Unit Operations in Aspen HYSYS
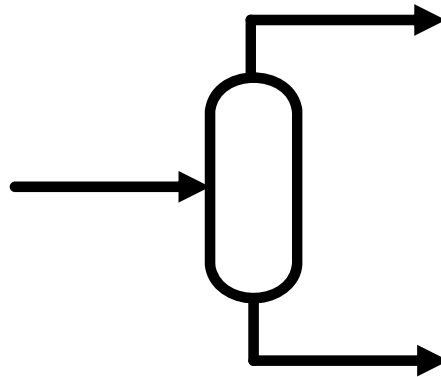
Part 4

Columns 1

Example

- Determine the number of process variables, equations, and constraints and the overall DOF for a flash separator.

$$N_v = 3(N_{sp}+2)+1$$
$$N_c = 2N_{sp}+1$$
$$N_d = N_{sp}+6$$

Columns

- Types:
  - Distillation
  - Absorber/Stripper
  - Liquid- Liquid Extractor

Case Study 1 - Depropanizer

- Learning Objectives:
    - Use the Shortcut Distillation tool in the design of a column.
    - Build a distillation column in HYSYS and add different specifications.
    - Perform Tray Sizing and Rating calculations.

Shortcut Distillation

- The Shortcut distillation tool allows users to estimate several column parameters without knowing a great deal of information about the specifics of the column.

- There are five pieces of required information: 2 component specifications, 2 pressure specifications, and the Reflux ratio. A fully defined feed stream is also required in order to solve the column.

Shortcut Distillation

- The two component specifications are Light Key in Bottoms and Heavy Key in Distillate.

- The Light Key is defined as the most volatile compound to appear at the bottom of the column.

- The Heavy Key is defined as the least volatile compound to appear at the top of the column.

- Typically, the Light and Heavy Keys define the operation of the column.

Shortcut Distillation

- Depropanizer separates C1, C2 and C3 from heavier molecules like the C4's and C5's. The split occurs between propane and i-butane. Therefore, propane is the Light Key and i-butane is the Heavy Key.

Shortcut Distillation

- The estimates for Condenser and Reboiler pressure have a direct relationship on the temperatures that HYSYS will estimate in these locations.

- Until the user is comfortable with making estimates about these values, they may have to make an initial guess and check that the temperature estimates are reasonable.

Shortcut Distillation

- The Reflux ratio must also be specified. After the other four specifactions are entered, HYSYS will calculate the Minimum Reflux Ratio. The estimated, or External, Reflux ratio must be greater than this value.

- Once all of the required data is entered, HYSYS will calculate the remaining column parameters. These values can be found on the Performance tab. The user should check the temperature estimates on this page and, if necessary, adjust the pressures.

Case Study 1 - Depropanizer

- Defining the Fluid Package:
  - Start a New Case and choose the Peng Robinson EOS package.
  - The components C1 to n-C9 must be added to the simulation.

Case Study 1 - Depropanizer

• Installing the Feed Stream:

In This Cell...	Enter...
Name	Feed
Temperature, ºC (ºF)	10 (50)
Pressure, kPa (psia)	500 (75)
Molar Flow, kgmole/hr (lbmole/hr)	50 (110)
Molar Composition - C1	0.32
Molar Composition - C2	0.16
Molar Composition - C3	0.11
Molar Composition - n-C4	0.11
Molar Composition - i-C4	0.11
Molar Composition - n-C5	0.05
Molar Composition - i-C5	0.05
Molar Composition - n-C6	0.03
Molar Composition - n-C7	0.03
Molar Composition - n-C8	0.02
Molar Composition - n-C9	0.01

Case Study 1 - Depropanizer

- Adding the Shortcut Distillation:

  - Enter the following information into the appropriate boxes.

  - On the Parameters page, enter the information as shown in next slide. The Field unit values for Condenser Pressure and Reboiler Pressure are 43.5 psia and 46.5 psia, respectively.

In This Cell...	Enter...
Feed	Feed
Top Product Phase	Vapour
Overhead Vapour	OVHD Product
Condenser Duty	Condenser Q
Bottoms	Bttm Product
Reboiler Duty	Reboiler Q

Case Study 1 - Depropanizer

Case Study 1 - Depropanizer

- Extract required information from Performance Tab, such as:
  - Minimum Number of Trays
  - Actual Number of Trays
  - Optimal Feed Stage
  - Condenser Temperature
  - Reboiler Temperature
  - Rectify Vapour Flow
  - Rectify Liquid Flow

Case Study 1 - Depropanizer

- Building the Distillation Column:
    - From the estimates generated by the Shortcut Distillation operation, a distillation column will be simulated.
    - Add a Distillation Column to the PFD.

Case Study 1 - Depropanizer

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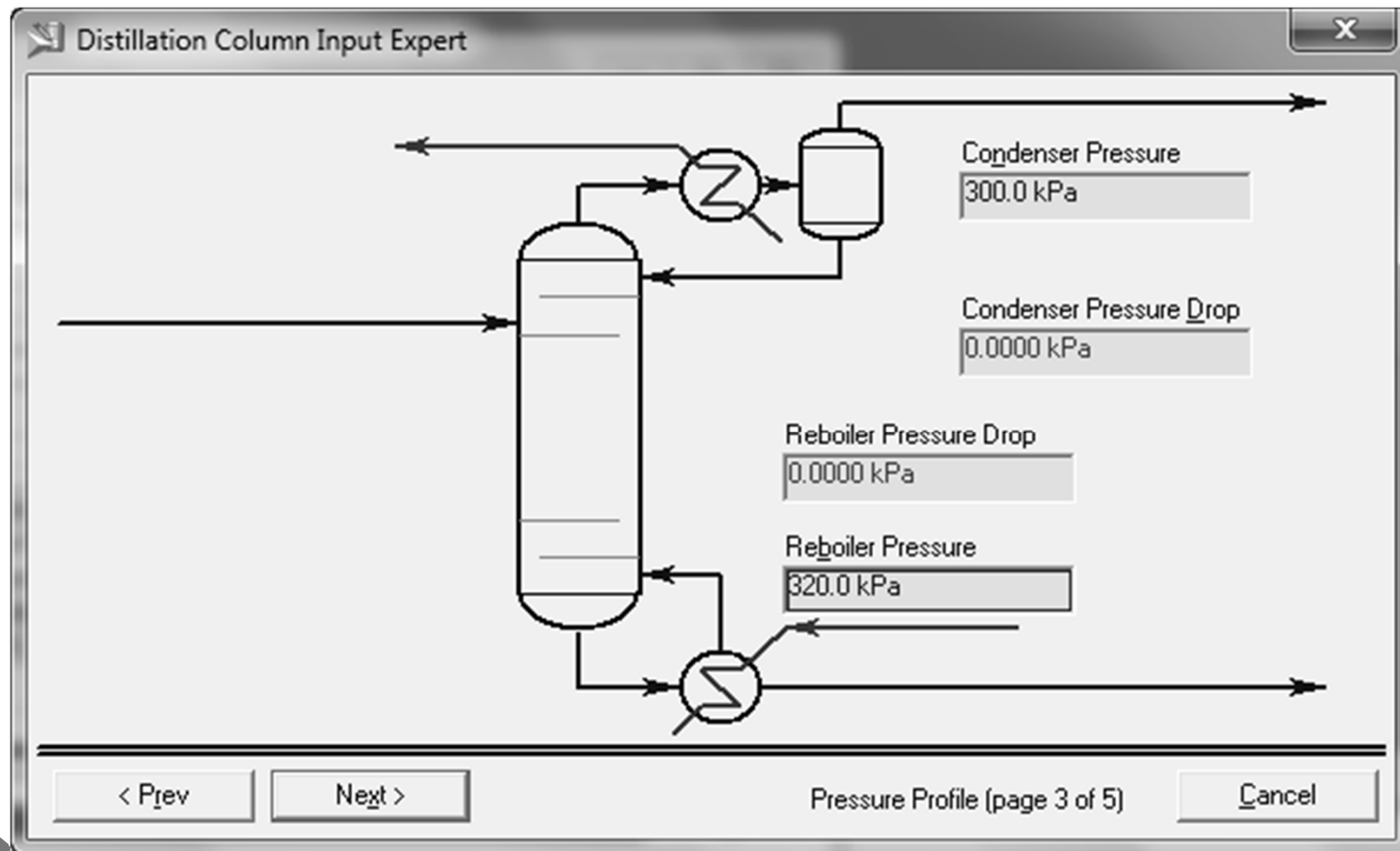
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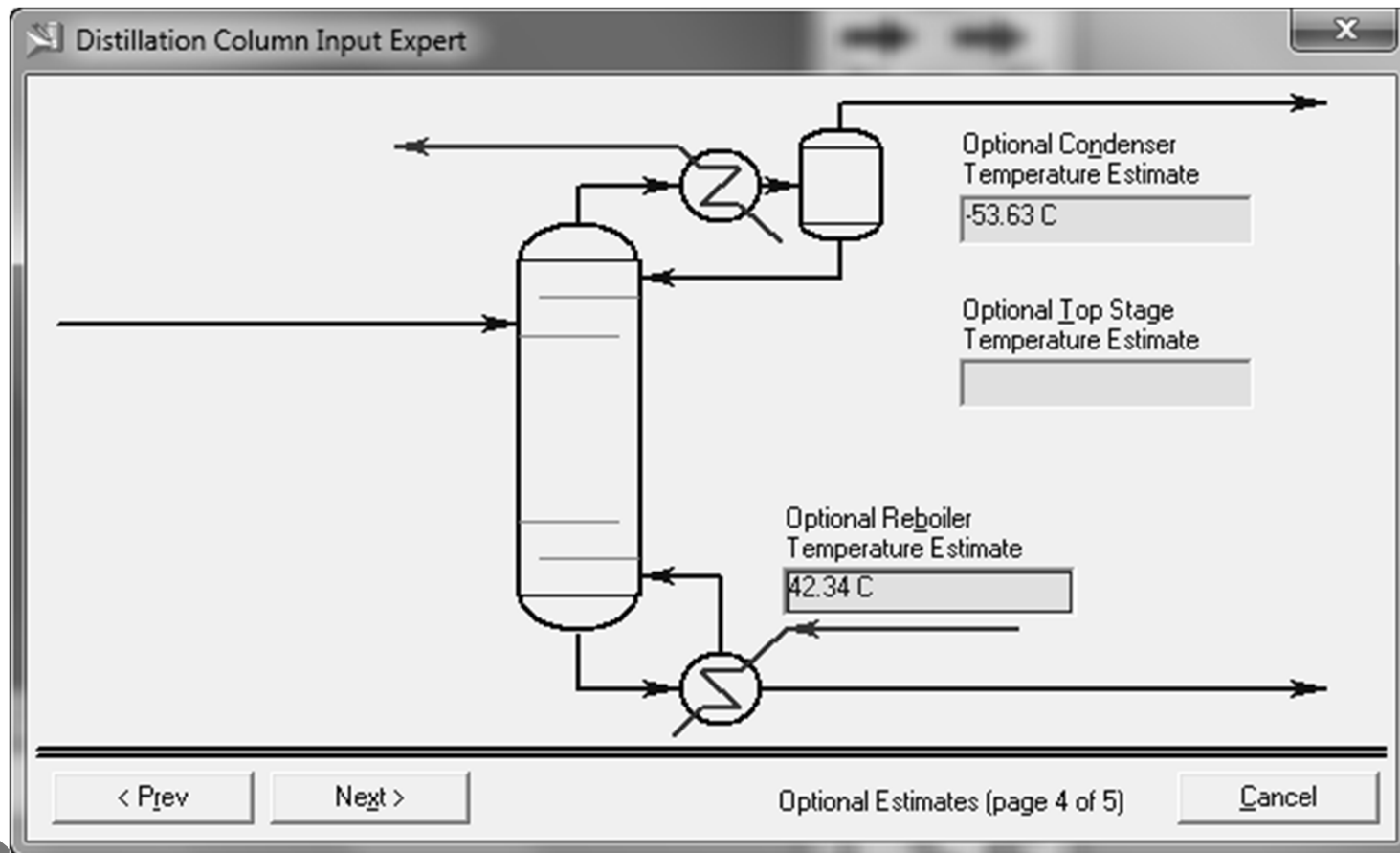
Case Study 1 - Depropanizer

- Building the Distillation Column:

  - Enter a Reflux Ratio of 2.0 on the final screen on the Input Expert. Press the Done button, and you will be placed on the Column Property View screen.

  - Note that the column can not converge now because the Overhead Vapour rate, a default specification, has not been specified.

  - Fortunately, HYSYS offers a wide variety of specifications that can be used to solve a column. To complete this exercise, we will use a composition specification similar to the Heavy and Light Key specifications used in the Shortcut column.

Case Study 1 - Depropanizer

- To complete this exercise, we will use a composition specification similar to the Heavy and Light Key specifications used in the Shortcut column:

1.Go to the Specs page (on the Design tab) of the Column Property View.

2. Press the Add button. Choose Column Component Fraction

from the list that appears. Press the Add Specs button.

3. Enter the information as shown below

ensure that the Target Type is selected as

Case Study 1 - Depropanizer

4. Add another Column Component Fraction specification with following information:

5. Return to the Monitor page and make sure that the active specifications are Reflux Ratio and Light Key.

6. Converge the Column.

This column can have only two active specifications. The Reflux Ratio,

Light Key, and Heavy Key cannot all be active simultaneously.

Change the Active specifications to Light Key and Heavy Key.
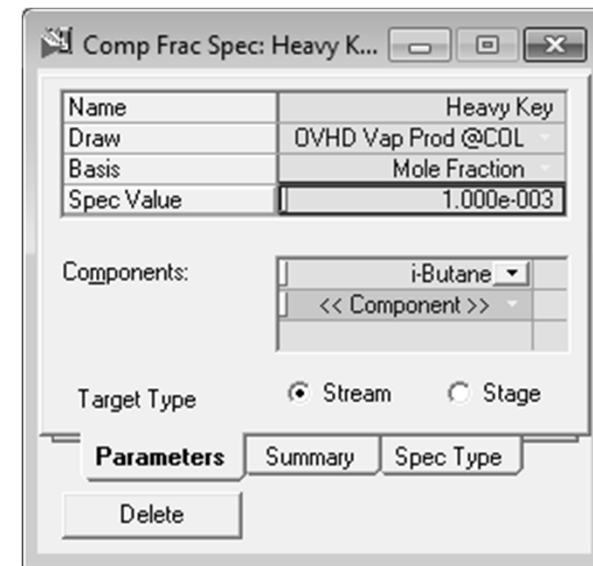
Case Study 1 - Depropanizer

- This column can have only two active specifications. The Reflux Ratio, Light Key, and Heavy Key cannot all be active simultaneously.

- Change the Active specifications to Light Key and Heavy Key.

- Note that the values calculated by the Distillation Column are different from the values found by the Shortcut Column. This is because the Shortcut column only estimates the values, while the Distillation Column performs rigorous calculations.

Column Sizing

- HYSYS contains a Tray Sizing utility that greatly simplifies the mechanical design of a distillation column. A user can size full towers, or sections of towers, by specifying information related to the trays, tower internals, the downcomers, and the weirs.

Column Sizing in Design Mode

1. Change the Feed flowrate to 300 kgmole/hr .

2. Select Tools/Utilities from the Main Menu bar, or press the hot key <Ctrl>+<U>.

3. Select Tray Sizing from the list of available utilities and press the Add Utility button.

4. Press the Select TS… button, and select T-101 as the Flowsheet and Main TS as the Object.

5. Press the Add Section button. Accept all of the default values that are presented.

Column Sizing in Design Mode

6. On the Performance tab, a summary of the calculations are presented. A brief explanation of the terms follows:

- Number of Flow Paths: The number of times liquid crosses the tray, most trays are single-pass or have NFP of 1.

- Maximum Downcomer Backup: Represents the maximum amount of liquid hold-up in the downcomer that can be tolerated by the column before flooding occurs.

- Maximum Weir Loading: Measures the amount of liquid flowing over the weir.

- Pressure Drops: Estimates the total pressure drop over the section and the maximum pressure drop per tray.

Column Sizing in Design Mode

What is the maximum pressure drop per tray in the Distillation Column?

Over which tray does this drop occur?

What is the diameter of the trays inside the column?

What is the total section height?

Column Sizing in Rating Mode

- In rating mode, HYSYS allows you to perform rating calculations based on a specified tower diameter and fixed tray configuration. If desired, some of the tray dimensions may be left unspecified and HYSYS will automatically calculate design values for them.

HW 5

- Head office is desperate to build a distillation column, but the fabrication mill is working overtime and there are very lengthy delays for special orders. The mill has the following trays in stock:

Diameter, m (ft.)	NFP (Passes)
0.75 (2.5)	1
1.0 (3.3)	1
1.25 (4.1)	1

- Obtain the flow parameters and pressure drops for a column that uses the trays as given above. The following requirements must be met in order for the column to be constructed.

  - Maximum% Flood = 85

  - Maximum weir loading = 80 m3/h-m

  - Maximum pressure drop over column = 10 kPa

  - Maximum downcomer backup = 50%

HW 5

- For each case, follow these steps:

1. On the Specs page, set the Calculation Mode to Rating .

2. For each case, set the diameter and number of flow paths and move to the Performance page.

3. Complete the following table with the information provided by HYSYS.

HW 5

Case #	1	2	3
Diameter, m (ft)	0.75 (2.5)	1.0 (3.3)	1.25 (4.1)
NFP	1	1	1
Weir Load			
Flood			
DC Back Up			
Total delta P			

Compare the table above with the specifications on the previous page; which set of trays will best meet the restrictions? Remember that smaller trays will be less expensive

Final Exam

1392/10/09