BAB IV

NERACA MASSA DAN NERACA PANAS

Bahan baku : Asam Asetat dan Hidrogen

Produk : Asetaldehida

Kapasitas Produksi : 50.000 ton/tahun

Operasi : 300 hari/tahun

Basis Perhitungan : 1 jam operasi

Satuan Massa : kg (kilogram)

Temperatur Referensi : $25^{o}C$

Satuan Panas : kilo Joule (kJ)

4.1. NERACA MASSA

4.1.1. Mixing Point-01 (MP-01)

Komponen	Input (Kg/jam)		Output(Kg/jam)
	Aliran 1	Aliran 43	Aliran 2
CH_3COOH	12.881,35	15.735,90	28.617,25
H_2O	17,09	1,45	17,21
Sub total	12.898,44	15.737,35	28.634,46
Total	**28.634,46**		**28.634,46**

4.1.2. Evaporator-01 (EV-01)

Komponen	Input (Kg/jam)	Output (Kg/jam)	
	Aliran 2	Uap Aliran 3	Liquid Aliran
CH_3COOH	28.617,25	28.614,39	2,86
H_2O	17,21	17,21	0,001
Sub total	**28.634,46**	**28.631,60**	**2,861**
Total	**28.634,46**	**28.634,46**	

4.1.3. Mix Point-02 (MP-02)

Komponen	Input (kg/jam)		Output (kg/jam)
	Recyle	Make up	
	Aliran 4	**Aliran 44**	**Aliran 5**
H_2	12.884,27	591,42	13.475,69
CO_2	10,03	-	10,03
C_2H_4	25,56	-	25,56
CO	6,38	-	6,38
CH_4	3,65	-	3,65
Total	**13.521,31**		**13.521,31**

4.1.4. Mix Point-03 (MP-03)

Komponen	Input (kg/jam)		Output (kg/jam)
	Aliran 6	**Aliran 3**	**Aliran 7**
H_2	13.475,69		13.475,69
CH_3COOH		28.614,39	28.614,39
H_2O		17,21	17,21
CO_2	10,03		10,03
C_2H_4	25,56		25,56
CH_4	6,38		6,38
C_2H_4	3,65		3,65
Subtotal	**13.521,31**	**28.631,61**	**42.152,91**
Total	**42.152,91**		**42.152,91**

4.1.5. Reaktor-01 (R-01)

Komponen	Input (kg/jam)	Output (kg/jam)

	Aliran 9	Aliran 10
CH_3COOH	28.614,40	15.737,92
H_2	13.475,69	12.951,72
CH_3CHO		6.944,44
CH_3CH_2OH		1.815,72
CO_2	10,03	112,06
H_2O	17,21	4.022,98
CH_3COCH_3		134,6
CO	6,38	77,70
CH_4	3,65	44,49
C_2H_6	25,56	311,14
Total	**42.152,900**	**42.152,90**

4.1.6. Parsial Kondensor-01 (PC-01)

Komponen	Input (kg/jam)	Output (kg/jam)	
	Aliran 13	Aliran 14	Aliran
H_2	12.951,72	12.951,72	0,000
H_2O	40.22,98	0,000	40.22,98
CO_2	112,06	112,06	0,000
C_2H_6	311,14	311,140	0,000
CH_3COOH	15.737,92	$4{,}04 \times 10^{-49}$	15.737,92
CH_3CH_2OH	1.815,72	$3{,}1 \times 10^{-49}$	1.815,72
CH_3CHO	6.944,44	$2{,}97 \times 10^{-49}$	6.944,44
CH_3COCH_3	134,65	$3{,}91 \times 10^{-49}$	134,65
CO	77,70	77,70	0,000
CH_4	44,49	44,496	0,000
Total	**42.152,84**	**42.152,84**	

4.1.7 .Knock Out Drum (KOD-01)

Komponen	Input (kg/jam)	Output (kg/jam)	
		Massa uap	Massa liquid
	Aliran 14	Aliran 16	Aliran 15

H_2	12.951,72	12.951,72	0,000
H_2O	40.22,98	0,000	40.22,98
CO_2	112,06	112,06	0,000
C_2H_6	311,14	311,14	0,000
CH_3COOH	15.737,92	$4{,}04 \times 10^{-49}$	15.737,92
CH_3CH_2OH	1.815,72	$3{,}1 \times 10^{-49}$	1.815,72
CH_3CHO	6.944,44	$2{,}97 \times 10^{-49}$	6.944,44
CH_3COCH_3	134,65	$3{,}91 \times 10^{-49}$	134,65
CO	77,70	77,70	0,000
CH_4	44,49	44,49	0,000
Total	**42.152,84**	**42.152,84**	

4.1.8. Absorber-01 (AB-01)

Komponen	**Input (kg/jam)**		**Output (kg/jam)**	
	Aliran 18	**Aliran 22**	**Aliran 19**	**Aliran 20**
H_2	12.951,720	-	-	12.951,72
H_2O	-	115.885,44	115.885,44	-
CO_2	112,060	-	102,72	9,33
C_2H_4	311,140	-	283,23	25,92
CO	77,700	-	71,23	6,47
CH_4	44,496	-	40,79	3,71
Sub total	**13.497,120**	-	**116.385,4**	**12.997,15**
Total	**129.382,56**		**129.382,56**	

4.1.9. Flash Drum-01 (FD-01)

Komponen	**Input (Kg/jam)**	**Output (Kg/jam)**	
		Uap	**Liquid**

	Aliran 21	Aliran 25	Aliran 24
H_2O	115.885	113.432	2453,73
CO_2	102,724	25,89	76,84
C_2H_4	285,225	100,238	184,987
CO	71,228	1,8 E-06	71,23
CH_4	40,789	9,435	31,35
Sub total	**116.385**	**113.567**	**2.818,14**
Total	**116.385**	**116.385**	

4.1.10. Kolom Distilasi-01 (KD-01)

Komponen	Input (Kg/jam)	Output (Kg/jam)	
		Top	Bottom
	Aliran 27	Aliran 29	Aliran 28
CH_3COOH	15.737,920	0,647	15.737,272
C_2H_5OH	1.815,724	0,006	1.815,720
C_2H_4O	6.944,444	6.942,96	1,490
C_3H_6O	134,651	6.4E-05	134.650
H_2O	4.022,979	0,066	4.022.910
Subtotal	**28.655,72**	**6.942,46**	**21.713,26**
Total	**28.655,72**	**28.655,72**	

4.1.11. Accumulator-01 (ACC-01)

Komponen	Input (Kg/jam)	Output (Kg/jam)	
	Aliran 30	Aliran 31	Aliran 32
CH_3COOH	2,14	1,49	0,6472
C_2H_5OH	0,02	0,013	0,006

C_2H_4O	22.922,15	15.978,35	6.943,80
C_3H_6O	0,0002	0,0002	6,42E-05
H_2O	0,22	0,151	0,066
Subtotal	**22.924,52**	**15.980,00**	**6.944,52**
Total	**22.924,52**	**22.924,52**	

4.1.12. Reboiler (RB-01)

Komponen	**Input (kg/jam)**	**Output (kg/jam)**	
	Aliran 28	**Bottom produk Aliran 34**	**Refluk Aliran 33**
CH_3COOH	31.274,930	15.735,906	15.538,200
C_2H_5OH	3.608,410	1.815,553	1.792,750
C_2H_4O	2,956	2,687	1,469
C_3H_6O	267,594	134,639	132,948
H_2O	7.994,801	4.022,555	3.972,030
subtotal	**31.274,930**	**21.711,339**	**21.437,400**
total	**43.148,690**	**43.148,690**	

4.1.13. Kolom Distilasi (KD-02)

Komponen	**Input (Kg/jam)**	**Output (Kg/jam)**	
	Aliran 35	**Top Aliran 37**	**Bottom Aliran 36**
CH_3COOH	15.736,698	5,639	15.730,059
C_2H_5OH	1.815,652	1.815,650	$3{,}75 \times 10^{-9}$
C_2H_4O	1,487	2,687	0,000

C_3H_6O	134,646	134,640	$1{,}001 \times 10^{-13}$
H_2O	4.022,7667	4.021,114	1,441
Subtotal	**21.711,252**	**5.979,950**	**15.732,501**
Total	**21.711,250**	**21.711,250**	

4.1.14. Accumulator-02 (ACC-02)

Komponen	**Input (Kg/jam)**	**Output (Kg/jam)**	
	Aliran 38	**Aliran 39**	**Aliran 40**
CH_3COOH	20,636	14,9993	5,637
C_2H_5OH	6.644,598	4.829,589	1.815,009
C_2H_4O	9,83149	7,146	2,686
C_3H_6O	492,753	358,155	134,598
H_2O	14.716,526	10.696,626	4.019,901
Subtotal	**21.884,345**	**15.906,515**	**5.977,830**
Total	**21.884,345**	**21.884,345**	

4.1.15. Reboiler-02 (RB-02)

Komponen	**Input (Kg/jam)**	**Output (Kg/jam)**	
	Aliran 36	**Bottom Produk Aliran 42**	**Refluk Aliran 41**
CH_3COOH	73.963,170	15.735,062	58.228,111
C_2H_5OH	$1{,}76 \times 10^{-8}$	$2{,}60327 \times 10^{-9}$	$9{,}634 \times 10^{-9}$
C_2H_4O	0,000	0,000	0,000
C_3H_6O	$4{,}71 \times 10^{-13}$	$1{,}002 \times 10^{-13}$	$3{,}707 \times 10^{-13}$
H_2O	6,778	1,442	5,336

subtotal	**73.969,951**	**15.736,504**	**58.233,447**
total	**73.969,951**	**73.969,951**	

4.2. NERACA PANAS

4.2.1. Mixing Point-01 (MP-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_1	139.940,303	0,000
Q_{43}	3.644.178,618	0,000
Q_2	0,000	3.784.118,921
Total	**3.784.118,921**	**3.784.118,921**

4.2.2. Evaporator-01 (EV-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_2	3.784.118,922	0,000
Q_3	0,000	5,118,065,300
Q_v	0,000	972,320
Q_{lv}	0,000	13.555.483,090
$Q_{s\text{-}in}$	34.764.668,071	0,0000
$Q_{s\text{-}out}$	0,000	19.874.266,280
Total	**38.548.786,996**	**38.548.786,996**

4.2.3. Mix Point-02 (MP-02)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{44}	-3.846.927,2	0,000
Q_4	42.123,138	0,000
Q_5	0,000	-3.804.804,058
Total	**-3.804.804,058**	**-3.804.804,058**

4.2.4. Heater-01 (H-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_5	-3.804.804,060	0,0000
Q_6	0,0000	15.766.434,320

$Q_{s\text{-}in}$	27.926.856,070	0,0000
$Q_{s\text{-}out}$	0,0000	15.965.225,750
Total	**41.944.449,854**	**41.944.449,854**

4.2.5. Point-03 (MP-03)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_3	5,118,065,307	0,000
Q_6	15,766,442,060	0,000
Q_7	0,000	20,884,507,370
Total	**20,884,507,370**	**20,884,507,370**

4.2.6. Heat Exchanger-01 (HE-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_7	20.884.507,370	0.0000
Q_8	0.0000	64.158.973.400
Q_{11}	0.0000	23.890.432,080
Q_{10}	67.361.337,820	0.0000
Total	**88.245.845,190**	**88.245.845,190**

4.2.7. Heater-02 (H-02)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_8	64.353.793,620	0.0000
Q_9	0.0000	68.026.154,670
$Q_{s\text{-}in}$	8.573.872,950	0.0000
$Q_{s\text{-}out}$	0.0000	4.901.511,900
Total	**72.927.666,570**	**72.927.666,570**

4.2.8. Reaktor-01 (R-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_9	68.026.427,670	0.0000
Q_{10}	0,0000	67.363.297,640
ΔH_R	0,0000	-663.423,843
Q_{win}	436.466,319	0,0000

Q_{wout}	0,0000	1.763.020,1952
Total	**68.462.893,993**	**68.462.893,993**

4.2.9.Cooler-01 (C-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q1	23.890.432,08	0,0000
Q2	0,0000	13.631.919,4
Qw-in	2.699.608,6 kJ	0,0000
Qw-out	0,0000	12.958.121,27
Total	**26.590.040,68**	**26.590.040,68**

4.2.10. Cooler-02 (C-02)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q1	13.631.919,410	0,0000
Q2	0,0000	3.537.374,270
Qw-in	2.656.459,250	0,0000
Qw-out	0,0000	12.751.004,390
Total	**16.288.378,650**	**16.288.378,650**

4.2.11. Parsial Kondensor-01 (PC-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q13	1.876.160,720	0,0000
Q14	0,0000	-3.566.021,260
Qlc	0,0000	639.278,400
Qlv	0,0000	6.099.529,980
Qw-in	-1.203.702,760	0,0000
Qw-out	0,0000	-475.182,620

Total	**2.623.366,420**	**2.623.366,420**

4.2.12. Knock Out Drum-01 (KOD-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{14}	-3.952.719	0,0000
Q_{15}	0,0000	2.771.226
Q_{16}	0,0000	-1.181.493
Total	**-3.952.719**	**-3.952.719**

4.2.13. Chiller-01 (CH-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{17}	-1.388.709,436	0,0000
Q_{18}	0,0000	-3.881.664
Qlv	0,0000	2.251.447
Qw-in	-444.308,510	0,0000
Qw-out	0,0000	-202.801
Total	**-1.833.017,900**	**-1.833.017,900**

4.2.14. Absorber-01 (AB-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{18}	-18.841.446,2	-
Q_{19}	-	-14.974.381,73
Q_{20}	-	-3.867.064
Total	**-18.841.446,2**	**-18.841.446,2**

4.2.15. Chiller-02 (CH-02)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{23}	425.617.441	0,0000
Q_{22}	0,0000	-1.742.358,460
Q-in	-386.388,980	0,0000
Q-out	0,0000	-176.364,210
Q-lv	0,0000	1.957.951,130
Total	**39.228,460**	**39.228,460**

4.2.16. Heater-05 (H-05)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{19}	-1.756.719,340	0.0000
Q_{21}	0.0000	11.113.115,460
$Q_{s\text{-}in}$	30.047.243,920	0.0000
$Q_{s\text{-}out}$	0.0000	17.177.409,124
Total	**28.290.254,600**	**28.290.254,600**

4.2.17. Flash Drum-01 (FD-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{21}	11.113.115,460	
Q_{25}		1.469.734,035
Q_{24}		9.643.381
Total	**-11.113.115,460**	**-11.113.115,46**

4.2.18. Heater-03 (H-03)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{26}	-1.181.492,900	0.0000
Q_{27}	0.0000	2.032,238
$Q_{s\text{-}in}$	7.503.106,700	0.0000
$Q_{s\text{-}out}$	0.0000	4.289.376,200

Total	**6.321.613,800**	**6.321.613,800**

4.2.19. Kolom Distilasi-01 (KD-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_1	2.021.940,600	0.0000
Q_2	0.0000	-57.682,620
Q_3	0.0000	3.576.189,321
Q_{lv}	0.0000	891.350,996
Q_{RB}	2.387.917,100	0.0000
Total	**4.409.857,700**	**4.409.857,700**

4.2.20. Kondensor (CD-01)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{29}	-64.570,000	0.0000
Q_{30}	0.0000	-239.937,710
$Q_{R\text{-}in}$	660.024,610	0.0000
Q_{Rout}	0.0000	301.186,413
$Q_{\text{-}hV}$	0.0000	3.878.752,300
Qlv	0.0000	-3.344.546,500
Total	**595.454,450**	**595.454,450**

4.2.21. Accumulator-01 (ACC-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{30}	791.852,750	0.0000
Q_{31}	0.0000	-551.977
Q_{32}	0.0000	-239.876
Total	**791.852,750**	**791.852,750**

4.2.22. Reboiler-01 (RB-01)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{28}	3.215.466,471	0.0000
Q_{33}	0.0000	-106.367,700
Q_{34}	0.0000	3.576.059

Q_{Lv}	0.0000	1.285.807,500
$Q_{s\text{-}in}$	3.595.517,990	0.0000
$Q_{s\text{-}out}$	0.0000	2.055.485,810
Total	**-1.157.174,121**	**-1.157.174,121**

4.2.23. Heater-04 (H-04)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{34}	3.576.058,880	0.0000
Q_{35}	0.0000	6.780.012,990
$Q_{s\text{-}in}$	7.480.281,780	0.0000
$Q_{s\text{-}out}$	0.0000	4.276.327,670
Total	**11.056.340,660**	**11.056.340,660**

4.2.24. Kolom Distilasi-2 (KD-02)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_{35}	6.780.013	0.0000
Q_{36}	0.0000	4.803.298,870
Q_{37}	0.0000	761.655
Q_{lv}	0.0000	1.604.968,700
Q_{RB}	-2.238.864,150	0.0000
Total	**7.767.535,962**	**7.767.535,962**

4.2.25. Kondensor-02 (CD-02)

Komponen	Panas Masuk (Kj)	Panas Keluar (Kj)
Q_1	2.328.381,514	0.0000
Q_2	0.0000	1.632.771,924
$Q_{R\text{-}in}$	-322.61,524	0.0000
Q_{Rout}	0.0000	-1.589.974,272
$Q_{\text{-}LV}$	0.0000	1.962.971,339
Total	**2.005.768,991**	**2.005.768,991**

4.2.26. Accumulator-02 (ACC-02)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{38}	5.975.326,174	0.0000
Q_{39}	0.0000	1.632.193,442
Q_{40}	0.0000	3.343.132,732
Total	**5.975.326,174**	**5.975.326,174**

4.2.27. Reboiler-02 (RB-02)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{36}	16.518.521,800	0.0000
Q_{40}	0.0000	-4.002.882,590
Q_{41}	0.0000	4.833.906,490
Q_{Lv}	0.0000	4.804.521,170
$Q_{s\text{-}in}$	-25.408.520,140	0.0000
$Q_{s\text{-}out}$	0.0000	-14.525.543,400
Total	**-8.889.998,350**	**-8.889.998,350**

4.2.28. Cooler-03 (C-03)

Komponen	Panas Masuk (kJ)	Panas Keluar (kJ)
Q_{42}	8.707.518,010	0.0000
Q_{43}	0.0000	6.541.425
Qw-in	570.024,500	0.0000
Qw-out	0.0000	2.736.117,500
Total	**9.277.542,500**	**9.277.542,500**