

#### IV. NERACA MASSA DAN NERACA ENERGI

Perhitungan neraca massa dan energi dilakukan dengan basis perhitungan dan data sebagai berikut :

Kapasitas Produksi : 100.000 ton/tahun

$$100.000 \text{ ton / tahun} \times \frac{1 \text{ tahun}}{330 \text{ hari}} \times \frac{1 \text{ hari}}{24 \text{ jam}}$$

$$= 12,626262 \text{ ton/jam}$$

$$= 12.626,262 \text{ kg/jam}$$

Operasi : 330 hari/tahun, 24 jam/hari

Basis : 1 jam

Proses : kontinyu

Bahan baku : *Etilen Dichlorida* (EDC)

Produk : *Vinyl Chloride Monomer* (VCM)

*Hidrochloride Acid* (HCl)

##### A. Neraca Massa

Persamaan Umum Neraca Massa :

$$\{\text{Massa masuk}\} - \{\text{Massa keluar}\} + \{\text{Massa tergenerasi}\} - \{\text{Massa terkonsumsi}\} = \{\text{Akumulasi massa}\}$$

(Himmelblau, 1996 : 144)

### 1. Tangki Penyimpanan EDC (TP-101)

**Tabel 4.1. Neraca Massa Tangki Penyimpanan EDC (TP-101)**

Komponen	Input (kg/jam)	Output (kg/jam)
	<i>Fresh Feed EDC</i>	F <sub>1</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	20.025,6128	20.025,6128
HCl	40,0512	40,0512
<b>Total</b>	<b>20.065,6641</b>	<b>20.065,6641</b>

### 2. Mixed Point (MP-101)

**Tabel 4.2. Neraca Massa Mixed Point (MP-101)**

Komponen	Input (kg/jam)		Output (kg/jam)
	F <sub>1</sub>	F <sub>7</sub>	F <sub>2</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	20.025,6128	13.328,1727	33.353,7855
C <sub>2</sub> H <sub>3</sub> Cl	-	12,6389	12,6389
Cl <sub>2</sub>	40,0512	0,0074	40,0586
<b>Total</b>	<b>20.065,6641</b>	<b>13.340,8190</b>	<b>33.406,4830</b>
	<b>33.406,4830</b>		

### 3. Vaporizer (VP-101)

**Tabel 4.3. Neraca Massa Vaporizer (VP-101)**

Komponen	Input (kg/jam)	Output (kg/jam)
	F <sub>2</sub>	F <sub>3</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	33.353,7855	33.353,7855
C <sub>2</sub> H <sub>3</sub> Cl	12,6389	12,6389
Cl <sub>2</sub>	40,0586	40,0586
<b>Total</b>	<b>33.406,4830</b>	<b>33.406,4830</b>

#### 4. Reaktor *Furnace* (RE-201)

Tabel 4.4. Neraca Massa Reaktor *Furnace* (RE-201)

Komponen	Input	Massa	Massa	Output
	(kg/jam)	Tergenerasi	Terkonsumsi	(kg/jam)
	F <sub>3</sub>	(kg/jam)	(kg/jam)	F <sub>4</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	33.353,7855	0,0000	20.012,2713	13.341,5142
C <sub>2</sub> H <sub>3</sub> Cl	12,6389	12.638,9142	0,0000	12.651,5531
HCl	40,0586	7.373,3572	0,0000	7.413,4158
<b>Total</b>	<b>33.406,4830</b>	<b>20.012,2713</b>	<b>20.012,2713</b>	<b>33.406,4830</b>
		<b>53.418,7543</b>	<b>53.418,7543</b>	

#### 5. Menara Destilasi (MD-301)

Tabel 4.5. Neraca Massa Menara Destilasi (MD-301)

Komponen	Input	Output (kg/jam)	
	(kg/jam)	F <sub>5</sub>	F <sub>6</sub>
	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	13.341,5142	13.341,5142	0,0000
C <sub>2</sub> H <sub>3</sub> Cl	12.651,5531	12.638,9015	12,6516
HCl	7.413,4158	7,4134	7.406,0023
<b>Total</b>	<b>33.406,4830</b>	<b>25.987,8291</b>	<b>7.418,6539</b>
		<b>33.406,4830</b>	

## 6. Menara Destilasi (MD-302)

Tabel 4.6. Neraca Massa Menara Destilasi (MD-302)

Komponen	Input (kg/jam)	Output (kg/jam)	
	F <sub>5</sub>	F <sub>7</sub>	F <sub>8</sub>
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	13.345,3027	13.328,1727	17,1300
C <sub>2</sub> H <sub>3</sub> Cl	16.224,2890	12,6389	16.211,6501
HCl	9,5164	0,0074	9,5090
<b>Total</b>	<b>29.579,1081</b>	<b>13.340,8190</b>	<b>16.238,2891</b>
		<b>29.579,1081</b>	

## 7. Absorber (AB-301)

Tabel 4.7. Neraca Massa Absorber (AB-301)

Komponen	Input (kg/jam)		Output (kg/jam)	
	F <sub>6</sub>	F <sub>9</sub>	F <sub>10</sub>	F <sub>11</sub>
C <sub>2</sub> H <sub>3</sub> Cl	12,6516	0,0000	0,0017	12,6499
HCl	7.406,0023	0,0000	7406,0023	0,0000
H <sub>2</sub> O	0,0000	15.182,5242	15.182,5242	0,0000
<b>Total</b>	<b>7.418,6539</b>	<b>15.182,5242</b>	<b>22.601,1781</b>	<b>12,6499</b>
	<b>22.601,1781</b>		<b>22.601,1781</b>	

## B. Neraca Energi

Dari hasil perhitungan neraca massa selanjutnya dilakukan perhitungan neraca energi. Perhitungan neraca energi didasarkan pada :

Basis waktu : Jam

Satuan panas : kJ

Temperature referensi : 25 C (298,15 K)

Persamaan Umum Neraca Energi :

$$\{ \text{Energi masuk} \} - \{ \text{Energi keluar} \} + \{ \text{Energi tergenerasi} \} - \{ \text{Energi terkonsumsi} \} = \{ \text{Akumulasi Energi} \}$$

(Himmelblau, 1996 : 144)

### 1. *Mixed Point* (MP-101)

**Tabel 4.8. Neraca Energi *Mixed Point* (MP-101)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>1</sub>	263.141,4562	Q <sub>2</sub>	7.859.409,6831
Q <sub>12</sub>	7.596.268,2269		
<b>Total</b>	<b>7.859.409,6831</b>		<b>7.859.409,6831</b>

### 2. *Vaporizer* (VP-101)

**Tabel 4.9. Neraca Energi *Vaporizer* (VP-101)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>2</sub> (umpan)	7.859.409,6831	Q <sub>3</sub>	12.266.559,2910
Q <sub>steam in</sub>	8.395.077,3554	Q <sub>kondensat</sub>	3.987.927,7475
<b>Total</b>	<b>16.254.487,0385</b>		<b>16.254.487,0385</b>

### 3. Reaktor *Furnace* (RE-201)

**Tabel 4.10. Neraca Energi Reaktor *Furnace* (RE-201)**

Q masuk (kJ/jam)	Q generasi (kJ/jam)	Q konsumsi (kJ/jam)	Q keluar (kJ/jam)
Q <sub>3</sub> 6.005.439,7242			Q <sub>4</sub> 21.329.207,8137
		24.239.567,0601	
Q <sub>suplai</sub>	39.563.335,1497		
<b>Total</b> 6.005.439,7242	<b>39.563.335,1497</b>	<b>24.239.567,0601</b>	<b>21.329.207,8137</b>
	<b>45.568.774,8738</b>	<b>45.568.774,8738</b>	

### 4. *Expander* (EX-201)

**Tabel B.4.11 Neraca Energi *Expander* (EX-201)**

Q masuk (kJ/jam)	Q keluar (kJ/jam)
Q <sub>4</sub> (in) 21.329.207,8137	Q <sub>5</sub> (out) 19.218.816,6087
	Q <sub>ev</sub> 2.110.391,
<b>Total</b> 21.329.207,8137	<b>21.329.207,8137</b>

### 5. *Cooler* (CO-201)

**Tabel 4.12. Neraca Energi *Cooler* (CO-201)**

Q masuk (kJ/jam)	Q keluar (kJ/jam)
Q <sub>5</sub> 17.565.256,25	Q <sub>6</sub> 12.757.054,51
Q <sub>p in</sub> 28.378.739,1773	Q <sub>p out</sub> 33.186.941,05
<b>Total</b> 45.943.995,56	<b>45.943.995,56</b>

## 6. Cooler (CO-202)

**Tabel 4.13. Neraca Energi Cooler (CO-202)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>6</sub>	12.757.054,5130	Q <sub>7</sub>	2.728.280,8446
Q <sub>cw in</sub>	2.500.324,1144	Q <sub>cw out</sub>	12.529.097,7828
<b>Total</b>	<b>15.257.378,6274</b>	<b>Total</b>	<b>15.257.378,6274</b>

## 7. Condensor (CD-201)

**Tabel 4.14. Neraca Energi Condensor (CD-201)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>7</sub>	2.990.224,3175	Q <sub>8</sub>	127.159,4219
Q <sub>cw in</sub>	713.805,1407	Q <sub>cw out</sub>	3.576.870,0362
<b>Total</b>	<b>3.704.029,4582</b>	<b>Total</b>	<b>3.704.029,4582</b>

## 8. Menara Destilasi (MD-301)

**Tabel 4.15. Neraca Energi Menara Destilasi (MD-301)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>8</sub> (umpan)	127.159,4219	Q <sub>10</sub> (destilat)	-1.96.054,6991
Q <sub>steam in</sub>	14.850.639,2781	Q <sub>9</sub> (bottom)	3.625.855,7859
		Q <sub>kondensat</sub>	7.054.524,2097
		Q <sub>condensor</sub>	4.493.473,4035
<b>Total</b>	<b>14.977.798,7000</b>	<b>Total</b>	<b>14.977.798,7000</b>

### 9. Cooler (CO-301)

**Tabel 4.16. Neraca Energi Cooler (CO-301)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>9</sub>	3.625.855,7859	Q <sub>11</sub>	638.970,9250
Q <sub>cw in</sub>	744.675,3204	Q <sub>cw out</sub>	3.731.560,1813
<b>Total</b>	<b>4.370.531,1063</b>	<b>Total</b>	<b>4.370.531,1063</b>

### 10. Menara Destilasi (MD-302)

**Tabel 4.17. Neraca Energi Menara Destilasi (MD-302)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>11</sub> (umpan)	638.970,9250	Q <sub>13</sub> (distilat)	2.241.473,9862
Q <sub>cw in</sub>	640.890,3902	Q <sub>12</sub> (bottom)	5.163.388,6428
Q <sub>steam in</sub>	17.784.875,8662	Q <sub>cw out</sub>	3.211.494,9901
		Q <sub>kondensat</sub>	8.448.379,5623
<b>Total</b>	<b>19.064.737,1814</b>	<b>Total</b>	<b>19.064.737,1814</b>

### 11. Cooler (CO-302)

**Tabel 4.18. Neraca Energi Cooler (CO-302)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>13</sub>	2.241.473,9862	Q <sub>14</sub>	176.030,9900
Q <sub>cw in</sub>	514.946,0044	Q <sub>cw out</sub>	2.580.389,0006
<b>Total</b>	<b>2.756.419,9906</b>	<b>Total</b>	<b>2.756.419,9906</b>



### 12. Expander (EX-302)

**Tabel 4.19. Neraca Energi Expander (EX-302)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>10</sub> (in)	-196.054,6991	Q <sub>14</sub> (out)	-197.546,3305
		Q <sub>ev</sub>	1.491,6314
<b>Total</b>	<b>-196.054,6991</b>		<b>-196.054,6991</b>

### 13. Heater (HE-301)

**Tabel 4.20. Neraca Energi Heater (HE-301)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>15</sub>	-198.434,5733	Q <sub>16</sub>	59.225,1788
Q <sub>steam in</sub>	490.810,1024	Q <sub>kondensat</sub>	233.150,3503
<b>Total</b>	<b>292.375,5291</b>		<b>292.375,5291</b>

### 14. Absorber (AB-301)

**Tabel 4.21. Neraca Energi Absorber (AB-301)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>16</sub> (umpan)	59.225,1788	Q <sub>18</sub> (liquid)	356.462,9506
Q <sub>17</sub>	297.350,6414	Q <sub>19</sub> (uap)	112,8697
<b>Total</b>	<b>356.575,8203</b>		<b>356.575,8203</b>

### 15. Condensor (CD-303)

**Tabel 4.22. Neraca Energi Condensor (CD-303)**

Q masuk (kJ/jam)		Q keluar (kJ/jam)	
Q <sub>19</sub>	1.020,36	Q <sub>20</sub>	112,869
Q <sub>cw in</sub>	226,25	Q <sub>cw out</sub>	1.133,75
<b>Total</b>	<b>1.246,61</b>		<b>1.246,61</b>