

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

$$\begin{aligned} \text{Kapasitas (K)} &= \frac{50.000 \text{ ton}}{\text{tahun}} \times \frac{1.000 \text{ kg}}{\text{ton}} \times \frac{1 \text{ tahun}}{330 \text{ hari}} \times \frac{\text{hari}}{24 \text{ jam}} \\ &= 6313,1313 \text{ kg/jam} \end{aligned}$$

A. NERACA MASSA

1. Neraca Massa Keseluruhan

Komponen	Masuk (kg/jam)	Keluar (kg/jam)
CaCO ₃	7.138,6244	356,9312
MgCO ₃	396,5902	
Fe ₂ O ₃	51,5567	51,5567
Al ₂ O ₃	126,9089	126,9089
SiO ₂	176,8792	176,8792
H ₂ O _(l)	4.904,6040	4.028,9477
H ₂ O _(g)		816,4457
CaO		113,5377
MgO		188,8525
CO ₂		441,6827
Ca(OH) ₂		243,4211
CaCO ₃ precipitated		6.250,0000
Total	12.795,1635	12.795,1635

2. Neraca Massa Komponen Tiap Alat

1. Rotary Kiln (RK-101)

Tabel 4.2 Neraca Massa sekitar Rotary Kiln (RK-101)

Komponen	Masuk (kg/jam)		Generasi (kg/jam)	Keluar (kg/jam)		Konsumsi (kg/jam)
	Aliran 1	Aliran 4		Aliran 2	Aliran 3	
CaCO ₃	7.138,6244	3,5690		3,6050	356,8952	6.995,8293
MgCO ₃	396,5902					409,1128
Fe ₂ O ₃	51,5567	0,5318		0,5155	0,5207	
Al ₂ O ₃	126,9089	1,3090		1,2690	1,2818	
SiO ₂	176,8793	1,8245		1,7686	1,7865	
H ₂ O _(l)	41,2454					
CaO		37,9737	3.917,6644	38,3497	3.797,3722	
MgO		1,8883	194,8156	1,9074	188,8334	
CO ₂			3.292,4621	3.191,6827		
H ₂ O _(g)				41,2454		
Total	7.931,8049	46,9841	7.404,9421	3.280,3792	4.698,4098	7.404,9421
	7.978,7889		7.404,9421	7.978,7889		7.404,9421
		15.383,7310		15.383,7310		

2. Rotary Cooler (RC-101)

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

Komponen	Masuk (kg/jam)	Keluar (kg/jam)	
	Aliran 3	Aliran 4	Aliran 5
CaO	3.797,3722	37,9737	3.759,3985
MgO	188,8334	1,8883	186,9451
Fe ₂ O ₃	51,5515	0,5155	51,0361
Al ₂ O 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	4.698,4098	

3. Mixing Point (MP-101)

Tabel 4.4. Neraca Massa Mixing Point (MP-101)

Komponen	Masuk (kg/jam)		Keluar (kg/jam)
	Aliran 6	Aliran 22	Aliran 7
H ₂ O	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

4. Reaktor 201 (R-201)

Tabel 4.5. Neraca Massa sekitar Reaktor 201 (R-201)

Komponen	Masuk (kg/jam)		Generasi (kg/jam)	Keluar (kg/jam) Aliran 8	Konsumsi (kg/jam)
	Aliran 5	Aliran 7			
CaO	3.759,3985			1.020,4511	2.738,9474
H ₂ O		15.789,4737		14.909,0977	880,3759
Ca(OH) ₂			3.619,3233	3.619,3233	
MgO	186,9451			186,9451	
Fe ₂ O ₃	51,0360			51,0360	
Al ₂ O ₃	125,6271			125,6271	
SiO ₂	175,0928			175,0928	
CaCO ₃	353,3262			353,3262	
Total	4.651,4257	15.789,4737	3.619,3233	20.440,8994	3.619,3233
	20.440,8994		3.619,3233	20.440,8994	3.619,3233
	24.060,2227			24.060,2227	

5. Reaktor 202 (R-202)

Tabel 4.6. Neraca Massa sekitar Reaktor 202 (R-202)

Komponen	Masuk	Generasi (kg/jam)	Keluar (kg/jam) Aliran 9	Konsumsi (kg/jam)
	(kg/jam) Aliran 8			
CaO	1.020,4511		276,9925	743,4574
H ₂ O	14.909,0977		14.670,1289	238,9685
Ca(OH) ₂	3.619,3233	982,4259	4.601,7508	
MgO	186,9451		186,9451	
Fe ₂ O ₃	51,0360		51,03601	
Al ₂ O ₃	125,6271		125,6271	
SiO ₂	175,0928		175,0928	
CaCO ₃	353,3262		353,3262	
Total	20.440,8994	982,4259	20.440,8994	982,4259
	20.440,8994	982,4259	20.440,8994	982,4259
	21.423,3253		21.423,3253	

6. Reaktor 203 (R-203)

Tabel 4.7. Neraca Massa sekitar Reaktor 203 (R-203)

Komponen	Masuk	Generasi	Keluar	Konsumsi
	(kg/jam)		(kg/jam)	
	Aliran 9		Aliran 10	
CaO	276,9925		75,1880	381,8058
H ₂ O	14.670,1289	180,0016	14.605,2632	64,8661
Ca(OH) ₂	4601,7508	266,6703	4.868,4211	
MgO	186,9451		186,9451	
Fe ₂ O ₃	51,0360		51,03601	
Al ₂ O ₃	125,6271		125,6271	
SiO ₂	175,0928		175,0928	
CaCO ₃	353,3262		353,3262	
Total	20.440,8994	446,6719	20.440,8994	446,6719
	20.707,5697		20.707,5697	

7. Screen (S-201)

Tabel 4.8. Neraca Massa Screen (S-201)

Komponen	Masuk	Keluar	
	(kg/jam)	(kg/jam)	(kg/jam)
	Aliran 10	Aliran 11	Aliran 12
CaO	75,1880	75,1880	4.868,4211
MgO	186,9451	186,9451	12,6263
Fe ₂ O ₃	51,0360	51,0360	6,3131
Al ₂ O ₃	125,6271	125,6271	6,3131
SiO ₂	175,0928	175,0928	6,3131
CaCO ₃	353,3262	353,3262	
H ₂ O	14.605,2632	246,8185	14.358,4446
Ca(OH) ₂	3.619,3233		3.619,3233
Total	20.440,8994	1.182,4681	19.258,4313
	20.440,8994	20.440,8994	

8. Venturi Scrubber (VS-101)

Tabel 4.9. Neraca Massa Venturi Scrubber (VS-101)

Komponen	Masuk (kg/jam)		Keluar (kg/jam)	
	Aliran 2	Aliran 13	Aliran 14	Aliran 15
CaCO ₃		3,6050		3,6050
Fe ₂ O ₃		0,5207		0,5207
Al ₂ O ₃		1,2818		1,2818
SiO ₂		1,7865		1,7865
CaO		38,3497		38,3497
MgO		1,9074		1,9074
CO ₂		3.191,6827	3.191,6827	
H ₂ O _(g)		41,2454		
H ₂ O _(l)	3.469,1029			3.510,3483
Total	3.469,1029	3.280,3792	3.191,6827	3.557,7994
	6.749,4821		6.749,4821	

9. Splitter (SP-101)

Tabel 4.10. Neraca Massa Splitter (SP-101)

Komponen	Masuk (kg/jam)		Keluar (kg/jam)	
	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	

10. Reaktor 301 (R-301)

Tabel 4.11. Neraca Massa Sekitar Reaktor 301 (R-301)

Komponen	Masuk (kg/jam)		Generasi (kg/jam)	Keluar (kg/jam)		Konsumsi (kg/jam)
	Aliran 12	Aliran 17		Aliran 18	Aliran 19	
Ca(OH) ₂	4.868,4211			243,4211		4.624,9990
CO ₂		2.894,7368			144,7368	2.749,9995
CaCO ₃ precipitaed			6.249,9987	6.249,9987		
MgO	12,6263			12,6263		
Fe ₂ O ₃	6,3131			6,3131		
Al ₂ O ₃	6,3131			6,3131		
SiO ₂	6,3131			6,3131		
H ₂ O	14.358,4446		1.124,9998	15.483,4446		
Total	19.258,4313	2.894,7368	7.374,9985	22.008,4313	144,7368	7.374,9985
	22.153,1682		7.374,9985	22.153,1682		7.374,9985
	29.528,1667			29.528,1667		

11. Screen (S-301)

Tabel 4.12. Neraca Massa Screen (S-301)

Komponen	Masuk	Keluar (kg/jam)	
	(kg/jam) Aliran 19	Aliran 20	Aliran 21
Ca(OH) ₂	243,4211	243,4211	243,4211
CaCO ₃ precipitated	6.249,9987		6.249,9987
MgO	12,6263		12,6263
Fe ₂ O ₃	6,3131		6,3131
Al ₂ O ₃	6,3131		6,3131
SiO ₂	6,3131		6,3131
H ₂ O	15.483,4446	240,2152	15.243,2294
Total	22.008,4313	483,6363	21.524,7950
	22.008,4313	22.008,4313	

12. Centrifuge (CF-301)

Tabel 4.13. Neraca Massa Centrifuge (CF-301)

Komponen	Masuk (kg/jam)	Keluar (kg/jam)	
	Aliran 21	Aliran 22	Aliran 23
CaCO ₃ precipitaed	6.249,9987		6.249,9987
MgO	12,6263		12,6263
Fe ₂ O ₃	6,3131		6,3131
Al ₂ O ₃	6,3131		6,3131
SiO ₂	6,3131		6,3131
H ₂ O	15.243,2294	14.395,2180	848,0112
Total	21.524,7950	14.395,2180	7.129,5770
	21.524,7950		21.524,7950

13. Rotary Dryer (RD-301)

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

Komponen	Masuk	Keluar	
	(kg/jam) Aliran 23	Aliran 24	Aliran 25
CaCO ₃ precipitaed	6.249,9987		6.249,9987
MgO	12,6263		12,6263
Fe ₂ O ₃	6,3131		6,3131
AlO ₃	6,3131		6,3131
SiO ₂	6,3131		6,3131
H ₂ O	848,0112	816,4455	31,5657
Total	7.129,5755	816,4455	6.313,1313
	7.129,5755	7.129,5755	

B. NERACA ENERGI

1. Rotary Kiln (RK-101)

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

Keterangan	Masuk (kkal/jam)	Generasi (kkal/jam)	Keluar (kkal/jam)	Konsumsi (kkal/jam)
Q ₁	8.049,0044			
Q ₂	3.640,2265			
Q ₃			749.458,3921	
Q ₄			117.318,8863	
Q _{reaksi}				
Q _{loss}			490.945,5689	
Q _{suplai}		4.196.115,7779		2.850.082,2480
Total	11.689,2309	4.196.115,7779	1.357.722,8478	2.850.082,2480
		4.207.805,0958	4.207.805,0958	

2. Venturi Scrubber (VS-101)

Tabel 4.16. Neraca Energi di Venturi Scrubber (VS-101)

Keterangan	Masuk (kkal/jam)	Generasi (kkal/jam)	Keluar (kkal/jam)
Q ₄	117.318,8900		
Q ₁₅	17.135,9892		
Q ₁₆			113.370,5471
Q ₁₇			20.976,3620
ΔH_c		-21,8495	
Total	134.454,8792	-21,8495	134.346,9091
		134.346,9091	134.346,9091

3. Rotary Cooler (RC-101)

Tabel 4.17. Neraca Energi di Rotary Cooler (RC-101)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₂		3.640,2265
Q ₃	749.458,3919	
Q ₅		38.158,1387
Q _{pendingin in}	7.528,2982	
Q _{pendingin out}		715.188,3249
Total	756.986,6901	756.986,6901

4. Mixing Point (MP – 101)

Tabel 4.18. Neraca Energi di *Mixing Point* (MP-101)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₆	6.967,4055	
Q ₇		194.001,2740
Q ₂₆	187.033,8684	
Total	194.001,2740	194.001,2740

5. Heater (H – 201)

Tabel 4.19. Neraca Energi di *Heater* (H-201)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₇	194.001,2740	
Q ₈		710.131,5789
Q _{steam in}	1.009.939,8741	
Q _{steam out}		493.809,5691
Total	1.203.941,1481	1.203.941,1481

6. Reaktor 201 (R – 201)

Tabel 4.20. Neraca Energi di Sekitar Reaktor 201 (R-201)

Keterangan	Masuk (kkal/jam)	Generasi (kkal/jam)	Keluar (kkal/jam)
Q ₅	38.158,1387		
Q ₈	710.131,5789		
Q ₉			732.597,0165
Q _{reaksi}		953.909,3402	
Q _{pendingin in}	242.400,5103		
Q _{pendingin out}			1.212.002,5517
Total	990.690,2280	953.909,3402	1.944.599,5682
	1.944.599,5682		1.944.599,5682

7. Reaktor 202 (R – 202)

Tabel 4.21. Neraca Energi di sekitar Reaktor 202 (R-202)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)	Generasi (kkal/jam)
Q ₉	7.325.997,0165		
Q ₁₀			728.337,3968
Q _{reaksi}		329.212,7641	
Q _{pendingin in}	83.368,0960		
Q _{pendingin out}			416.840,4799
Total	815.965,1125	329.212,7640	1.145.177,8766

1.145.177,8766

1.145.177,8766

8. Reaktor 203 (R-203)

Tabel 4.22. Neraca Energi di sekitar Reaktor 203 (R-203)

Keterangan	Masuk (kkal/jam)	Generasi (kkal/jam)	Keluar (kkal/jam)
Q ₁₀	728.337,3968		
Q ₁₁			727.181,1650
Q _{reaksi}		94.540,4076	
Q _{pendingin in}	23.924,1598		
Q _{pendingin out}			119.620,7992
Total	752.261,5566	94.540,4076	846.801,9642
	846.801,9642		846.801,9642

9. Screen (S-201)Tabel 4.23. Neraca Energi di *Screen* (S-201)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₁₁	727.181,1650	
Q ₁₂		19.262,0990
Q ₁₃		707.919,0660
Total	727.181,1650	727.181,1650

10. Cooler (CO-201)Tabel 4.24. Neraca Energi di *Cooler* (CO-201)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₁₁	707.919,0660	
Q ₁₂		204.509,9524
Q _{pendingin in}	125.852,2784	
Q _{pendingin out}		629.261,3920
Total	833.771,3444	833.771,3444

11. Splitter (SP- 101)Tabel 4.25. Neraca Energi di *Splitter* (SP-101)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₁₇	21.118,0130	
Q ₁₈		1.964,7653
Q ₁₉		19.153,2478
Total	21.118,0130	21.118,0130

12. Kompresor (CPR-101)

Tabel 4.26. Neraca Energi di Kompresor (CPR-101)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₁₉	19.153,2478	
Q ₂₀		79.827,4473
W _s	60.674,1996	
Total	79.827,4473	79.827,4473

13. Cooler (CO-301)

Tabel 4.27. Neraca Energi di Cooler (CO-301)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₂₀	80.232,5246	
Q ₂₁		7.586,1842
Q _{pendingin in}	18.161,5851	
Q _{pendingin out}		90.807,9255
Total	98.394,1097	98.394,1097

14. Reaktor 301 (R – 301)

Tabel 4.28. Neraca Energi di sekitar Reaktor 301 (R-301)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)	Generasi (kkal/jam)
Q ₁₂	204.509,9524		
Q ₂₁	7.586,1842		
Q ₂₂			379,3092
Q ₂₄			218.314,3274
Q _{reaksi}		1.528.740,0000	
Q _{pendingin in}	53.235,8378		
Q _{pendingin out}			1.575.378,3378
Total	265.331,9744	1.528.740,0000	1.794.071,9744
	1.749.071,9744		1.749.071,9744

15. Screen (S-301)

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

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₂₃	218.314,3274	
Q ₂₄		4.014,8134
Q ₂₅		214.299,5140
Total	218.314,3274	218.314,3274

16. Centrifuge (CF-301)

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

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₂₅	214.299,5140	
Q ₂₆		187.033,8684
Q ₂₇		27.265,6456
Total	214.299,5140	214.299,5140

17. Heater (H-301)

Tabel 4.32. Neraca Energi di *Heater* (H-301)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q _{udara in}	198.554,3148	
Q _{udara out}		1.127.200,9136
Q _{steam in}	1.817.132,6504	
Q _{steam out}		888.486,0516
Total	2.015.686,9652	2.015.686,9652

18. Rotary Dryer (RD-301)

Tabel 4.31. Neraca Energi di *Rotary Dryer* (RD-301)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
H _{S1} , Q ₂₅	84.754,2656	
H _{S2} , Q ₂₆		108.261,1415
H _{G1}		1.103.694,0377
H _{G2}	1.127.200,9136	
Total	1.211.955,1792	1.211.955,1792

19. Screw Conveyor (SC-301)

Tabel 4.33. Neraca Energi di *Screw Conveyor* (SC-301)

Keterangan	Masuk (kkal/jam)	Keluar (kkal/jam)
Q ₂₈	76.206,7506	
Q ₂₉		6.406,8261
Q _{pendingin in}	17.449,9811	
Q _{pendingin out}		87.249,9056
Total	93.656,7317	93.656,7317