

BAB IV  
NERACA MASSA DAN NERACA PANAS

**4.1. Neraca Massa**

**a) Perhitungan Neraca Massa**

Kapasitas pabrik per tahun = 15.000 ton NH<sub>4</sub>Cl/tahun

Waktu operasi satu tahun = 330 hari

Kapasitas pabrik per jam =  $15.000 \frac{\text{ton}}{\text{tahun}} \times \frac{1.000 \text{ kg}}{1 \text{ ton}} \times \frac{1 \text{ tahun}}{330 \text{ hari}} \times \frac{1 \text{ hari}}{24 \text{ jam}}$   
= 1.893,9394 kg/jam

Kadar NH<sub>4</sub>Cl dipasaran = 99,5% (<http://indonesian.alibaba.com>)

Komposisi umpan masuk:

1. Komposisi umpan (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>

(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> = 98,9000 % berat

H<sub>2</sub>SO<sub>4</sub> = 0,1000 % berat

H<sub>2</sub>O = 1,0000 % berat

= 100% berat

([www.petrokimia-gresik.com](http://www.petrokimia-gresik.com))

2. Komposisi umpan NaCl

NaCl = 99,5000 % berat

H<sub>2</sub>O = 0,5000 % berat

= 100% berat

([www.ptgaram.com](http://www.ptgaram.com))

Dari perhitungan neraca massa basis : 1.000 kg/jam (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> umpan reaktor

Umpan basis = 1.000,0000 kg/jam (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>

= 443,2810 kg/jam NaCl

Produk basis = 386,4458 kg/jam

Produk sebenarnya = 1.893,9394 kg/jam

*Scale Up* =  $\frac{\text{produk sebenarnya}}{\text{produk basis}} = \frac{1.893,9394 \text{ kg/jam}}{386,4458 \text{ kg/jam}} = 4,9009$

Komposisi umpan masuk :

Komposisi umpan (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>

(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> = (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> masuk reaktor - (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> dari arus recycle

= 4.900,9181 – 2.542,1602

= 2.358,7579 kg/jam

$$\begin{aligned} \text{H}_2\text{SO}_4 &= \frac{0,1}{98,9} \times \text{massa } (\text{NH}_4)_2\text{SO}_4 \\ &= \frac{0,1}{98,9} \times 2.358,7579 \text{ kg/jam} \\ &= 2,3850 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{H}_2\text{O} &= \frac{1}{98,9} \times \text{massa } (\text{NH}_4)_2\text{SO}_4 \\ &= \frac{1}{98,9} \times 2.358,7579 \text{ kg/jam} \\ &= 23,8499 \text{ kg/jam} \end{aligned}$$

Komposisi umpan NaCl

$$\begin{aligned} \text{NaCl} &= \text{massa NaCl masuk reaktor} - \text{NaCl dari arus recycle} \\ &= 2.169,4152 - 101,9340 \\ &= 2.067,4811 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{H}_2\text{O} &= \frac{0,5}{99,5} \times \text{massa NaCl} \\ &= \frac{0,5}{99,5} \times 2.067,4811 \\ &= 10,3894 \text{ kg/jam} \end{aligned}$$

*MIXER* (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (M-01)

Fungsi : Melarutkan amonium sulfat dengan air.

**Tabel 4.1.1. Neraca massa *mixer* (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (M-01)**

Komponen	Masuk (kg/jam)		Keluar (kg/jam)
	Arus 1	Arus 2	Arus 3
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.358,7579	-	2.358,7579
H <sub>2</sub> SO <sub>4</sub>	2,3850	-	2,3850
H <sub>2</sub> O	23,8499	2.283,4055	2.307,2554
Sub total	2.384,9928	2.283,4055	4.668,3982
Total	4.668,3982		4.668,3982

MIXER NaCl (M-02)

Fungsi : Melarutkan natrium klorida dengan air.

**Tabel 4.1.2. Neraca massa mixer NaCl (M-02)**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 4	Arus 5	Arus 6
NaCl	2.067,4811	-	2.067,4811
H <sub>2</sub> O	10,3894	5.194,6763	5.205,0656
Sub total	2.077,8705	5.194,6763	7.272,5468
Total	7.272,5468		7.272,5468

REAKTOR

Fungsi : Mereaksikan amonium sulfat dengan natrium klorida

Reaksi yang terjadi :  $(\text{NH}_4)_2\text{SO}_{4(l)} + 2\text{NaCl}_{(l)} \longrightarrow 2\text{NH}_4\text{Cl}_{(l)} + \text{Na}_2\text{SO}_{4(s)}$

Yield produk = 95% (Faith and Keyes, 1957)

$$\text{Yield} = \frac{\text{kmol produk}}{\text{kmol reaktan mula-mula}}$$

kmol produk = yield x kmol reaktan mula-mula

$$= 95\% \times 37,1282 \text{ kmol}$$

kmol produk = 35,2718 kmol

Reaksi 1

	$(\text{NH}_4)_2\text{SO}_4$	+	$2\text{NaCl}$	$\longrightarrow$	$2\text{NH}_4\text{Cl}$	+	$\text{Na}_2\text{SO}_4$
Awal :	37,1282		37,0840		-		-
Reaksi :	17,6359		35,2718		35,2718		17,6359
Akhir :	19,4923		1,8123		35,2718		17,6359

Reaksi 2

	$\text{H}_2\text{SO}_4$	+	$2\text{NaCl}$	$\longrightarrow$	$\text{Na}_2\text{SO}_4$	+	$2\text{HCl}$
Awal :	0,0243		1,8123		-		-
Reaksi :	0,0243		0,0487		0,0243		0,0487
Akhir :	-		1,7636		0,0243		0,0487

**Tabel 4.1.3. Neraca massa reaktor**

Komponen	Masuk (Kg/jam)			Keluar (kg/jam)	
	Arus 3	Arus 6	Arus 38	Arus 7	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.358,7579	-	2.542,1602	2.572,9820	
H <sub>2</sub> SO <sub>4</sub>	2,3850	-	-	-	
NaCl	-	2.067,4811	101,9340	103,1699	
NH <sub>4</sub> Cl	-	-	47,7864	1.934,8255	
Na <sub>2</sub> SO <sub>4</sub>	-	-	29,5363	2.537,2870	
HCl	-	-	-	1,7766	
H <sub>2</sub> O	2.307,2554	5.205,0656	2.848,3813	10.360,7023	
Sub total	4.668,3982	7.272,5468	5.569,7983	17.510,7433	
Total		17.510,7433		17.510,7433	

**ROTARY VACUUM FILTER (RFV)**

Fungsi : Memisahkan natrium sulfat dan filtrat

**Tabel 4.1.4. Neraca massa rotary vacuum filter**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)	
	Arus 7	Arus 8	Arus 9	Arus 19
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.572,9820	-	2,5730	2.570,4090
NaCl	103,1699	-	0,1032	103,0667
NH <sub>4</sub> Cl	1.934,8255	-	1,8870	1.932,9385
Na <sub>2</sub> SO <sub>4</sub>	2.537,2870	-	2.507,4225	29,8646
HCl	1,7766	-	0,0018	1,7748
H <sub>2</sub> O	10.360,7023	125,5430	103,6070	10.382,6383
Sub total	17.510,7433	125,5430	2.615,5945	15.020,6919
Total		17.636,2863		17.636,2863

ROTARY DRYER-01

Fungsi : Mengeringkan natrium sulfat dengan udara panas

**Tabel 4.1.5. Neraca massa rotary dryer-01**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)	
	Arus 9	Arus 10	Arus 11	Arus 12
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5730	-	0,0257	2,5473
NaCl	0,1032	-	0,0010	0,1021
NH <sub>4</sub> Cl	1,8870	-	0,0189	1,8682
Na <sub>2</sub> SO <sub>4</sub>	2.507,4225	-	25,0742	2.482,3482
HCl	0,0018	-	1,78E-05	0,0018
H <sub>2</sub> O	103,6070	90,8343	186,4062	8,0351
Udara	-	4.780,7547	4.780,7547	-
Sub total	2.615,5945	4.871,5890	4.992,2808	2.494,9027
Total	7.487,1835		7.487,1835	

CYCLONE-01

Fungsi : Memisahkan padatan dan udara panas

**Tabel 4.1.6. Neraca massa cyclone-01**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 11	Arus 13	Arus 14
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0,0257	0,0003	0,0255
NaCl	0,0010	1,03E-05	0,0010
NH <sub>4</sub> Cl	0,0189	0,0002	0,0187
Na <sub>2</sub> SO <sub>4</sub>	25,0742	0,2507	24,8235
HCl	1,78E-05	1,78E-07	1,78E-05
H <sub>2</sub> O	186,4062	186,4062	-
Udara	4.780,7547	4.780,7547	-
Sub total	4.992,2808	4.967,4121	24,8687
Total	4.992,2808		4.992,2808

*BELT CONVEYOR-06*

Fungsi : Mendinginkan natrium sulfat sampai suhu kamar

**Tabel 4.1.7. Neraca massa *belt conveyor-06***

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 12	Arus 14	Arus 15
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5473	0,0255	2,5727
NaCl	0,1021	0,0010	0,1032
NH <sub>4</sub> Cl	1,8682	0,0187	1,8869
Na <sub>2</sub> SO <sub>4</sub>	2.482,3482	24,8235	2.507,1717
HCl	0,0018	1,76E-05	0,0018
H <sub>2</sub> O	8,0351	-	8,0351
Sub total	2.494,9027	24,8687	2.519,7714
Total	2.519,7714		2.519,7714

*BALL MILL-01*

Fungsi : Menghaluskan natrium sulfat menjadi 100 mesh

**Tabel 4.1.8. Neraca massa *ball mill-01***

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 15	Arus 17	Arus 16
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5727	0,1286	2,7014
NaCl	0,1032	0,0052	0,1083
NH <sub>4</sub> Cl	1,8869	0,0943	1,9812
Na <sub>2</sub> SO <sub>4</sub>	2.507,1717	125,3586	2.632,5303
HCl	0,0018	0,0001	0,0019
H <sub>2</sub> O	8,0351	0,4018	8,4369
Sub total	2.519,7714	125,9886	2.645,7599
Total	2.645,7599		2.645,7599

SCREEN-01

Fungsi : Memisahkan ukuran 100 mesh

**Tabel 4.1.9. Neraca massa screen-01**

Komponen	Masuk (Kg/jam)	Keluar (kg/jam)	
	Arus 16	Arus 17	Arus 18
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,7014	0,1286	2,5727
NaCl	0,1083	0,0052	0,1032
NH <sub>4</sub> Cl	1,9812	0,0943	1,8869
Na <sub>2</sub> SO <sub>4</sub>	2.632,5303	125,3586	2.507,1717
HCl	0,0019	0,0001	0,0018
H <sub>2</sub> O	8,4369	0,4018	8,0351
Sub Total	2.645,7599	125,9886	2.519,7714
Total	2.645,7599	2.645,7599	

EVAPORATOR-01

Fungsi : Memekatkan larutan amonium klorida

**Tabel 4.1.10. Neraca massa evaporator-01**

Komponen	Masuk (Kg/jam)	Keluar (kg/jam)	
	Arus 19	Arus 20	Arus 21
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.570,4090	-	2.570,4090
NaCl	103,0667	-	103,0667
NH <sub>4</sub> Cl	1.932,9385	-	1.932,9385
Na <sub>2</sub> SO <sub>4</sub>	29,8646	-	29,8646
HCl	1,7748	1,7748	-
H <sub>2</sub> O	10.382,6383	5.064,5446	5.318,0937
Sub Total	15.020,6919	5.066,3194	9.954,3725
Total	15.020,6919	15.020,6919	

### KRISTALISER

Fungsi : membentuk kristal amonium klorida

**Tabel 4.1.11. Neraca massa kristaliser**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)	
	Arus 21		Arus 22	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.570,4090		2.570,4090	
NaCl	103,0667		103,0667	
NH <sub>4</sub> Cl (aq)	1.932,9385		23,4857	
NH <sub>4</sub> Cl (s)	-		1.909,4528	
Na <sub>2</sub> SO <sub>4</sub>	29,8646		29,8646	
HCl	-		-	
H <sub>2</sub> O	5.318,0937		5.318,0937	
<b>Total</b>	<b>9.954,3725</b>		<b>9.954,3725</b>	

### SENTRIFUGE FILTER

Fungsi : Memisahkan kristal dan *mother liquor*

**Tabel 4.1.12. Neraca massa sentrifuge filter**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)	
	Arus 22	Arus23	Arus 24	Arus 25
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.570,4090		2,5704	2.567,8386
NaCl	103,0667		0,1031	102,9637
NH <sub>4</sub> Cl	23,4857		0,0235	48,2810
NH <sub>4</sub> Cl (s)	1.909,4528		1.884,6340	
Na <sub>2</sub> SO <sub>4</sub>	29,8646		0,0299	29,8347
HCl	-		-	-
H <sub>2</sub> O	5.318,0937	92,6882	53,1809	5.357,6010
<b>Sub total</b>	<b>9.954,3725</b>	<b>92,6882</b>	<b>1.940,5418</b>	<b>8.106,5189</b>
<b>Total</b>	<b>10.047,0607</b>		<b>10.047,0607</b>	



*ROTARY DRYER-02*

Fungsi : Mengeringkan kristal amonium klorida dengan udara panas

**Tabel 4.1.13. Tabel neraca massa rotary dryer-02**

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)	
	Arus 24	Arus 26	Arus 27	Arus 28
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5704		0,0257	2,5447
NaCl	0,1031		0,0010	0,1020
NH <sub>4</sub> Cl	1.884,6575		18,8466	1.865,8109
Na <sub>2</sub> SO <sub>4</sub>	0,0299		0,0003	0,0296
HCl	-		-	-
H <sub>2</sub> O	53,1809	161,0334	207,4471	6,7673
Udara		8.475,4429	8.475,4429	
Sub total	1.940,5418	8.636,4763	8.701,7636	1.875,2545
Total	10.577,0181		10.577,0181	

*CYCLONE-02*

Fungsi : Memisahkan padatan dengan udara panas

**Tabel 4.1.14. Neraca massa cyclone-02**

Komponen	Masuk (Kg/jam)	Keluar (kg/jam)	
	Arus 27	Arus 30	Arus 29
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0,0257	0,0003	0,0254
NaCl	0,0010	1,03E-05	0,0010
NH <sub>4</sub> Cl	18,8466	0,1885	18,6581
Na <sub>2</sub> SO <sub>4</sub>	0,0003	2,99E-06	0,0003
HCl	-	-	-
H <sub>2</sub> O	207,4471	207,4471	-
Udara	8.475,4429	8.475,4429	-
Sub total	8.701,7636	8.683,0787	18,6849
Total	8.701,7636	8.701,7636	

*BELT CONVEYOR-08*

Fungsi : Mendinginkan kristal sampai suhu kamar

**Tabel 4.1.15. Neraca massa *belt conveyor-08***

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 28	Arus 29	Arus 31
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5447	0,0254	2,5702
NaCl	0,1020	0,0010	0,1031
NH <sub>4</sub> Cl	1.865,8109	18,6581	1.884,4690
Na <sub>2</sub> SO <sub>4</sub>	0,0296	0,0003	0,0299
HCl	-	-	-
H <sub>2</sub> O	6,7673	-	6,7673
Sub total	1.875,2545	18,6849	1.893,9394
Total	1.893,9394		1.893,9394

*BALL MILL-02*

Fungsi : Menghaluskan amonium klorida menjadi 100 *mesh*

**Tabel 4.1.16. Neraca massa *ball mill-02***

Komponen	Masuk (Kg/jam)		Keluar (kg/jam)
	Arus 31	Arus 33	Arus 32
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,5702	0,1285	2,6987
NaCl	0,1031	0,0052	0,1082
NH <sub>4</sub> Cl	1.884,4690	94,2235	1.978,6925
Na <sub>2</sub> SO <sub>4</sub>	0,0299	0,0015	0,0314
HCl	-	-	-
H <sub>2</sub> O	6,7673	0,3384	7,1057
Sub total	1.893,9394	94,6970	1.988,6364
Total	1.988,6364		1.988,6364

SCREEN-02

Fungsi : Memisahkan ukuran 100 mesh

**Tabel 4.1.17. Neraca massa screen-02**

Komponen	Masuk (Kg/jam)	Keluar (kg/jam)	
	Arus 32	Arus 33	Arus 34
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2,6987	0,1285	2,5702
NaCl	0,1082	0,0052	0,1031
NH <sub>4</sub> Cl	1.978,6925	94,2235	1.884,4690
Na <sub>2</sub> SO <sub>4</sub>	0,0314	0,0015	0,0299
HCl	-	-	-
H <sub>2</sub> O	7,1057	0,3384	6,7673
Sub Total	1.988,6364	94,6970	1.893,9394
Total	1.988,6364	1.988,6364	

EVAPORATOR-02

Fungsi : menjenuhkan sisa reaktan sebelum recycle ke reaktor

**Tabel 4.1.18. Neraca massa Evaporator-02**

Komponen	Masuk (Kg/jam)	Keluar (kg/jam)	
	Arus 36	Arus 37	Arus 38
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	2.542,1602	-	2.542,1602
NaCl	101,9340	-	101,9340
NH <sub>4</sub> Cl	47,7864	-	47,7864
Na <sub>2</sub> SO <sub>4</sub>	29,5363	-	29,5363
HCl	-	-	-
H <sub>2</sub> O	5.306,0250	2.455,6437	2.848,3813
Sub Total	8.025,4420	2.455,6437	5.569,7983
Total	8.025,4420	8.025,4420	

## 1.2. Neraca Panas

Basis perhitungan : 1 jam operasi

Suhu referensi : 298 K

Satuan Panas (energi) : KJ

Satuan Cp : J/mol K

Tekanan : atm

Kapasitas panas bahan dipengaruhi suhu,  $C_p = f(T)$  mengikuti persamaan :

$$C_p = A + BT + CT^2 + DT^3 + ET^4 \dots \dots \dots (2.7)$$

Dalam bentuk integral:

$$\int C_p dT = A(T - 298) + \frac{B}{2}(T^2 - 298^2) + \frac{C}{3}(T^3 - 298^3) + \frac{D}{4}(T^4 - 298^4) + \frac{E}{5}(T^5 - 298^5) \dots \dots \dots (2.8)$$

Keterangan:

$C_p$  = Kapasitas panas (J/kmol K)

A,B,C,D,E = Koefisien regresi komponen

Data-data konstanta kapasitas panas masing-masing komponen dalam berbagai wujud:

**Tabel 4.2.1 Konstanta kapasitas panas masing-masing komponen**

Komponen	A	B	C	D	E
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> (s)	24,5600	0,1311	-2,1300,E-5		
H <sub>2</sub> SO <sub>4</sub> (l)	26,0040	0,7034	-1,3856,E-3	1,0342E-6	
NaCl (s)	41,2930	0,0336	-1,3900,E-5		
NH <sub>4</sub> Cl (s)	23,1180	0,1500	-3,0300,E-5		
Na <sub>2</sub> SO <sub>4</sub> (s)	12,2020	0,5810	-6,0600,E-4		
HCl (l)	73,9930	-1,2946,E-5	-7,8980,E-5	2,6409E-6	
H <sub>2</sub> O (l)	92,0530	-0,0400	-2,1100,E-4	5,3200,E-7	
H <sub>2</sub> O (g)	33,9330	-8,4186E-3	2,9906,E-5	-1,7825E-8	3,6934E-12

(Yaws, 1999)

**Tabel 4.2.2 Kapasitas panas masing-masing komponen pada berbagai suhu**

<b>Komponen</b>	<b>Cp (J/mol), 303 K</b>	<b>Cp (J/mol), 308 K</b>	<b>Cp (J/mol), 318 K</b>	<b>Cp (J/mol), 332,6860 K</b>	<b>Cp (J/mol), 333 K</b>	<b>Cp (J/mol), 373 K</b>	<b>Cp (J/mol), 373,4669 K</b>	<b>Cp (J/mol), 373,82 K</b>	<b>Cp (J/mol), 378 K</b>	<b>Cp (J/mol), 393 K</b>
<b>(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (s)</b>	310,1606	623,2759	1.258,3497	2.212,3140	2.232,9884	4.960,2399	4.993,1685	5.017,9756	5.314,1634	6.393,1622
<b>H<sub>2</sub>SO<sub>4</sub> (l)</b>	701,5448	1.406,8035	2.828,0288	4.939,6560	4.985,1110	10.868,6307	10.938,3306	10.990,8192	11.616,1575	13.873,4140
<b>NaCl (s)</b>	250,6730	501,9754	1.006,4545	1.751,8114	1.767,8070	3.824,6023	3.848,8339	3.867,0802	4.084,3516	4.867,0495
<b>NH<sub>4</sub>Cl (s)</b>	327,2842	657,8593	1.328,8522	2.337,9503	2.359,8343	5.251,3666	5.286,3302	5.312,6711	5.905,4400	6.773,8129
<b>Na<sub>2</sub>SO<sub>4</sub> (s)</b>	660,3464	1.326,0370	2.672,8443	4.685,8718	4.729,3486	10.397,3945	10.464,9257	10.515,7855	11.121,9949	13.313,6198
<b>HCl (l)</b>	692,6170	1.402,2224	2.874,7495	5.174,8411	5.225,9082	12.452,8835	12.546,4035	12.616,9610	13.466,2935	16.670,3196
<b>H<sub>2</sub>O (l)</b>	377,0807	753,6282	1.505,4017	2.607,3095	2.630,8556	5.634,3979	5.669,5990	5.696,1040	6.011,6470	7.148,0725
<b>H<sub>2</sub>O (g)</b>	168,2510	336,6321	673,8003	1.170,0006	1.180,6249	2.539,1413	2.555,0640	2.567,1059	2.709,7327	3.222,6216

Data-data diatas dan neraca massa aktual yang telah dihitung kemudian dimasukkan ke dalam perhitungan neraca panas dalam bentuk tabel-tabel yang dibuat seperti berikut:

MIXER (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (M-01)

Fungsi : Melarutkan amonium sulfat dengan air

**Tabel 4.2.3. Neraca panas mixer (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> (M-01)**

Komponen	Q masuk, kJ/jam		Q keluar, kJ/jam
	Arus 1	Arus 2	Arus 3
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	5.542,3760	-	89.668,1010
H <sub>2</sub> SO <sub>4</sub>	17,0733	-	267,4798
H <sub>2</sub> O	499,6305	47.834,9005	730.131,4784
<b>Subtotal</b>	6.059,0798	47.834,9005	820.067,0592
Panas Pelarutan	-		-205.742,6538
<i>Steam</i>	560.430,4252		-
<b>Total</b>	614.324,4054		614.324,4054

MIXER NaCl (M-02)

Fungsi : Melarutkan natrium klorida dengan air.

**Tabel 4.2.4. Neraca panas mixer NaCl (M-02)**

Komponen	Q masuk, kJ/jam		Q keluar, kJ/jam
	Arus 4	Arus 5	Arus 6
NaCl	8.859,1740	-	136.023,7874
H <sub>2</sub> O	217,6458	108.822,9072	1.639.479,7129
<b>Subtotal</b>	9.076,8198	108.822,9072	1.775.503,5003
Panas Pelarutan	-		-172.234,7933
<i>Steam</i>	1.485.368,9801		-
<b>Total</b>	1.603.268,7070		1.603.268,7070

REAKTOR

Fungsi : Mereaksikan amonium sulfat dengan natrium klorida

Reaksi yang terjadi : (NH<sub>4</sub>)<sub>2</sub>SO<sub>4(l)</sub> + 2NaCl<sub>(l)</sub> → 2NH<sub>4</sub>Cl<sub>(l)</sub> + Na<sub>2</sub>SO<sub>4(s)</sub>

Yield produk = 95% (Faith and Keyes, 1957)

**Tabel 4.2.5. Neraca Panas Reaktor**

Komponen	Q Masuk (Kj/Jam)			Q Keluar (Kj/jam)
	Arus 3	Arus 6	Arus 38	Arus 7
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	89.668,1010	-	95.528,2161	96.686,4237
H <sub>2</sub> SO <sub>4</sub>	267,4798	-	-	-
NaCl	-	136.023,7874	6.664,2237	6.745,0224
NH <sub>4</sub> Cl	-	-	4.690,5449	189.915,4805
Na <sub>2</sub> SO <sub>4</sub>	-	-	2.162,6836	185.782,9158
HCl	-	-	-	606,1232
H <sub>2</sub> O	730.131,4784	1.639.479,7129	891.606,3096	3.243.128,8607
<b>Sub total</b>	820.067,0592	1.775.503,5003	1.000.651,9780	3.722.864,8264
Panas Reaksi		-		398.763,5702
Beban Pemanas		525.405,8591		-
<b>Total</b>		4.121.628,3966		4.121.628,3966

**COOLER**

Fungsi : Mendinginkan larutan produk keluar reaktor

**Tabel 4.2.6. Neraca panas cooler**

Komponen	Q masuk, kJ/jam	Q keluar, kJ/jam
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	96.686,4237	43.526,0522
NaCl	6.745,0224	3.117,6831
NH <sub>4</sub> Cl	189.915,4805	85.343,3212
Na <sub>2</sub> SO <sub>4</sub>	185.782,9158	84.505,0343
HCl	606,1232	254,3623
H <sub>2</sub> O	3.243.128,8607	1.514.306,2104
<b>Subtotal</b>	<b>3.722.864,8264</b>	<b>1.731.052,6635</b>
Beban Pendingin	-	1.991.812,1629
<b>Total</b>	<b>3.722.864,8264</b>	<b>3.722.864,8264</b>

*ROTARY VACUUM FILTER (RFV)*

Fungsi : Memisahkan natrium sulfat dan filtrat

**Tabel 4.2.7. Neraca panas rotary vacuum filter**

Komponen	Q Masuk (Kj/Jam)		Q Keluar (Kj/jam)	
	Arus 7	Arus 8	Arus 9	Arus 16
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	43.526,0522	-	43,1231	43.079,9373
NaCl	3.117,6831	-	3,0895	3.086,3840
NH <sub>4</sub> Cl	85.343,3212	-	82,4636	84.469,4249
Na <sub>2</sub> SO <sub>4</sub>	84.505,0343	-	82.742,6773	985,5035
HCl	254,3623	-	0,2519	251,6248
H <sub>2</sub> O	1.514.306,2104	2.629,9923	15.007,5320	1.503.930,6439
<b>Sub total</b>	1.731.052,6635	2.629,9923	97.879,1373	1.635.803,5185
<b>Total</b>	1.733.682,6558		1.733.682,6558	

*ROTARY DRYER-01*

Fungsi : Mengeringkan natrium sulfat dengan udara panas

**Tabel 4.2.8 Neraca panas rotary dryer-01**

Komponen	Q Masuk (Kj/Jam)		Q Keluar (Kj/jam)	
	Arus 9	Arus 10	Arus 11	Arus 12
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	43,1231	-	0,9669	95,7196
NaCl	3,0895	-	0,0675	6,6776
NH <sub>4</sub> Cl	82,4636	-	1,8522	183,3727
Na <sub>2</sub> SO <sub>4</sub>	82.742,6773	-	1.835,9620	181.760,2381
HCl	0,2519	-	0,0061	0,6001
H <sub>2</sub> O	15.007,5320	16.262,4834	26.511,3721	2.515,1781
Udara	-	581.148,5416	482.378,1494	-
<b>Sub total</b>	97.879,1373	597.411,0250	510.728,3761	184.561,7861
<b>Total</b>	695.290,1623		695.290,1623	



*EVAPORATOR-01*

Fungsi : Memekatkan larutan amonium klorida

**Tabel 4.2.9. Neraca panas evaporator-01**

Komponen	Q Masuk (Kj/Jam)	Q Keluar (Kj/jam)	
	Arus 19	Arus 20	Arus 21
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	43.079,9373	-	96.589,7373
NaCl	3.086,3840	-	6.738,2774
NH <sub>4</sub> Cl	84.469,4249	-	189.730,2556
Na <sub>2</sub> SO <sub>4</sub>	985,5035	-	2.186,7156
HCl	251,6248	706,1599	-
H <sub>2</sub> O	1.503.930,6439	821.930,8814	1.664.680,8956
<b>Sub total</b>	1.635.803,5185	822.637,0412	1.959.925,8816
Beban pemanas	1.207.115,1624		
Q loss		60.355,7581	
<b>Total</b>	2.842.918,6809	2.842.918,6809	

*KRISTALISER*

Fungsi : Memisahkan kristal dan *mother liquor*

**Tabel 4.2.10. Neraca panas kristaliser**

Komponen	Q Masuk (Kj/Jam)	Q Keluar (Kj/jam)
	Arus 21	Arus 22
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	96.589,7373	6.039,6930
NaCl	6.738,2774	441,6418
NH <sub>4</sub> Cl	189.730,2556	143,6727
NH <sub>4</sub> Cl (s)	-	11.681,0044
Na <sub>2</sub> SO <sub>4</sub>	2.186,7156	138,8800
HCl	-	-
H <sub>2</sub> O	1.664.680,8956	111.408,3706
<b>Sub total</b>	1.959.925,8816	129.853,2624
Panas kristalisasi	-570.822,0367	-
Beban pendingin	-	1.259.250,5825

<b>Total</b>	1.389.103,8448	1.389.103,8448
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*SENTRIFUGE FILTER*

Fungsi : Memisahkan kristal dan *mother liquor*

**Tabel 4.2.11. Neraca panas *sentrifuge filter***

Komponen	Q Masuk (Kj/Jam)		Q Keluar (Kj/jam)	
	Arus 22	Arus 23	Arus 24	Arus 25
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	6.039,6930	-	6,0397	6.033,6533
NaCl	441,6418	-	0,4416	441,2001
NH <sub>4</sub> Cl	143,6727	-	0,1437	295,3572
NH <sub>4</sub> Cl (s)	11.681,0044	-	11.529,1762	-
Na <sub>2</sub> SO <sub>4</sub>	138,8800	-	0,1389	138,7411
HCl	-	-	-	-
H <sub>2</sub> O	111.408,3706	1.941,7188	1.114,0837	112.236,0056
<b>Sub total</b>	129.853,2624	1.941,7188	12.650,0238	119.144,9573
<b>Total</b>	131.794,9811		131.794,9811	

*ROTARY DRYER-02*

Fungsi : Mengeringkan kristal amonium klorida dengan udara panas

**Tabel 4.2.12. Neraca panas *rotary dryer-02***

Komponen	Q Masuk (Kj/Jam)		Q Keluar (Kj/jam)	
	Arus 24	Arus 26	Arus 27	Arus 28
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	6,0397	-	0,9659	95,6238
NaCl	0,4416	-	0,0674	6,6709
NH <sub>4</sub> Cl	0,1437	-	-	-
NH <sub>4</sub> Cl (s)	11.529,1762	-	1.849,9117	183.141,2550
Na <sub>2</sub> SO <sub>4</sub>	0,1389	-	0,0219	2,1648
HCl	-	-	-	-
H <sub>2</sub> O	1.114,0837	28.830,5421	29.368,2206	2.118,3146
Udara	-	1.030.274,8415	855.172,1908	-
<b>Sub total</b>	12.650,0238	1.059.105,3837	886.391,3782	185.364,0293

<b>Total</b>	1.071.755,4075	1.071.755,4075
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*EVAPORATOR-02*

Fungsi : menjenuhkan sisa reaktan sebelum recycle ke reaktor

**Tabel 4.1.13. Neraca panas *Evaporator-02***

Komponen	Q Masuk (Kj/Jam)	Q Keluar (Kj/jam)	
	Arus 36	Arus 37	Arus 38
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	5.973,3167	-	95.528,2161
NaCl	436,7881	-	6.664,2237
NH <sub>4</sub> Cl	292,3318	-	4.690,5449
Na <sub>2</sub> SO <sub>4</sub>	137,3537	-	2.162,6836
HCl	-	-	-
H <sub>2</sub> O	111.113,6456	398.529,2922	891.606,3096
<b>Sub total</b>	117.953,4359	398.529,2922	1.000.651,9780
Beban pemanas	1.348.660,8782		
Q loss		67.433,0439	
<b>Total</b>	1.466.614,3140	1.466.614,3140	

*KONDENSER*

Fungsi : mencairkan uap yang keluar dari evaporator

**Tabel 4.2.14. Neraca panas *kondenser***

Komponen	Q masuk, KJ/jam	Q keluar, KJ/jam
H <sub>2</sub> O (gas)	1.220.460,1735	59.704,7560
HCl (gas)	706,1599	28,1139
H <sub>2</sub> O (kondensat)	-	238.819,0239
HCl (kondensat)	-	112,4556
Pendingin	-	922.501,9840
<b>Total</b>	1.221.166,3334	1.221.166,3334

*HEATER*

Fungsi : memanaskan udara sampai suhu 120 °C

**Tabel 4.1.15. Neraca panas heater**

<b>Komponen</b>	<b>Q Masuk (Kj/Jam)</b>	<b>Q Keluar (Kj/jam)</b>
Udara	13.322,4786	1.611.423,3831
Uap air	2.354,2775	45.093,0255
Steam	1.727.199,6342	-
Q loss	-	86.359,9817
<b>Total</b>	<b>1.742.876,3903</b>	<b>1.742.876,3903</b>