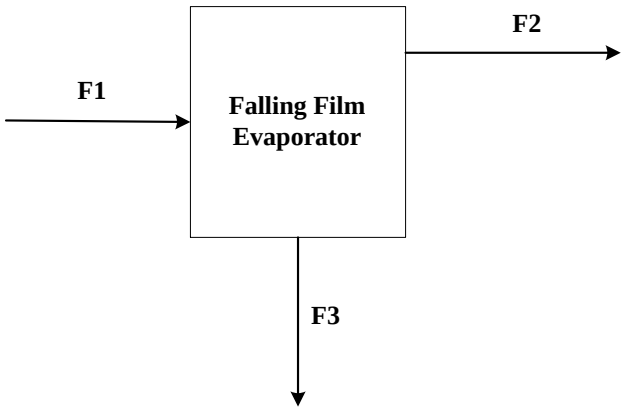
BAB IX
URAIAN TUGAS KHUSUS

EVALUASI FALLING FILM EVAPORATOR PADA PROSES PEMBUATAN MSG SECTION H56

Data yang diketahui :

T steam in ©		133,5
Q steam in FFE (kg/jam)		2833,3333
V in FFE (kL/h)		12,166
Rho out FFE		1,245
rho in FFE		1,2110



Perhitungan Neraca Massa Total

$$V_{F1} = 12{,}166\ kL/h$$

$$m_{F1} = V_{F1} \times \rho_{F1}$$

$$m_{F1} = \frac{12{,}166 \times 10^3 L}{h} \times \frac{1{,}211 g}{cm^3} \times \frac{1000 cm^3}{dm^3} \times \frac{1\ kg}{1000 g}$$

$$m_{F1} = \frac{14.733{,}026 kg}{h} = \frac{14{,}733026 ton}{h}$$

Perhitungan Neraca Massa Komponen MSG

1. Feed (F1)

$$m_{MSG} = \frac{12{,}166\ kL}{h} . \frac{42{,}25\ g}{dL} . \frac{10\ dL}{L}$$

$m_{MSG} = 5.140{,}135 \frac{kg}{h}$

$m_w = 14.733{,}026 \text{ kg} - 5.140{,}135 \text{ kg} = 9.592{,}891 \text{ kg}$

$$\rho_c = \frac{(m_w + m_{MSG})}{V_{total}}$$

$$\rho_c = \frac{m_w + m_{MSG}}{V_w + V_{MSG}}$$

Dengan :

$$\rho_w = \frac{m_w}{V_w}$$

ρ_w pada tekanan 260mmHg adalah 0,96 kg/L

$$\frac{0{,}96\ kg}{L} = \frac{9.592{,}891\ kg}{V_w}$$

$V_w = 9.992{,}594$ L

Sehingga

$$1{,}211 \frac{kg}{L} = \frac{14.733{,}026 \text{ kg}}{9.992{,}594L + V_{MSG}}$$

$V_{MSG} = 2.173{,}406$ L

2. Discharge (F3)

Menghitung massa air discharge:

$$\rho_c = \frac{m_w + m_{MSG}}{V_w + V_{MSG}}$$

$$\rho_c = \frac{m_w + m_{MSG}}{\frac{m_w}{\rho_w} + V_{MSG}}$$

$$1{,}245 \frac{kg}{l} = \frac{(m_w + 5.140{,}135kg)}{\frac{m_w}{0{,}96 \frac{kg}{l}} + 2.173{,}406\ L}$$

$m_{wout} = 8.199{,}560\ kg$

$m_{f3} = m_w + m_{MSG}$

$m_{f3} = 8.199{,}560\ kg + 5.140{,}135$ kg

$= 13.339{,}695\ kg$

Menghitung volume air discharge

$$V_{wout} = 8.199{,}560\ kg.\frac{L}{0{,}96\ kg} = 8.541{,}208\ L$$

Menghitung volume total discharge

$V_{f3} = V_{MSG} + V_w$

$V_{f3} = 2.173{,}406\ \text{L} + 8.541{,}208\ L = 10.714{,}614\ L$

3. Vapour (F2)

$$m_v = m_{w_{in}} - m_{w_{out}} = 9.592{,}891\ kg - 8.199{,}560\ kg$$

$$m_v = 1.393{,}331\ kg/\text{h}$$

Neraca Massa Komponen			
Komponen	Massa (Kg/jam)		
	Input	Output	
	F1	F2	F3
MSG	5.140,135		5.140,135
H2O	9.592,891	1.393,331	8.199,560
Total	14.733,026	14.733,026	

Perhitungan Neraca Panas

Data yang diketahui

Steam In = 2833,333 Kg/Jam

T = 133,5

P = 3 Bar

$$\Delta H = n \int_{T\,ref}^{T} Cp\, dT = n \int_{T\,ref}^{T} (A + B.T + C.T^2 + D.T^{-2}) dT$$

$$\Delta H = n[(A(T - T_{ref}) + \frac{B}{2}(T^2 - {T_{ref}}^2) + \frac{C}{3}(T^3 - {T_{ref}}^3) + D\left(\frac{T - T_{ref}}{T \times T_{ref}}\right)]$$

Komponen	BM	A	B	C	D	Literatur
$H_2O_{(g)}$	18	8,22	0,00015	0,00000134		Perry 7ed:T.-194
$H_2O_{(l)}$	18	7,701	$4{,}505 \times 10^{-4}$	$2{,}2521 \times 10^{-6}$	$-8{,}590 \times 10^{-10}$	Sheerwood:App A:20

$$\Delta H_{H_2O} = n[(8{,}22(363{,}15 - 298{,}15) + \left(\frac{0{,}00015}{2} \times (374{,}15^2 - 298{,}15^2)\right) + \left(\frac{0{,}00000134}{3} \times (374{,}15^3 - 298{,}15^3)\right)$$

Tekanan Operasi = 260mmHg

Suhu Operasi = 112℃ = 385,15 K

Neraca Energi Total

Entalpi Bahan Masuk

Komponen	Berat (kg/jam)	BM	n(kmol/jam)	$\int_{T_{ref}}^{T} Cp.dT$ (kkal/kmol)	ΔH (kkal/jam)
$C_5H_8NO_4Na$	5.140,135	169	30,415		94.894,8
H_2O	9.592,891	18	532,938	526,302	280.486,335
Total	14.733,026				375.381,135

Feed masuk pada suhu 90 ℃ = 363,15 K

$$\Delta H_{MSG} = n \times Cp \times dT = 30{,}415\ kmol\ \times 48 \frac{kkal}{kmol\ K} \times (363{,}15 - 298{,}15)K$$

$$\Delta H_{MSG} = 94.894{,}8 \frac{kkal}{jam}$$

$$\Delta H_{H_2O} = n \int_{T_{ref}}^{T} Cp\, dT = n[(A(T - T_{ref}) + \frac{B}{2}(T^2 - {T_{ref}}^2) + \frac{C}{3}(T^3 - {T_{ref}}^3) + D\left(\frac{T - T_{ref}}{T \times T_{ref}}\right)]$$

$$\Delta H_{H_2O} = 532{,}938 kkmol[(7{,}701(363{,}15 - 298{,}15) + \left(\frac{4{,}505 \times 10^{-4}}{2} \times (363{,}15^2 - 298{,}15^2)\right) + \left(\frac{2{,}2521 \times 10^{-6}}{3} \times (363{,}15^3 - 298{,}15^3)\right) + 8{,}590 \times 10^{-10} \times \left(\frac{363{,}15 - 298{,}15}{363{,}15 \times 298{,}15}\right)$$

$$\Delta H_{H_2O} = 280.486{,}335 \frac{kkal}{jam}$$

Entalpi Bahan Keluar

Komponen	Berat (kg/jam)	BM	n(kmol/jam)	$\int_{T_{ref}}^{T} Cp.dT$ (kkal/kmol)	ΔH (kkal/jam)
$C_5H_8NO_4Na$	5.140,135	169	30,415		110.953,92
H_2O	8.199,560	18	455,531	616,2079	280.701,800
H_2O (vapour)	1.393,331	18	77,407	640,108	49.548,839
Total	14.733,026				801.712,658

Feed keluar pada suhu 101 ℃ = 374,15 K

$$\Delta H_{MSG} = n \times Cp \times dT = 30{,}415\ kmol\ \times 48 \frac{kkal}{kmol\ K} \times (374{,}15 - 298{,}15)K$$

$$\Delta H_{MSG} = 94.894{,}8 \frac{kkal}{jam}$$

$$\Delta H_{H_2O(l)} = 455{,}531\ kkmol[(7{,}701(374{,}15 - 298{,}15) + \left(\frac{4{,}505\times10^{-4}}{2} \times (374{,}15^2 - 298{,}15^2)\right) + \left(\frac{2{,}2521\times10^{-6}}{3} \times (374{,}15^3 - 298{,}15^3)\right) + 8{,}590 \times 10^{-10} \times \left(\frac{374{,}15-298{,}15}{374{,}15\times298{,}15}\right)$$

$$\Delta H_{H_2O(l)} = 280.701{,}800\,\frac{kkal}{jam}$$

$$\lambda\, H_2O = 9.717\,\frac{kkal}{kmol}$$

$$\Delta H_{H_2O(g)} = (77{,}407[\left(8{,}22(363{,}15 - 298{,}15) + \left(\frac{0{,}00015}{2} \times (374{,}15^2 - 298{,}15^2)\right) + \left(\frac{0{,}00000134}{3} \times (374{,}15^3 - 298{,}15^3)\right)\right) + 77{,}407 \times 9.717\,\frac{kkal}{kmol}$$

$$\Delta H_{H_2O(g)} = 801.712{,}658\,\frac{kkal}{jam}$$

Kebutuhan steam

Steam yang digunakan pada tekanan 3 bar dan pada suhu 133,5℃

Massa Steam = 2833,333 Kg/Jam

$$\lambda\, steam = 2723{,}7\,\frac{kj}{kg} = 650{,}954\,\frac{kkal}{kg}$$

Specific Enthalpy of Superheated Steam	2724.89	kJ/kg
Specific Enthalpy of Superheated Steam	650.954	kcal/kg

$$Q\ steam = 2833{,}33\,\frac{kg}{jam} \times 650{,}954\,\frac{kkal}{kg} = 1.844.367{,}496\,\frac{kkal}{jam}$$

$$Q\ loss = 10\% \times 2833{,}33\,\frac{kg}{jam} \times 650{,}954\,\frac{kkal}{kg} = 184.436{,}749\,\frac{kkal}{jam}$$

$$\Delta H_{in\ total} = (94.894{,}8 + 280.486{,}335 + 1.844.367{,}496)\,\frac{kkal}{jam}$$

$$\Delta H_{in\ total} = 2.219.748{,}631\,\frac{kkal}{jam}$$

$$\Delta H_{out\ total} = (110.953{,}92 + 280.701{,}800 + 801.712{,}658 + 184.436{,}749)\,\frac{\text{kkal}}{\text{jam}}$$

$$\Delta H_{out\ total} = 1.377.805{,}127\,\frac{kkal}{jam}$$

$$efisiensi\ FFE = \frac{\Delta H_{out\ total}}{\Delta H_{in\ total}} \times 100\%$$

$$efisiensi\ FFE = \frac{1.377.805{,}127\,\frac{kkal}{jam}}{2.219.748{,}631\,\frac{kkal}{jam}} \times 100\%$$

$$efisiensi\ FFE = 62{,}07\%$$