

## IV. NERACA MASSA DAN NERACA ENERGI

|                    |                               |
|--------------------|-------------------------------|
| Kapasitas produksi | : 30.000 ton/tahun            |
| Waktu operasi      | : 330 hari/tahun, 24 jam/hari |
| Basis perhitungan  | : 1 jam operasi               |

### A. Neraca Massa

#### 1. Neraca Massa Keseluruhan

Tabel 4.1 Neraca Massa Keseluruhan

| Komponen                | Masuk             | Keluar            |
|-------------------------|-------------------|-------------------|
|                         | kg/jam            | kg/jam            |
| 1-Butena                | 22,8645           | 3.787,8788        |
| Etilen                  | 3.799,4685        | 0,1753            |
| Etana                   | 4,0774            | 4,0777            |
| 3-Metil 1-Pentena       | 0                 | 11,4321           |
| 1-Heksena               | 0,8618            | 6,5778            |
| 2-Etil 1-Butena         | 0                 | 17,1481           |
| Katalis $Ti(OC_4H_9)_4$ | 4,3832            | 4,3832            |
| Katalis $Al(C_2H_5)_3$  | 5,8730            | 5,8730            |
| n-Heptana               | 860,9137          | 860,9137          |
| <b>Total</b>            | <b>4.698,4601</b> | <b>4.698,4597</b> |

## 2. Neraca Massa per Alat

Tabel 4.2 Neraca massa di Reaktor (R-01)

| Komponen   | Input (kg)       |                | Output (kg)      |                |
|--|------------------|----------------|------------------|----------------|
|  | Aliran 2         | Aliran 6       | Aliran 7         | Aliran 8       |
| 1-Butena   | 22,864           | 0,000          | 3.710,192        | 77,687         |
| Etilen   | 3.969,508        | 0,000          | 167,379          | 2,818          |
| Etana  | 4,082            | 0,011          | 0,476            | 3,617          |
| 3-Metil 1-Pentena  | 0,000            | 0,000          | 0,000            | 11,432         |
| 1-Heksena  | 0,000            | 0,862          | 0,000            | 6,578          |
| 2-Etil 1-Butena  | 0,000            | 0,000          | 0,000            | 17,148         |
| Katalis Ti(OC <sub>4</sub> H <sub>9</sub> ) <sub>4</sub> | 0,000            | 4,383          | 0,000            | 4,383          |
| Katalis Al(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>  | 0,000            | 5,873          | 0,000            | 5,873          |
| n-Heptana  | 0,000            | 860,914        | 0,000            | 860,914        |
|  | <b>3.996,454</b> | <b>872,043</b> | <b>3.878,047</b> | <b>990,451</b> |
| <b>Total</b>   | <b>4.868,497</b> |                | <b>4.868,497</b> |                |

Tabel 4.3 Neraca Massa di *Flash Drum* (FD-01)

| Komponen          | F (kmol)       | V (kmol)       | L (kmol)      | F (kg)          | V (kg)          | L (kg)          |
|-------------------|----------------|----------------|---------------|-----------------|-----------------|-----------------|
| 1-Butena          | 1,3846         | 1,3559         | 0,0287        | 77,6872         | 76,0764         | 1,6108          |
| Etilen            | 0,1005         | 0,1003         | 0,0002        | 2,8184          | 2,8131          | 0,0053          |
| Etana             | 0,1203         | 0,1200         | 0,0002        | 3,6169          | 3,6098          | 0,0071          |
| 3-metil-1-Pentena | 0,1358         | 0,1222         | 0,0137        | 11,4321         | 10,2829         | 1,1492          |
| 1-Heksena         | 0,0782         | 0,0684         | 0,0097        | 6,5778          | 5,7606          | 0,8172          |
| 2-etil-1-butena   | 0,2038         | 0,1778         | 0,0259        | 17,1481         | 14,9646         | 2,1836          |
| katalis Ti        | 0,0129         | 0,0000         | 0,0129        | 4,3832          | 0,0000          | 4,3832          |
| katalis Al        | 0,0515         | 0,0000         | 0,0515        | 5,8730          | 0,0000          | 5,8730          |
| n-heptana         | 8,5916         | 6,1659         | 0,4257        | 860,9137        | 617,8472        | 243,0665        |
| <b>Total</b>      | <b>10,6791</b> | <b>8,1105</b>  | <b>2,5686</b> | <b>990,4505</b> | <b>731,3546</b> | <b>259,0959</b> |
|                   |                | <b>10,6791</b> |               |                 | <b>990,4505</b> |                 |

Tabel 4.4 Neraca Massa di Menara Distilasi (DC-01)

| KOMPONEN          | F                        |                | D                            |               | W                        |                |
|-------------------|--------------------------|----------------|------------------------------|---------------|--------------------------|----------------|
|                   | Kg                       | kgmol          | kg                           | kgmol         | kg                       | kgmol          |
| 1-Butena          | 3786,2680                | 67,4818        | 0,0000                       | 0,0000        | 3.786,2680               | 67,4818        |
| Etilen            | 170,1920                 | 6,0666         | 170,0218                     | 6,0605        | 0,1702                   | 0,0061         |
| Etana             | 4,0859                   | 0,1359         | 0,0041                       | 0,0001        | 4,0818                   | 0,1357         |
| 3 Metil 1-Pentena | 10,2829                  | 0,1222         | 0,0000                       | 0,0000        | 10,2829                  | 0,1222         |
| 1 Heksena         | 5,7606                   | 0,0684         | 0,0000                       | 0,0000        | 5,7606                   | 0,0684         |
| 2 Etil - 1 Butena | 14,9646                  | 0,1778         | 0,0000                       | 0,0000        | 14,9646                  | 0,1778         |
| n-Heptane         | 617,8472                 | 6,1659         | 0,0000                       | 0,0000        | 617,8472                 | 6,1659         |
| <b>Total</b>      | <b>4.609,4011</b>        | <b>80,2186</b> | <b>170,0259</b>              | <b>6,0607</b> | <b>4.439,3753</b>        | <b>74,1579</b> |
|                   | <b>F = 4.609,4011 kg</b> |                | <b>D = 170,0259 kg</b>       |               | <b>W = 4.439,3753 kg</b> |                |
|                   |                          |                | <b>D + W = 4.609,4011 kg</b> |               |                          |                |

Tabel 4.5 Neraca Massa di Menara Distilasi (DC-02)

| Komponen          | F                            |                | D                        |                | W                      |               |
|-------------------|------------------------------|----------------|--------------------------|----------------|------------------------|---------------|
|                   | Kg                           | kgmol          | Kg                       | kgmol          | kg                     | kgmol         |
| 1-Butena          | 3.786,2680                   | 67,4818        | 3.782,4817               | 67,4143        | 3,7863                 | 0,0675        |
| Etilen            | 0,1702                       | 0,0061         | 0,1700                   | 0,0061         | 0,0002                 | 0,0000        |
| Etana             | 4,0818                       | 0,1357         | 4,0777                   | 0,1356         | 0,0041                 | 0,0001        |
| 3-Metil 1-Pentena | 10,2829                      | 0,1222         | 0,0000                   | 0,0000         | 10,2829                | 0,1222        |
| 1-Heksena         | 5,7606                       | 0,0684         | 0,0000                   | 0,0000         | 5,7606                 | 0,0684        |
| 2-Etil-1-Butena   | 14,9646                      | 0,1778         | 0,0000                   | 0,0000         | 14,9646                | 0,1778        |
| n-Heptana         | 617,8472                     | 6,1659         | 0,0000                   | 0,0000         | 617,8472               | 6,1659        |
| <b>Total</b>      | <b>4.439,3753</b>            | <b>74,1579</b> | <b>3.786,7295</b>        | <b>67,5560</b> | <b>652,6458</b>        | <b>6,6019</b> |
|                   | <b>F = 4.439,3753 kg</b>     |                | <b>D = 3.786,7295 kg</b> |                | <b>W = 652,6458 kg</b> |               |
|                   | <b>D + W = 4.439,3753 kg</b> |                |                          |                |                        |               |

Tabel 4.6 Neraca Massa di Adsorber (AD-01 A/B)

| Komponen  | Input (kg)      | Akumulasi (kg)  | Output (kg)     | Input (kmol)  | Akumulasi (kmol) | Output (kmol) |
|---|-----------------|-----------------|-----------------|---------------|------------------|---------------|
| 1-Butena  | 5,3971          | 5,3971          | 0,0000          | 0,0962        | 0,0962           | 0,0000        |
| Etilen  | 0,0053          | 0,0053          | 0,0000          | 0,0002        | 0,0002           | 0,0000        |
| Etana   | 0,0112          | 0,0000          | 0,0112          | 0,0004        | 0,0000           | 0,0004        |
| 3-Metil 1-Pentena   | 11,4321         | 11,4321         | 0,0000          | 0,1358        | 0,1358           | 0,0000        |
| 1-Heksena   | 6,5778          | 6,5778          | 0,0000          | 0,0782        | 0,0782           | 0,0000        |
| 2-Etil 1-Butena   | 17,1481         | 17,1481         | 0,0000          | 0,2038        | 0,2038           | 0,0000        |
| Katalis<br>Ti(OC <sub>4</sub> H <sub>9</sub> ) <sub>4</sub> | 4,3832          | 0,0000          | 4,3832          | 0,0129        | 0,0000           | 0,0129        |
| Katalis Al(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>     | 5,8730          | 0,0000          | 5,8730          | 0,0515        | 0,0000           | 0,0515        |
| n-Heptana   | 860,9137        | 0,0000          | 860,9137        | 8,5916        | 0,0000           | 8,5916        |
| <b>Total</b>  | <b>911,7416</b> | <b>40,5604</b>  | <b>871,1812</b> | <b>9,1705</b> | <b>0,5141</b>    | <b>8,6564</b> |
|   |                 | <b>911,7416</b> |                 |               | <b>9,1705</b>    |               |

Tabel 4.7 Neraca Massa di *Mix-Point* (MX-01)

| Komponen          | Input (kg)           |                   | Input (kmol)         |                   | Output (kg)       | Output (kmol)   |
|-------------------|----------------------|-------------------|----------------------|-------------------|-------------------|-----------------|
|                   | Input Fresh Ethylene | Output atas MD-01 | Input Fresh Ethylene | Output atas MD-01 | Input R-01        | Input R-01      |
| 1-Butena          | 0,0000               | 0,0000            | 0,0000               | 0,0000            | 0,0000            | 0,0000          |
| Etilen            | 3.799,4865           | 170,0218          | 135,4348             | 6,0605            | 3.969,5083        | 141,4953        |
| Etana             | 4,0774               | 0,0041            | 0,1356               | 0,0001            | 4,0927            | 0,1357          |
| 3-metil-1-pentena | 0,0000               | 0,0000            | 0,0000               | 0,0000            | 0,0000            | 0,0000          |
| 1-Heksena         | 0,0000               | 0,0000            | 0,0000               | 0,0000            | 0,0000            | 0,0000          |
| 2-etil-1-butena   | 0,0000               | 0,0000            | 0,0000               | 0,0000            | 0,0000            | 0,0000          |
| n-heptana         | 0,0000               | 0,0000            | 0,0000               | 0,0000            | 0,0000            | 0,0000          |
| <b>Total</b>      | <b>3.803,5639</b>    | <b>170,0259</b>   | <b>135,5703</b>      | <b>6,0607</b>     | <b>3.973,6010</b> | <b>141,6310</b> |
|                   | <b>3.973,5898</b>    |                   | <b>141,6310</b>      |                   |                   |                 |

Tabel 4.8 Neraca Massa di *Mix-Point* (MX-02)

| Komponen          | Input (kg)      |                 | Input (kmol)  |               | Output (kg)     | Output (kmol) |
|-------------------|-----------------|-----------------|---------------|---------------|-----------------|---------------|
|                   | Bottom          | Output          | Bottom        | Output        | Input HT-01     | Input HT-01   |
|                   | FD-01           | EV-01           | FD-01         | EV-01         |                 |               |
| 1-Butena          | 1,6108          | 3,7863          | 0,0287        | 0,0675        | 5,3971          | 0,0962        |
| Etilen            | 0,0053          | 0,0000          | 0,0002        | 0,0000        | 0,0053          | 0,0002        |
| Etana             | 0,0071          | 0,0041          | 0,0002        | 0,0001        | 0,0112          | 0,0004        |
| 3-metil-1-pentena | 1,1492          | 10,2829         | 0,0137        | 0,1222        | 11,4321         | 0,1358        |
| 1-Heksena         | 0,8172          | 5,7606          | 0,0097        | 0,0684        | 6,5778          | 0,0782        |
| 2-etil-1-butena   | 2,1836          | 14,9646         | 0,0259        | 0,1778        | 17,1481         | 0,2038        |
| Katalis Ti        | 4,3832          | 0,0000          | 0,0129        | 0,0000        | 4,3832          | 0,0129        |
| Katalis Al        | 5,8730          | 0,0000          | 0,0515        | 0,0000        | 5,8730          | 0,0515        |
| n-heptana         | 243,0665        | 617,8472        | 2,4257        | 6,1659        | 860,9137        | 8,5916        |
| <b>Total</b>      | <b>259,0959</b> | <b>652,6456</b> | <b>2,5686</b> | <b>6,6019</b> | <b>911,7416</b> | <b>9,1705</b> |

Tabel 4.9 Neraca Massa di *Mix-Point* (MX-03)

| Komponen          | Input (kg)        |                 | Input (kmol)   |               | Output (kg)       | Output (kmol)  |
|-------------------|-------------------|-----------------|----------------|---------------|-------------------|----------------|
|                   | Output atas       | Output          | Output         | Output        | Input DC-01       | Input DC-01    |
|                   | R-01              | CP-01           | atas R-01      | CP-01         |                   |                |
| 1-Butena          | 3.710,1916        | 76,0764         | 66,1259        | 1,3559        | 3786,2680         | 67,4818        |
| Etilen            | 167,3789          | 2,8131          | 5,9663         | 0,1003        | 170,1920          | 6,0666         |
| Etana             | 0,4761            | 3,6098          | 0,0158         | 0,1200        | 4,0859            | 0,1359         |
| 3-metil-1-pentena | 0,0000            | 10,2829         | 0,0000         | 0,1222        | 10,2829           | 0,1222         |
| 1-Heksena         | 0,0000            | 5,7606          | 0,0000         | 0,0684        | 5,7606            | 0,0684         |
| 2-etil-1-butena   | 0,0000            | 14,9646         | 0,0000         | 0,1778        | 14,9646           | 0,1778         |
| Katalis Ti        | 0,0000            | 0,0000          | 0,0000         | 0,0000        | 0,0000            | 0,0000         |
| Katalis Al        | 0,0000            | 0,0000          | 0,0000         | 0,0000        | 0,0000            | 0,0000         |
| n-heptana         | 0,0000            | 617,8472        | 0,0000         | 6,1659        | 617,8472          | 6,1659         |
| <b>Total</b>      | <b>3.878,0466</b> | <b>731,3545</b> | <b>72,1080</b> | <b>8,1105</b> | <b>4.609,4011</b> | <b>80,2185</b> |

Tabel 4.10 Neraca Massa di *Mixing Tank* (MT-01)

| Komponen     | Input (kg)     |                 | Input (kmol)  |               | Output (kg)     | Output (kmol) |
|--------------|----------------|-----------------|---------------|---------------|-----------------|---------------|
|              | Fresh          | Fresh           | Fresh         | Fresh         | Input DC-01     | Input DC-01   |
|              | Catalyst       | Solvent         | Catalyst      | Solvent       |                 |               |
| 1-Heksena    | 0,0000         | 0,8618          | 0,0000        | 0,0102        | 4,3832          | 0,0129        |
| Katalis Ti   | 4,3832         | 0,0000          | 0,0129        | 0,0000        | 5,8730          | 0,0515        |
| Katalis Al   | 5,8730         | 0,0000          | 0,0515        | 0,0000        | 0,8618          | 0,0102        |
| n-heptana    | 0,0000         | 860,9137        | 0,0000        | 8,5916        | 860,9137        | 8,5916        |
| <b>Total</b> | <b>10,2562</b> | <b>861,7755</b> | <b>0,0644</b> | <b>8,6018</b> | <b>872,0317</b> | <b>8,6662</b> |

## B. Neraca Energi

Tabel 4.11 Neraca energi di sekitar *Mixing Tank* (MT-01)

| Komponen                           | Panas Masuk (kJ)   | Panas Keluar (kJ)  |
|------------------------------------|--------------------|--------------------|
| $Q_{in}$ ( <i>fresh catalyst</i> ) | 0,0000             | 85.381,6177        |
| $Q_{in}$ ( <i>fresh solvent</i> )  | 85.381,6177        |                    |
| $Q_{out}$                          |                    |                    |
| <b>Total</b>                       | <b>85.381,6177</b> | <b>85.381,6177</b> |

Tabel 4.12 Neraca energi di sekitar Reaktor (R-01)

| Komponen   | Q in (kJ)            | Q out (kJ)           |
|--|----------------------|----------------------|
| 1-Butena   | 1.587,993            | 259.617,9610         |
| Etilen   | 270.837,514          | 11.461,1740          |
| Etana  | 318,217              | 314,0700             |
| 3-Metil 1-Pentena  | 0,000                | 859,710              |
| 1-Heksena  | 79,109               | 461,604              |
| 2-Etil-1-Butena  | 0,000                | 1.220,024            |
| Katalis Ti(OC <sub>4</sub> H <sub>9</sub> ) <sub>4</sub> | 269,770              | 266,379              |
| Katalis Al(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>  | 550,862              | 543,938              |
| n-Heptana  | 85.302,509           | 84.201,114           |
| Q reaksi   |                      | 7.110.099,4318       |
| Q pendingin  | 7.110.099,4318       |                      |
| <b>Total</b>   | <b>7.469.045,405</b> | <b>7.469.045,405</b> |

Tabel 4.13 Neraca energi di sekitar *Flash Drum* (FD-01)

| Komponen                         | Q <sub>in</sub> (kJ) | Q <sub>v</sub> (kJ) | Q <sub>t</sub> (kJ) |
|----------------------------------|----------------------|---------------------|---------------------|
| 1-Butena <sub>(g)</sub>          | 8.555,2713           | 8.555,2713          |                     |
| 1-Butena <sub>(l)</sub>          | 272,2299             |                     | 272,2299            |
| Etilen <sub>(g)</sub>            | 309,1767             | 309,1767            |                     |
| Etilen <sub>(l)</sub>            | 1,9233               |                     | 1,9233              |
| Etana <sub>(g)</sub>             | 453,5330             | 453,5330            |                     |
| Etana <sub>(l)</sub>             | 2,1767               |                     | 2,1767              |
| 3-Metil-1-Pentena <sub>(g)</sub> | 1.264,7861           | 1.264,7861          |                     |
| 3-Metil-1-Pentena <sub>(l)</sub> | 189,2528             |                     | 189,2528            |
| 1-Heksena <sub>(g)</sub>         | 663,5332             | 663,5332            |                     |
| 1-Heksena <sub>(l)</sub>         | 120,8232             |                     | 120,8232            |
| 2-Etil-1-Butena <sub>(g)</sub>   | 1.748,0418           | 1.748,0418          |                     |
| 2-Etil-1-Butena <sub>(l)</sub>   | 335,8925             |                     | 335,8925            |
| katalis Ti                       | 269,7700             |                     | 269,7700            |
| katalis Al                       | 550,8616             |                     | 550,8616            |
| n-Heptana <sub>(g)</sub>         | 74.965,8151          | 74.965,8151         |                     |
| n-Heptana <sub>(l)</sub>         | 38.615,4853          |                     | 38.615,4853         |
| <b>Total</b>                     | <b>128.318,5725</b>  | <b>87.960,1572</b>  | <b>40.358,4153</b>  |
|                                  |                      | <b>128.318,5725</b> |                     |

Tabel 4.14 Neraca energi di sekitar Menara Distilasi (DC-01)

| <b>Komponen</b>   | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------|---------------------|---------------------|
| 1-Butena          | 450.403,1679        | 819.038,7705        |
| Etilen            | 41.475,1985         | -14.046,1932        |
| Etana             | 849,8863            | 1.641,2062          |
| 3-Metil 1-Pentena | 1.205,8296          | 2.143,7976          |
| 1-Heksena         | 606,3407            | 1.078,4950          |
| 2-Etil-1-Butena   | 1.640,3175          | 2.912,2065          |
| n-Heptana         | 70.121,1509         | 123.889,4117        |
| Q reboiler        | 426.113,9528        |                     |
| Q kondensor       |                     | 55.758,1498         |
| <b>Total</b>      | <b>992.415,8442</b> | <b>992.415,8442</b> |

Tabel 4.15 Neraca energi di sekitar Menara Distilasi (DC-02)

| <b>Komponen</b>   | <b>Q in (kJ)</b>      | <b>Q out (kJ)</b>     |
|-------------------|-----------------------|-----------------------|
| 1-Butena          | 108.957,1094          | 62.986,4794           |
| Etilen            | 9,2264                | 2,7473                |
| Etana             | 193,4615              | 77,4916               |
| 3-Metil 1-Pentena | 297,6576              | 3.272,2319            |
| 1-Heksena         | 149,6716              | 1.648,1252            |
| 2-Etil-1-Butena   | 405,3649              | 4.436,8901            |
| n-Heptana         | 17.408,7777           | 187.725,4581          |
| Q reboiler        | 1.188.245,3107        |                       |
| Q kondensor       |                       | 1.055.517,1563        |
| <b>Total</b>      | <b>1.315.666,5797</b> | <b>1.315.666,5797</b> |

Tabel 4.16 Neraca energi di sekitar Adsorber (AD-01 A/B)

| <b>Komponen</b>         | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------------|---------------------|---------------------|
| 1-Butena                | 693,8368            | 0,0000              |
| Etilen                  | 0,6664              | 0,0000              |
| Etana                   | 1,6098              | 1,6098              |
| 3-Metil 1-Pentena       | 1605,7727           | 0,0000              |
| 1-Heksena               | 866,2481            | 0,0000              |
| 2-Etil-1-Butena         | 2290,3619           | 0,0000              |
| Katalis $Ti(OC_4H_9)_4$ | 0,0000              | 0,0000              |
| Katalis $Al(C_2H_5)_3$  | 0,0000              | 0,0000              |
| n-Heptana               | 119496,1016         | 119.496,1016        |
| Q akumulasi             |                     | 5.456,8859          |
| <b>Total</b>            | <b>124.954,5974</b> | <b>124.954,5974</b> |

Tabel 4.17 Neraca energi di sekitar *Cooler* (CO-01)

| <b>Komponen</b>   | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------|---------------------|---------------------|
| 1-Butena          | 11.898,6164         | 5.283,6946          |
| Etilen            | 428,1926            | 191,9368            |
| Etana             | 629,8394            | 280,6662            |
| 3-Metil 1-Pentena | 1.754,1714          | 783,5381            |
| 1-Heksena         | 923,0931            | 409,6448            |
| 2-Etil-1-Butena   | 2.432,3085          | 1.078,8769          |
| n-Heptana         | 104.445,8215        | 46.203,3814         |
| Q air pendingin   |                     | 68.280,3040         |
| <b>Total</b>      | <b>122.512,0429</b> | <b>122.512,0429</b> |

Tabel 4.18 Neraca energi di sekitar *Cooler* (CO-02)

| <b>Komponen</b>   | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------|---------------------|---------------------|
| 1-Butena          | 549.974,3459        | 450.403,1679        |
| Etilen            | 24.082,5383         | 41.475,1985         |
| Etana             | 662,3099            | 849,8863            |
| 3-Metil 1-Pentena | 1.630,2319          | 1.205,8296          |
| 1-Heksena         | 857,2413            | 606,3407            |
| 2-Etil-1-Butena   | 2.258,6996          | 1.640,3175          |
| n-Heptana         | 96.960,2872         | 70.121,1509         |
| Q air pendingin   |                     | 110.123,7628        |
| <b>Total</b>      | <b>676.425,6541</b> | <b>676.425,6541</b> |

Tabel 4.19 Neraca energi di sekitar *Cooler* (CO-03)

| <b>Komponen</b>   | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------|---------------------|---------------------|
| 1-Butena          | 819.038,7705        | 109.616,5514        |
| Etilen            | 82,1062             | 9,2837              |
| Etana             | 1.641,5865          | 194,6551            |
| 3-Metil 1-Pentena | 2.143,7976          | 299,4478            |
| 1-Heksena         | 1.078,4950          | 150,5717            |
| 2-Etil-1-Butena   | 2.912,2065          | 407,8021            |
| n-Heptana         | 123.889,4117        | 17.513,2959         |
| Q air pendingin   |                     | 822.594,7663        |
| <b>Total</b>      | <b>950.786,3740</b> | <b>128.191,6077</b> |

Tabel 4.20 Neraca energi di sekitar *Cooler* (CO-04)

| <b>Komponen</b>   | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-------------------|---------------------|---------------------|
| 1-Butena          | 1.569,6798          | 693,8368            |
| Etilen            | 3,6563              | 0,6664              |
| Etana             | 6,3320              | 1,6098              |
| 3-Metil 1-Pentena | 3.150,0312          | 1605,7727           |
| 1-Heksena         | 1.628,6715          | 866,2481            |
| 2-Etil-1-Butena   | 4.405,6545          | 2290,3619           |
| Katalis Ti        | 269,7700            | 0,0000              |
| Katalis Al        | 550,8616            | 0,0000              |
| n-Heptana         | 227.126,6171        | 119496,1016         |
| Q air pendingin   |                     | 113.756,6766        |
| <b>Total</b>      | <b>238.711,2740</b> | <b>238.711,2740</b> |

Tabel 4.21 Neraca energi di sekitar *Condenser* (CD-03)

| <b>Komponen</b>  | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|------------------|---------------------|---------------------|
| Etana            | 1,6098              | 2,0067              |
| Katalis Ti       | 0,0000              | 269,7700            |
| Katalis Al       | 0,0000              | 550,8616            |
| n-Heptana        | 119.496,1016        | 85.302,5087         |
| $\Delta h_{vap}$ | 54.486,4359         |                     |
| Q air pendingin  |                     | 87.859,0003         |
| <b>Total</b>     | <b>173.984,1473</b> | <b>173.984,1473</b> |

Tabel 4. 22 Neraca energi di sekitar *Heater* (HT-01)

| <b>Komponen</b> | <b>Q in (kJ)</b>   | <b>Q out (kJ)</b>  |
|-----------------|--------------------|--------------------|
| 1-Heksena       | 9,1538             | 79,1090            |
| n-Heptana       | 9.926,8523         | 85.302,5087        |
| Q steam         | 75.445,6116        |                    |
| <b>Total</b>    | <b>85.381,6177</b> | <b>85.381,6177</b> |

Tabel 4. 23 Neraca energi di sekitar *Heater* (HT-02)

| <b>Komponen</b> | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|-----------------|---------------------|---------------------|
| Etilen          | 84.615,0353         | 270.837,5139        |
| Etana           | 76,6349             | 318,2156            |
| Q steam         | 186.464,0593        |                     |
| <b>Total</b>    | <b>271.155,7295</b> | <b>271.155,7295</b> |

Tabel 4. 24 Neraca energi di sekitar *Heater* (HT-03)

| <b>Komponen</b> | <b>Q in (kJ)</b>   | <b>Q out (kJ)</b>  |
|-----------------|--------------------|--------------------|
| Etilen          | -14.128,2994       | 14.430,4236        |
| Etana           | -0,3803            | 0,3957             |
| Q steam         | 28.559,4990        |                    |
| <b>Total</b>    | <b>14.430,8193</b> | <b>14.430,8193</b> |



Tabel 4. 25 Neraca energi di sekitar *Heater* (HT-04)

| <b>Komponen</b>  | <b>Q in (kJ)</b>    | <b>Q out (kJ)</b>   |
|--|---------------------|---------------------|
| 1-Butena   | 8.031,2776          | 13.208,5404         |
| Etilen   | 588,4611            | 1.027,3886          |
| Etana  | 647,1808            | 1.111,1150          |
| 3-Metil 1-Pentena  | 1.169,2098          | 1.893,5575          |
| 1-Heksena  | 603,8290            | 978,1291            |
| 2-Etil-1-Butena  | 1.639,7099          | 2.653,0928          |
| Katalis Ti(OC <sub>4</sub> H <sub>9</sub> ) <sub>4</sub> | 269,7700            | 269,7700            |
| Katalis Al(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>  | 550,8616            | 550,8616            |
| n-Heptana  | 85.302,5087         | 137.554,4455        |
| Q steam  | 60.444,0921         |                     |
| <b>Total</b>   | <b>159.246,9006</b> | <b>159.246,9006</b> |

Tabel 4. 26 Neraca energi di sekitar *Mix-Point* (MX-01)

| <b>Komponen</b> | <b>Q in (kJ)</b>            |                       | <b>Q out (kJ)</b>   |
|-----------------|-----------------------------|-----------------------|---------------------|
|                 | <b>Umpan Fresh Ethylene</b> | <b>Recycle Etilen</b> |                     |
| Etilen          | 259.237,0161                | 11.600,4979           | 270.837,5139        |
| Etana           | 317,0259                    | 0,3177                | 317,3436            |
| <b>Total</b>    | <b>259.554,0420</b>         | <b>11.600,8155</b>    | <b>271.154,8576</b> |

Tabel 4. 27 Neraca energi di sekitar *Mix-Point* (MX-02)

| <b>Komponen</b>   | <b>Q in (kJ)</b>        |                     | <b>Q out (kJ)</b>   |
|-------------------|-------------------------|---------------------|---------------------|
|                   | <b>Produk Atas R-01</b> | <b>Output CO-01</b> |                     |
| 1-Butena          | 257.682,0063            | 5.283,6946          | 262.965,7010        |
| Etilen            | 11.420,1732             | 191,9368            | 11.612,1100         |
| Etana             | 37,0177                 | 280,6662            | 317,6840            |
| 3-metil-1-pentena | 0,0000                  | 783,5381            | 783,5381            |
| 1-Heksena         | 0,0000                  | 409,6448            | 409,6448            |
| 2-etil-1-butena   | 0,0000                  | 1.078,8769          | 1.078,8769          |
| katalis Ti        | 0,0000                  | 0,0000              | 0,0000              |
| katalis Al        | 0,0000                  | 0,0000              | 0,0000              |
| n-heptana         | 0,0000                  | 46.203,3814         | 46.203,3814         |
| <b>Total</b>      | <b>269.139,1972</b>     | <b>54.231,7389</b>  | <b>323.370,9361</b> |

Tabel 4. 28 Neraca energi di sekitar *Mix-Point* (MX-03)

| Komponen          | Q in (kJ)          |                     |                     |
|-------------------|--------------------|---------------------|---------------------|
|                   | Produk Bawah       |                     | Q out (kJ)          |
|                   | FD-01              | Output EV-03        |                     |
| 1-Butena          | 272,2299           | 1.285,6332          | 1.569,6798          |
| Etilen            | 1,9233             | 0,0000              | 3,6563              |
| Etana             | 2,1767             | 2,7623              | 6,3320              |
| 3-metil-1-pentena | 189,2528           | 3.271,9230          | 3.150,0312          |
| 1-Heksena         | 120,8232           | 1.647,9689          | 1.628,6715          |
| 2-etil-1-butena   | 335,8925           | 4.436,4736          | 4.405,6545          |
| katalis Ti        | 269,7700           | 0,0000              | 269,7700            |
| katalis Al        | 550,8616           | 0,0000              | 550,8616            |
| n-heptana         | 38.615,4853        | 187.708,0976        | 227.126,6171        |
| <b>Total</b>      | <b>40.358,4153</b> | <b>198.352,8587</b> | <b>238.711,2740</b> |

Tabel 4. 29 Neraca energi di sekitar Kompresor (CP-01)

| Keterangan       | Stage 1              |                       | Keterangan       | Stage 2              |                       |
|------------------|----------------------|-----------------------|------------------|----------------------|-----------------------|
|                  | Q <sub>in</sub> (kJ) | Q <sub>out</sub> (kJ) |                  | Q <sub>in</sub> (kJ) | Q <sub>out</sub> (kJ) |
| Q <sub>12</sub>  | 87.960,0926          |                       | Q <sub>12b</sub> | 87.960,0926          |                       |
| Qkompresi        | 34.848,9305          |                       | Qkompresi        | 34.551,9503          |                       |
| W <sub>s</sub>   | 37.521,4669          |                       | W <sub>s</sub>   | 37.028,6605          |                       |
| Q <sub>12a</sub> |                      | 122.809,0231          | Q <sub>14</sub>  |                      | 122.512,0429          |
| ΔEK              |                      | 37.521,4669           | ΔEK              |                      | 37.028,6605           |
| <b>Total</b>     | <b>160.330,4900</b>  | <b>160.330,4900</b>   | <b>Total</b>     | <b>159.540,7034</b>  | <b>159.540,7034</b>   |

Tabel 4. 30 Neraca energi di sekitar Kompresor (CP-02)

| Panas Masuk     |                      | Panas Keluar     |                      |
|-----------------|----------------------|------------------|----------------------|
| Keterangan      | Q <sub>in</sub> (kJ) | Keterangan       | Q <sub>in</sub> (kJ) |
| Q <sub>in</sub> | 323.370,9361         | Q <sub>out</sub> | 676.425,6541         |
| Qkompresi       | 353.054,7180         | ΔEK              | 2.999,9704           |
| W <sub>s</sub>  | 2.999,9704           |                  |                      |
| <b>Total</b>    | <b>679.425,6245</b>  | <b>Total</b>     | <b>679.425,6245</b>  |