

**BAB IV**  
**NERACA MASSA DAN NERACA PANAS**

Perhitungan neraca massa dan energi dilakukan dengan basis perhitungan dan data konversi seperti dibawah ini :

Kapasitas : 50.000 ton/th

Operasi : 300 hari/tahun, 24 jam/hari

Proses : kontinyu

Basis : 1 jam

Bahan baku : Karbon Tetraklorida (  $\text{CCl}_4$  ) dan Metanol (  $\text{CH}_3\text{OH}$  )

Produk : Metil Klorida

Kapasitas produksi per tahun:

$$= \frac{50.000 \text{ ton}}{\text{tahun}} \times \frac{1000 \text{ kg}}{\text{ton}} \times \frac{1 \text{ tahun}}{300 \text{ hari}} \times \frac{1 \text{ hari}}{24 \text{ jam}}$$

$$= 6.944,444 \text{ kg/jam}$$

**A. Neraca Massa**

**Neraca Massa Overall**

**Tabel 4.1 Neraca Massa Overall**

<b>Komponen</b>	<b>Masuk (kg/jam)</b>	<b>Keluar (kg/jam)</b>
Karbon Tetraklorida	5.928,800	0,000
Air	19.255,3282	20.367,0282
Asam Klorida	0,000	602,830
Karbon Dioksida	0,000	1.697,757
Methanol	4.489,573	12,688
Metil Klorida	0,000	6.944,444
Dimetil Eter	0,000	48,954
<b>Total</b>	<b>29.673,7012</b>	<b>29.673,7012</b>

## Neraca Massa per Alat

### 1) Mixed Point 01 (M-101)

Tabel 4.2 Neraca massa *Mixing Point* -101(MP-101)

No	Komponen	Input (kg/jam)		Output (kg/jam)
		Aliran 1	Aliran 3	Aliran 2
1.	CCl <sub>4</sub>	5928,8	1482,2	7411
<b>Total</b>		<b>7411</b>		<b>7411</b>

### 2) Vaporizer 01 (V-101)

Tabel 4.3 Neraca massa *Vaporizer*-101 (V-101)

No	Komponen	Input (kg/jam)	Ouput (kg/jam)	
		Aliran 2	Aliran 3	Aliran 4
1.	CCl <sub>4</sub>	7411	1482,2	5928,8
<b>Total</b>		<b>7411</b>	<b>7411</b>	

### 3) Reaktor (R-201)

Tabel 4.4 Neraca massa *Reaktor* -201 (R-201)

No	Komponen	Input (kg/jam)		Output (kg/jam)
		Aliran 5	Aliran 7	Aliran 8
1.	CCl <sub>4</sub>	5928,8	-	-
2.	H <sub>2</sub> O	-	6249,4	4860,645
3.	HCl	-	-	5619,798
4.	CO <sub>2</sub>	-	-	1697,757
<b>Total</b>		<b>12178,2</b>		<b>12178,2</b>

### 4) Absorber Cooler 01 (ABS-301)

Tabel 4.5 Neraca massa *Absorber Cooler*-301(ABS-301)

No	Senyawa	Input (kg/jam)		Output (kg/jam)	
		Aliran 10	Aliran 11	Aliran 12	Aliran 13
1.	HCl	5619,798	-	0,0001	5619,7979
2.	H <sub>2</sub> O	4860,645	3309,8191	-	8170,4641
3.	CO <sub>2</sub>	1697,757	-	1697,757	-
		12178,2	3309,8191	1697,7571	13790,2620
<b>Total</b>		<b>15488,0191</b>		<b>15488,0191</b>	

5) *Stripper 01 (ST-301)*Tabel 4.6 Neraca massa *Stripper-301 (ST-301)*

No	Komponen	Input (kg/jam)		Ouput (kg/jam)	
		Aliran 2	Aliran 3	Aliran 3	Aliran 4
1.	HCl	5619,7979	5619,7979	-	
2.	H <sub>2</sub> O	8170,4641	3832,824	4337,6401	
			9452,6219	4337,6401	
<b>Total</b>		<b>13790,262</b>	<b>13790,262</b>		

6) *Mixed Point 02 ( M-102 )*Tabel 4.7 Neraca massa *Mixed Point-302 (M-302)*

No	Komponen	Input (kg/jam)		Output (kg/jam)
		Aliran 18	Aliran 20	Aliran 19
1.	CH <sub>3</sub> OH	4489,573	1122,393	5611,966
2.	H <sub>2</sub> O	18,03	4,508	22,538
<b>Total</b>		<b>5634,504</b>		<b>5634,504</b>

7) *Vaporizer 02 ( V-302 )*Tabel 4.8 Neraca massa *Vaporizer-302 (V-302)*

No	Komponen	Input (kg/jam)		Ouput (kg/jam)	
		Aliran 19	Aliran 21	Aliran 21	Aliran 20
1.	CH <sub>3</sub> OH	5611,966	4489,573	1122,393	
2.	H <sub>2</sub> O	22,538	18,03	4,508	
			4507,379	1126,901	
<b>Total</b>		<b>5634,504</b>		<b>5634,504</b>	

### 8) Reaktor 02 ( R-402 )

Tabel 4.9 Neraca massa *Reaktor-402* (R-402)

No	Komponen	Input (kg/jam)		Output (kg/jam)
		Aliran 22	Aliran 17	Aliran 23
1.	CH <sub>3</sub> OH	4489,573	-	12,688
2.	HCl	-	5619,7979	602,8299
3.	CH <sub>3</sub> Cl	-	-	6944,444
4.	CH <sub>3</sub> OCH <sub>3</sub>	-	-	48,954
5.	H <sub>2</sub> O	18,03	3832,824	6351,309
<b>Total</b>		<b>13960,2249</b>		<b>13960,2249</b>

### 9) Absorber Cooler 02 ( ABS-502)

Tabel 4.10 Neraca massa *Absorber Cooler-02* (ABS-502)

No	Senyawa	Input (kg/jam)		Output (kg/jam)	
		Aliran 25	Aliran 26	Aliran 27	Aliran 28
1.	CH <sub>3</sub> OH	12,6880	-	-	12,6880
2.	HCl	602,8299	-	0,0001	602,8298
3.	CH <sub>3</sub> Cl	6351,3090	9678,0791	-	16029,3881
4.	CH <sub>3</sub> OCH <sub>3</sub>	6944,4440	-	6944,4440	-
5.	H <sub>2</sub> O	48,9540	-	48,9540	-
		13960,2249	9678,0791	6993,3981	16644,9059
<b>Total</b>		<b>23638,304</b>		<b>23638,304</b>	

## B. Neraca Panas

### 1) Mixed Point 01 (M-101)

Tabel 4.11 Neraca Panas *Mixing Point* (MP-101)

Panas masuk (kJ)		Panas keluar (kJ)	
Q <sub>1</sub>	25.256,069	Q <sub>2</sub>	195.928,140
Q <sub>3</sub>	170672,071		
<b>Total</b>	<b>195.928,140</b>	<b>Total</b>	<b>195.928,140</b>

2) *Vaporizer 01 ( V-101 )*Tabel 4.12 Neraca Panas *Vaporizer (V-101)*

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>2</sub>	195.928,140	-	-	Q <sub>3</sub>	170.672,071
Q <sub>8</sub>	3.026.934,020			Q <sub>4</sub>	557.531,061
				Q <sub>9</sub>	2.494.659,028
<b>Total</b>	<b>3.222.862,160</b>	<b>Total -</b>	<b>Total -</b>	<b>Total</b>	<b>3.222.862,160</b>

3) *Heater (H-101)*Tabel 4.13 Neraca Panas *Heater (H-101)*

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>4</sub>	557.531,061	-	-	Q <sub>5</sub>	696.933,515
Q <sub>steam</sub>	139.402,454				
<b>Total</b>	<b>696.933,515</b>	<b>Total -</b>	<b>Total -</b>	<b>Total</b>	<b>696.933,515</b>

4) *Heater (H-102)*Tabel 4.14 Neraca Panas *Heater (H-102)*

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>6</sub>	1.600.823,203	-	-	Q <sub>7</sub>	2.330.000,505
Q <sub>steam</sub>	1.458.355,298				
<b>Total</b>	<b>2.330.000,505</b>	<b>Total -</b>	<b>Total -</b>	<b>Total</b>	<b>2.330.000,505</b>

5) *Reaktor (R-201)*

Tabel 4.15 Neraca Panas Reaktor (R-201)

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>5</sub>	696.933,515	Q <sub>Reaksi</sub> 6.916.665,353		Q <sub>8</sub>	3.026.934,020
Q <sub>7</sub>	2.330.000,505			Q <sub>cw</sub>	6.916.665,353
<b>Total</b>	<b>3.026.934,020</b>	<b>Total 6.916.665,353</b>	<b>Total -</b>	<b>Total</b>	<b>9.943.599,373</b>

### 6) Absorber Cooler (ABS-301)

Tabel 4.16 Neraca Panas *Absorber Cooler* (ABS-301)

	<b>Panas Masuk (kJ/jam)</b>		<b>Panas Generasi (kJ/jam)</b>		<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>10</sub>	2.494.659,028	Q <sub>pelarutan</sub>	9.035.144,048	-		Q <sub>12</sub>	14.406,475
Q <sub>11</sub>	68.811,729					Q <sub>13</sub>	-590.922,86
						Q <sub>CW</sub>	11.228.063,985
<b>Total</b>	<b>2.563.470,757</b>	<b>Total</b>	<b>9.035.144,048</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>10.941.140,842</b>

### 7) Stripper (ST-301)

Tabel 4.17 Neraca Panas *Stripper* (ST-301)

	<b>Panas Masuk (kJ/jam)</b>		<b>Panas Generasi (kJ/jam)</b>		<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>13</sub>	590.922,86	-		Q <sub>Pelepasn</sub>	9.035.144,048	Q <sub>14</sub>	584.500,528
Q <sub>Steam</sub>	10.857.785,780					Q <sub>15</sub>	945.015,628
<b>Total</b>	<b>11.448.708,640</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>9.035.144,048</b>	<b>Total</b>	<b>2.413.564,590</b>

### 8) Mixing Point (MP-302)

Tabel 4.18 Neraca Panas *Mixing Point* (MP-302)

<b>Panas masuk (kJ)</b>		<b>Panas keluar (kJ)</b>	
Q <sub>18</sub>	56.524,858	Q <sub>19</sub>	332.052,230
Q <sub>20</sub>	275.527,372		
<b>Total</b>	<b>332.052,230</b>	<b>Total</b>	<b>332.052,230</b>

### 9) Vaporizer (V-302)

Tabel 4.19 Neraca Panas *Vaporizer* (V-302)

	<b>Panas Masuk (kJ/jam)</b>		<b>Panas Generasi (kJ/jam)</b>		<b>Panas Konsumsi (kJ/jam)</b>		<b>Panas Keluar (kJ/jam)</b>
Q <sub>19</sub>	332.052,230	-		-		Q <sub>21</sub>	615.032,016
Q <sub>steam</sub>	558.507,158					Q <sub>20</sub>	275.527,372
<b>Total</b>	<b>890.559,388</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>890.559,388</b>

### 10) Heater (H-303)

Tabel 4.20 Neraca Panas Heater (H-303)

Panas Masuk (kJ/jam)		Panas Generasi (kJ/jam)		Panas Konsumsi (kJ/jam)		Panas Keluar (kJ/jam)	
Q <sub>14</sub>	584.500,528		-		-	Q <sub>16</sub>	1.999.915,853
Q <sub>steam</sub>	1.415.415,325						
<b>Total</b>	<b>1.999.915,853</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>1.999.915,853</b>

### 11) Compresor (K-301)

Tabel 4.21 Neraca Panas Compresor (K-301)

Panas Masuk (kJ/jam)		Panas Generasi (kJ/jam)		Panas Konsumsi (kJ/jam)		Panas Keluar (kJ/jam)	
Q <sub>16</sub>	1.999.915,853	W <sub>s</sub>	306.009,530		-	Q <sub>17</sub>	2.305.925,383
<b>Total</b>	<b>1.999.915,853</b>	<b>Total</b>	<b>306.009,530</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>2.305.925,383</b>

### 12) Heater-304 (H-304)

Tabel 4.22 Neraca Panas Heater-304 (H-304)

Panas Masuk (kJ/jam)		Panas Generasi (kJ/jam)		Panas Konsumsi (kJ/jam)		Panas Keluar (kJ/jam)	
Q <sub>21</sub>	615.032,016		-		-	Q <sub>22</sub>	1.413.324,638
Q <sub>steam</sub>	798.292,622						
<b>Total</b>	<b>1.413.324,638</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>1.413.324,638</b>

### 13) Reaktor-402 (R-402)

Tabel 4.23 Neraca Panas Reaktor-402 (R-402)

Panas Masuk (kJ/jam)		Panas Generasi (kJ/jam)		Panas Konsumsi (kJ/jam)		Panas Keluar (kJ/jam)	
Q <sub>17</sub>	2.305.925,383	Q <sub>R</sub>	4.786.357,740			Q <sub>23</sub>	3.719.250,021
Q <sub>22</sub>	1.413.324,638					Q <sub>cw</sub>	4.786.357,740
<b>Total</b>	<b>3.719.250,021</b>	<b>Total</b>	<b>4.786.357,740</b>	<b>Total</b>	<b>-</b>	<b>Total</b>	<b>8.505.607,761</b>

#### 14) WHB-501 (WHB-501)

Tabel 4.24 Neraca Panas WHB-501 (WHB-501)

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>	<b>Panas Keluar (kJ/jam)</b>
Q <sub>24</sub>	3.719.250,021	-	-	Q <sub>25</sub> 1.773.729,911
Q <sub>air</sub>	8.886,576			Q <sub>steam</sub> 1.955.406,686
<b>Total</b>	<b>3.728.136,597</b>	<b>Total -</b>	<b>Total -</b>	<b>Total 3.728.136,597</b>

#### 15) Absorber cooler-502 (ABS-502)

Tabel 4.25 Neraca Panas Absorber cooler-502 (ABS-502)

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>	<b>Panas Keluar (kJ/jam)</b>
Q <sub>25</sub>	1.773.729,911	Q <sub>pelarutan</sub> 969.190,012		Q <sub>27</sub> 587.159,341
Q <sub>26</sub>	214.727,389			Q <sub>28</sub> 565.348,123
				Q <sub>cw</sub> 1.765.139,868
<b>Total</b>	<b>1.988.457,300</b>	<b>Total 969.190,012</b>	<b>Total -</b>	<b>Total 2.957.647,312</b>

#### 16) Chiller-501 (CH-501)

Tabel 4.26 Neraca Panas Chiller-501 (CH-501)

	<b>Panas Masuk (kJ/jam)</b>	<b>Panas Generasi (kJ/jam)</b>	<b>Panas Konsumsi (kJ/jam)</b>	<b>Panas Keluar (kJ/jam)</b>
Q <sub>27</sub>	587.159,341	-	-	Q <sub>29</sub> -544.090,611
				Q <sub>refrigerasi</sub> 1.131.249,952
<b>Total</b>	<b>587.159,341</b>	<b>Total -</b>	<b>Total -</b>	<b>Total 587.159,341</b>