DSTWU – A Shortcut Distillation Model in Aspen Plus® V8.0

1. Lesson Objectives

- Learn how to use DSTWU to start distillation column design.
- Learn the strengths and limitations of shortcut methods

2. Prerequisites

- Aspen Plus V8.0

3. Background

DSTWU implements the following methods:

- Winn method to estimate minimum number of stages
- Underwood to calculate minimum reflux ratio
- Gilliland to relate actual number of stages and RR

DSTWU provides a very good starting point for distillation column design. Of course, we must be fully aware of the two assumptions on which the above three methods are based:

- Constant relative volatilities
- Constant molar overflow

DSTWU should not be used for systems that significantly deviate from these two assumptions. For systems with strongly non-ideal mixtures (e.g., ethanol-water), these shortcut methods won't work because those two assumptions just cannot represent those systems well.

If we need to design a column to separate a mixture of n-butane and cis-2-butene, DSTWU can be very helpful. In this case we would like to design a column to recover 99% of n-butane and 1% of butene in the distillate stream.

The examples presented are solely intended to illustrate specific concepts and principles. They may not reflect an industrial application or real situation.

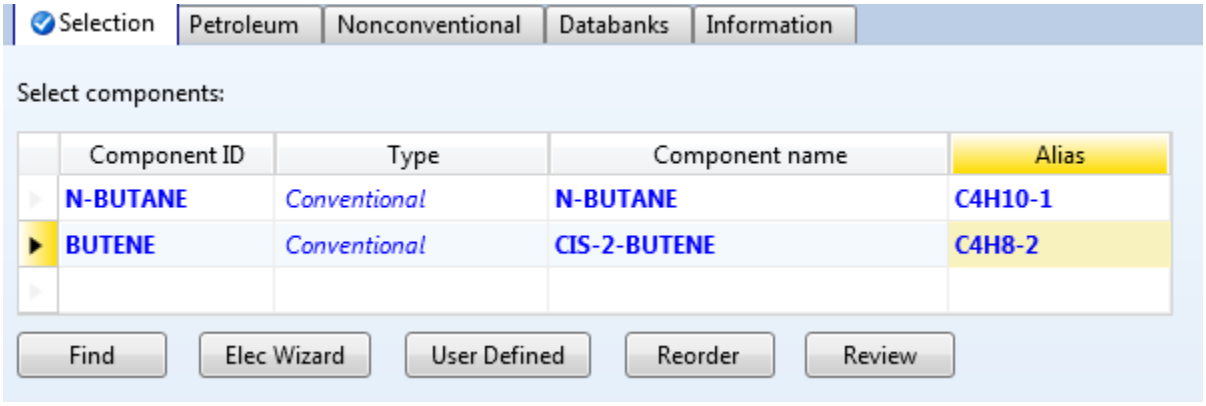
4. Aspen Plus Solution

If you are unfamiliar with how to start Aspen Plus, select components, define methods, or construct a flowsheet, consult **Get Started Guide for New Users of Aspen Plus.pdf** for instructions.

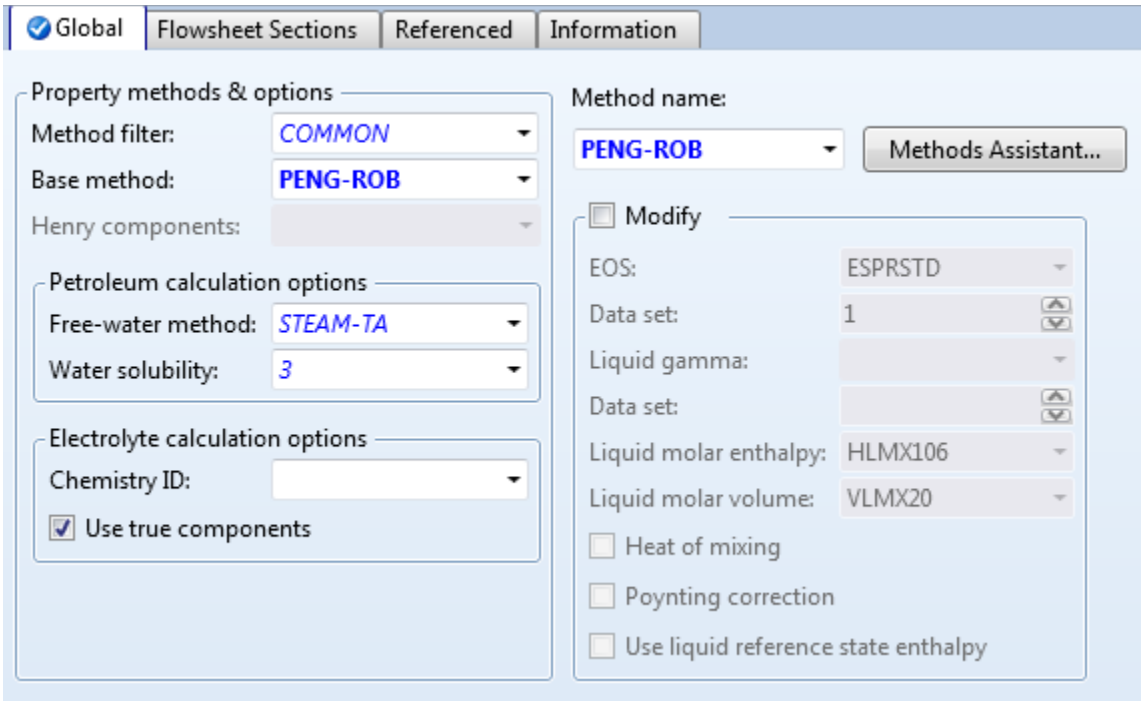
First we will create a simulation for the separation of n-butane and cis-2-butene using the DSTWU model.

4.01. Start a new simulation using the **Blank Simulation** template in Aspen Plus.

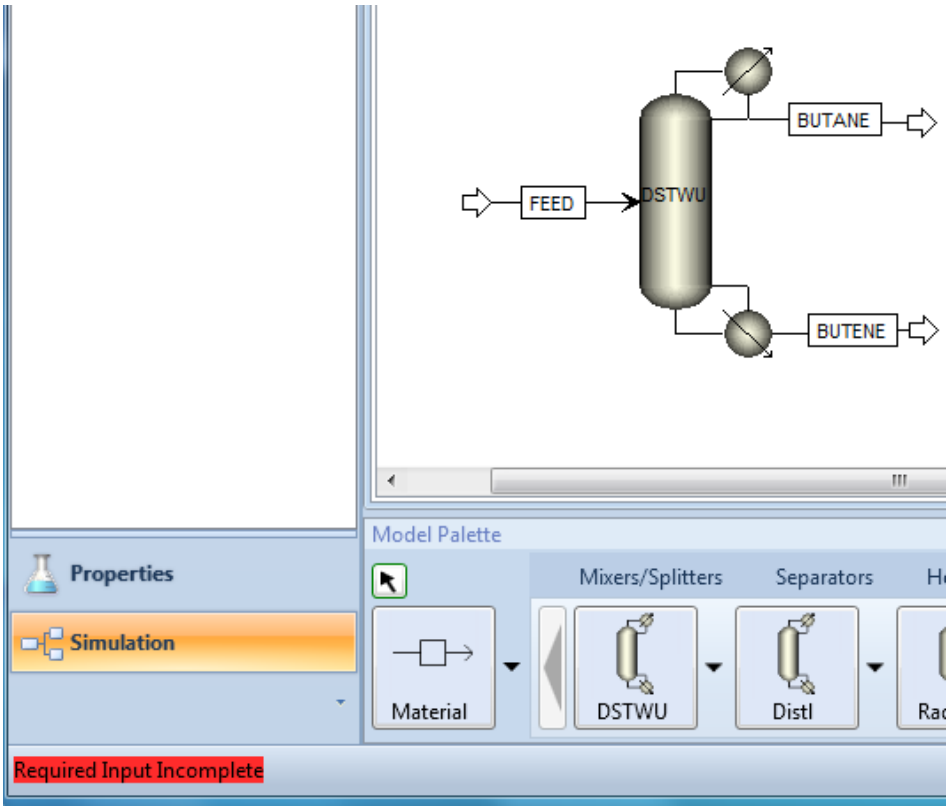
4.02. The **Components | Specifications | Selection** sheet is displayed. Enter **N-BUTANE** in the **Component ID** column. Note that **Component name** and **Alias** are automatically filled for this component. Enter **BUTENE** as **Component ID** for the second component. Since **BUTENE** cannot uniquely identify a component, enter **CIS-2-BUTENE** as the **Component name** for the second component. Its **Alias** is automatically filled in.



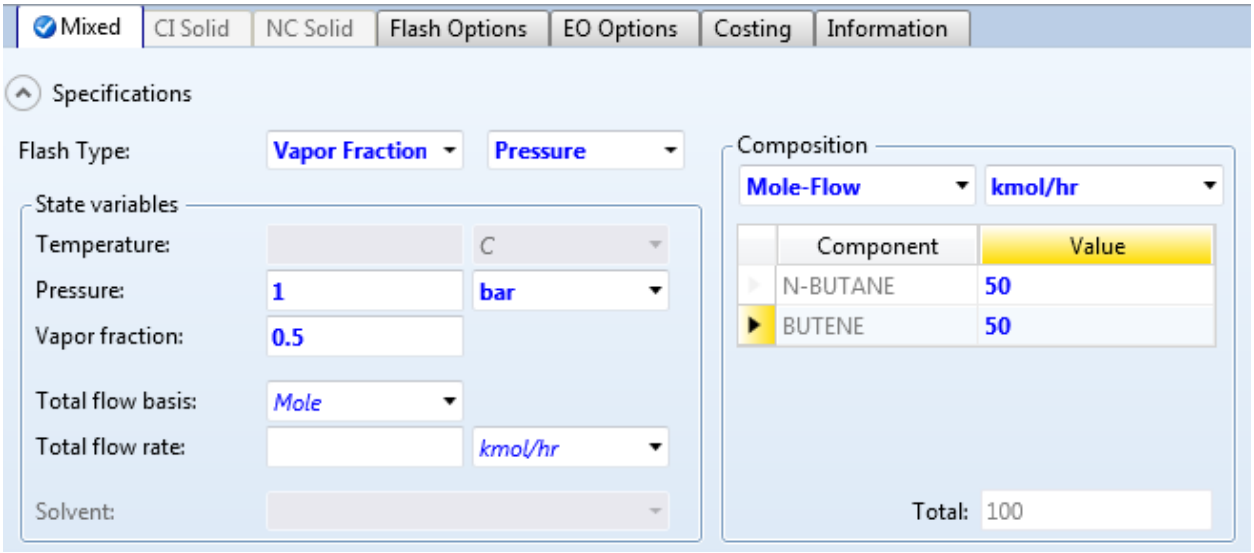
4.03. Define methods. Go to the **Methods | Specifications | Global** sheet. Select **PENG-ROB** for **Base method**.



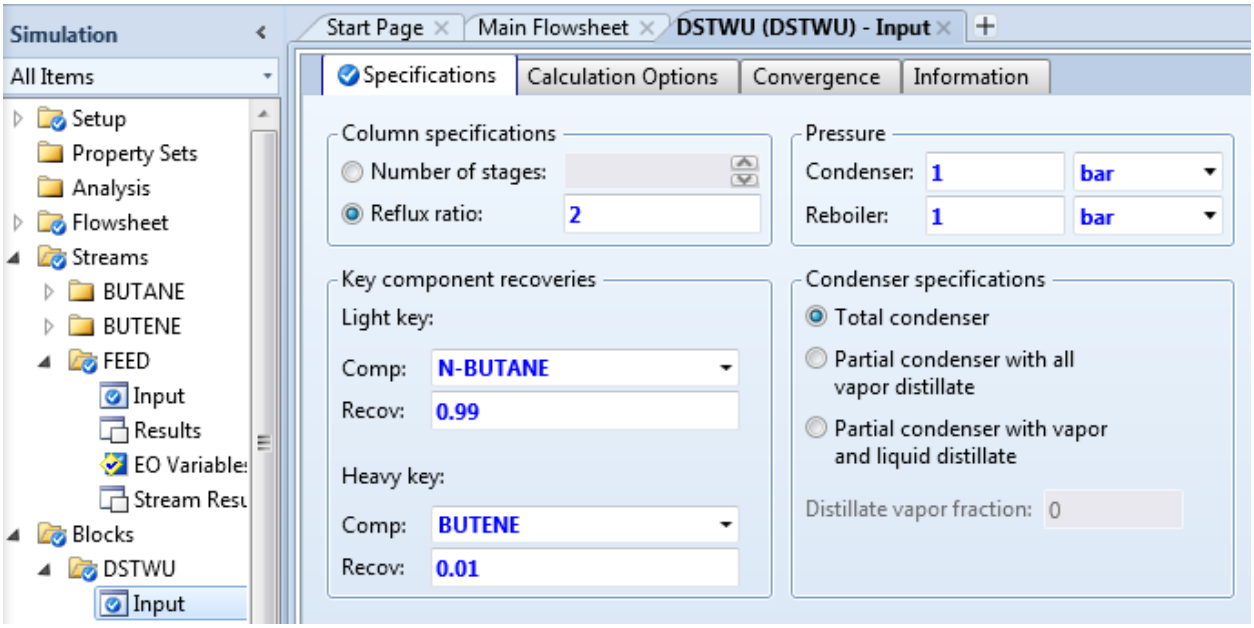
4.04. Go to the simulation environment and place a **DSTWU** block onto the **Main Flowsheet**. The **DSTWU** model is located under the **Columns** tab in the **Model Palette**. Connect the inlet and outlet ports with **Material** streams and rename them accordingly.



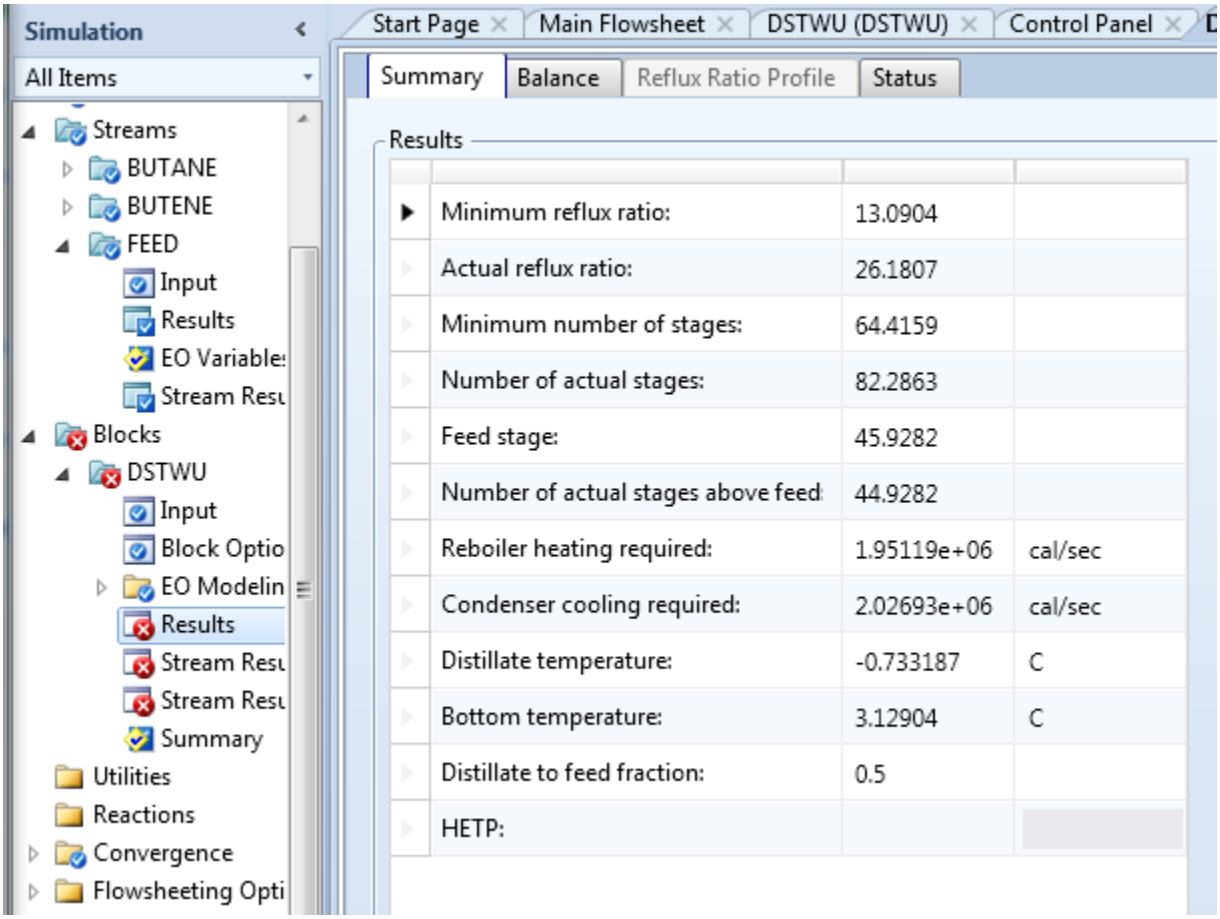
4.05. Specify feed streams. Double click on stream **FEED** or go to the **Streams | FEED | Input | Mixed** sheet. Select **Vapor Fraction** and **Pressure** for **Flash Type**. Enter **1** for **Pressure** and **0.5** for **Vapor fraction**. In the **Composition** frame, enter **50** for both **N-BUTANE** and **BUTENE**.



4.06. Specify column operating conditions. Double click the column block on the **Main Flowsheet** or go to the **Blocks | DSTWU | Input | Specifications** sheet. In the **Column specifications** frame, select the **Reflux ratio** option and enter **2** for **Reflux ratio.** In the **Pressure** frame, enter **1** for both **Condenser** and **Reboiler**. In the **Key component recoveries** frame, select **N-BUTANE** for **Comp** and enter **0.99** for **Recov** for **Light key**. Select **BUTENE** for **Comp** and enter **0.01** for **Recov** for **Heavy key**.



4.07. Run the simulation by pressing the **F5** key. After running the simulation, you should receive an error for the **DSTWU** block stating that the specified reflux ratio is less than the minimum reflux ratio. **DSTWU** also took corrective action and calculated the actual reflux ratio based on the minimum reflux ratio. Therefore, the results are valid despite the error message. Go to the **Blocks | DSTWU | Results | Summary** sheet.

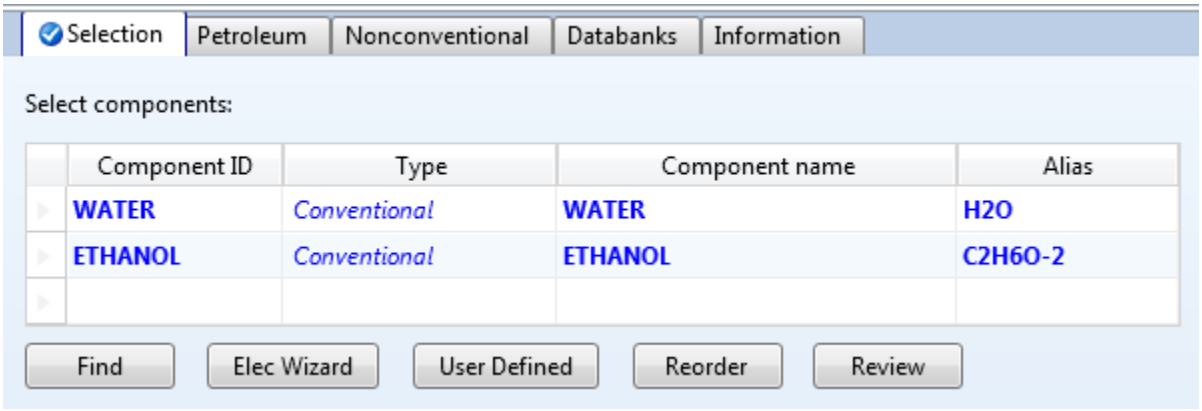


4.08. This table provides very useful design information including **Minimum reflux ratio**, **Minimum number of stages**, and estimated duties. This table also provides an **Actual reflux ratio** and an **Actual number of stages**. These values will serve as good design estimates for this separation.

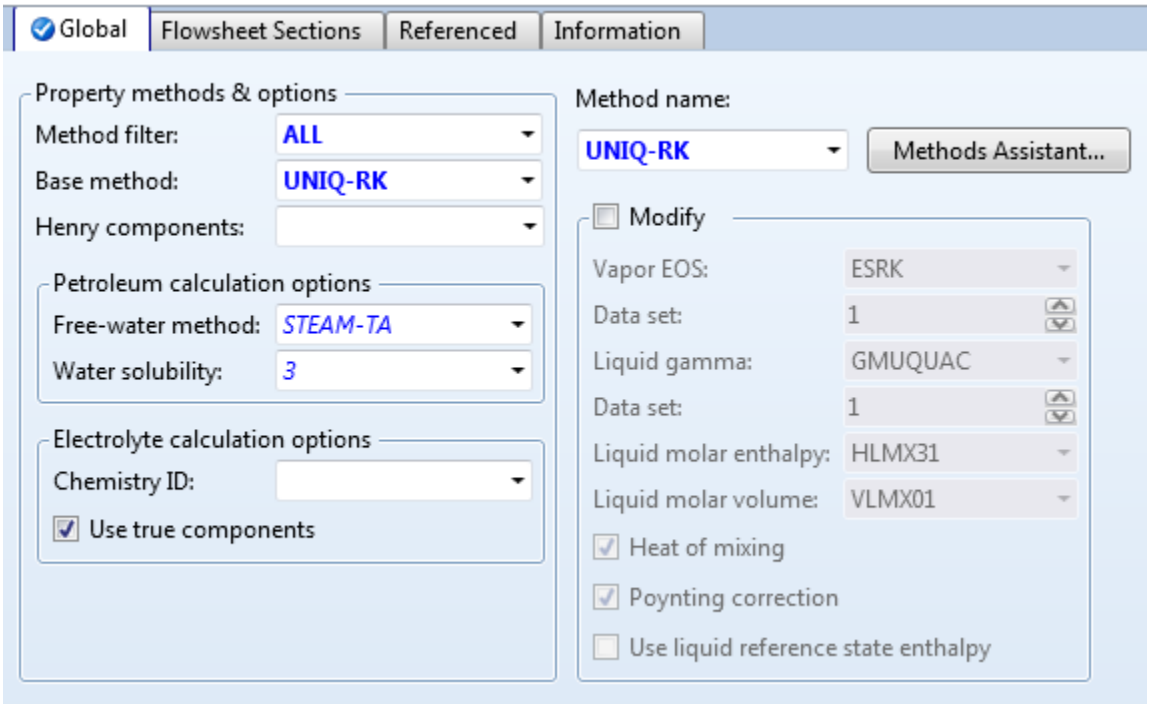
4.09. Now, save the simulation. On the ribbon, click **File** and then click **Save As** to save the simulation as **Dist-006_DSTWU-C4-C4.bkp**. Close the Aspen Plus simulation window.

4.10. We will now create a simulation for the separation of ethanol and water using the **DSTWU** model. Start another new simulation using the **Blank Simulation** template in Aspen Plus.

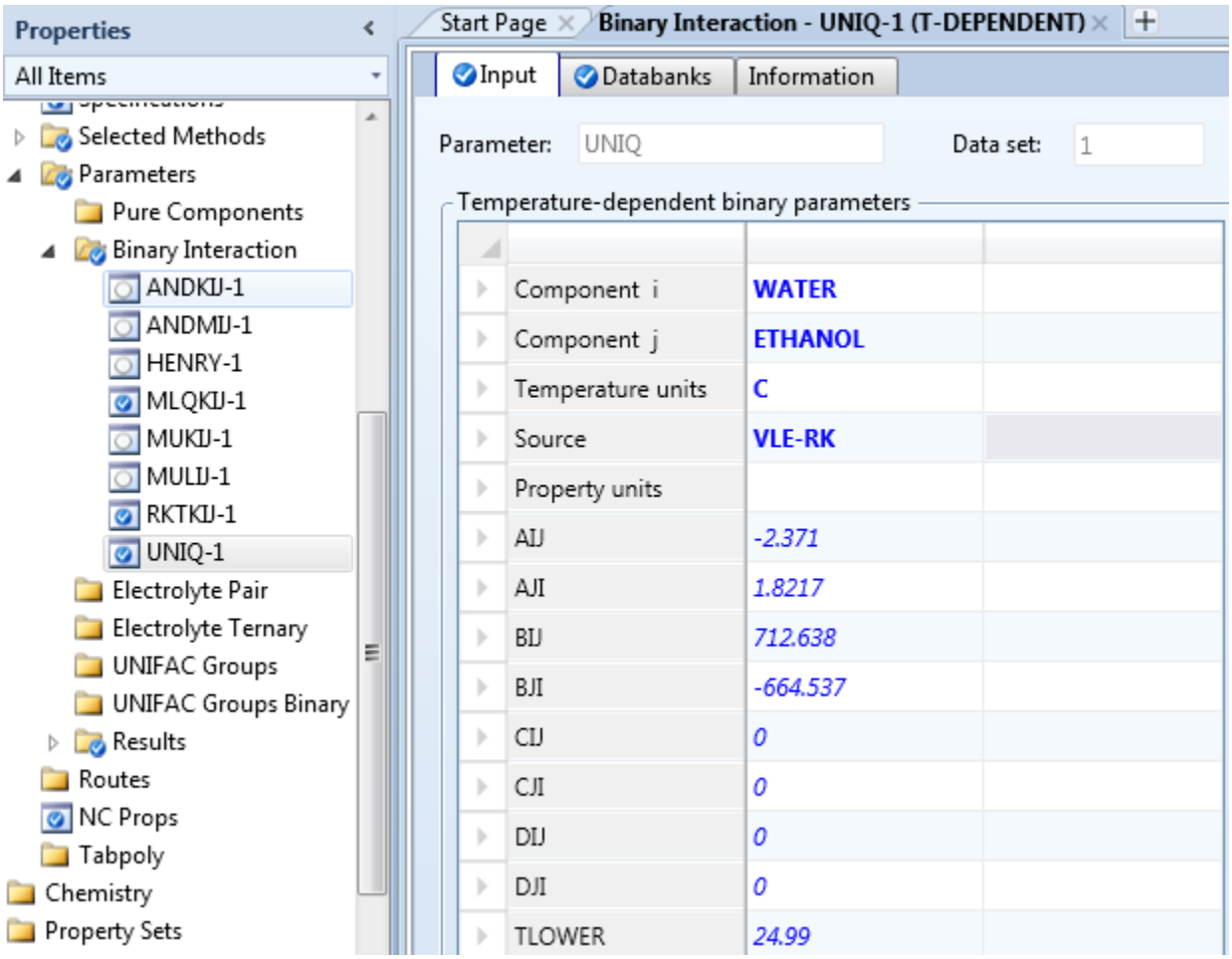
4.11. The **Components | Specifications | Selection** sheet is displayed. Enter **WATER** and **ETHANOL** in the **Component ID** column.



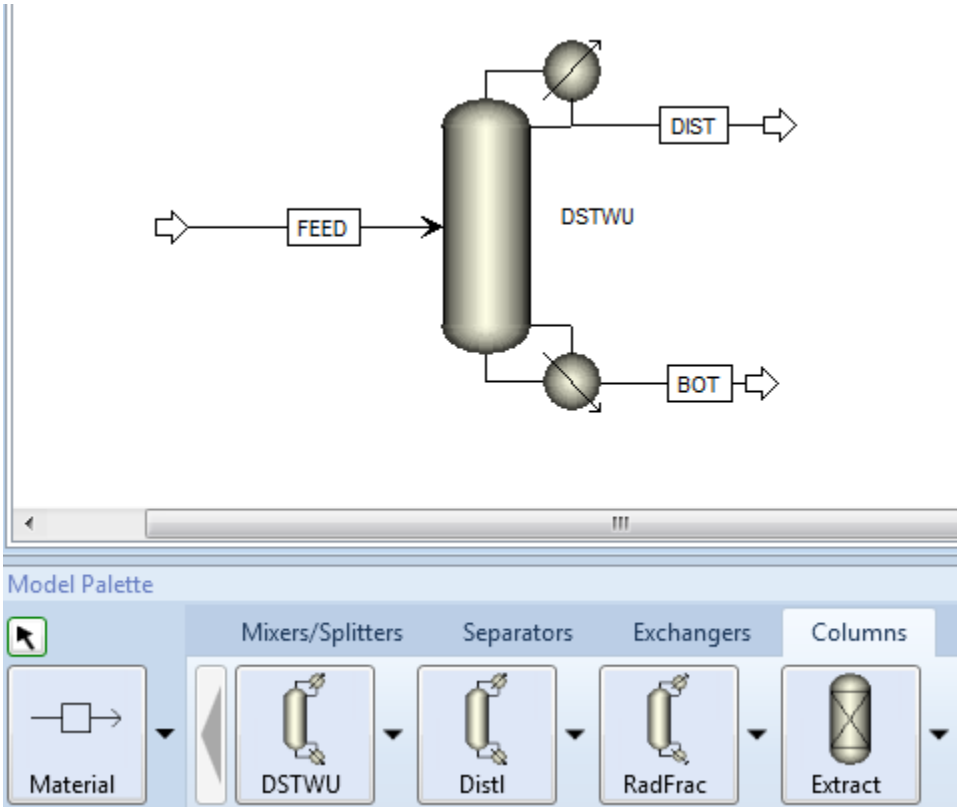
4.12. Define methods. Go to the **Methods | Specifications | Global** sheet. Select **ALL** for **Method filter**. Select **UNIQ-RK** for **Base method.**



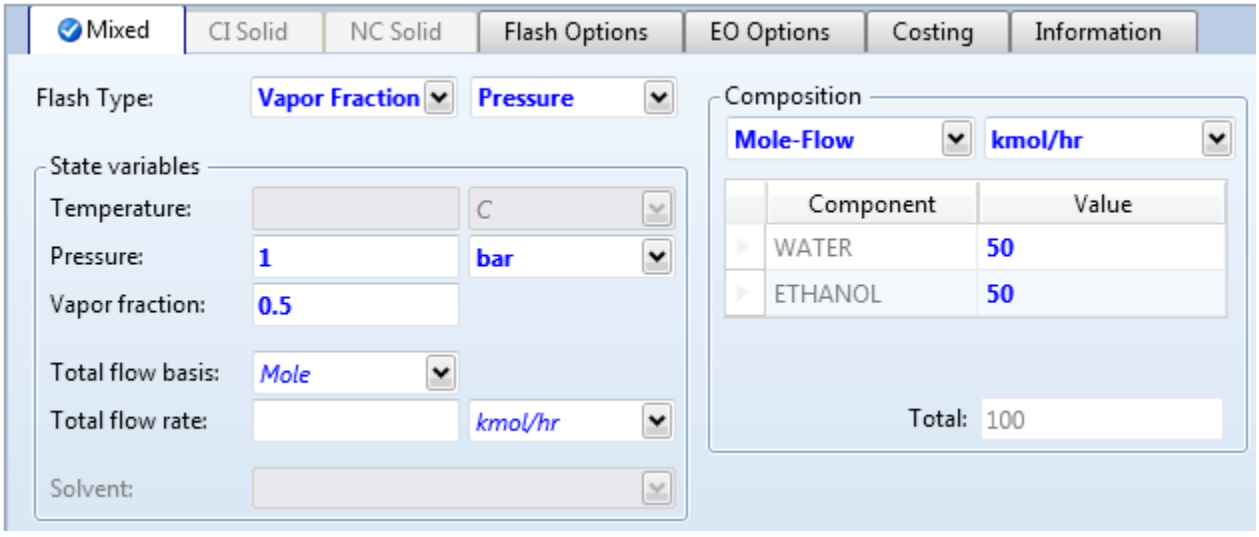
4.13. Press the **Next Input** button on the **Quick Access Toolbar** (or press the **F4** key on your keyboard). Binary parameters are automatically populated on the **Methods | Parameters | Binary Interaction | UNIQ-1 | Input** sheet.



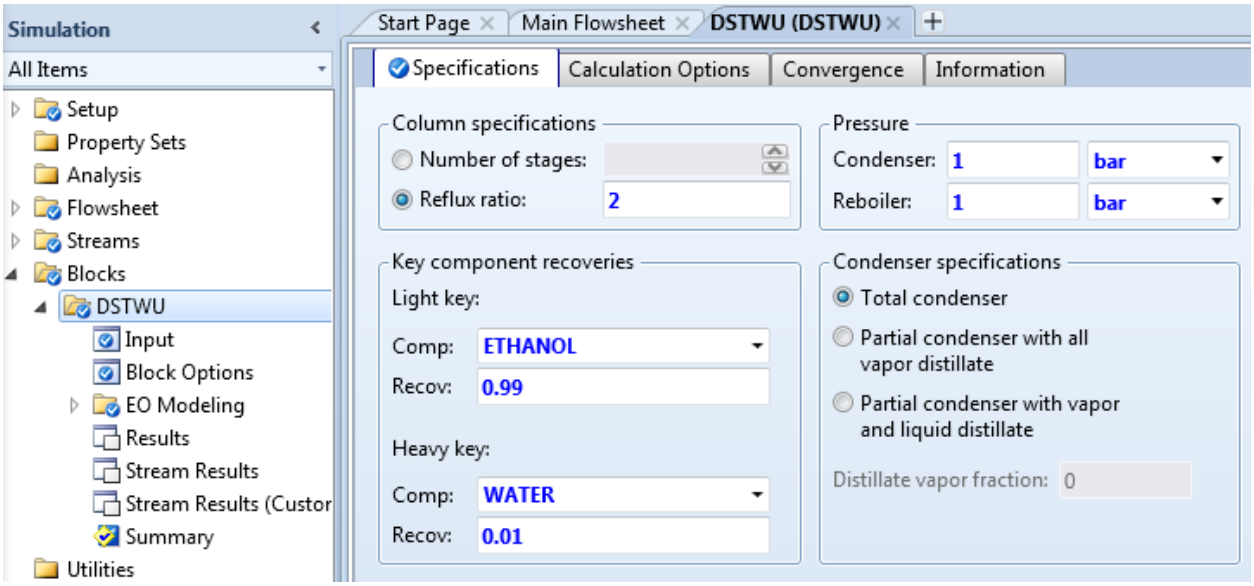
4.14. Go to the **Simulation** environment and place a **DSTWU** block onto the **Main Flowsheet**. The **DSTWU** model is located under the **Columns** tab in the **Model Palette**. Connect the inlet and outlet ports with **Material** streams and name them accordingly.



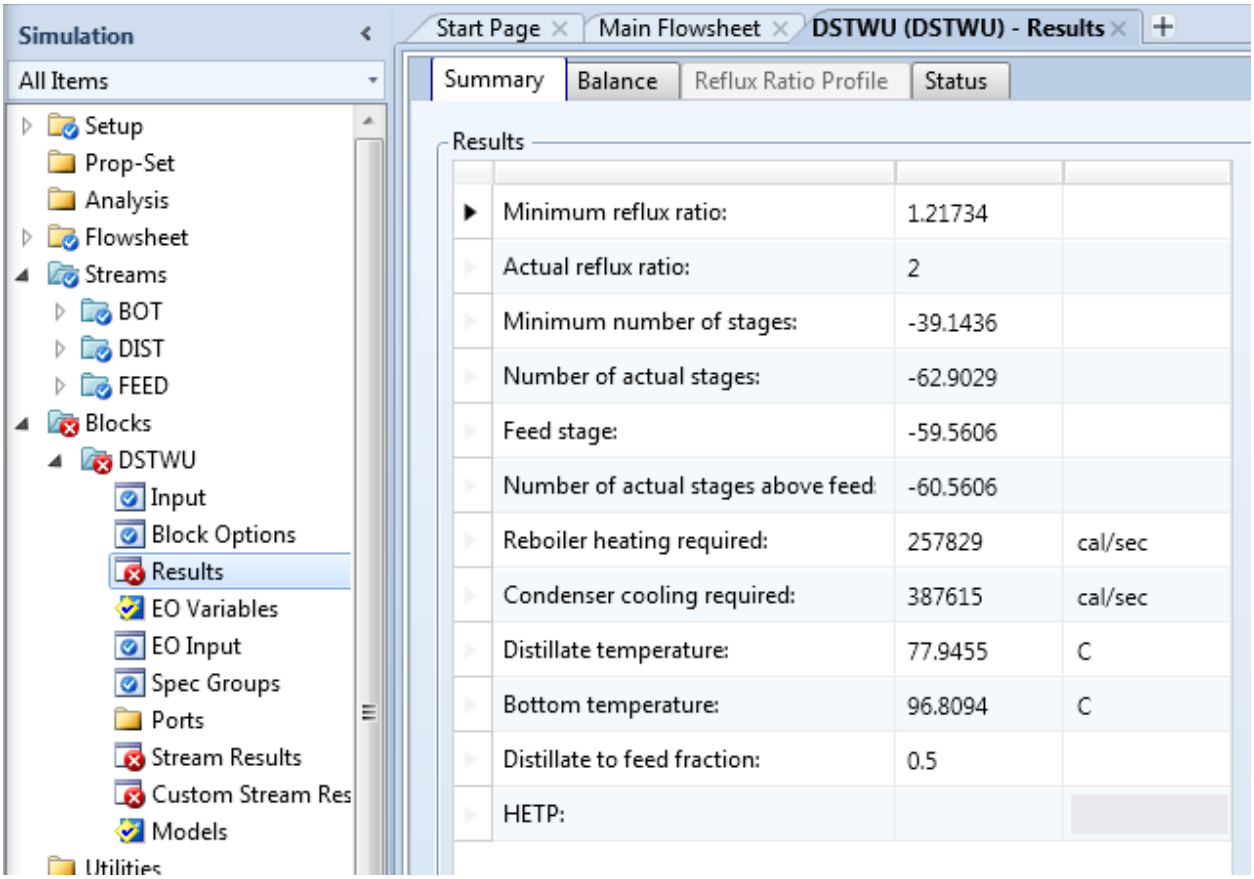
4.15. Specify the feed stream. Go to the **Streams | FEED | Input | Mixed** sheet. Select **Vapor Fraction** and **Pressure** for **Flash Type**. Enter **1** for **Pressure** and **0.5** for **Vapor fraction**. In the **Composition** frame, enter **50** for both **WATER** and **ETHANOL**.



4.16. Specify column operating conditions. Go to the **Blocks | DSTWU | Input | Specifications** sheet. In the **Column specifications** frame, select the **Reflux ratio** option and enter **2** for **Reflux ratio.** In the **Pressure** frame, enter **1** for both **Condenser** and **Reboiler**. In the **Key component recoveries** frame, select **ETHANOL** for **Comp** and enter **0.99** for **Recov** for **Light key**. Select **WATER** for **Comp** and enter **0.01** for **Recov** for **Heavy key**.



4.17. Run the simulation by pressing the **F5** key. There are error messages during simulation and the calculated minimum number of stages is a negative number. Therefore, the results cannot be used. We know that water and ethanol form an azeotrope and thus the assumption of constant relative volatility is not valid for this system.



5. Conclusions

For mixtures where the following two assumptions are good approximations, the shortcut methods implemented in **DSTWU** are very useful and efficient to get us started.

- Constant relative volatilities
- Constant molar overflow

For systems that significantly deviate from those two assumptions (e.g., ethanol-water), these shortcut methods are not useful and we should not rely on results from these shortcut methods. For such cases, we need to use more rigorous models (e.g., **RadFrac**).

6. Copyright