LAMPIRAN A

PERHITUNGAN EFISIENSI VAPORIZER

1) Data Vaporizer Awal Pabrik didirikan tahun 2013 :

Data	Nilai	Satuan	Nilai	Satuan
Feed	80	Ton/jam	80000	Kg/jam
Produk	59,26	Ton/jam	59260	Kg/jam
Vapor	20,74	Ton/jam	20740	Kg/jam
Steam	27,68	Ton/jam	27680	Kg/jam
XF	0,4			
XL	0,54			
T Feed	50	^oC	122	^oF
T Produk	88	^oC	190	^oF
T Steam	133	^oC	271	^oF
T Vapor	88	^oC	190	^oF
P Steam	2	bar		

1. Perhitungan Neraca Massa

   A. Neraca Massa Over All

$$F = L + V$$

$$80000\frac{Kg}{jam} = 59259{,}259\frac{Kg}{jam} + V$$

$$V = (80000 - 59259{,}259)\frac{Kg}{jam}$$

$$V = 20740{,}7407\frac{Kg}{jam}$$

Jadi Vapor yang dihasilkan sebesar 20740,7407 Kg/jam

   B. Neraca Massa Komponen

$$F.XF = L.XL + V.y$$

$$80000\frac{Kg}{jam} \times 0{,}4 = (L \times 0{,}54) + 0$$

$$32000\frac{Kg}{jam} = 0{,}54L$$

$$L = 59259{,}259\frac{Kg}{jam}$$

Jadi Produk Asam Fosfat 54% yang dihasilkan sebesar 59259,259 Kg/jam

2. Perhitungan Neraca Energi

$$Qinput = Qoutput$$

$$F.hF + S.Hs = L.hL + V.Hv + C.hc$$

$$F.hF + S(Hs + hc) = L.hL + V.Hv$$

$$F.hF + S.\lambda = L.hL + V.Hv$$

Dari Steam Table McCabe Appendix 7 diperoleh :

Tf = 122°F	hF	=	90	Btu/lb	=	209,34	kJ/Kg
Tv = 190°F	Hv	=	1142	Btu/lb	=	2656,292	kJ/Kg
Tl = 190°F	hL	=	158	Btu/lb	=	367,508	kJ/Kg
Ts = 271°F	Hs	=	1171,3	Btu/lb	=	2724,4438	kJ/Kg
Tc = 271°F	hc	=	240	Btu/lb	=	558,24	kJ/Kg

Interpolasi (hF)		Interpolasi (Hs)		Interpolasi (hc)	
Suhu (°F)	hF (Btu/lb)	Suhu (°F)	hL (Btu/lb)	Suhu (°F)	hL (Btu/lb)
120	88	270	1171	270	239
130	98	280	1174	280	249
122	90	271	1171,3	271	240

$$F.hF + S(Hs - hc) = L.hL + V.Hv$$

$$80000(209,34) + S(2724,4438 - 558,24) = 59529,259(367,508) + 20740,7407(2656,292)$$

$$16747200 + S(2166,2038) = 21778252 + 55093463,7$$

$$S = 27755,7\frac{Kg}{jam}$$

Banyak panas yang dipindahkan dari permukaan bidang pemanas adalah

$$Q = S \times \lambda$$

$$Q = 277555,7\frac{Kg}{jam} \times 2166,2038\frac{kJ}{Kg}$$

$$Q = 60124515,6\frac{kJ}{jam}$$

3. Perhitungan Koefisiensi Panas

   Diameter (D) = 6000 mm = 6 m

   Panjang Tube (t) = 4200 mm = 4,2 m

$$A = 2\pi r(r + t)$$

$$A = 2 \times 3{,}14 \times 3 \times (3 + 4{,}2)$$

$$A = 135{,}648\ m^2$$

   Diperoleh nilai luas permukaan vaporizer sebesar 135,648 m^2

$$Q = U \times A \times (Ts - Tv)$$

$$60124515{,}6\frac{kJ}{jam} = U \times 135{,}648\ m^2 \times (271 - 190)°\text{F}$$

$$U = 5472{,}089\frac{kJ}{m^2.jam.°\text{F}}$$

   Jadi nilai koefisien perpindahan panas (U) sebesar 5472,089 kJ/m^2.jam.°F

4. Perhitungan Steam Ekonomi

   Nilai Steam Ekonomi untuk Single Evaporator ≤ 1

$$SE = \frac{V}{S}$$

$$SE = \frac{20740{,}7407\ Kg/jam}{27755{,}7\ Kg/jam}$$

$$SE = 0{,}747$$

   Jadi nilai Steam Ekonomi memenuhi untuk single evaporator

5. Perhitungan Efisiensi Vaporizer

$$Efisiensi = \frac{Steoritis}{Saktual}$$

$$Efisiensi = \frac{27756\frac{Kg}{jam}}{27680\frac{Kg}{jam}} \times 100\%$$

$$Efisiensi = 100\%$$

   Jadi efisiensi vaporizer awal pabrik didirikan tahun 2013 sebesar 100 %

2) Data Aktual Vaporizer tahun 2024 :

Data	Nilai	Satuan	Nilai	Satuan
Feed	50	Ton/jam	50000	Kg/jam
Produk	37	Ton/jam	37037,037	Kg/jam
Vapor	12,962	Ton/jam	12962	Kg/jam
Steam	20	Ton/jam	20000	Kg/jam
XF	0,4			
XL	0,54			
T Feed	58	^oC	136	^oF
T Produk	78	^oC	172	^oF
T Steam	120	^oC	248	^oF
T Vapor	88	^oC	190	^oF
P Steam	1,36	bar		

6. Perhitungan Neraca Massa

C. Neraca Massa Over All

$$F = L + V$$

$$50000\,\frac{Kg}{jam} = 37037{,}037\,\frac{Kg}{jam} + V$$

$$V = (50000 - 37037{,}037)\,\frac{Kg}{jam}$$

$$V = 12962\,\frac{Kg}{jam}$$

Jadi Vapor yang dihasilkan sebesar 12962 Kg/jam

D. Neraca Massa Komponen

$$F.XF = L.XL + V.y$$

$$50000\,\frac{Kg}{jam} \times 0{,}4 = (L \times 0{,}54) + 0$$

$$20000\,\frac{Kg}{jam} = 0{,}54L$$

$$L = 37037{,}037\,\frac{Kg}{jam}$$

Jadi Produk Asam Fosfat 54% yang dihasilkan sebesar 37037,037 Kg/jam

7. Perhitungan Neraca Energi

$$Qinput = Qoutput$$

$$F.hF + S.Hs = L.hL + V.Hv + C.hc$$

$$F.hF + S(Hs + hc) = L.hL + V.Hv$$

$$F.hF + S.\lambda = L.hL + V.Hv$$

Dari Steam Table McCabe Appendix 7 diperoleh :

Tf = 136°F	hF	=	104	Btu/lb	=	241,904	kJ/Kg
Tv = 190°F	Hv	=	1142	Btu/lb	=	2656,292	kJ/Kg
Tl = 172°F	hL	=	140	Btu/lb	=	325,64	kJ/Kg
Ts = 248°F	Hs	=	1163,3	Btu/lb	=	2705,8358	kJ/Kg
Tc = 248°F	hc	=	216,452	Btu/lb	=	503,4674	kJ/Kg

Interpolasi (hF)		Interpolasi (hL)		Interpolasi (Hs)		Interpolasi (hc)	
Suhu (°F)	hF (Btu/lb)	Suhu (°F)	hL (Btu/lb)	Suhu (°F)	hL (Btu/lb)	Suhu (°F)	hL (Btu/lb)
130	98	170	138	240	1160,5	240	208,34
140	108	180	148	250	1164	250	218,48
136	104	172	140	248	1163,3	248	216,452

$$F.hF + S(Hs + hc) = L.hL + V.Hv$$

$$50000(241{,}904) + S(2705{,}8358 - 503{,}4674) = 37037{,}037(325{,}64) + 12962(2656{,}292)$$

$$12095200 + S(2202{,}3684) = 12060740{,}7 + 34433414{,}8$$

$$S = 15619{,}1\frac{Kg}{jam}$$

Banyak panas yang dipindahkan dari permukaan bidang pemanas adalah

$$Q = S \times \lambda$$

$$Q = 15619{,}1\frac{Kg}{jam} \times 2202{,}3684\frac{kJ}{Kg}$$

$$Q = 34398955{,}6\frac{kJ}{jam}$$

8. Perhitungan Koefisiensi Panas

   Diameter (D) = 6000 mm = 6 m

   Panjang Tube (t) = 4200 mm = 4,2 m

$$A = 2\pi r(r + t)$$

$$A = 2 \times 3{,}14 \times 3 \times (3 + 4{,}2)$$

$$A = 135{,}648\ m^2$$

   Diperoleh nilai luas permukaan vaporizer sebesar 135,648 m^2

$$Q = U \times A \times (Ts - Tv)$$

$$34398956{,}6\frac{kJ}{jam} = U \times 135{,}648\ m^2 \times (271 - 190)°\text{F}$$

$$U = 4372{,}2387\frac{kJ}{m^2.jam.°\text{F}}$$

   Jadi nilai koefisien perpindahan panas (U) sebesar 4372,2387 kJ/m^2.jam.^{o}F

9. Perhitungan Steam Ekonomi

   Nilai Steam Ekonomi untuk Single Evaporator ≤ 1

$$SE = \frac{V}{S}$$

$$SE = \frac{12962{,}963\ Kg/jam}{15619{,}1\ Kg/jam}$$

$$SE = 0{,}83$$

   Jadi nilai Steam Ekonomi memenuhi untuk single evaporator

10. Perhitungan Efisiensi Vaporizer

$$Efisiensi = \frac{Steoritis}{Saktual}$$

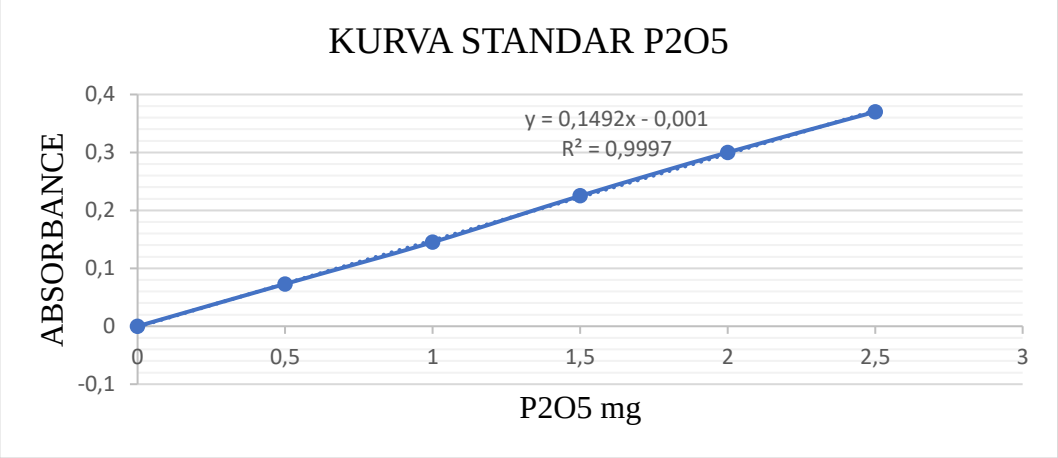
$$Efisiensi = \frac{15619{,}1\frac{Kg}{jam}}{20000\frac{Kg}{jam}} \times 100\%$$

$$Efisiensi = 78\%$$

   Jadi efisiensi vaporizer pabrik tahun 2024 sebesar 100 %

LAMPIRAN B
PERHITUNGAN CRYSTAL MODIFIER

1. Perhitungan % P_2O_5 pada Filtrat (Seal Tank)



A. Tanpa Surfaktan

$$\%\ P_2O_5 = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5 = \frac{\left(\left(\frac{0{,}805 + 0{,}0001429}{0{,}149}\right) \times 25\right)}{543{,}5\ mg} \times 100\%$$

$$\%\ P_2O_5 = 24{,}851\ \%$$

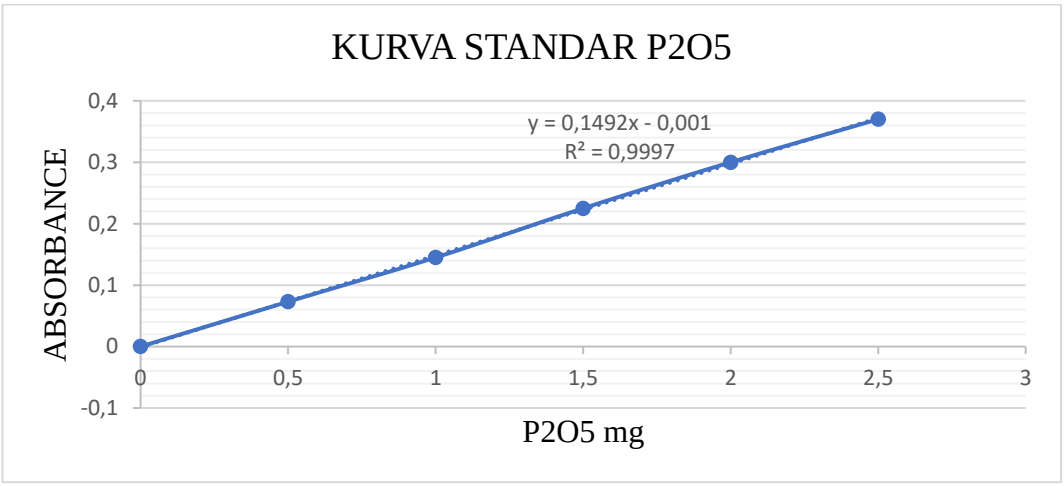
B. Surfaktan 1,5 ml

$$\%\ P_2O_5 = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5 = \frac{\left(\left(\frac{0{,}842 + 0{,}0001429}{0{,}149}\right) \times 25\right)}{486{,}1\ mg} \times 100\%$$

$$\%\ P_2O_5 = 29{,}528\ \%$$

2. Perhitungan % P_2O_5 Total pada Cake (Seal Tank)



A. Tanpa Surfaktan

$$\%\ P_2O_5\ Total = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5\ Total = \frac{\left(\left(\frac{0{,}828 + 0{,}000333}{0{,}149}\right) \times 50\right)}{2153{,}5\ mg} \times 100\%$$

$$\%\ P_2O_5\ Total = 11{,}074\ \%$$

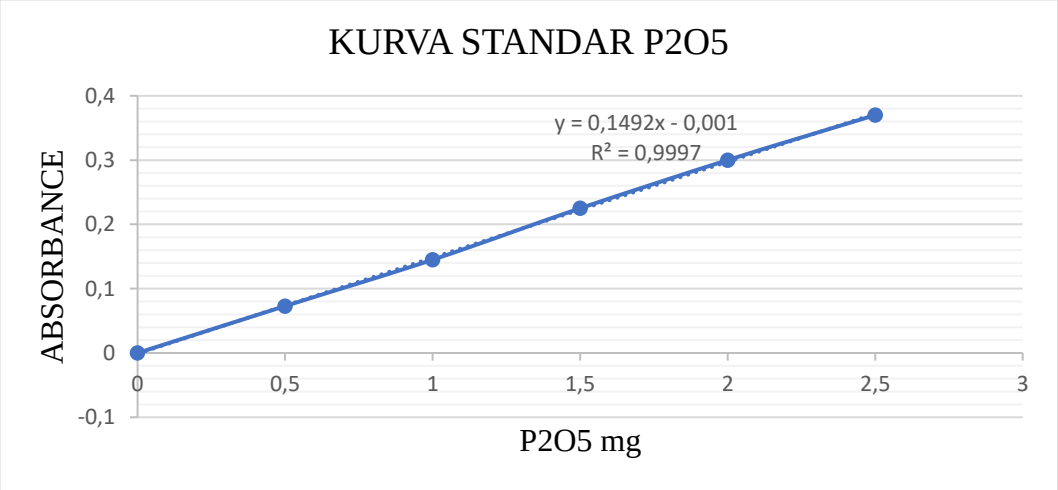
B. Surfaktan 1,5 ml

$$\%\ P_2O_5\ Total = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5\ Total = \frac{\left(\left(\frac{0{,}797 + 0{,}000333}{0{,}149}\right) \times 50\right)}{2508{,}2\ mg} \times 100\%$$

$$\%\ P_2O_5\ Total = 10{,}68\ \%$$

3. Perhitungan % P_2O_5 WS pada Cake (Seal Tank)



A. Tanpa Surfaktan

$$\%\ P_2O_5\ WS = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5\ WS = \frac{\left(\left(\frac{0{,}866 + 0{,}000619}{0{,}149}\right) \times 25\right)}{2506{,}3\ mg} \times 100\%$$

$$\%\ P_2O_5\ WS = 5{,}81\ \%$$

B. Surfaktan 1,5 ml

$$\%\ P_2O_5\ WS = \frac{\left(\left(\frac{Abs + Intercept}{Slope}\right) \times Faktor\ Pengenceran\right)}{massa(mg)} \times 100\%$$

$$\%\ P_2O_5\ WS = \frac{\left(\left(\frac{0{,}876 + 0{,}000333}{0{,}149}\right) \times 25\right)}{2502{,}5\ mg} \times 100\%$$

$$\%\ P_2O_5\ WS = 5{,}88\ \%$$