CHAPTER III
PROCEDURES

3.1 Distillation Column Design

3.1.1 Synthesis of Distillation Column Sequences

The distillation sequences were obtained by equation 2.10, which depended on quantity and number of feed components. The feed of this study was a liquid petroleum gas (LPG) from a gas separation plant (GSP) at Rayong province. The feed streams were divided into six different streams including LPG from GSP1, LPG from GSP2, LPG from GSP3, LPG mixture from GSP1 and GSP2, LPG mixture from GSP1 and GSP3 and LPG mixture from GSP2 and GSP3. Each feed consisted of three main compositions, which was separated as propane, isobutane and normal butane. The compositions and other properties of each feed are shown in Table 3.1.

3.1.2 Shortcut Column Design

Shortcut distillation method was selected as a design algorithm shown in Figure 3.1. The design parameters, which have to be calculated, are the minimum number of theoretical stage, the minimum reflux ratio, the actual theoretical stage and the feed stage location. PRO/II have a shortcut distillation module but not completely supported. For calculation, this module is imported as an input keyword file. The shortcut distillation module uses a generalized Fenske method to predict product distribution for multi-products fractionators, and Underwood method to determine the minimum reflux ratio. The PRO/II will also determine the number of theoretical trays, the actual reflux rates, and

Table 3.1 Feed stream compositions and properties summary

Components	Feed 1	Feed 2	Feed 3	Feed 4	Feed 5	Feed 6
Source	GSP 1	GSP 2	GSP 3	GSP 1&2	GSP 1&3	GSP 2&3
Molar Fractions						
1 Ethane	0.0004	0.0058	0.0015	0.0029	0.0009	0.0038
2 Propane	0.6031	0.6598	0.5772	0.6289	0.5924	0.6219
3 Isobutane	0.2022	0.1686	0.2219	0.1869	0.2104	0.1931
4 Butane	0.1822	0.1547	0.1940	0.1697	0.1871	0.1727
5 Isopentane	0.0107	0.0109	0.0045	0.0108	0.0081	0.0080
6 Pentane	0.0014	0.0002	0.0009	0.0085	0.0012	0.0005
Total Rate, lb/hr	95502.49	77981.24	67715.04	173483.74	163217.53	145696.28
Temperature, F	76.46	59.72	63.14	68.98	71.01	61.36
Pressure, psia	232.25	200.34	261.26	200.34	232.25	200.34

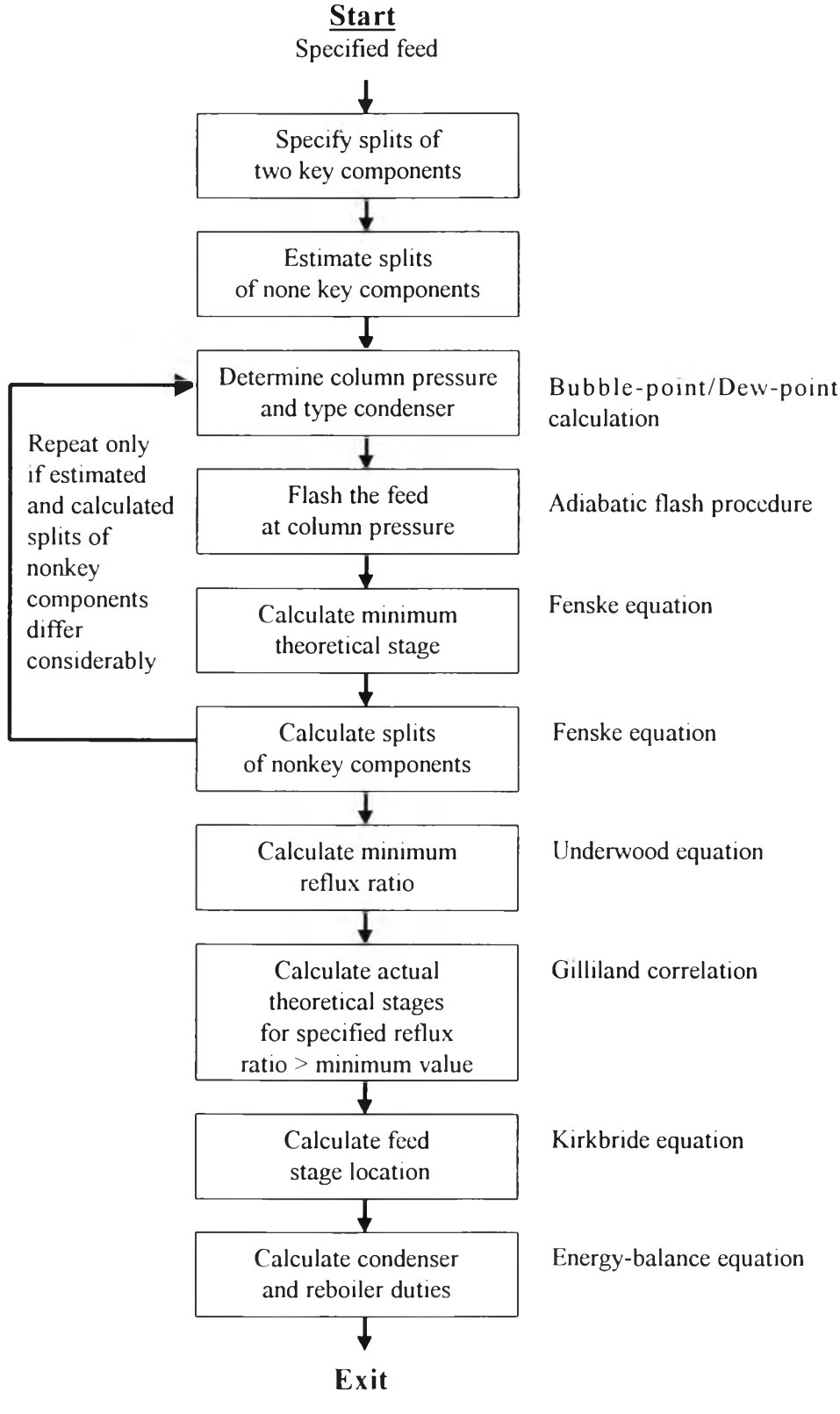

Figure 3.1 Algorithm for multi-component distillation by shortcut distillation method (Henley and Seader, 1981)

condenser and reboiler duties, for a given R/R_{min} value which is selected at economics consideration value of 1.3 multiplied by minimum reflux ratio, based on a Gilliland-type correlation. The method of Kirkbride is used to determine the optimum feed tray location for each operation.

In order to write input keywords, the input parameters have to be specified. They are feed conditions and compositions, key components, column pressure, condenser type, thermodynamic methods and product specifications. The feed condition and compositions were taken from GSP and calculated from the PRO/II. The specifications of key components and nonkey components were accomplished by an iterative procedure. Two key

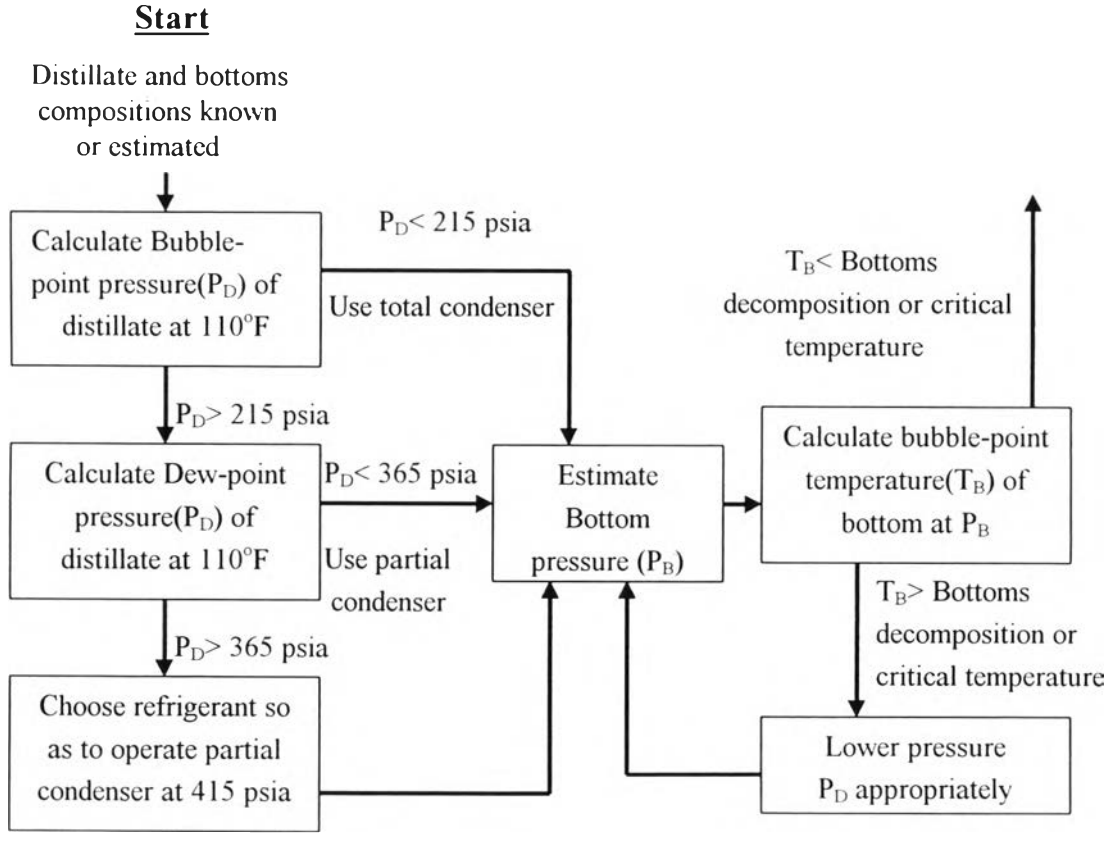

Figure 3.2 Algorithm for establishing distillation column pressure and type condenser (Henley and Seader, 1981)

components, light key and heavy key component are always adjacent in the order of volatility. The column operating pressure and type of condenser were established by the procedure shown in Figure 3.2. Both column and condenser pressure drops of 5 psia are assumed. A total condenser is used for a reflux drum pressure to 215 psia. A partial condenser is used from 215 to 365 psia.

A refrigerant is used for overhead condenser coolant if the pressure tends to exceed 365 psia. With operating pressures established in the column, the feed can be adiabatically flashed at an estimated feed tray pressure of the reflux drum pressure plus 7.5 psia to determine feed-phase condition.

The Soave-Ridlich-Kwong (SRK) equation of state is used to calculate equilibrium K-values, enthalpies, and vapor densities. The SRK method has been found to predict liquid densities which maybe 10-20% lower than the accurate value. For this reason, the Lee-Kesler method has been selected as the most suitable for light hydrocarbon (Simulation Sciences Inc., 1992; 1994).

3.2 Distillation Column Sequencing

For screening sequences of distillation columns, An overall boiling capacity variable was used. This variable is the weight average of the capacity variables calculated by using the existing results from the shortcut column design. The calculation parameters consisted of the number of stages and internal flow rates in the columns.

3.3 Stage Efficiency and Column Sizing

From survey, the values of stage efficiencies for sieve and valve finite-stage contactor in the design product columns are in the range of 100 to 120 percent. The valve stage contactor with overall stage efficiencies equal to 100

percent was selected to calculate the column capacity. From the defined stage efficiency, the actual total number of stage was equaled to the number of actual theoretical stage. Column capacity or column diameter was determined by PRO/II using the column sizing module which based on Glitsch methods. In order to use this module, the rigorous column model was developed by using the shortcut design results, specified stage spacing of 24 inches, flooding factor of 78 percent and a system loading factor of 1 (Simulation Sciences Inc., 1994; Walas, 1990).

3.4 Column Cost and Profitability Estimation

3.4.1 Capital Investment

The total direct plant cost and total indirect total capital investment was estimated by using the percentage of delivered-equipment cost method. The calculation was based on the delivered equipment cost calculated by the equipment cost curve and Marshall and Swift equipment cost index in the 3rd quarter of 1999 for cost update, and the average values of the various percentages which are shown in Table 2.1.

3.4.2 Return on Investment and Net Present Value

The rate of return on investment and the net present value were calculated by equations 2.16 and 2.17 respectively. The calculation assumed 16 years for the service life of distillation columns, 5% of the fixed capital investment for the savage value, 30% for the tax rate and 10% for the interest rate.