CHAPTER III
PROCEDURES

3.1 Modeling of Gas Separation Process

Gas separation plant which is used in this research is PTT gas separation plant Unit1. This plant consists of three main distillation columns(demethanizer , deethanizer and depropanizer) and eleven heat exchangers.

Demethanizers : This is the chimney tray column that will separate methane at the top of the column because it has lowest boiling point than others) and the rest (heavier components than methane) comes out at the bottom of column. This column does not have condenser because temperature of methane is too low to condense .

Deethanizers : This column recieves the bottom product from demethanizer.it separates ethane at the top of the column and the bottom products are heavier hydrocarbons than ethane.

Depropanizer : This is the last column to separate the product. This column gets the bottom products from deethanizer. This column gives three main products for this plant which are propane, liquefied petroleum gas (LPG) and natural gasoline (NGL) .

For accomplishing the heat integration part , it was necessary to simulate this plant and get the result in order to do the heat integration part because data which were directly collected from the plant were not enough. For example, some thermal properties were not given. Therefore, the following three steps of simulation were employed.

1. Collect the data to be used in process modeling which includes the operating condition of each unit operation; the stream data such as flow rate, composition, temperature and pressure and the connectivity of the streams to the unit operation as appears in the process flow-sheet.

2. Construct a model representing the plant, by using commercial process simulation program, Aspen Plus.

3. Input the data of feed streams and unit operations and then run the simulation. Compare the results with the design data to check the validity of the model.

3.1.1 Distillation Column Modeling

Distillation column modeling was done by using RADFRAC model of Aspen Plus simulator. In modeling, the column specification; tray efficiency, condenser and reboiler duties were calculated in order to match the simulation values with the design values.

Demethanizer: The modeling of this column consists of 40 trays and does not have condenser. This modeling is more complex than other columns because it has many feeds including recycling part from the side stream. The feed stages are 1,7,16,21,30 and 39. The reason is that this column has many side streams and the real process will bring those streams to exchange heat with the other stream in the plant. This process also contains chimney trays which do not allow liquid flowing down through the tray. The chimney trays are at tray No.15, No.20, No.29.

Deethanizer : The modeling of this column consists of 80 trays and normally has condenser to condense ethane .

Depropanizer : The modeling of this column consists of 89 trays. In the actual process there is a condenser to condense propane but in this modeling it is rejected because top product(mainly propane) has high temperature enough to exchange heat with other stream in the process.

To find the best condition of distillation column, some parameter should be tested for getting the best operating condition which could give high purity of the product. Therefore, either feed location or reflux ratio was considered by varying these parameters and observe the purity of products from all three columns(demethanizer, deethanizer , depropanizer).

3.1.2 Overall Process Modeling

Process model was designed to integrate with other unit operations such as shell and tube heat exchangers, LNG heat exchangers, flash drums and compressors with expanders. This aims to construct the model that represents the existing plant and reach the desired product quality and temperature.

3.2 Collected Data from Gas Separation Plant

There were many collected data especially temperature but unfortunately there were very few data for flow rate. These data were collected between 2/09/03 to 19/09/03. The reliability of these data were proved by PTT process engineer for doing simulation because these data were stable and good among the data of the year 2003.The following tables show properties of various measured streams.

Table 3.1 Temperature of Part 703

STREAM	TEMPERATURE
S70201	290.3228
S70301	255.4573
S70301-1	242.2464
S70303	23[illegible].9
S70305	205.55302
S70307	175.7208
S70308	175.1211
S70309	228.355
S70309-1	235.847
S70310	288.58948
S70310-1	289.37948
S70312-1	202.21766
S70313	225.89399
S70314-1	226.0578
S70315	233.51868
S70316-1	261.14392
S70317	271.14474

S70318-1	273.72675
S70319	280.14273
S70320	280.2323
S70321	277.381
S70321-1	278.62257
S70323	278.95039
S70327	250.05994
S70328	286.44713

Table 3.2 Temperature of Part 704

STREAM	TEMPERATURE (K)
S70401	317.34881
S70402	280.34648
S70404	276.553085
S70406	372.00652
S70408	372.02708
S70409	320.6236
S70411	313.09254
S70412	295.31177
S70413P	294.95967
S70414	338.921
S70415P	292.07
S70416	437.7359
S70417	317.81069
S70418P	300.17718
S70419	313.63338
S70420	298.80893
S70422-1	314.7259

Table 3.3 Temperature of Part 706

STREAM	TEMPERATURE (K)
S70601	308.03402
S70601-1	310.2967
S70602	399.6418
S70603	358.30685
S70603-2	366.54261
S70604	301.06871
S70605	280.44164
S70608	316.05848

Table 3.4 Pressure of Part 703, Part 704, Part 706

STREAM	PRESSURE (BARG)
S70305	39.3718
S70310-2	14.39787
S70402	27.01313
S70409	15.07761
S70601	15.00556
S70604	42.77252

3.3 Constraints of Modeling

Because there were not many data provided for doing heat integration so simulation needed to be done in order to get complete data.

The modeling should have some constraints to assure the reliability of process data representation as shown in Table 3.5

Table 3.5 The constraint of process simulation

PARAMETER	SIMULATION VALUE
Composition	measured value ± 0.001
Flow rate (mol/s)	measured value ± 10%
Temperature (K)	measured value ± 3 K
Pressure (barg)	measured value ± 0.5 barg

3.4 Pinch Analysis

There are five main steps for doing Pinch Analysis

1. Predicting minimum energy consumption
2. Design Heat Exchanger Networks
3. Changing process to save energy
4. State of the art improvement
5. Overall retrofit strategy

The model of pinch was the main area. Pinch point was applied and led to the ways to save energy for the network. There were 9 hot streams and 8 cold streams to match with each other.

First of all, pinch point needed to specify by fixing one value of different temperature minimum (ΔT min). In this research the ΔT min was 5 K because this was cryogenic and contained threshold problem so it was difficult to specify the exact value of ΔT min. Rule of thumb was used in order to specify ΔT min of gas separation plant which normally was at 3-5 K. In this research, 5 K is used due to cost of heat exchanger. If ΔT min was high the heat exchanger cost would be consequently high.

After ΔT min was specified, the grid diagram was continually generated. This grid diagram was built based on structure of existing plant i.e. the position of heat exchanger and all parameter such as the actual valve of temperature, heat capacity. Column grand composite curve (CGCC) could be plotted together after the simulation results were issued. The function of generating CGCC was contained in

ASPEN PLUS simulation program. Grand composite curve (GCC), Composite curve (CC) could also be plotted in this step. These two curves were made on Microsoft excel spread sheet by putting temperature and fixing ΔT min. The intervals of GCC and CC were divided and heat deficit flowing from top interval to bottom interval was calculated.

3.5 Retrofit

As described before, the modification was based on existing network so that retrofit technique needed to be proposed. Three alternatives were presented and each alternative was investigated in different ways; inspection, integration and recommendation from PTT public company. Some alternatives need the change of the plant structure so these three alternatives were required to prove the possibility of modifications. For example, some modifications were needed to add one new exchanger to the network because it would create energy saving to the process so that discussion with company representative is necessary.

After proving the possibility, economics was continually studied if the process change is worth. Cost of heat exchanger in each alternative was compared with energy saving cost. After that the best alternative was determined.

In the first and second alternatives, the inspection technique was used by checking the measured values of temperature and comparing with the design value. If both valves were different, correction of the temperature values was necessary.

In the third alternative, integration technique between the column and the process was possibly found. To study this modification, column grand composite curve (CGCC) and grand composite curve (GCC) were plotted together. If either column or process curve was above each other, heat could possibly transfer to another source. The benefit of this modification was to save the energy of both process and column.

In fourth alternative, UA analysis and maximum operating pressure in depropanizer were also considered. The pressure were varied to find the minimum duty on both condenser and reboiler. Therefore if the pressure was changed the value of UA in condenser and reboiler would consequently changed as well.

To compare the results before and after retrofit, GCCs were plotted again in each alternative because this curve would clearly explain the energy consumption profile before and after this work was done.

3.6 Data Reconciliation

Due to few measurements that were done in this plant, data reconciliation was needed to get other data. Data Reconciliation turns real time process data that are subject to random error as well as gross error into consistent and reliable information. Such information is essential for effective plant operation and management. It uses statistically sound techniques to reconcile flow, temperature, and composition measurements in such a way that material, enthalpy and component balances around each unit in a plant are satisfied.

Mathematically, Data Reconciliation is nothing more than minimizing a sum of errors (the difference between each measured data and its reconciled value) weighted by the standard deviation of the measurement, subject to a number of constraints (the energy and material balance equations).

The model in this plant had 79 measured variables and 348 unmeasured variables. Variables included flow rate , temperature and composition. After modeling was done, they were found that there were 74 useless measured variables, which called non-redundant variables and 322 unobservable variables (never measured and cannot be predicted).