CHAPTER IV
RESULTS AND DISCUSSION

4.1 Column and Process Model

4.1.1 Distillation Column Design

The simulation results based on the design case from the distillation shortcut of five main product streams were shown in the Table 4.2 and the gas separation plant 1(GSP1) model was shown in the Figure 4.1. The model was designed to fit with the base case desirably because the different value was very small so this model could be used for column analysis. The modeling result of the actual case is shown on Table 4.3 which gives the small difference from the specification in Table 3.2.

4.1.2 Column Grand Composite Curve

The design case from the process licenser data, is represented by CGCC for the energy optimization for each column. The flow diagram and CGCC of demethanizer are shown in Figure 4.2 and represent one pinch point in this column. This column has four feed streams with composition as shown in Table 4.1 and is chimney-tray type, modeled as four conventional columns connected in series as shown in Figure 4.3. The CGCC of deethanizer is shown in Figure 4.4 with energy loss gap of 5 MJ/sec., so this column needed some modifications. The CGCC of depropanizer is represented in the Figure 4.5 with a pinch point.

The design cases of deethanizer and depropanizer are operated at minimum reflux ratio, which are 1.86 and 2.96 as shown in Figure 4.6 and Figure 4.7, with ethane purity of 93.6% and propane purity 97.9%, respectively.

The actual case with the operating condition of Table 4.3 are represented to the energy optimization. The CGCC of demethanizer shown in Figure 4.10 had a pinch point. While the CGCC of the deethanizer and depropanizer shown in the Figure 4.11 and Figure 4.12 have energy loss gap of 1.8189 MJ/sec and 6.6579 MJ/sec., respectively.

4.1.3 Column Integration

Individual Column Grand Composite Curve shows the energy profile for each column. However, this research work still need to study more in the excess energy in the system of three by using the column integration. This method is to study the energy over lap between the columns and reduce the energy loss. Figure 4.9 shows the three CGCCs of three columns plotted in one graph. Increase the pressure in depropanizer column can shift CGCC of depropanizer up and reduce energy overlap in the graph.

4.1.4 Grand Composite Curve of the Background Process

Grand Composite Curve of the design case is the energy flow between the cold and hot streams in the heat exchanger networks which is shown in Figure 4.8 representing the cold utility requirement is 20.0143 MJ/sec. and hot utility equal 1.9559 MJ/sec. This curve was plotted by Hint program using six hot streams which are H1, H2, H3, H4, H5, and H6 and cold stream which are C1, C2, C3, C4, C5, C6 and C7 as shown in Figure 4.1.

4.1.5 Modifications of the design case.

From the CGCCs of three columns, only deethanizer requires column modifications. The suitable methods are changing reflux, installing sidecondenser and side reboiler. Figure 4.6 showed the plot between product purity and reflux ratio. This graph is used as a tool for checking minimum reflux ratio at operating condition shown the operation reflux ratio at 1.86 which is the minimum reflux ratio at the desire product specification more over than 93.5 %. Figure 4.12 showed the result after changing the reflux ratio from 1.86 to 1.61 that the energy gap was reduced to 4.5148 MJ/sec but the ethane purity was reduced to 91.30 % that lower than the product specification. Figure 4.14 showed the condenser duty of 8.8834 MJ/sec. with the reflux ratio 1.4 that is the lowest reflux ratio in the operation from this curve, the scope for reducing the condenser duty and increasing the product purity to reach the desired specification is to modify the column by installing side-condenser. Figure 4.16 showed the column modification that is installing side-condenser with the reflux ratio 1.4. This method can reduce the main condenser duty from 9.2932 to 2.2 MJ/sec. while the side-condenser duty is 6.6 MJ/sec.

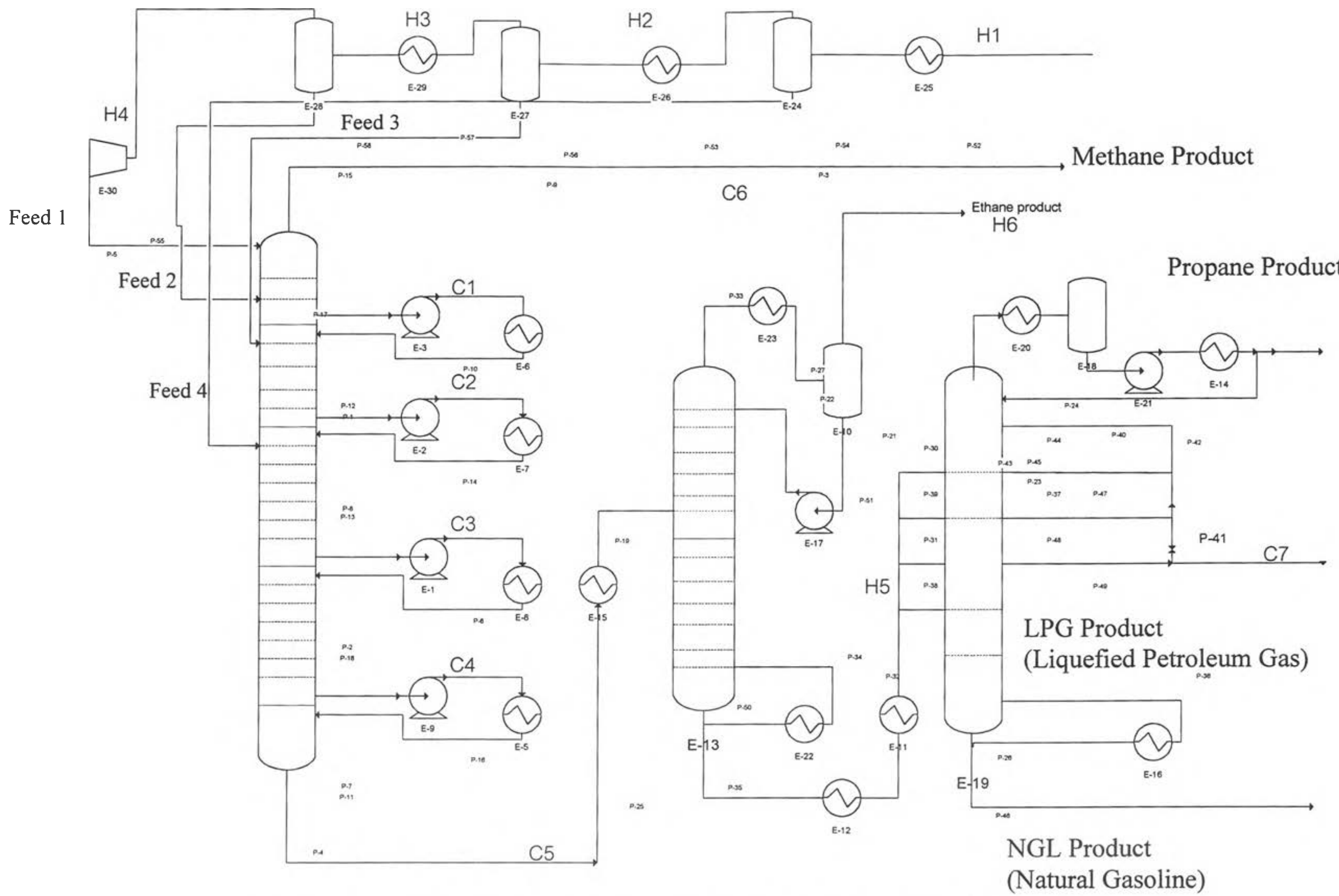


Figure 4.1 Process flow diagram of Gas Separation Plant 1(GSP1)

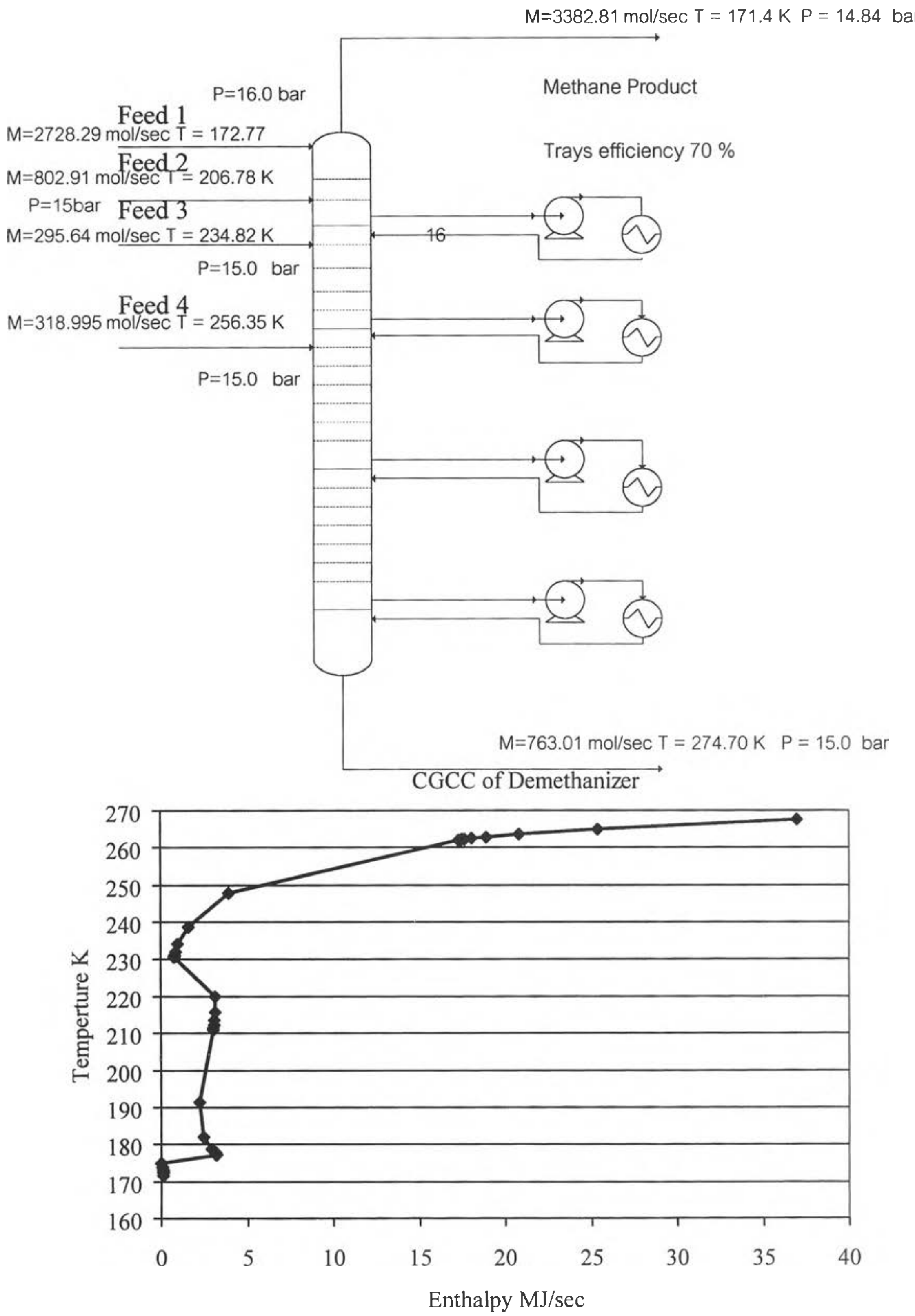


Figure 4.2 Flow diagram, column grand composite curve of demethanizer in the design case

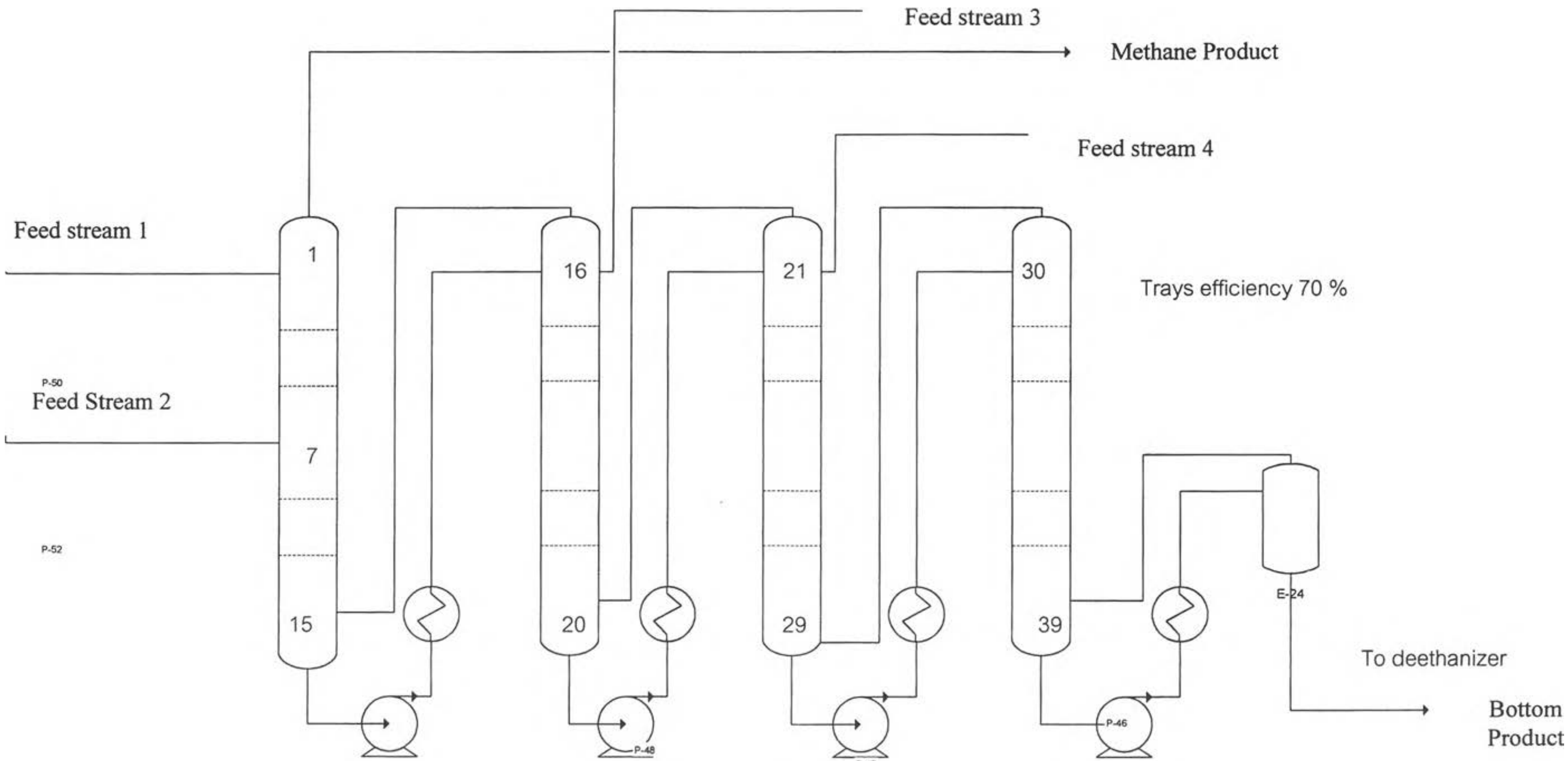
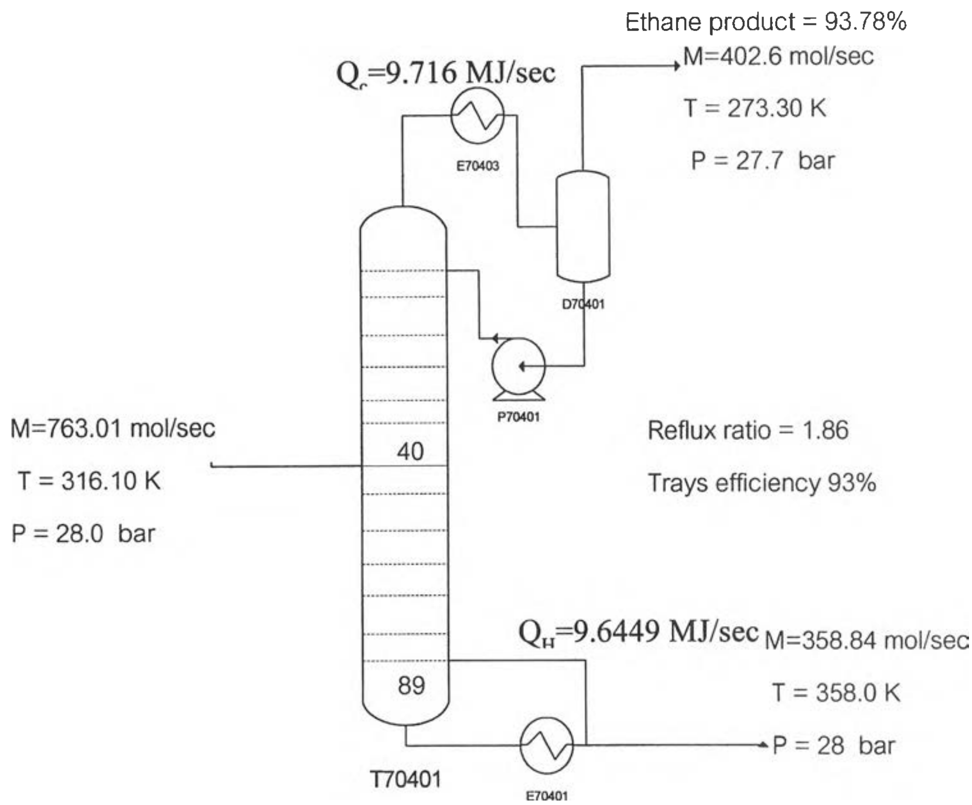


Figure 4.3 Simulation model of chimney tray type demethanizer.

Table 4.1 Feed stream composition.

Component (mole fraction)	Feed 1 Stream	Feed 2 Stream	Feed 3 Stream	Feed 4 Stream
N_2	00222	0.00055	0.0025	0.0002
CH_4	0.9188	0.6725	0.3923	0.2902
C_2H_6	0..0481	0.2151	0.2460	0.1897
C_3H_8	0..0050	0.0826	0.2427	0.2571
i-C_4H_{10}	0.0002	0.0078	0.0540	0.0920
n-C_4H_{10}	0..00007	0.0045	0.0425	0.0318
i-C_5H_{12}	0.0003	0.0013	0.0071	0.0183
n-C_5H_{12}	0.0001	0.0036	0.0036	0.0103
n-C_6H_{14}	0.0000	0.0006	0.0006	0.0007
C 7 plus	0.0000	0.00001	0.0002	0.0006
CO_2	0.0056	0.0011	0.0085	0.0061
Flow rate (Mol/sec)	2727.87	803.04	293.40	321.55
Temperature (K)	172.77	178.22	215.00	241.22
Pressure (Bar G)	16.00	15.00	15.00	15.00



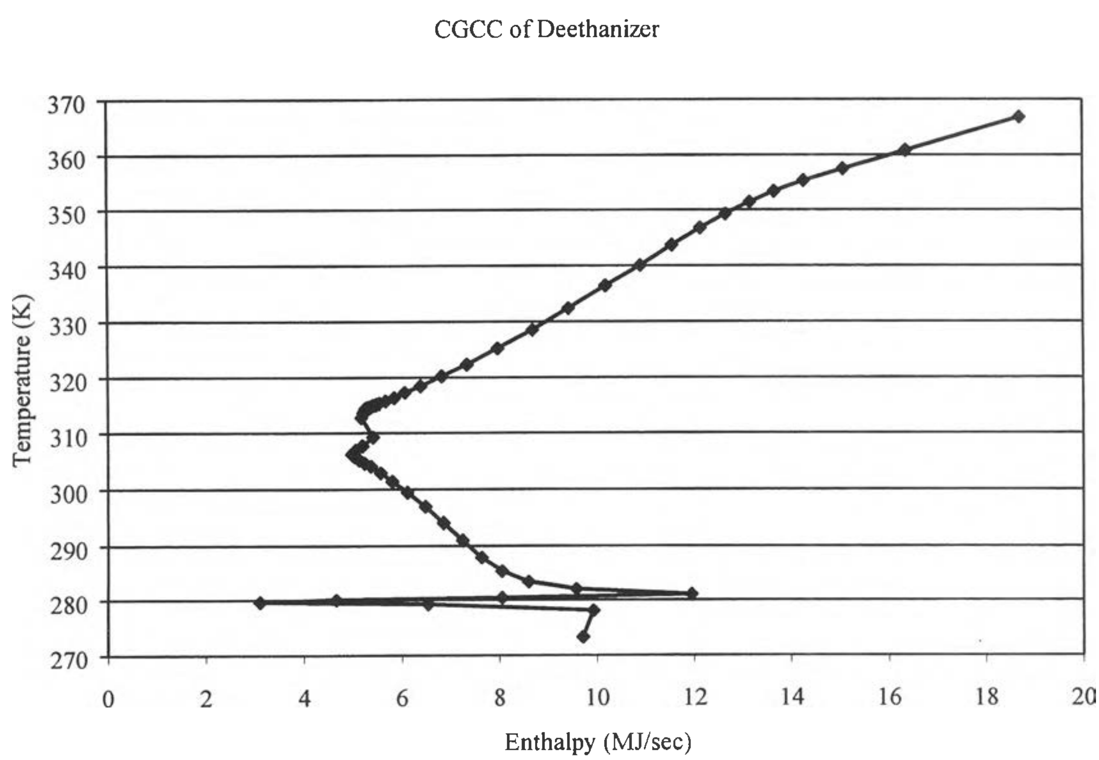
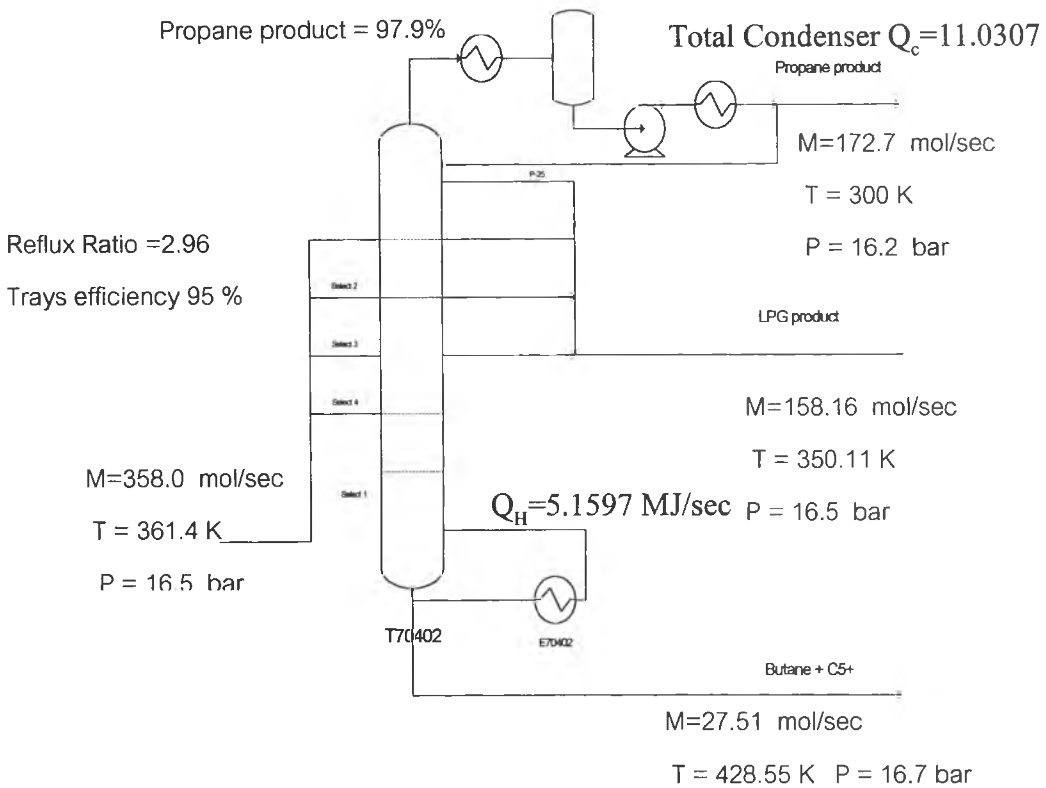


Figure 4.4 Flow diagram, column grand composite curve of deethanizer in the design case



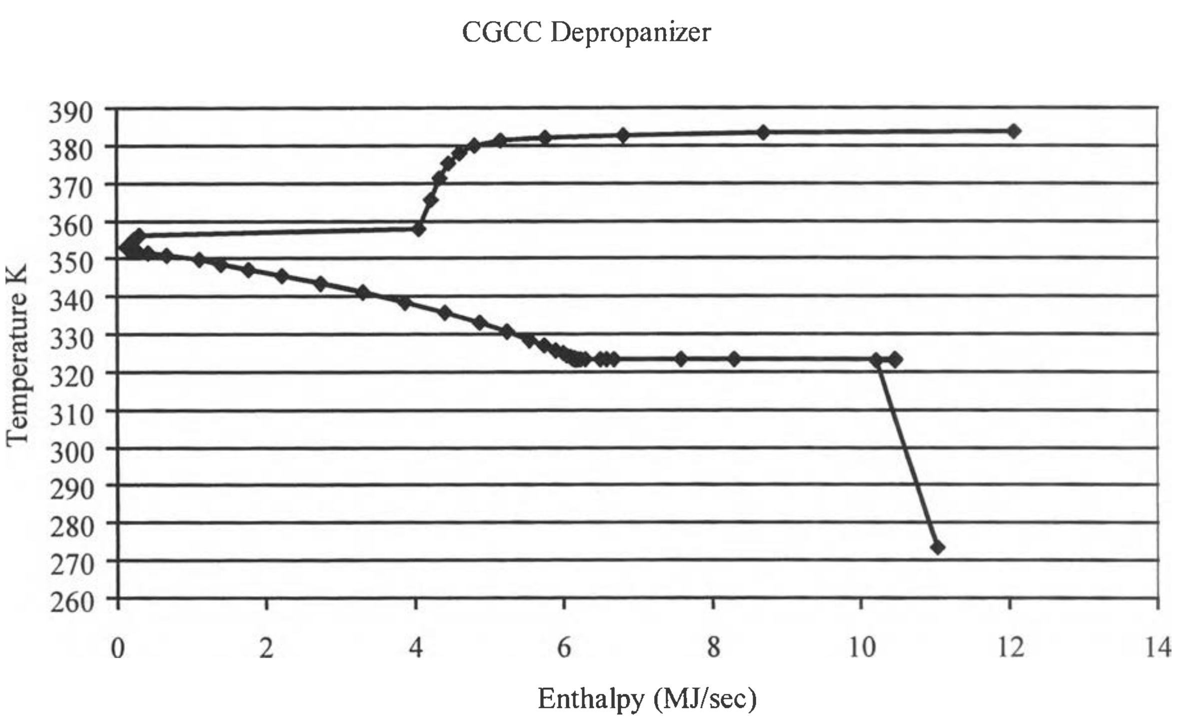


Figure 4.5 Flow diagram, column grand composite curve of depropanizer in the design case

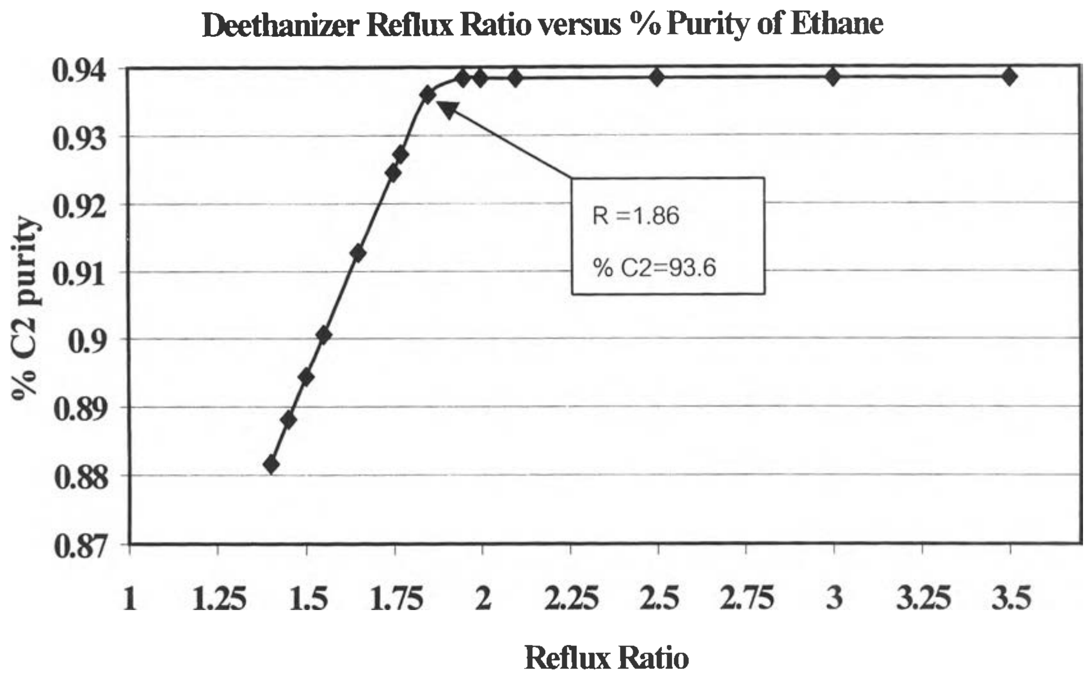


Figure 4.6 Reflux ratio and percent ethane purity of deethanizer

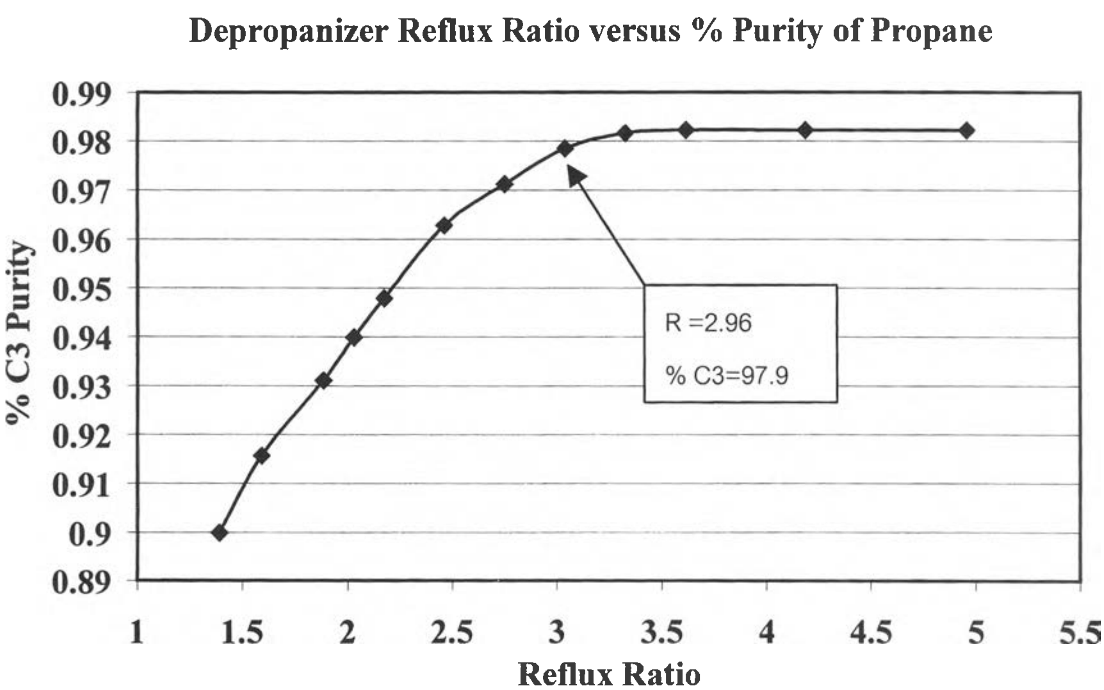


Figure 4.7 Reflux ratio and percent propane purity of depropanizer

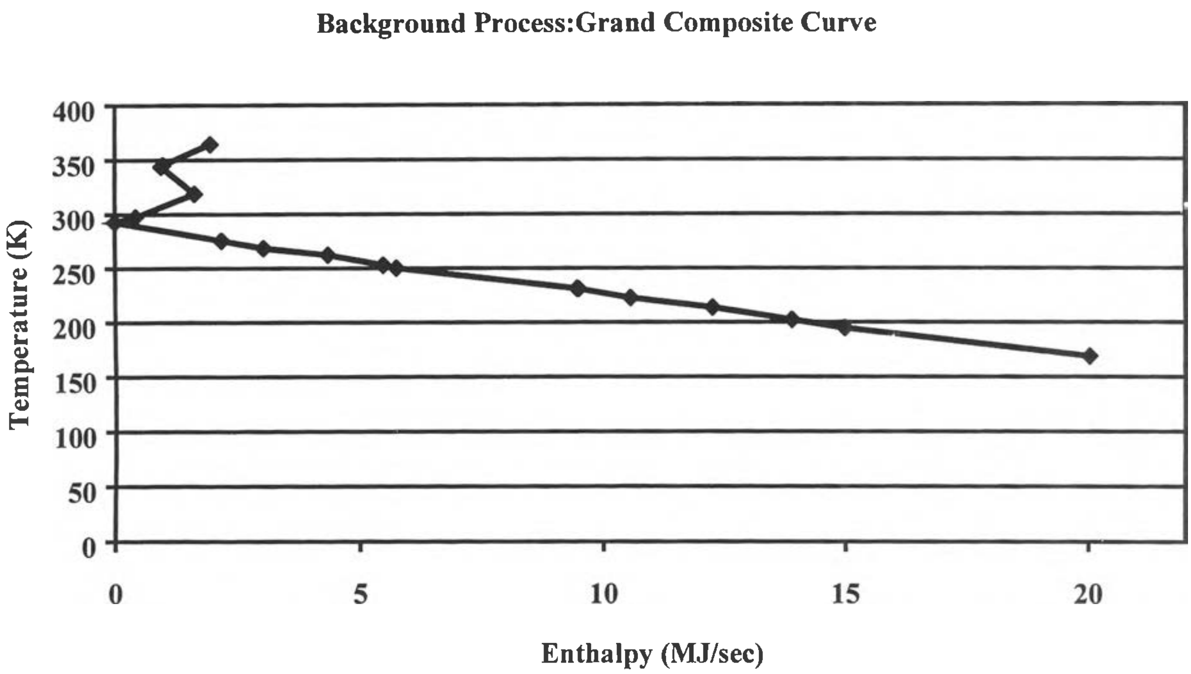


Figure 4.8 The composite curve of background process of GSP1.

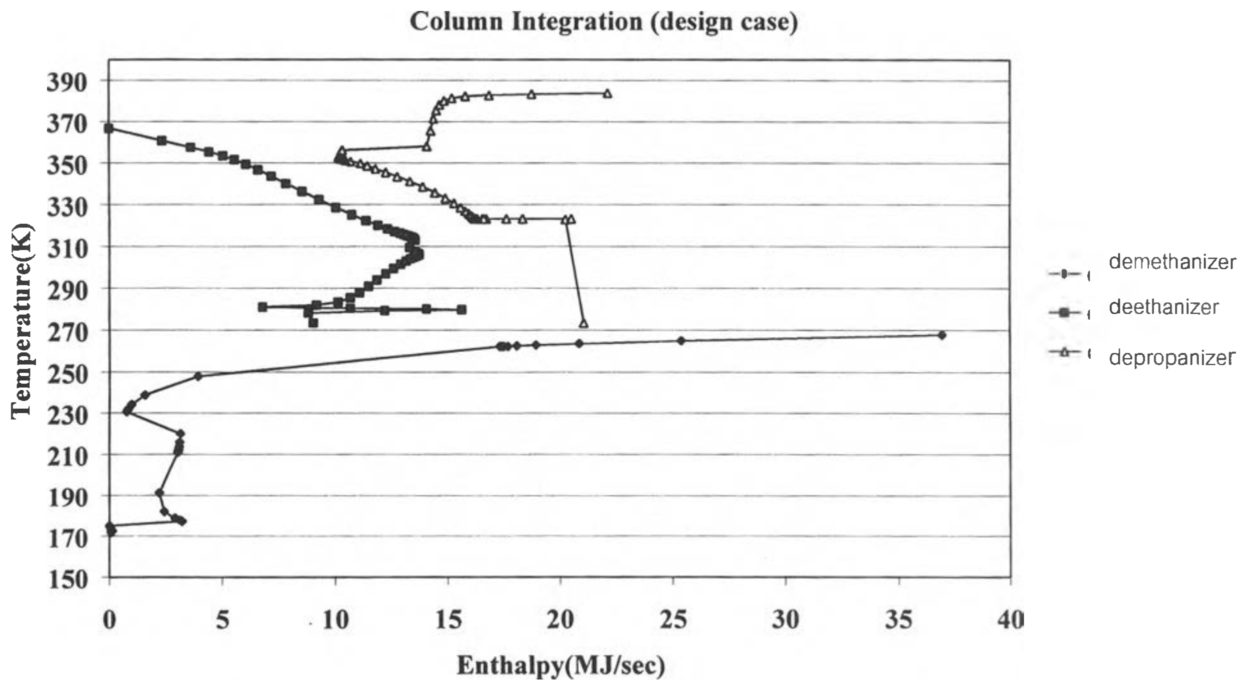


Figure 4.9 Column integration of demethanizer, deethanizer and depropanizer.

Table 4.2 Product stream composition and flow rate from the model

Component	Methane Product (mole fraction)	Ethane Product (mole fraction)	Propane Product (mole fraction)	LPG Product (mole fraction)	NGL Product (mole fraction)
N_2	0.01960	0.00000	0.00000	0.00000	0.00000
CH_4	0.95950	0.02370	0.0000	0.00000	0.00000
C_2H_6	0.01660	0.93870	0.00340	0.00096	0.00000
C_3H_8	0.00022	0.000004	0.99520	0.38830	0.00000
i-C_4H_{10}	0.000000	0.000000	0.00130	0.33830	0.00159
n-C_4H_{10}	0.00000	0.00000	0.00001	0.27230	0.0986
i-C_5H_{12}	0.00000	0.00000	0.00000	0.00011	0.4335
n-C_5H_{12}	0.00000	0.00000	0.00000	0.00002	0.2441
n-C_6H_{14}	0.00000	0.00000	0.00000	0.00000	0.1203
C 7 plus	0.00000	0.00000	0.00000	0.00000	0.101896
CO_2	0.00404	0.0376	0.00000	0.00000	0.0000
Flow rate (Mol/sec)	3381.4680	402.6900	172.70	158.1289	28.8732
Temp. (K)	171.60	273.30	300.00	349.70	428.00
Press. (Bar)	15.0	27.70	20.60	16.50	16.50

Table 4.3 Condition results of actual case from the model.

Column	Specification			
	Top Column Temperature (°C)	Bottom Column Temperature (°C)	Bottom pressure (ΔP drop) (BarG)	Bottom Product Flowrate (kg/hr)
Demethanizer Column	-97.6	2.76	15.41 (0.079)	104458.71
Deethanizer Column	6.19	97.5	26.89 (0.1)	N/A
Depropanizer Column	45.3	164.5	15.12 (0.1)	N/A

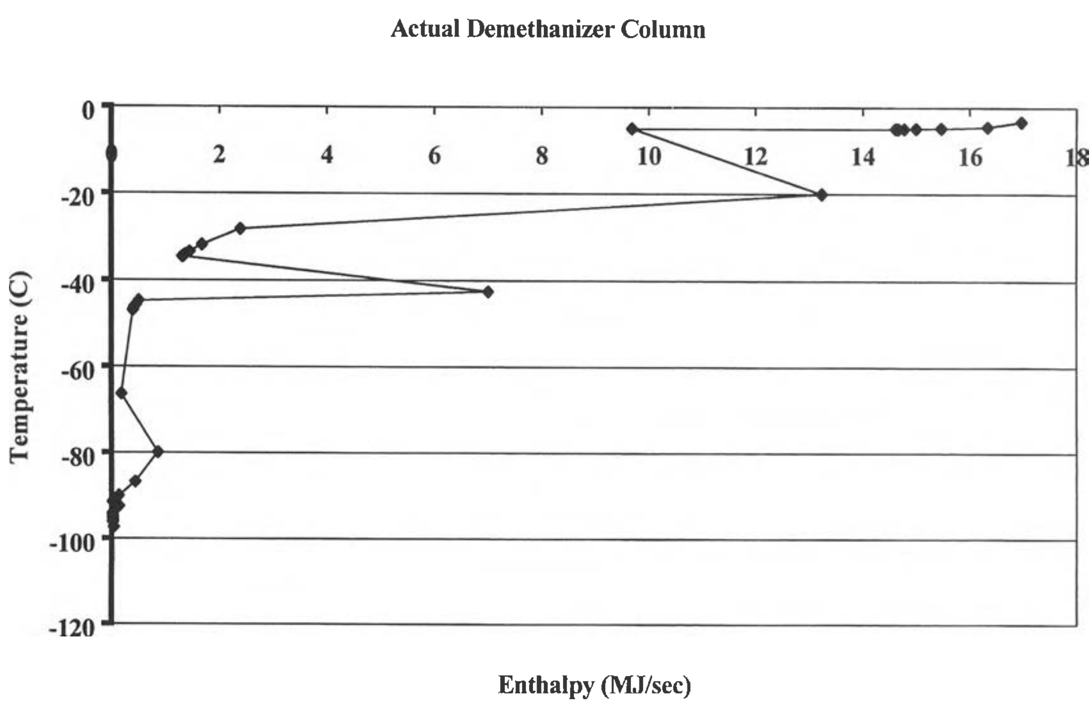


Figure 4.10 Column grand composite curve of demethanizer in the actual case

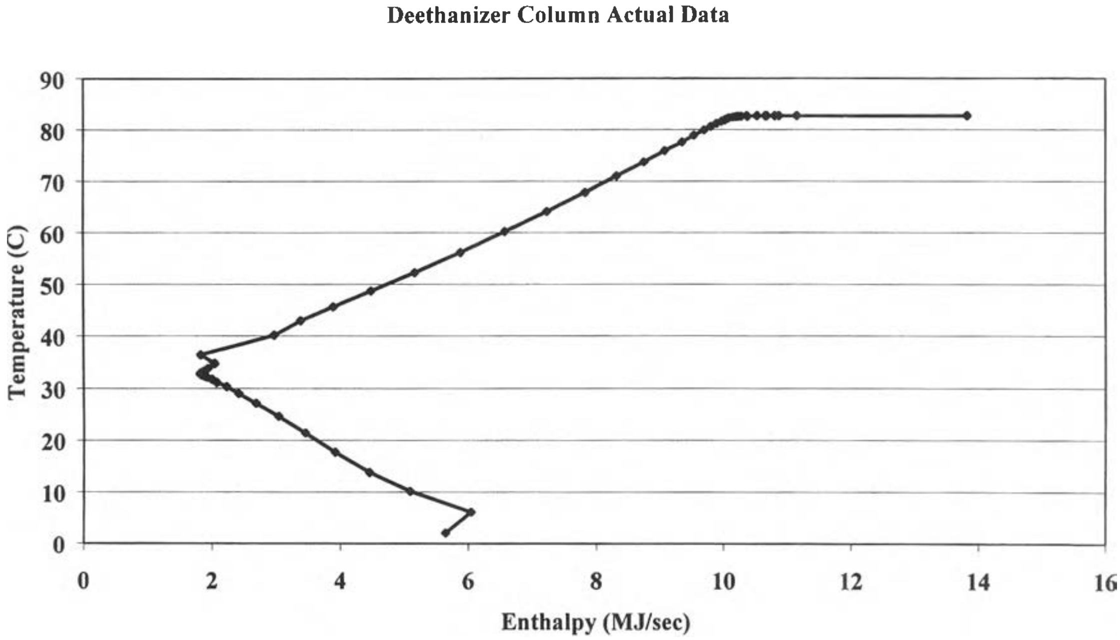


Figure 4.11 Column grand composite curve of deethanizer in the actual case

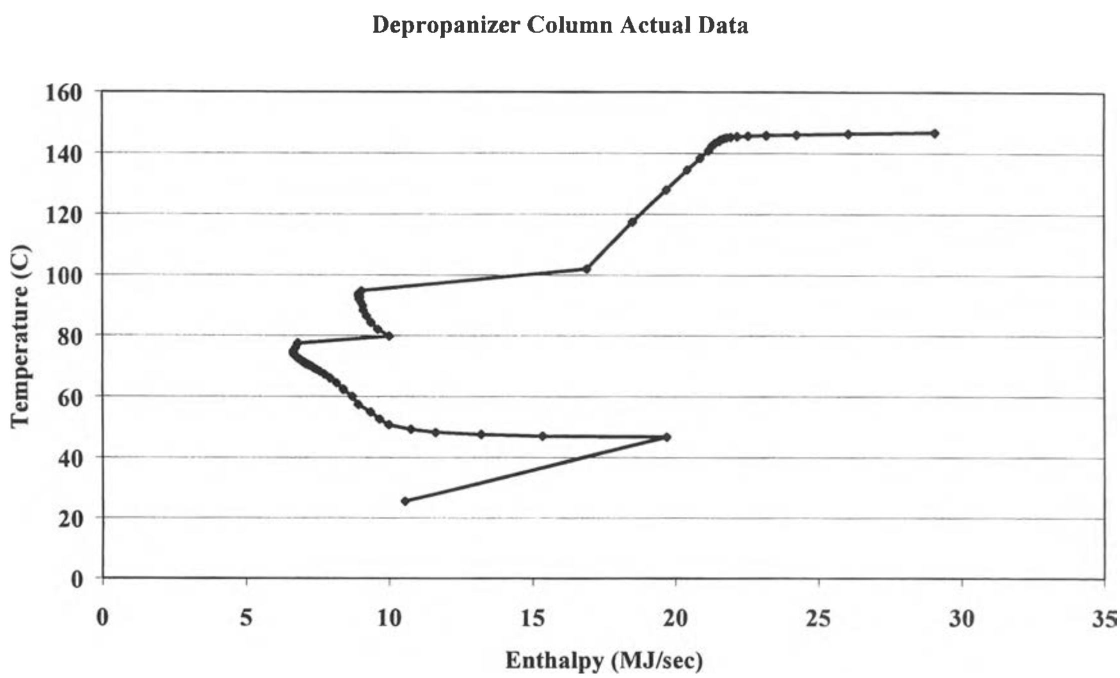
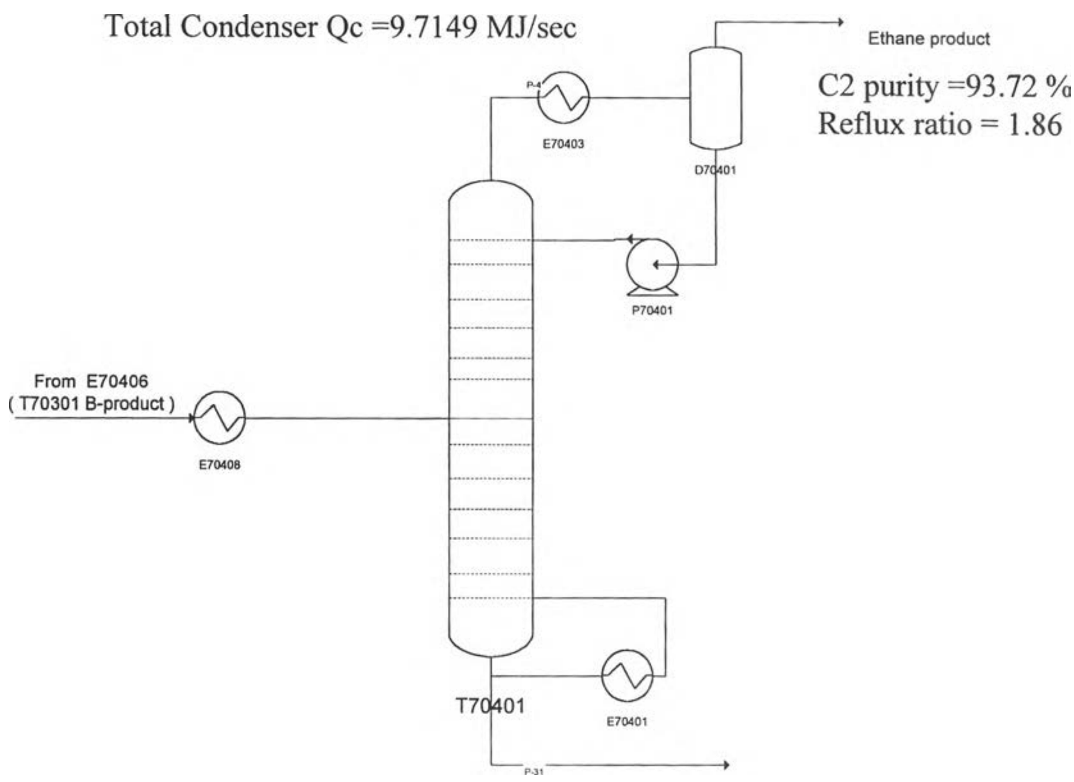


Figure 4.12 Column grand composite curve of depropanizer in the actual case



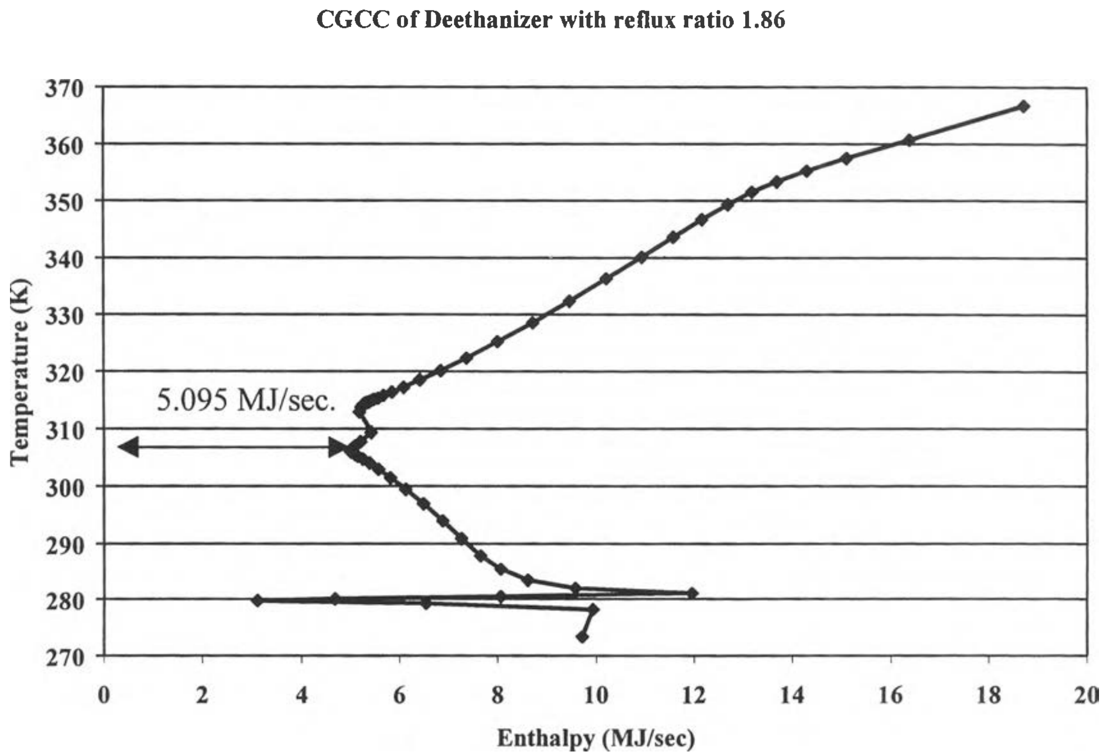
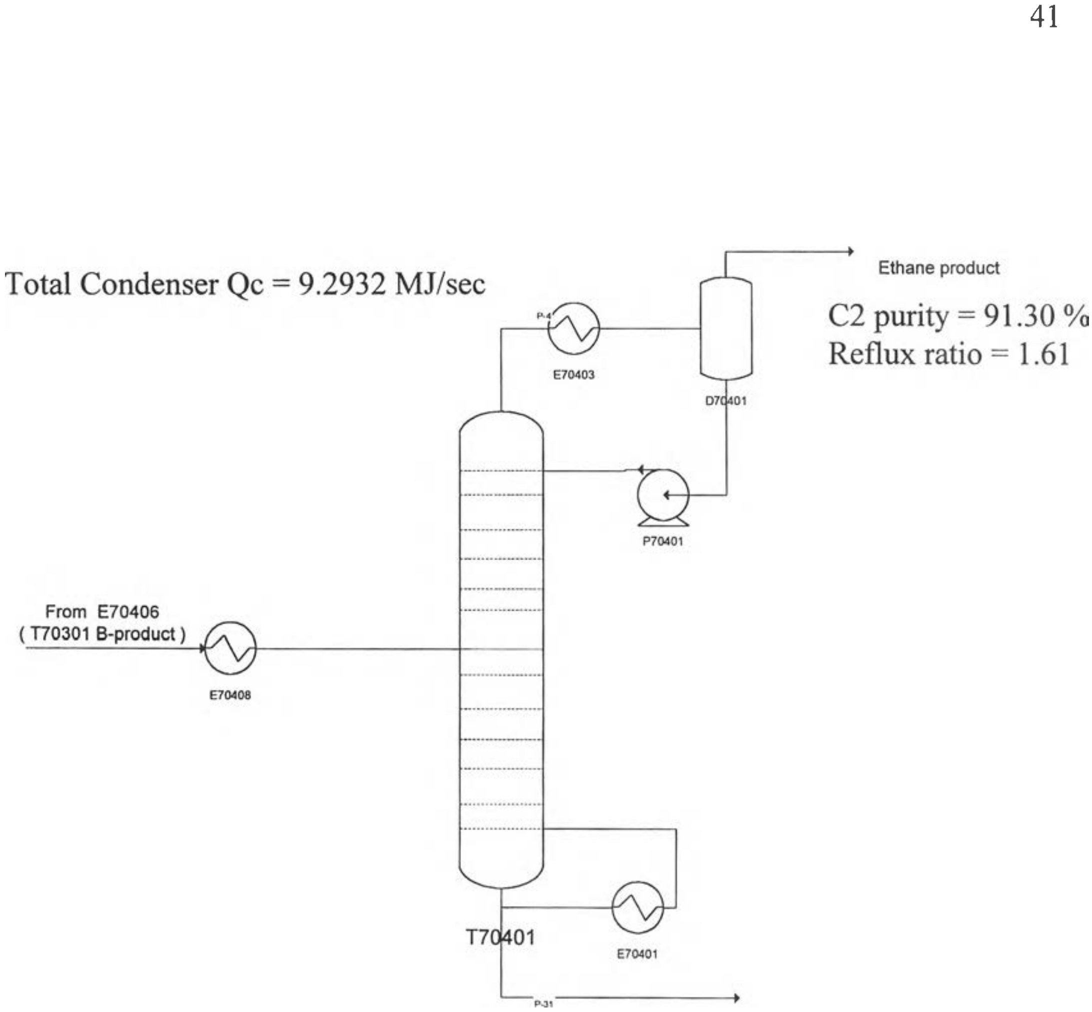


Figure 4.13 Column grand composite curve of deethanizer with reflux ratio of 1.86 (design case)



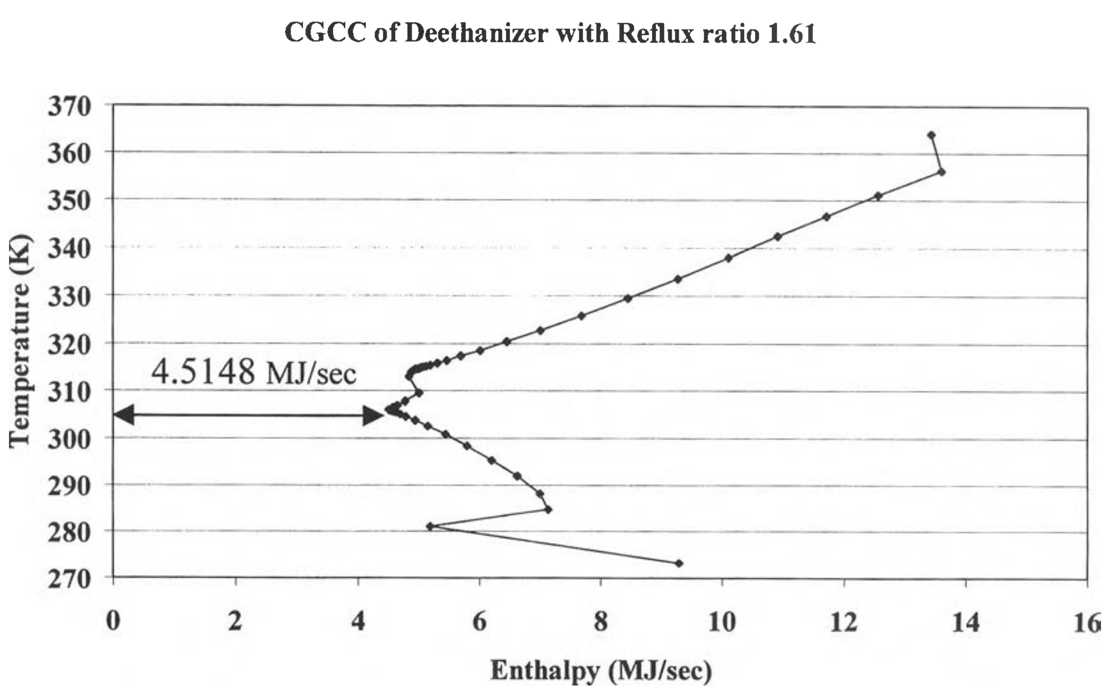
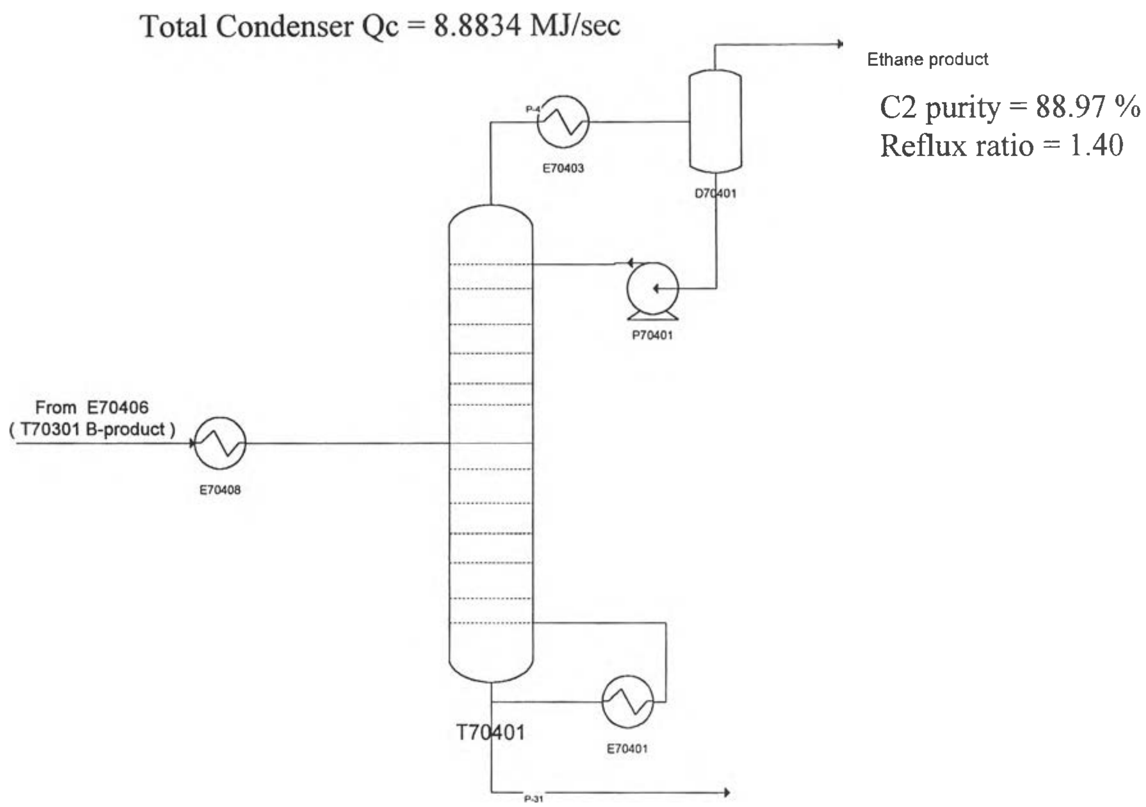


Figure 4.14 Column grand composite curve of deethanizer with reflux ratio 1.61 (design case)



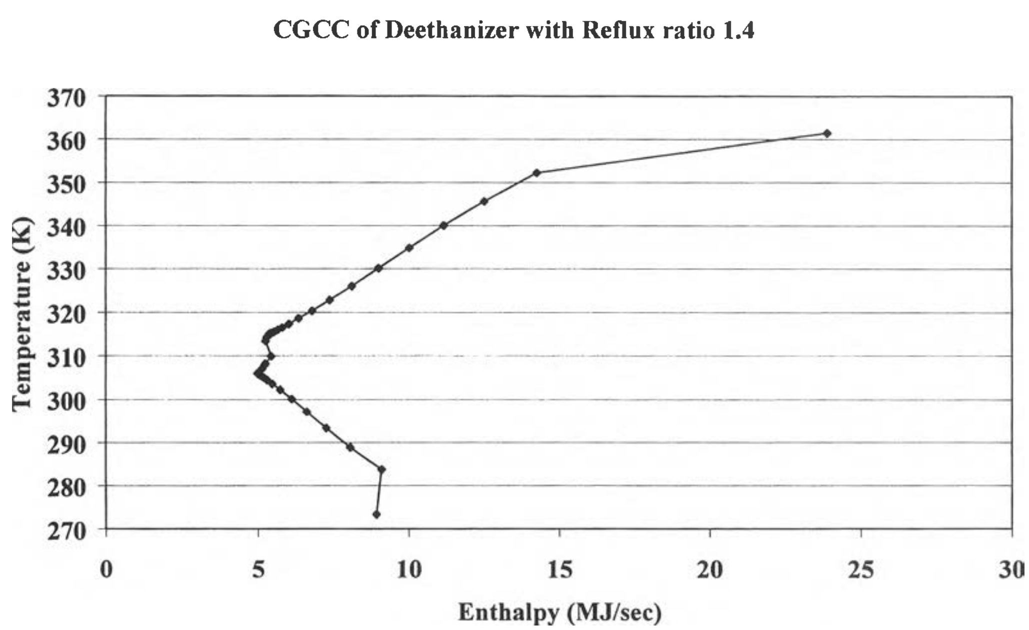


Figure 4.15 Column grand composite curve of deethanizer with reflux ratio 1.40 (design case)

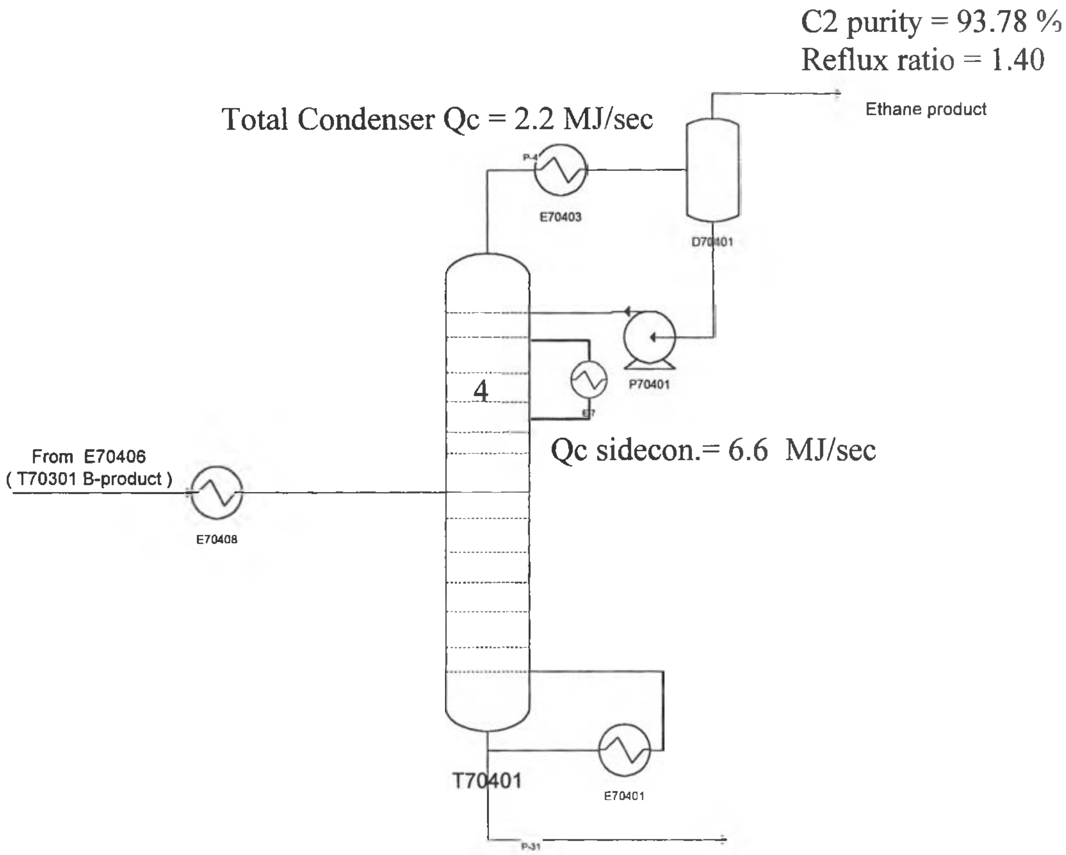


Figure 4.16 Column modifications of deethanizer with reflux ratio 1.4 and installing side condenser 6.6 MJ/sec at tray no. 4. (design case)