,7	kPa	Molar Flow	0,0000	kgmole/h	Master Comp Mass Flow (water*)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	<table> <tr><td>Temperature</td><td>119,0</td><td>C</td></tr> <tr><td>Pressure</td><td>141,7</td><td>kPa</td></tr> <tr><td>Molar Flow</td><td>6581</td><td>kgmole/h</td></tr> <tr><td>Master Comp Mass Flow (water*)</td><td>1,1856e+005</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (zat lainnya *)</td><td>0,00000</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (sukrosa*)</td><td>0,00000</td><td>kg/h</td></tr> </table>	Temperature	119,0	C	Pressure	141,7	kPa	Molar Flow	6581	kgmole/h	Master Comp Mass Flow (water*)	1,1856e+005	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h	<table> <tr><td>Temperature</td><td>106,7</td><td>C</td></tr> <tr><td>Pressure</td><td>140,1</td><td>kPa</td></tr> <tr><td>Molar Flow</td><td>0,0000</td><td>kgmole/h</td></tr> <tr><td>Master Comp Mass Flow (water*)</td><td>0,00000</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (zat lainnya *)</td><td>0,00000</td><td>kg/h</td></tr> <tr><td>Master Comp Mass Flow (sukrosa*)</td><td>0,00000</td><td>kg/h</td></tr> </table>	Temperature	106,7	C	Pressure	140,1	kPa	Molar Flow	0,0000	kgmole/h	Master Comp Mass Flow (water*)	0,00000	kg/h	Master Comp Mass Flow (zat lainnya *)	0,00000	kg/h	Master Comp Mass Flow (sukrosa*)	0,00000	kg/h
Temperature	119,0	C																																																						
Pressure	141,7	kPa																																																						
Molar Flow	0,0000	kgmole/h																																																						
Master Comp Mass Flow (water*)	0,00000	kg/h																																																						
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Gambar IX. 3 Hasil Perhitungan Material Streams

C. Perbandingan Hasil

Pada bagian ini dilakukan perbandingan data melalui 2 data yaitu data hasil perhitungan manual dan data berdasarkan simulasi unisim. Data yang dibandingkan berupa data neraca massa dan neraca panas pada evaporator *quintuple effect*. Perbandingan ini bertujuan untuk mengetahui tingkat perbedaan hasil antara perhitungan manual dengan perhitungan menggunakan simulasi unisim.

Tabel IX.1 Perbandingan Hasil Neraca Massa

perbandingan neraca masa					
Evaporator	Komponen	Jumlah Komponen		Selisih	%Selisih
		Perhitungan Manual	Simulasi Unisim		
Badan 1	Sukrosa	25770	25770	0	0,00%
	Air	161489,9755	161500,0485	10,07302	0,01%
	Zat lain	12885	12885	0	0,00%
Badan 2	Sukrosa	25770	25770	0	0,00%
	Air	123280,6108	122679,8156	600,7952	0,49%
	Zat lain	12885	12885	0	0,00%
Badan 3	Sukrosa	25770	25770	0	0,00%
	Air	94041,30874	93555,3415	485,9672	0,52%
	Zat lain	12885	12885	0	0,00%
Badan 4	Sukrosa	25770	25770	0	0,00%
	Air	61435,81082	61716,7559	280,9451	0,46%
	Zat lain	12885	12885	0	0,00%
Badan 5	Sukrosa	25770	25770	0	0,00%
	Air	22948,91798	26174,9228	3226,005	14,06%
	Zat lain	12885	12885	0	0,00%
Rata - rata					1,03%

Berdasarkan tabel perbandingan neraca massa antara hasil perhitungan manual dan simulasi menggunakan unisim pada rangkaian evaporator dapat diketahui bahwa secara umum hasil simulasi menunjukkan kesesuaian yang sangat baik dengan perhitungan manual. Hal ini ditunjukkan oleh selisih dan persentase selisih yang relative kecil bahkan untuk beberapa komponen tidak ditemukan perbedaan sama sekali. Perbedaan hasil perhitungan terjadi pada komponen air yang merupakan komponen volatile utama dalam proses evaporasi. Pada badan 1 hingga badan 4 persentase selisih massa air masih berada pada rentang yang kecil yaitu antara 0,01% hingga 0,52% sehingga dapat dianggap tidak signifikan dan masih dalam batas toleransi perhitungan Teknik. Namun, pada badan 5 persentase selisih massa air meningkat hingga 14,06% yang mengindikasikan adanya perbedaan pendekatan antara perhitungan manual dan simulasi. Secara keseluruhan, nilai rata-rata persentase selisih sebesar 1,03% menunjukkan bahwa hasil simulasi unisim telah mampu merepresentasikan neraca massa system evaporator dengan baik dan dengan demikian, simulasi yang dilakukan dapat digunakan sebagai alat bantu analisis yang andal untuk evaluasi kinerja evaporator sekaligus memvalidasi hasil perhitungan manual yang telah dilakukan.

Tabel IX. 2 Perbandingan Hasil Neraca Panas

Perbandingan Neraca Panas						
Evaporator	Komponen		Perhitungan manual	Simulasi Unisim	Selisih	%Selisih
Badan 1	Aliran masuk	Nira	27034147,35	35680000	8645852,65	32%
		Uap bekas	31362962,48	12970000	18392962,5	59%
	Aliran keluar	Nira	20913130,01	26280000	5366869,99	26%
		Kondensat	6586370,68	12000000	5413629,32	82%
		Uap bleeding	30897609,14	5018000	25879609,1	84%
Badan 2	Aliran masuk	Nira	20913130,01	26280000	5366869,99	26%
		Uap bleeding	19230905,66	5018000	14212905,7	74%
	Aliran keluar	Nira	15854956,41	20009000	4154043,59	26%
		Kondensat	3620758,89	5820000	2199241,11	61%
		Uap bleeding	20668320,37	6608000	14060320,4	68%
Badan 3	Aliran masuk	Nira	15854956,41	20009000	4154043,59	26%
		Uap bleeding	13998265,82	6608000	7390265,82	53%
	Aliran keluar	Nira	11430742,22	15370000	3939257,78	34%
		Kondensat	2396330,86	4159000	1762669,14	74%
		Uap bleeding	16026149,16	5023000	11003149,2	69%
Badan 4	Aliran masuk	Nira	11430742,22	15370000	3939257,78	34%
		Uap bleeding	16026149,16	5023000	11003149,2	69%
	Aliran keluar	Nira	6927049,38	10190000	3262950,62	47%
		Kondensat	2305429,32	2694000	388570,678	17%
		Uap bleeding	18224412,67	5510000	12714412,7	70%
Badan 5	Aliran masuk	Nira	6927049,38	10190000	3262950,62	47%
		Uap bleeding	18224412,67	5510000	12714412,7	70%
	Aliran keluar	Nira	1556541	519700	1036841	67%
		Kondensat	1646789,00	505200	1141589	69%
		Uap bleeding	21948132,06	5449000	16499132,1	75%
Rata - rata						54%

Berdasarkan table perbandingan neraca panas antara hasil perhitungan manual dan simulasi menggunakan unisim pada rangkaian evaporator terlihat bahwa terdapat yang cukup signifikan pada hamper

seluruh aliran panas baik pada aliran masuk maupun aliran keluar. Nilai persentase selisih panas bervariasi pada setiap badan evaporator dengan rata-rata selisih sebesar 54% yang menunjukkan bahwa kesesuaian antara perhitungan manual dan simulasi panas tidak sebaik neraca massa. Ketidaksesuaian ini dapat dijelaskan berdasarkan perbedaan pendekatan perhitungan panas antara metode manual dan metode simulasi. Pada buku Hugot, Handbook of cane sugar engineering perhitungan neraca panas evaporator dilakukan dengan pendekatan praktis dan empiris sedangkan simulasi Unisim menggunakan perhitungan neraca panas berdasarkan model termodinamika yang lebih kompleks. Akibatnya, nilai panas hasil simulasi bisa cenderung lebih besar atau lebih kecil dibandingkan hasil perhitungan manual. Hal ini sesuai dengan penjelasan Hugot bahwa perhitungan panas secara manual pada pabrik gula dimaksudkan sebagai pendekatan operasional bukan sebagai representasi termodinamika yang sepenuhnya akurat. Dengan demikian, meskipun terdapat perbedaan yang cukup besar antara neraca panas hasil perhitungan manual dan simulasi Unisim, hasil tersebut masih dapat diterima secara teknis selama simulasi digunakan untuk analisis kecenderungan proses dan evaluasi kinerja alat. Perhitungan manual berdasarkan Hugot tetap relevan sebagai acuan desain awal dan estimasi cepat sedangkan simulasi berfungsi sebagai alat validasi dan analisis lanjutan dengan tingkat ketelitian yang lebih tinggi.