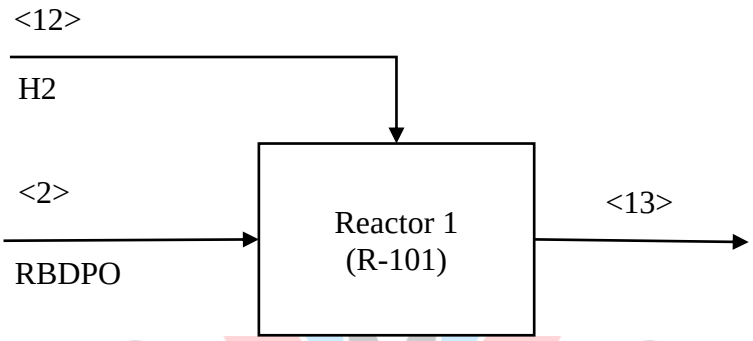
BAB IV
NERACA MASSA DAN ENERGI

4.1 Neraca Massa

4.1.1 Reaktor 1 (R-101)

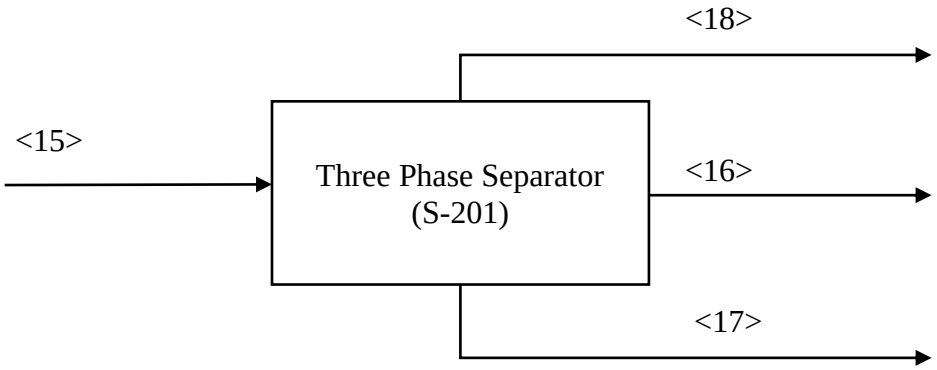


Gambar 4. 1 Diagram Alir Reaktor *Hydrotreating*

Tabel 4.1 Neraca Massa Unit Operasi Reaktor *Hydrotreating*

Nomor Arus	Arus Masuk		Arus Keluar
	2	12	13
Suhu (°C)	300	300	300
Tekanan (bar)	1	50	50
Fraksi Uap	0	1	0,80
Laju Alir Massa (kg/jam)	447.495	17.731	465.226
Laju Alir Komponen (kg/jam)			
$C_{57}H_{104}O_6$	189.128,00	0,00	1.891,28
$C_{51}H98O6$	180.227,86	0,00	1.802,28
$C_{57}H98O6$	53.400,85	0,00	534,01
$C_{57}H_{110}O_6$	22.250,35	0,00	2.643,47
H_2	0,00	17.632,34	7.735,17
C_3H_8	0,00	0,00	22.678,52
$C_{15}H_{32}$	0,00	0,00	66.172,42
$C_{16}H_{34}$	0,00	0,00	79.547,70
$C_{17}H_{36}$	0,00	0,00	103.740,57
$C_{18}H_{38}$	0,00	0,00	114.273,42
H_2O	0,00	0,00	28.867,55
CO_2	0,00	0,00	32.753,00

4.1.2 Three Phase Separator (S-201)

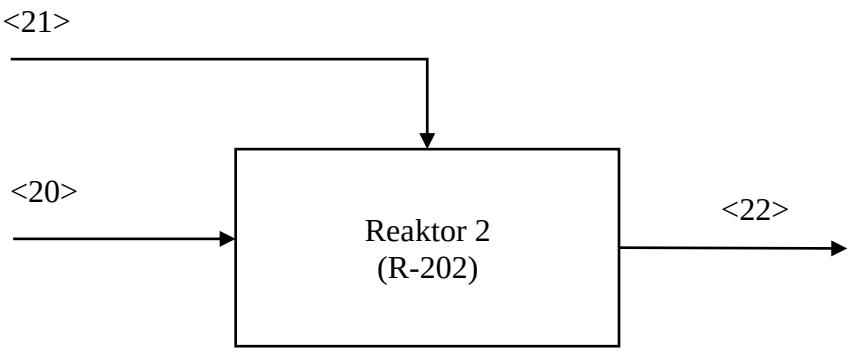


Gambar 4. 2 Diagram Alir *Three Phase Separator*

Tabel 4.2 Neraca Massa Unit Operasi *Three Phase Separator*

Nomor Arus	Arus Masuk		Arus Keluar	
	15	18	17	16
Suhu (°C)	100	100	100	100
Tekanan (bar)	13	13	13	13
Fraksi Uap	0,63	1	0	0
Laju Alir Massa (kg/jam)	462.639	63.291	373.879	25.470
Laju Alir Komponen (kg/jam)				
$C_{57}H_{104}O_6$	1.891,28	0,00	1.891,28	0,00
$C_{51}H98O6$	1.802,28	0,00	1.802,28	0,00
$C_{57}H98O6$	534,01	0,00	534,01	0,00
$C_{57}H_{110}O_6$	2.643,47	0,00	2.643,47	0,00
H_2	7.735,17	7.735,17	0,00	0,00
C_3H_8	22.678,52	19.368,32	3.310,20	0,00
$C_{15}H_{32}$	66.172,42	17,32	66.155,11	0,00
$C_{16}H_{34}$	79.547,70	9,65	79.538,05	0,00
$C_{17}H_{36}$	103.740,57	5,64	103.734,94	0,00
$C_{18}H_{38}$	114.273,42	3,87	114.269,55	0,00
H_2O	28.867,55	3.397,80	0,00	25.469,75
CO_2	32.753,00	32.753,00	0,00	0,00

4.1.3 Reaktor 2 (R-202)

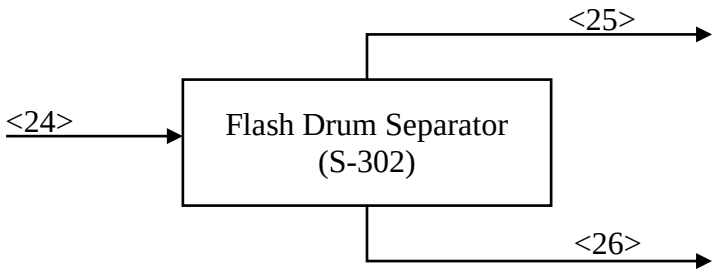


Gambar 4. 3 Diagram Alir Reaktor 2

Tabel 4.3 Neraca Massa Unit Operasi Reaktor 2

Nomor Arus	Arus Masuk		Arus Keluar
	20	21	22
Suhu (°C)	278	278	278
Tekanan (bar)	13	50	50
Fraksi Uap	0	1,00	0,52
Laju Alir Massa (kg/jam)	373.879	5.203	379.082
Laju Alir Komponen (kg/jam)			
$C_{57}H_{104}O_6$	1.891,28	0,00	1.891,28
$C_{51}H98O6$	1.802,28	0,00	1.802,28
$C_{57}H98O6$	534,01	0,00	534,01
$C_{57}H_{110}O_6$	2.643,47	0,00	2.643,47
H_2	0,00	5.203,23	1.688,80
C_3H_8	3.310,20	0,00	45.239,34
$C_{15}H_{32}$	66.155,11	0,00	4.630,86
$C_{16}H_{34}$	79.538,05	0,00	5.567,66
$C_{17}H_{36}$	103.734,94	0,00	7.261,45
$C_{18}H_{38}$	114.269,55	0,00	7.998,87
$C_{14}H_{30}$	0,00	0,00	222,85
$C_{13}H_{28}$	0,00	0,00	4.215,66
$C_{12}H_{26}$	0,00	0,00	49.335,48
$C_{11}H_{24}$	0,00	0,00	46.062,70
$C_{10}H_{22}$	0,00	0,00	62.829,27
C_9H_{20}	0,00	0,00	49.394,43
C_8H_{18}	0,00	0,00	59.731,69
C_7H_{16}	0,00	0,00	28.032,03

4.1.4 Flash Drum Separator 2 (S-302)

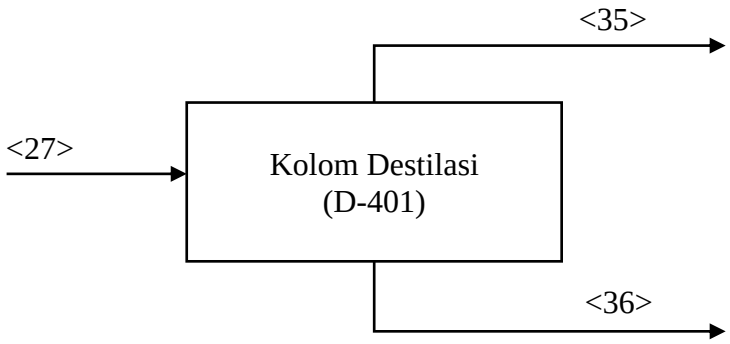


Gambar 4. 4 Diagram Alir *Flash Drum Separator* 2

Tabel 4.4 Neraca Massa Unit Operasi *Flash Drum Separator* 2

Nomor Arus	Arus Masuk	Arus Keluar	
	24	25	26
Suhu (°C)	30	30	30
Tekanan (bar)	13	13	13
Fraksi Uap	0,25	1,00	0
Laju Alir Massa (kg/jam)	379.082	11.675	367.407
Laju Alir Komponen (kg/jam)			
$C_{57}H_{104}O_6$	1.891,28	0,00	1.891,28
$C_{51}H98O6$	1.802,28	0,00	1.802,28
$C_{57}H98O6$	534,01	0,00	534,01
$C_{57}H_{110}O_6$	2.643,47	0,00	2.643,47
H_2	1.688,80	1.688,80	0,00
C_3H_8	45.239,34	9.876,54	35.362,80
$C_{15}H_{32}$	4.630,86	0,00	4.630,86
$C_{16}H_{34}$	5.567,66	0,00	5.567,66
$C_{17}H_{36}$	7.261,45	0,00	7.261,45
$C_{18}H_{38}$	7.998,87	0,00	7.998,87
$C_{14}H_{30}$	222,85	0,00	222,85
$C_{13}H_{28}$	4.215,66	0,01	4.215,65
$C_{12}H_{26}$	49.335,48	0,30	49.335,18
$C_{11}H_{24}$	46.062,70	0,92	46.061,77
$C_{10}H_{22}$	62.829,27	4,00	62.825,27
C_9H_{20}	49.394,43	9,95	49.384,47
C_8H_{18}	59.731,69	37,99	59.693,70
C_7H_{16}	28.032,03	56,33	27.975,70

4.1.5 Destilator 1 (D-401)

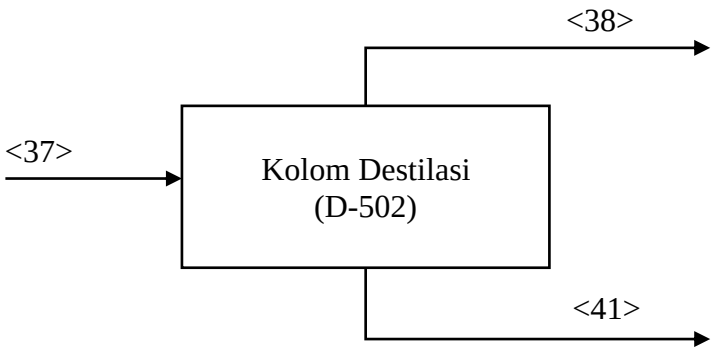


Gambar 4. 5 Diagram Alir Distilator 1

Tabel 4.5 Neraca Massa Unit Operasi Distilator 1

Nomor Arus	Arus Masuk	Arus Keluar	
	27	35	36
Suhu (°C)	143	143	143
Tekanan (bar)	13	13	13
Fraksi Uap	0,14	1,00	0
Laju Alir Massa (kg/jam)	367.407	34.617	332.790
Laju Alir Komponen (kg/jam)			
$C_{57}H_{104}O_6$	1.891,28	0,00	1.891,28
$C_{51}H98O6$	1.802,28	0,00	1.802,28
$C_{57}H98O6$	534,01	0,00	534,01
$C_{57}H_{110}O_6$	2.643,47	0,00	2.643,47
C_3H_8	35.362,80	34.470,32	892,48
$C_{15}H_{32}$	4.630,86	0,00	4.630,86
$C_{16}H_{34}$	5.567,66	0,00	5.567,66
$C_{17}H_{36}$	7.261,45	0,00	7.261,45
$C_{18}H_{38}$	7.998,87	0,00	7.998,87
$C_{14}H_{30}$	222,85	0,00	222,85
$C_{13}H_{28}$	4.215,65	0,00	4.215,65
$C_{12}H_{26}$	49.335,18	0,01	49.335,17
$C_{11}H_{24}$	46.061,77	0,08	46.061,69
$C_{10}H_{22}$	62.825,27	0,72	62.824,55
C_9H_{20}	49.384,47	3,86	49.380,61
C_8H_{18}	59.693,70	32,61	59.661,08
C_7H_{16}	27.975,70	109,81	27.865,89

4.1.6 Destilator 2 (D-502)

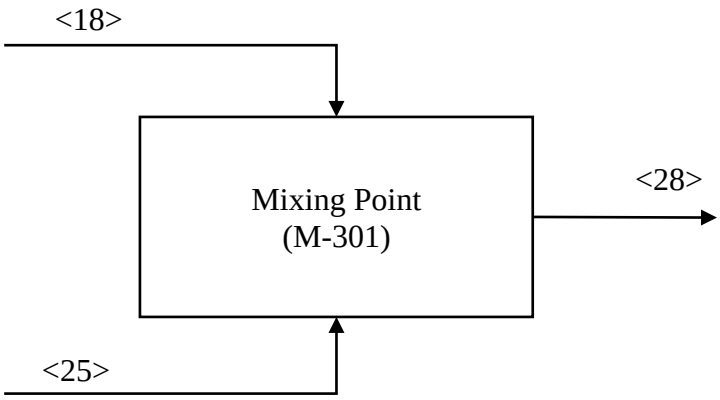


Gambar 4. 6 Diagram Alir Distilator 2

Tabel 4.6 Neraca Massa Unit Operasi Distilator 2

Nomor Arus	Arus Masuk	Arus Keluar	
	37	38	41
Suhu (°C)	298	242	384
Tekanan (bar)	13	13	13
Fraksi Uap	0,46	1,00	1,00
Laju Alir Massa (kg/jam)	332.790	252.522	80.268
Laju Alir Komponen (kg/jam)			
$C_{57}H_{104}O_6$	1.891,28	0,00	1.891,28
$C_{51}H98O6$	1.802,28	0,00	1.802,28
$C_{57}H98O6$	534,01	0,00	534,01
$C_{57}H_{110}O_6$	2.643,47	0,00	2.643,47
C_3H_8	892,48	892,48	0,00
$C_{15}H_{32}$	4.630,86	0,00	4.630,86
$C_{16}H_{34}$	5.567,66	0,00	5.567,66
$C_{17}H_{36}$	7.261,45	0,00	7.261,45
$C_{18}H_{38}$	7.998,87	0,00	7.998,87
$C_{14}H_{30}$	222,85	0,00	222,85
$C_{13}H_{28}$	4.215,65	0,33	4.215,32
$C_{12}H_{26}$	49.335,17	5.974,14	43.361,03
$C_{11}H_{24}$	46.061,69	45.922,87	138,82
$C_{10}H_{22}$	62.824,55	62.824,48	0,07
C_9H_{20}	49.380,61	49.380,61	0,00
C_8H_{18}	59.661,08	59.661,08	0,00
C_7H_{16}	27.865,89	27.865,89	0,00

4.1.7 *Mixing Point* 2 (M-301)

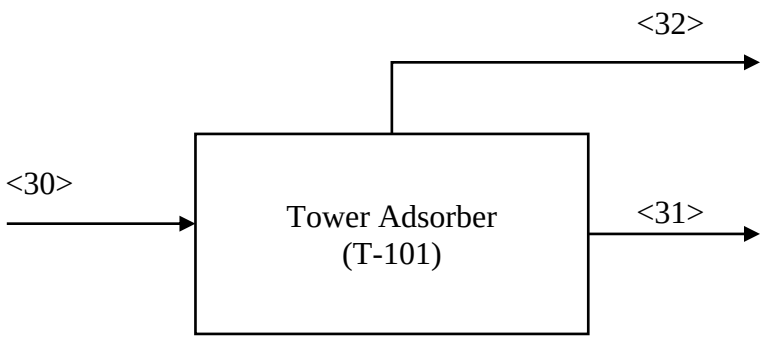


Gambar 4. 7 Diagram Alir Mixing Point (M-101)

Tabel 4.7 Neraca Massa Unit Operasi Mixing Point (M-101)

Nomor Arus	Arus Masuk		Arus Keluar
	18	25	28
Suhu (°C)	1000	30	85
Tekanan (bar)	13	13	13
Fraksi Uap	1,00	1,00	1,00
Laju Alir Massa (kg/jam)	63.291	11.675	74.966
Laju Alir Komponen (kg/jam)			
H_2	7.735,17	1.688,80	9.423,96
C_3H_8	19.368,32	9.876,54	29.244,86
$C_{15}H_{32}$	17,32	0,00	17,32
$C_{16}H_{34}$	9,65	0,00	9,65
$C_{17}H_{36}$	5,64	0,00	5,64
$C_{18}H_{38}$	3,87	0,00	3,87
H_2O	3.397,80	0	3.397,80
CO_2	32.753,00	0	32.753,00
$C_{14}H_{30}$	0,00	0,00	0,00
$C_{13}H_{28}$	0,00	0,01	0,01
$C_{12}H_{26}$	0,00	0,30	0,30
$C_{11}H_{24}$	0,00	0,92	0,92
$C_{10}H_{22}$	0,00	4,00	4,00
C_9H_{20}	0,00	9,95	9,95
C_8H_{18}	0,00	37,99	37,99
C_7H_{16}	0,00	56,33	56,33

4.1.8 *Tower Adsorber* (T-101)



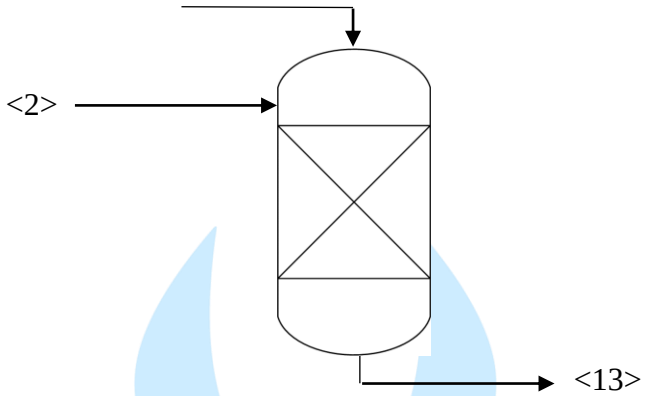
Gambar 4. 8 Diagram Alir *Tower Adsorber*

Tabel 4.8 Neraca Massa Unit Operasi *Tower Adsorber*

Nomor Arus	Arus Masuk	Arus Keluar	
	30	32	31
Suhu (°C)	30	30	30
Tekanan (bar)	7	7	7
Fraksi Uap	1,00	1,00	1,00
Laju Alir Massa (kg/jam)	74.966	66.993	7.973
Laju Alir Komponen (kg/jam)			
H_2	9.423,96	1.451,29	7.972,67
C_3H_8	29.244,86	29.244,86	0,00
$C_{15}H_{32}$	17,32	17,32	0,00
$C_{16}H_{34}$	9,65	9,65	0,00
$C_{17}H_{36}$	5,64	5,64	0,00
$C_{18}H_{38}$	3,87	3,87	0,00
H_2O	3.397,80	3.397,80	0,00
CO_2	32.753,00	32.753,00	0,00
$C_{14}H_{30}$	0,00	0,00	0,00
$C_{13}H_{28}$	0,01	0,01	0,00
$C_{12}H_{26}$	0,30	0,30	0,00
$C_{11}H_{24}$	0,92	0,92	0,00
$C_{10}H_{22}$	4,00	4,00	0,00
C_9H_{20}	9,95	9,95	0,00
C_8H_{18}	37,99	37,99	0,00
C_7H_{16}	56,33	56,33	0,00

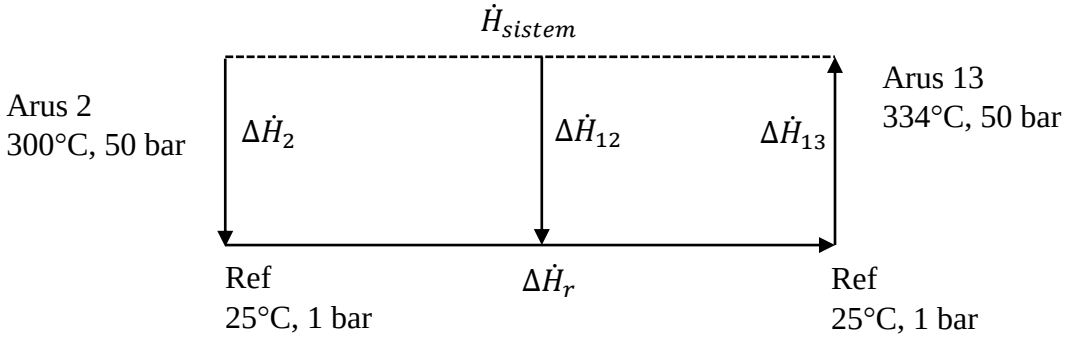
4.2 Neraca Energi

4.2.1 Reaktor 1 (R-101)



Gambar 4. 9 Diagram Alir Reaktor 1 (R-101)

Jalur Hipotetik:

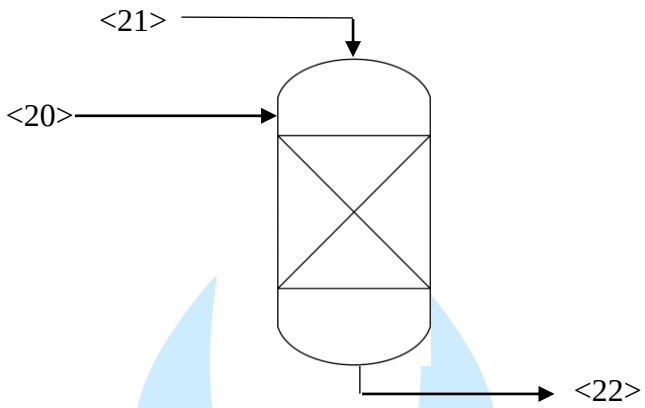


Simbol	Perhitungan
$\Delta\dot{H}_{12}$	$\sum \dot{n}_2 \int_{300}^{25} C_p\, dT = -\sum \dot{n}_2 \int_{25}^{300} C_p\, dT$
$\Delta\dot{H}_{12}$	$\sum \dot{n}_{12} \int_{300}^{25} C_p\, dT = -\sum \dot{n}_{12} \int_{25}^{300} C_p\, dT$
$\Delta\dot{H}_{13}$	$\sum \dot{n}_{13} \int_{25}^{334} C_p\, dT$
$\Delta\dot{H}_r$	$\Sigma\varepsilon_i\, \Delta\hat{\dot{H}}_{ri}$
$\dot{Q}$	$\dot{Q} = \Delta\dot{H}$ $\dot{Q} = \Delta\dot{H}_r + \Delta\dot{H}_{13} - \Delta\dot{H}_2 + \Delta\dot{H}_{12}$

Tabel 4.9 Neraca Energi Unit Operasi Reaktor 1 (R-101)

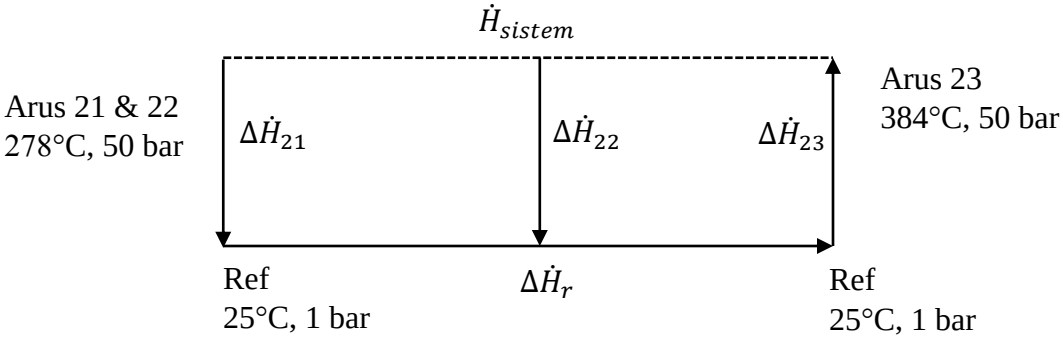
Komponen	Input (kj/jam) $\Delta\dot{H}_{2+12}$	Output (kj/jam) $\Delta\dot{H}_{13}$	$\Delta\dot{H}_r$
$C_{57}H_{104}O_6$	159.207.693	1.789.607	
$C_{51}H98O6$	155.329.134	1.746.009	
$C_{57}H98O6$	43.453.571	488.449	
$C_{57}H_{110}O_6$	19.346.557	2.583.659	
H_2	87.280.095	43.039.628	
C_3H_8	0	28.678.790	
$C_{15}H_{32}$	0	72.943.945	
$C_{16}H_{34}$	0	87.478.537	
$C_{17}H_{36}$	0	113.842.196	
$C_{18}H_{38}$	0	125.164.243	
H_2O	0	30.240.815	
CO_2	0	14.266.467	
Total	464.617.050	522.262.345	-57.645.295

4.2.2 Reaktor 2 (R-202)



Gambar 4. 10 Diagram Alir Reaktor 2 (R-202)

Jalur Hipotetik:

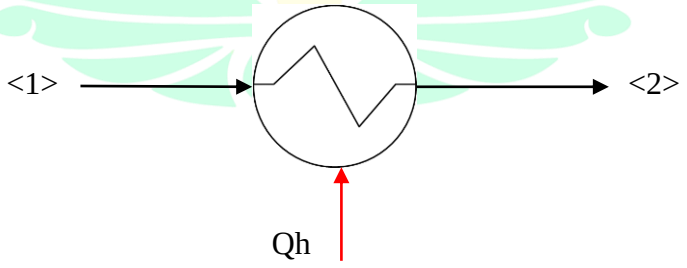


Simbol	Perhitungan
$\Delta\dot{H}_{21}$	$\sum \dot{n}_{21} \int_{278}^{25} C_p \, dT = -\sum \dot{n}_{21} \int_{25}^{278} C_p \, dT$
$\Delta\dot{H}_{22}$	$\sum \dot{n}_{22} \int_{278}^{25} C_p \, dT = -\sum \dot{n}_{22} \int_{25}^{278} C_p \, dT$
$\Delta\dot{H}_{23}$	$\sum \dot{n}_2 \int_{25}^{384} C_p \, dT$
$\Delta\dot{H}_r$	$\Sigma\varepsilon_i \, \Delta\hat{\dot{H}}_{ri}$
$\dot{Q}$	$\dot{Q} = \Delta\dot{H}$ $\dot{Q} = \Delta\dot{H}_r + \Delta\dot{H}_{23} - \Delta\dot{H}_{21} + \Delta\dot{H}_{22}$

Tabel 4.10 Neraca Energi Unit Operasi Reaktor 2 (R-202)

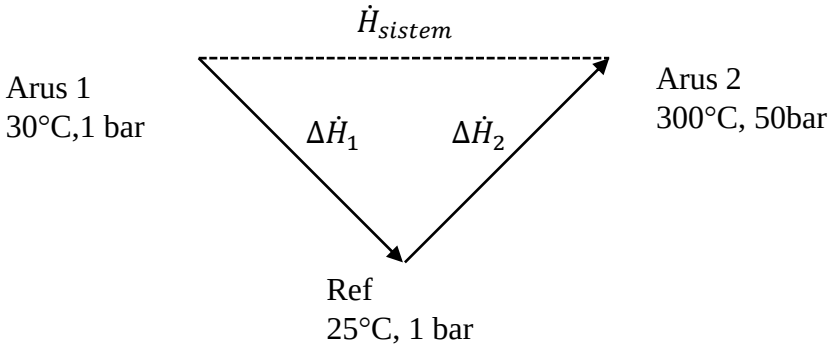
Komponen	Input (kj/jam) $\Delta\dot{H}_{21+20}$	Output (kj/jam) $\Delta\dot{H}_{22}$	$\Delta\dot{H}_r$
$C_{57}H_{104}O_6$	1.464.711	2.077.629	
$C_{51}H98O6$	1.429.028	2.027.015	
$C_{57}H98O6$	399.773	567.061	
$C_{57}H_{110}O_6$	2.114.606	2.999.478	
H_2	80.297.688	10.909.038	
C_3H_8	3.426.057	61.556.301	
$C_{15}H_{32}$	59.685.636	5.926.306	
$C_{16}H_{34}$	71.588.468	7.108.162	
$C_{17}H_{36}$	93.169.532	9.250.989	
$C_{18}H_{38}$	102.437.702	10.171.244	
$C_{14}H_{30}$	0	285.973	
$C_{13}H_{28}$	0	5.426.604	
$C_{12}H_{26}$	0	63.738.024	
$C_{11}H_{24}$	0	59.764.126	
$C_{10}H_{22}$	0	81.933.227	
C_9H_{20}	0	64.811.273	
C_8H_{18}	0	78.974.327	
C_7H_{16}	0	37.422.621	
Total	416.013.200	504.949.398	-88.936.197

4.2.3 *Heater* (E-101)



Gambar 4. 11 Diagram Alir *Heater* (E-101)

Jalur Hipotetik:

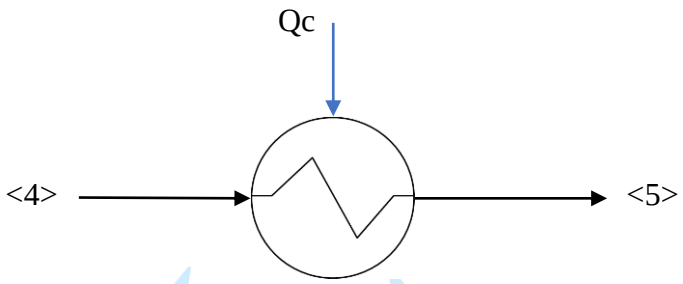


Simbol	Perhitungan
$\Delta\dot{H}_1$	$\sum \dot{n}_1 \int_{30}^{25} C_p\, dT = -\sum \dot{n}_1 \int_{25}^{30} C_p\, dT$
$\Delta\dot{H}_2$	$\sum \dot{n}_2 \int_{25}^{300} C_p\, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\dot{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_2 - \Delta\dot{H}_1$

Tabel 4.11 Neraca Energi Unit Operasi *Heater* (E-101)

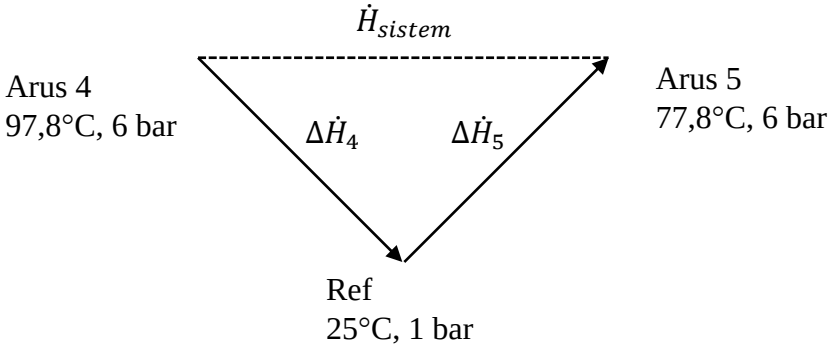
Komponen	Input (kj/jam)	Output (kj/jam)	Qh
	$\Delta\dot{H}_1$	$\Delta\dot{H}_2$	
$C_{57}H_{104}O_6$	3.087.086	169.789.746	
$C_{51}H98O6$	3.011.880	165.653.390	
$C_{57}H98O6$	842.578	46.341.798	
$C_{57}H_{110}O_6$	375.136	20.632.464	
Total	7.316.680	402.417.397	395.100.717

4.2.4 *Cooler* (E-102)



Gambar 4. 12 Diagram Alir *Cooler* (E-102)

Jalur Hipotetik:

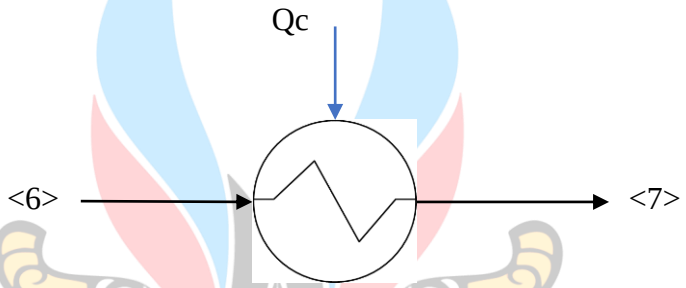


Simbol	Perhitungan
$\Delta\dot{H}_4$	$\sum \dot{n}_4 \int_{98}^{25} C_p \, dT = -\sum \dot{n}_4 \int_{25}^{98} C_p \, dT$
$\Delta\dot{H}_5$	$\sum \dot{n}_5 \int_{25}^{78} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_4 - \Delta\dot{H}_5$

Tabel 4.12 Neraca Energi Unit Operasi *Cooler* (E-102)

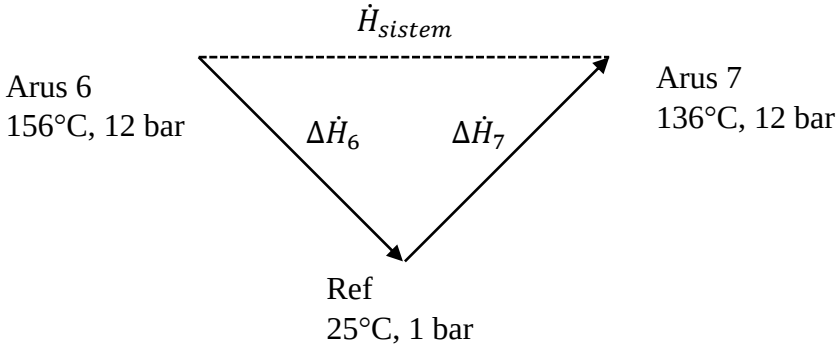
Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_4$	$\Delta\dot{H}_5$	
H_2	30.078.547	21.815.210	
Total	30.078.547	21.815.210	8.263.337

4.2.5 *Cooler* (E-103)



Gambar 4. 13 Diagram Alir *Cooler* (E-103)

Jalur Hipotetik:

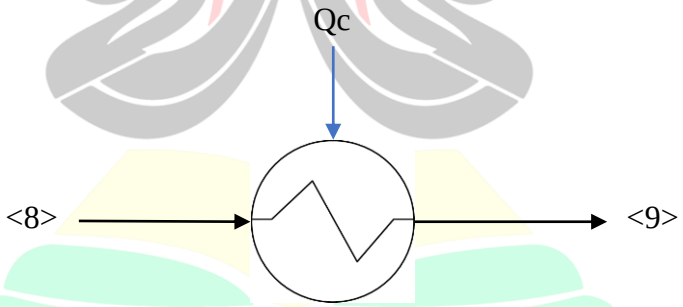


Simbol	Perhitungan
$\Delta\dot{H}_6$	$\sum \dot{n}_6 \int_{156}^{25} C_p \, dT = -\sum \dot{n}_6 \int_{25}^{156} C_p \, dT$
$\Delta\dot{H}_7$	$\sum \dot{n}_7 \int_{25}^{136} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \dot{Q}_{hot} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_7 - \Delta\dot{H}_6$

Tabel 4.13 Neraca Energi Unit Operasi *Cooler* (E-103)

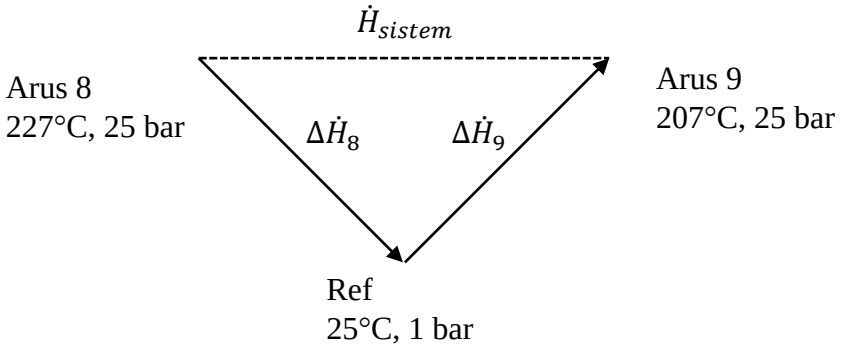
Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_6$	$\Delta\dot{H}_7$	
H_2	54.124.858	45.861.521	
Total	54.124.858	45.861.521	8.263.337

4.2.6 *Cooler* (E-104)



Gambar 4. 14 Diagram Alir *Cooler* (E-104)

Jalur Hipotetik:

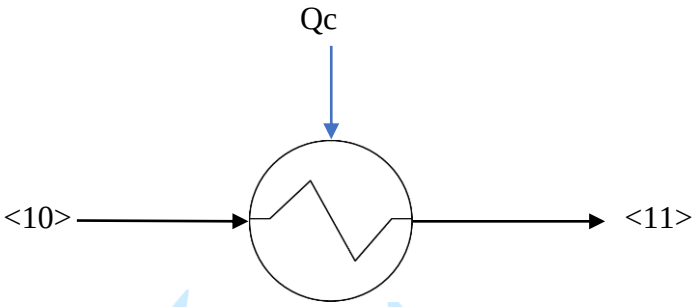


Simbol	Perhitungan
$\Delta\dot{H}_8$	$\sum \dot{n}_8 \int_{227}^{25} C_p \, dT = -\sum \dot{n}_8 \int_{25}^{227} C_p \, dT$
$\Delta\dot{H}_9$	$\sum \dot{n}_9 \int_{25}^{207} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \dot{Q}_{hot} = \Delta\hat{H}$
	$\Delta\hat{H} = \Delta\dot{H}_9 - \Delta\dot{H}_8$
$\dot{Q}$	$\dot{Q} = \dot{Q}_{cold} - \dot{Q}_{hot}$

Tabel 4.14 Neraca Energi Unit Operasi *Cooler* (E-104)

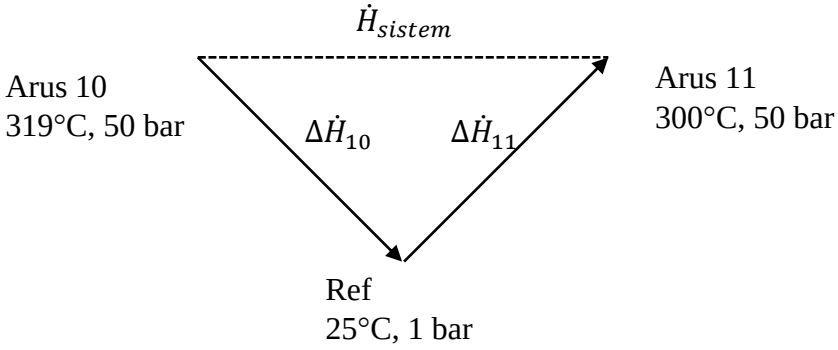
Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_8$	$\Delta\dot{H}_9$	
H_2	83.377.071	75.113.734	
Total	83.377.071	75.113.734	8.263.337

4.2.7 *Cooler* (E-105)



Gambar 4. 15 Diagram Alir *Cooler* (E-105)

Jalur Hipotetik:

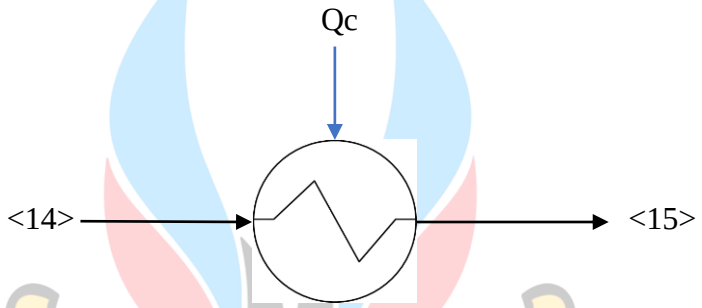


Simbol	Perhitungan
$\Delta\dot{H}_{10}$	$\sum \dot{n}_{10} \int_{312}^{25} C_p \, dT = - \sum \dot{n}_{10} \int_{25}^{312} C_p \, dT$
$\Delta\dot{H}_{11}$	$\sum \dot{n}_{11} \int_{25}^{300} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{11} - \Delta\dot{H}_{10}$

Tabel 4.15 Neraca Energi Unit Operasi *Cooler* (E-105)

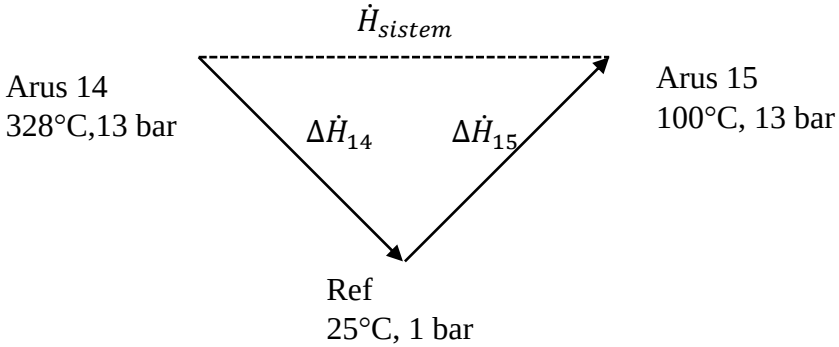
Komponen	Input (kj/jam) $\Delta\dot{H}_{10}$	Output (kj/jam) $\Delta\dot{H}_{11}$	Qc
H_2	118.578.888	113.620.885	
Total	118.578.888	113.620.885	4.958.002

4.2.8 *Cooler* (E-106)



Gambar 4. 16 Diagram Alir *Cooler* (E-106)

Jalur Hipotetik:

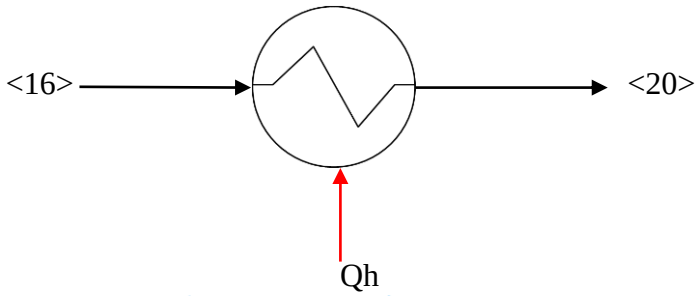


Simbol	Perhitungan
$\Delta\dot{H}_{14}$	$\sum \dot{n}_{14} \int_{287}^{25} C_p \, dT = -\sum \dot{n}_{14} \int_{25}^{287} C_p \, dT$
$\Delta\dot{H}_{15}$	$\sum \dot{n}_{15} \int_{25}^{150} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{15} - \Delta\dot{H}_{14}$

Tabel 4.16 Neraca Energi Unit Operasi *Cooler* (E-106)

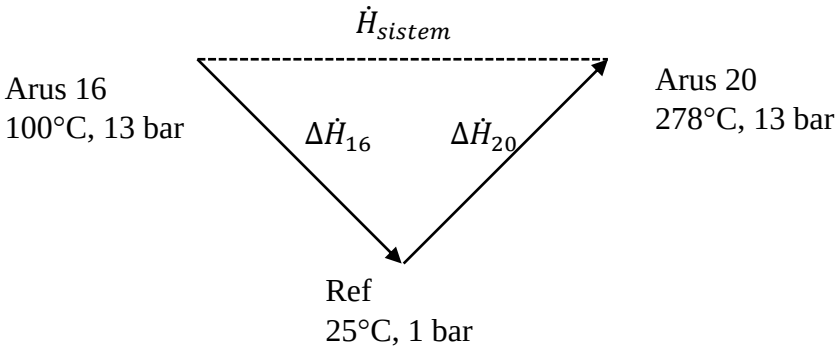
Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_{14}$	$\Delta\dot{H}_{15}$	
$C_{57}H_{104}O_6$	1.754.179	434.203	
$C_{51}H98O6$	1.711.445	423.625	
$C_{57}H98O6$	478.779	118.510	
$C_{57}H_{110}O_6$	2.532.513	626.860	
H_2	139.233	139.233	
C_3H_8	92.776	92.776	
$C_{15}H_{32}$	71.499.929	17.698.002	
$C_{16}H_{34}$	85.746.791	21.224.453	
$C_{17}H_{36}$	111.588.549	27.620.928	
$C_{18}H_{38}$	122.686.461	30.367.936	
H_2O	97.829	97.829	
CO_2	46.152	46.152	
Total	398.374.636	98.890.506	299.484.130

4.2.9 *Heater* (E-207)



Gambar 4. 17 Diagram Alir *Heater* (E-207)

Jalur Hipotetik:

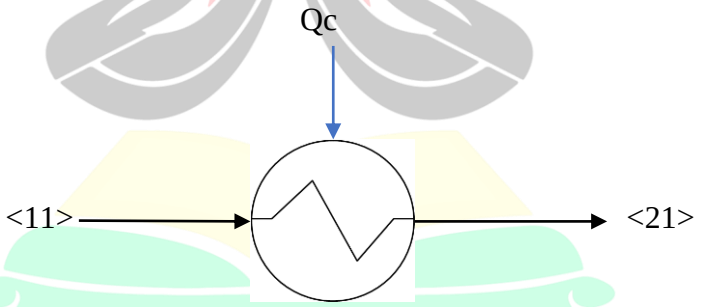


Simbol	Perhitungan
$\Delta\dot{H}_{16}$	$\sum \dot{n}_{16} \int_{100}^{25} C_p \, dT = - \sum \dot{n}_{16} \int_{25}^{100} C_p \, dT$
$\Delta\dot{H}_{20}$	$\sum \dot{n}_{20} \int_{25}^{278} C_p \, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\widehat{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_{20} - \Delta\dot{H}_{16}$

Tabel 4.17 Neraca Energi Unit Operasi *Heater* (E-207)

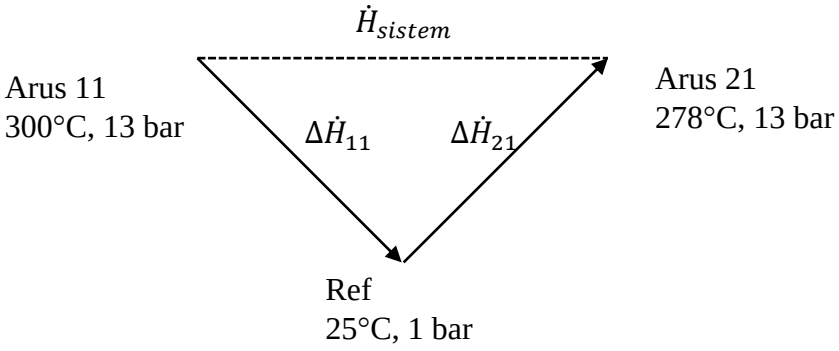
Komponen	Input (kj/jam)	Output (kj/jam)	Qh
	$\Delta\dot{H}_{16}$	$\Delta\dot{H}_{20}$	
$C_{57}H_{104}O_6$	434.203	1.464.711	
$C_{51}H98O6$	423.625	1.429.028	
$C_{57}H98O6$	118.510	399.773	
$C_{57}H_{110}O_6$	626.860	2.114.606	
C_3H_8	1.015.629	3.426.057	
$C_{15}H_{32}$	17.693.370	59.685.636	
$C_{16}H_{34}$	21.221.878	71.588.468	
$C_{17}H_{36}$	27.619.426	93.169.532	
$C_{18}H_{38}$	30.366.908	102.437.702	
Total	99.520.409	335.715.513	236.195.104

4.2.10 *Cooler* (E-208)



Gambar 4. 18 Diagram Alir *Cooler* (E-208)

Jalur Hipotetik:

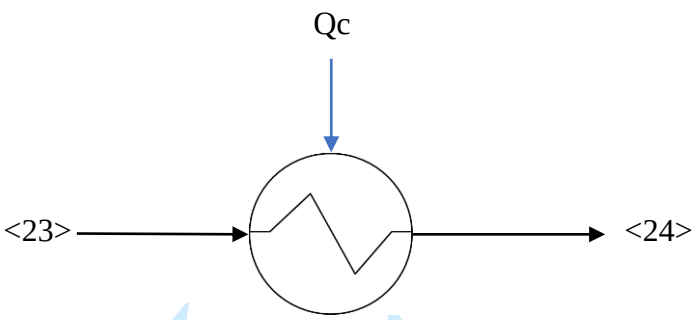


Simbol	Perhitungan
$\Delta\dot{H}_{11}$	$\sum \dot{n}_{11} \int_{300}^{25} C_p \, dT = - \sum \dot{n}_{11} \int_{25}^{300} C_p \, dT$
$\Delta\dot{H}_{21}$	$\sum \dot{n}_{21} \int_{25}^{278} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{21} - \Delta\dot{H}_{11}$

Tabel 4.18 Neraca Energi Unit Operasi *Cooler* (E-208)

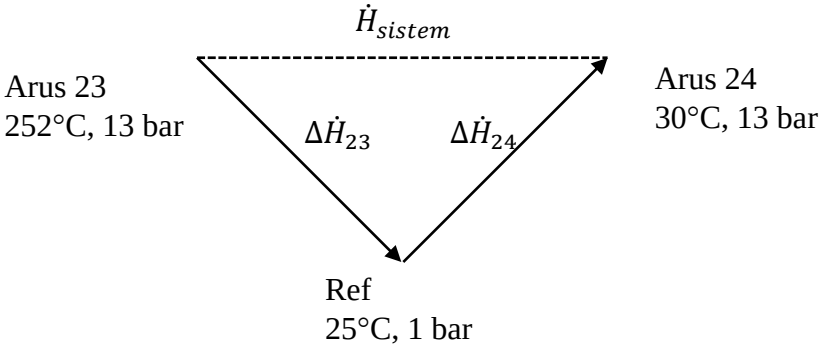
Komponen	Input (kj/jam)	Output (kj/jam)	Qh
	$\Delta\dot{H}_{21}$	$\Delta\dot{H}_{11}$	
H_2	25.755.994	23.695.515	
Total	25.755.994	23.695.515	2.060.480

4.2.11 *Cooler* (E-309)



Gambar 4. 19 Diagram Alir *Cooler* (E-309)

Jalur Hipotetik:

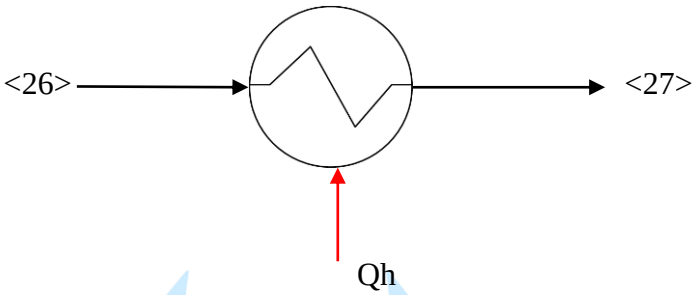


Simbol	Perhitungan
$\Delta\dot{H}_{23}$	$\sum \dot{n}_{23} \int_{252}^{25} C_p \, dT = -\sum \dot{n}_{23} \int_{25}^{252} C_p \, dT$
$\Delta\dot{H}_{24}$	$\sum \dot{n}_{24} \int_{25}^{30} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\hat{H}$ $\Delta\hat{H} = \Delta\dot{H}_{24} - \Delta\dot{H}_{23}$

Tabel 4.19 Neraca Energi Unit Operasi *Cooler* (E-309)

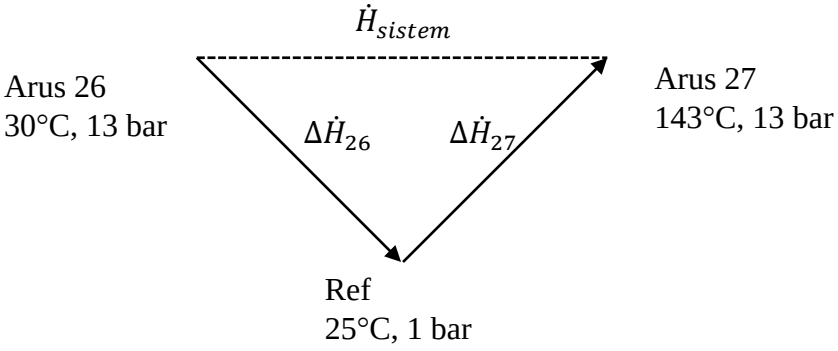
Komponen	Input (kj/jam) $\Delta\dot{H}_{23}$	Output (kj/jam) $\Delta\dot{H}_{24}$	Qh
$C_{57}H_{104}O_6$	1.314.187	28.947	
$C_{51}H98O6$	1.282.171	28.242	
$C_{57}H98O6$	358.689	7.901	
$C_{57}H_{110}O_6$	1.897.295	41.791	
H_2	6.900.421	151.992	
C_3H_8	42.010.897	925.350	
$C_{15}H_{32}$	3.748.635	82.569	
$C_{16}H_{34}$	4.496.209	99.035	
$C_{17}H_{36}$	5.851.636	128.891	
$C_{18}H_{38}$	6.433.736	141.712	
$C_{14}H_{30}$	180.890	3.984	
$C_{13}H_{28}$	3.432.553	75.607	
$C_{12}H_{26}$	40.316.956	888.039	
$C_{11}H_{24}$	37.803.300	832.672	
$C_{10}H_{22}$	51.826.180	1.141.546	
C_9H_{20}	40.995.831	902.992	
C_8H_{18}	49.954.553	1.100.321	
C_7H_{16}	23.671.367	521.396	
Total	322.475.507	7.102.985	315.372.522

4.2.13 *Heater* (E-310)



Gambar 4. 20 Diagram Alir *Heater* (E-310)

Jalur Hipotetik:

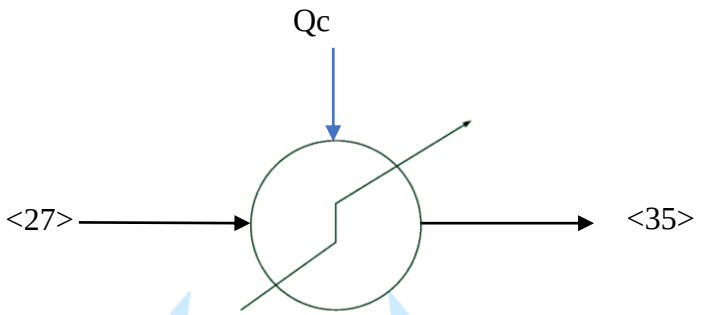


Simbol	Perhitungan
$\Delta\dot{H}_{26}$	$\sum \dot{n}_{26} \int_{30}^{25} C_p \, dT$
$\Delta\dot{H}_{27}$	$\sum \dot{n}_{27} \int_{25}^{143} C_p \, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\widehat{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_{27} - \Delta\dot{H}_{26}$
$\dot{Q}$	$\dot{Q} = \dot{Q}_{hot} - \dot{Q}_{cold}$

Tabel 4.20 Neraca Energi Unit Operasi *Heater* (E-310)

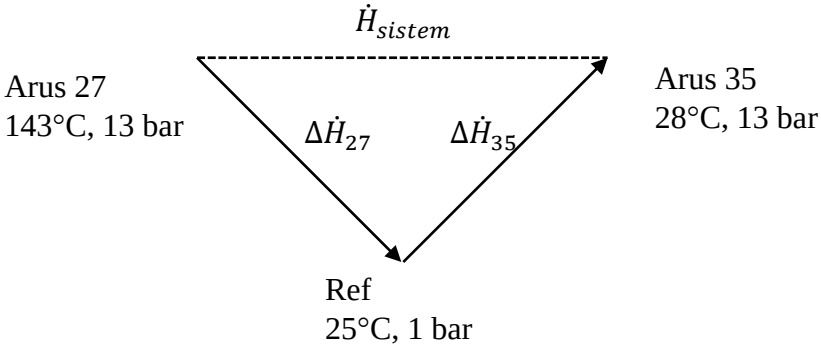
Komponen	Input (kj/jam) $\Delta\dot{H}_{27}$	Output (kj/jam) $\Delta\dot{H}_{26}$	Qh
$C_{57}H_{104}O_6$	28.947	683.146	
$C_{51}H98O6$	28.242	666.503	
$C_{57}H98O6$	7.901	186.455	
$C_{57}H_{110}O_6$	41.791	986.259	
C_3H_8	723.330	17.070.589	
$C_{15}H_{32}$	82.569	1.948.630	
$C_{16}H_{34}$	99.035	2.337.236	
$C_{17}H_{36}$	128.891	3.041.819	
$C_{18}H_{38}$	141.712	3.344.409	
$C_{14}H_{30}$	3.984	94.031	
$C_{13}H_{28}$	75.607	1.784.319	
$C_{12}H_{26}$	888.033	20.957.585	
$C_{11}H_{24}$	832.655	19.650.661	
$C_{10}H_{22}$	1.141.473	26.938.767	
C_9H_{20}	902.810	21.306.313	
C_8H_{18}	1.099.621	25.951.049	
C_7H_{16}	520.348	12.280.214	
Total	6.746.949	159.227.985	152.481.037

4.2.14*Condenser* (E-411)



Gambar 4. 21 Diagram Alir *Condenser* (E-411)

Jalur Hipotetik:

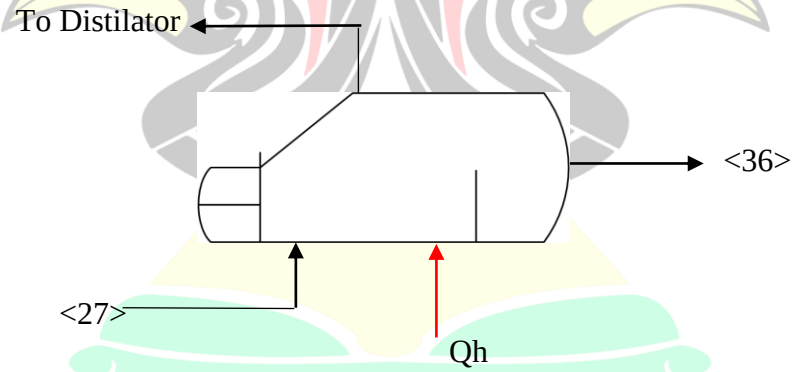


Simbol	Perhitungan
$\Delta\dot{H}_{27}$	$\sum \dot{n}_{27} \int_{143}^{25} C_p \, dT = -\sum \dot{n}_{27} \int_{143}^{25} C_p \, dT$
$\Delta\dot{H}_{35}$	$\sum \dot{n}_{35} \int_{25}^{35} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{35} - \Delta\dot{H}_{27}$

Tabel 4.21 Neraca Energi Unit Operasi *Condenser* (E-411)

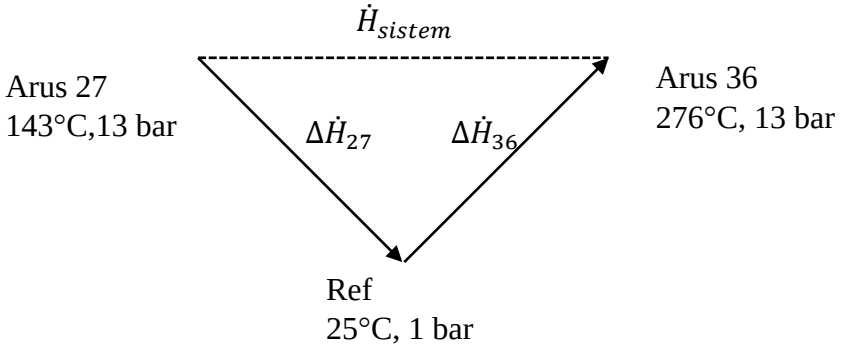
Komponen	Input (kj/jam) $\Delta\dot{H}_{35}$	Output (kj/jam) $\Delta\dot{H}_{27}$	Qc
C_3H_8	16.639.763	423.045	
$C_{12}H_{26}$	128	3	
$C_{11}H_{24}$	394	10	
$C_{10}H_{22}$	1.714	44	
C_9H_{20}	4.295	109	
C_8H_{18}	16.516	420	
C_7H_{16}	24.726	629	
Total	16.687.536	424.259	16.263.276

4.2.16 *Reboiler* (E-412)



Gambar 4. 22 Diagram Alir *Reboiler* (E-412)

Jalur Hipotetik:



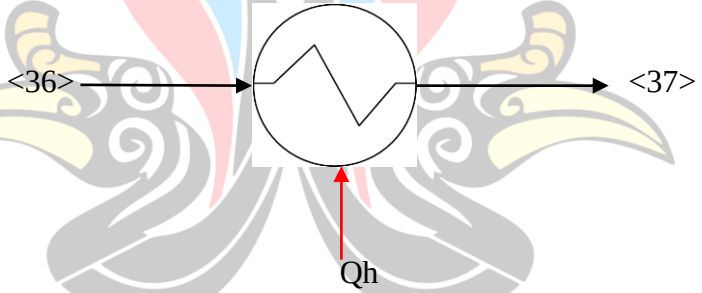
Simbol	Perhitungan
$\Delta\dot{H}_{27}$	$\sum \dot{n}_{27} \int_{143}^{25} C_p \, dT = -\sum \dot{n}_{27} \int_{25}^{143} C_p \, dT$
$\Delta\dot{H}_{36}$	$\sum \dot{n}_{36} \int_{25}^{276} C_p \, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\widehat{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_{36} - \Delta\dot{H}_{27}$

Tabel 4.22 Neraca Energi Unit Operasi *Reboiler* (E-412)

Komponen	Input (kj/jam)	Output (kj/jam)	Qh
	$\Delta\dot{H}_{27}$	$\Delta\dot{H}_{36}$	
$C_{57}H_{104}O_6$	683.146	1.453.132	
$C_{51}H98O6$	666.503	1.417.731	
$C_{57}H98O6$	186.455	396.613	
$C_{57}H_{110}O_6$	986.259	2.097.890	
C_3H_8	430.826	3.651	
$C_{15}H_{32}$	1.948.630	4.144.966	
$C_{16}H_{34}$	2.337.236	4.971.578	
$C_{17}H_{36}$	3.041.819	6.470.311	
$C_{18}H_{38}$	3.344.409	7.113.954	
$C_{14}H_{30}$	94.031	200.015	

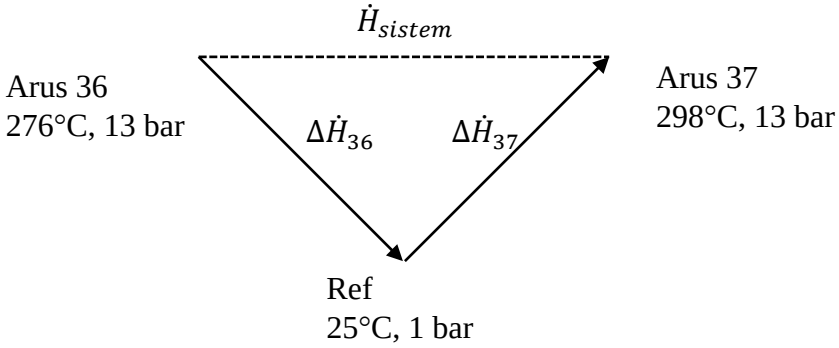
Komponen	Input (kj/jam) $\Delta\dot{H}_{27}$	Output (kj/jam) $\Delta\dot{H}_{36}$	Qh
$C_{13}H_{28}$	1.784.319	3.795.459	
$C_{12}H_{26}$	20.957.579	44.579.258	
$C_{11}H_{24}$	19.650.627	41.799.216	
$C_{10}H_{22}$	26.938.459	57.301.299	
C_9H_{20}	21.304.647	45.317.513	
C_8H_{18}	25.936.871	55.170.801	
C_7H_{16}	12.232.011	26.018.939	
Total	142.523.828	302.252.325	159.728.496

4.2.17 *Heater* (E-413)



Gambar 4. 23 Diagram Alir *Heater* (E-413)

Jalur Hipotetik:

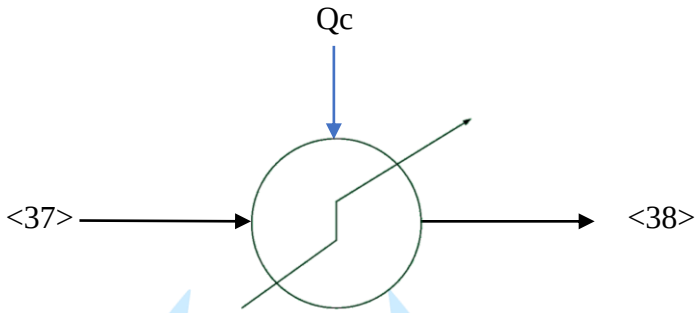


Simbol	Perhitungan
$\Delta\dot{H}_{36}$	$\sum \dot{n}_{36} \int_{276}^{25} C_p \, dT = - \sum \dot{n}_{36} \int_{25}^{276} C_p \, dT$
$\Delta\dot{H}_{37}$	$\sum \dot{n}_{37} \int_{25}^{298} C_p \, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\widehat{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_{37} - \Delta\dot{H}_{36}$

Tabel 4.23 Neraca Energi Unit Operasi *Heater* (E-413)

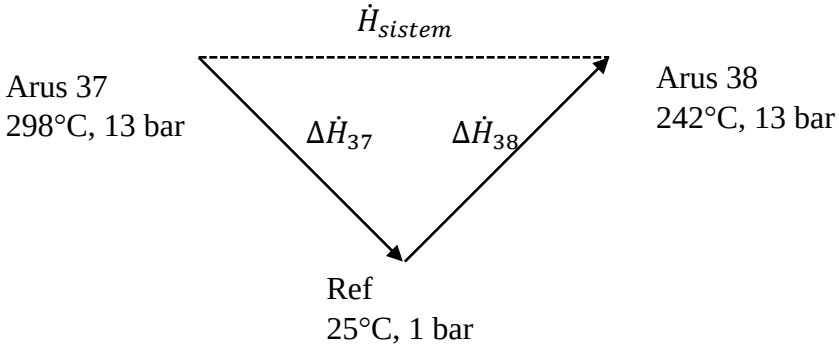
Komponen	Input (kj/jam)	Output (kj/jam)	Qh
	$\Delta\dot{H}_{36}$	$\Delta\dot{H}_{37}$	
$C_{57}H_{104}O_6$	1.453.132	1.580.498	
$C_{51}H98O6$	1.417.731	1.541.995	
$C_{57}H98O6$	396.613	431.375	
$C_{57}H_{110}O_6$	2.097.890	2.281.769	
C_3H_8	916.419	3.651	
$C_{15}H_{32}$	4.144.966	4.508.270	
$C_{16}H_{34}$	4.971.578	5.407.334	
$C_{17}H_{36}$	6.470.311	7.037.430	
$C_{18}H_{38}$	7.113.954	7.737.488	
$C_{14}H_{30}$	200.015	217.546	
$C_{13}H_{28}$	3.795.459	4.128.129	
$C_{12}H_{26}$	44.579.258	48.486.603	
$C_{11}H_{24}$	41.799.216	45.462.892	
$C_{10}H_{22}$	57.301.299	62.323.723	
C_9H_{20}	45.317.513	49.289.566	
C_8H_{18}	55.170.801	60.006.489	
C_7H_{16}	26.018.939	28.299.483	
Total	303.165.093	328.744.241	25.579.148

4.2.18 *Condenser* (E-514)



Gambar 4.24 Diagram Alir *Condenser* (E-514)

Jalur Hipotetik:

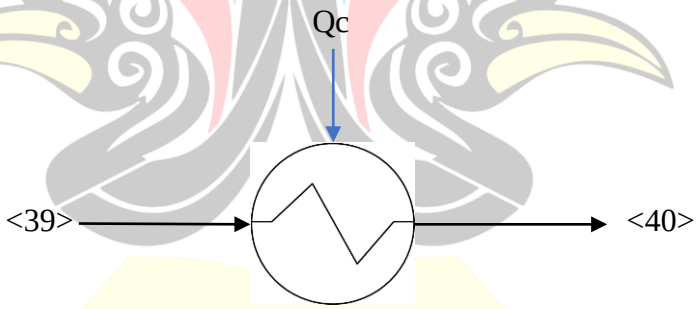


Simbol	Perhitungan
$\Delta\dot{H}_{37}$	$\sum \dot{n}_{37} \int_{298}^{25} C_p \, dT = - \sum \dot{n}_{37} \int_{25}^{298} C_p \, dT$
$\Delta\dot{H}_{38}$	$\sum \dot{n}_{38} \int_{25}^{242} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{38} - \Delta\dot{H}_{37}$

Tabel 4.24 Neraca Energi Unit Operasi *Condenser* (E-514)

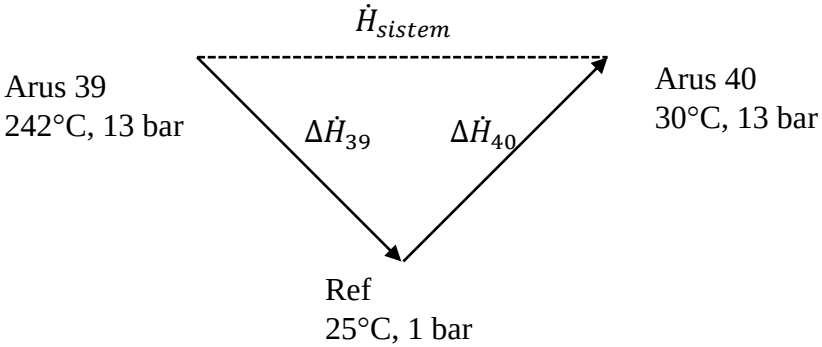
Komponen	Input (kj/jam) $\Delta\dot{H}_{37}$	Output (kj/jam) $\Delta\dot{H}_{38}$	Qc
C_3H_8	996.742	792.282	
$C_{12}H_{26}$	5.871.383	4.666.997	
$C_{11}H_{24}$	45.325.874	36.028.259	
$C_{10}H_{22}$	62.323.657	49.539.317	
C_9H_{20}	49.289.566	39.178.885	
C_8H_{18}	60.006.489	47.697.466	
C_7H_{16}	28.299.483	22.494.461	
Total	252.113.194	200.397.667	51.715.527

4.2.19 *Cooler* (E-516)



Gambar 4.25 Diagram Alir *Cooler* (E-516)

Jalur Hipotetik:

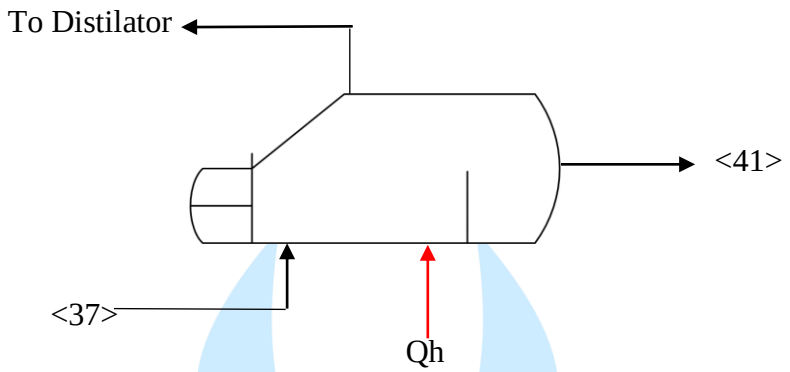


Simbol	Perhitungan
$\Delta\dot{H}_{39}$	$\sum \dot{n}_{39} \int_{242}^{25} C_p \, dT = - \sum \dot{n}_{39} \int_{25}^{242} C_p \, dT$
$\Delta\dot{H}_{40}$	$\sum \dot{n}_{40} \int_{25}^{30} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{40} - \Delta\dot{H}_{39}$

Tabel 4.25 Neraca Energi Unit Operasi *Cooler* (E-516)

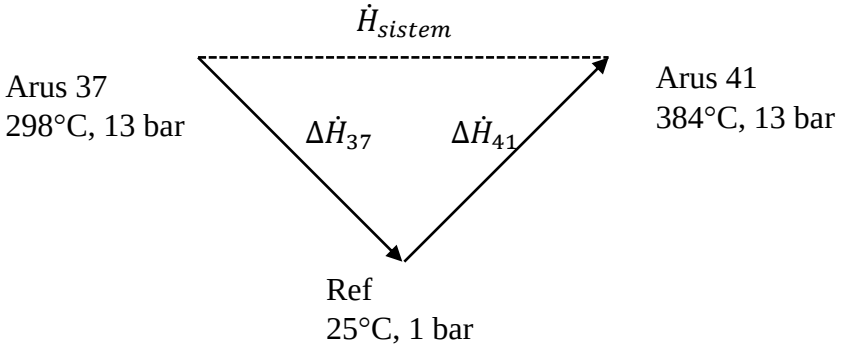
Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_{40}$	$\Delta\dot{H}_{39}$	
C_3H_8	458.541	10.565	
$C_{12}H_{26}$	5.286.447	121.808	
$C_{11}H_{24}$	36.189.337	833.856	
$C_{10}H_{22}$	49.646.364	1.143.925	
C_9H_{20}	39.207.056	903.388	
C_8H_{18}	47.516.508	1.094.850	
C_7H_{16}	22.172.172	510.880	
Total	200.476.425	4.619.272	195.857.152

4.2.20 *Reboiler* (E-515)



Gambar 4. 26 Diagram Alir *Reboiler* (E-515)

Jalur Hipotetik:

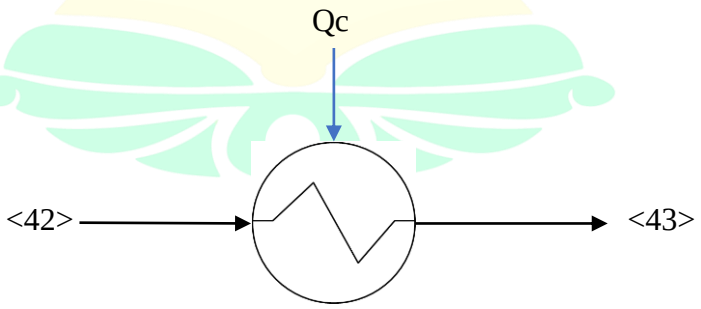


Simbol	Perhitungan
$\Delta\dot{H}_{37}$	$\sum \dot{n}_{37} \int_{298}^{25} C_p \, dT = - \sum \dot{n}_{37} \int_{25}^{298} C_p \, dT$
$\Delta\dot{H}_{41}$	$\sum \dot{n}_{41} \int_{25}^{384} C_p \, dT$
$\dot{Q}_{hot}$	$\dot{Q}_{hot} = \Delta\hat{H}$ $\dot{Q}_{hot} = \Delta\dot{H}_{41} - \Delta\dot{H}_{37}$

Tabel 4.26 Neraca Energi Unit Operasi *Reboiler* (E-515)

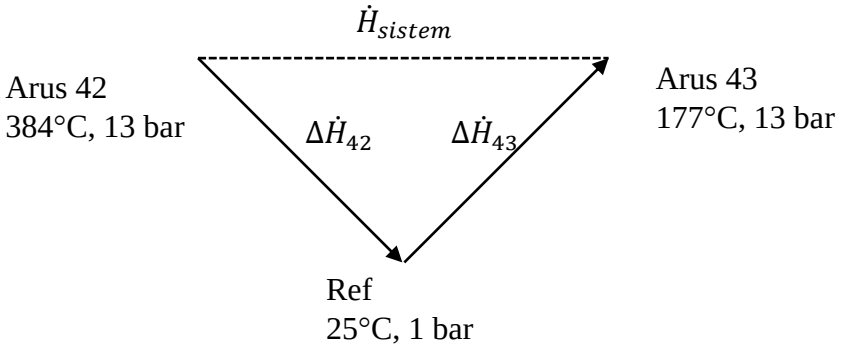
Komponen	Input (kj/jam) $\Delta\dot{H}_{37}$	Output (kj/jam) $\Delta\dot{H}_{41}$	Qh
$C_{57}H_{104}O_6$	1.580.498	2.078.384	
$C_{51}H98O6$	1.541.995	2.027.751	
$C_{57}H98O6$	431.375	567.267	
$C_{57}H_{110}O_6$	2.281.769	3.000.568	
$C_{15}H_{32}$	4.508.270	16.514	
$C_{16}H_{34}$	5.407.334	7.110.744	
$C_{17}H_{36}$	7.037.430	6.681.278	
$C_{18}H_{38}$	7.737.488	7.959.788	
$C_{14}H_{30}$	217.546	7.690.234	
$C_{13}H_{28}$	4.127.810	7.461.622	
$C_{12}H_{26}$	42.615.220	247.286	
$C_{11}H_{24}$	137.018	4.638.597	
$C_{10}H_{22}$	66	47.249.239	
Total	77.623.818	96.729.269	19.105.451

4.2.21 *Cooler* (E-517)



Gambar 4. 27 Diagram Alir *Cooler* (E-517)

Jalur Hipotetik:



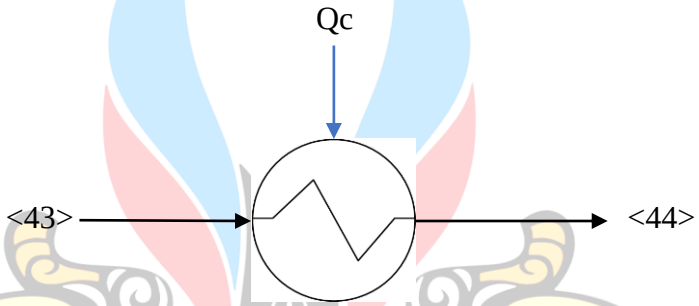
Simbol	Perhitungan
$\Delta\dot{H}_{42}$	$\sum \dot{n}_{42} \int_{339}^{25} C_p \, dT = -\sum \dot{n}_{42} \int_{25}^{339} C_p \, dT$
$\Delta\dot{H}_{43}$	$\sum \dot{n}_{43} \int_{25}^{177} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\hat{H}$ $\Delta\hat{H} = \Delta\dot{H}_{43} - \Delta\dot{H}_{42}$

Tabel 4.27 Neraca Energi Unit Operasi *Cooler* (E-517)

Komponen	Input (kj/jam)	Output (kj/jam)	Qc
	$\Delta\dot{H}_{42}$	$\Delta\dot{H}_{43}$	
$C_{57}H_{104}O_6$	2.078.384	879.984	
$C_{51}H98O6$	2.027.751	858.546	
$C_{57}H98O6$	567.267	240.180	
$C_{57}H_{110}O_6$	3.000.568	1.270.435	
$C_{15}H_{32}$	5.928.458	2.510.099	
$C_{16}H_{34}$	7.110.744	3.010.677	
$C_{17}H_{36}$	9.254.349	3.918.276	
$C_{18}H_{38}$	10.174.938	4.308.052	
$C_{14}H_{30}$	286.077	121.124	
$C_{13}H_{28}$	5.428.145	2.298.268	

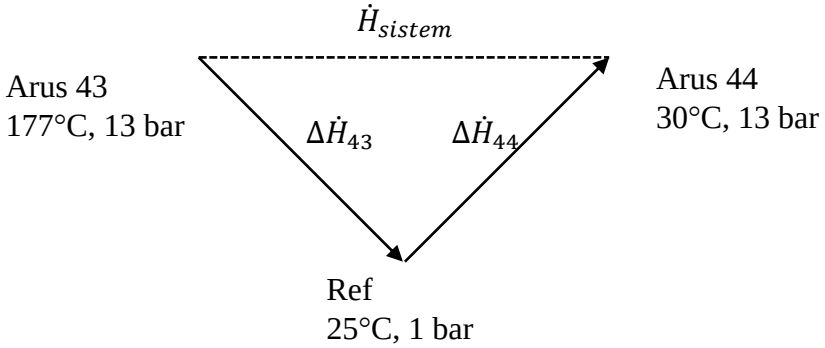
Komponen	Input (kj/jam) $\Delta\dot{H}_{42}$	Output (kj/jam) $\Delta\dot{H}_{43}$	Qc
$C_{12}H_{26}$	56.039.795	23.727.155	
$C_{11}H_{24}$	180.181	76.289	
$C_{10}H_{22}$	87	37	
Total	102.076.743	43.219.122	58.857.621

4.2.22 *Cooler* (E-518)



Gambar 4. 28 Diagram Alir *Cooler* (E-518)

Jalur Hipotetik:



Simbol	Perhitungan
$\Delta\dot{H}_{43}$	$\sum \dot{n}_{43} \int_{177}^{25} C_p \, dT = -\sum \dot{n}_{43} \int_{25}^{177} C_p \, dT$
$\Delta\dot{H}_{44}$	$\sum \dot{n}_{44} \int_{25}^{30} C_p \, dT$
$\dot{Q}_{cold}$	$\dot{Q}_{cold} = \Delta\widehat{H}$ $\Delta\widehat{H} = \Delta\dot{H}_{44} - \Delta\dot{H}_{43}$

Tabel 4.28 Neraca Energi Unit Operasi *Cooler* (E-118)

Komponen	Input (kj/jam) $\Delta\dot{H}_{43}$	Output (kj/jam) $\Delta\dot{H}_{44}$	Qc
$C_{57}H_{104}O_6$	879.984	28.947	
$C_{51}H98O6$	858.546	28.242	
$C_{57}H98O6$	240.180	7.901	
$C_{57}H_{110}O_6$	1.270.435	41.791	
$C_{15}H_{32}$	2.510.099	82.569	
$C_{16}H_{34}$	3.010.677	99.035	
$C_{17}H_{36}$	3.918.276	128.891	
$C_{18}H_{38}$	4.308.052	141.712	
$C_{14}H_{30}$	121.124	3.984	
$C_{13}H_{28}$	2.298.268	75.601	
$C_{12}H_{26}$	23.727.155	780.499	
$C_{11}H_{24}$	76.289	2.509	
$C_{10}H_{22}$	37	1	
Total	43.219.122	1.421.682	41.797.441