IV. NERACA MASSA DAN NERACA ENERGI

Kapasitas : 50.000 ton/tahun

Operasi : 330 hari /tahun, 24 jam/hari

Proses : kontinyu

Basis : 1 jam

Satuan : kg

Kapasitas (K) = $\frac{50.000\ ton}{tahun} x \frac{1.000\ kg}{ton} x \frac{1\ tahun}{330\ hari} x \frac{hari}{24\ jam}$

= 6313,1313 kg/jam

A. Neraca Massa

1. Neraca Massa Keseluruhan

Tabel 4.1. Neraca Massa Keseluruhan

Komponen	Masuk (kg)	Keluar (kg)
$CaCO_3$	7.138,6244	356,9312
$MgCO_3$	396,5902	0,0000
Fe_2O_3	51,5567	51,5567
Al_2O_3	126,9089	126,9089
SiO_2	176,8792	176,8792
$H_2O_{(l)}$	4.904,6040	4.028,9477
$H_2O_{(g)}$	0,0000	816,4457
CaO	0,0000	113,5377
MgO	0,0000	188,8525
CO_2	0,0000	441,6827
$Ca(OH)_2$	0,0000	243,4211
$CaCO_{3\ precipitated}$	0,0000	6.250,0000
Total	**12.795,1635**	**12.795,1635**

2. Neraca Massa Komponen Tiap Alat

a. *Rotary Kiln* (RK-101)

Tabel 4.2. Neraca Massa di Sekitar *Rotary Kiln* (RK-101)

Komponen	Masuk (kg)		Keluar (kg)		Tergenerasi (kg)	Terkonsumsi (kg)
	Aliran 1	Aliran 4	Aliran 2	Aliran 3		
$CaCO_3$	7.138,6244	3,5690	3,6050	356,8952	0,0000	6.781,6932
$MgCO_3$	396,5902	0,0000	0,0000	0,0000	0,0000	396,5902
Fe_2O_3	51,5567	0,5318	0,5155	0,5207	0,0000	0,0000
Al_2O_3	126,9089	1,3090	1,2690	1,2818	0,0000	0,0000
SiO_2	176,8793	1,8245	1,7686	1,7865	0,0000	0,0000
$H_2O_{(l)}$	41,2454	0,0000	0,0000	0,0000	0,0000	0,0000
CaO	0,0000	37,9737	38,3497	3.797,3722	3.797,7482	0,0000
MgO	0,0000	1,8883	1,9074	188,8334	188,8525	0,0000
CO_2	0,0000	0,0000	3.191,6827	0,0000	3.191,6827	0,0000
$H_2O_{(g)}$	0,0000	0,0000	41,2454	0,0000	0,0000	0,0000
Total	**7.931,8049**	**46,9841**	**3.280,3792**	**4.698,4098**	**7.178,2834**	**7.178,2834**
	7.978,7889		**7.978,7889**			

b. *Rotary Cooler* (RC-101)

Tabel 4.3. Neraca Massa di Sekitar *Rotary Cooler* (RC-101)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 3	Aliran 4	Aliran 5
CaO	3.797,3722	37,9737	3.759,3985
MgO	188,8334	1,8883	186,9451
Fe_2O_3	51,5515	0,5155	51,0361
Al_2O_3	126,8961	1,2690	125,6271
SiO_2	176,8613	1,7686	175,0928
$CaCO_3$	356,8952	3,5690	353,3262
Total	**4.698,4098**	**37,9737**	**4.651,4257**
		4.698,4098	

c. *Mixing Point* (MP – 101)

Tabel 4.4. Neraca Massa di Sekitar *Mixing Point* (MP – 101)

Komponen	Masuk (kg)		Keluar (kg)
	Aliran 6	Aliran 22	Aliran 7
H_2O	1.290,5077	14.498,9660	15.789,4737
Total	**1.290,5077**	**14.498,9660**	**15.789,4737**
	15.789,4737		**15.789,4737**

d. Reaktor 201 (R – 201)

Tabel 4.5. Neraca Massa di Sekitar Reaktor 201 (R – 201)

Komponen	Masuk (kg)		Keluar (kg)	Tergenerasi (kg)	Terkonsumsi (kg)
	Aliran 5	Aliran 7	Aliran 8		
CaO	3.759,3985	0,0000	1.020,4511	0,0000	2.738,9474
H_2O	0,0000	15.789,4737	14.909,0977	0,0000	880,3759
$Ca(OH)_2$	0,0000	0,0000	3.619,3233	3.619,3233	0,0000
MgO	186,9451	0,0000	186,9451	0,0000	0,0000
Fe_2O_3	51,0360	0,0000	51,0360	0,0000	0,0000
Al_2O_3	125,6271	0,0000	125,6271	0,0000	0,0000
SiO_2	175,0928	0,0000	175,0928	0,0000	0,0000
$CaCO_3$	353,3262	0,0000	353,3262	0,0000	0,0000
Total	**4.651,4257**	**15.789,4737**	**20.440,8994**	**3.619,3233**	**3.619,3233**
	20.440,8994				

e. Reaktor 202 (R – 202)

Tabel 4.6. Neraca Massa di Sekitar Reaktor 202 (R – 202)

Komponen	Masuk (kg)	Keluar (kg)	Tergenerasi (kg)	Terkonsumsi (kg)
	Aliran 8	Aliran 9		
CaO	1020,4511	276,9925	0,0000	743,4586
H_2O	14909,0977	14670,1289	0,0000	238,9689
$Ca(OH)_2$	3619,3233	4601,7508	982,4275	0,0000
MgO	186,9451	186,9451	0,0000	0,0000
Fe_2O_3	51,0360	51,03601	0,0000	0,0000
Al_2O_3	125,6271	125,6271	0,0000	0,0000
SiO_2	175,0928	175,0928	0,0000	0,0000
$CaCO_3$	353,3262	353,3262	0,0000	0,0000
Total	**20440,8994**	**20440,8994**	**982,4275**	**982,4275**

f. Reaktor 203 (R – 203)

Tabel 4.7. Neraca Massa di Sekitar Reaktor 203 (R – 203)

Komponen	Masuk (kg)	Keluar (kg)	Tergenerasi (kg)	Terkonsumsi (kg)
	Aliran 9	Aliran 10		
CaO	276,9925	75,1880	0,0000	201,8045
H_2O	14670,1289	14605,2632	0,0000	64,8657
$Ca(OH)_2$	4601,7508	4868,4211	266,6702	0,0000
MgO	186,9451	186,9451	0,0000	0,0000
Fe_2O_3	51,0360	51,03601	0,0000	0,0000
Al_2O_3	125,6271	125,6271	0,0000	0,0000
SiO_2	175,0928	175,0928	0,0000	0,0000
$CaCO_3$	353,3262	353,3262	0,0000	0,0000
Total	**20440,8994**	**20440,8994**	**266,6702**	**266,6702**

g. *Screen* (S-201)

Tabel 4.8. Neraca Massa di Sekitar *Screen* (S-201)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 10	Aliran 11	Aliran 12
CaO	75,1880	75,1880	4.868,4211
MgO	186,9451	186,9451	12,6263
Fe_2O_3	51,0360	51,0360	6,3131
Al_2O_3	125,6271	125,6271	6,3131
SiO_2	175,0928	175,0928	6,3131
$CaCO_3$	353,3262	353,3262	0,0000
H_2O	14.605,2632	246,8185	14.358,4446
$Ca(OH)_2$	3.619,3233	0,0000	3.619,3233
Total	**20.440,8994**	**1.182,4681**	**19.258,4313**
	20.440,8994	**20.440,8994**	

h. *Scrubber* (SB-101)

Tabel 4.9. Neraca Massa di Sekitar *Scrubber* (SB-101)

Komponen	Masuk (kg)		Keluar (kg)	
	Aliran 2	Aliran 13	Aliran 14	Aliran 15
$CaCO_3$	0,0000	3,6050	0,0000	3,6050
Fe_2O_3	0,0000	0,5207	0,0000	0,5207
Al_2O_3	0,0000	1,2818	0,0000	1,2818
SiO_2	0,0000	1,7865	0,0000	1,7865
CaO	0,0000	38,3497	0,0000	38,3497
MgO	0,0000	1,9074	0,0000	1,9074
CO_2	0,0000	3.191,6827	3.191,6827	0,0000
$H_2O_{(g)}$	0,0000	41,2454	0,0000	0,0000
$H_2O_{(l)}$	3.469,1029	0,0000	0,0000	3.510,3483
Total	**3.469,1029**	**3.280,3792**	**3.191,6827**	**3.557,7994**
	6.749,4821		**6.749,4821**	

i. *Splitter* (SP – 101)

Tabel 4.10. Neraca Massa di Sekitar *Splitter* (SP – 101)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 14	Aliran 16	Aliran 17
CO_2	3.191,6827	296,9459	2.894,7368
Total	**3.191,6827**	**296,9459**	**2.894,7362**
	3.191,6827	**3.191,6827**	

j. Reaktor 301 (R – 301)

Tabel 4.11. Neraca Massa di Sekitar Reaktor 301 (R – 301)

Komponen	Masuk (kg)		Keluar (kg)		Tergenerasi (kg)	Terkonsumsi (kg)
	Aliran 12	Aliran 17	Aliran 18	Aliran 19		
$Ca(OH)_2$	4868,4211	0,0000	0,0000	243,4211	0,0000	4625,0000
CO_2	0,0000	2894,7368	144,7368	0,0000	0,0000	2750,0000
$CaCO_{3\ prec}$	0,0000	0,0000	0,0000	6250,0000	6250,0000	0,0000
MgO	12,6263	0,0000	0,0000	12,6263	0,0000	0,0000
Fe_2O_3	6,3131	0,0000	0,0000	6,3131	0,0000	0,0000
Al_2O_3	6,3131	0,0000	0,0000	6,3131	0,0000	0,0000
SiO_2	6,3131	0,0000	0,0000	6,3131	0,0000	0,0000
H_2O	14358,4446	0,0000	0,0000	15483,4446	1125,0000	0,0000
Total	**19258,4313**	**2894,7368**	**144,7368**	**22008,4313**	**7375,0000**	**7375,0000**
	22153,1682		**22153,1682**			

k. *Screen* (S-301)

Tabel 4.12. Neraca Massa di Sekitar *Screen* (S-301)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 19	Aliran 20	Aliran 21
$Ca(OH)_2$	243,4211	243,4211	243,4211
$CaCO_{3precipitated}$	6.249,9987	0,0000	6.249,9987
MgO	12,6263	0,0000	12,6263
Fe_2O_3	6,3131	0,0000	6,3131
Al_2O_3	6,3131	0,0000	6,3131
SiO_2	6,3131	0,0000	6,3131
H_2O	15.483,4446	240,2152	15.243,2294
Total	**22.008,4313**	**483,6363**	**21.524,7950**
		22.008,4313	

l. *Centrifuge* (CF-301)

Tabel 4.13. Neraca Massa di Sekitar *Centrifuge* (CF-301)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 21	Aliran 22	Aliran 23
$CaCO_{3\ precipitaed}$	6.249,9987	0,0000	6.249,9987
MgO	12,6263	0,0000	12,6263
Fe_2O_3	6,3131	0,0000	6,3131
Al_2O_3	6,3131	0,0000	6,3131
SiO_2	6,3131	0,0000	6,3131
H_2O	15.243,2294	14.395,2180	848,0112
Total	**21.524,7950**	**14.395,2180**	**7.129,5770**
		21.524,7950	

m. *Rotary Dryer* (RD-301)

Tabel 4.14. Neraca Massa di Sekitar *Rotary Dryer* (RD-301)

Komponen	Masuk (kg)	Keluar (kg)	
	Aliran 23	Aliran 24	Aliran 25
$CaCO_{3\ precipitaed}$	6.249,9987	0,0000	6.249,9987
MgO	12,6263	0,0000	12,6263
Fe_2O_3	6,3131	0,0000	6,3131
AlO_3	6,3131	0,0000	6,3131
SiO_2	6,3131	0,0000	6,3131
H_2O	848,0112	816,4455	31,5657
Total	**7.129,5755**	**816,4455**	**6.313,1313**
		7.129,5755	

B. Neraca Energi

a. *Rotary Kiln* (RK-101)

Tabel 4.15. Neraca Energi di Sekitar *Rotary Kiln* (RK-101)

Panas Masuk (kkal)		Panas Keluar (kkal)		Panas konsumsi (kkal)	
Q_1	8.049,0044	Q_3	117.318,8863	Q_{rx}	2.546.602,8000
Q_6	3.640,2265	Q_5	749.458,3919		
$Q_{bahan\ bakar}$	4.007.201,2493	Q_{vap}	22,2930		
		Q_{loss}	605.488,1088		
TOTAL	**4.018.890,4802**	**TOTAL**	**1.472.287,6802**	**2.546.602,8000**	
			4.018.890,4802		

b. *Rotary Cooler* (RC-101)

Tabel 4.16. Neraca Energi di Sekitar *Rotary Cooler* (RC-101)

Panas Masuk		Panas Keluar	
Keterangan	**kkal**	**Keterangan**	**Kkal**
Q_5	749.458,3919	Q_6	3.640,2265
$Q_{pendingin\ in}$	7.528,2982	Q_7	38.158,1387
		$Q_{pendingin\ out}$	715.188,3249
TOTAL	**756.986,6901**	**TOTAL**	**756.986,6901**

c. *Mixing Point* (MP – 101)

Tabel 4.17. Neraca Energi di Sekitar *Mixing Point* (MP – 101)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_9	6.967,4055	Q_{10}	194.001,2740
Q_{29}	187.033,8684		
TOTAL	**194.001,2740**	**TOTAL**	**194.001,2740**

d. *Heater* (HT – 101)

Tabel 4.18. Neraca Energi di Sekitar *Heater* (HT-101)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{10}	194.001,2740	Q_{11}	710.131,5789
$Q_{steam\ in}$	1.009.939,8741	$Q_{steam\ out}$	493.809,5691
TOTAL	**1.203.941,1481**	**TOTAL**	**1.203.941,1481**

e. Reaktor 201 (R – 201)

Tabel 4.19. Neraca Energi di Sekitar Reaktor 201 (R – 201)

Panas Masuk (kkal)		Panas generasi (kkal)		Panas Keluar (kkal)	
Q_7	38.158.1387	Q_{reaksi}	953.909,3402	Q_{12}	732.597,0165
Q_{11}	710.131.5789			$Q_{cw\ out}$	1.212.002,5517
$Q_{cw\ in}$	242.400,5103				
TOTAL	**990690,2280**	**953.909,3402**		**TOTAL**	**1.944.599,5682**
	1.944.599,5682				

f. Reaktor 202 (R – 202)

Tabel 4.20 Neraca Energi di Sekitar Reaktor 202 (R – 202)

Panas Masuk (kkal)		Panas generasi (kkal)		Panas Keluar (kkal)	
Q_{12}	732.597,0165	Q_{reaksi}	329.212,7641	Q_{13}	728.337.3968
$Q_{cw\ in}$	83.368,0960			$Q_{cw\ out}$	416.840,4799
TOTAL	**815965,1125**	**329.212,7641**		**TOTAL**	**1.145.177,8766**
	1.145.177,8766				

h. Reaktor 203 (R – 203)

Tabel 4.21. Neraca Energi di Sekitar Reaktor 203 (R – 203)

Panas Masuk (kkal)		Panas generasi (kkal)		Panas Keluar (kkal)	
Q_{13}	728.337.3968	Q_{reaksi}	94.540,4076	Q_{14}	727.181,1650
$Q_{cw\ in}$	23.924,1598			$Q_{cw\ out}$	119.620,7992
TOTAL	**752.261,5566**		**94.540,4076**	**TOTAL**	**846.801,9642**
			846.801,9642		

i. *Screen* (S-201)

Tabel 4.22. Neraca Energi di Sekitar *Screen* (S-201)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{14}	727.181,1650	Q_{15}	19.262,0990
		Q_{16}	707.919,0660
TOTAL	**727.181,1650**	**TOTAL**	**727.181,1650**

j. *Cooler* (CO-201)

Tabel 4.23. Neraca Energi di Sekitar *Cooler* (CO-201)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{16}	707.919,0660	Q_{17}	204.509,9524
$Q_{pendingin\ in}$	125.852,2784	$Q_{pendingin\ out}$	629.261,3920
TOTAL	**833.771,3444**	**TOTAL**	**833.771,3444**

k. *Scrubber* (SB-101)

Tabel 4.24. Neraca Energi di Sekitar *Scrubber* (SB-101)

Panas Masuk (kkal)		Panas Keluar (kkal)	
Q_3	117.318,8900	Q_{19}	113.478,4497
Q_{18}	17.135,9892	Q_{20}	20.998,2789
ΔH_c	21,8494		
TOTAL	**134.476,7286**	**TOTAL**	**134.476,7286**

l. *Splitter* (SP – 101)

Tabel 4.25. Neraca Energi di Sekitar *Splitter* (SP – 101)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{20}	20.998,2789	Q_{21}	1.953,6255
		Q_{22}	19.044,6534
TOTAL	**20.998,2789**	**TOTAL**	**20.998,2789**

m. Kompresor (CP-101)

Tabel 4.26. Neraca Energi di Sekitar Kompresor (CP-101)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{22}	19.044,6534	Q_{23}	79.723,5872
Ws	60.678,9338		
TOTAL	**79.723,5872**	**TOTAL**	**79.723,5872**

n. *Cooler* (CO-102)

Tabel 4.27. Neraca Enrgi di Sekitar *Cooler* (CO-102)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{23}	79.723,5872	Q_{24}	7.586,1842
$Q_{pendingin\ in}$	18.034,3508	$Q_{pendingin\ out}$	901.71,7538
TOTAL	**977.57,9380**	**TOTAL**	**977.57,9380**

o. Reaktor 301 (R – 301)

Tabel 4.28. Neraca Energi di Sekitar Reaktor 301 (R – 301)

Panas Masuk (kkal)		Panas generasi (kkal)		Panas Keluar (kkal)	
Q_{17}	204.509,9524	Q_{reaksi}	1.528.740,0000	Q_{25}	379,3092
Q_{24}	7.586,1842			Q_{26}	218.314,3274
$Q_{ref\ in}$	232.909,7698			$Q_{ref\ out}$	1.755.052,2698
TOTAL	**445.005,9064**	**1.528.740,0000**		**TOTAL**	**1.973.745,9064**
	1.973.745,9064				

p. *Screen* (S-301)

Tabel 4.29. Neraca Energi di Sekitar *Screen* (S-301)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{26}	218.314,3274	Q_{27}	4.014,8134
		Q_{28}	214.299,5140
TOTAL	**218.314,3274**	**TOTAL**	**218.314,3274**

q. *Centrifuge* (CF-301)

Tabel 4.30. Neraca Energi di Sekitar *Centrifuge* (CF-301)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{28}	214.299,5140	Q_{29}	187.033,8684
		Q_{30}	27.265,6456
TOTAL	**214.299,5140**	**TOTAL**	**214.299,5140**

r. *Heater* (HT-301)

Tabel 4.31. Neraca Energi di Sekitar *Heater* (HT-301)

Keterangan	Kkal	Keterangan	Kkal
$Q_{udara\ in}$	198.554,3148	$Q_{udara\ out}$	1.127.200,9136
$Q_{steam\ in}$	1.817.132,6504	$Q_{sream\ out}$	888.486,0516
TOTAL	**2.015.686,9652**	**TOTAL**	**2.015.686,9652**

s. *Rotary Dryer* (RD-301)

Tabel 4.32. Neraca Energi di Sekitar *Rotary Dryer* (RD-301)

Panas Masuk		Panas Keluar	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
H_{S1}	84.754,2656	H_{S2}	108.261,1415
H_{G2}	1.127.200,9136	H_{G1}	1.103.694,0377
TOTAL	**1.211.955,1792**	**TOTAL**	**1.211.955,1792**

t. *Screw Conveyor* (SC-302)

Tabel 4.33. Neraca Energi di Sekitar *Screw Conveyor* (SC-302)

Panas Masuk		**Panas Keluar**	
Keterangan	**Kkal**	**Keterangan**	**Kkal**
Q_{33}	76.206,7506	Q_{35}	6.406,8261
$Q_{pendingin\ in}$	17.449,9811	$Q_{pendingin\ out}$	87.249,9056
TOTAL	**93.656,7317**	**TOTAL**	**93.656,7317**