

## Perhitungan Neraca Massa

Kapasitas produksi = 15.000 ton/tahun.

Waktu Operasi = 24 jam/hari ; 330 hari /tahun.

Satuan massa = kilogram.

Kapasitas produksi = 15.000 ton/tahun.

= 1.893.9399 kg/jam.

Komposisi Bahan Batu =

Komposisi Amunium Sulfat (PT. Petrokimia Gresik)

| Komponen                     | % Berat |
|------------------------------|---------|
| $(\text{NH}_4)_2\text{SO}_4$ | 98,9 %  |
| $\text{H}_2\text{SO}_4$      | 0,1 %   |
| $\text{H}_2\text{O}$         | 1 %     |

Komposisi Garam (PT. Garam)

| Komponen             | % Berat |
|----------------------|---------|
| $\text{NaCl}$        | 99,5 %  |
| $\text{H}_2\text{O}$ | 0,5 %   |

### Neraca Massa Basik

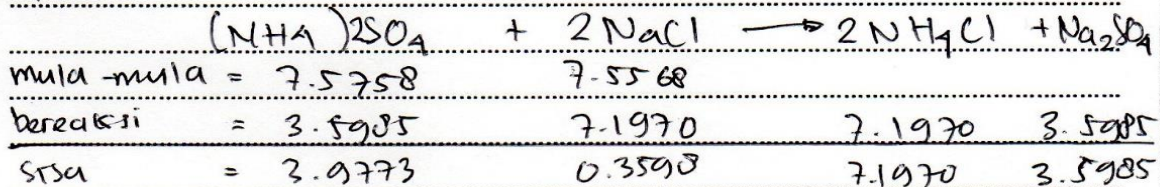
Umpan masuk, 1.000 kg/jam  $(\text{NH}_4)_2\text{SO}_4$

$$\begin{aligned}
 (\text{NH}_4)_2\text{SO}_4 \text{ mula-mula} &= 1.000 \text{ kg/jam} \\
 &= 1.000 \text{ kg/jam} \\
 &\quad 132 \text{ kg/jam} \\
 &= 7.5758 \text{ kmol/jam}
 \end{aligned}$$

$$\begin{aligned}
 \text{Yield} &= 95\% \\
 &= 95\% \times 7.5758 \text{ kmol/jam} \\
 &= 7.1970 \text{ kmol/jam}
 \end{aligned}$$

NaCl mula-mula = excess 5%

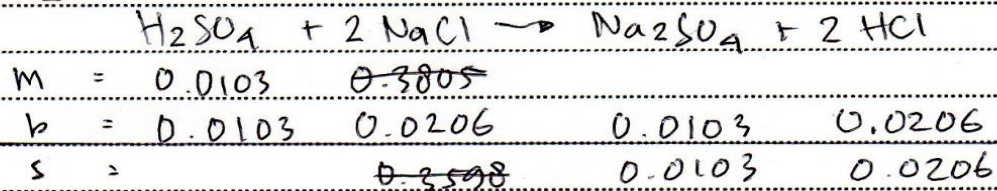
Reaksi I



Komposisi Umpan  $(\text{NH}_4)_2\text{SO}_4$

|                              |          |                     |
|------------------------------|----------|---------------------|
| $(\text{NH}_4)_2\text{SO}_4$ | = 98.90% | = 1.000 kg/jam      |
| $\text{H}_2\text{SO}_4$      | = 0.10%  | = 1.011 kg/jam      |
| $\text{H}_2\text{O}$         | = 1%     | = 10.1112 kg/jam +  |
| total                        | = 100%   | = 1.011,1223 kg/jam |

Reaksi II



$$\begin{aligned}
 \text{Umpun NaCl} &= 7.5568 \text{ kmol/jam} + 0.0206 \text{ kmol/jam} \\
 &= 7.5775 \text{ kmol/jam} \\
 &= 7.5775 \text{ kmol/jam} \times 58,5 \text{ kg/kmol} \\
 &= 443.2810 \text{ kg/jam}
 \end{aligned}$$

komposisi umpun NaCl

$$\begin{aligned}
 \text{NaCl} &= 99,5\% = 443.2810 \text{ kg/jam} \\
 \text{H}_2\text{O} &= 0,5\% = 2,2275 \text{ kg/jam} \\
 &= 445,5086 \text{ kg/jam}
 \end{aligned}$$

Dengan menjalankan sekali proses dengan menggunakan bahan batu yang telah diketahui di atas diperoleh data massa komponen pada arus 30 yang akan di recycle ke reaktor sehayai berikut.

Arus 30.

| komponen  | massa (kg/jam) |
|---|----------------|
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 518.7110       |
| NaCl  | 20.7990        |
| NH <sub>4</sub> Cl                              | 9.9903         |
| Na <sub>2</sub> SO <sub>4</sub>                 | 6.0267         |
| HCl   |                |
| H <sub>2</sub> O                                | 518.5637       |
| Total   | 1.137.0307     |

Neraca Massa Mixer 01

Fungsi : Memanaskan amonium sulfat dengan penambahan air proses sehingga menjadi larutan jenuh.

Ajar arus 30 massa komponennya tetap, maka digunakan fitur solver pada ms. excel sehingga diperoleh massa amonium sulfat 1.043.9379 kg/jam.

Arus 1

| Komponen                      | massa (kg/jam) |
|-------------------------------|----------------|
| $(\text{NH}_4)_2 \text{SO}_4$ | 1.000          |
| $\text{H}_2 \text{SO}_4$      | 1.0111         |
| $\text{H}_2\text{O}$          | 10.1112        |
| Total                         | 1.011.1223     |

Arus 2

Kelenturan  $(\text{NH}_4)_2 \text{SO}_4$  pada suhu  $100^\circ\text{C} = 103.3 \text{ kg}$   
 $100 \text{ kg H}_2\text{O}$

$$\begin{aligned} \text{kebutuhan air proses} &= \frac{1.000 \times 100}{103.3} \\ &= 968.0592 \text{ kg/jam} \end{aligned}$$

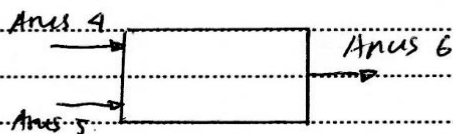
Arus 3

$$\begin{aligned} (\text{NH}_4)_2 \text{SO}_4 &= 1.000 \text{ kg/jam} \\ \text{H}_2 \text{SO}_4 &= 1.0111 \text{ kg/jam} \\ \text{H}_2\text{O} &= 10.1112 + 968.0592 \\ &= 978.1654 \text{ kg/jam} \end{aligned}$$

| Komponen                      | Masuk      |          | Keluar     |
|-------------------------------|------------|----------|------------|
|                               | Arus 1     | Arus 2   | Arus 3     |
| $(\text{NH}_4)_2 \text{SO}_4$ | 1.000      |          | 1.000      |
| $\text{H}_2 \text{SO}_4$      | 1.0111     |          | 1.0111     |
| $\text{H}_2\text{O}$          | 10.1112    | 968.0592 | 978.1654   |
| Sub total                     | 1.011.1223 | 968.0592 | 1.979.1766 |
| total                         | 1.979.1766 |          | 1.979.1766 |

Neraca Massa Mixer 02

Fungsi : Melenturan NaCl dengan penambahan air proses sehingga menjadi larutan jenuh.



Agar arus 38 massa komponennya tetap maka digunakan fitur solver pada ms. excel sehingga diperoleh massa NaCl 443.2810 kg/jam

Arus 4.

$$\text{NaCl} = 443.2810 \text{ kg/jam}$$

$$\text{H}_2\text{O} = 2.2275 \text{ kg/jam}$$

Arus 5

$$\text{kelarutan NaCl pada suhu } 100^\circ\text{C} = 39.8 \text{ kg/100 kg H}_2\text{O}$$

$$\text{kebutuhan air proses} = \frac{443.280}{39.8} \times 100$$

$$= 1.113.7714 \text{ kg/jam.}$$

Arus 6.

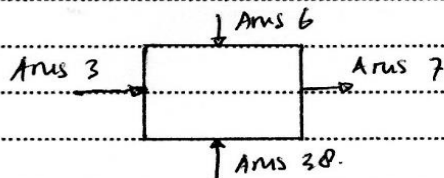
$$\text{NaCl} = 443.280 \text{ kg/jam}$$

$$\text{H}_2\text{O} = 1.113.7714 \text{ kg/jam} + 2.2275$$

$$= 1.115.9989 \text{ kg/jam.}$$

| Komponen         | Masuk (kg/jam) |            | Keluar (kg/jam) |
|------------------|----------------|------------|-----------------|
|                  | arus 4         | arus 5     | arus 6          |
| NaCl             | 443.2810       |            | 443.2810        |
| H <sub>2</sub> O | 2.2275         | 1.113.7714 | 1.115.9989      |
| Sub total        | 445.5086       | 1.113.7714 | 1.559.280       |
| total            |                | 1.559.280  | 1.559.280       |

Neraca Massa Reaktor



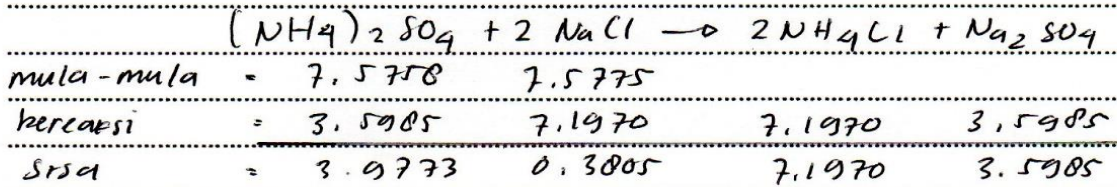
**Reaksi 1**

$$(NH_4)_2SO_4 \text{ mula-mula} = 7.5758 \text{ kmol/jam}$$

$$NaCl \text{ mula-mula} = 7.5775 \text{ kmol/jam}$$

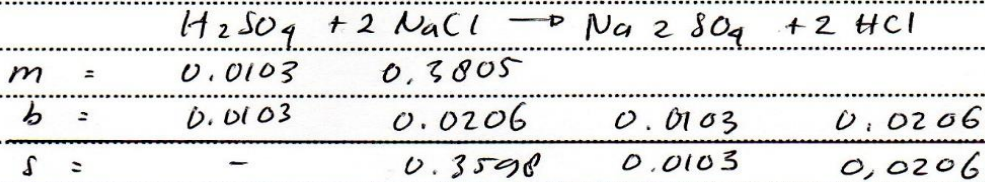
$$\text{Yield} = 95\%$$

$$= 95\% \times 7.5758 \text{ kmol/jam} = 7.1970 \text{ kmol/jam}$$


**Reaksi 02**

$$H_2SO_4 \text{ mula-mula} = 0.0103 \text{ kmol/jam}$$

$$NaCl \text{ mula-mula} = 0.3805 \text{ kmol/jam}$$


**Anus 7 (siswa reaktan dan produk)**

$$\begin{aligned} (NH_4)_2SO_4 &= 3.9773 \text{ kmol/jam} \\ &= 3.9773 \times 132 \text{ kg/kmol} \\ &= 525.0000 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} NaCl &= 0.3598 \text{ kmol/jam} \\ &= 0.3598 \text{ kmol/jam} \times 58.5 \text{ kg/kmol} \\ &= 21.0511 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned}
 \text{NH}_4\text{Cl} &= 7.1970 \text{ kmol/jam} \\
 &= 7.1970 \text{ kmol/jam} \times 53.5 \text{ kg/jam kmol} \\
 &= 385.0379 \text{ kg/jam} + 9.7485 \text{ kg/jam} \\
 &= 394.7864 \text{ kg/jam}
 \end{aligned}$$

$$\begin{aligned}
 \text{Na}_2\text{SO}_4 &= 3.6088 \text{ kmol/jam} \\
 &= 3.6088 \times 142 \\
 &= 512.4499 \text{ kg/jam}
 \end{aligned}$$

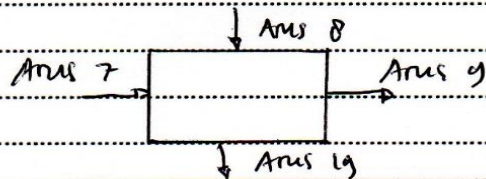
$$\begin{aligned}
 \text{HCl} &= 0.0206 \text{ kmol/jam} \\
 &= 0.0206 \times 36.5 \text{ kg/kmol} \\
 &= 0.7532 \text{ kg/jam}
 \end{aligned}$$

$$\text{H}_2\text{O} = 2.099.1694 \text{ kg/jam}$$

| Komponen  | Masuk kg/jam |            |         | Keluar (kg/jam) |
|---|--------------|------------|---------|-----------------|
|   | arus 3       | arus 6     | arus 30 | arus 7          |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 1.000        |            |         | 525.0000        |
| H <sub>2</sub> SO <sub>4</sub>                  | 1.011        |            |         |                 |
| NaCl  |              | 443.2810   |         | 21.0511         |
| NH <sub>4</sub> Cl                              |              |            |         | 385.0379        |
| Na <sub>2</sub> SO <sub>4</sub>                 |              |            |         | 512.4499        |
| HCl   |              |            |         | 0.7532          |
| H <sub>2</sub> O                                | 978.1654     | 1.115.9989 |         | 2.099.1694      |
| Sub total                                       | 1.979.1766   | 1.559.2800 |         | 3.538.4565      |
| total   |              | 3.538.4565 |         | 3.538.4565      |

### Neraca Massa Rotary Vacuum Filter

Fungsi : Memisahkan produk natrium sulfat dari mother liquor.



Anus 8

$$\begin{aligned} \text{kebutuhan air pencuci} &= 5\% \text{ dari padatan.} \\ &= 5\% \times 512.4999 \\ &= 25.6225 \text{ kg/jam.} \end{aligned}$$

Anus 9.

$$\text{Komponen terikat produk} = 1\%$$

$$\begin{aligned} (\text{NH}_4)_2\text{SO}_4 &= 1\% \times 525.0000 \\ &= 5.2500 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{NaCl} &= 1\% \times 21.0511 \\ &= 0.2105 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{NH}_4\text{Cl} &= 305.0379 \times 1\% \\ &= 3.0504 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{HCl} &= 0.7532 \times 1\% \\ &= 0.0075 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{H}_2\text{O} &= 2.094.1644 \text{ kg/jam} \times 1\% \\ &= 20.9416 \text{ kg/jam.} \end{aligned}$$

Air pencuci recovery 90% mother liquor

$$\begin{aligned} (\text{NH}_4)_2\text{SO}_4 &= 90\% \times 5.2500 \text{ kg/jam} \\ &= 4.7250 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{NaCl} &= 90\% \times 0.2105 \\ &= 0.1895 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{NH}_4\text{Cl} &= 90\% \times 3.0504 \\ &= 2.7454 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{HCl} &= 90\% \times 0.0075 \\ &= 0.0068 \text{ kg/jam} \end{aligned}$$

Kelentutan  $(\text{NH}_4)_2\text{SO}_4$  pada suhu  $60^\circ\text{C}$  adalah 88 kg /  
 100 kg  $\text{H}_2\text{O}$ .

$$\text{air yang melentutkan} = \frac{4.7250 \times 100}{88} = 5.3693 \text{ kg/jam}$$



Kelarutan NaCl pada suhu  $60^{\circ}\text{C}$  adalah  $37,04 \text{ kg}/100 \text{ kg H}_2\text{O}$   
 air yang melarutkan NaCl =  $0,1895 \times 100$   

$$\frac{37,04}{100}$$
  
 =  $0,5115 \text{ kg/jam}$

Kelarutan  $\text{NH}_4\text{Cl}$  pada suhu  $60^{\circ}\text{C}$  adalah  $55,2 \text{ kg}/100 \text{ kg H}_2\text{O}$   
 air yang melarutkan  $\text{NH}_4\text{Cl}$  =  $3,4653 \times 100$   

$$\frac{55,2}{100}$$
  
 =  $6,2778 \text{ kg/jam}$

Kelarutan HCl pada suhu  $60^{\circ}\text{C}$  adalah  $56,1 \text{ kg}/100 \text{ kg H}_2\text{O}$   
 air yang melarutkan HCl =  $0,0069 \times 100$   

$$\frac{56,1}{100}$$
  
 =  $0,0121 \text{ kg/jam}$ .

Jumlah air yang melarutkan komponen =  $12,1707 \text{ kg/jam}$   
 air pencuci =  $25,6225$   
 sisa air pencuci =  $25,6225 - 12,1707$   
 =  $13,4518 \text{ kg/jam}$ .

Sisa air pencuci melarutkan produk  $\text{Na}_2\text{SO}_4$  dan masuk ke  
 arus 9 kelarutan  $\text{Na}_2\text{SO}_4$  pada suhu  $60^{\circ}\text{C}$  adalah  $45,3 \text{ kg}/100 \text{ kg}$   
 $\text{H}_2\text{O}$ . Banyak  $\text{Na}_2\text{SO}_4$  yang larut =  $13,4518 \times 45,3$   

$$\frac{100}{100}$$
  
 =  $6,0937 \text{ kg/jam}$ .

Arus 9.

$(\text{NH}_4)_2\text{SO}_4$  =  $5,2500 - 4,7250 = 0,5250 \text{ kg/jam}$   
 NaCl =  $0,2105 - 0,1895 = 0,0211 \text{ kg/jam}$   
 $\text{NH}_4\text{Cl}$  =  $3,8504 - 3,4653 = 0,3851 \text{ kg/jam}$   
 $\text{Na}_2\text{SO}_4$  =  $512,4999 - 6,0937 = 506,3563 \text{ kg/jam}$   
 HCl =  $0,0075 - 0,0068 = 0,0008 \text{ kg/jam}$   
 $\text{H}_2\text{O}$  =  $20,9416 \text{ kg/jam}$ .

Arus 19

$$\begin{aligned} (\text{NH}_4)_2\text{SO}_4 &= 525.000 - 0,5250 = 524.4750 \text{ kg/jam} \\ \text{NaCl} &= 21.0511 - 0,0211 = 21.0301 \text{ kg/jam} \\ \text{NH}_4\text{Cl} &= 385.0379 - 0,3850 = 384,6529 \text{ kg/jam} \\ \text{Na}_2\text{SO}_4 &= 512.4999 - 506,3563 = 6.0937 \text{ kg/jam} \\ \text{HCl} &= 0,7532 - 0,0008 = 0,7524 \text{ kg/jam} \\ \text{H}_2\text{O} &= (2.099,1644 + 25.6225) - 20,9416 \\ &= 2.098,8452 \text{ kg/jam} \end{aligned}$$

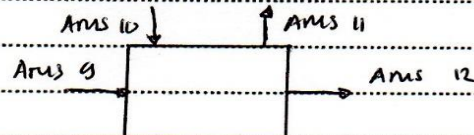
Total

$$\begin{aligned} \text{Masuk (in)} &= \text{arus 7} + \text{arus 8} \\ &= 3.538,4565 + 25.6225 \\ &= 3.564,0790 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{Keluar (out)} &= \text{Arus 9} + \text{arus 19} \\ &= 528.2298 + 3.035,8493 \\ &= 3.564,0790 \text{ kg/jam} \end{aligned}$$

Neraca Massa Rotary Dryer 01

Fungsi : Mengeringkan produk Natrium Sulfat



Arus 10

Kebutuhan udara dihitung pada perhitungan Neraca Panas.

Arus 11

Akan dibuat produk dengan kadar 99,5%

$$\begin{aligned} \text{air yang harus dihilangkan} &= 528.2298 - \frac{506.3563}{99,5\%} \\ &= 19,3290 \text{ kg/jam} \end{aligned}$$

Asumsi komponen terikat udara pengering 1%

$$\begin{aligned} (\text{NH}_4)_2\text{SO}_4 &= 1\% \times 0,5250 \text{ kg/jam} = 0,0053 \text{ kg/jam} \\ \text{NaCl} &= 1\% \times 0,0211 \text{ kg/jam} = 0,0002 \text{ kg/jam} \\ \text{NH}_4\text{Cl} &= 1\% \times 0,3858 \text{ kg/jam} = 0,0039 \text{ kg/jam} \\ \text{Na}_2\text{SO}_4 &= 1\% \times 506,3563 \text{ kg/jam} = 5,0636 \text{ kg/jam} \\ \text{HCl} &= 1\% \times 0,0008 \text{ kg/jam} = 0,0000 \text{ kg/jam} \\ \text{H}_2\text{O} &= 19,3290 \text{ kg/jam} \end{aligned}$$

Udara = dihitung di neraca panas.

arus 12

( arus 9 - arus 12 )

$$\begin{aligned} (\text{NH}_4)_2\text{SO}_4 &= 0,5197 \text{ kg/jam} \\ \text{NaCl} &= 0,0208 \text{ kg/jam} \\ \text{NH}_4\text{Cl} &= 0,3812 \text{ kg/jam} \\ \text{Na}_2\text{SO}_4 &= 501,2927 \text{ kg/jam} \\ \text{HCl} &= 0,0007 \text{ kg/jam} \\ \text{H}_2\text{O} &= 1,6127 \text{ kg/jam} \end{aligned}$$

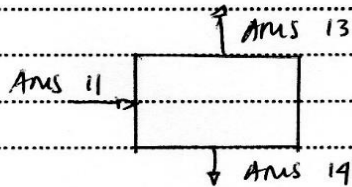
Jadi total arus yg masuk dan keluar rotary  
 Dryer di adalah :

$$\begin{aligned} \text{Masuk (in)} &= \text{arus 9} + \text{arus 10} \\ &= 520,2928 \text{ kg/jam} \end{aligned}$$

$$\begin{aligned} \text{keluar (out)} &= \text{arus 11} + \text{arus 12} \\ &= 29,9019 + 503,8279 \\ &= 528,2298 \text{ kg/jam} \end{aligned}$$

### Neraca Massa cyclone D1

Fungsi : Memisahkan partikulat dari udara pengering



Arus 13

Kehilangan komponen non air pada cyclone 1%

$$(NH_4)_2SO_4 = 1\% \times 0,0053 = 0,0001 \text{ kg/jam}$$

$$NaCl = 1\% \times 0,0002 = 2,11E-06 \text{ kg/jam}$$

$$NH_4Cl = 1\% \times 0,0039 = 0,0000 \text{ kg/jam}$$

$$Na_2SO_4 = 5\% \times 5,0636 = 0,0506 \text{ kg/jam}$$

$$HCl = 1\% \times 0,0000 = 7,53E-08 \text{ kg/jam}$$

$$H_2O = 19,3290 \text{ kg/jam}$$

Arus 14

(Arus 11 - arus 13)

$$(NH_4)_2SO_4 = 0,0052 \text{ kg/jam}$$

$$NaCl = 0,0002 \text{ kg/jam}$$

$$NH_4Cl = 0,0038 \text{ kg/jam}$$

$$Na_2SO_4 = 5,0129 \text{ kg/jam}$$

$$HCl = 0,0000 \text{ kg/jam}$$

$$H_2O = -$$

Jadi komponen yang masuk dan keluar cyclone D1 adalah:

$$\text{Masuk (in)} = \text{Arus 11}$$

$$= 29,9019$$

$$\text{Keluar (out)} = \text{Arus 13} + \text{Arus 14} = 29,9019 \text{ kg/jam}$$