Process Simulation Using Aspen HYSYS V8

Why Aspen HYSYS?

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Aspen HYSYS is a market-leading process modeling tool for conceptual design, optimization, business planning, asset management, and performance monitoring for oil & gas production, gas processing, petroleum refining, and air separation industries. Aspen HYSYS is a core element of AspenTech's aspenONE™ Process Engineering applications.

Objectives

• Learn to build, navigate and optimize process simulations using Aspen HYSYS

• Learn the efficient use of different HYSYS functions to build steady state process simulations

Who Should Attend

• New engineering graduates/technologists who will be using Aspen HYSYS in their daily work

• Process engineers doing process design and optimization projects and studies

• Plant engineers checking plant performance under different operating conditions

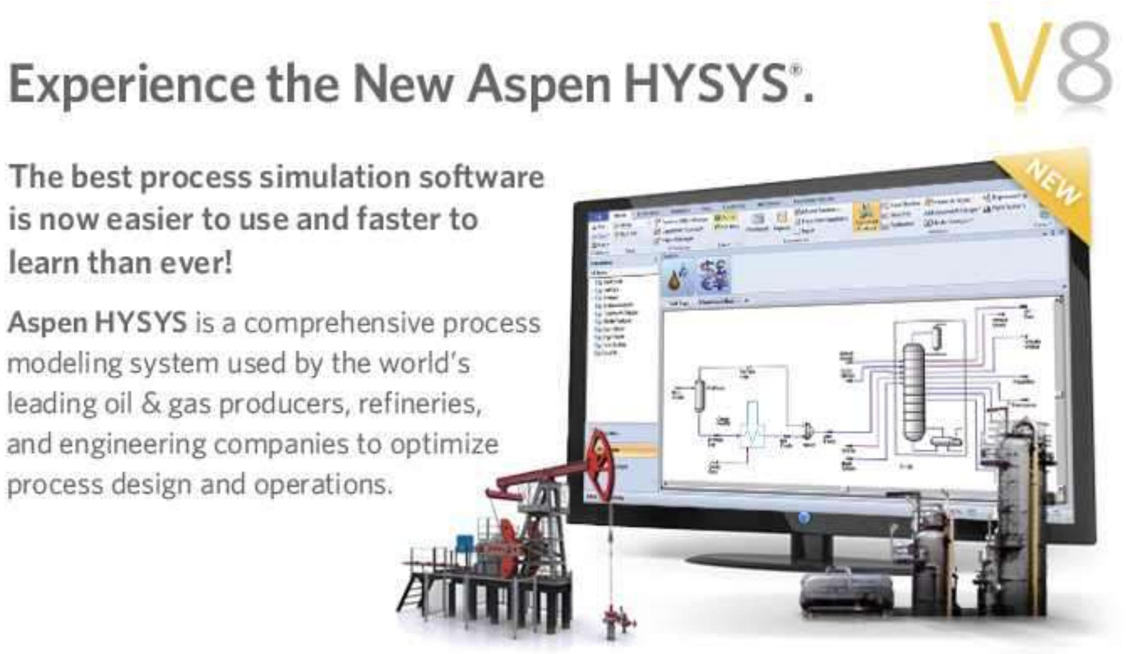
• R&D engineers and researchers using Aspen HYSYS for process synthesis

Prerequisites

• A background in chemical engineering or industrial chemistry

Content:

Getting Started



1

Workshop

The Getting Started module introduces you to some of the basic concepts necessary for creating simulations in HYSYS. You will use HYSYS to define three gas streams to be used as feeds to a gas plant. In addition, you will learn how to determine properties of these streams by using the Phase Envelope and the Property Table utilities.

Learning Objectives

- Define a fluid package (property package, components, hypotheticals).
- Add streams.
- Understand flash calculations.
- Attach stream utilities.
- Customize the Workbook.

Example:

We have a stream containing 15% ethane, 20% propane, 60% i-butane and 5% n-butane at 50°F and atmospheric pressure, and a flow rate of 100lbmole/hr. This stream is to be compressed to 50 psia and then cooled to 32°F. The resulting vapor and liquid are to be separated as the two product streams. Neglect the pressure drop inside the condenser.

- Fluid pkg: Peng Robinson

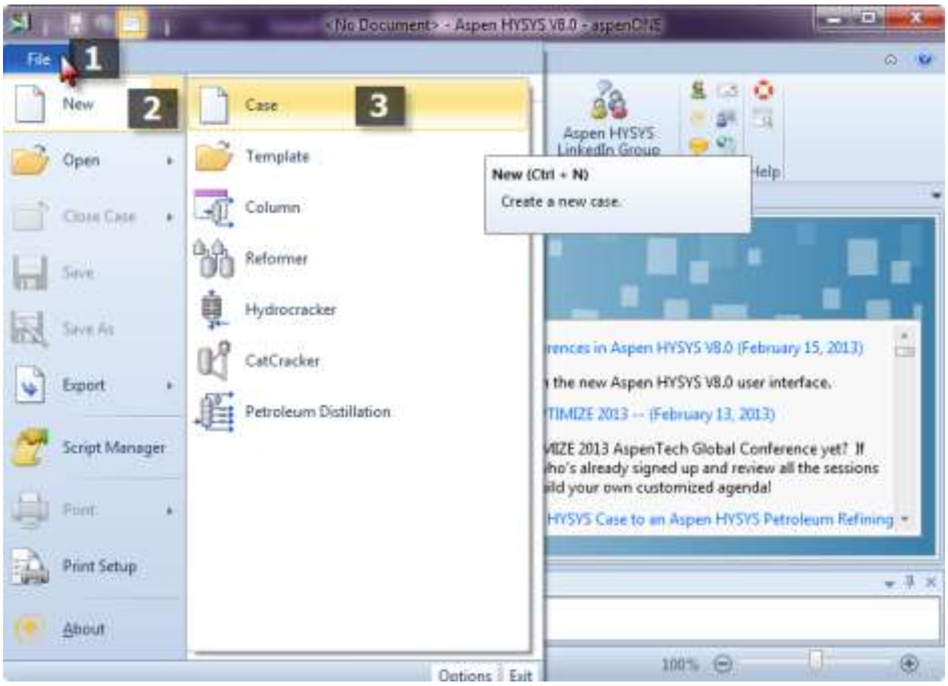
* What are the flow rates and molar compositions of two product streams?

Component	Vapor	Liquid
Ethane		
Propane		
I-Butane		
N-Butane		
Total Flow rate		

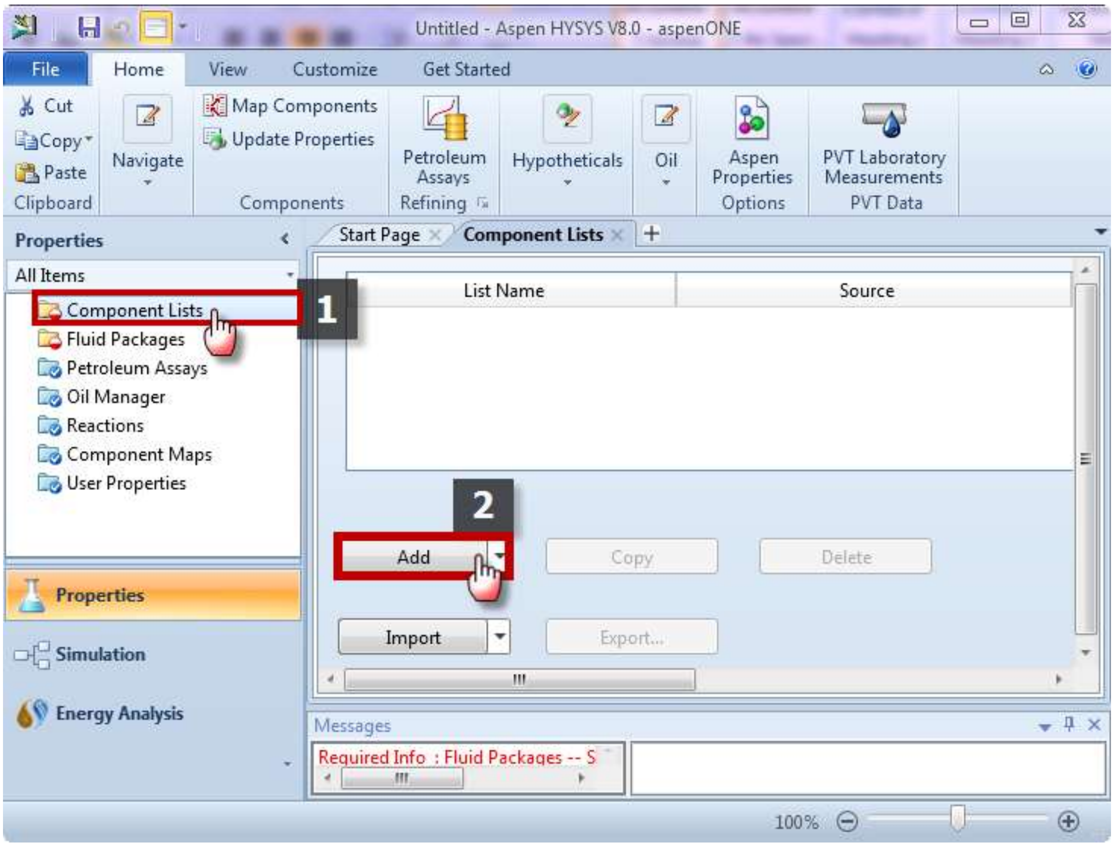
* Create a case study to see the effect of changing temperature of the cooler out stream on the molar flow of the liquid product stream, and write your comment.

To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS

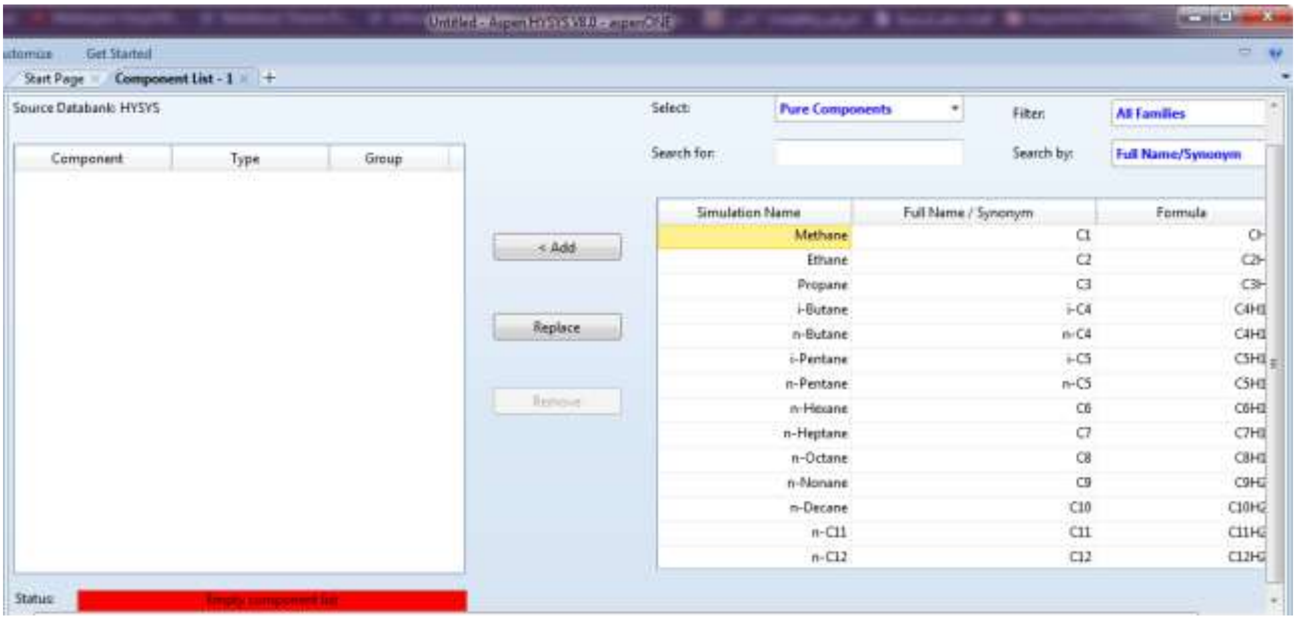
1- First, Start a new case

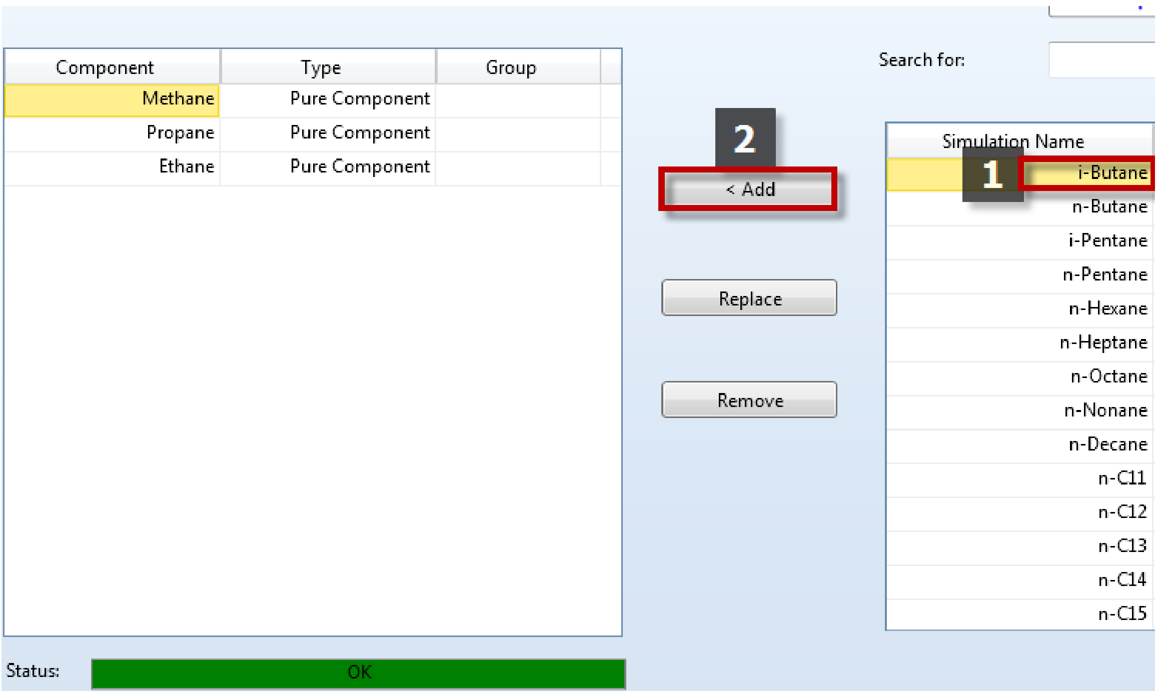


2- Add the Components



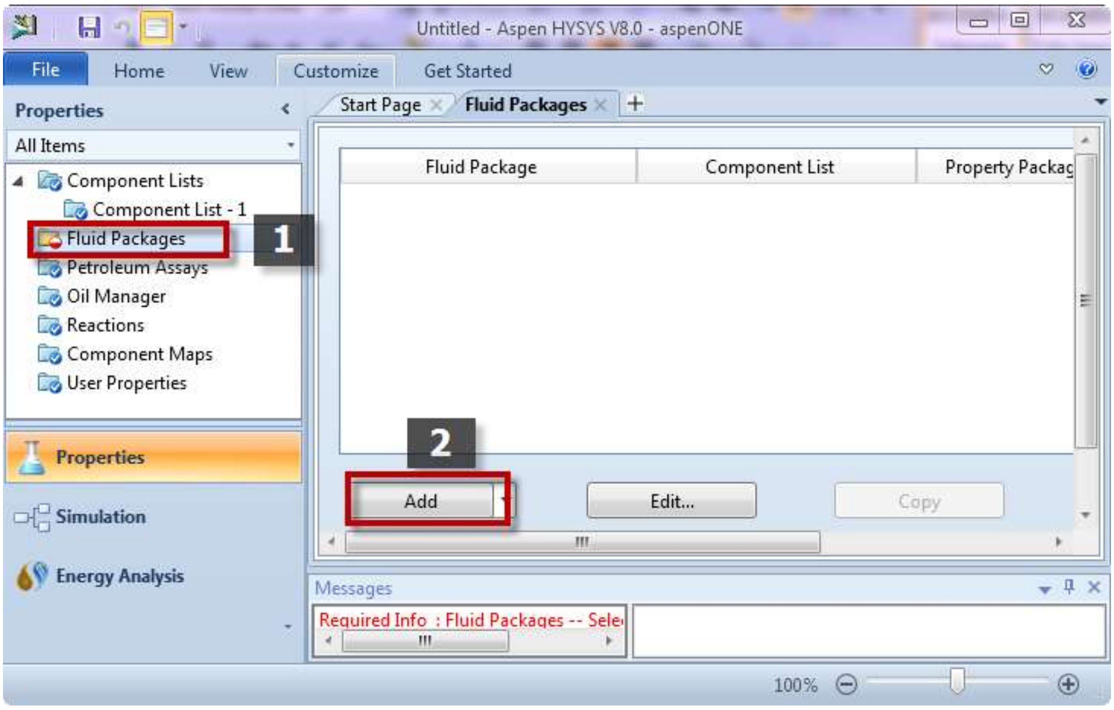
3- Choose the system components from the databank:





Now, select the suitable fluid package

When you have established a component list, you combine the component list with a property package. The property package is a collection of methods for calculating the properties of the selected components. The combination of the component list and the property package, along with other simulation settings, is called the fluid package.



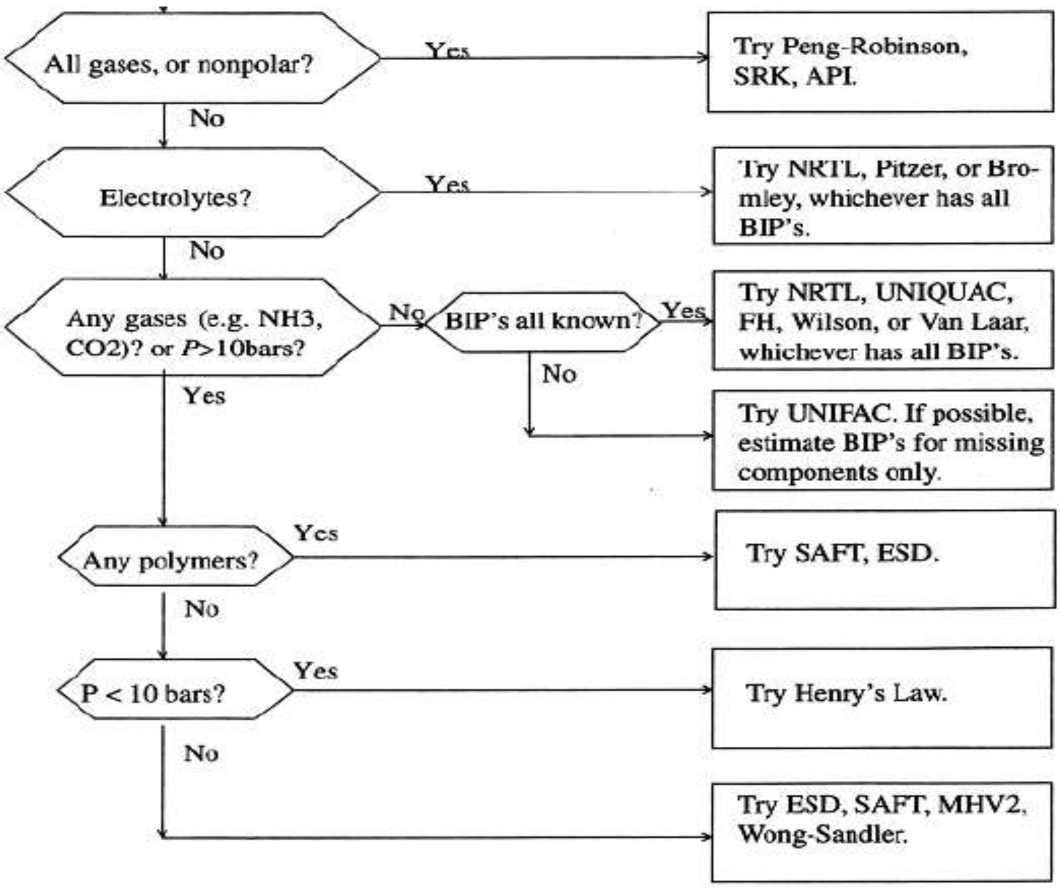
The built-in property packages in HYSYS provide accurate thermodynamic, physical and transport property predictions for hydrocarbon, non-hydrocarbon, petrochemical and chemical fluids.

The database consists of an excess of 1500 components and over 16000 fitted binary coefficients. If a library component cannot be found within the database, a comprehensive selection of estimation methods is available for creating fully defined hypothetical components.

There are about 33 property packages inside HYSYS database; the question now is **HOW TO SELECT THE SUITABLE FLUID PACKAGE?**

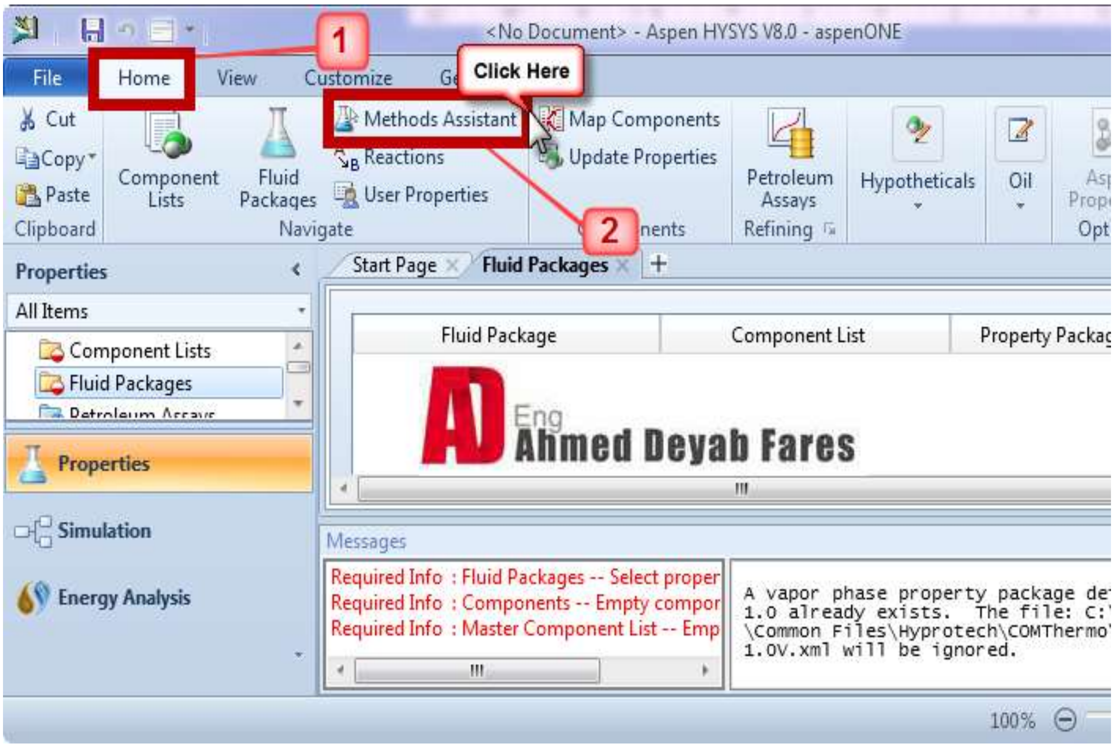
We can select the suitable one by specifying:

1- Process / Application type
2- Temperature and Pressure Range

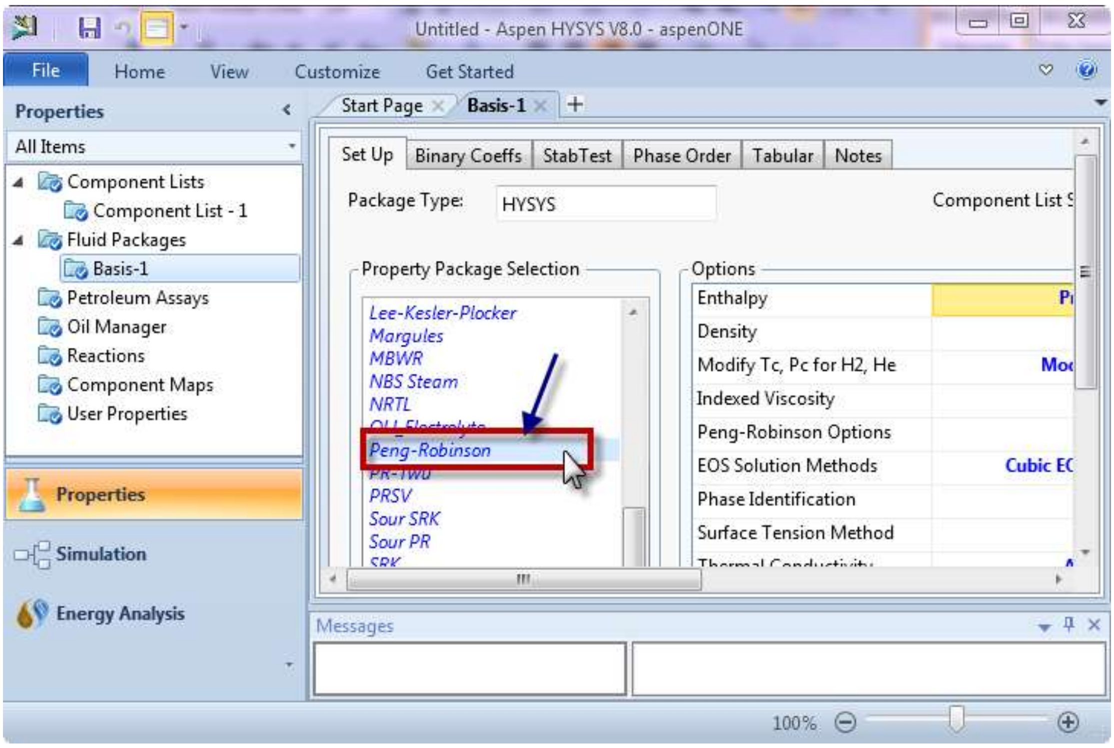

All gases, or nonpolar?
Yes
Try Peng-Robinson, SRK, API.
No
Electrolytes?
Yes
Try NRTL, Pitzer, or Bromley, whichever has all BIP's.
No
Any gases (e.g. NH3, CO2)? or P>10bars?
No
BIP's all known?
Yes
Try NRTL, UNIQUAC, FH, Wilson, or Van Laar, whichever has all BIP's.
No
Try UNIFAC. If possible, estimate BIP's for missing components only.
Yes
Any polymers?
Yes
Try SAFT, ESD.
No
P < 10 bars?
Yes
Try Henry's Law.
No
Try ESD, SAFT, MHV2, Wong-Sandler.

Type of System	Recommended Property Method
TEG Dehydration	PR
Sour Water	PR, Sour PR
Cryogenic Gas Processing	PR, PRSV
Air Separation	PR, PRSV
Atm. Crude Towers	PR, PR Options, GS
Vacuum Towers	PR, PR Options, GS (<10 mmHg), Braun K10, Esso K
Ethylene Towers	Lee Kesler Plocker
High H_2 Systems	PR, ZJ or GS
Reservoir Systems	Steam Package, CS or GS
Hydrate Inhibition	PR
Chemical Systems	Activity Models, PRSV
HF Alkylation	PRSV, NRTL
TEG Dehydration with Aromatics	PR
Hydrocarbon systems where H_2O solubility in HC is important	Kabadi Danner
Systems with select gases and light HC	MBWR

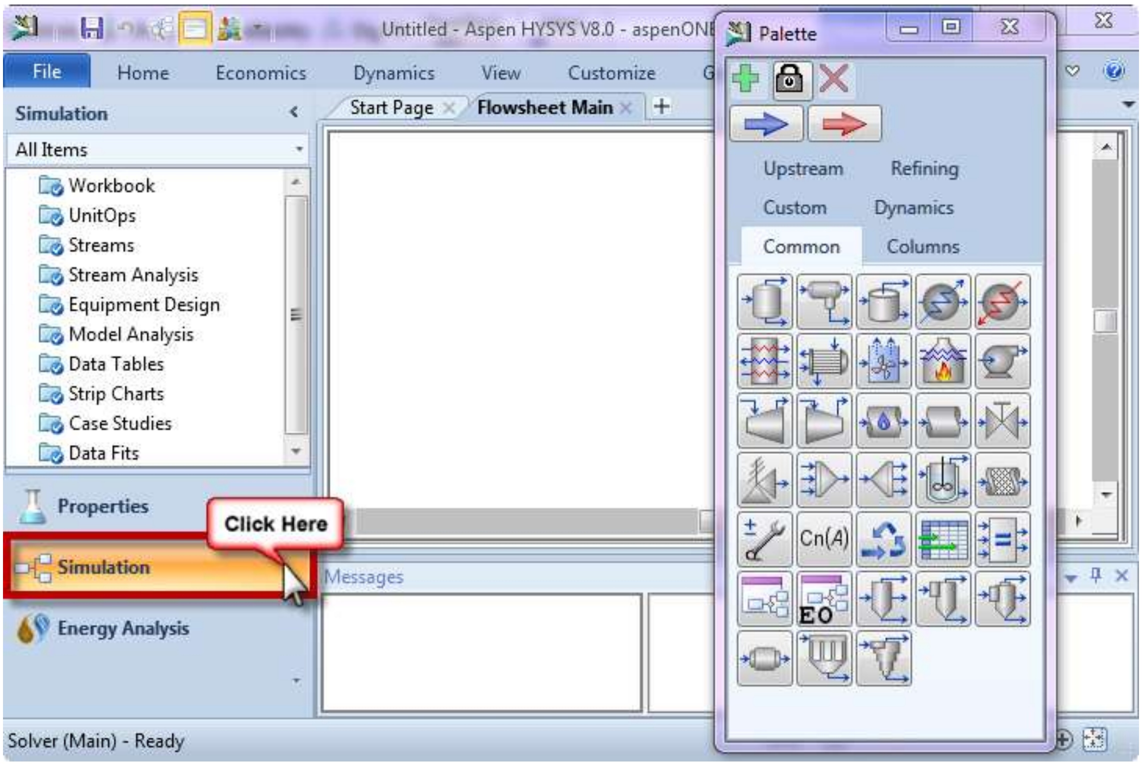
ASPEN HYSYS contains an assistant tool to help you in the selection f the suitable FP, called Methods Assistant:



In this case, select Peng-Robinson

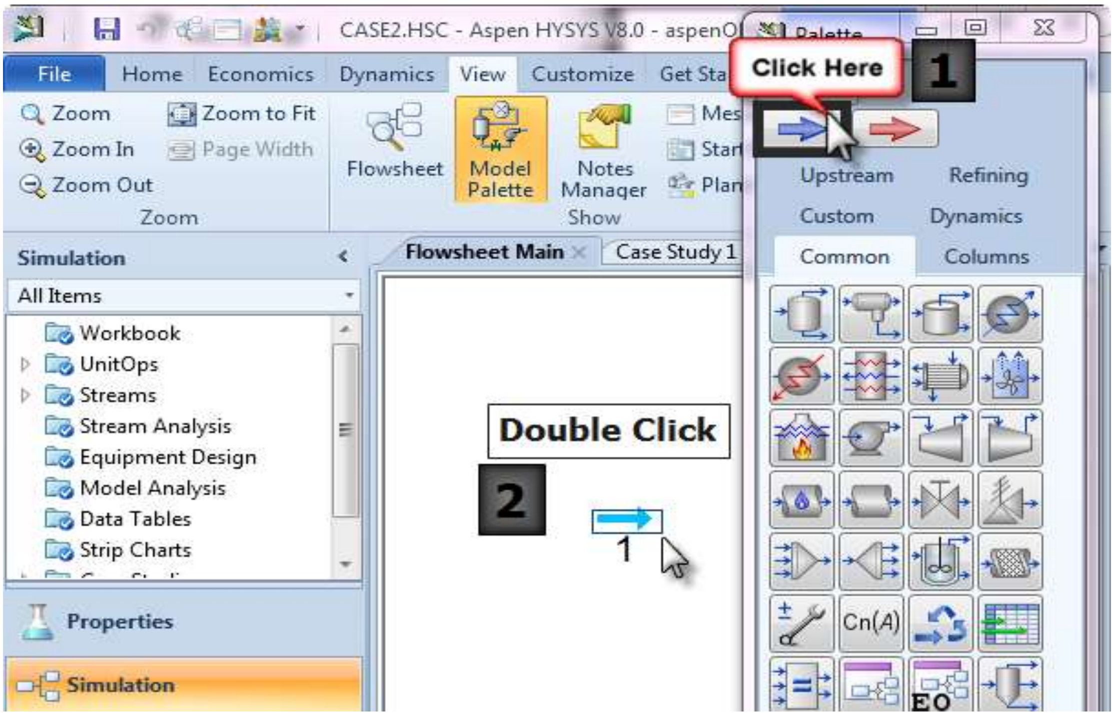


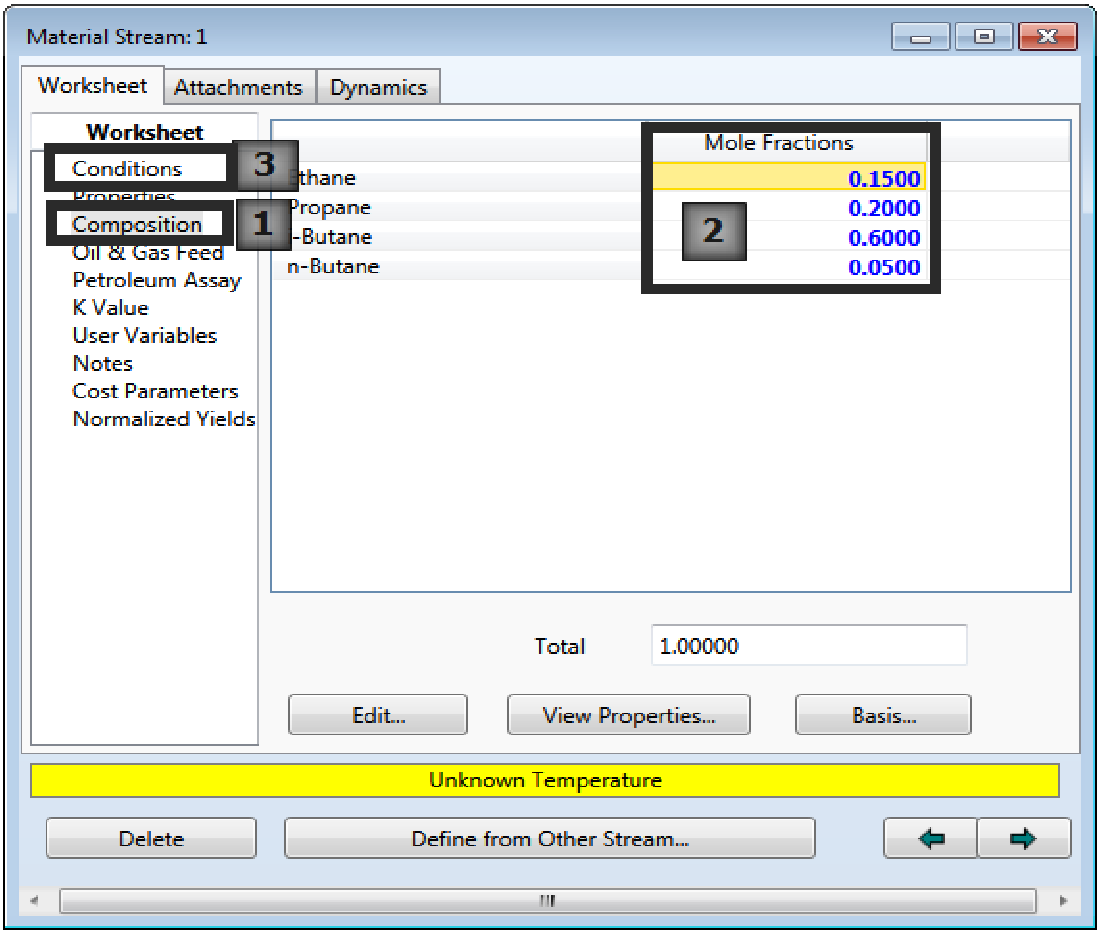
Now you can start drawing the flow sheet for the process by clicking the Simulation button:

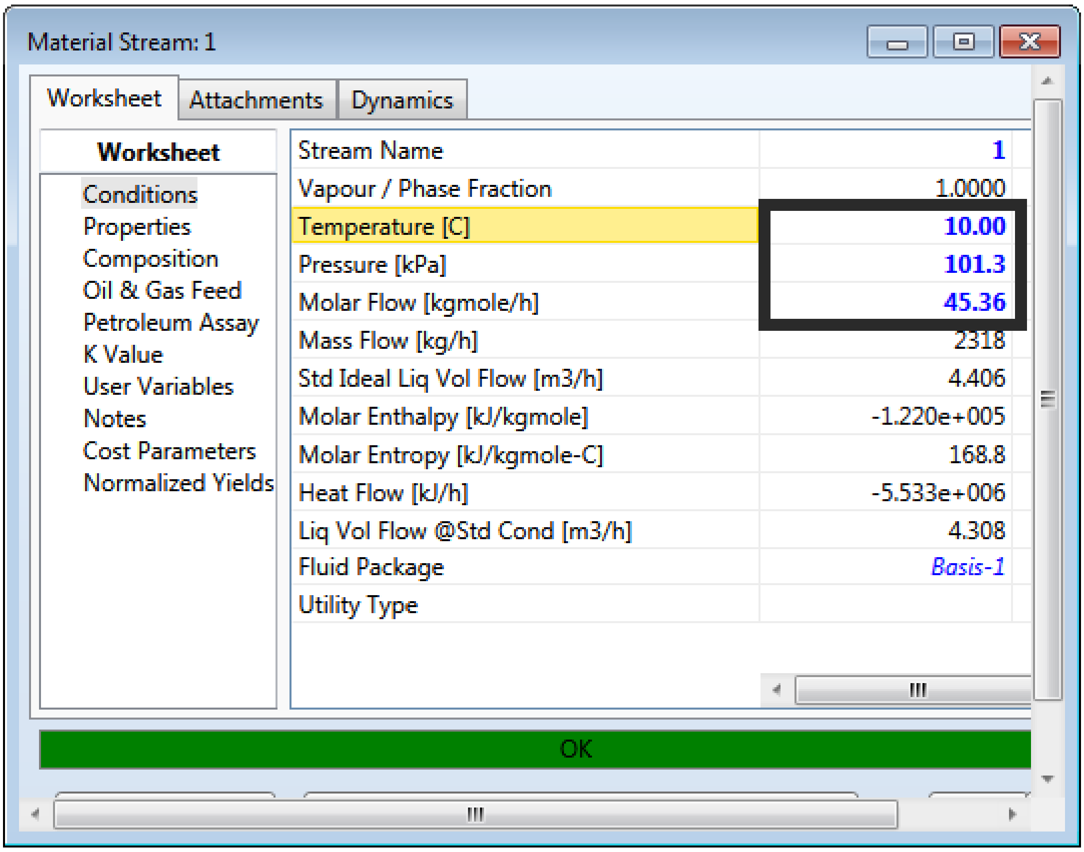


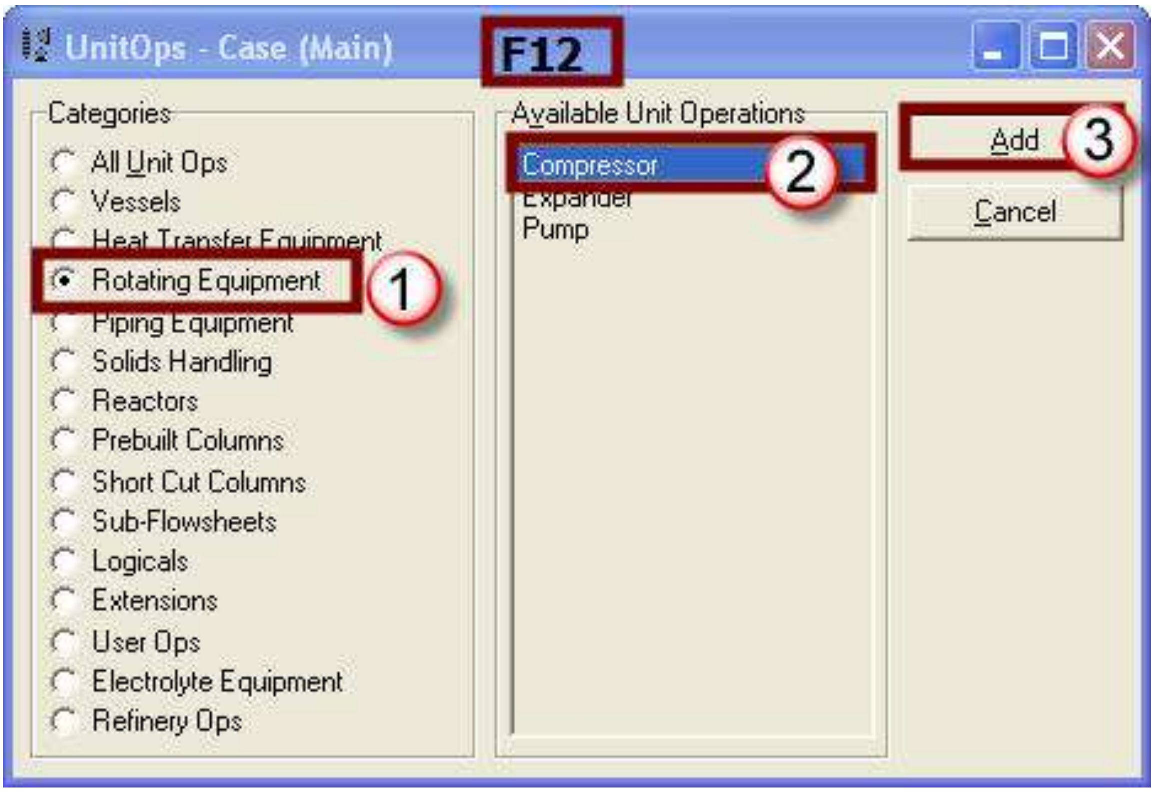
Now add a material stream to define the composition and the conditions of the feed stream

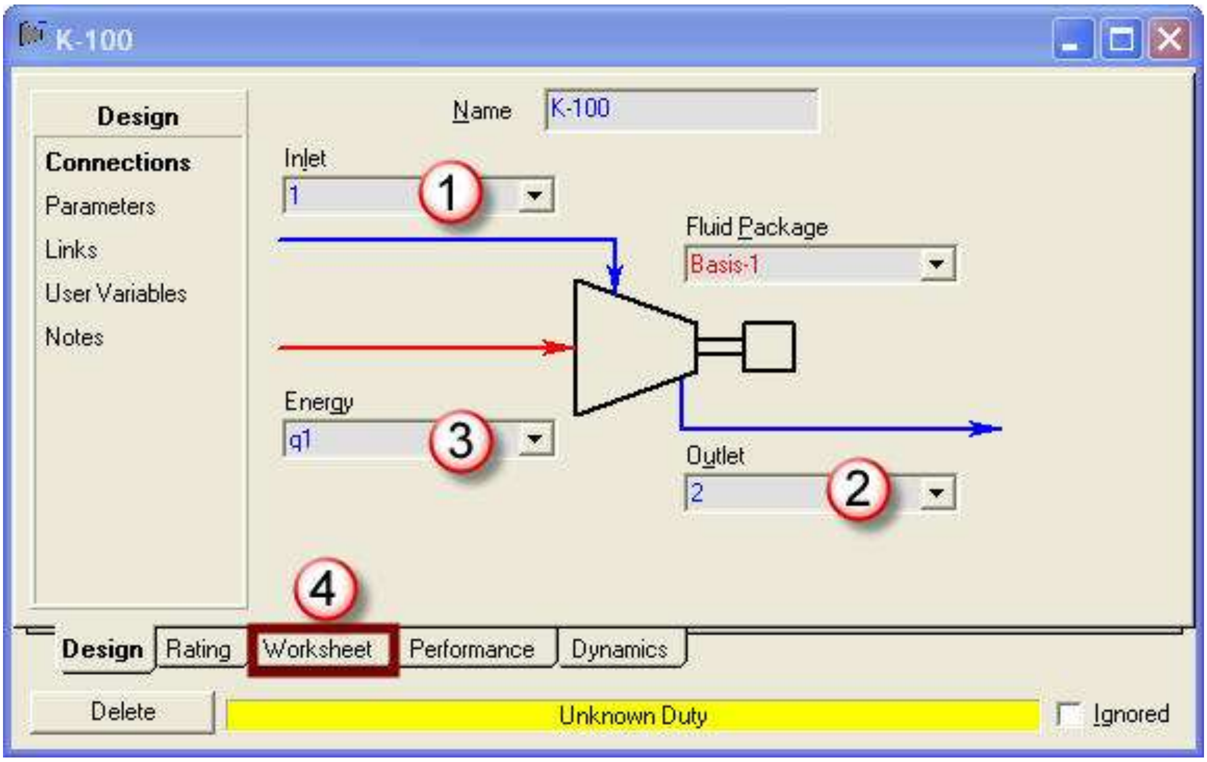
From the palette:

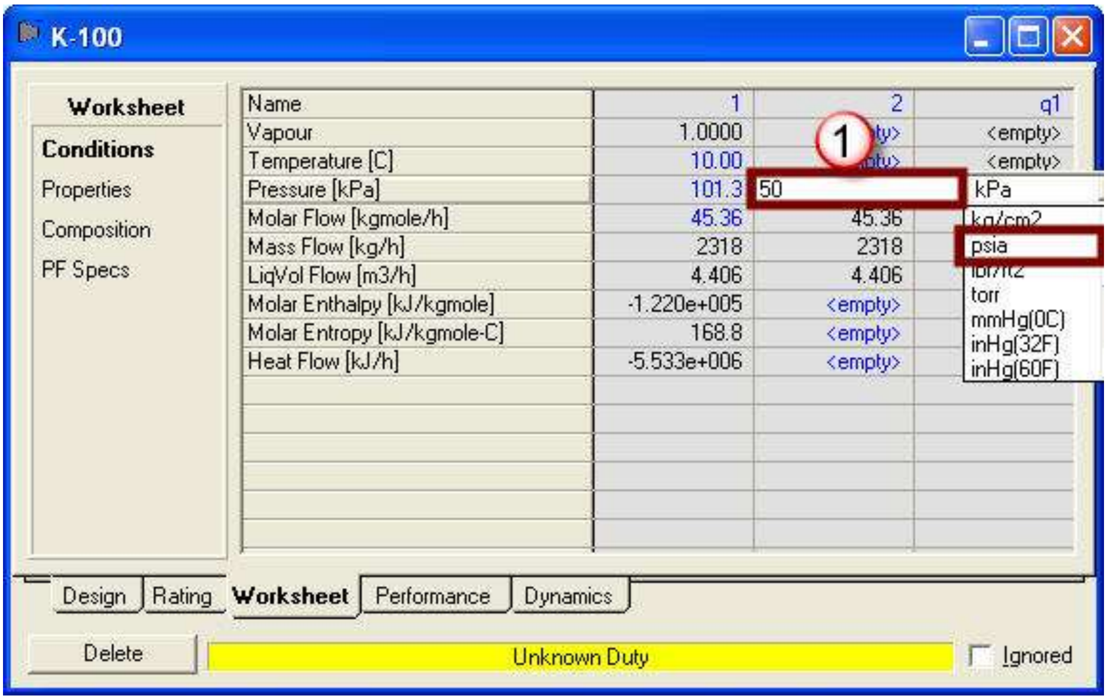




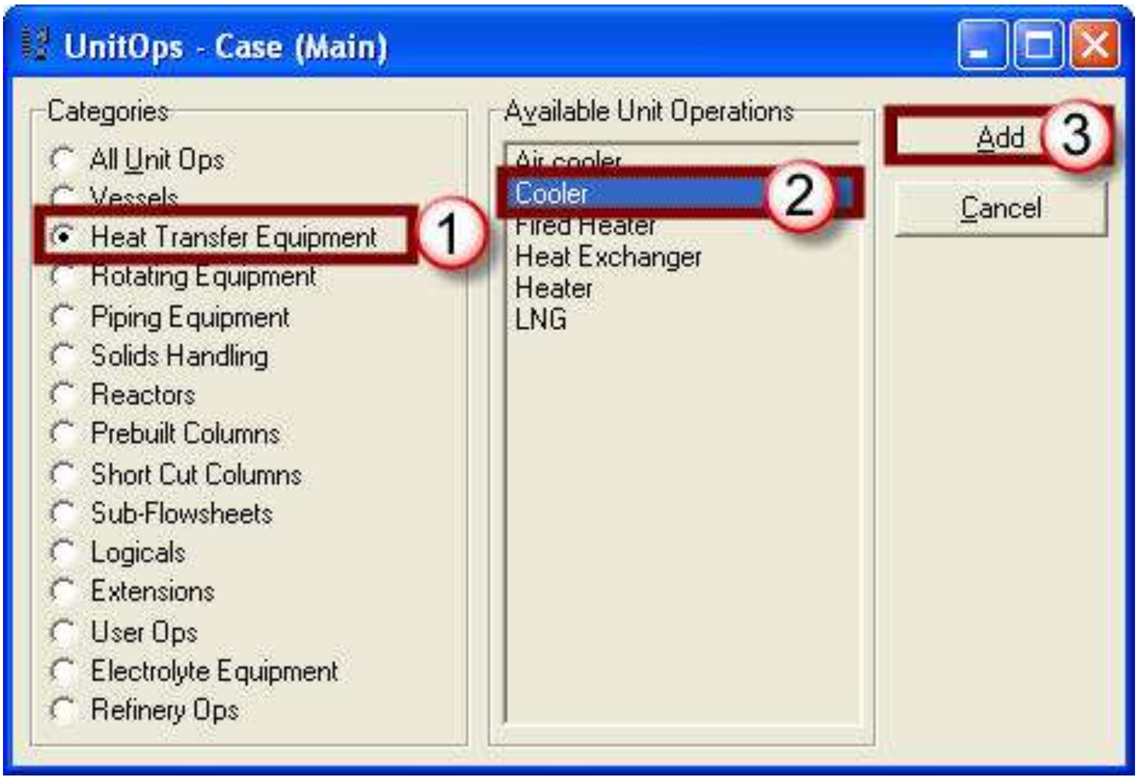

Material Stream: 1
Worksheet
Attachments
Dynamics
Worksheet
Conditions
Properties
Composition
Oil & Gas Feed
Petroleum Assay
K Value
User Variables
Notes
Cost Parameters
Normalized Yields
Stream Name 1
Vapour / Phase Fraction 1.0000
Temperature [C] 10.00
Pressure [kPa] 101.3
Molar Flow [kgmole/h] 45.36
Mass Flow [kg/h] 2318
Std Ideal Liq Vol Flow [m3/h] 4.406
Molar Enthalpy [kJ/kgmole] -1.220e+005
Molar Entropy [kJ/kgmole-C] 168.8
Heat Flow [kJ/h] -5.533e+006
Liq Vol Flow @Std Cond [m3/h] 4.308
Fluid Package Basis-1
Utility Type
OK

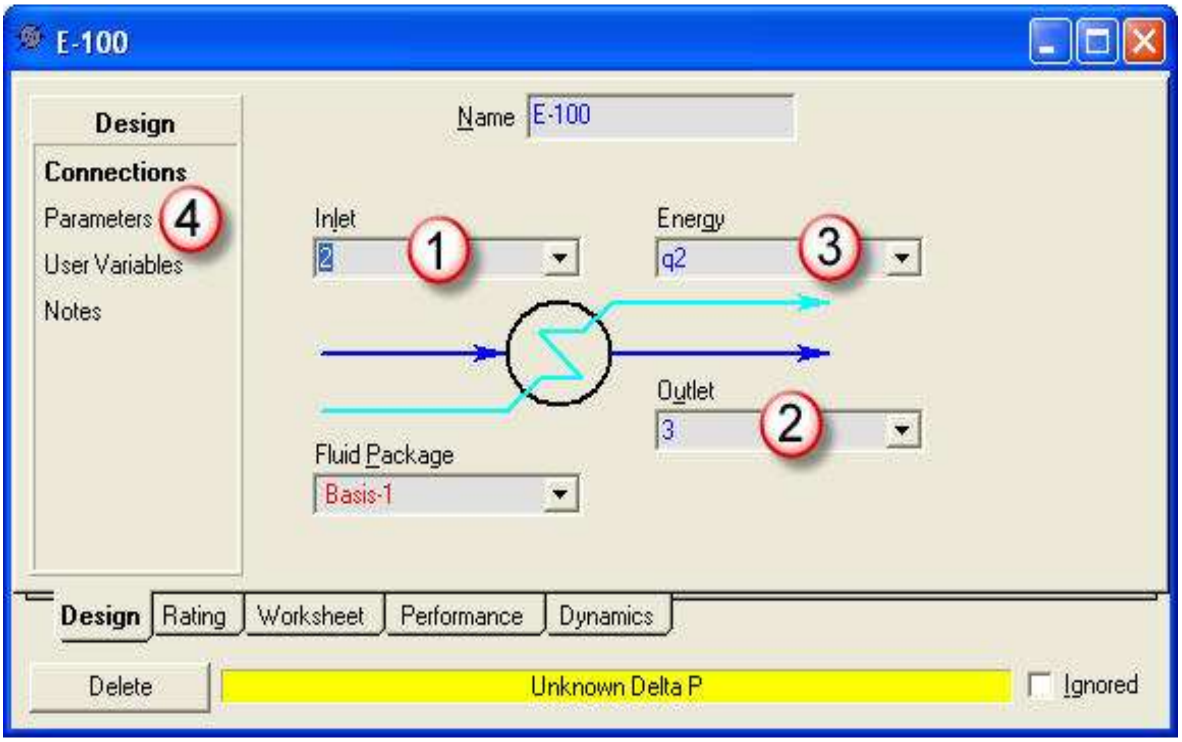

UnitOps - Case (Main)
F12
Categories
All Unit Ops
Vessels
Heat Transfer Equipment
Rotating Equipment
1
Piping Equipment
Solids Handling
Reactors
Prebuilt Columns
Short Cut Columns
Sub-Flowsheets
Logicals
Extensions
User Ops
Electrolyte Equipment
Refinery Ops
Available Unit Operations
Compressor
2
Expander
Pump
Add
3
Cancel

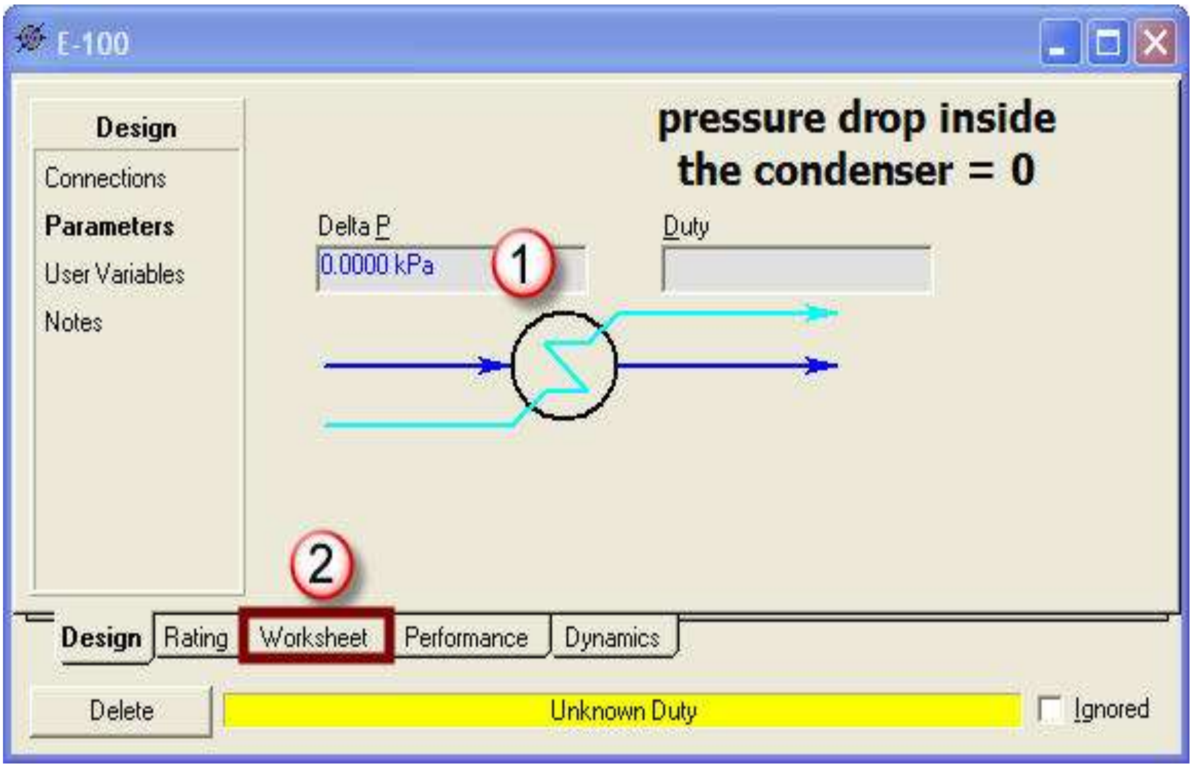

K-100
Design
Connections
Parameters
Links
User Variables
Notes
Name
K-100
Inlet
1
Fluid Package
Basis-1
Energy
q1
Outlet
2
Design
Rating
Worksheet
Performance
Dynamics
Delete
Unknown Duty
Ignored

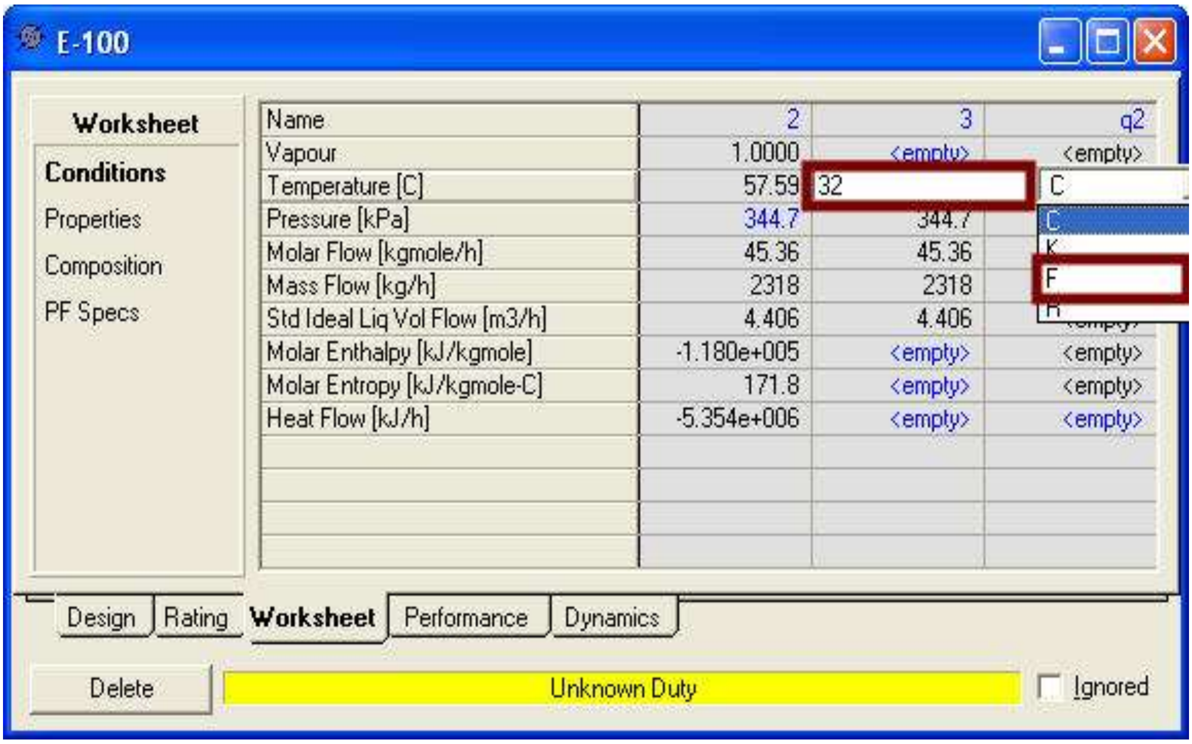

K-100
Worksheet
Conditions
Properties
Composition
PF Specs
Name
Vapour
Temperature [C]
Pressure [kPa]
Molar Flow [kgmole/h]
Mass Flow [kg/h]
LiqVol Flow [m3/h]
Molar Enthalpy [kJ/kgmole]
Molar Entropy [kJ/kgmole-C]
Heat Flow [kJ/h]
kPa
kg/cm2
psia
torr
mmHg(0C)
inHg(32F)
inHg(60F)
Design
Rating
Worksheet
Performance
Dynamics
Delete
Unknown Duty
Ignored

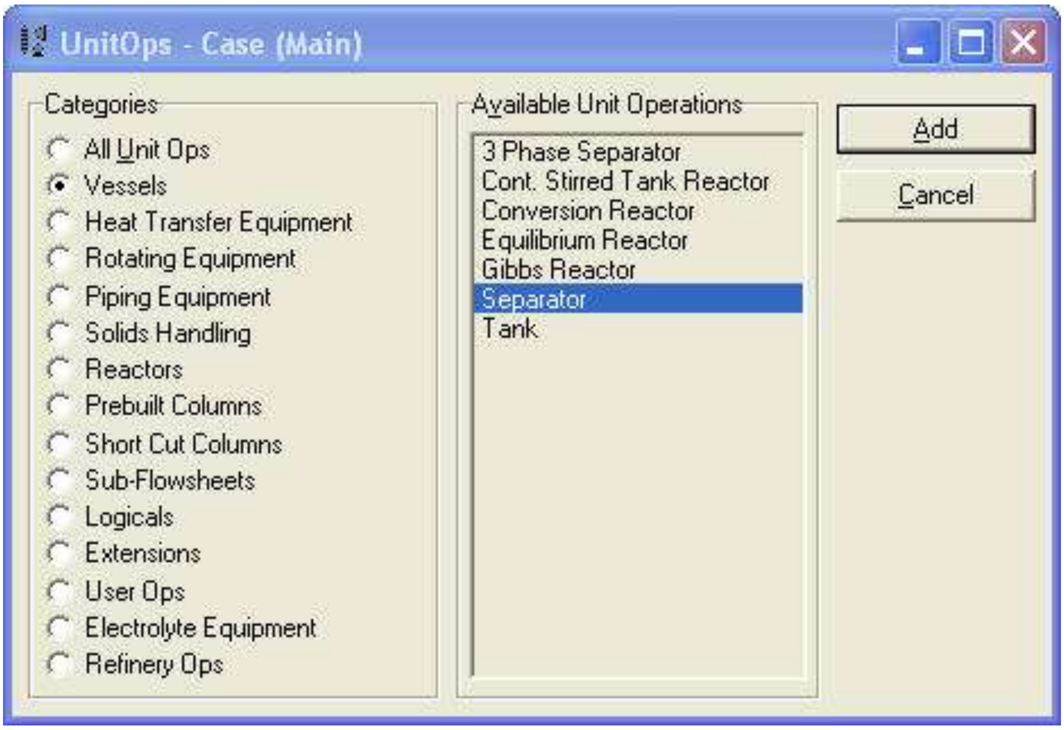

K-100
Worksheet
Conditions
Properties
Composition
PF Specs
Name | 1 | 2 | q1
Vapour | 1.0000 | 1.0000 | <empty>
Temperature [C] | 10.00 | 57.59 | <empty>
Pressure [kPa] | 101.3 | 344.7 | <empty>
Molar Flow [kgmole/h] | 45.36 | 45.36 | <empty>
Mass Flow [kg/h] | 2318 | 2318 | <empty>
LiqVol Flow [m3/h] | 4.406 | 4.406 | <empty>
Molar Enthalpy [kJ/kgmole] | -1.220e+005 | -1.180e+005 | <empty>
Molar Entropy [kJ/kgmole-C] | 168.8 | 171.8 | <empty>
Heat Flow [kJ/h] | -5.533e+006 | -5.354e+006 | 1.783e+005
Design
Rating
Worksheet
Performance
Dynamics
Delete
OK
Ignored

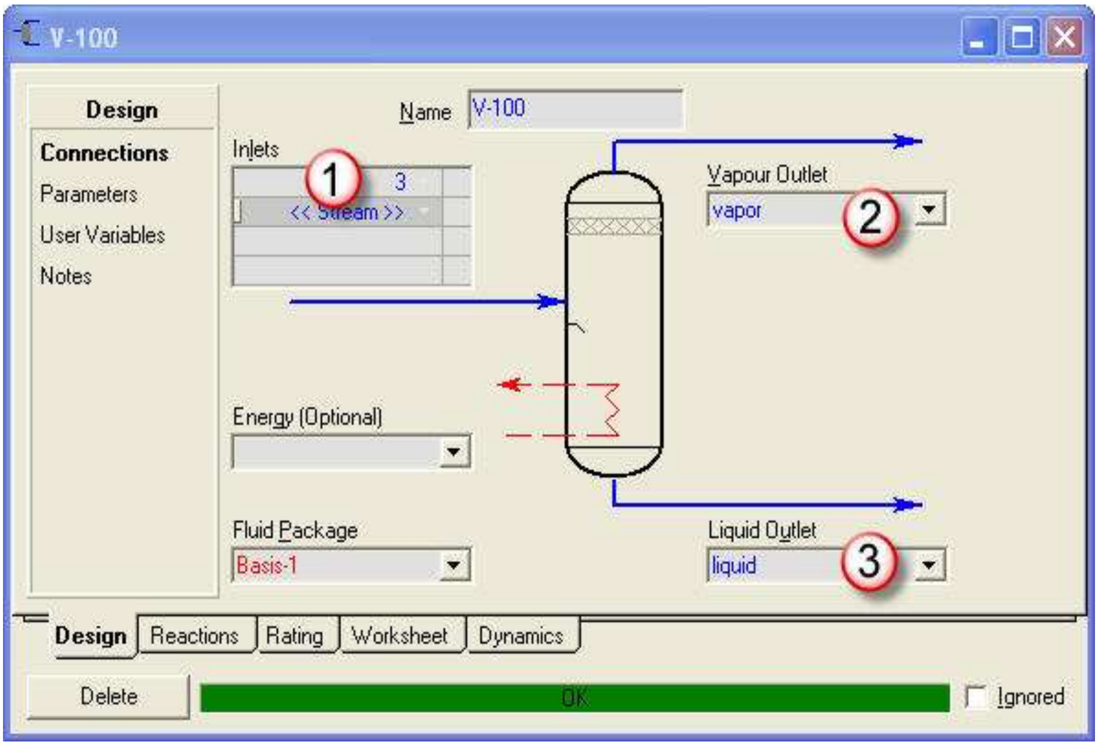

UnitOps - Case (Main)
Categories
All Unit Ops
Vessels
Heat Transfer Equipment
1
Rotating Equipment
Piping Equipment
Solids Handling
Reactors
Prebuilt Columns
Short Cut Columns
Sub-Flowsheets
Logicals
Extensions
User Ops
Electrolyte Equipment
Refinery Ops
Available Unit Operations
Air cooler
Cooler
2
Fired Heater
Heat Exchanger
Heater
LNG
Add
3
Cancel

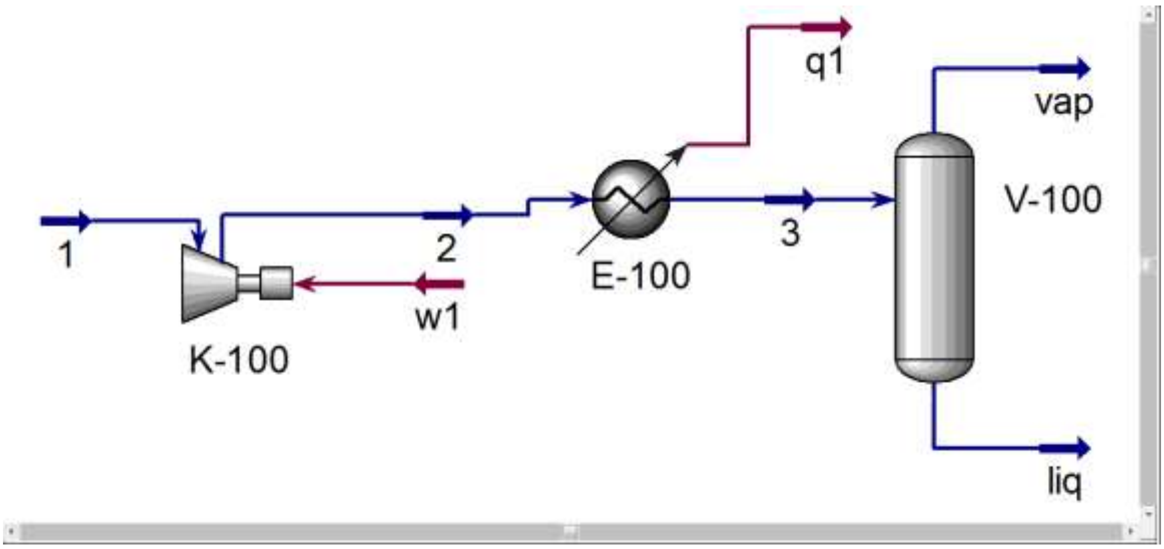

E-100
Design
Connections
Parameters
User Variables
Notes
Name
E-100
Inlet
2
Energy
q2
Outlet
3
Fluid Package
Basis-1
1
2
3
4
Design
Rating
Worksheet
Performance
Dynamics
Delete
Unknown Delta P
Ignored


E-100
Design
Connections
Parameters
User Variables
Notes
pressure drop inside
the condenser = 0
Delta P
0.0000 kPa
Duty
1
2
Design
Rating
Worksheet
Performance
Dynamics
Delete
Unknown Duty
Ignored

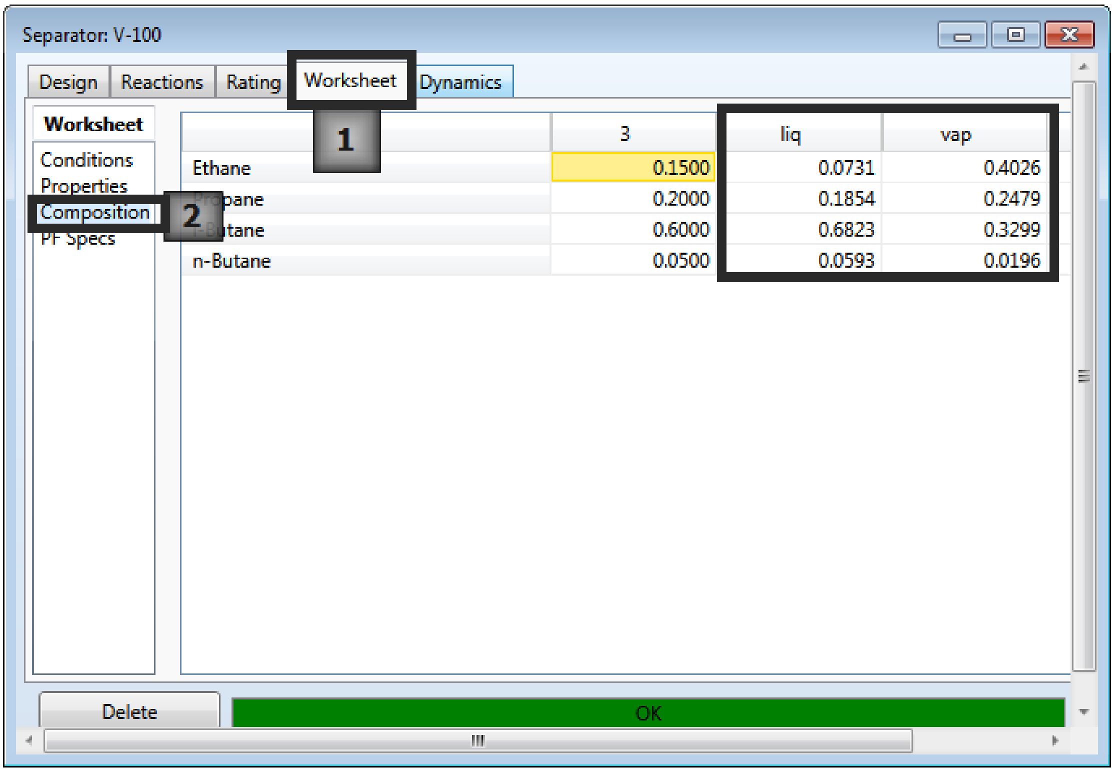

E-100
Worksheet
Conditions
Properties
Composition
PF Specs
Name
Vapour
Temperature [C]
Pressure [kPa]
Molar Flow [kgmole/h]
Mass Flow [kg/h]
Std Ideal Liq Vol Flow [m3/h]
Molar Enthalpy [kJ/kgmole]
Molar Entropy [kJ/kgmole-C]
Heat Flow [kJ/h]
2
3
q2
1.0000
57.59
32
344.7
45.36
2318
4.406
-1.180e+005
171.8
-5.354e+006
<empty>
C
K
F
Design
Rating
Worksheet
Performance
Dynamics
Delete
Unknown Duty
Ignored


UnitOps - Case (Main)
Categories
All Unit Ops
Vessels
Heat Transfer Equipment
Rotating Equipment
Piping Equipment
Solids Handling
Reactors
Prebuilt Columns
Short Cut Columns
Sub-Flowsheets
Logicals
Extensions
User Ops
Electrolyte Equipment
Refinery Ops
Available Unit Operations
3 Phase Separator
Cont. Stirred Tank Reactor
Conversion Reactor
Equilibrium Reactor
Gibbs Reactor
Separator
Tank
Add
Cancel





Now you can view the results by double clicking on the separator, in the worksheet tab:



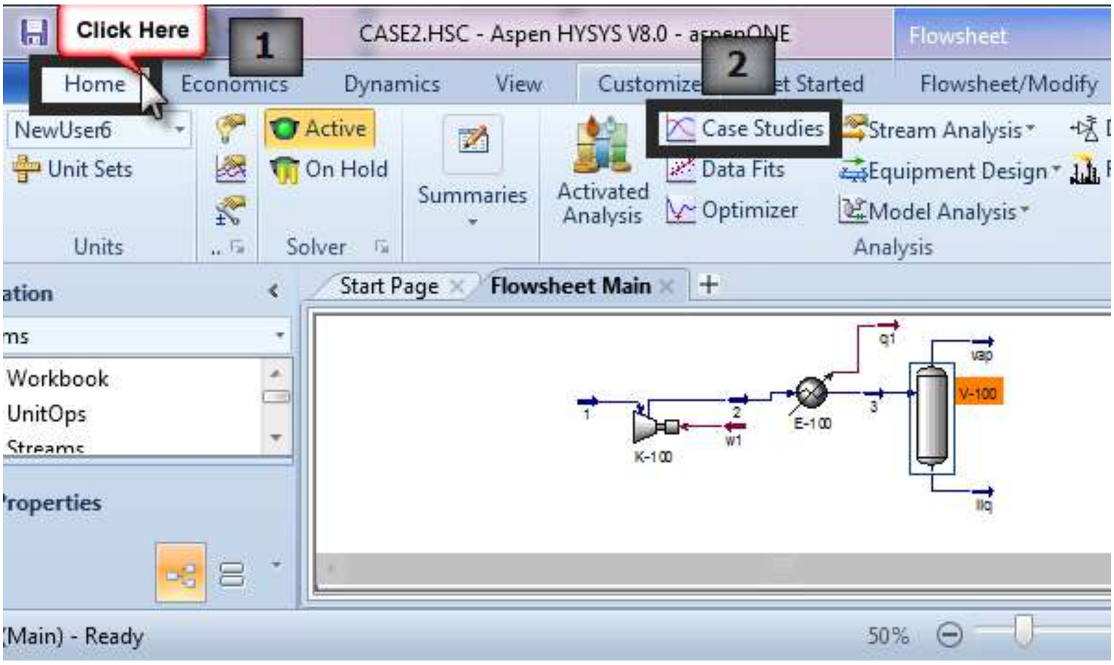
Save Your Case!

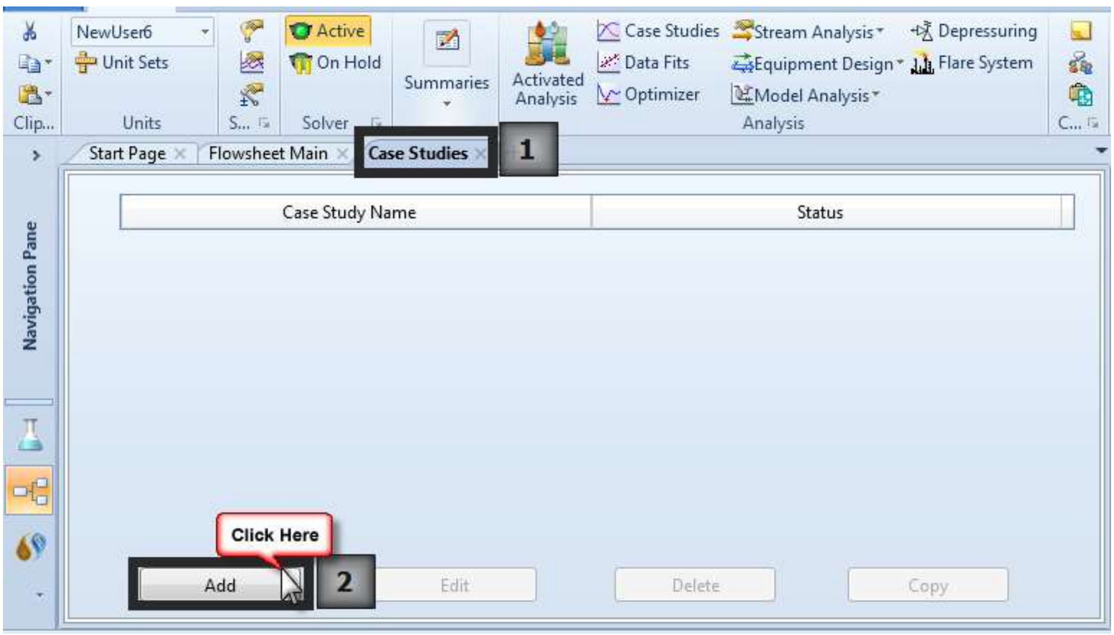
Case Study

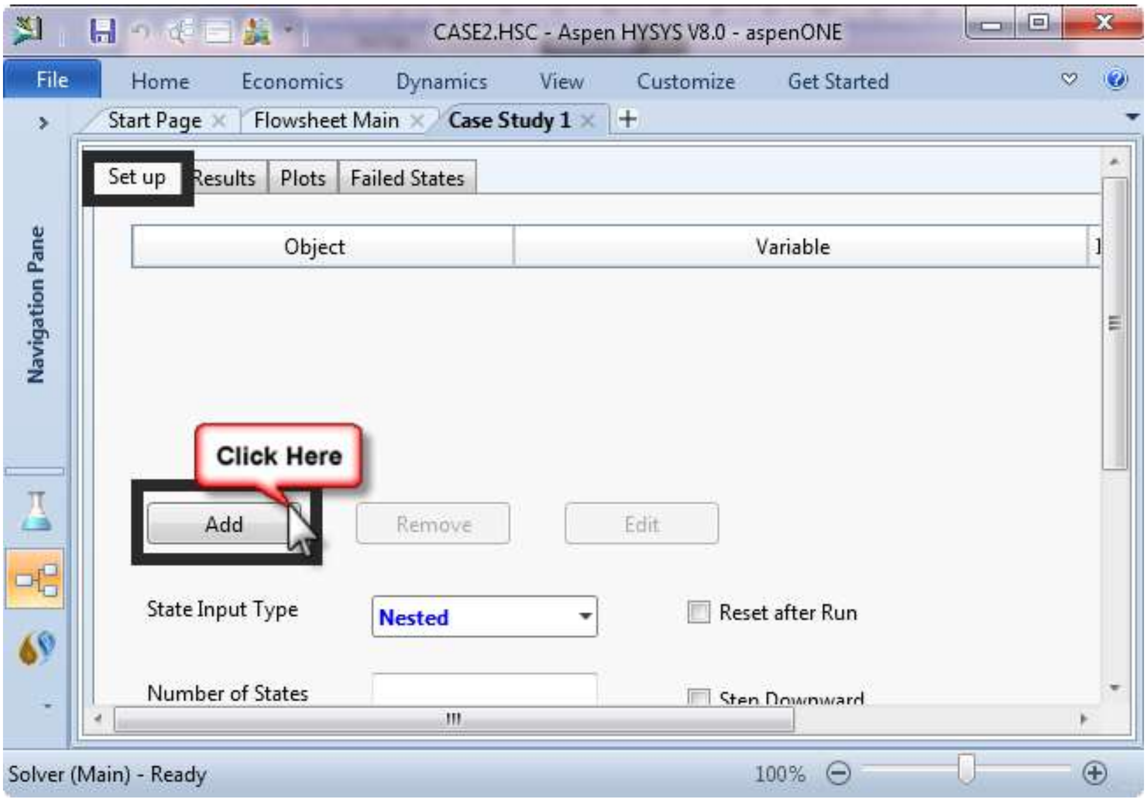
We need to study the effect of changing the Temperature of the cooler out stream (stream no 3) on the flow rate of the liquid product stream.

Use range: from -30 to 30 °C with step size =5 °C

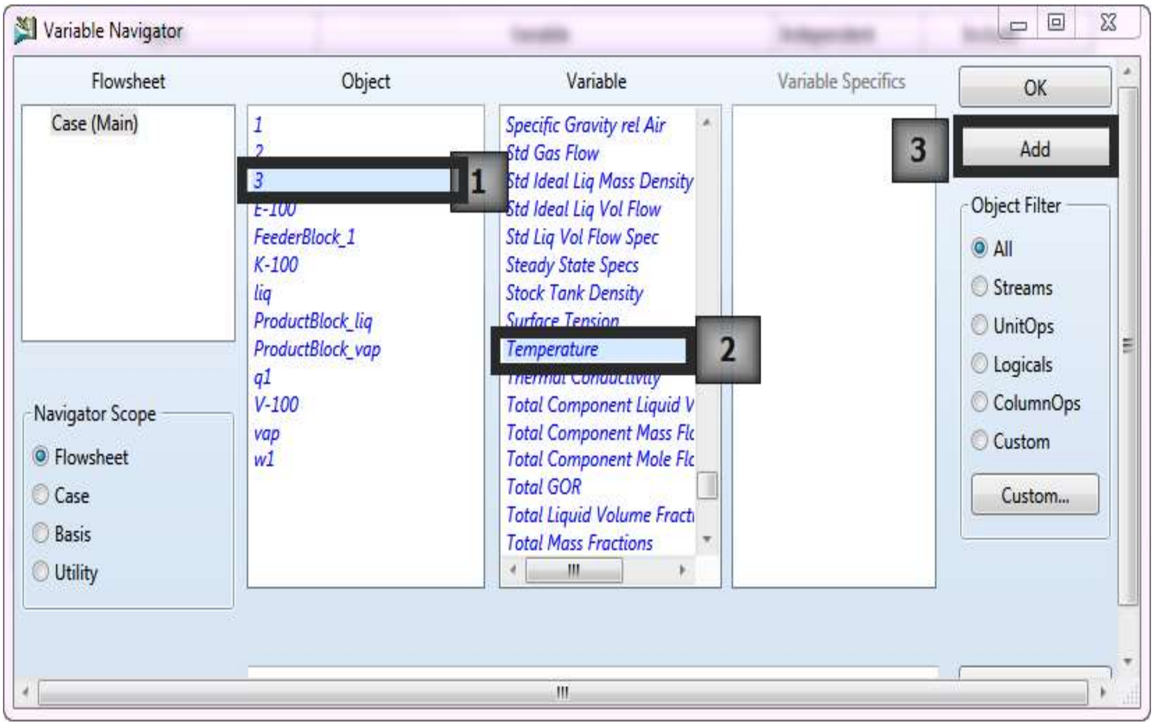
To create a case study in HYSYS you can simply click on Case Studies button on the Home menu:

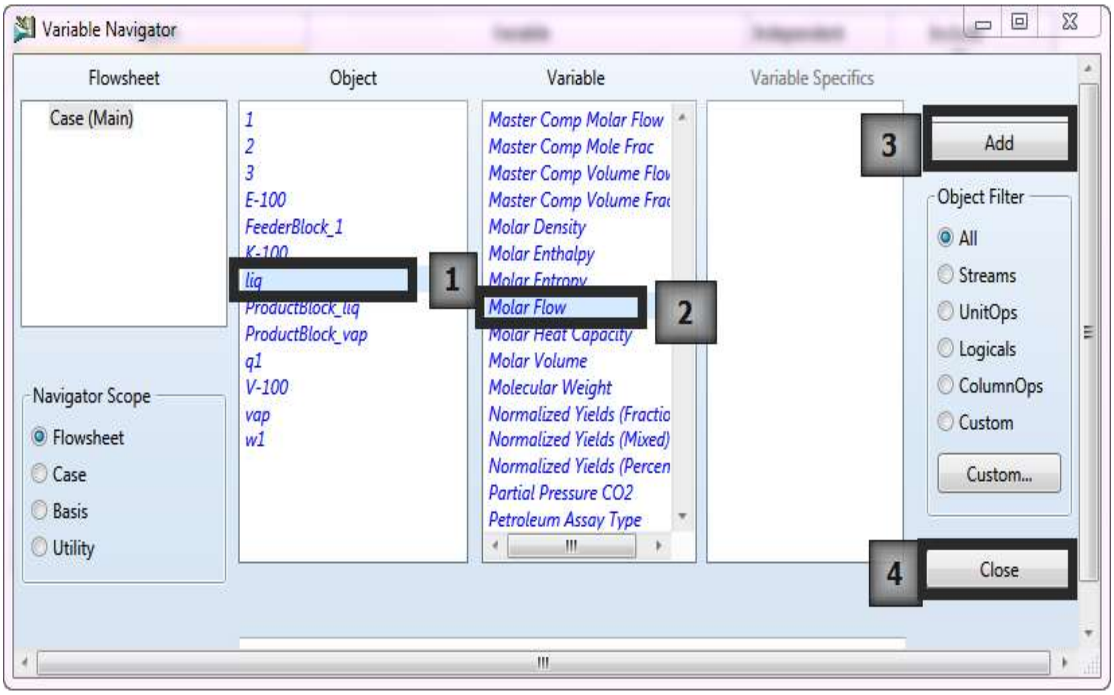




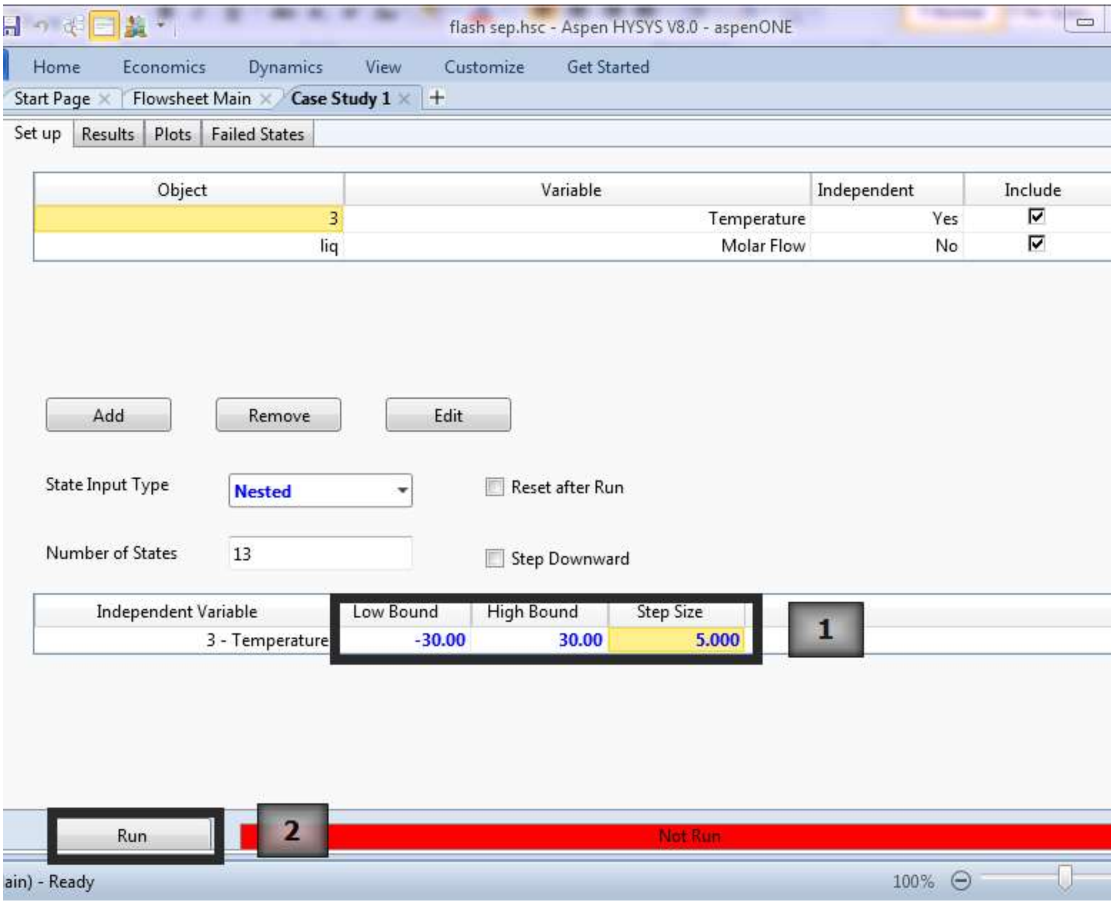


Add the two variables:

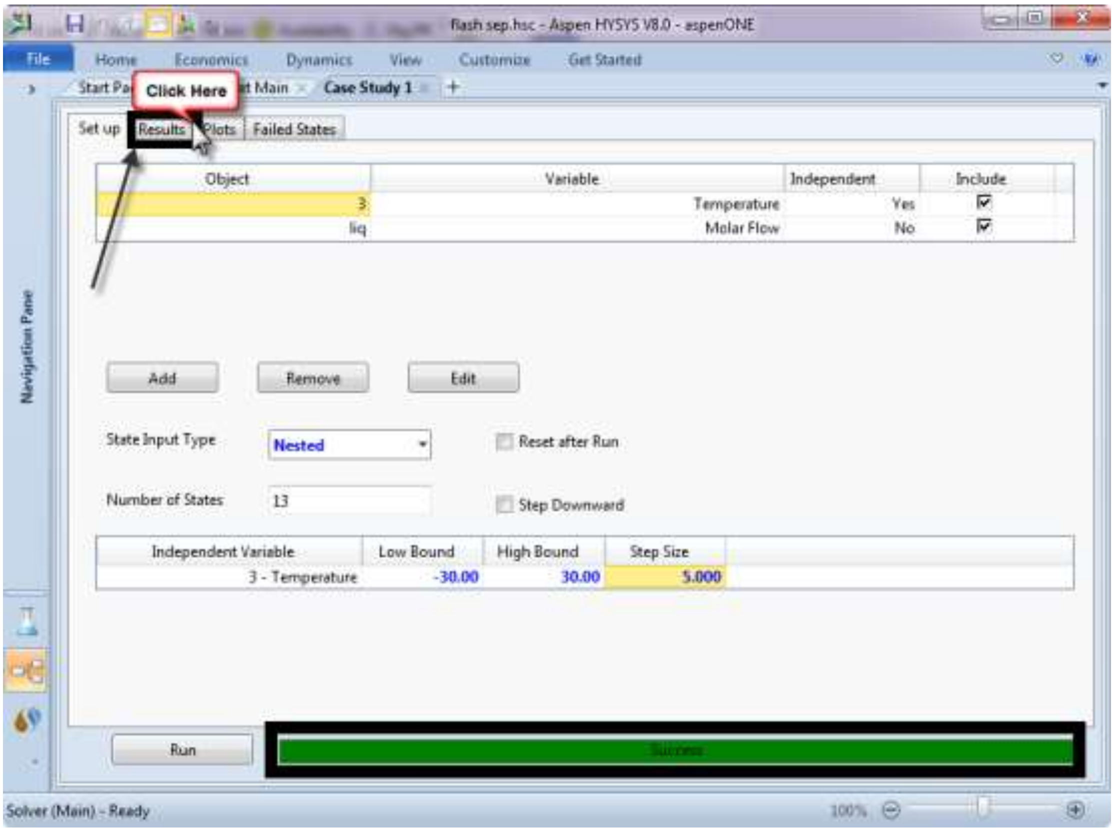


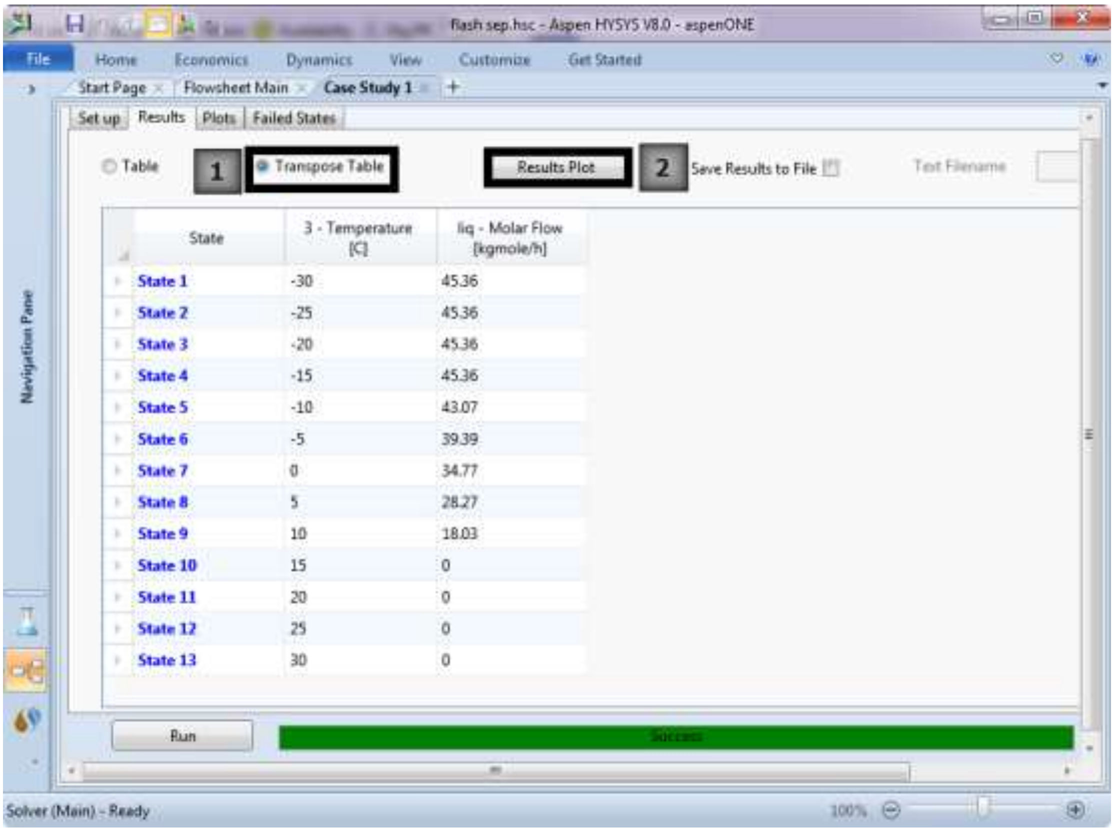


Specify the range of the study:

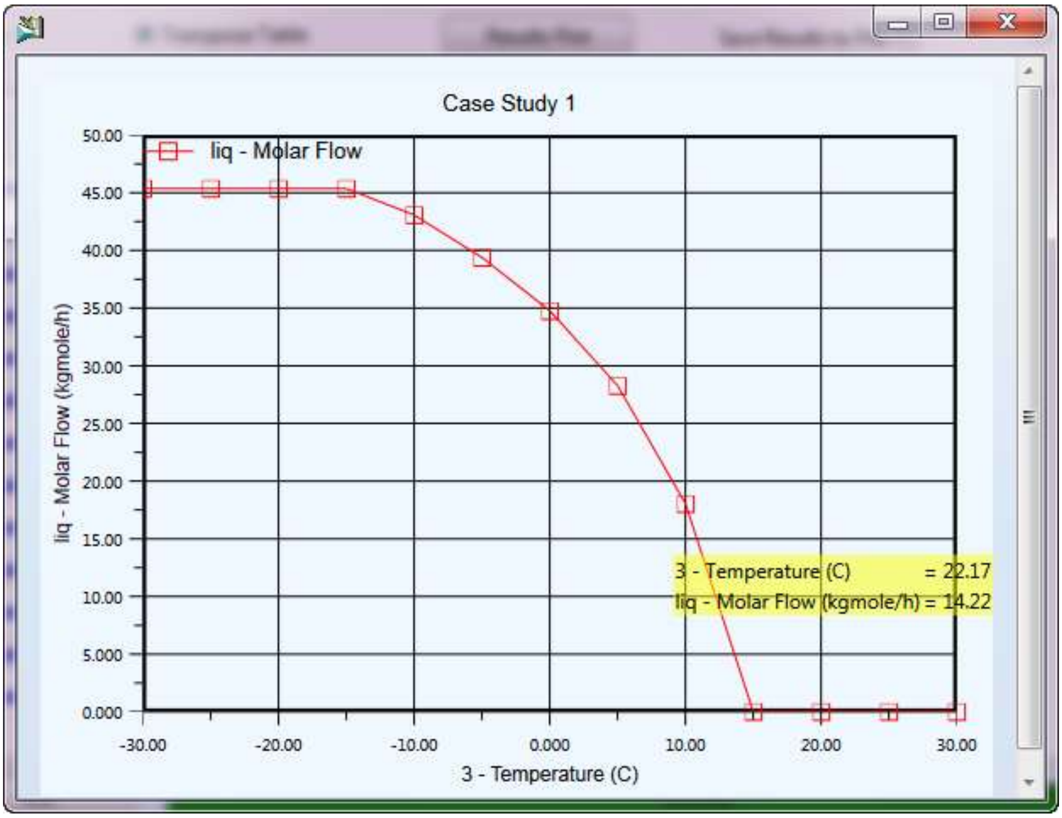


Click run, and then you can view results from the Results tab


Flash sep.hsc - Aspen HYSYS V8.0 - aspenONE
Click Here
Set up
Results
Plots
Failed States
Object
Variable
Independent
Include
3
Temperature
Yes
liq
Molar Flow
No
Add
Remove
Edit
State Input Type
Nested
Reset after Run
Number of States
13
Step Downward
Independent Variable
Low Bound
High Bound
Step Size
3 - Temperature
-30.00
30.00
5.000
Run
Solver (Main) - Ready


Flash sep.hsc - Aspen HYSYS V8.0 - aspenONE
Table
1
Transpose Table
Results Plot
2
Save Results to File
State
3 - Temperature [C]
liq - Molar Flow [kgmole/h]
State 1 -30 45.36
State 2 -25 45.36
State 3 -20 45.36
State 4 -15 45.36
State 5 -10 43.07
State 6 -5 39.39
State 7 0 34.77
State 8 5 28.27
State 9 10 18.03
State 10 15 0
State 11 20 0
State 12 25 0
State 13 30 0
Run
Solver (Main) - Ready

Click **Results Plot** to view graph

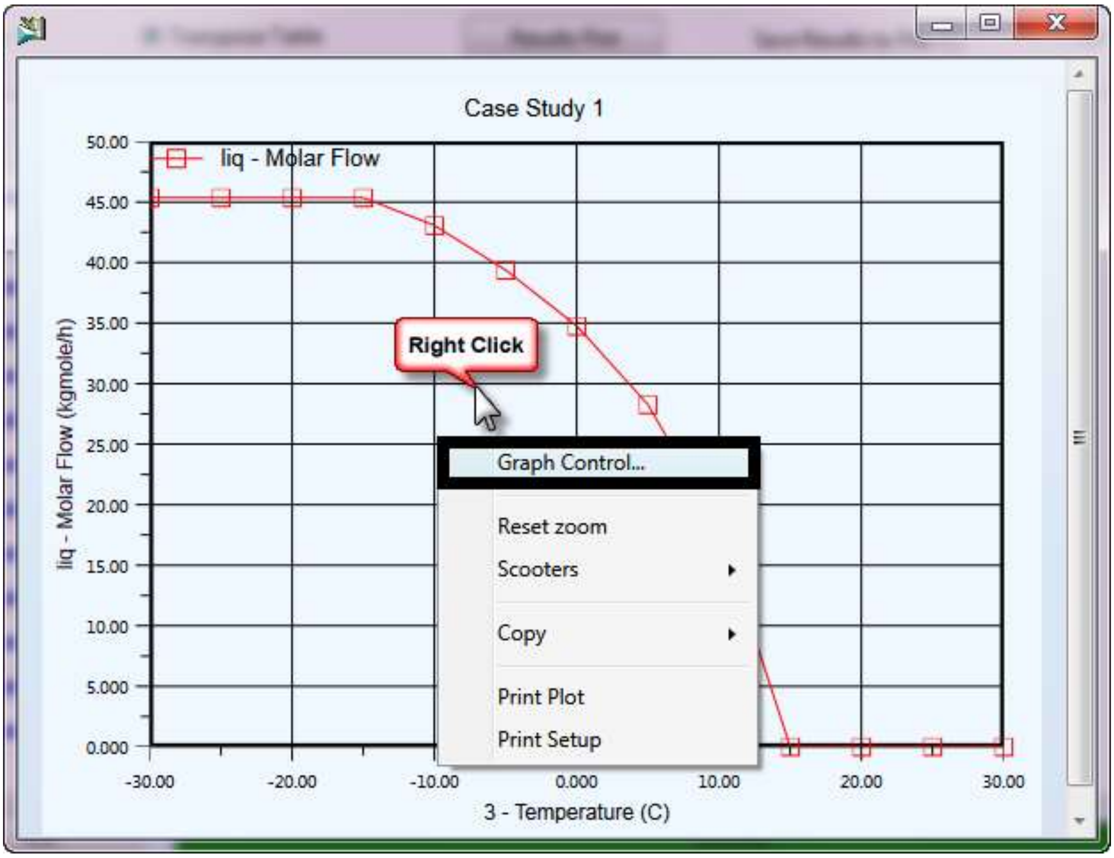


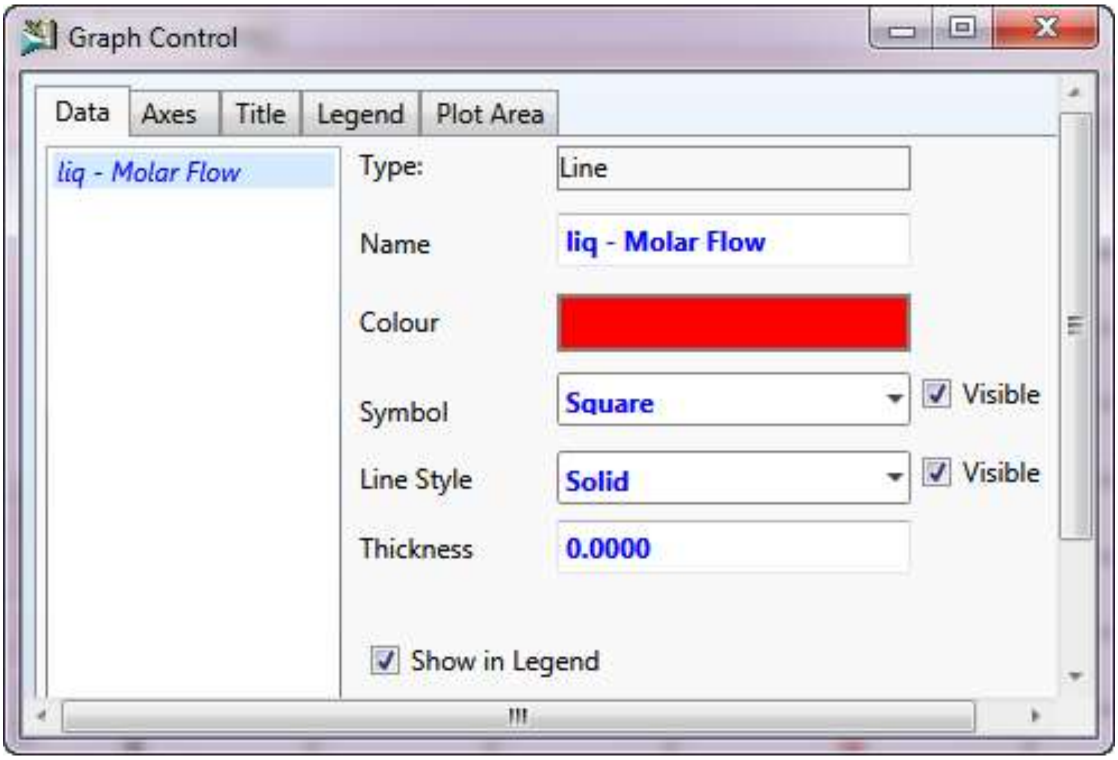
Comment:

As we see, when the temperature increases the liquid flow rate decrease, the liquid start to decrease @ -15 °C, and @ 15 °C there will be no liquid product and all the product will be vapor.

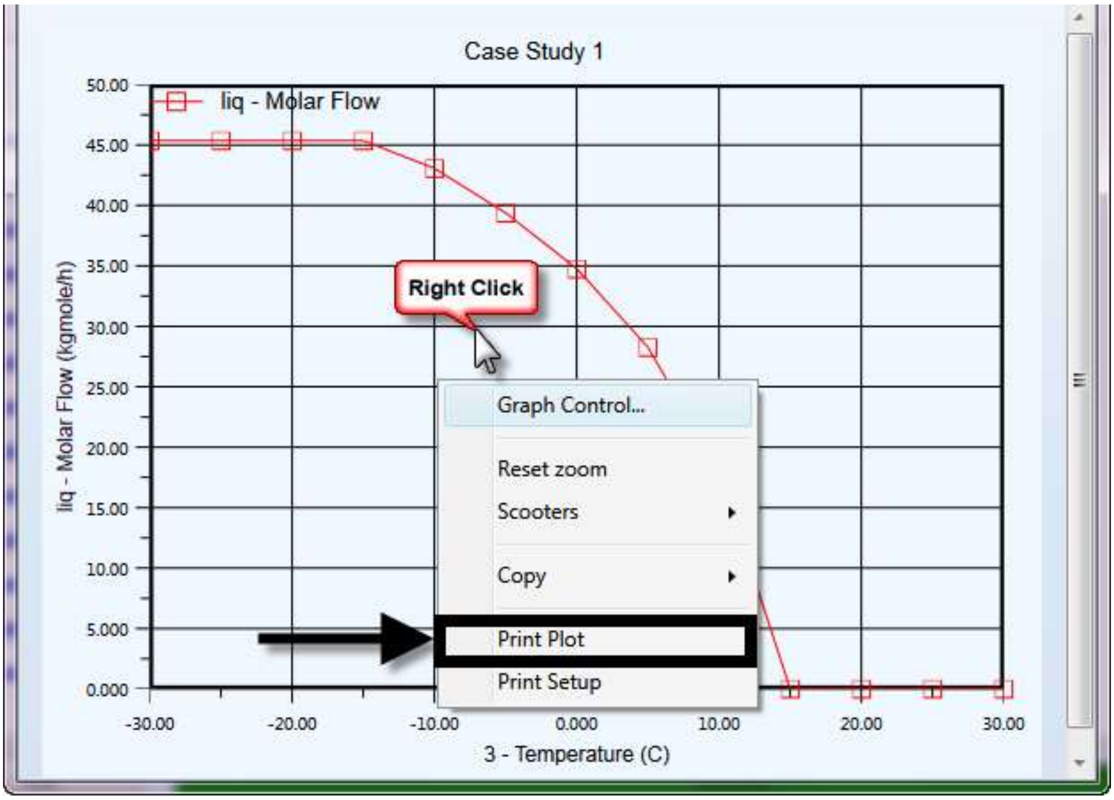
This is a simple case; you can create your own case study with the same steps.

You can change the scale of axis & the curve color by right click on the plot area and click graph control:





You can also print this plot from the same menu:



Save Your Case!

Refrigerated Gas Plant

2

Workshop

In this simulation, a simplified version of a refrigerated gas plant is going to be modeled. The purpose is to find the LTS (Low Temperature Separator) temperature at which the hydrocarbon dew point target is met. The Sales Gas hydrocarbon dew point should not exceed -15°C at 6000 kPa. The incoming gas is cooled in two stages—first by exchange with product Sales Gas in a gas-gas exchanger (Gas-Gas) and then in a propane chiller (Chiller), represented here by a Cooler operation. A Balance operation will be used to evaluate the hydrocarbon dew point of the product stream at 6000 kPa.

Learning Objectives

- Add a hypothetical component
- Install and converge heat exchangers.
- Understand logical operations (Balances and Adjusts).
- Use the Case Study tool to perform case studies on your simulation.

Example:

The feed stream enters an **inlet separator**, which removes the free liquids. Overhead gas from the Separator is fed to the Chiller where it is cooled to -20°C, which will be modeled simply as a Cooler (Pressure Drop=35 kPa). The cold stream is then separated in a low-temperature separator (LTS). Overhead gas from the LTS is fed to the heater (Pressure drop=5kPa) where it is heated to 10°C to meet Sales Gas Specifications.

Feed Stream:

Temperature	Pressure	Molar Flow Rate
15°C	6200 kPa	1440 kgmole/h

Composition:

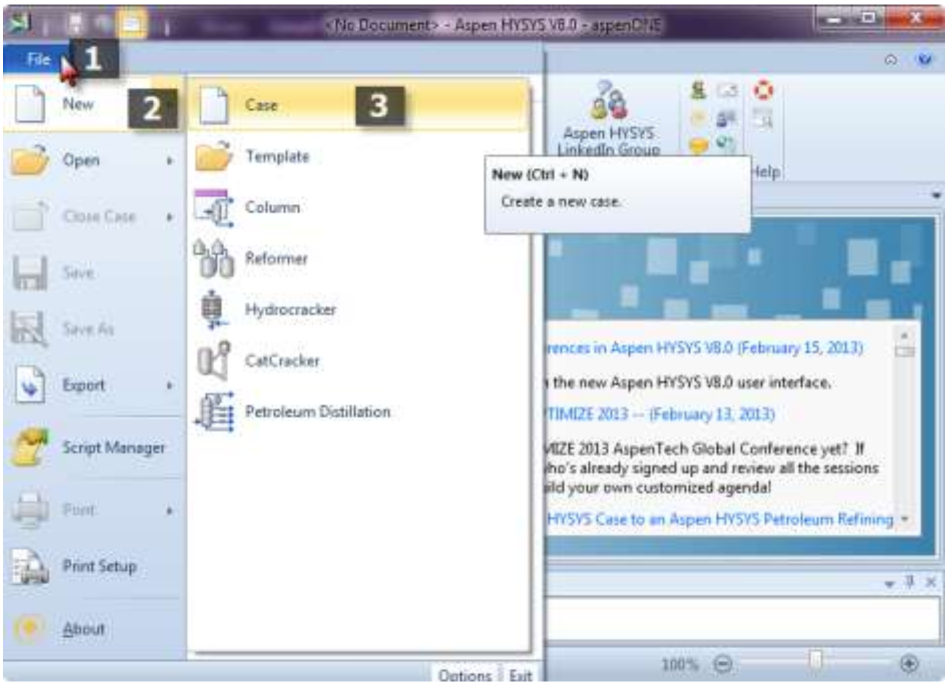
Component	Mole	Component	Mole
N_2	0.0066	n-Butane	**0.0101**
H_2S	0.0003	i-Pentane	**0.0028**
CO_2	0.0003	n-Pentane	**0.0027**
Methane	0.7575	n-Hexane	**0.0006**
Ethane	0.1709	H_2O	**0.0000**
Propane	0.0413	C7+ (NBP=110°C)	**0.0001**
i-Butane	0.0068		

FP: Peng Robinson

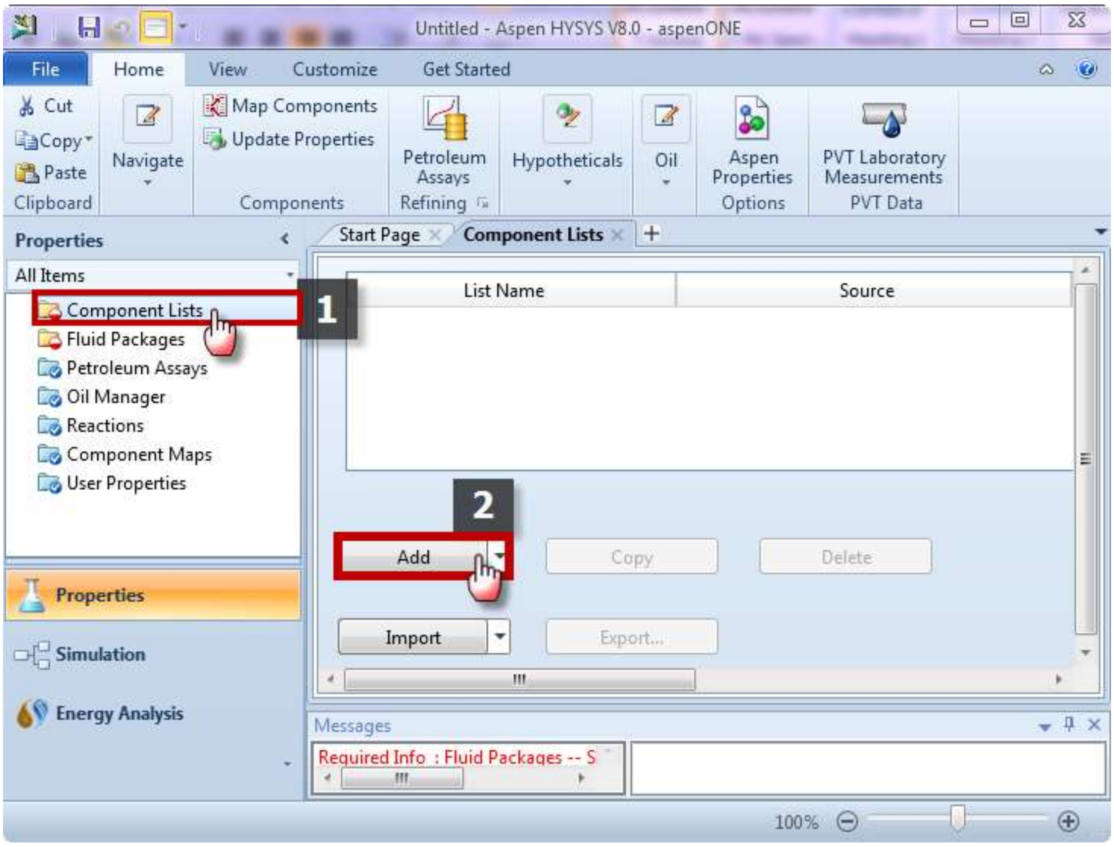
- Calculate the duty rejected from the chiller ………………
- Calculate the duty Absorbed inside the Heater ……………

To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >> Aspen HYSYS

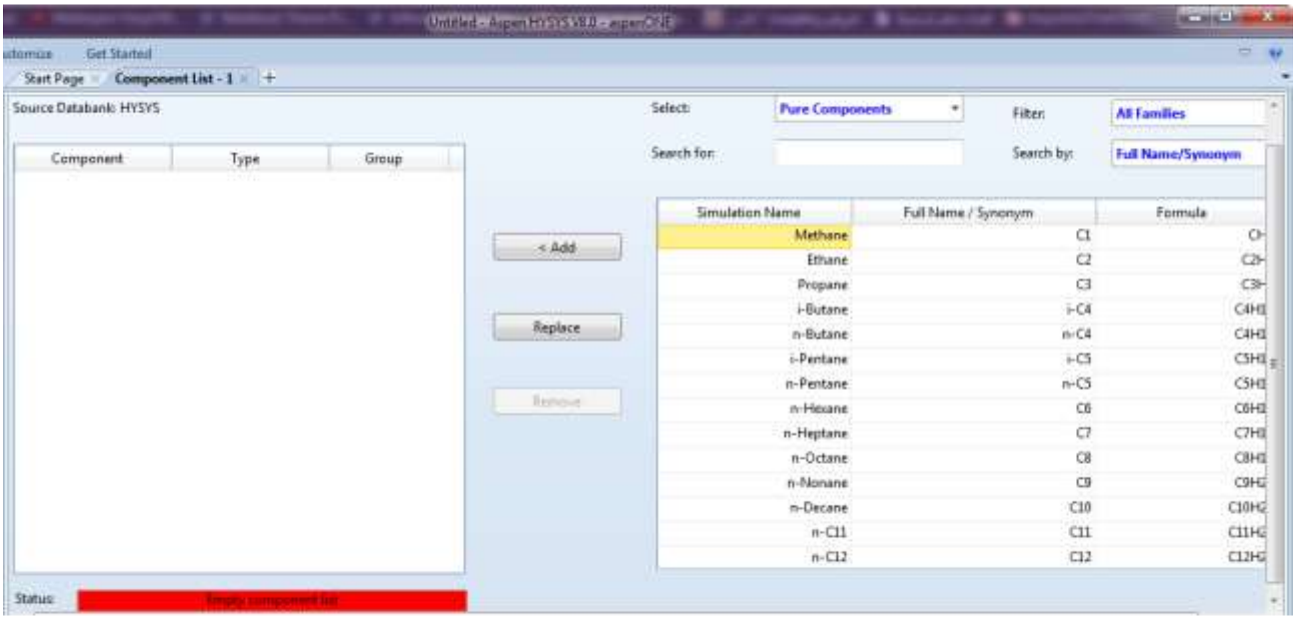
4- First, Start a new case

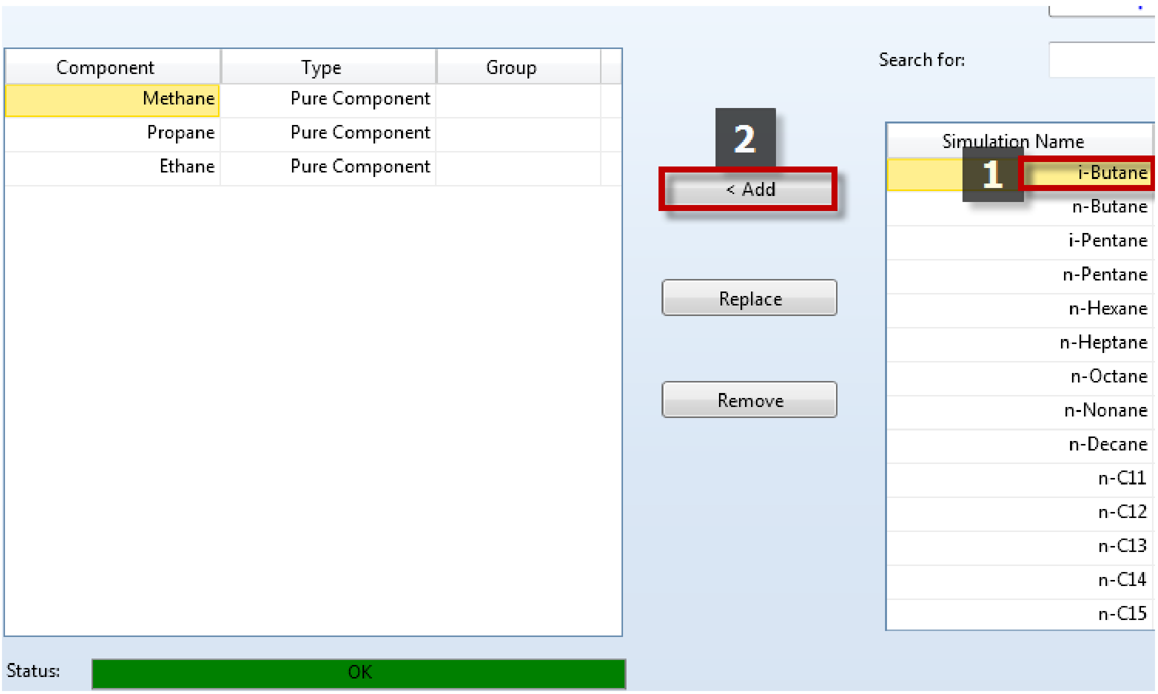


5- Add the Components



6- Choose the system components from the databank:

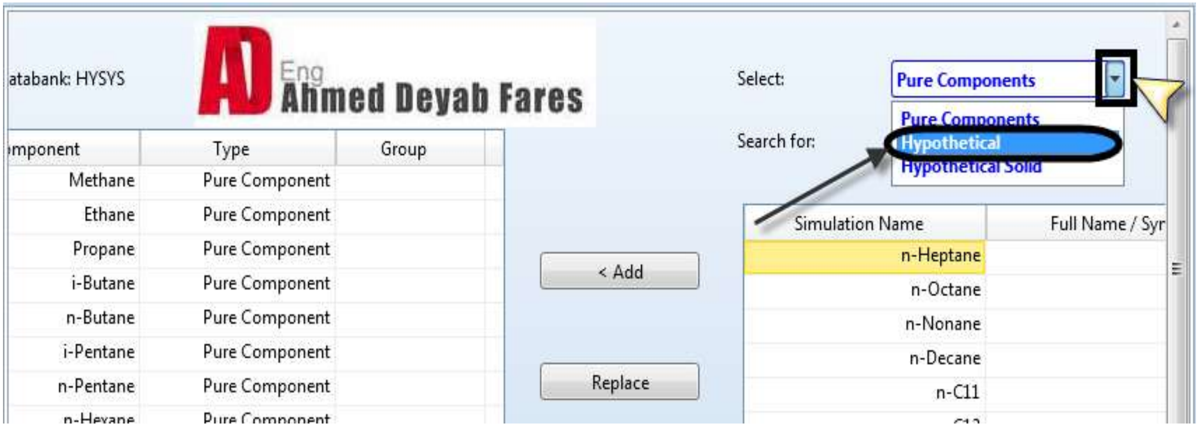




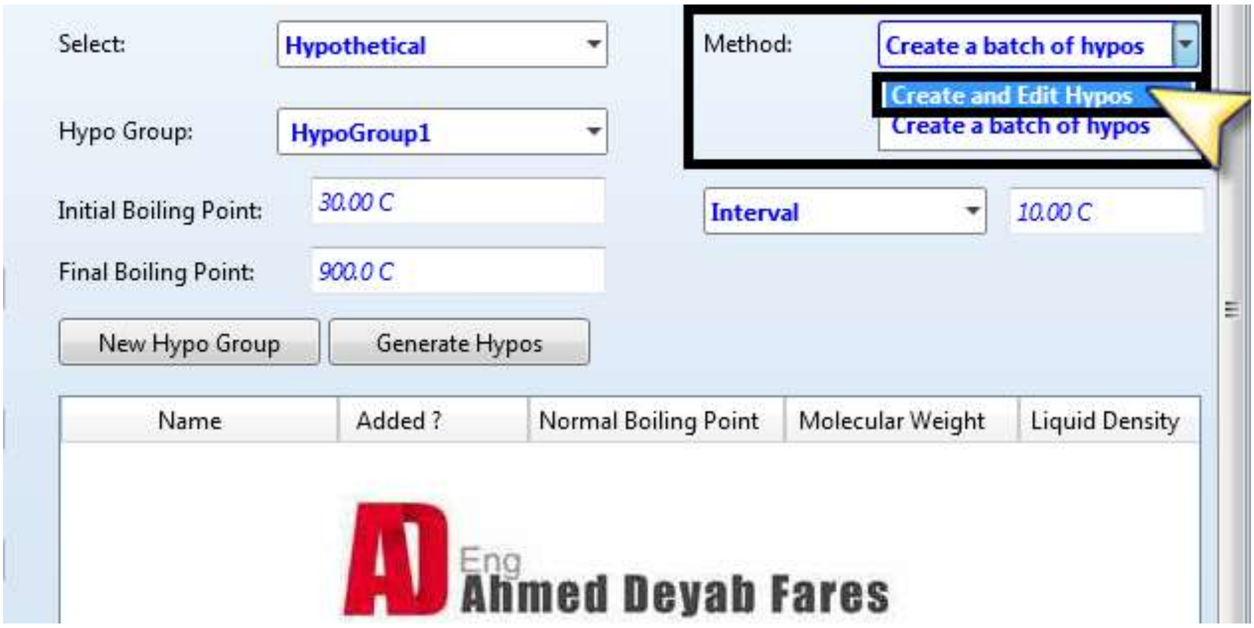
After adding the pure components (N_2, H_2S, CO_2, C1, C2, C3, n-C4, i-C4, n-C5, i-C5, n-C6, H_2O) we have to add the last component ($C7^+$) which is not a pure component as it represents all components above C7 including C7 in the feed.

To define C7+ we have to create it as a hypothetical component as the following:

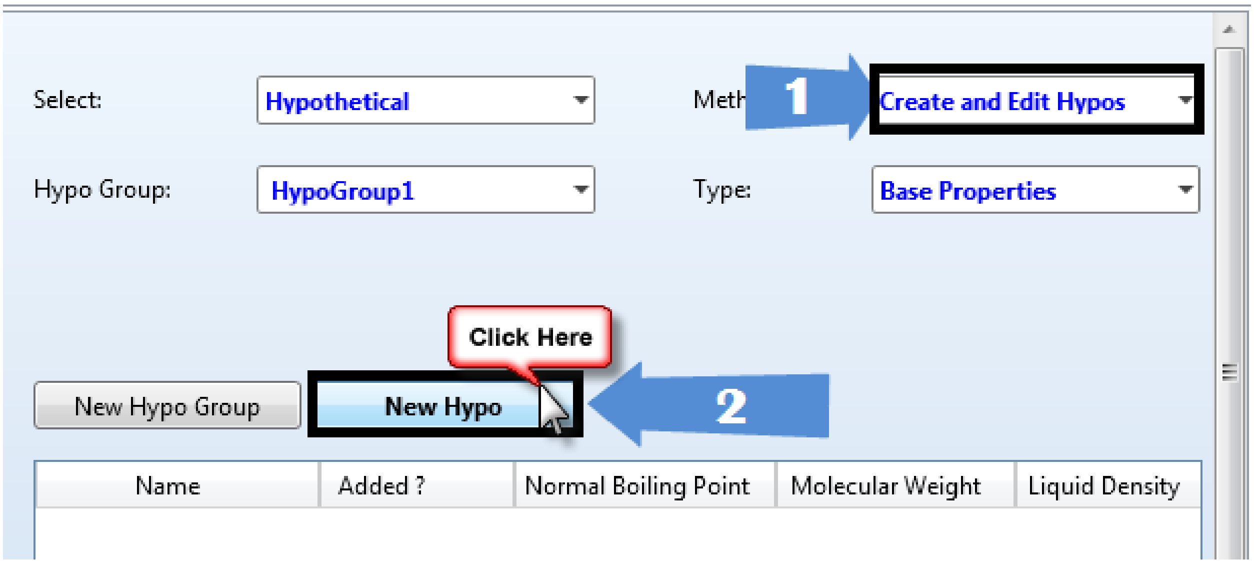
From the drop menu select Hypothetical instead of pure components



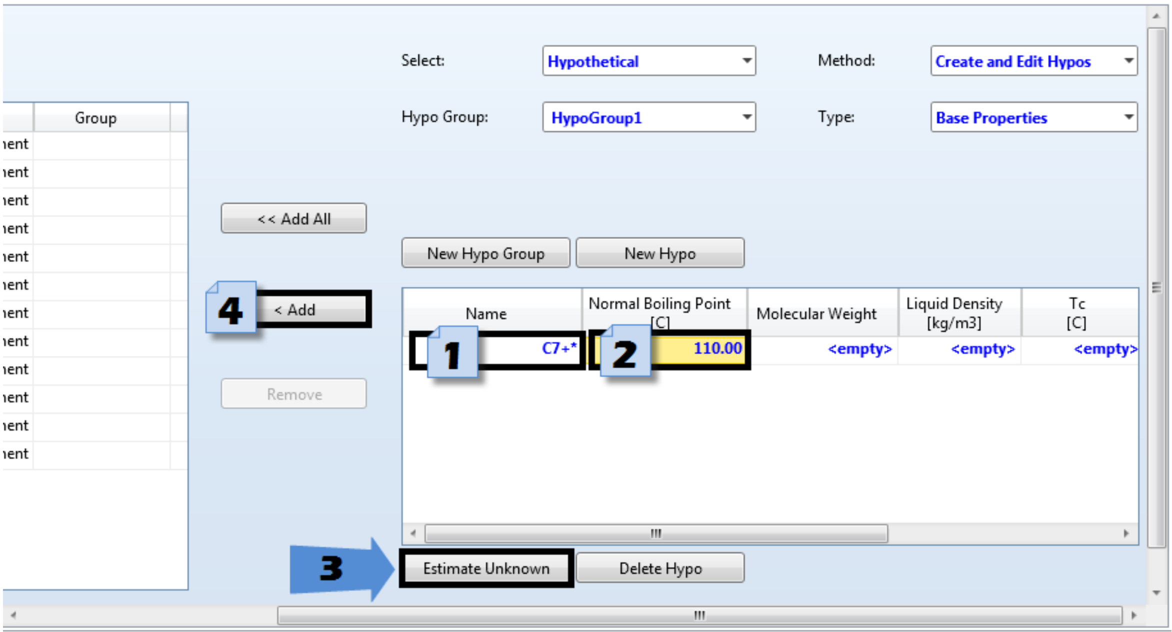
Select create and edit hypos



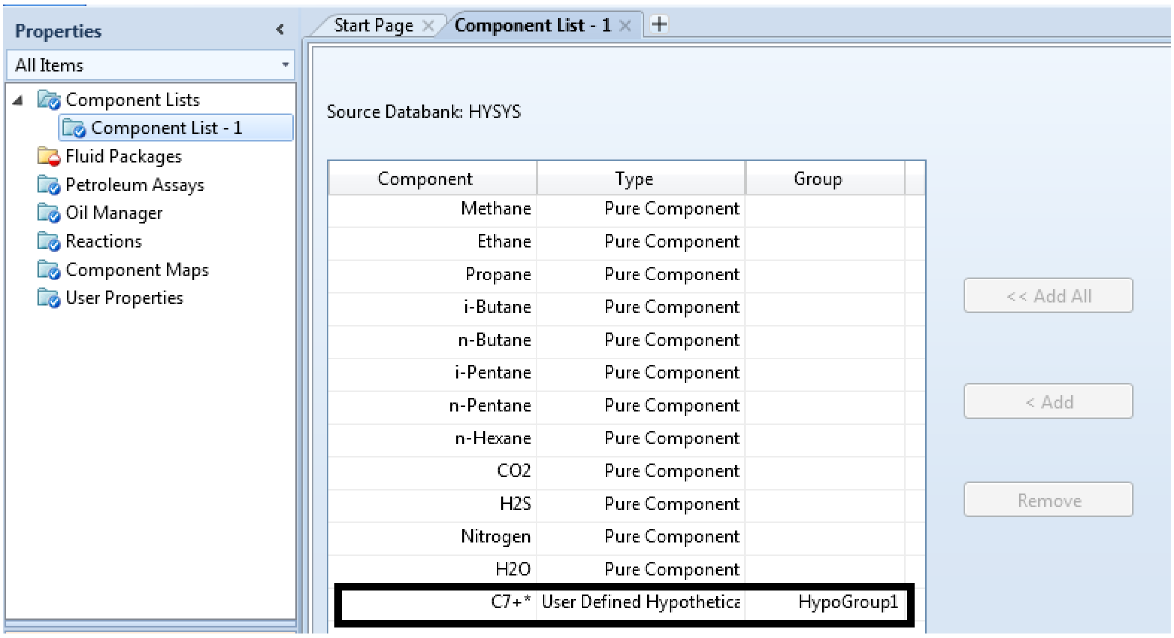
Click on New Hypo



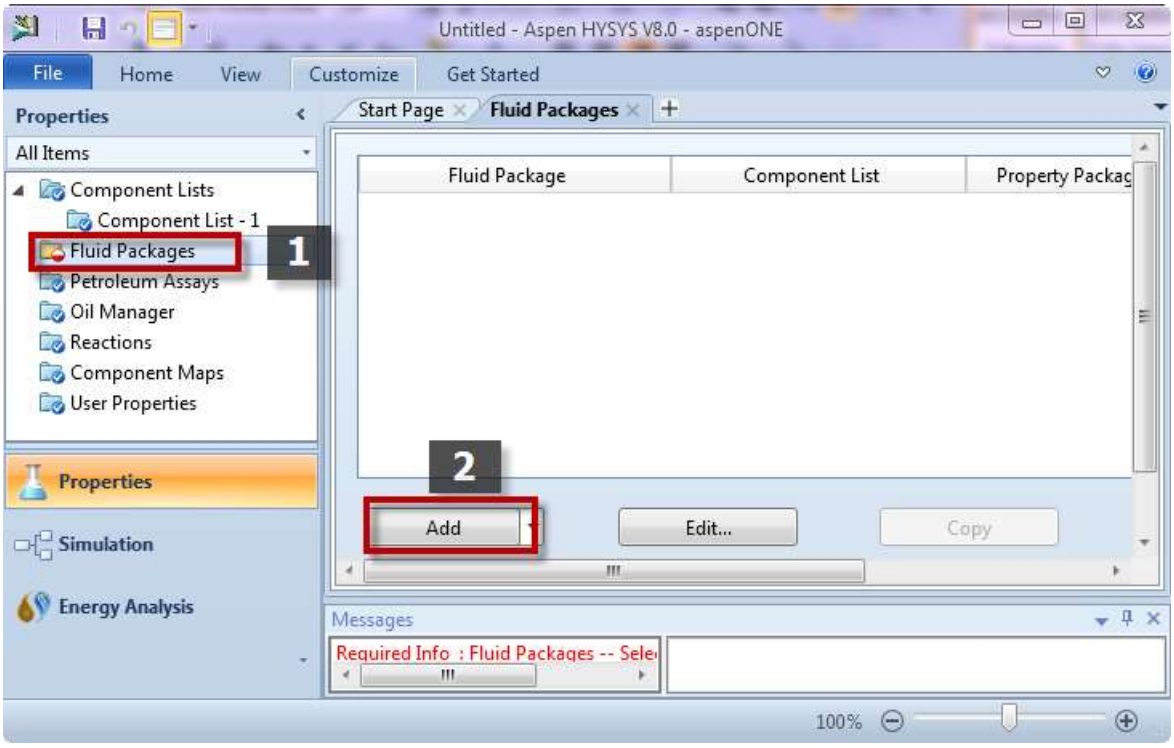
After adding a hypo component you can edit the name, add the properties you have, and estimate the unknown properties as follows:



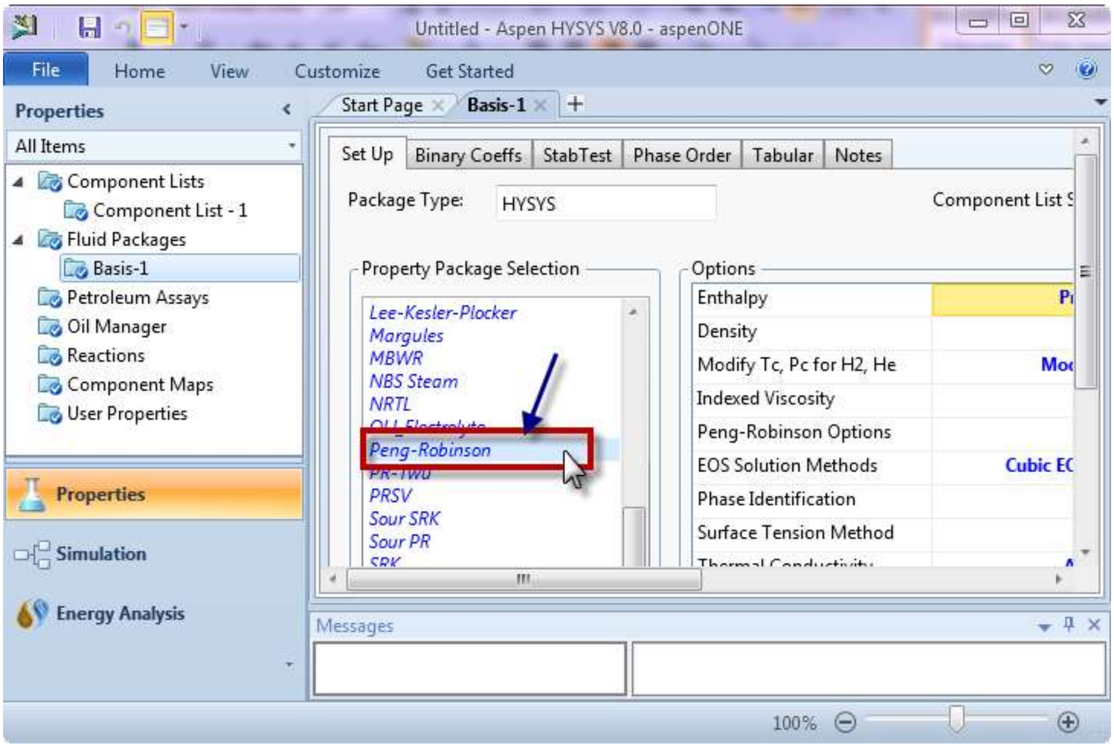
Finally add the hypo component to the component list



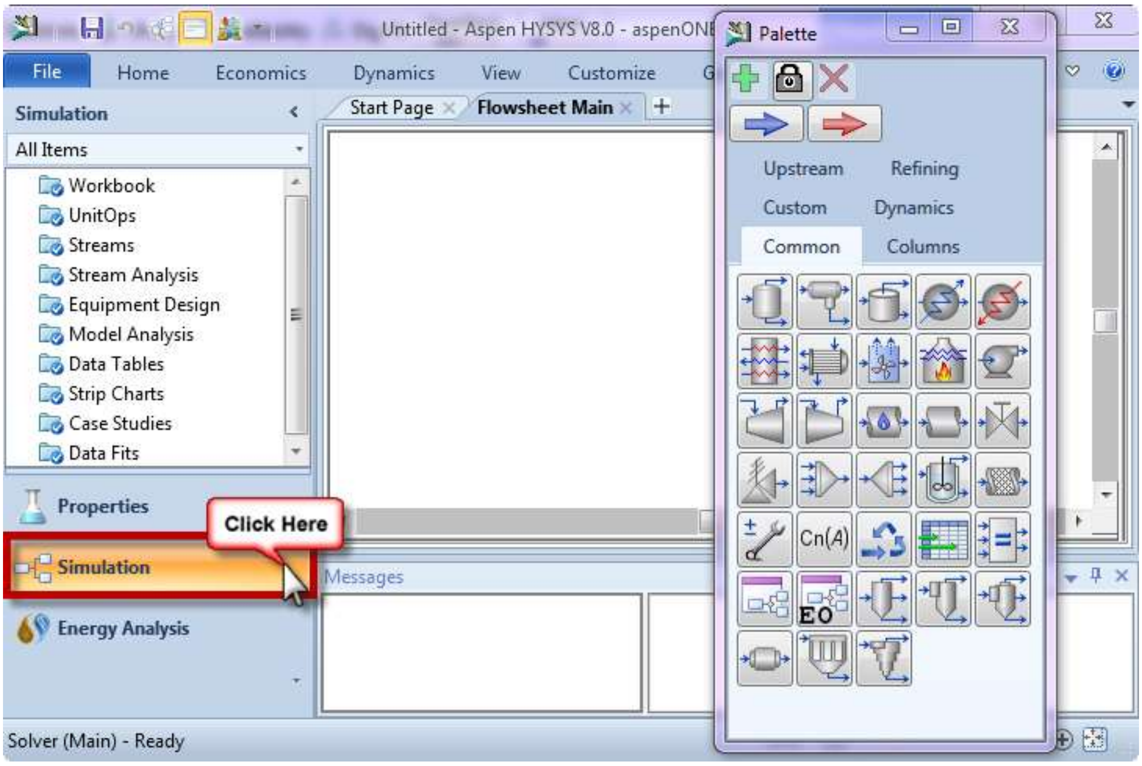
Now, select the suitable fluid package



In this case, select Peng-Robinson

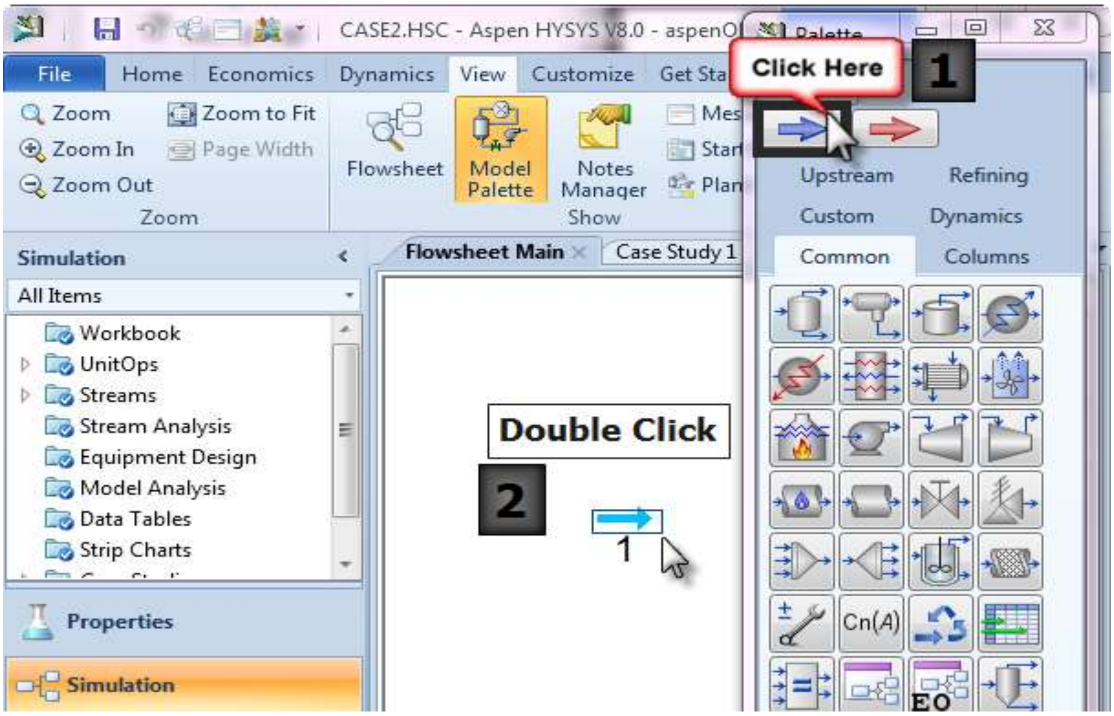


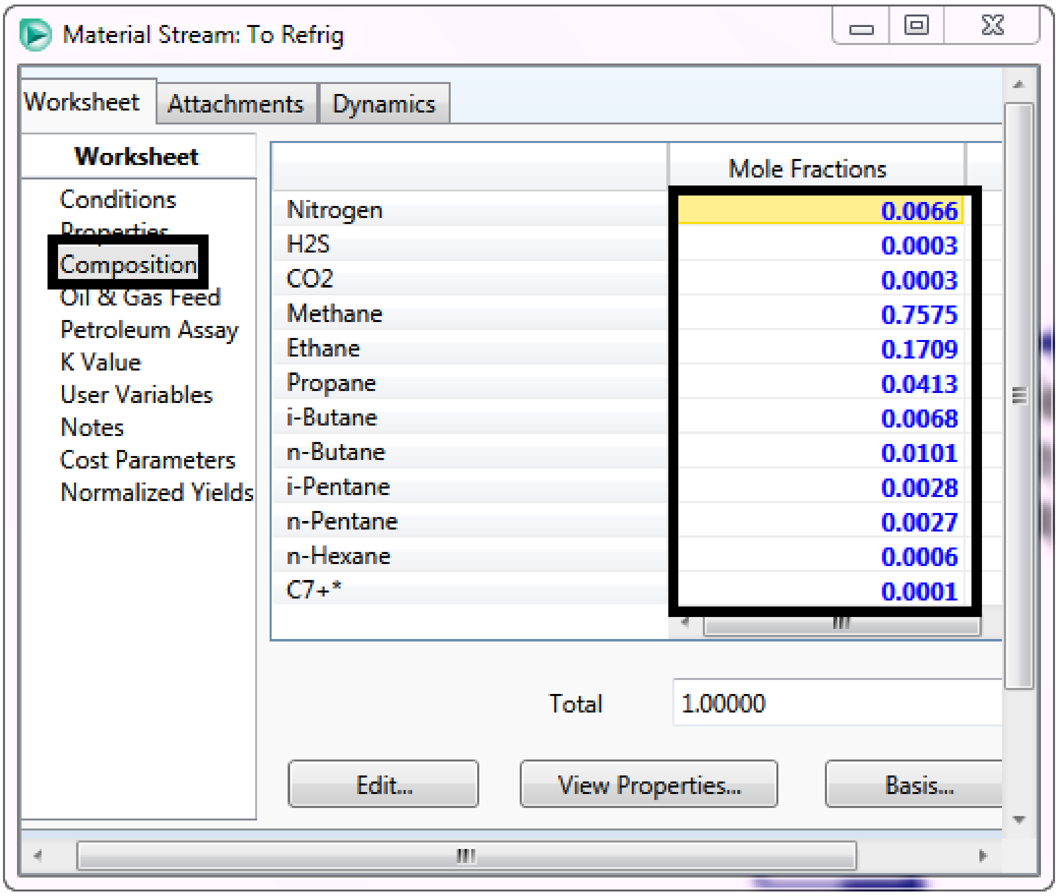
Now you can start drawing the flow sheet for the process by clicking the Simulation button:

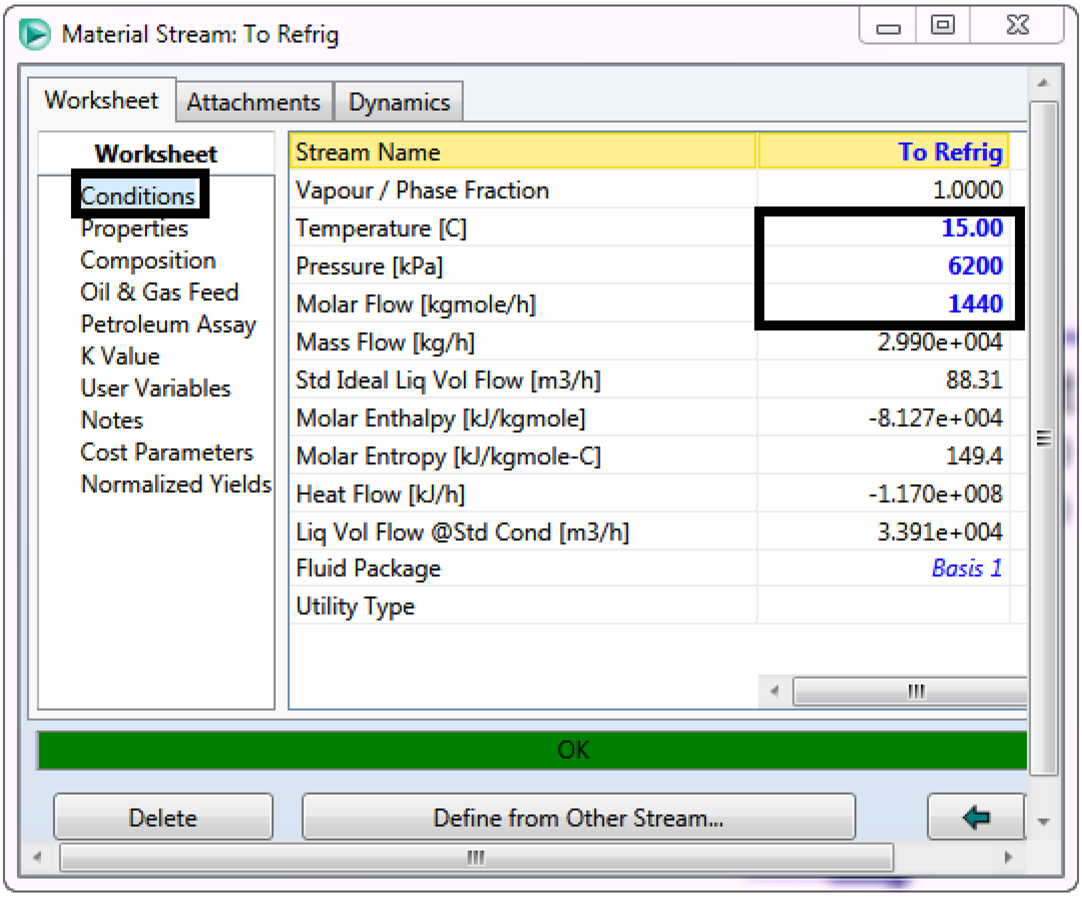


Now add a material stream to define the composition and the conditions of the feed stream

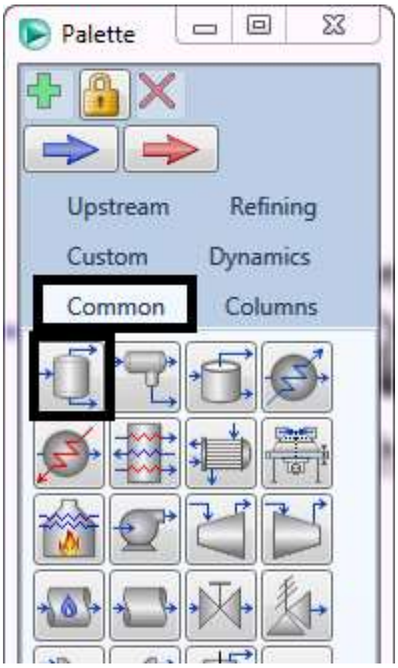
From the palette:

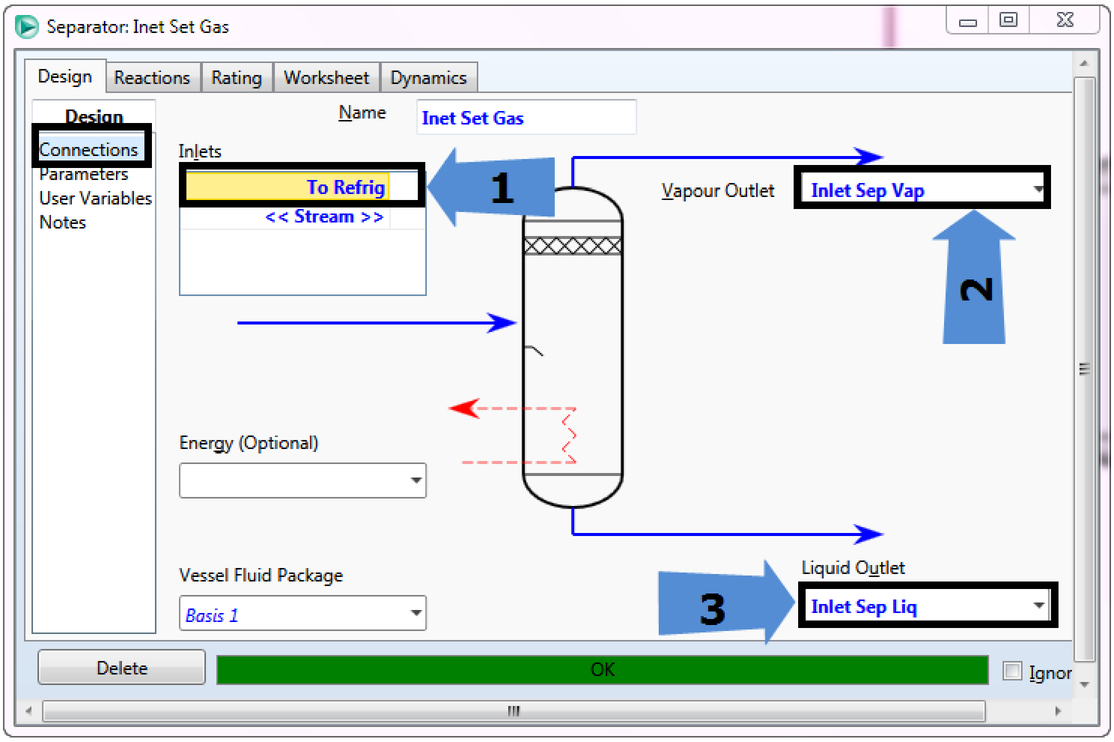




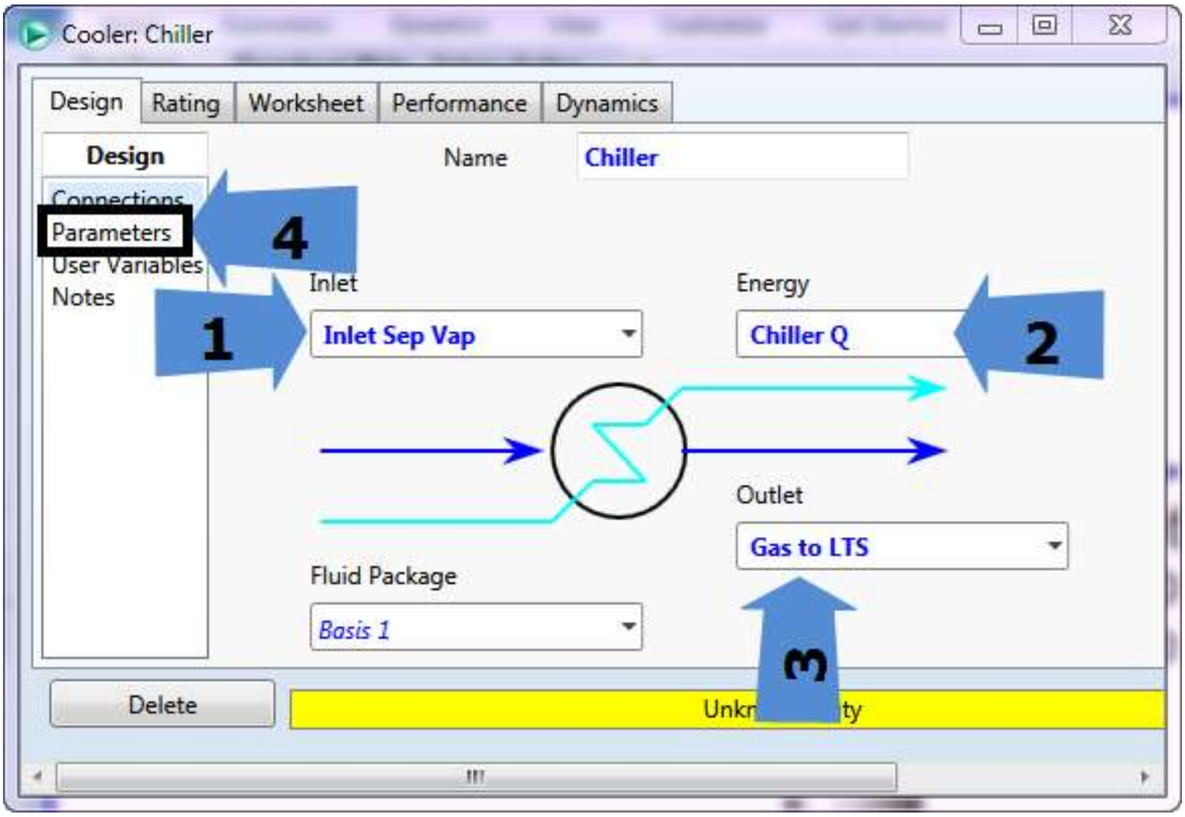


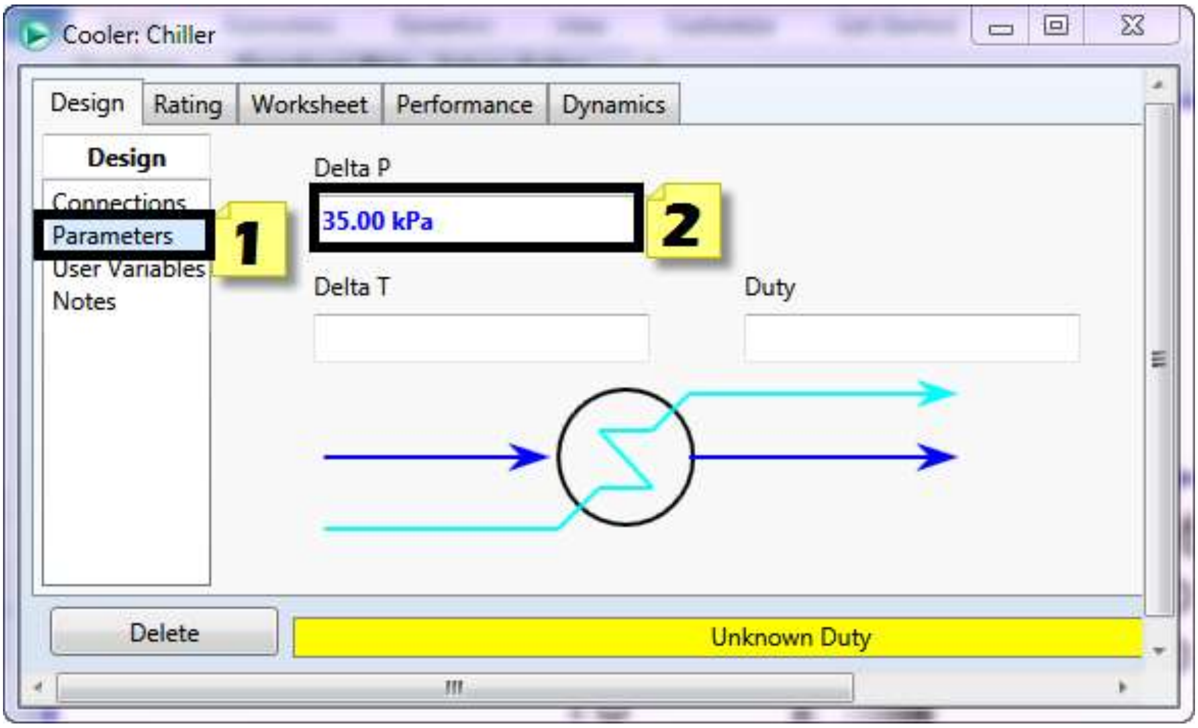
From the palette select the separator:

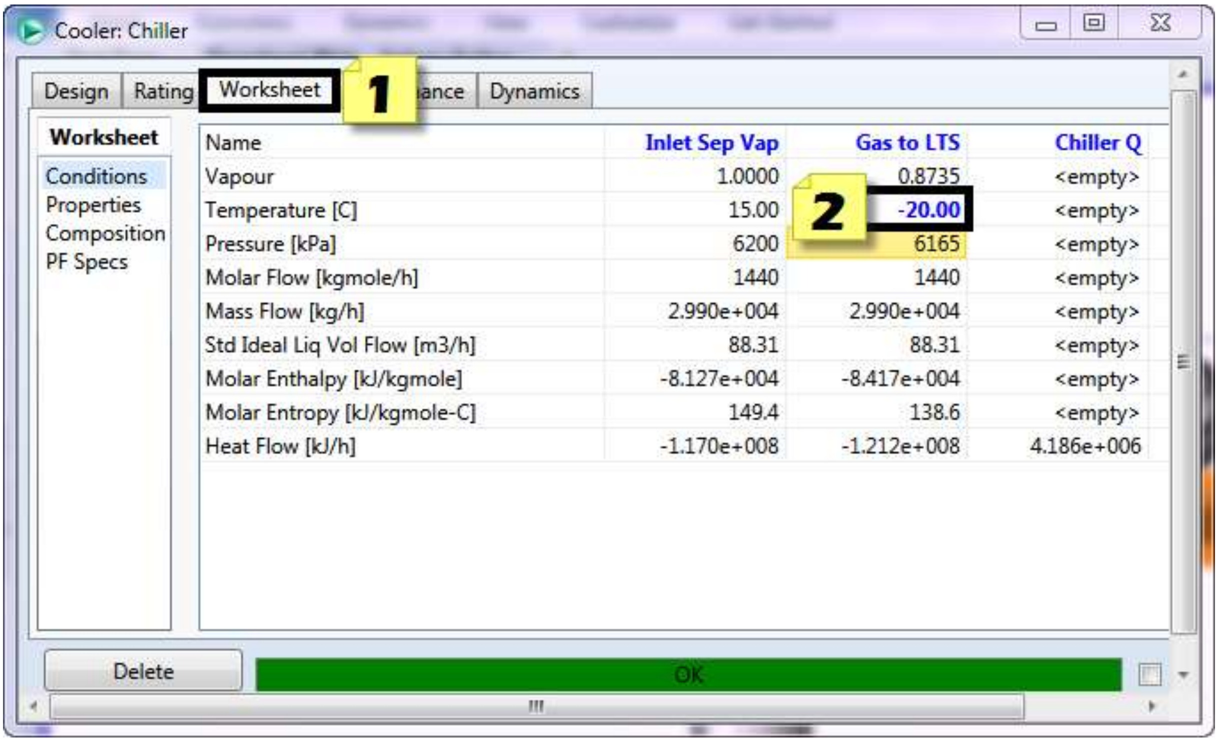



Separator: Inet Set Gas
Design
Reactions
Rating
Worksheet
Dynamics
Design
Connections
Parameters
User Variables
Notes
Name
Inet Set Gas
Inlets
To Refrig
<< Stream >>
1
Vapour Outlet
Inlet Sep Vap
2
Energy (Optional)
Vessel Fluid Package
Basis 1
Liquid Outlet
3
Inlet Sep Liq
Delete
OK
Ignor

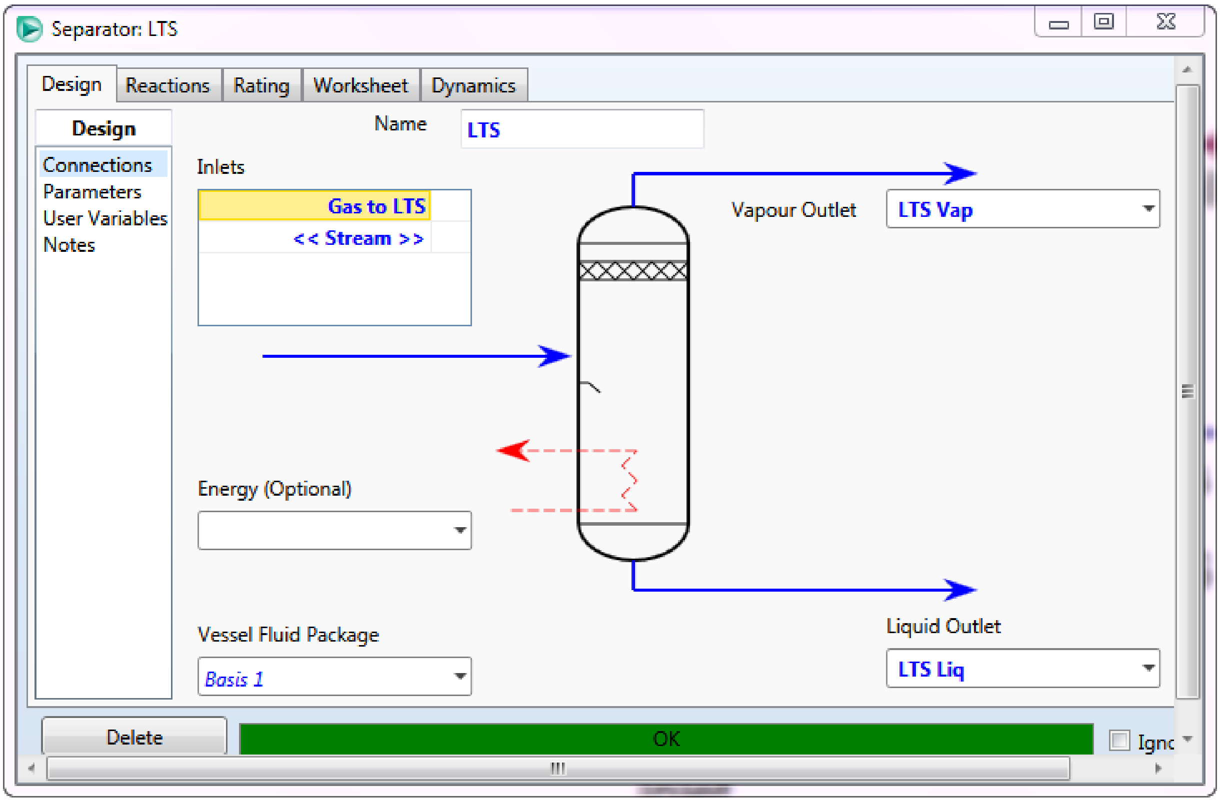
Add a cooler:


Cooler: Chiller
Design
Rating
Worksheet
Performance
Dynamics
Design
Connections
Parameters
User Variables
Notes
Name
Chiller
4
Inlet
Inlet Sep Vap
1
Energy
Chiller Q
2
Outlet
Gas to LTS
Fluid Package
Basis 1
3
Delete

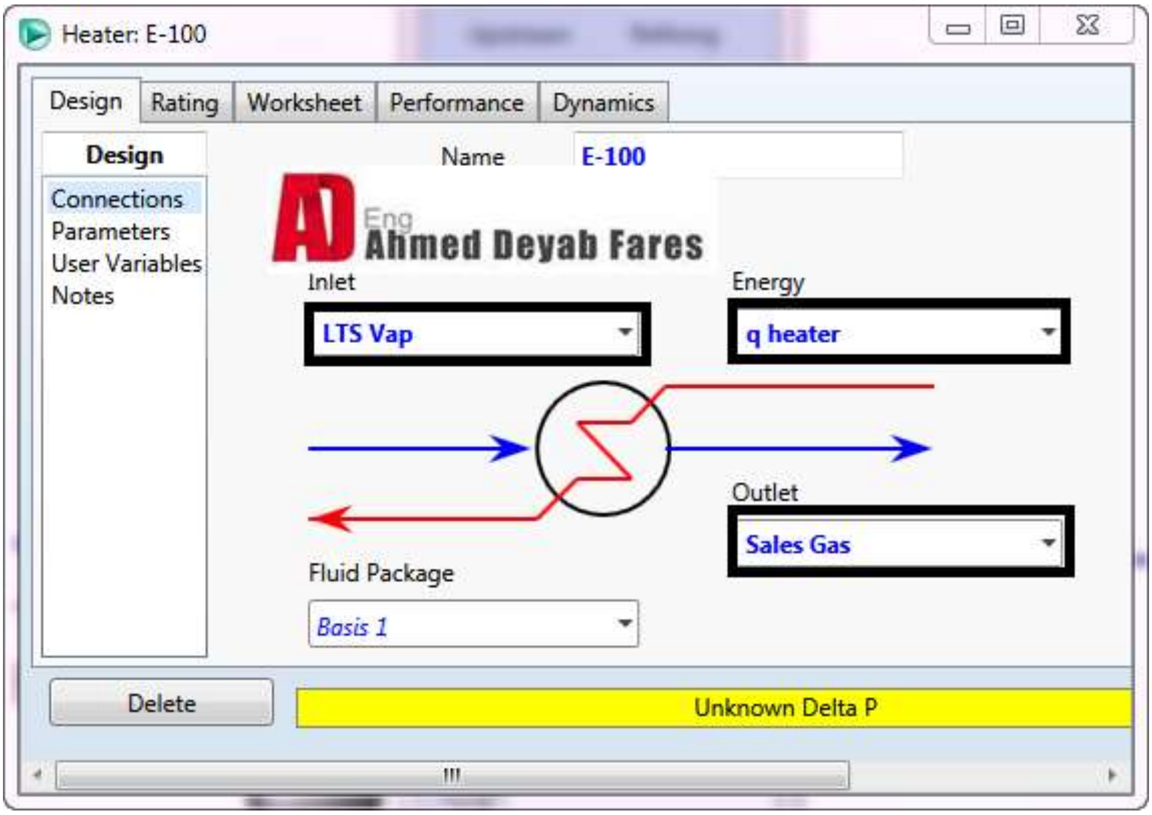


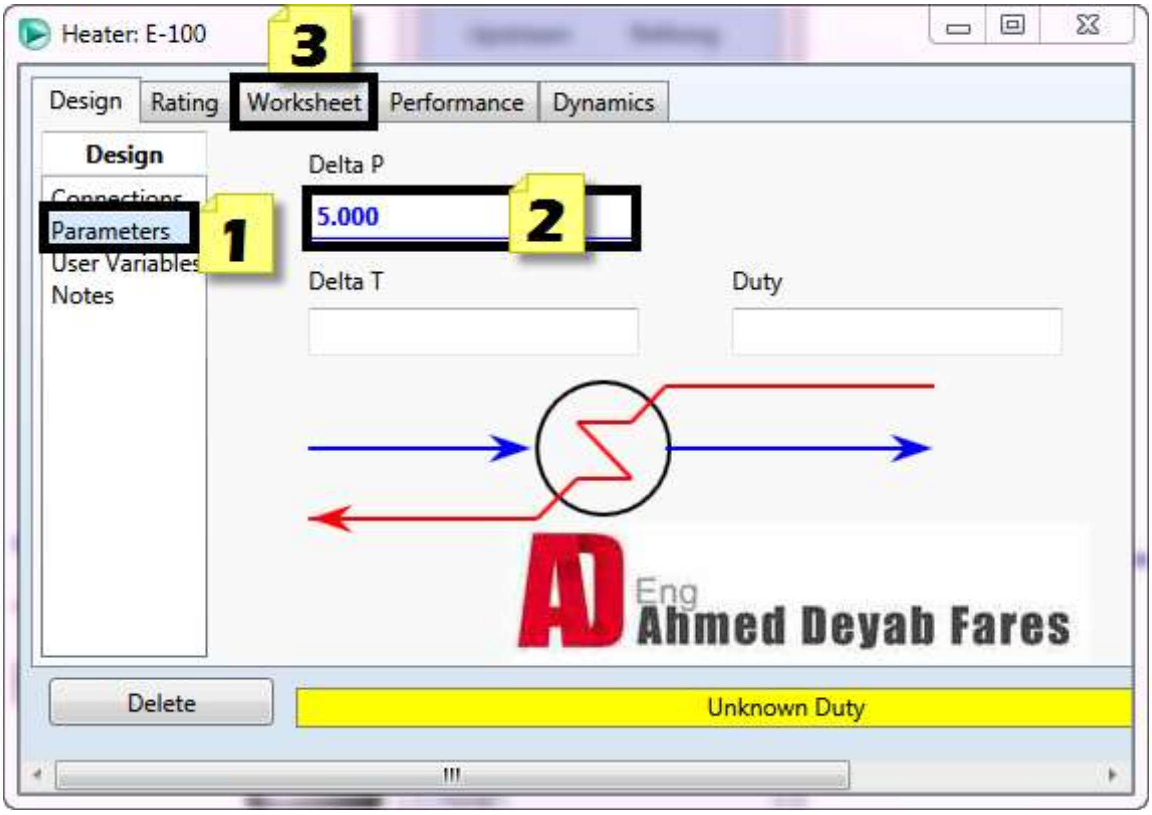


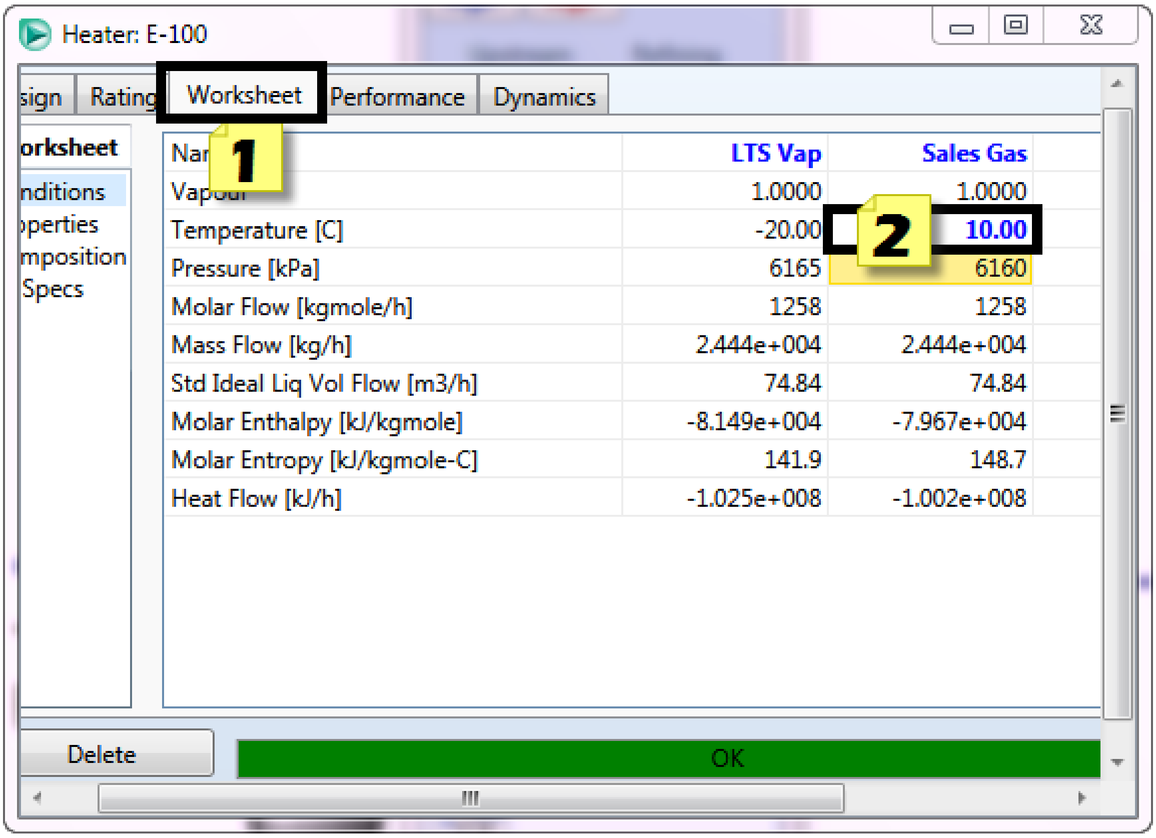
Add the LTS Separator:

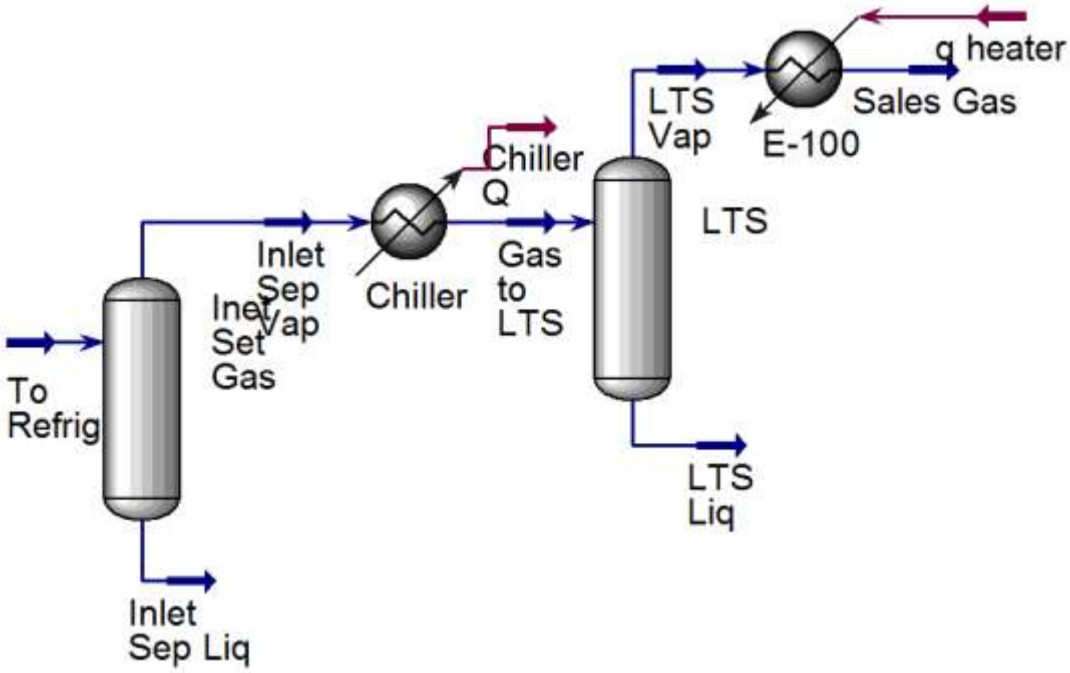

Separator: LTS
Design
Reactions
Rating
Worksheet
Dynamics
Design
Connections
Parameters
User Variables
Notes
Name
LTS
Inlets
Gas to LTS
<< Stream >>
Vapour Outlet
LTS Vap
Energy (Optional)
Vessel Fluid Package
Basis 1
Liquid Outlet
LTS Liq
Delete
OK

Add a heater:


Heater: E-100
Design
Rating
Worksheet
Performance
Dynamics
Design
Connections
Parameters
User Variables
Notes
Name
E-100
Eng
Ahmed Deyab Fares
Inlet
LTS Vap
Energy
q heater
Outlet
Sales Gas
Fluid Package
Basis 1
Delete
Unknown Delta P


Heater: E-100
3
Design
Rating
Worksheet
Performance
Dynamics
Design
Connections
Parameters
1
User Variables
Notes
Delta P
5.000
2
Delta T
Duty
Eng
Ahmed Deyab Fares
Delete
Unknown Duty


Heater: E-100
sign
Rating
Worksheet
Performance
Dynamics
orksheet
nditions
perties
mposition
Specs
1
2
Name
LTS Vap
Sales Gas
Vapour
1.0000
1.0000
Temperature [C]
-20.00
10.00
Pressure [kPa]
6165
6160
Molar Flow [kgmole/h]
1258
1258
Mass Flow [kg/h]
2.444e+004
2.444e+004
Std Ideal Liq Vol Flow [m3/h]
74.84
74.84
Molar Enthalpy [kJ/kgmole]
-8.149e+004
-7.967e+004
Molar Entropy [kJ/kgmole-C]
141.9
148.7
Heat Flow [kJ/h]
-1.025e+008
-1.002e+008
Delete
OK



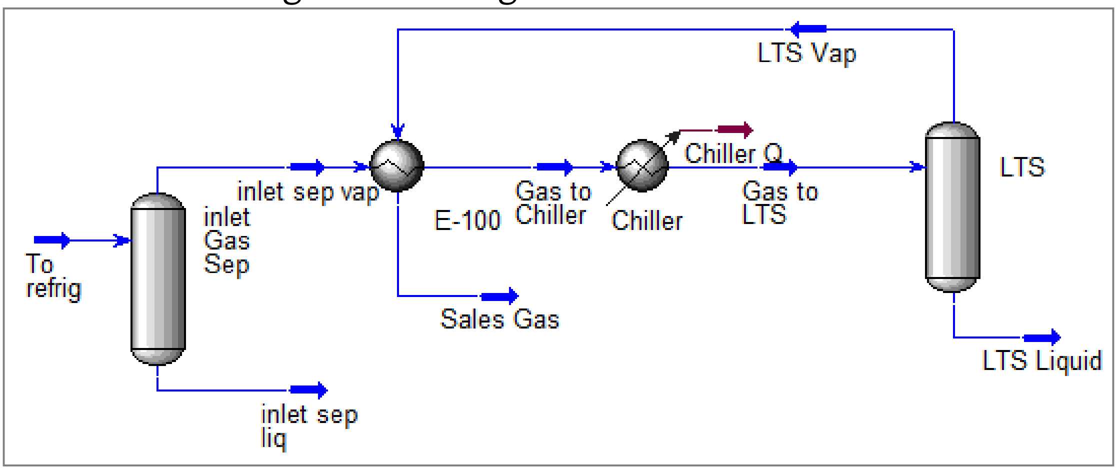
- The duty rejected from the chiller = **4.186 e6** (4.186 *10^6) kJ/hr
- The duty Absorbed inside the **Heater = 2.287 e6 (2.287 *10^6)** kJ/hr

Heat Exchanger

The design is modified to reduce the operating cost represented in Chiller & Heater duties, by adding a Heat Exchanger before the Chiller where the overhead from the inlet separator is pre-cooled by already refrigerated gas from LTS.

Heat Exchanger Design Specifications:

- Sales Gas Temperature= 10°C
- Tube side Pressure drop=35kPa
- Shell side Pressure drop= 5kPa
- No heat losses inside the heat exchanger.
- Choose Weighted Exchanger as Model



Calculate the duty rejected from the chiller after this modification ……………

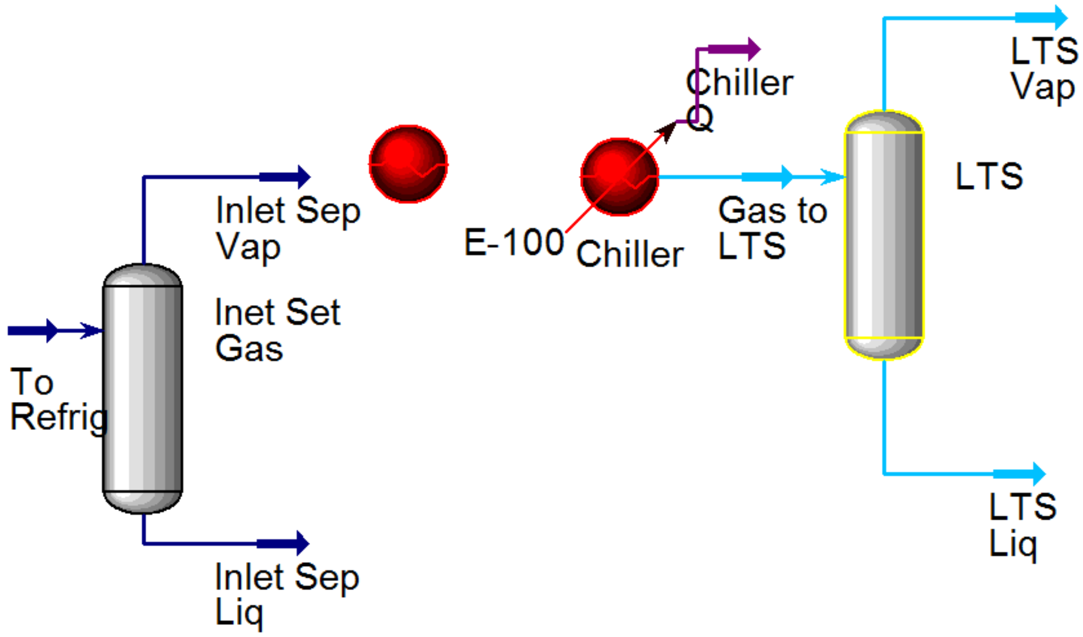
Calculate the Overall Heat Transfer Coefficient (UA) for the HX ……………

Solution:

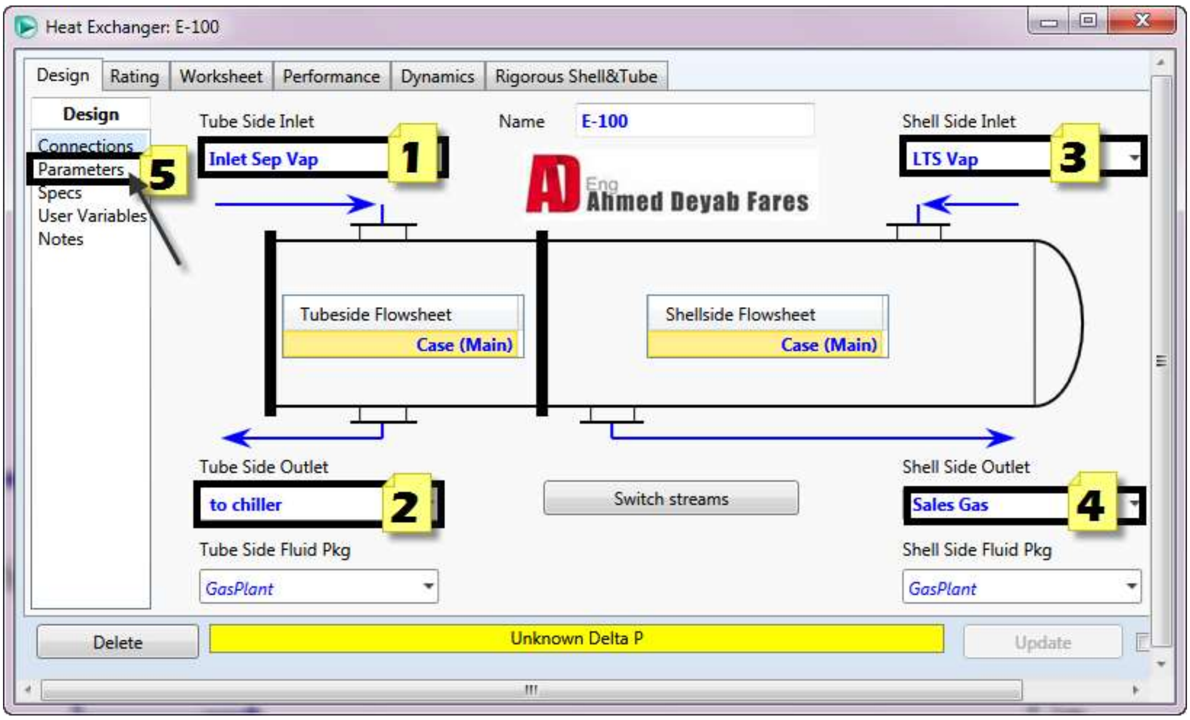
1- Remove the heater, outlet stream and heater energy stream.

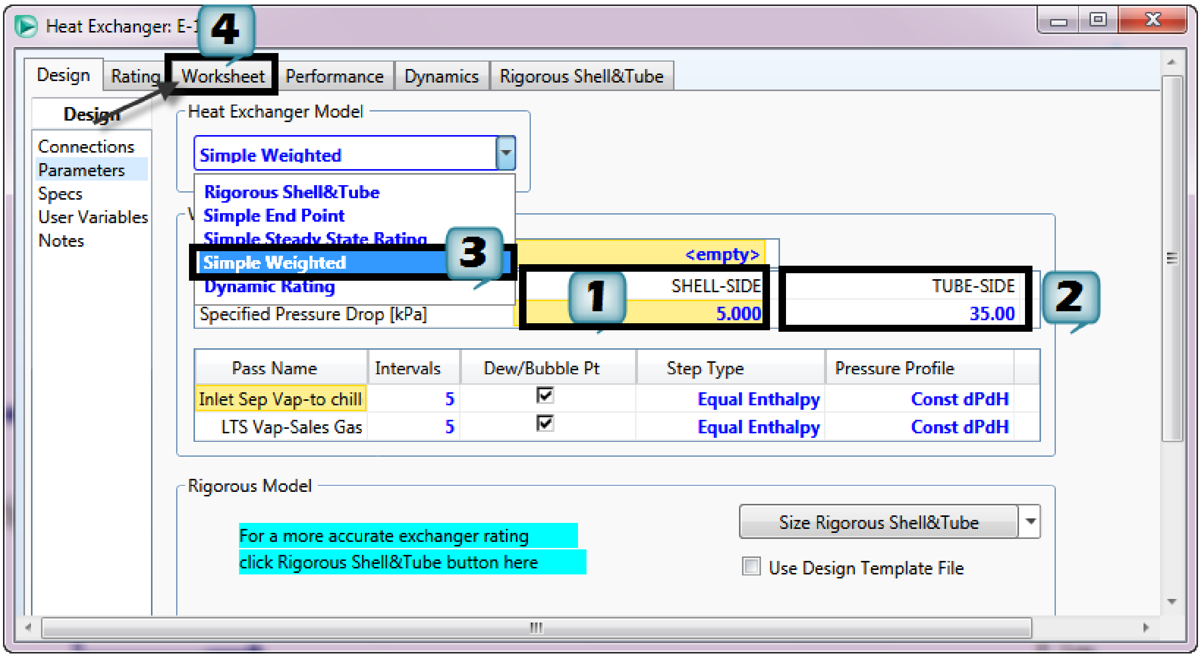
2- Disconnect the chiller inlet from the chiller (cooler).

3- Add a heat exchanger from the palette:



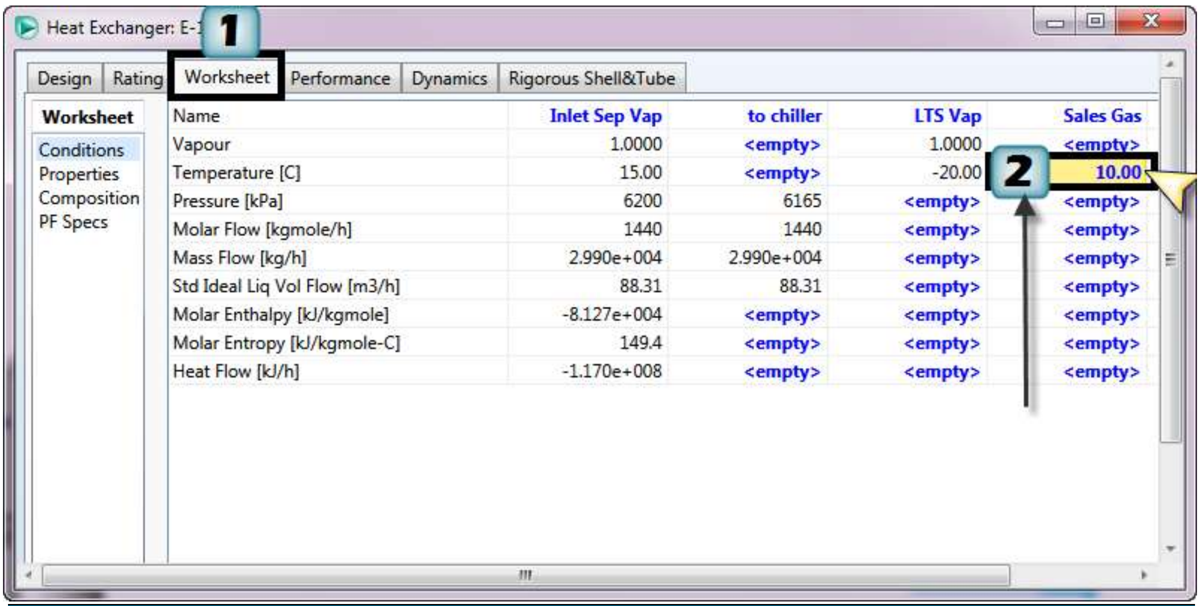
4- Open the heat exchanger and complete the required data:



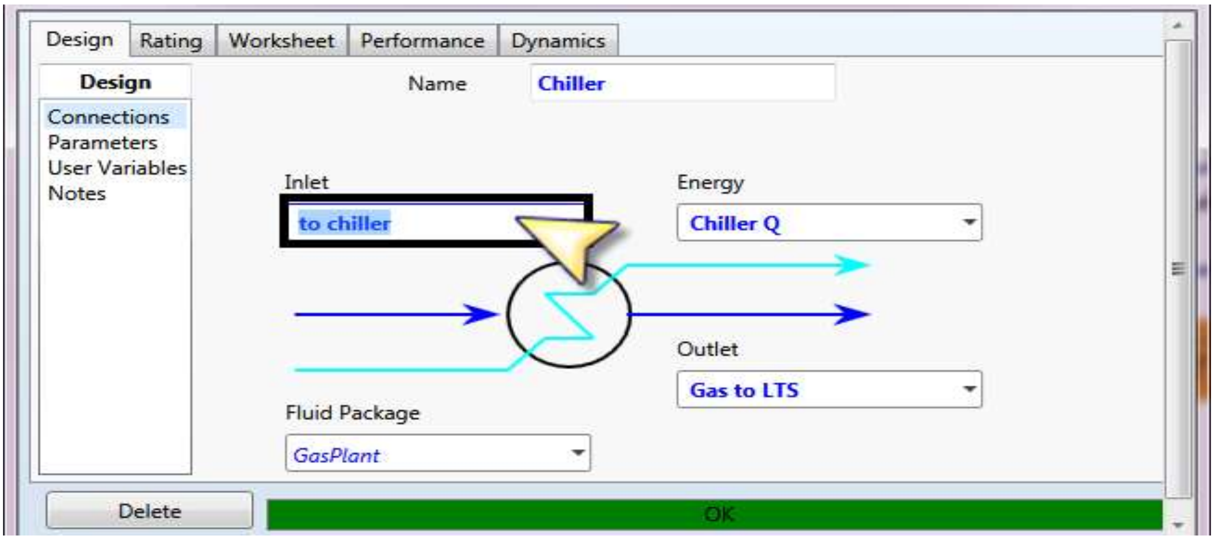


- ***Weighted***. *The heating curves are broken into intervals, which then exchange energy individually. An LMTD and UA are calculated for each interval in the heat curve and summed to calculate the overall exchanger UA. The Weighted method is available only for Counter-Current exchangers.*

- ***Endpoint***. *A single LMTD and UA are calculated from the inlet and outlet conditions. For simple problems where there is no phase change and Cp is relatively constant, this option may be sufficient.*



5- Open the chiller and re-connect the tube side outlet to the chiller inlet



The duty rejected from the chiller after this modification **= 1.878 e6** kJ/hr

The Overall Heat Transfer Coefficient (UA) for the HX**= 2.786 e5** kJ/C-h

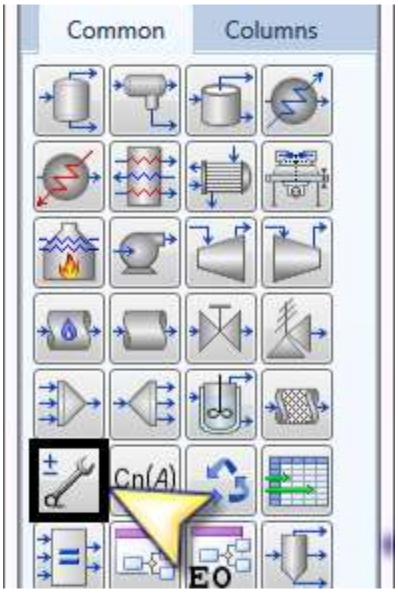
	Before Modification	**After Modification**
Chiller Duty	**4.186 $*10^6$**	**1.878 $*10^6$**
Heater Duty	**2.287 $*10^6$**	**0**

Adjust

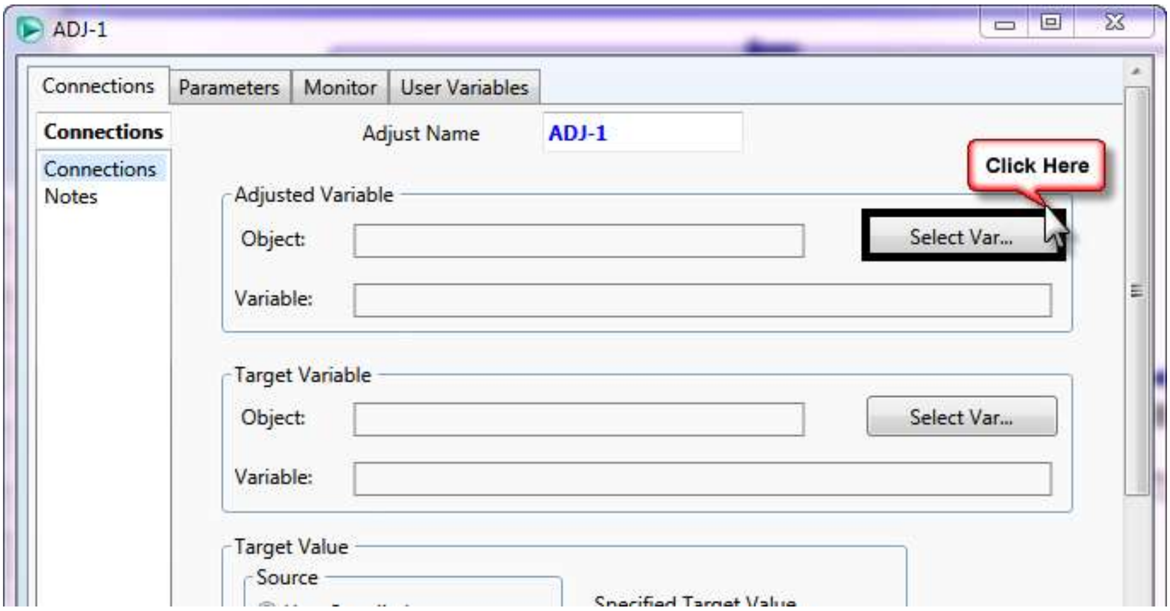
Adjust the LTS feed temperature to ensure the LTS vapor rate of 1200 kgmole/hr using Adjust operation.

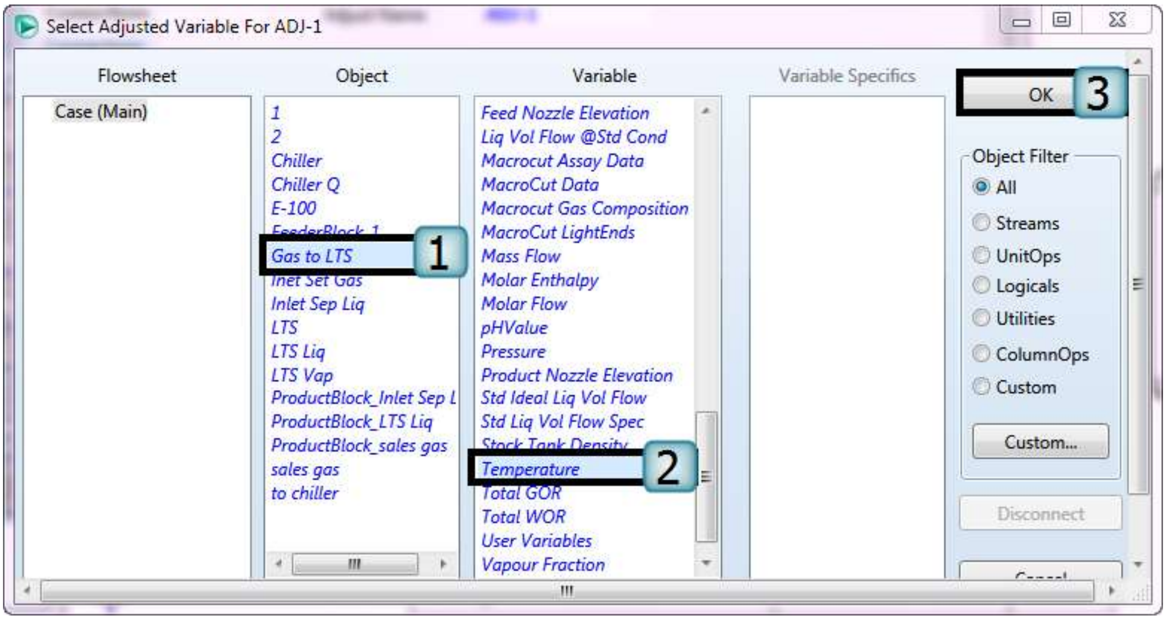
Calculate the temperature of LTS feed ……………….

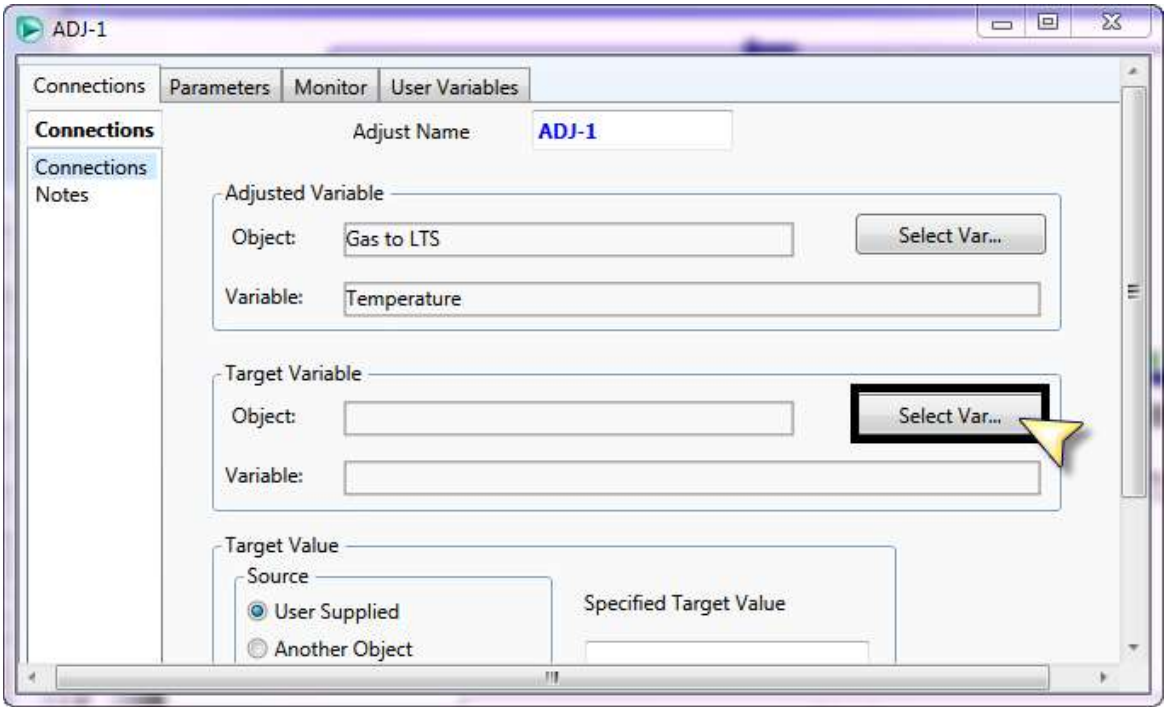
1- Select an adjust operation from the palette:

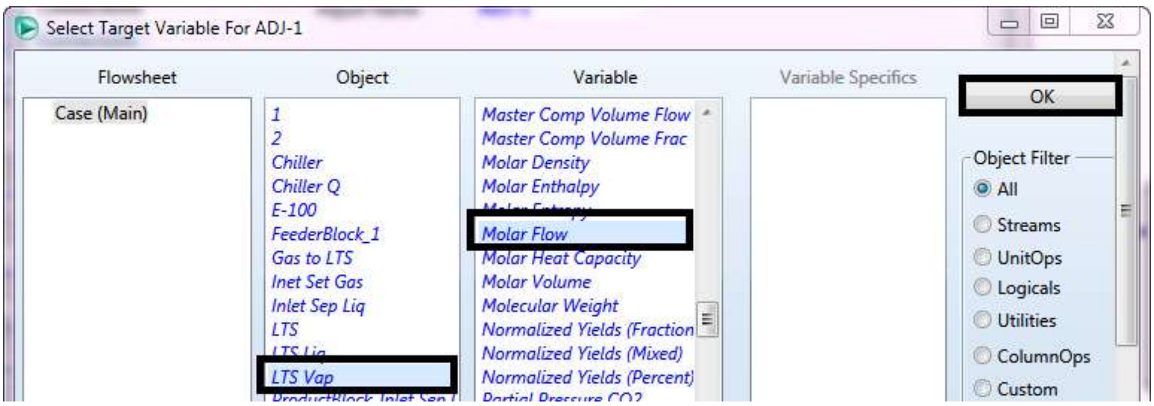


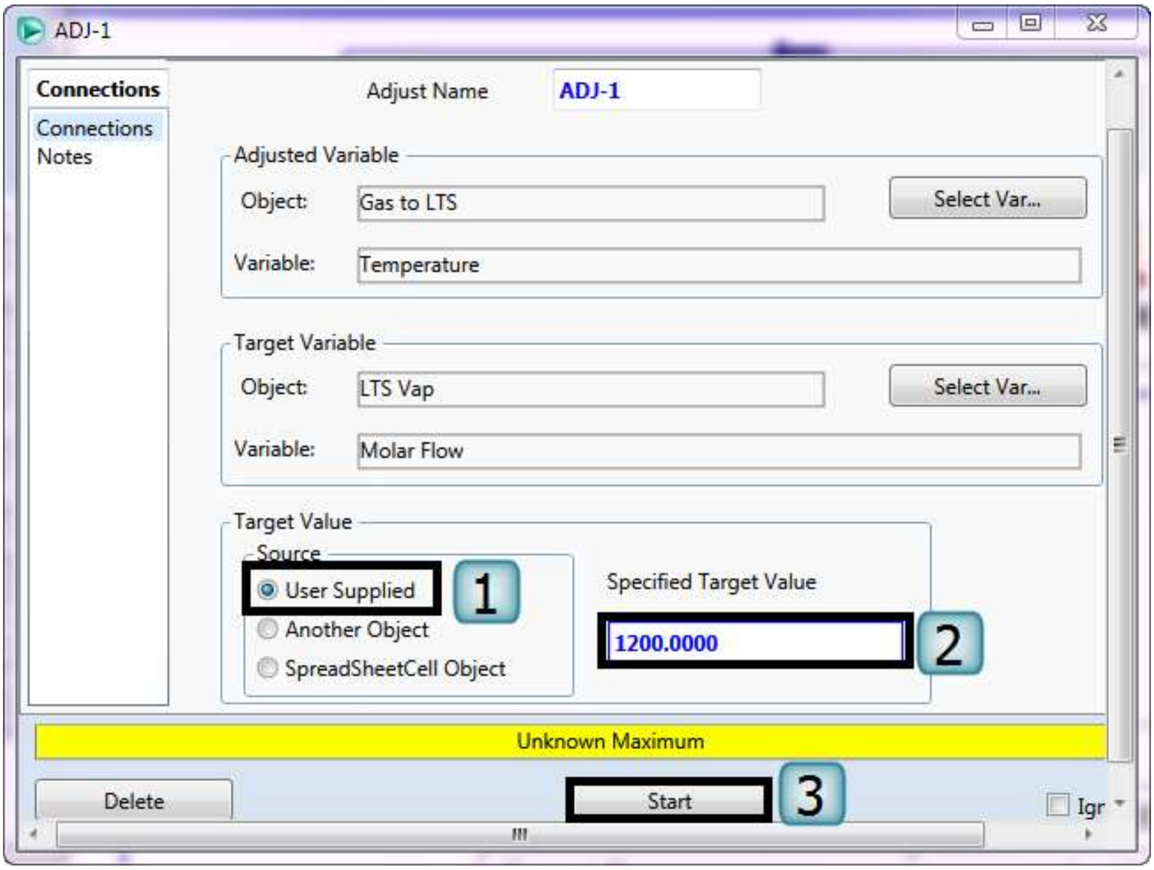
2- Open the adjust operation and select the adjusted variable (LTS feed Temperature) and the Target variable (LTS Vapor molar flow).



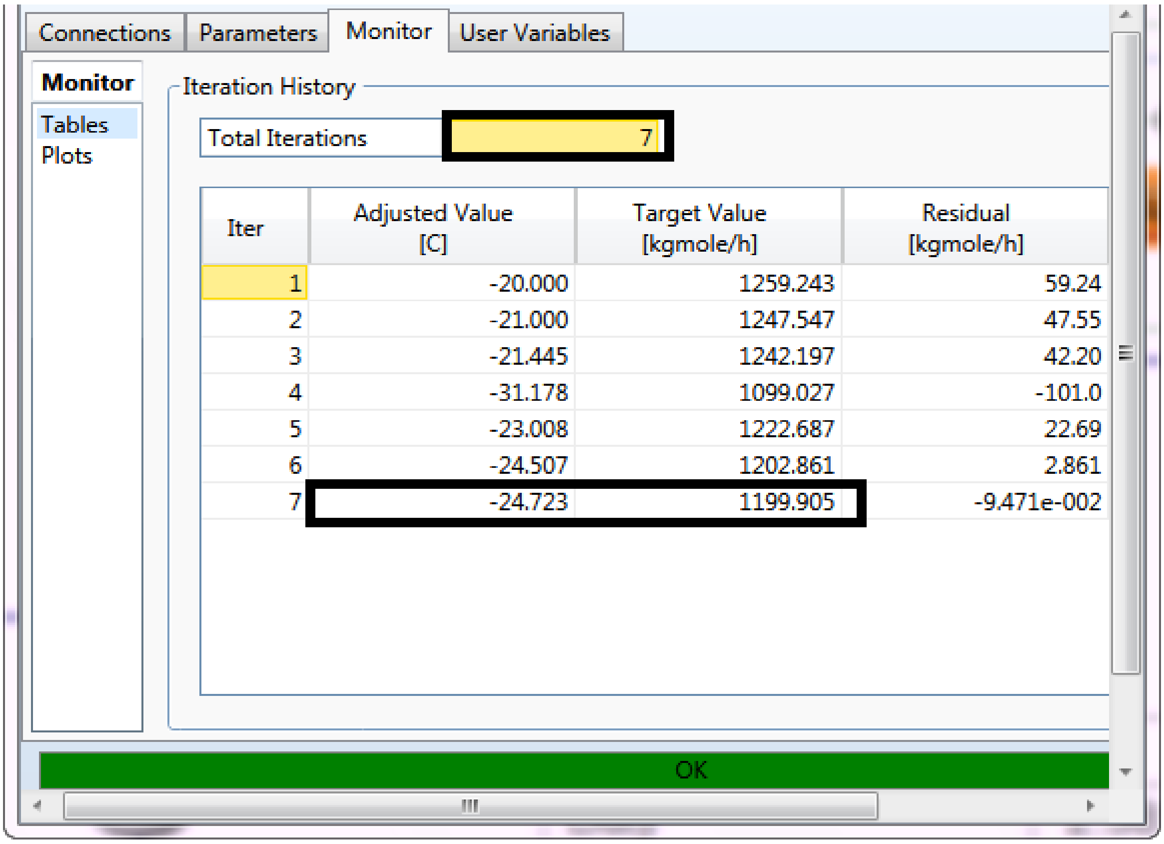

Select Adjusted Variable For ADJ-1
Flowsheet
Object
Variable
Variable Specifics
Case (Main)
1
2
Chiller
Chiller Q
E-100
FeederBlock_1
Gas to LTS
Inet Set Gas
Inlet Sep Liq
LTS
LTS Liq
LTS Vap
ProductBlock_Inlet Sep L
ProductBlock_LTS Liq
ProductBlock_sales gas
sales gas
to chiller
Feed Nozzle Elevation
Liq Vol Flow @Std Cond
Macrocut Assay Data
MacroCut Data
Macrocut Gas Composition
MacroCut LightEnds
Mass Flow
Molar Enthalpy
Molar Flow
pHValue
Pressure
Product Nozzle Elevation
Std Ideal Liq Vol Flow
Std Liq Vol Flow Spec
Stock Tank Density
Temperature
Total GOR
Total WOR
User Variables
Vapour Fraction
OK
Object Filter
All
Streams
UnitOps
Logicals
Utilities
ColumnOps
Custom
Custom...
Disconnect
1
2
3


ADJ-1
Connections
Parameters
Monitor
User Variables
Connections
Connections
Notes
Adjust Name
ADJ-1
Adjusted Variable
Object:
Gas to LTS
Select Var...
Variable:
Temperature
Target Variable
Object:
Select Var...
Variable:
Target Value
Source
User Supplied
Another Object
Specified Target Value


Select Target Variable For ADJ-1
Flowsheet
Object
Variable
Variable Specifics
Case (Main)
1
2
Chiller
Chiller Q
E-100
FeederBlock_1
Gas to LTS
Inet Set Gas
Inlet Sep Liq
LTS
LTS Liq
LTS Vap
Master Comp Volume Flow
Master Comp Volume Frac
Molar Density
Molar Enthalpy
Molar Entropy
Molar Flow
Molar Heat Capacity
Molar Volume
Molecular Weight
Normalized Yields (Fraction
Normalized Yields (Mixed)
Normalized Yields (Percent)
OK
Object Filter
All
Streams
UnitOps
Logicals
Utilities
ColumnOps
Custom

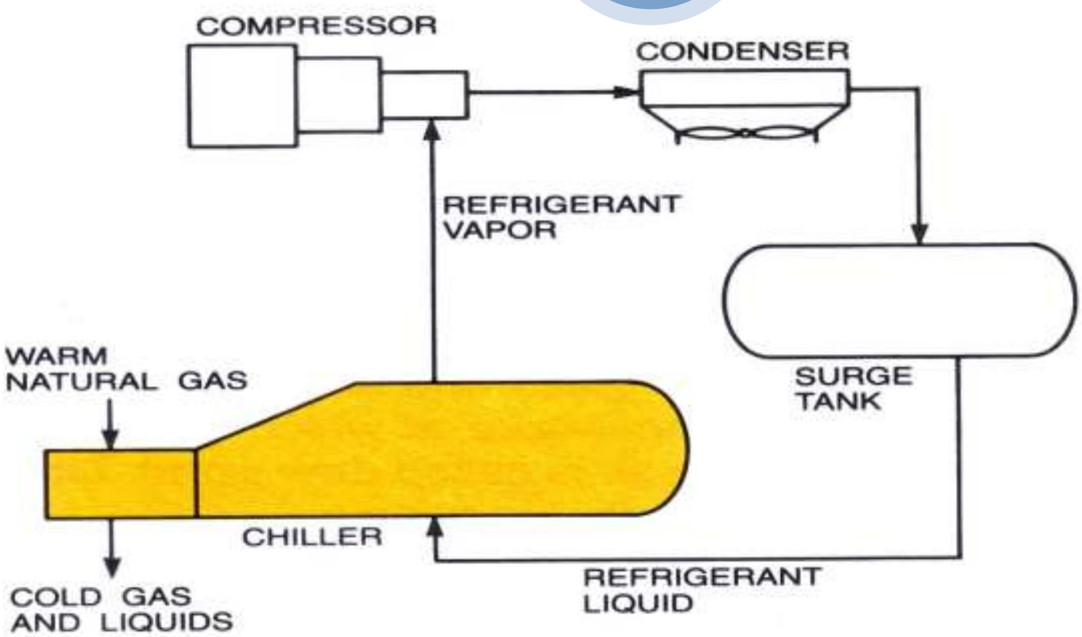


You can see the total number of iterations from the monitor tab:



Propane Refrigeration Loop

3



Workshop

Refrigeration systems are commonly found in the natural gas processing industry and in processes related to the petroleum refining, petrochemical, and chemical industries. Refrigeration is used to cool gas to meet a hydrocarbon dewpoint specification and to produce a marketable liquid.

In this module you will construct, run, analyze and manipulate a propane refrigeration loop simulation. You will convert the completed simulation to a template, making it available to connect to other simulations.

Learning Objectives

Once you have completed this module, you will be able to:

- *Add and connect operations to build a flowsheet.*
- *Understand how to simulate the vapor compression loop.*
- *Understand forward-backward information propagation in HYSYS.*
- *Using the spread sheet to calculate the COP (Coefficient Of Performance) for the loop.*

Example:

A Refrigeration cycle utilizes propane as the working fluid is used in the liquefaction of the NG. Propane is fed to an evaporator (Heater) the pressure drop=5 kPa, where it absorbed 1.50e+6 kJ/hr from the NG and leaves at the dew point (Vapor Fraction=1.0) at T= -15°C. The output of the evaporator is then compressed adiabatically with efficiency of 75%, and then it's condensed to reject heat. Inside the Condenser there is a pressure drop of 30 kPa, and leaves as saturated liquid at 45°C. Finally, the propane passes through a valve to return the pressure of the Evaporator.

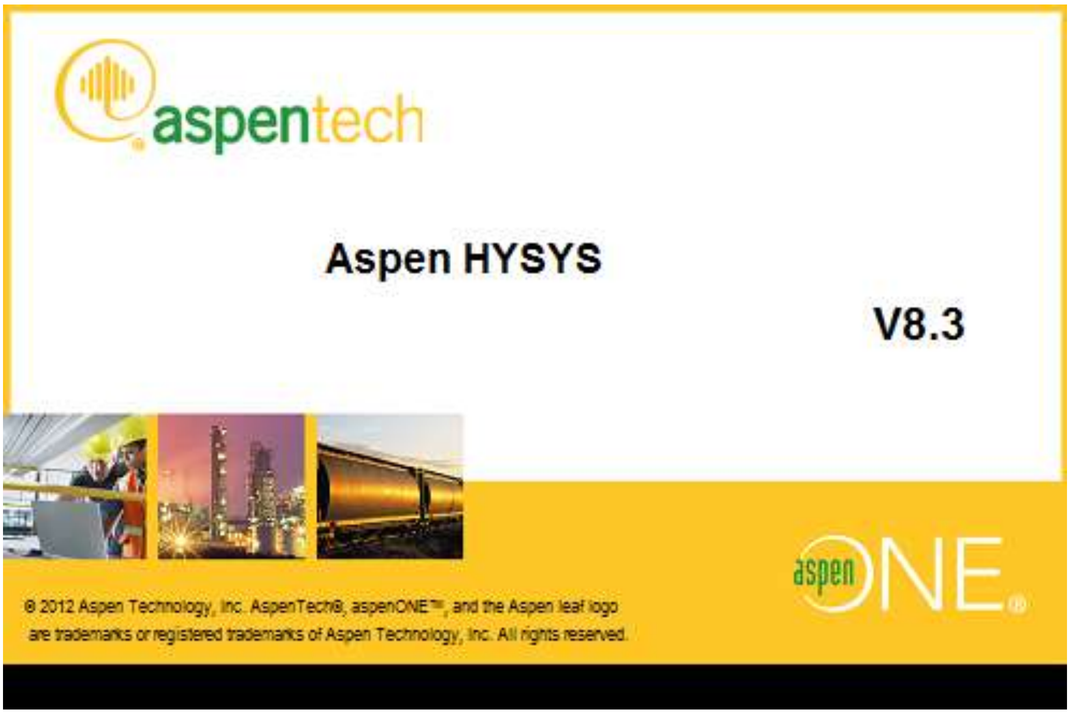
Fluid Pkg: Peng Robinson

Calculate:

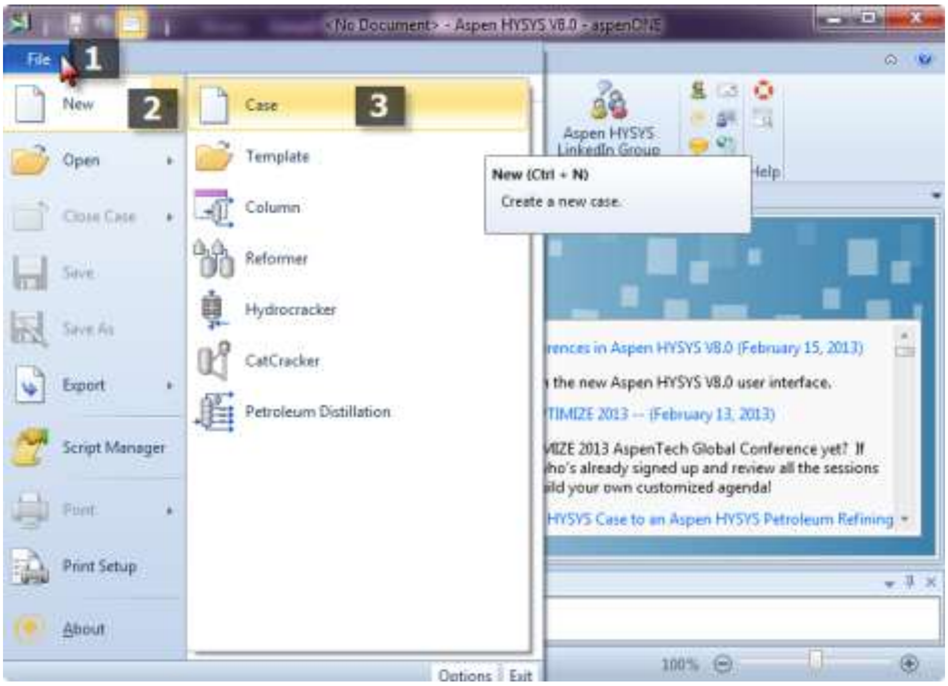
Pressure of the evaporator fed in kPa.	
Flow rate of propane in kmol/hr.	
Valve pressure drop in kPa.	
Temperature of the valve outlet in °C.	
Compressor duty in hp.	
Condenser duty in kJ/hr.	

* Calculate the COP (Coefficient of Performance) for the cycle

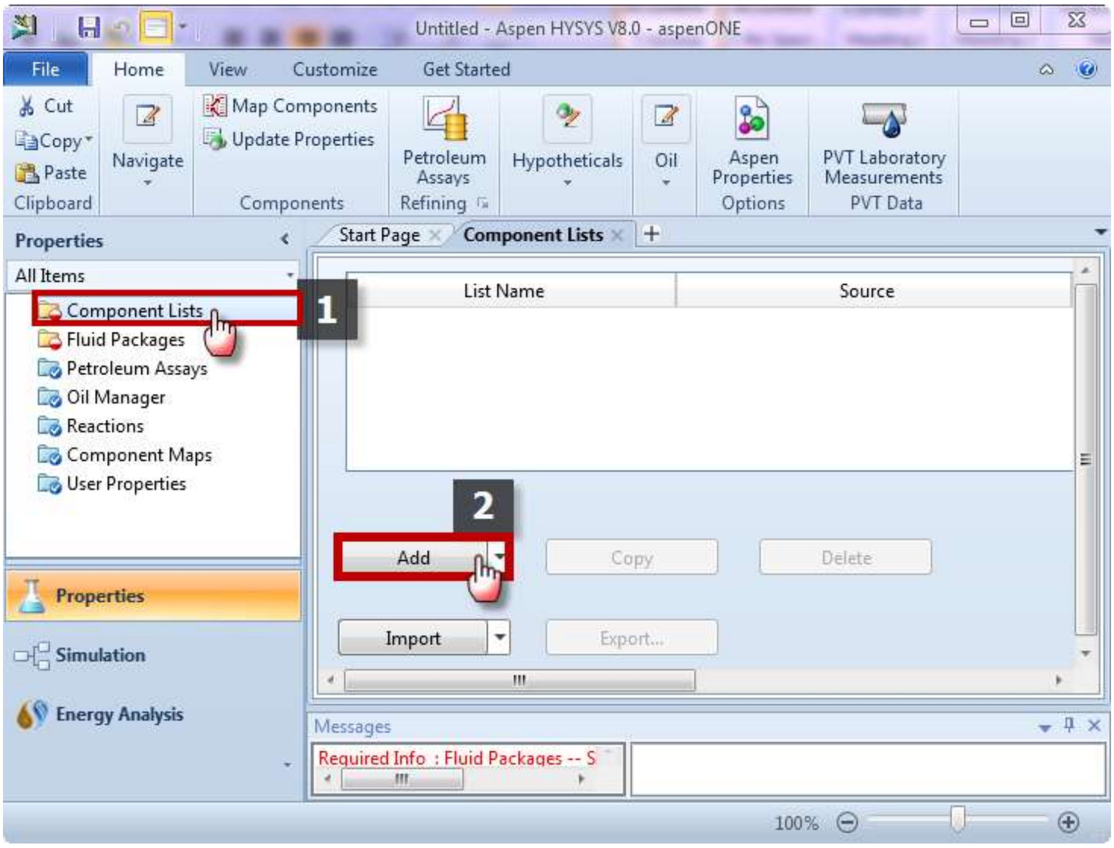
To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.3 >>>> Aspen HYSYS >> Aspen HYSYS



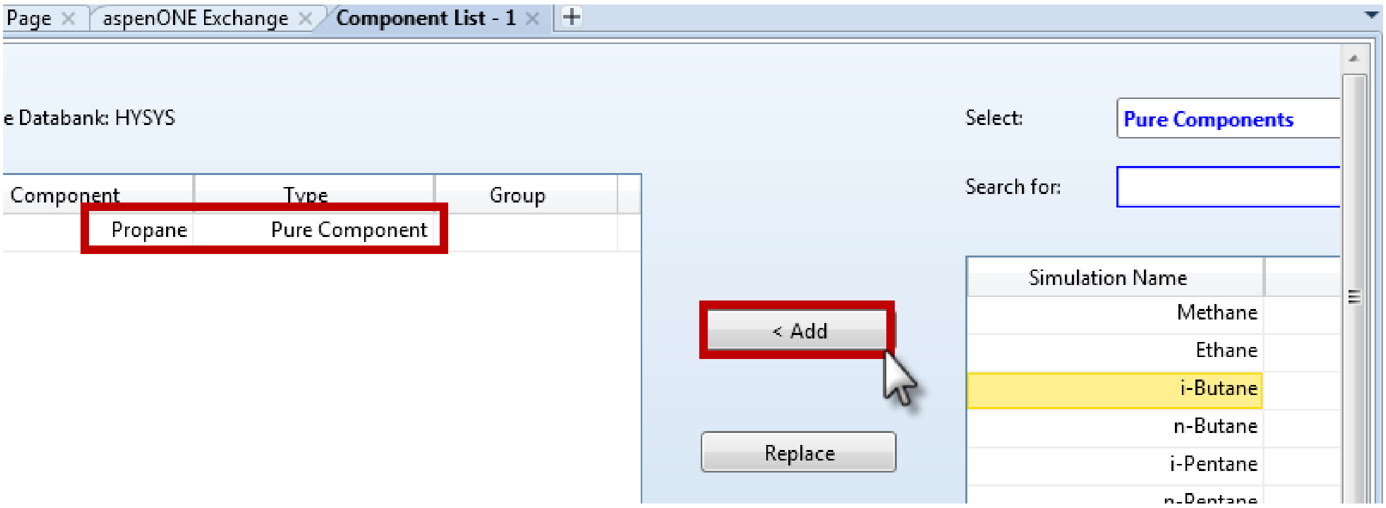
1- First, Start a new case



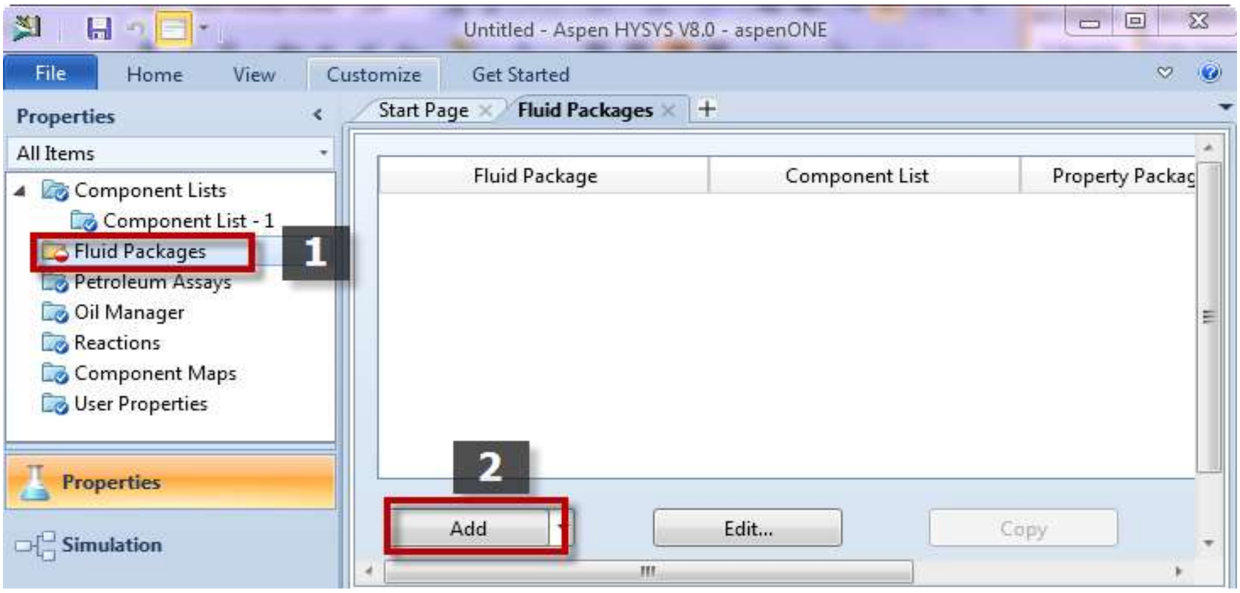
2- Add the Components



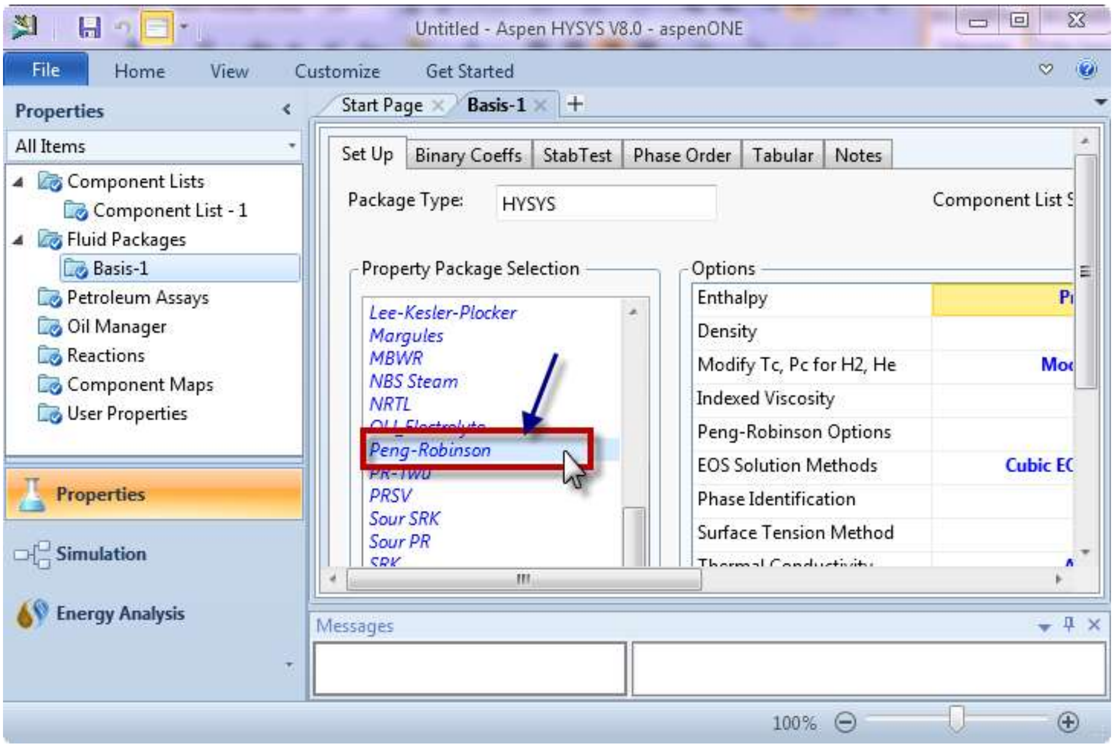
3- Choose the system components from the databank:



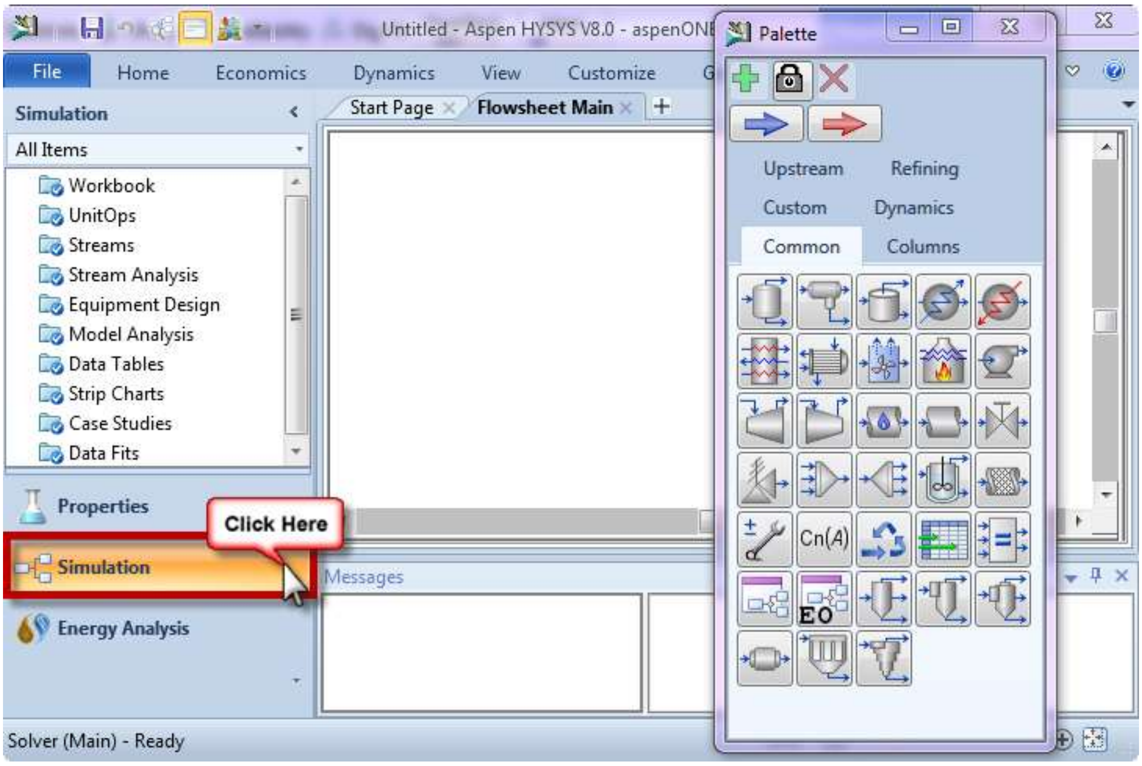
Now, select the suitable fluid package



In this case, select Peng-Robinson

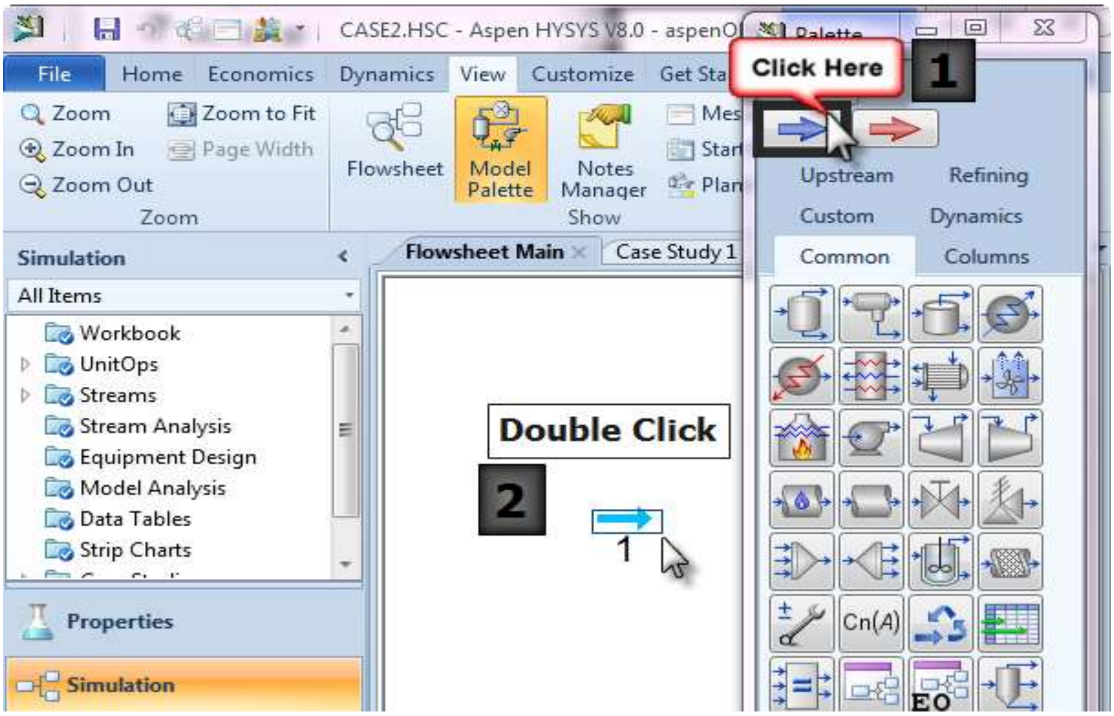


Now you can start drawing the flow sheet for the process by clicking the Simulation button:

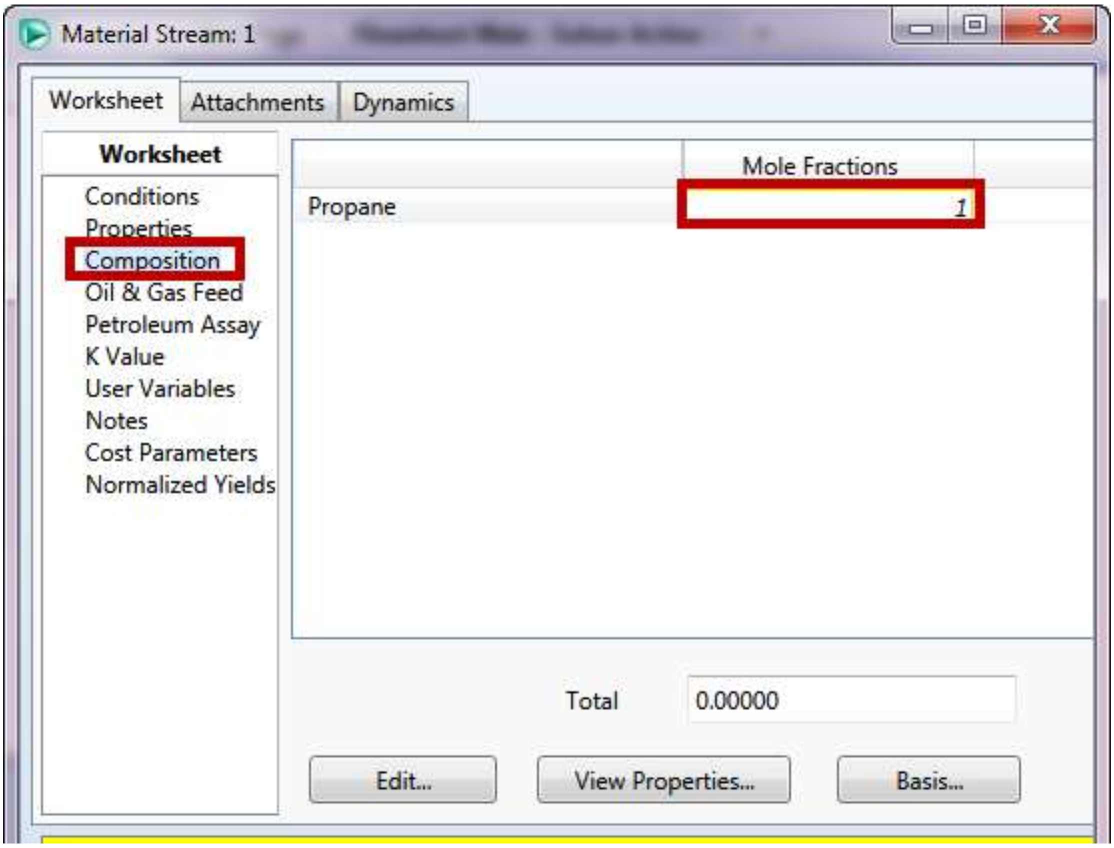


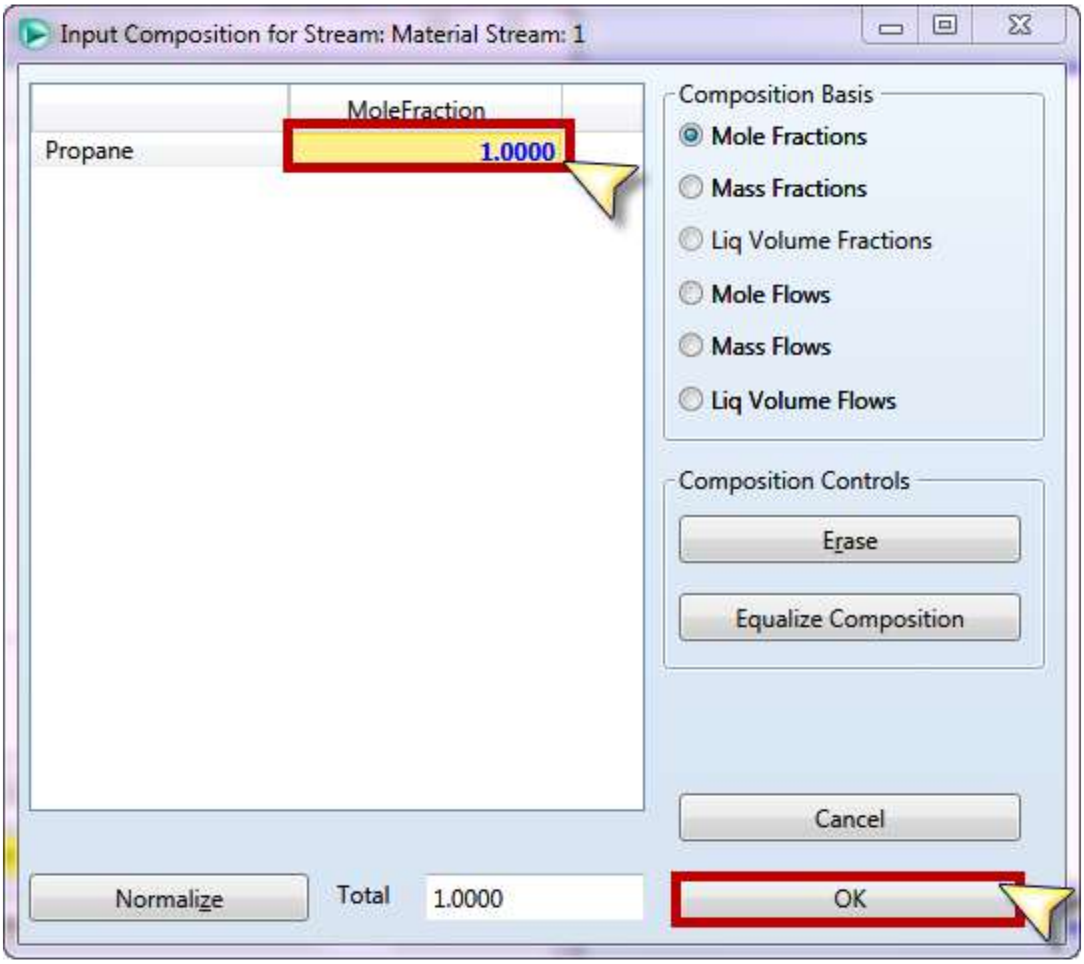
Now add a material stream to define the composition and the conditions of the feed stream

From the palette:



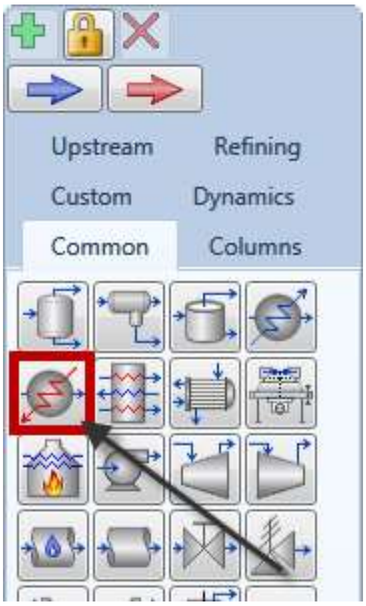
Add the mole fraction for the inlet stream (Propane =1)



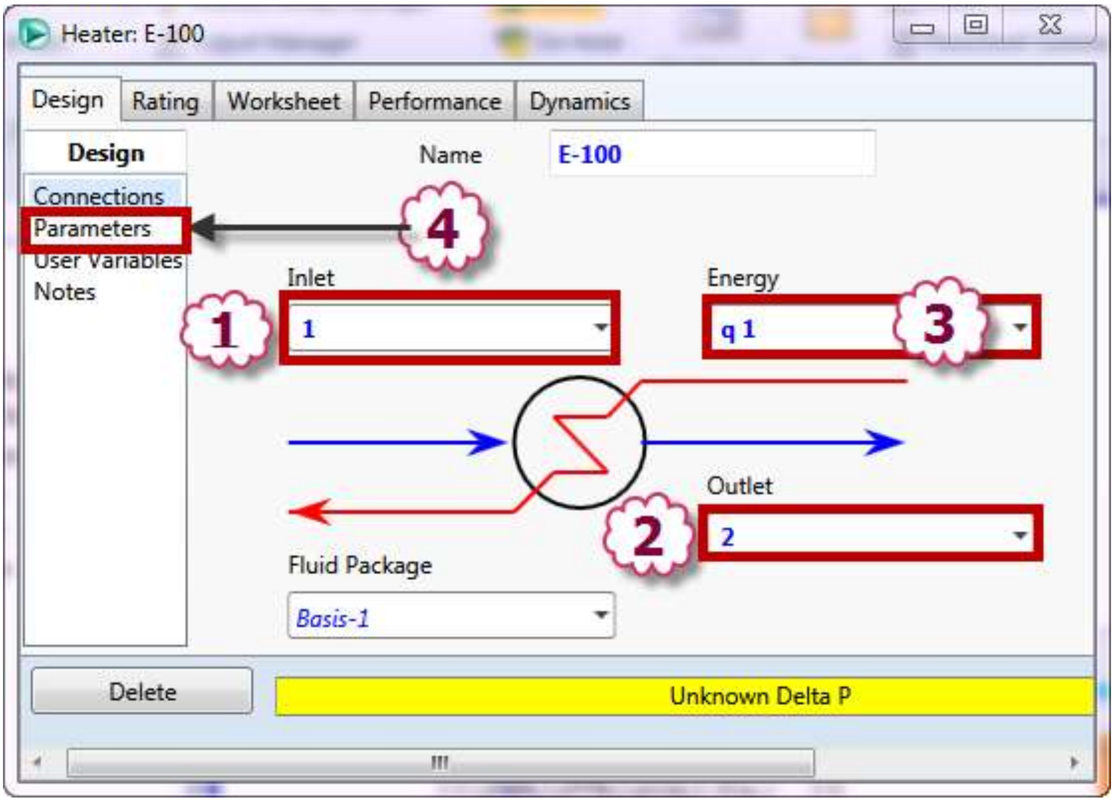


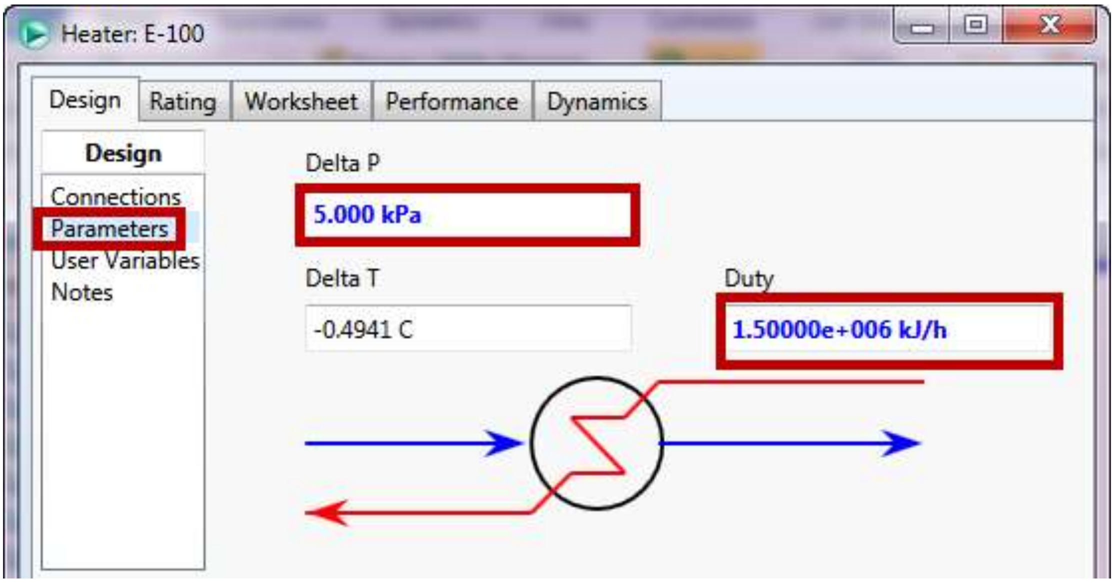
Then leave the stream not solved till the loop is closed

Add the evaporator (heater)

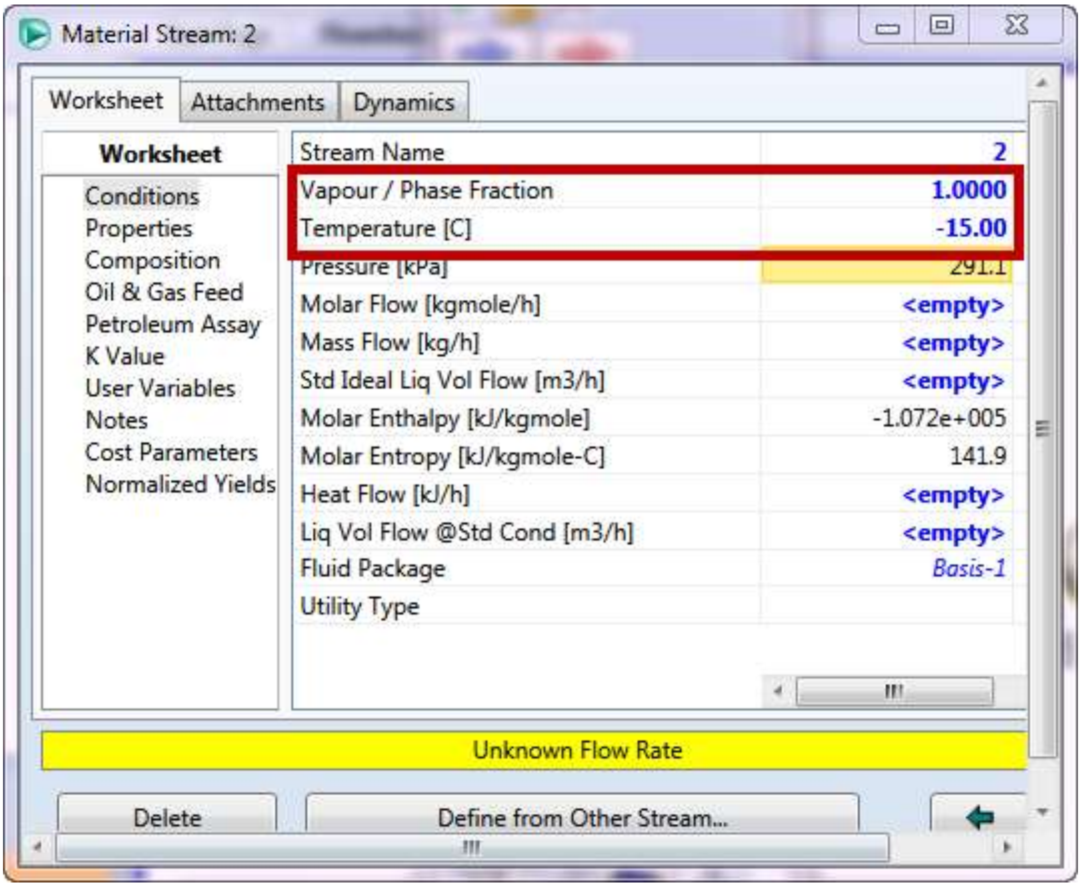


Complete the connections and then go to parameters page to add the pressure drop and the duty rejected

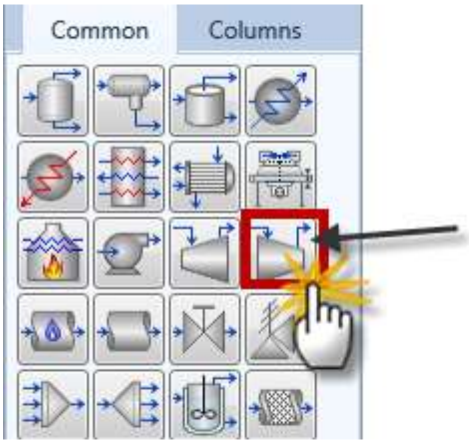


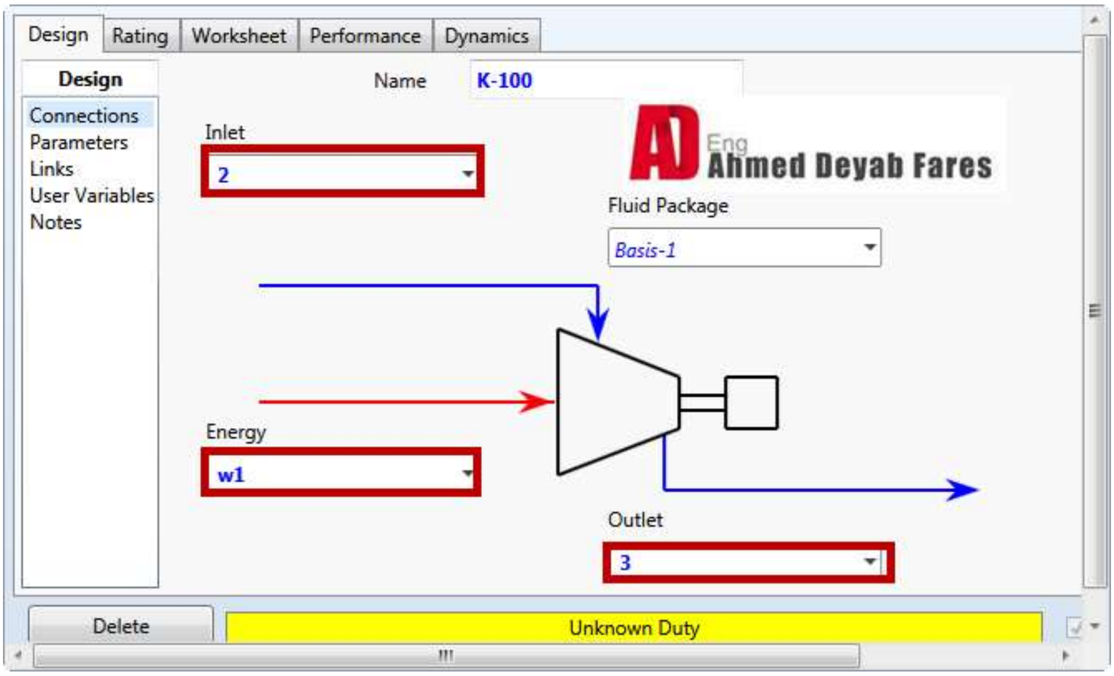


Go to stream 2 and complete the vapor fraction & temperature

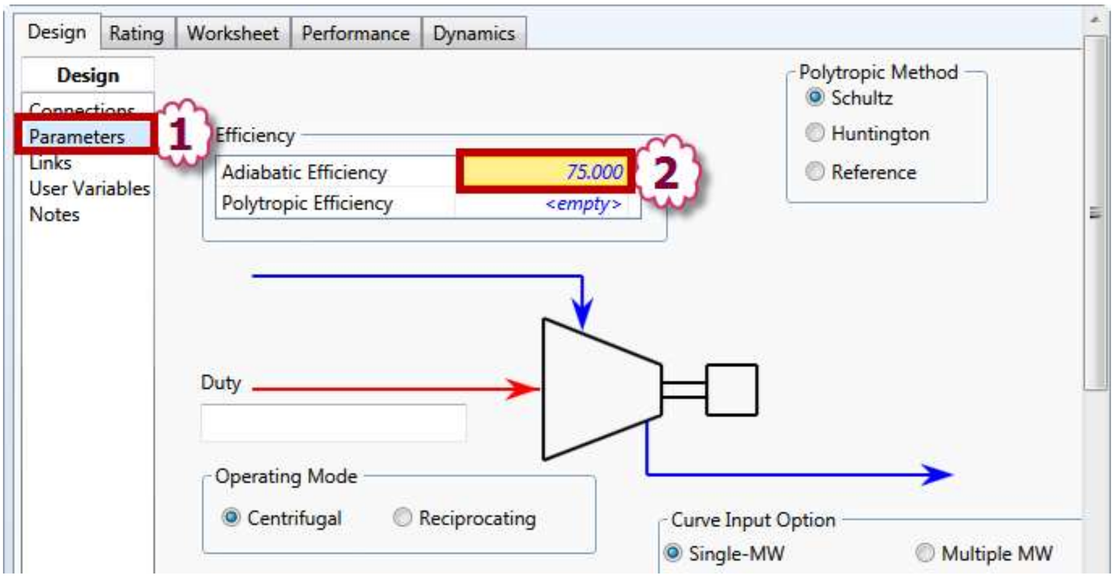


Then add a compressor to raise the pressure of the vapor out from the heater

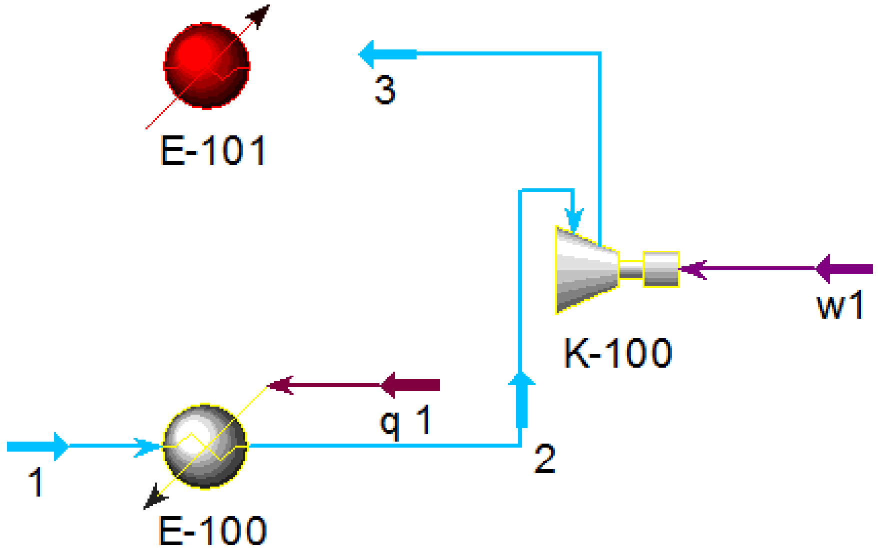


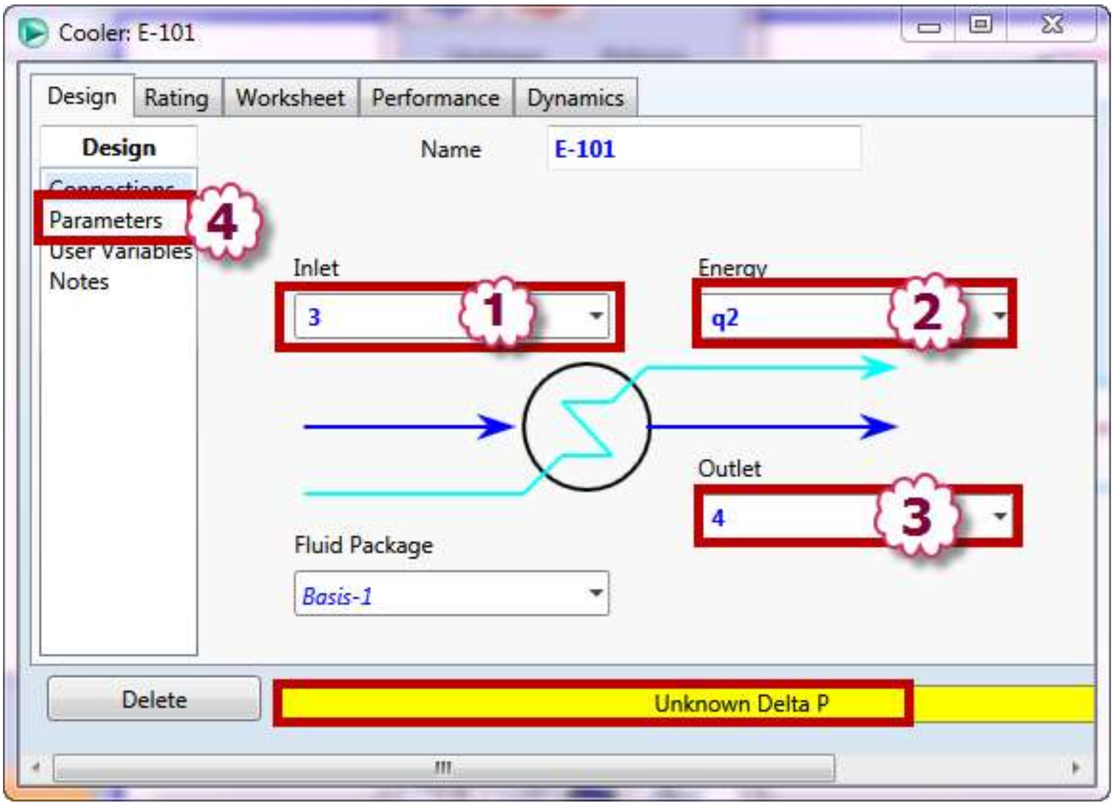


Then go to parameters to make sure that the adiabatic efficiency is 75%

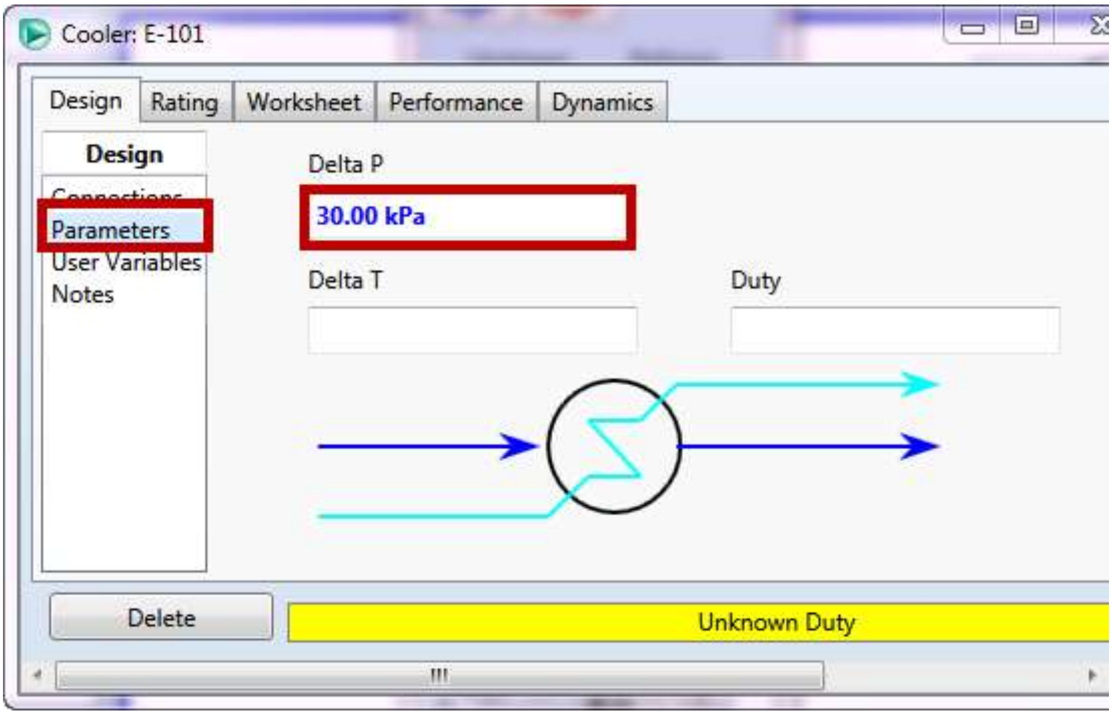


Leave the compressor not solved till the loop is closed then add a cooler

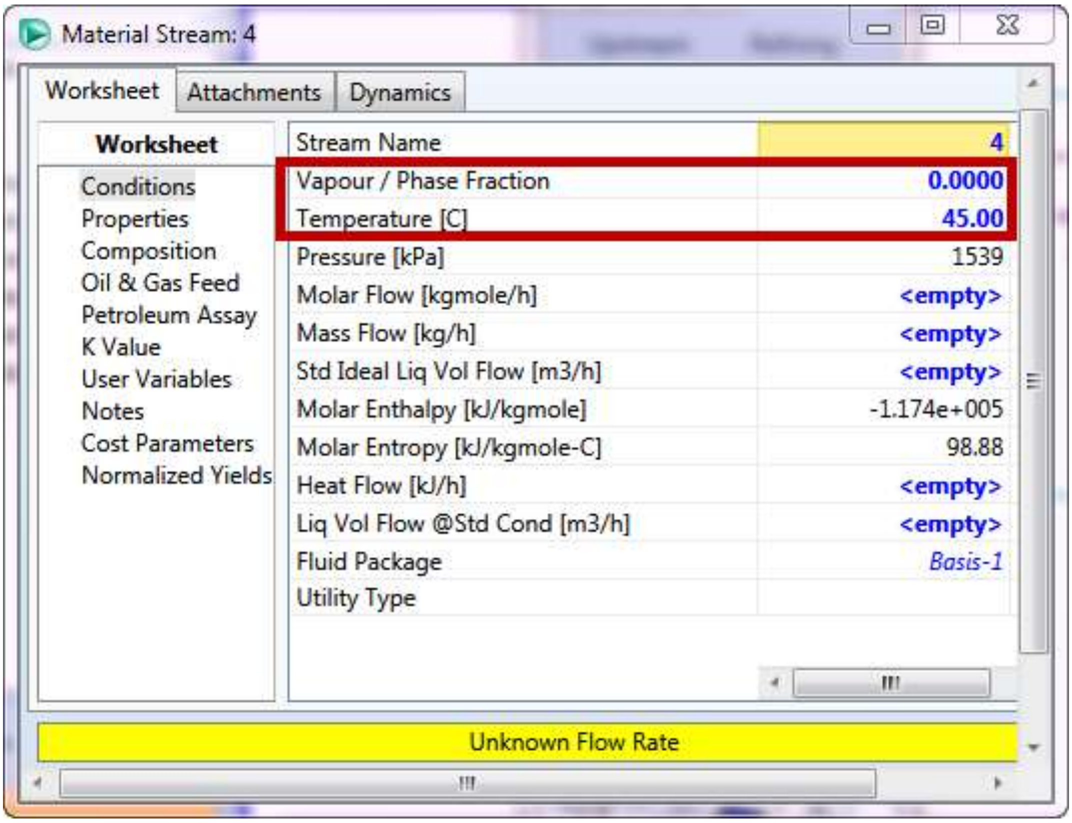




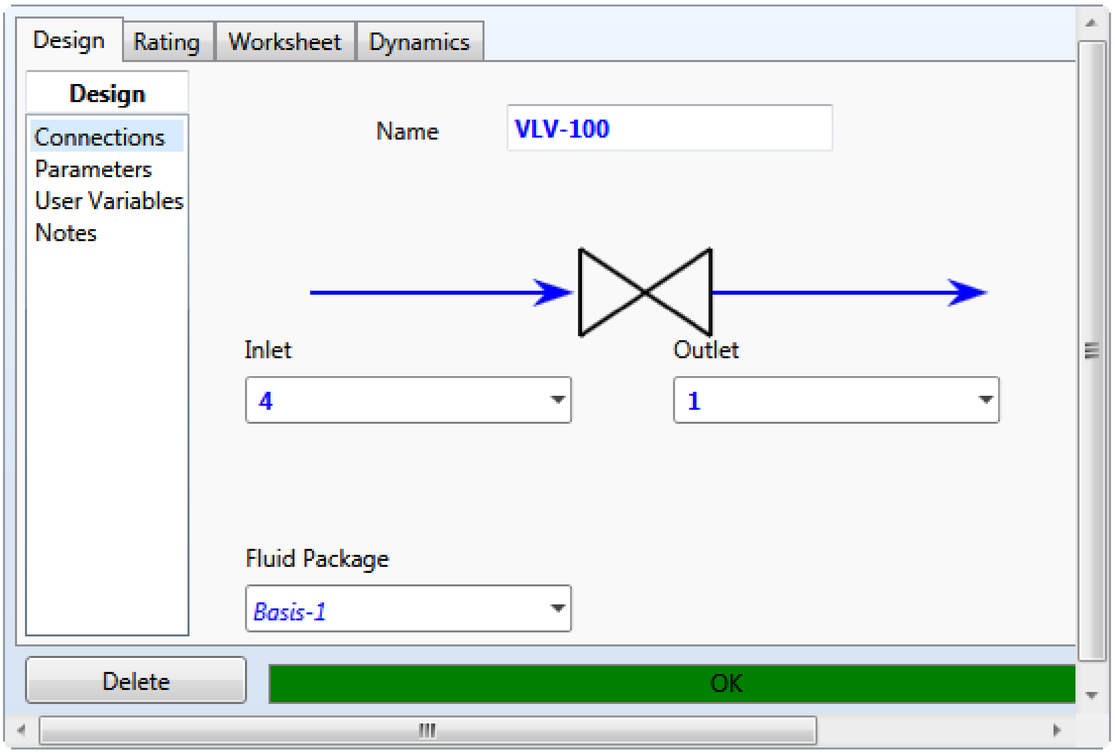
Complete the connections and then go to parameters page to add the pressure drop =30 kPa



Go to stream 4 and complete the vapor fraction (Saturated liquid=0.0) & temperature (45°C)



Then add a valve to close the loop



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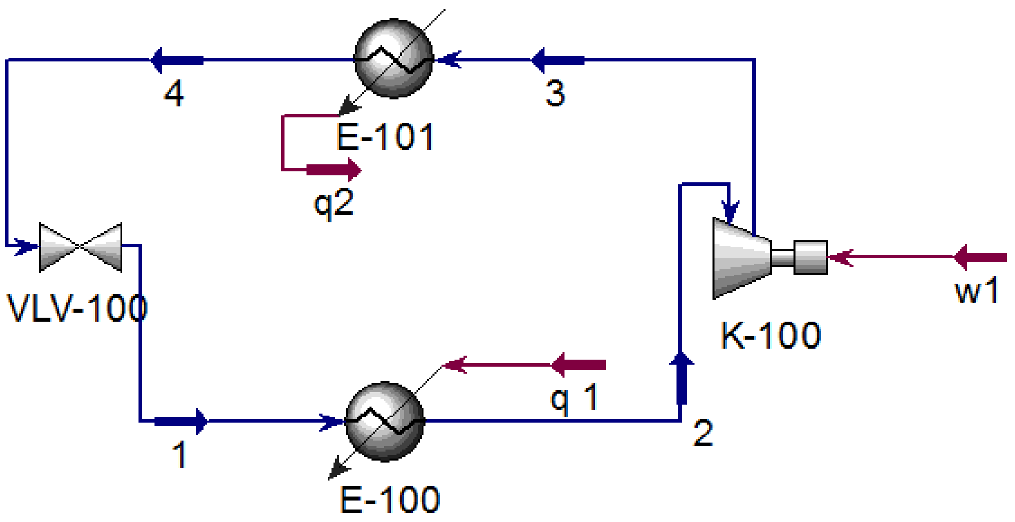
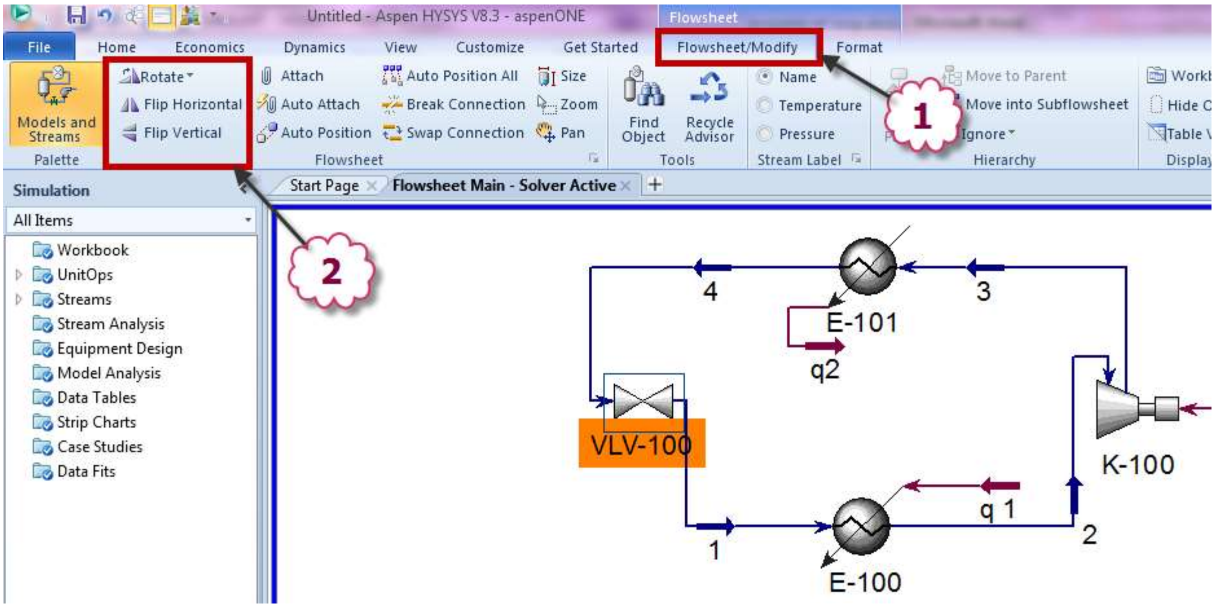


You can adjust the Flowsheet and rotate the streams and equipment from the above menu (Flowsheet/Modify)



Results:

Pressure of the evaporator fed in kPa.	296.1
Flow rate of propane in kmol/hr.	146.4
Valve pressure drop in kPa.	1243.34
Temperature of the valve outlet in ºC.	-14.51
Compressor duty in hp.	252.8
Condenser duty in kJ/hr.	2.179 e+6

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Coefficient of Performance (COP)

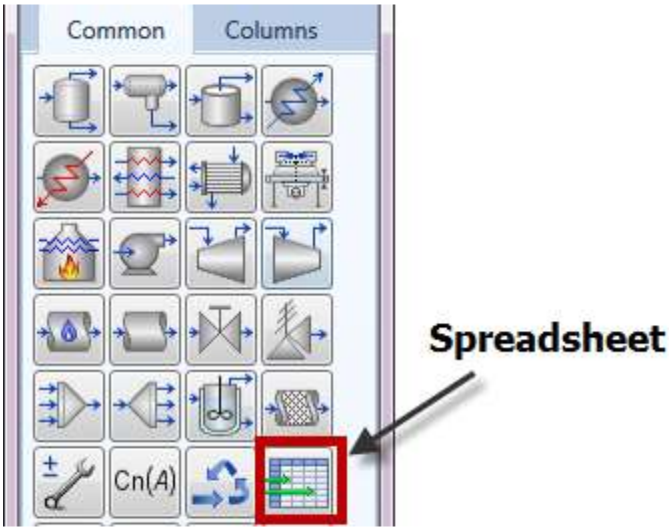
Is a measure of the efficiency of a refrigeration cycle is the *coefficient of performance*, COP

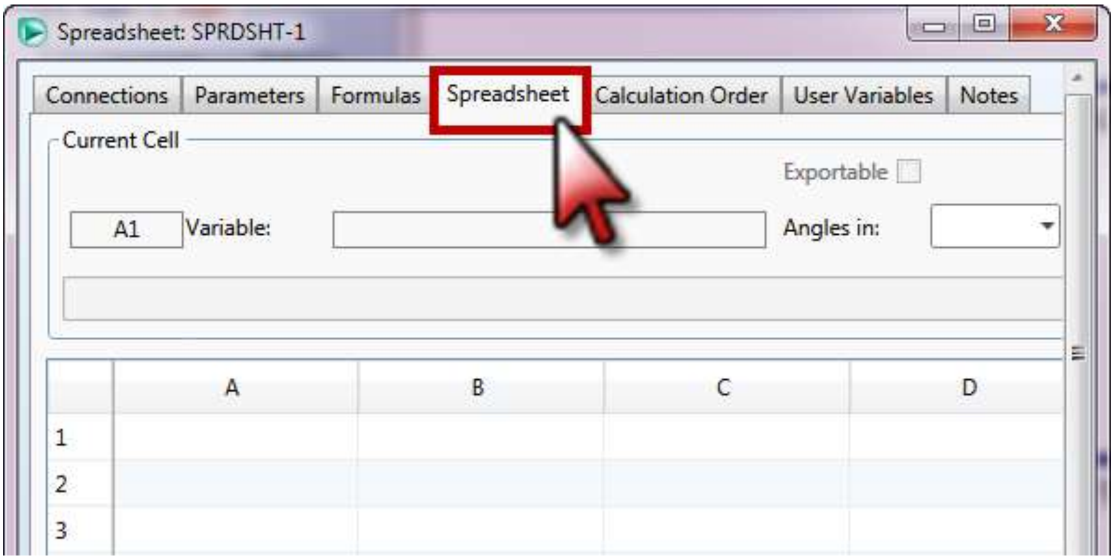
It is the ratio of desired output divided by the required input.

In the vapor-compression system, the net power input is equal to the compressor power, since the expansion valve involves no power input or output.

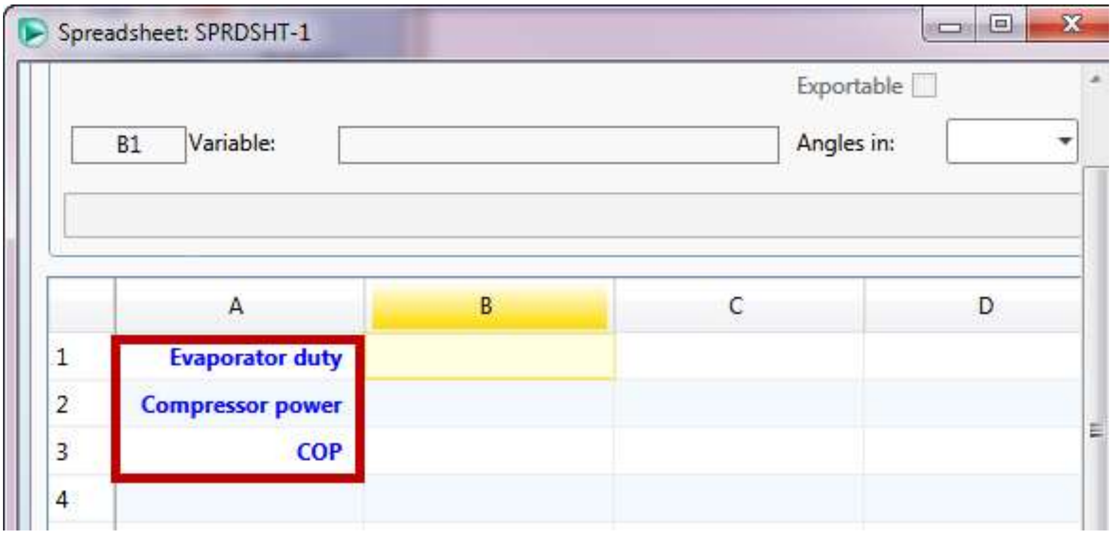
COP= Evaporator Duty/ Compressor Power

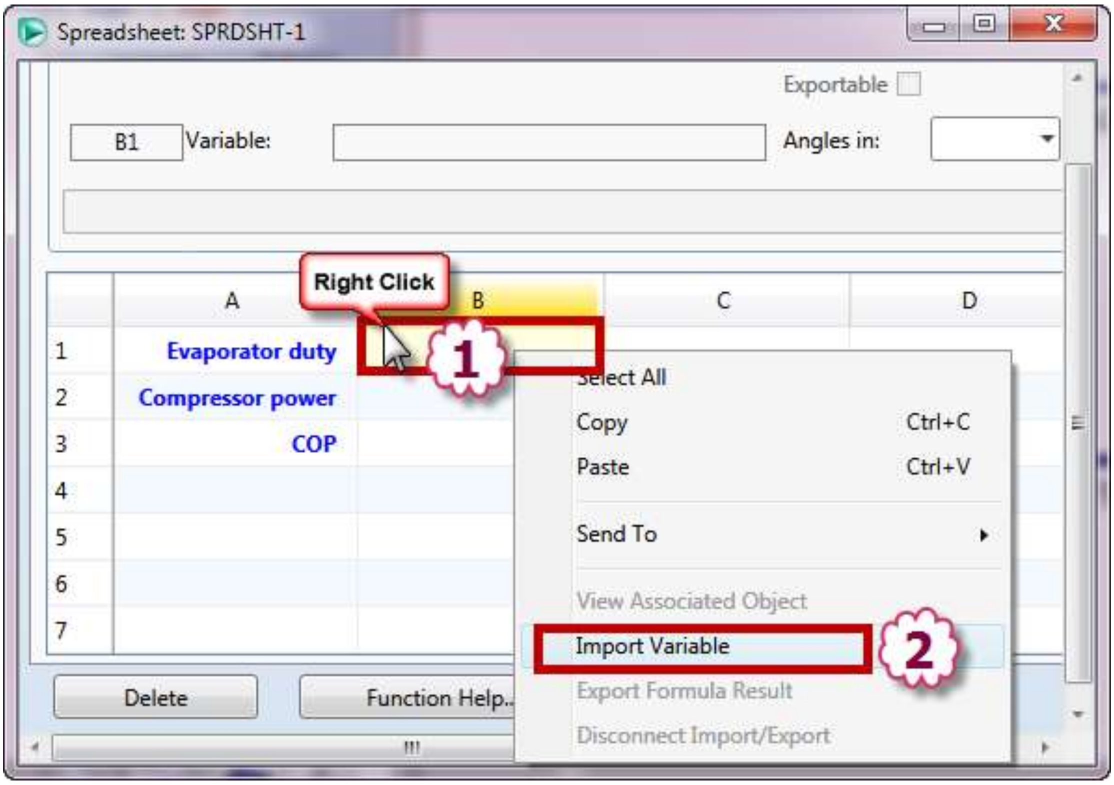
We can use the spreadsheet operation in HYSYS to calculate the COP of the cycle:



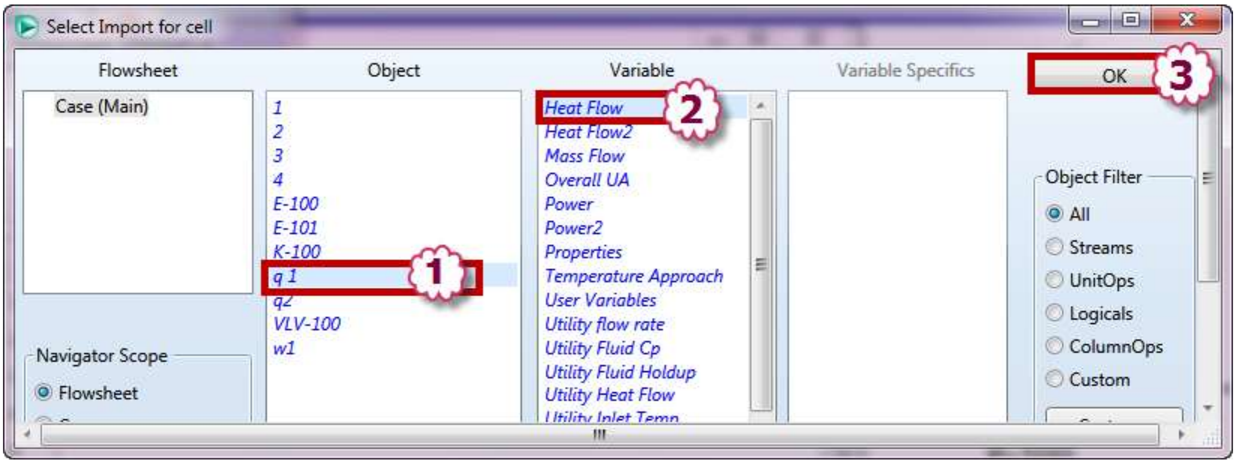


Now we can calculate the COP by importing the two variables; Evaporator duty & Compressor power

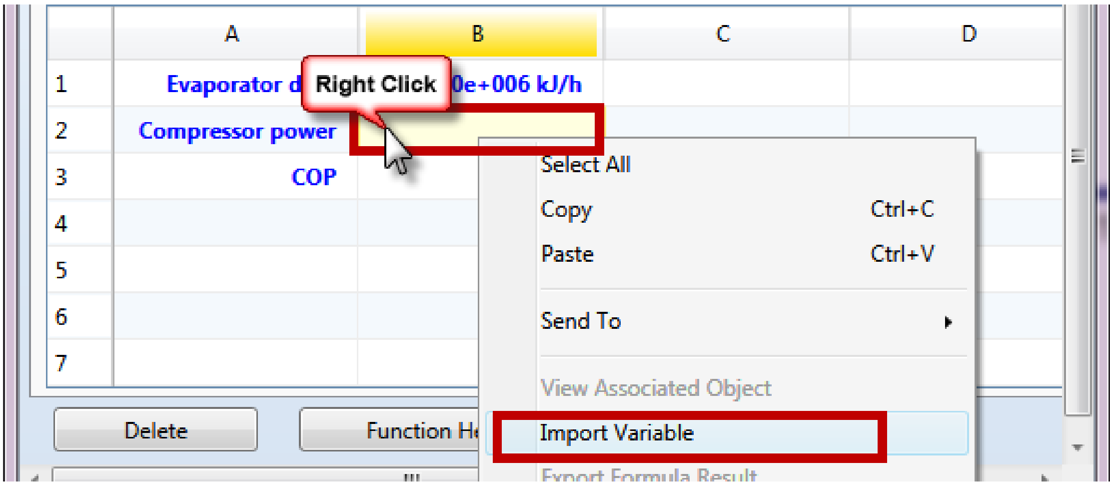




Right click on the cell B1 and select import variable to import the duty of the evaporator

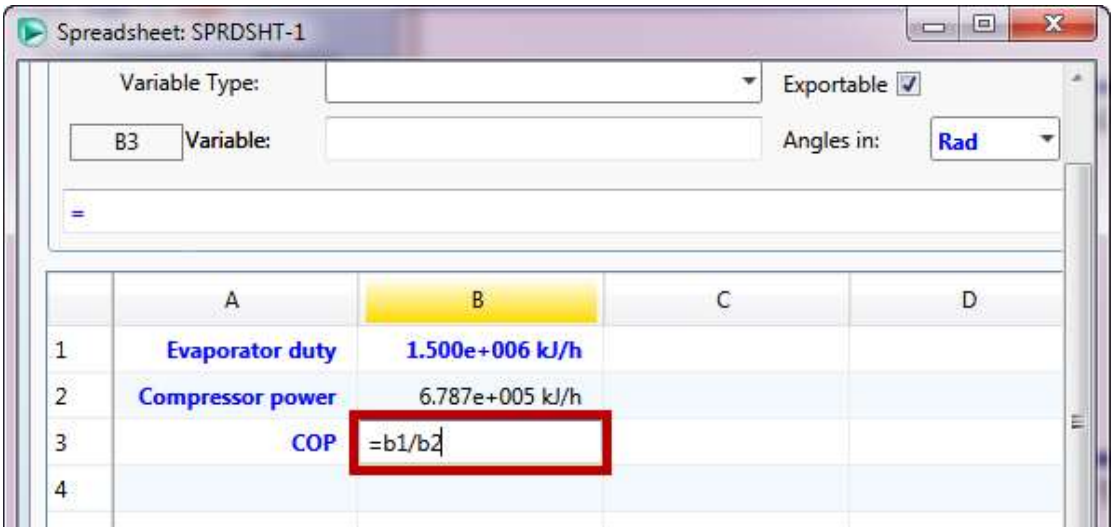


Right click on the cell B2 and select import variable to import the power of the Compressor

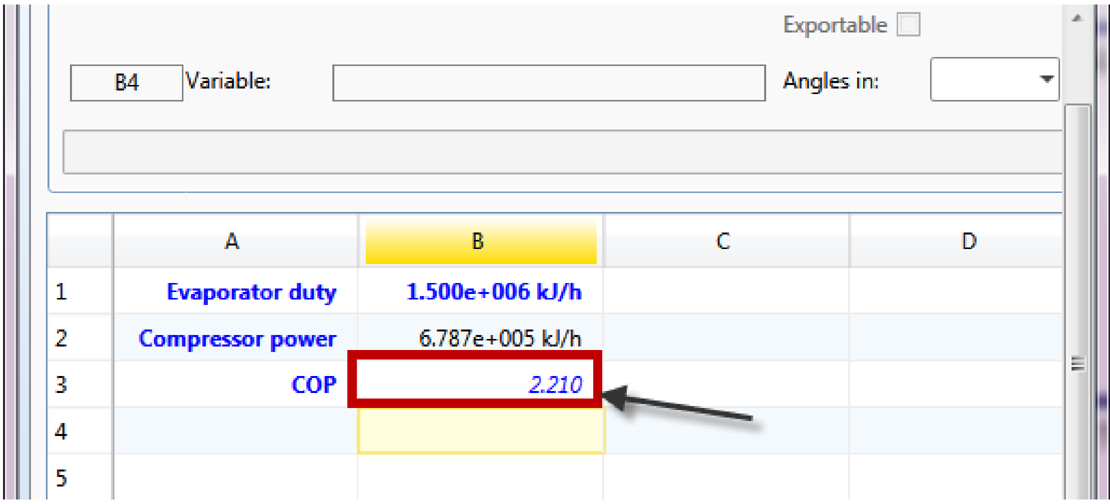


Note that the 2 variables must be in the same units (kJ/hr or KW)

Now, divide the two variables in the cells b1 & b2 to calculate the COP in b3



The result will be 2.2



Challenge:

Now change the duty of the evaporator to 3 e6 kJ/hr (in the evaporator not in the spreadsheet), then open the spreadsheet to calculate the COP & explain the results.

………………………………………………………………………………
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Distillation Column 4

Workshop

Separation of light products is present in any Hydrocarbons operations. In this module, a column will be modeled to separate Light and heavy components from each other using a distillation column with 12 trays.

Learning Objectives

Once you have completed this section, you will be able to:

- *Add columns using the Input Experts.*
- *Add extra specifications to columns.*

Example:

We need to separate a mixture of five paraffins into light and heavy fraction by using a distillation column with 12 trays, a full reflux condenser, and a Kettle reboiler.

The feed stream (1000 lbmol/hr) consists of 3% (mole %) ethane, 20% propane, 37% n-butane, 35% n-pentane and 5% n-hexane at 225 ^oF and 250 psia, which enters the column on the sixth tray, counting from the top. The condenser and reboiler pressures are 248 and 252 psia, respectively. The preliminary design specifications require a **reflux ratio of 6.06** and **a vapor overhead product of 226 lbmol/hr**. Subsequently, the design is modified to ensure propane overhead flow of 191 lb_{mol}/hr and n-butane bottom flow of 365 lb_{mol}/hr.

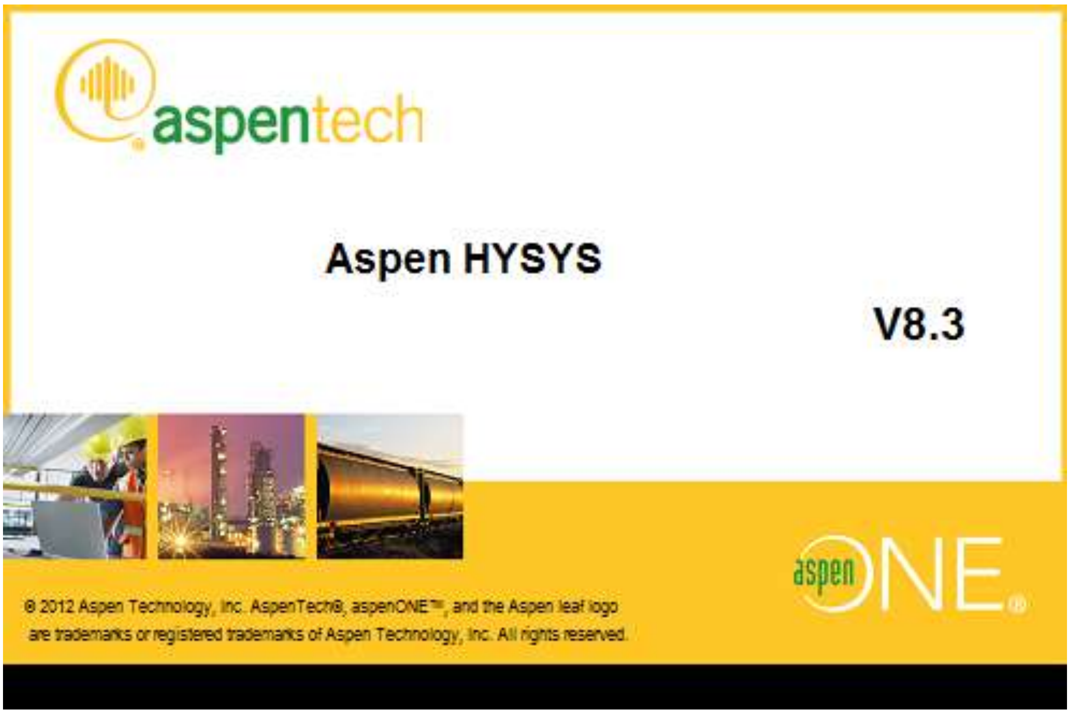
Use SRK Fluid Pkg

Calculate:

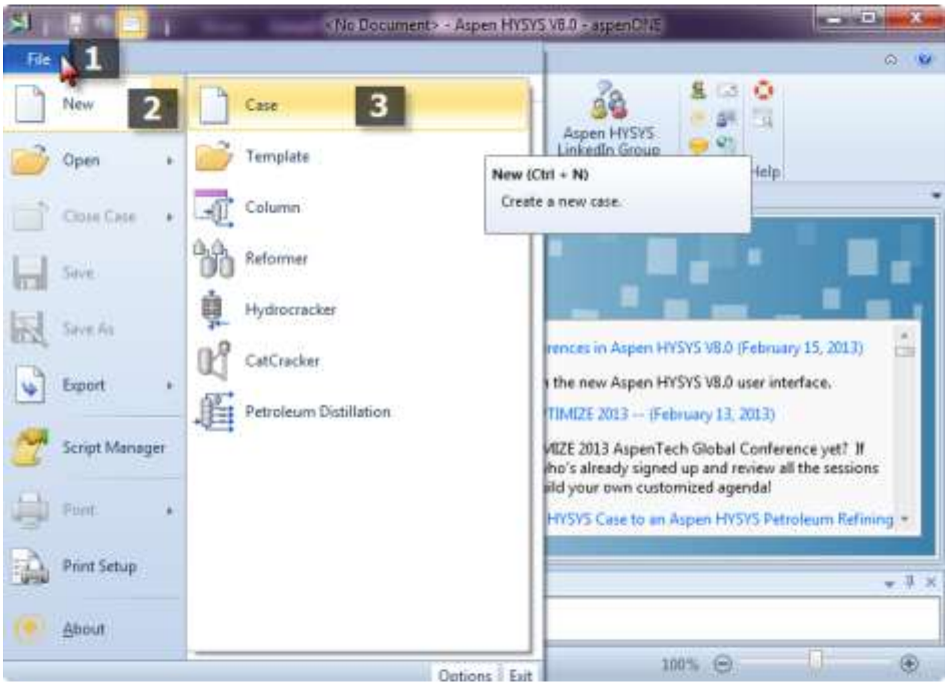
The Condenser, the Reboiler Temperatures & the Reflux Ratio **after modification**

Condenser Temp	**………………^{o}C**
Reboiler Temp	……………… ^{o}C
Reflux Ratio	…………………

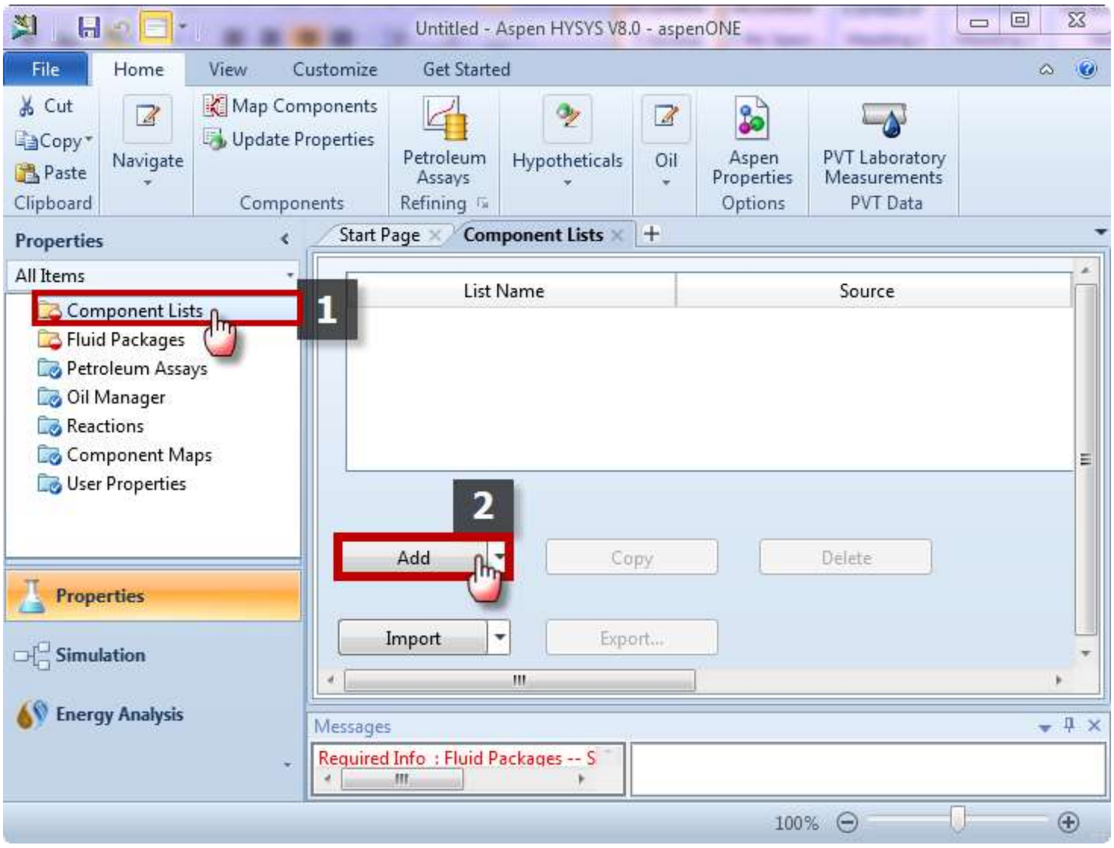
To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.3 >>>> Aspen HYSYS >> Aspen HYSYS



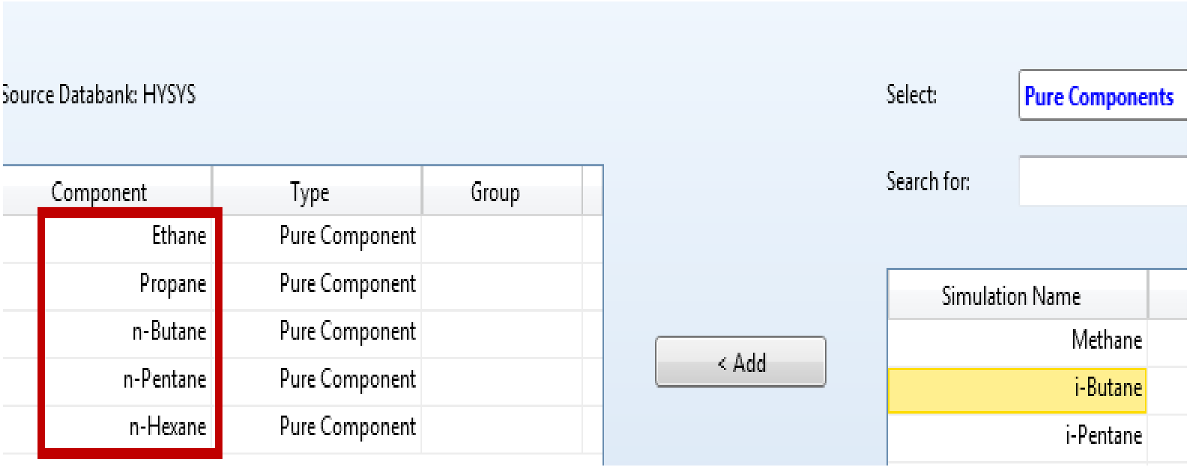
7- First, Start a new case



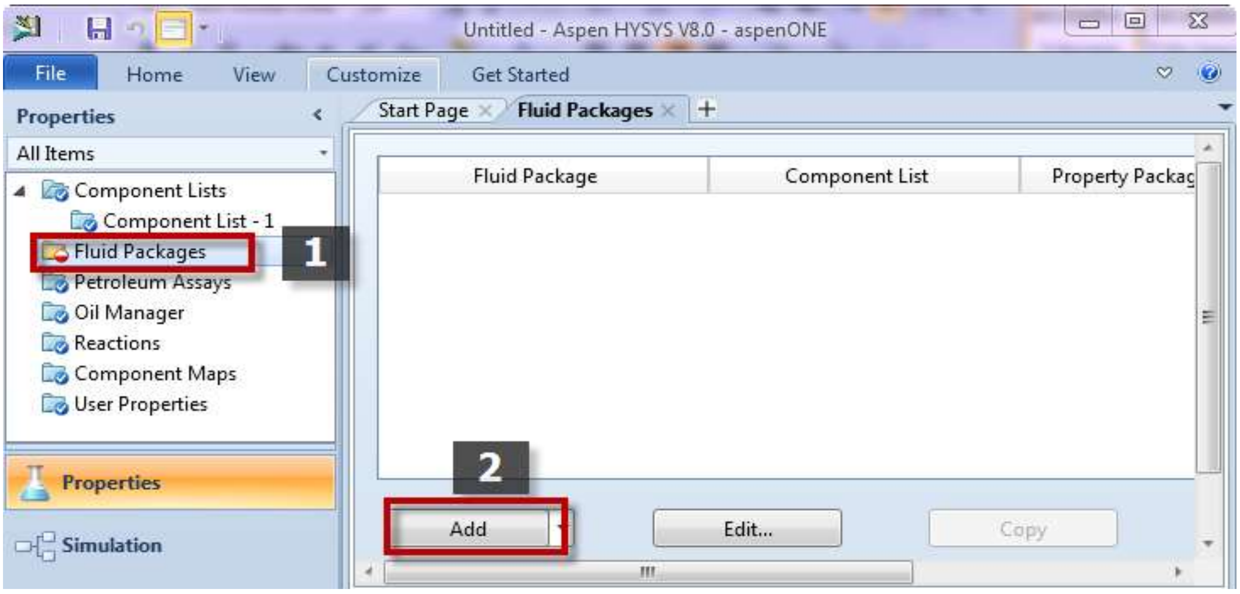
8- Add the Components



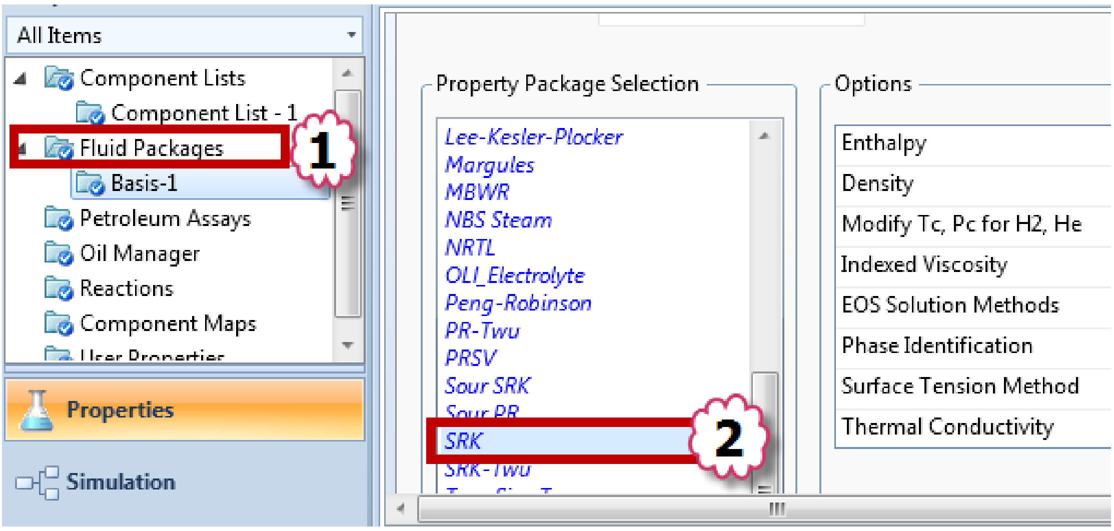
9- Choose the system components from the databank:



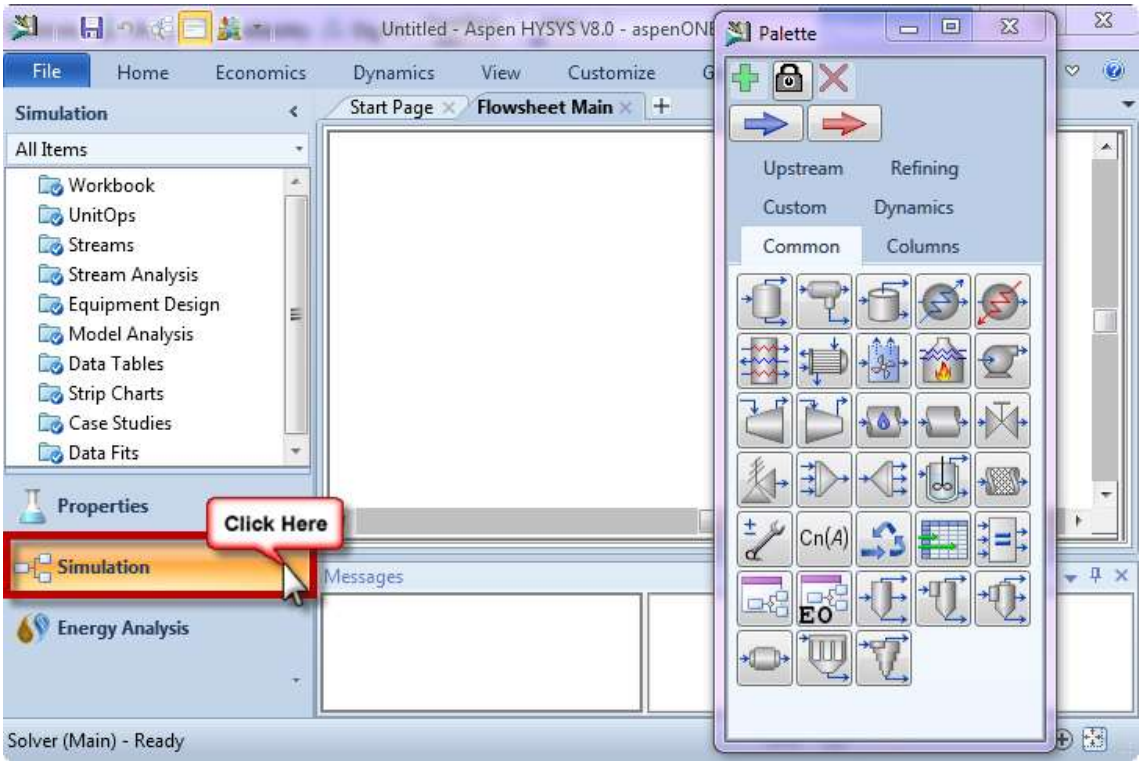
Now, select the suitable fluid package



In this case, select SRK

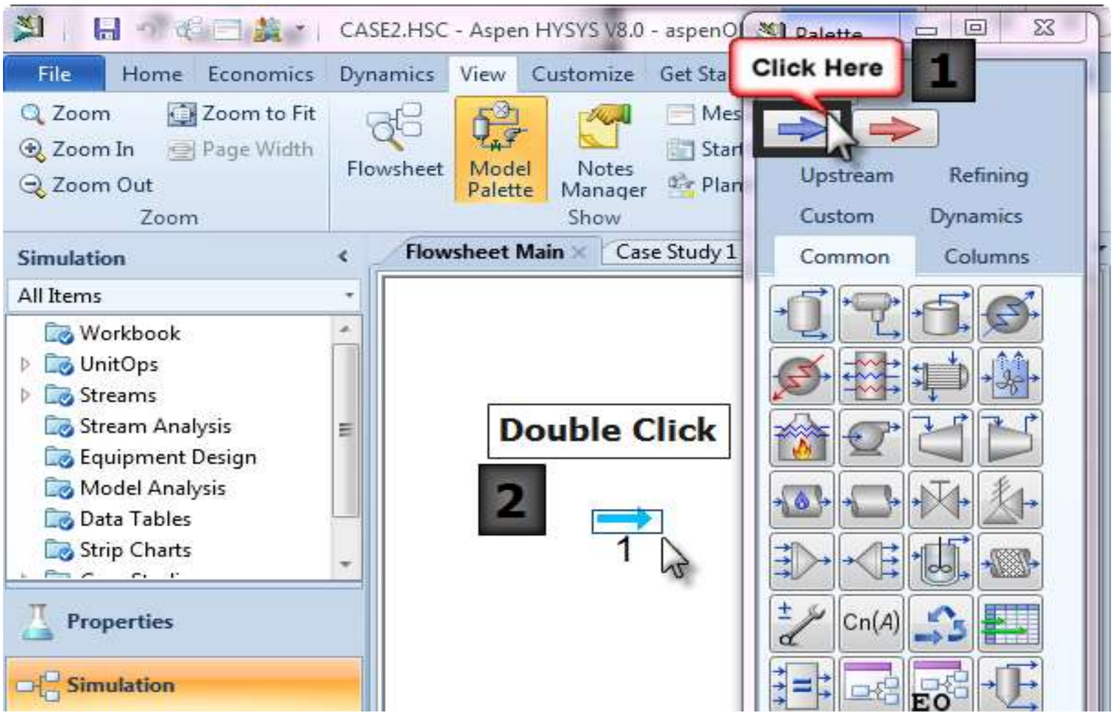


Now you can start drawing the flow sheet for the process by clicking the Simulation button:

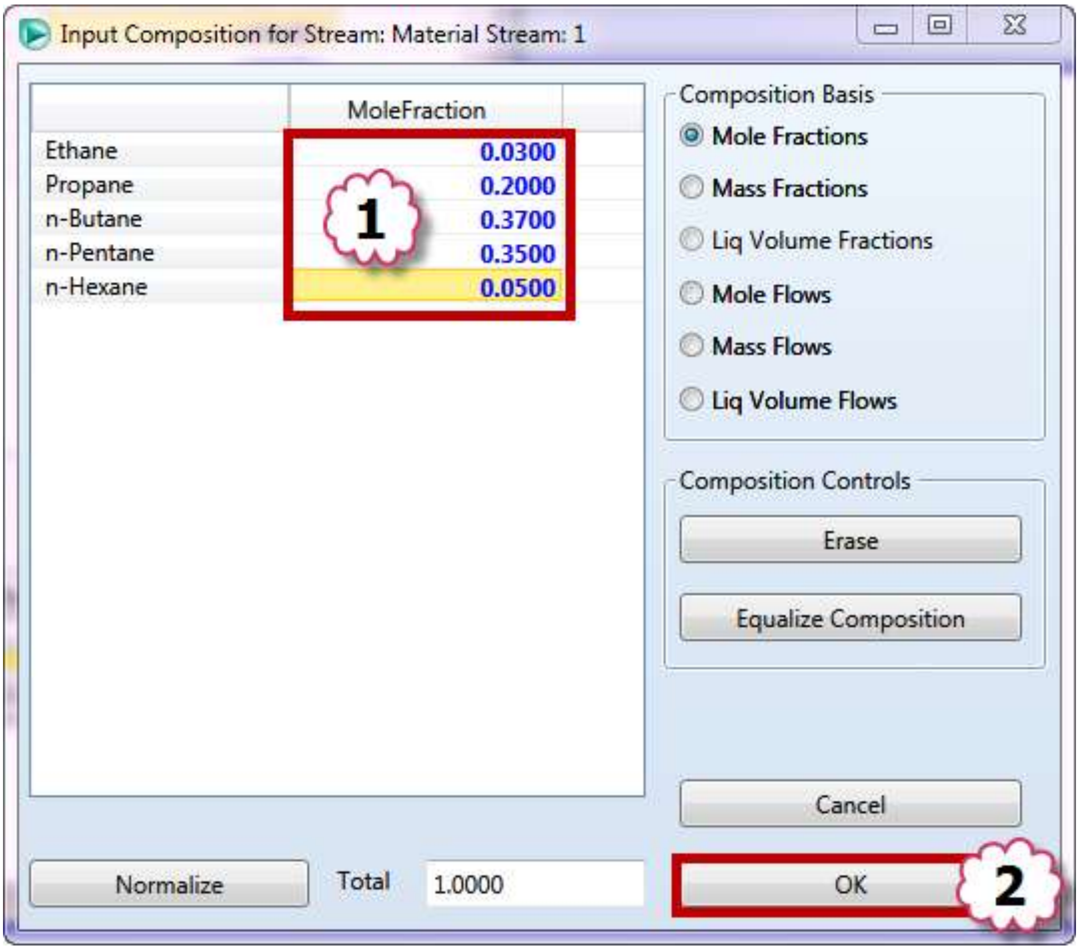


Now add a material stream to define the composition and the conditions of the feed stream

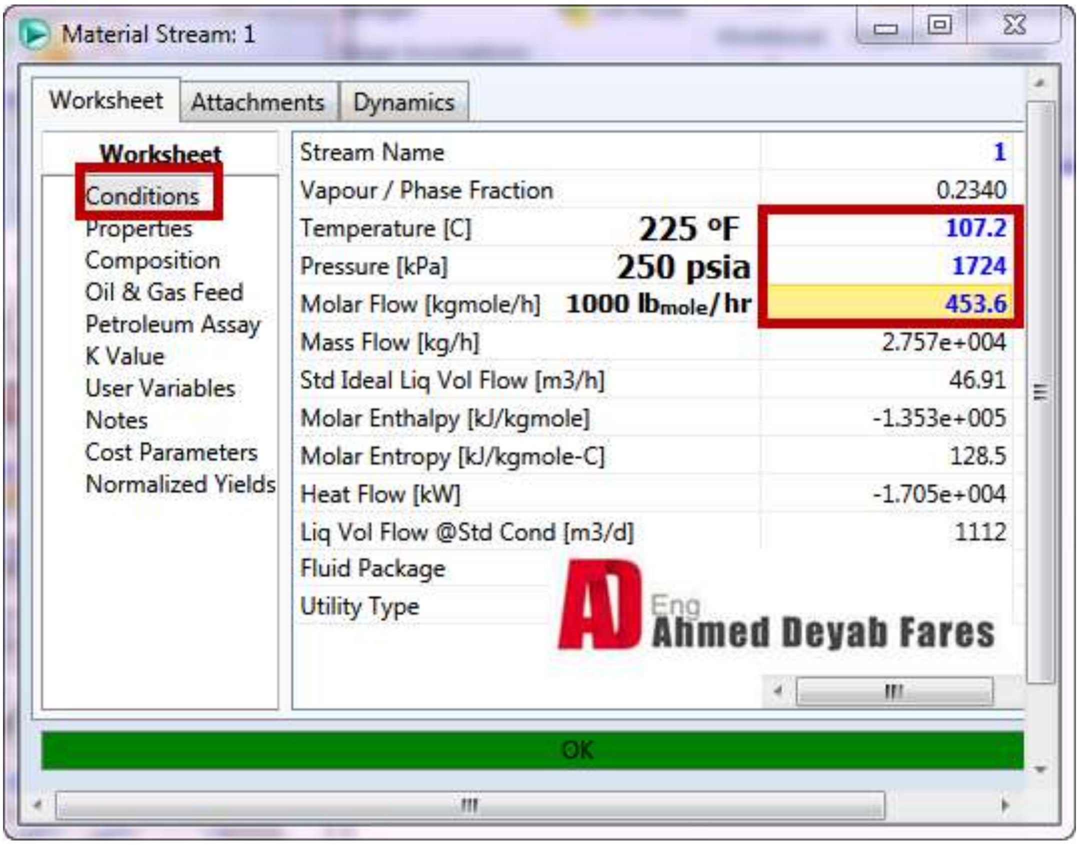
From the palette:



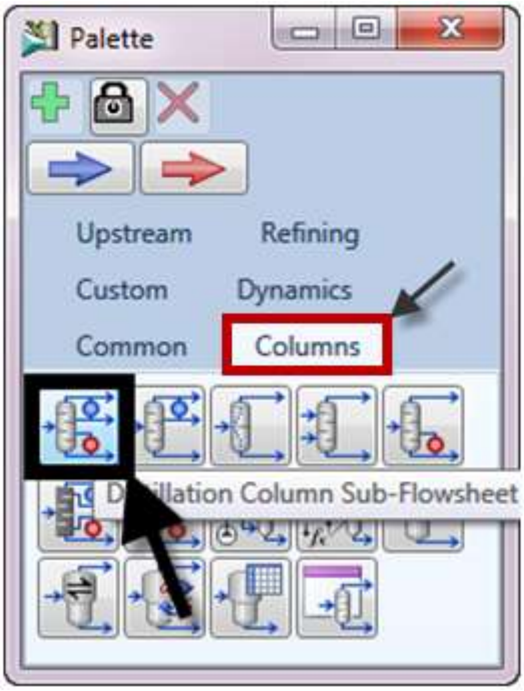
Add the mole fraction for the inlet stream



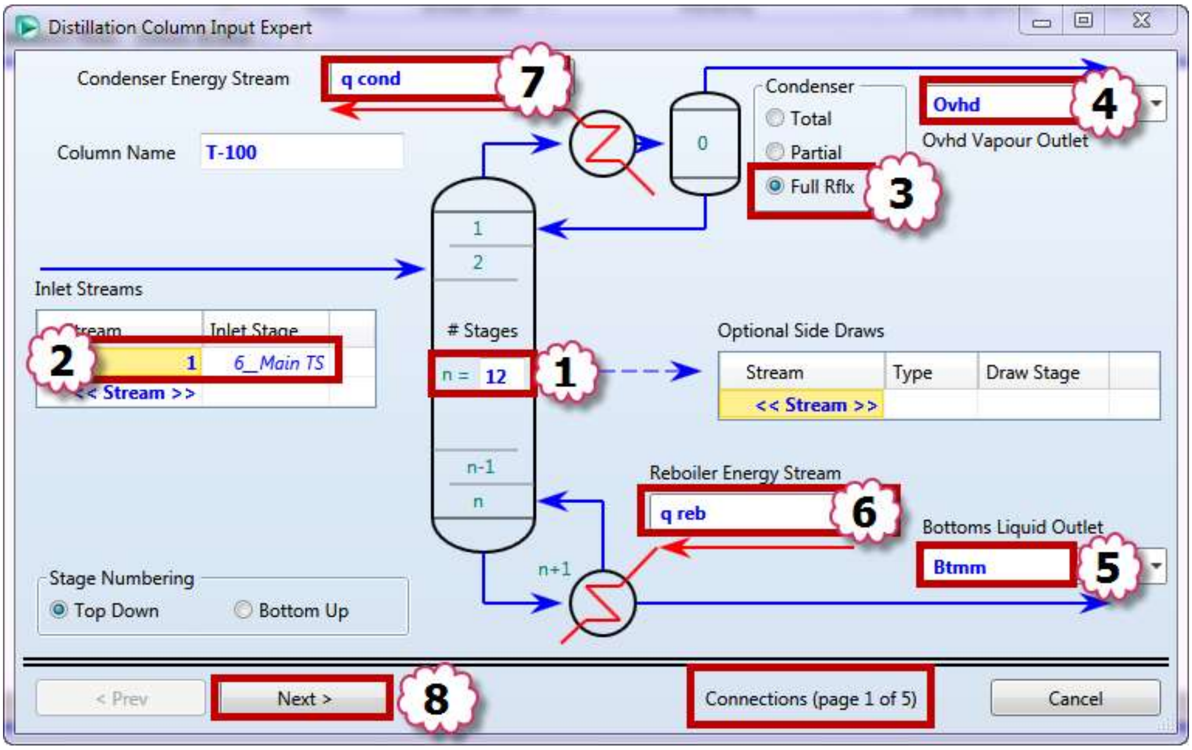
Then go to the conditions page to complete the feed stream conditions:



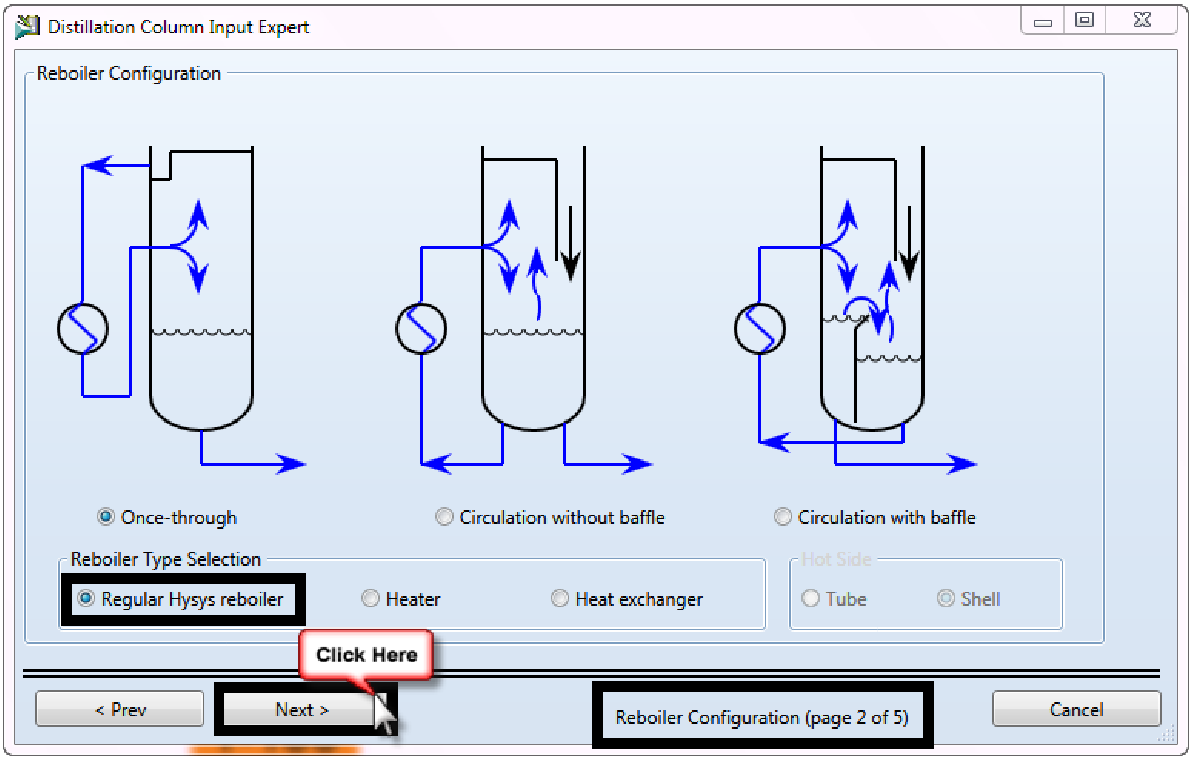
Add a distillation tower (with condenser & Reboiler):

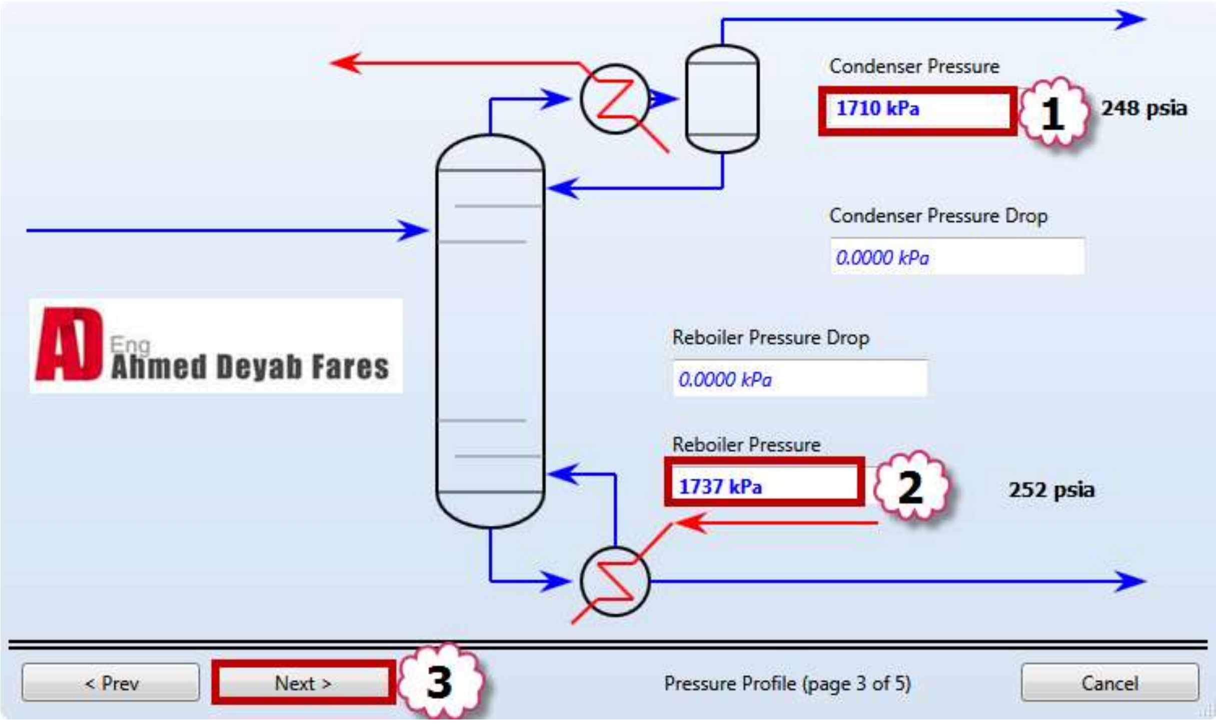


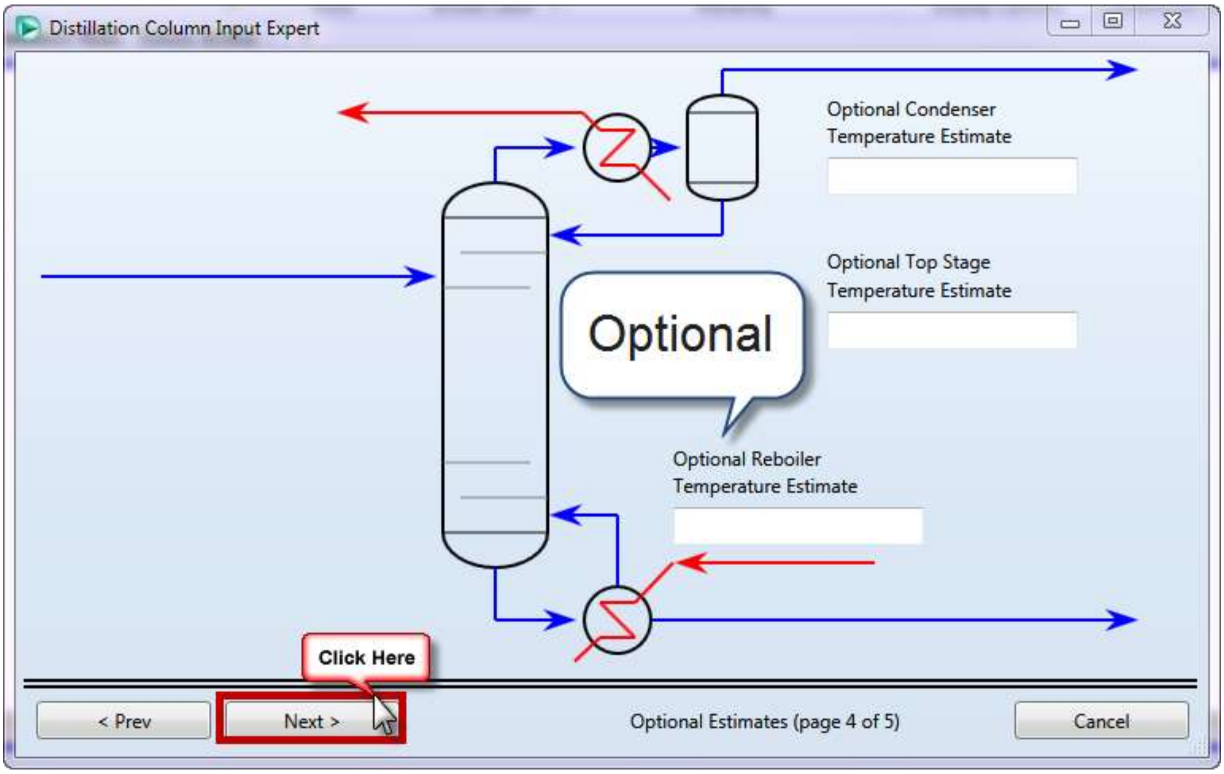
Now, start building the column:



Select Regular Hysys Reboiler in the reboiler configuration page for Kettle Reboiler as follows:



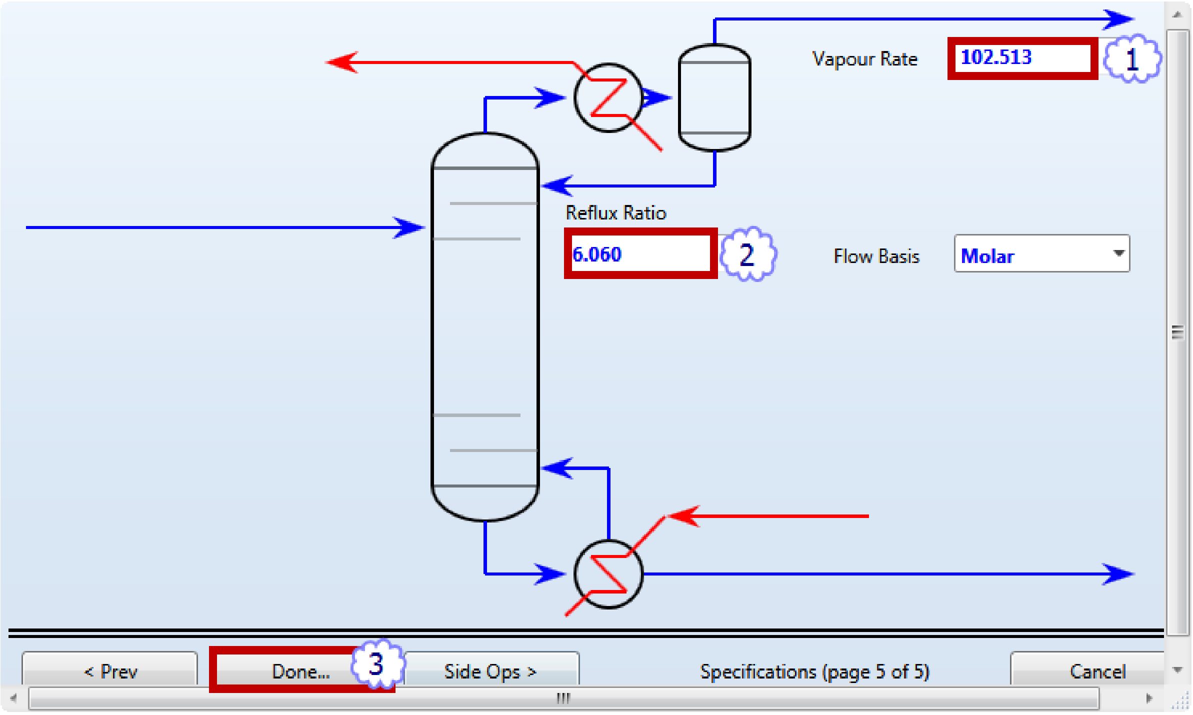


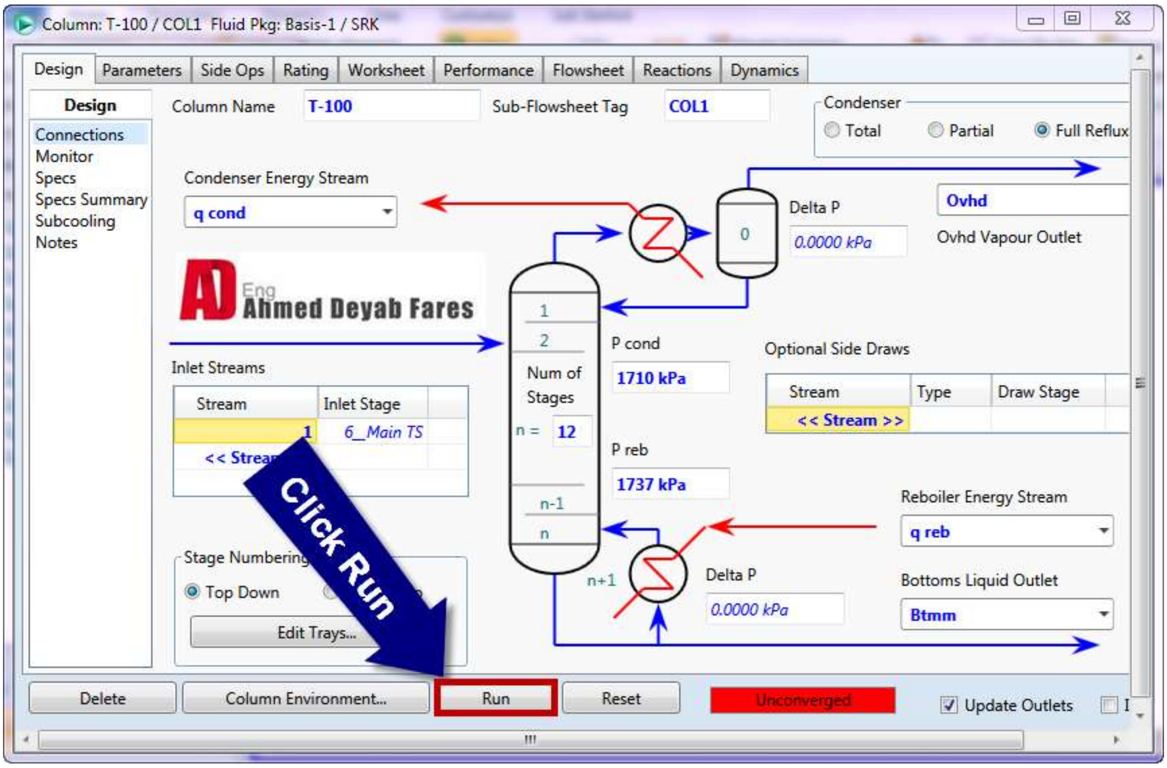


The target is to run the column with 2 specifications:

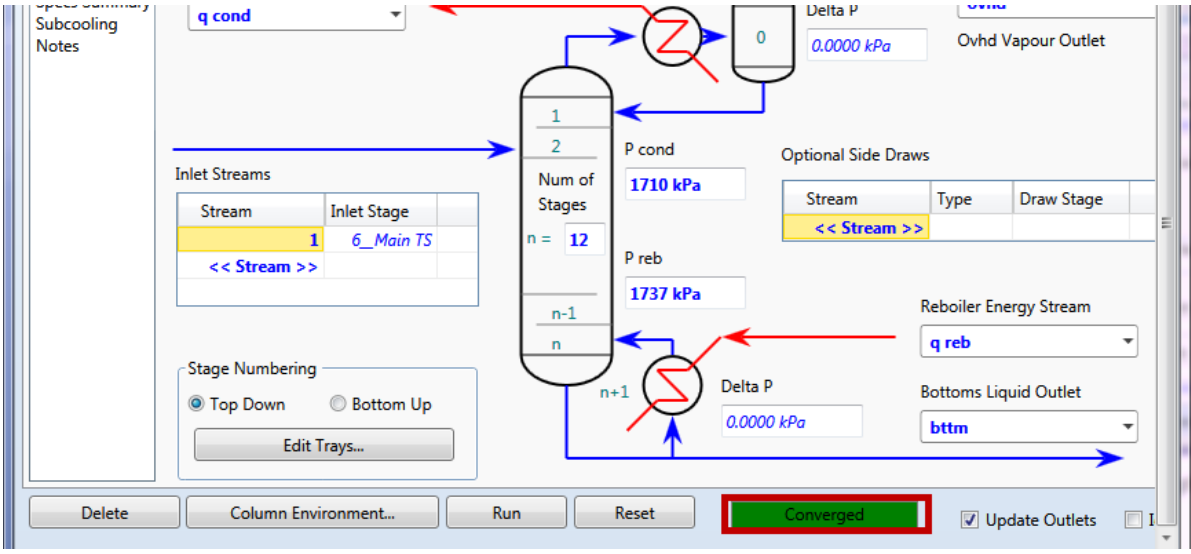
1- Reflux Ratio = 6.06

2- Overhead vapor rate (Vent rate) =226 lb_{mole}/hr

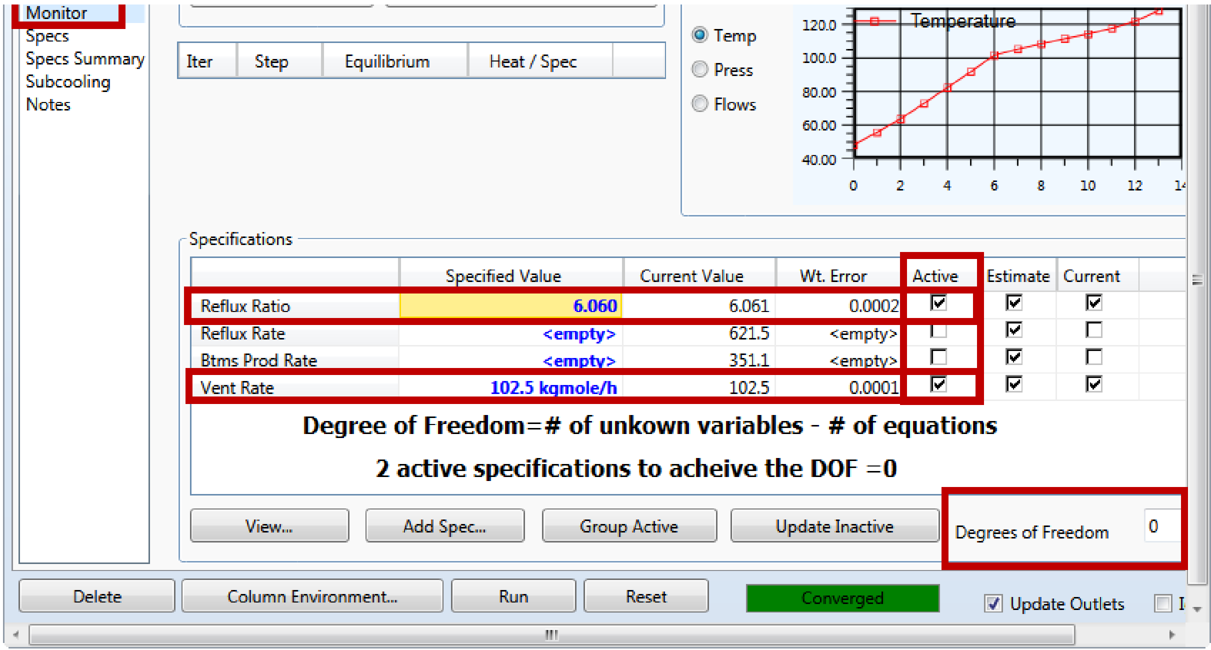




The column statues bar (Red bar) is now unconverged till clicking the RUN button to converge the column.



Let's go to the monitor page and see the current specifications:



We must make 2 specifications active to make the DOF=0.0 and to converge the column.

The two specifications are the target that you want to achieve from the column.

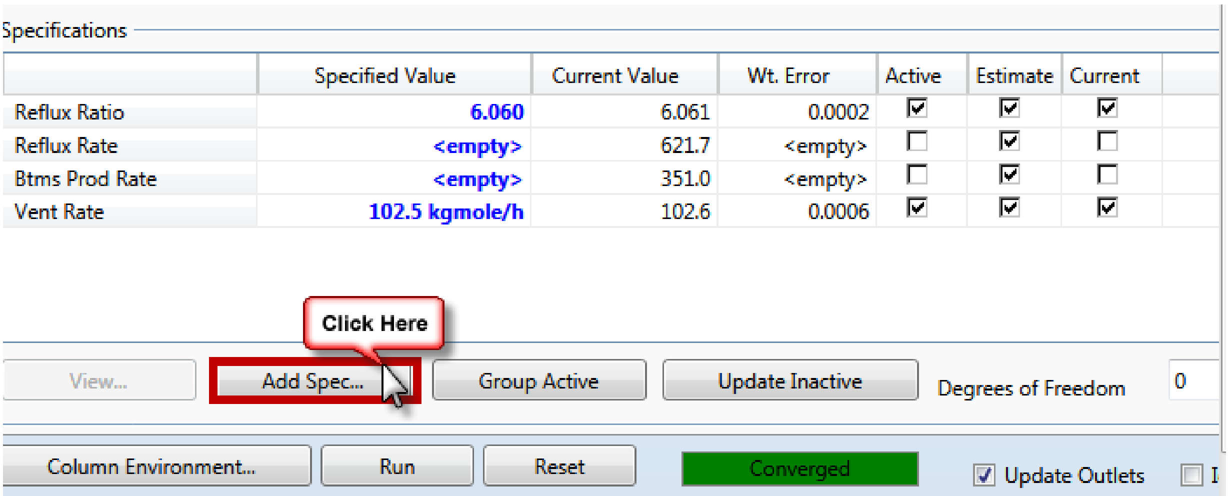
Although the column is converged, it is not always practical to have vapor rate & reflux ratio specifications. These specifications can result in columns which cannot be converged or that produce product streams with undesirable properties if the column feed conditions change.

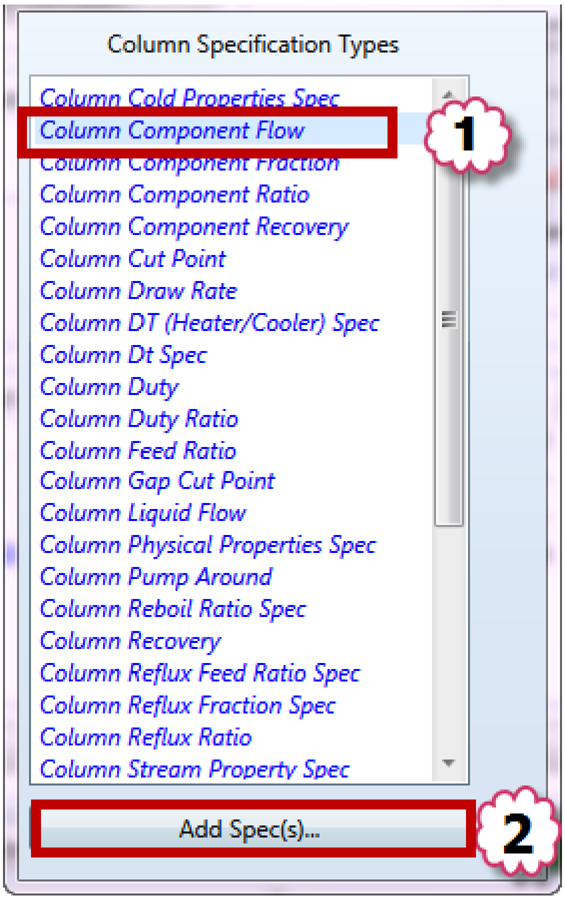
An alternative approach is to specify either component fractions or component flow rates for the column product streams.

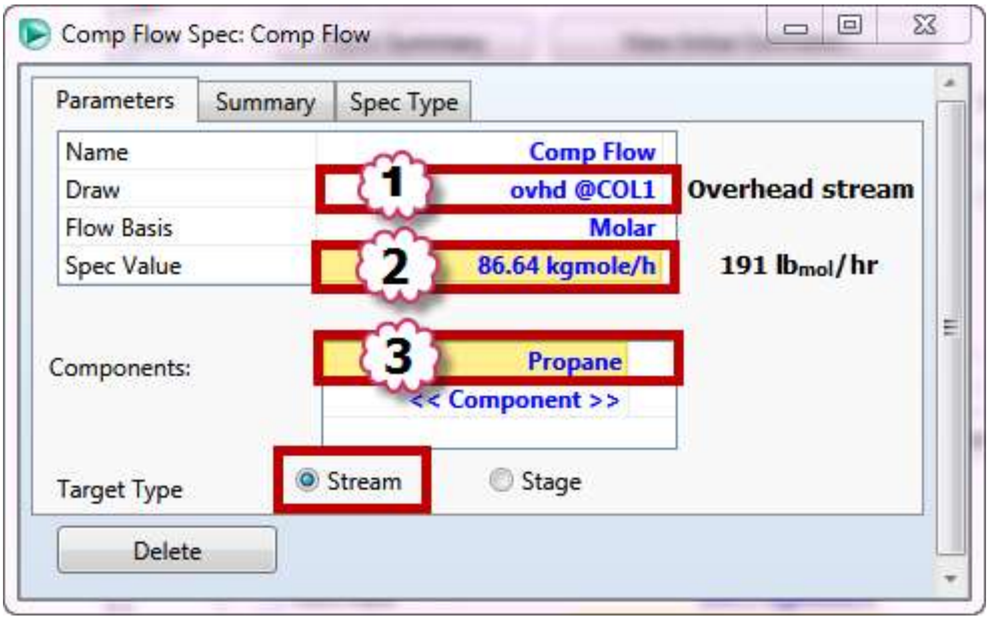
Now we have to give the column another 2 new specifications to run with (more practical)

1- Propane overhead flow of 191 lb_{mol}/hr

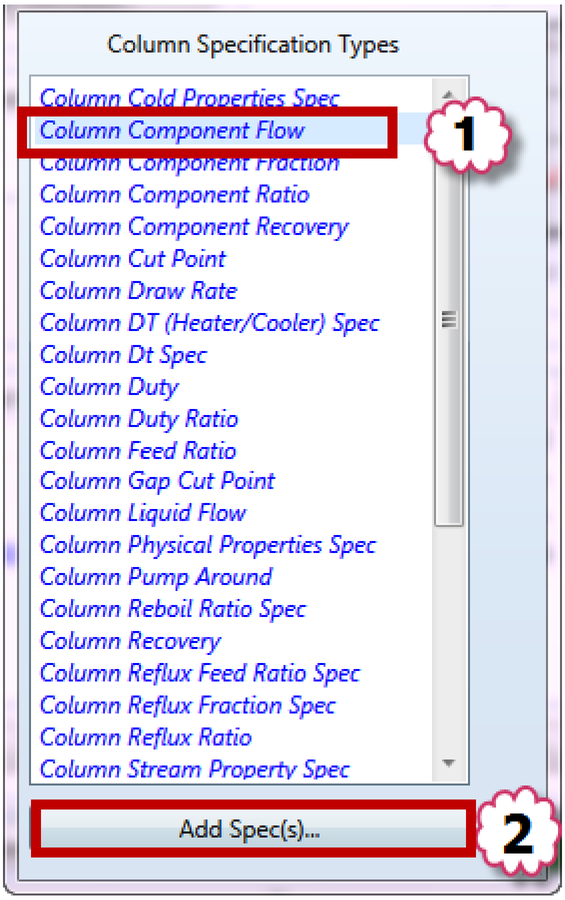
2- Butane bottom flow of 365 lb_{mol}/hr.

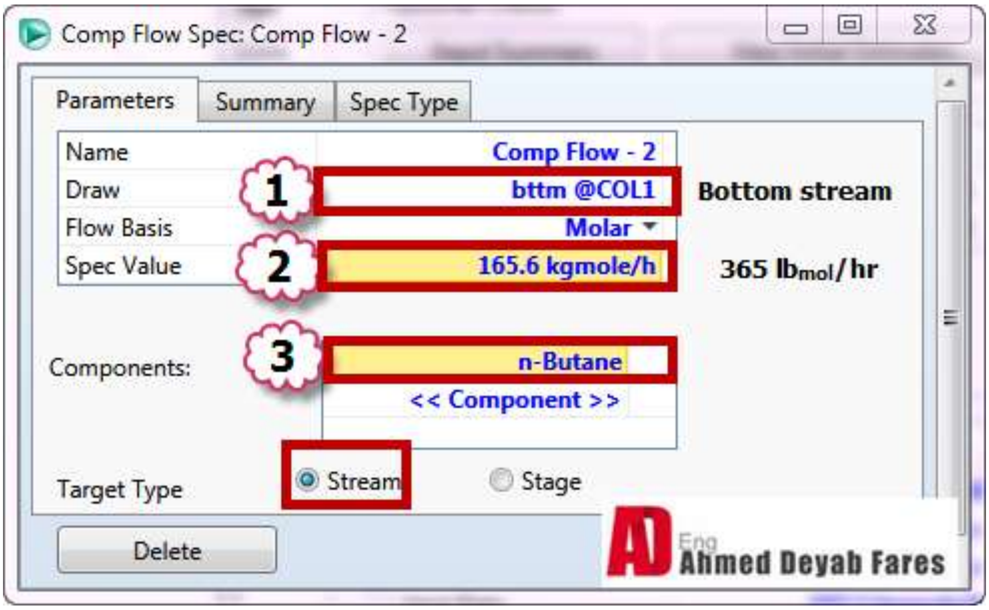




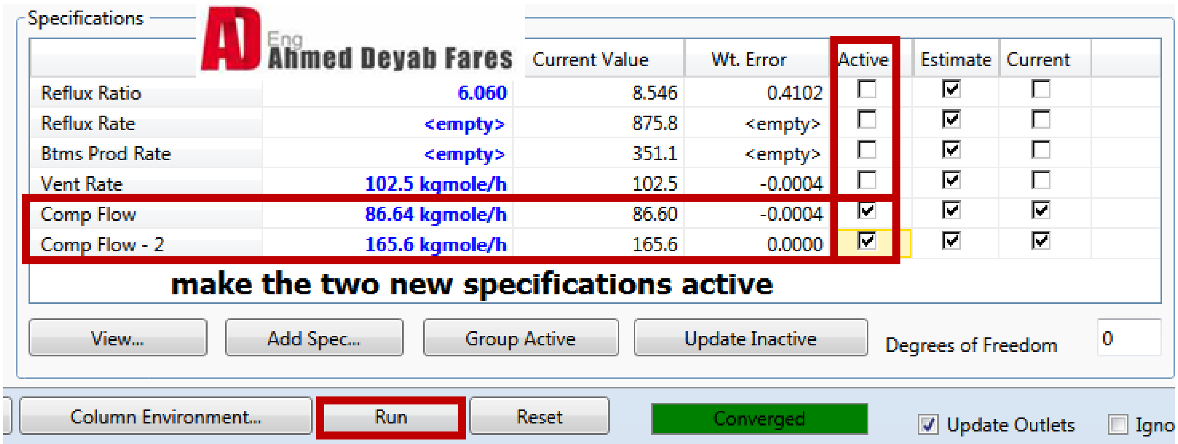


Add the other specification:

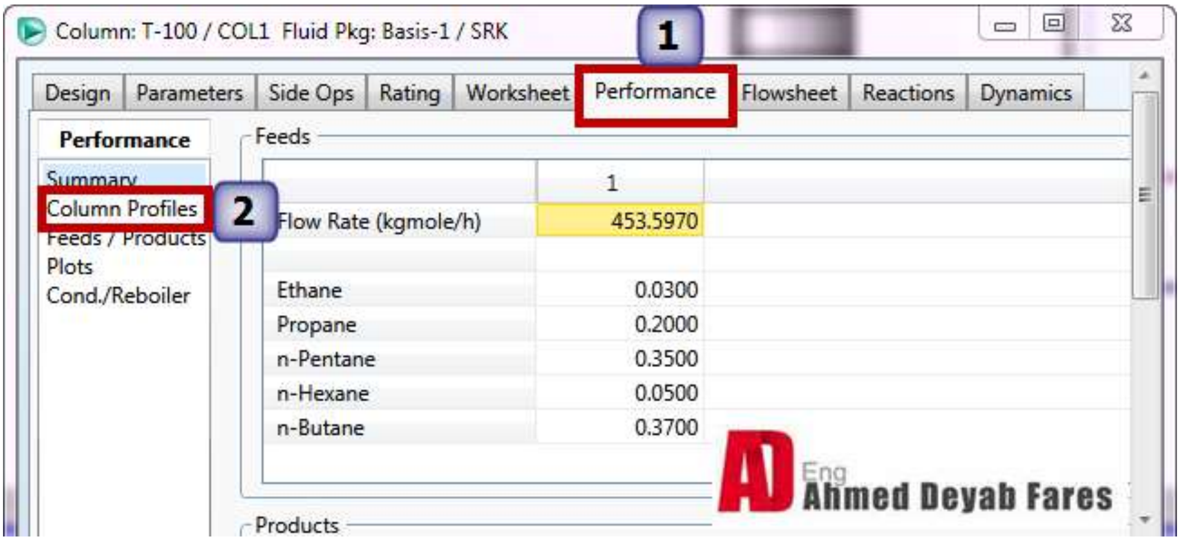




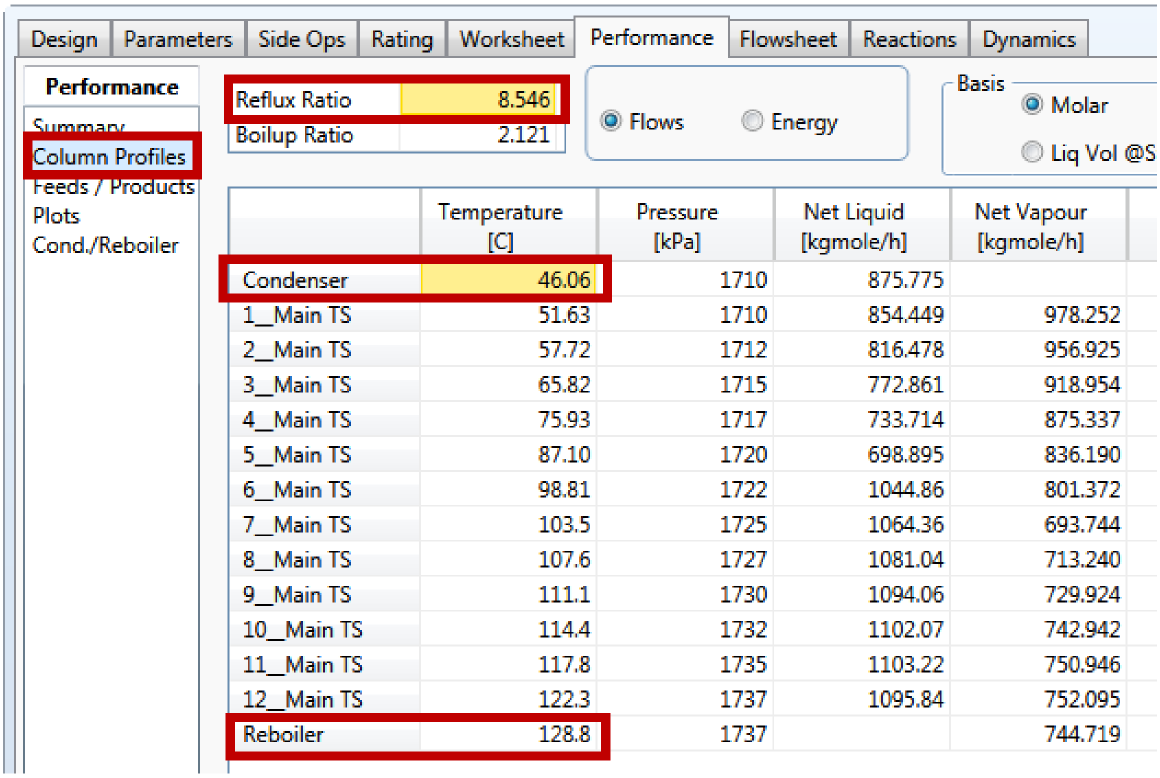
You can change the specifications by marking the Active check box on the 2 new specifications



The Results is always inside the performance page:



Go to column profile to see the temperature & Pressure profile across the tower.



	Temperature [C]	Pressure [kPa]	Net Liquid [kgmole/h]	Net Vapour [kgmole/h]
Condenser	46.06	1710	875.775	
1__Main TS	51.63	1710	854.449	978.252
2__Main TS	57.72	1712	816.478	956.925
3__Main TS	65.82	1715	772.861	918.954
4__Main TS	75.93	1717	733.714	875.337
5__Main TS	87.10	1720	698.895	836.190
6__Main TS	98.81	1722	1044.86	801.372
7__Main TS	103.5	1725	1064.36	693.744
8__Main TS	107.6	1727	1081.04	713.240
9__Main TS	111.1	1730	1094.06	729.924
10__Main TS	114.4	1732	1102.07	742.942
11__Main TS	117.8	1735	1103.22	750.946
12__Main TS	122.3	1737	1095.84	752.095
Reboiler	128.8	1737		744.719

Condenser Temp	46 °C
Reboiler Temp	128.8 °C
Reflux Ratio	8.54

Oil Characterization

5

Workshop

The petroleum characterization method in HYSYS will convert laboratory analyses of condensates, crude oils, petroleum cuts and coaltar liquids into a series of discrete hypothetical components. These petroleum hypo components provide the basis for the property package to predict the remaining thermodynamic and transport properties necessary for fluid modeling.

HYSYS will produce a complete set of physical and critical properties for the petroleum hypo components with a minimal amount of information. However, the more information you can supply about the fluid, the more accurate these properties will be, and the better HYSYS will predict the fluid's actual behavior.

In this example, the Oil Characterization option in HYSYS is used to model a crude oil. The crude is the feed stock to a Pre-heat Train, followed by the Atmospheric Crude Column, which will be modelled in a subsequent module.

Learning Objectives

Once you have completed, you will be able to use the Oil Characterization option in HYSYS.

The petroleum characterization method in HYSYS will convert laboratory analyses of condensates, crude oils, petroleum cuts and coal-tar liquids into a series of discrete hypothetical components. These petroleum hypocomponents provide the basis for the property package to predict the remaining thermodynamic and transport properties necessary for fluid modeling.

In this example, the Oil Characterization option in HYSYS is used to model a crude oil. The crude is the feed stock to oil refining process. (FPkg=PR)

Bulk Properties of the crude:

API Gravity of 29 for the crude

Light Ends (Liquid Volume):

Light Ends	***Liquid Vol %***
Methane	0.0065
Ethane	0.0225
Propane	0.3200
i-butane	0.2400
n-butane	1.7500
i-pentane	1.6500
n-pentane	2.2500

TBP distillation data (Liquid Volume %):

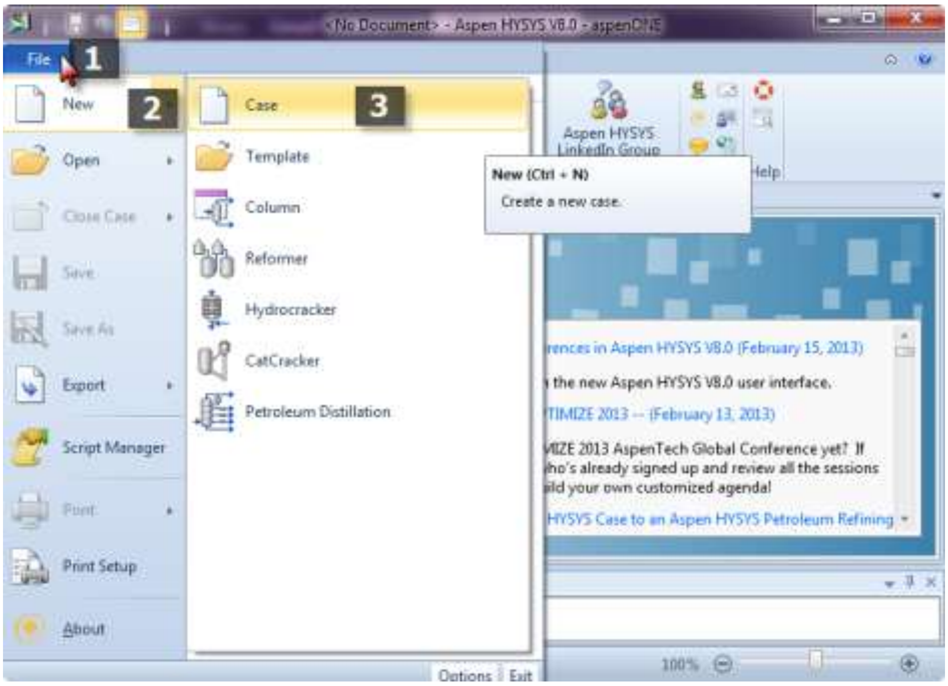
Assay Percent	Temperature (ºC)
0	-12
4	32
9	74
14	116
20	154
30	224
40	273
50	327
60	393
70	450
76	490
80	516

To start the program, From Start Menu, Select All Programs >>

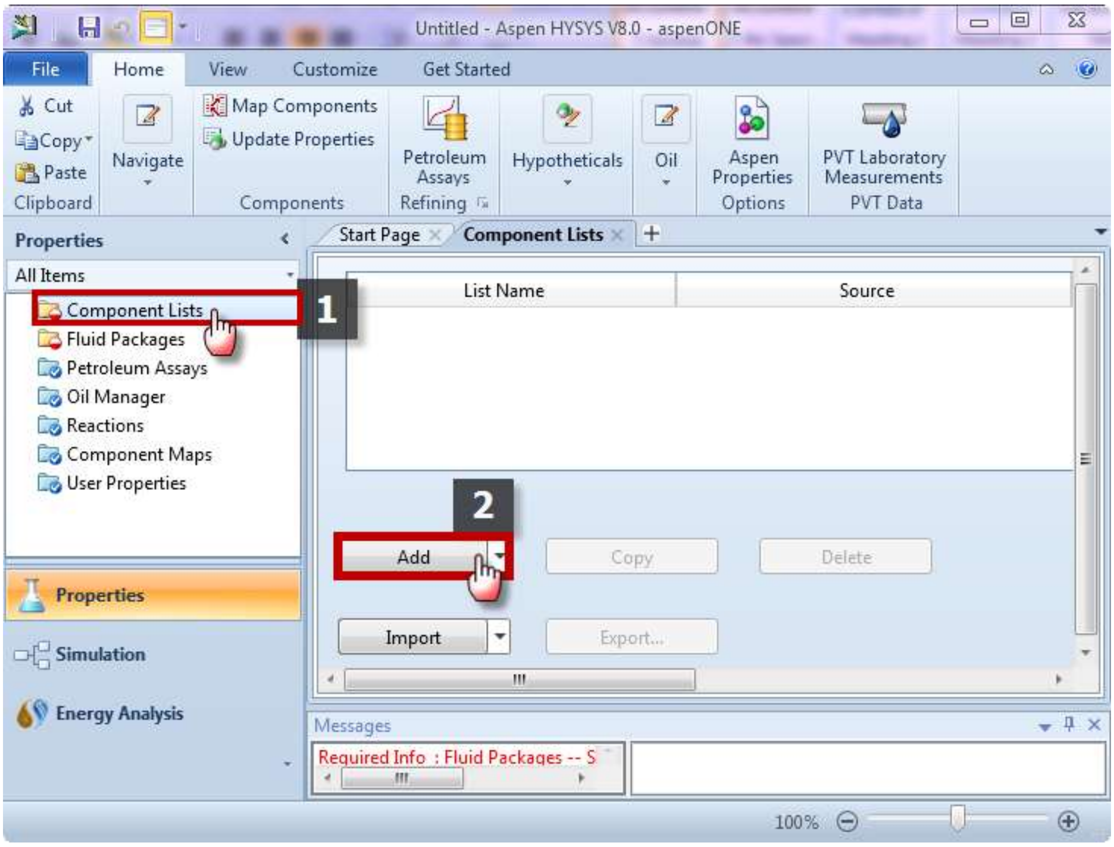
Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >>

Aspen HYSYS

1- First, Start a new case



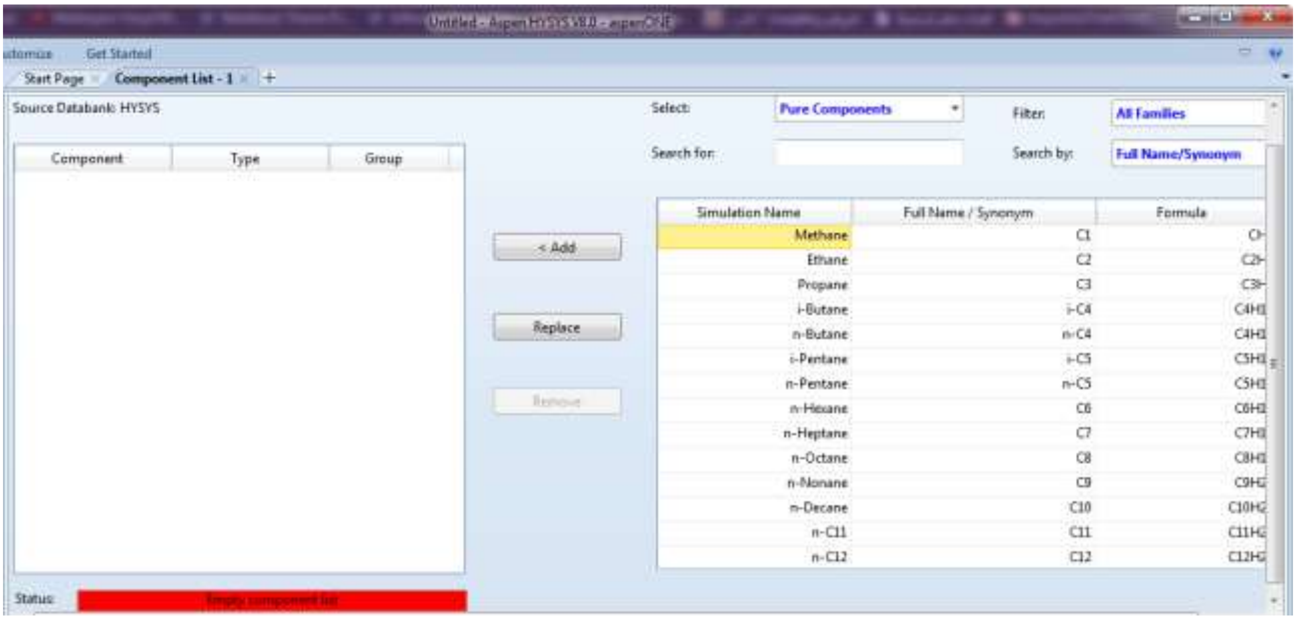
2- Add the Components

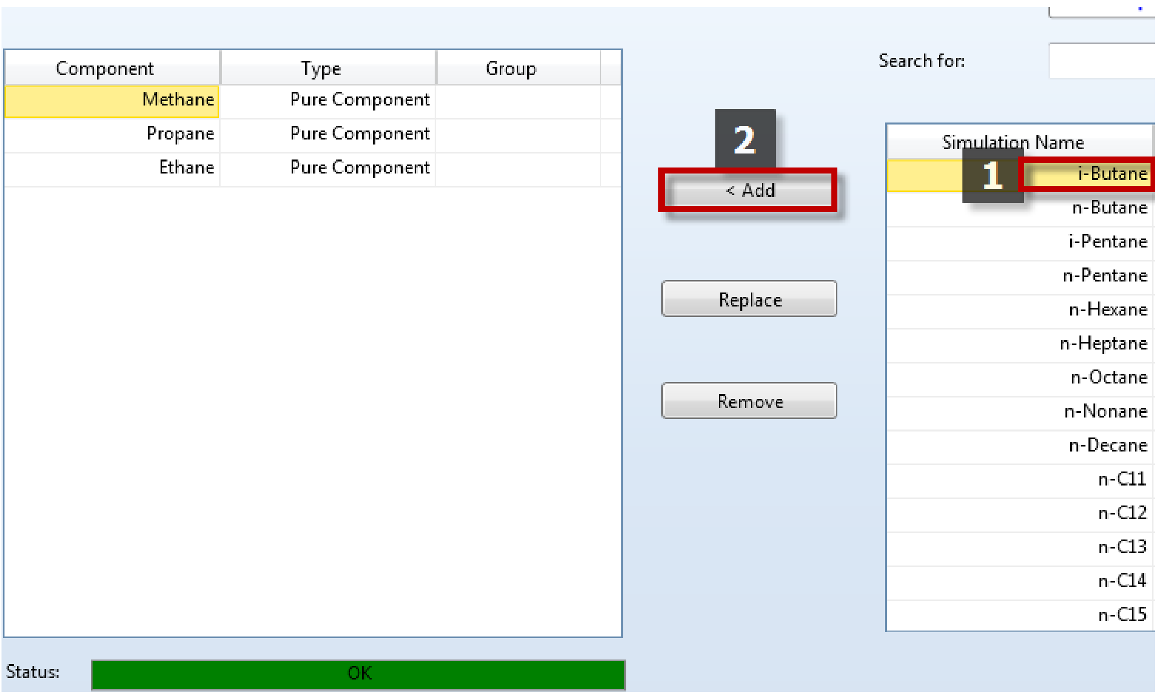


3- Choose the system components from the databank:

4- First we should add the pure components first (Light Ends)

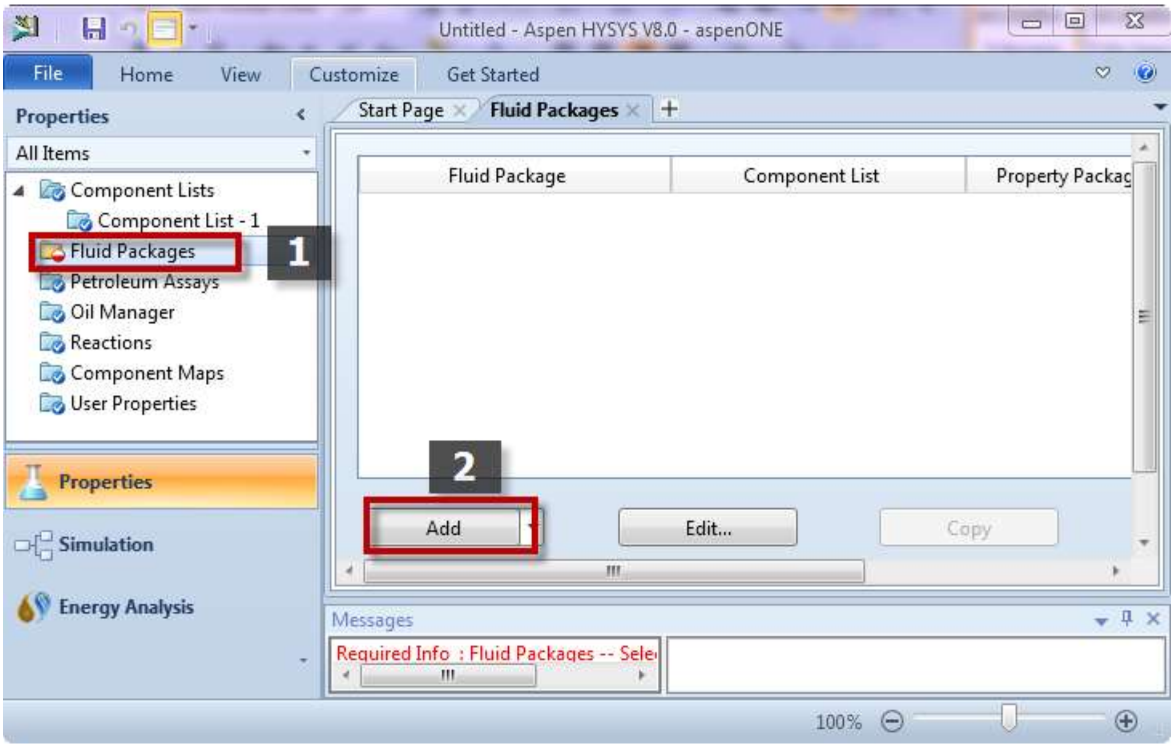
Light Ends are defined as pure components with low boiling points. Components in the boiling range of C1 to n-C5 are most commonly of interest.



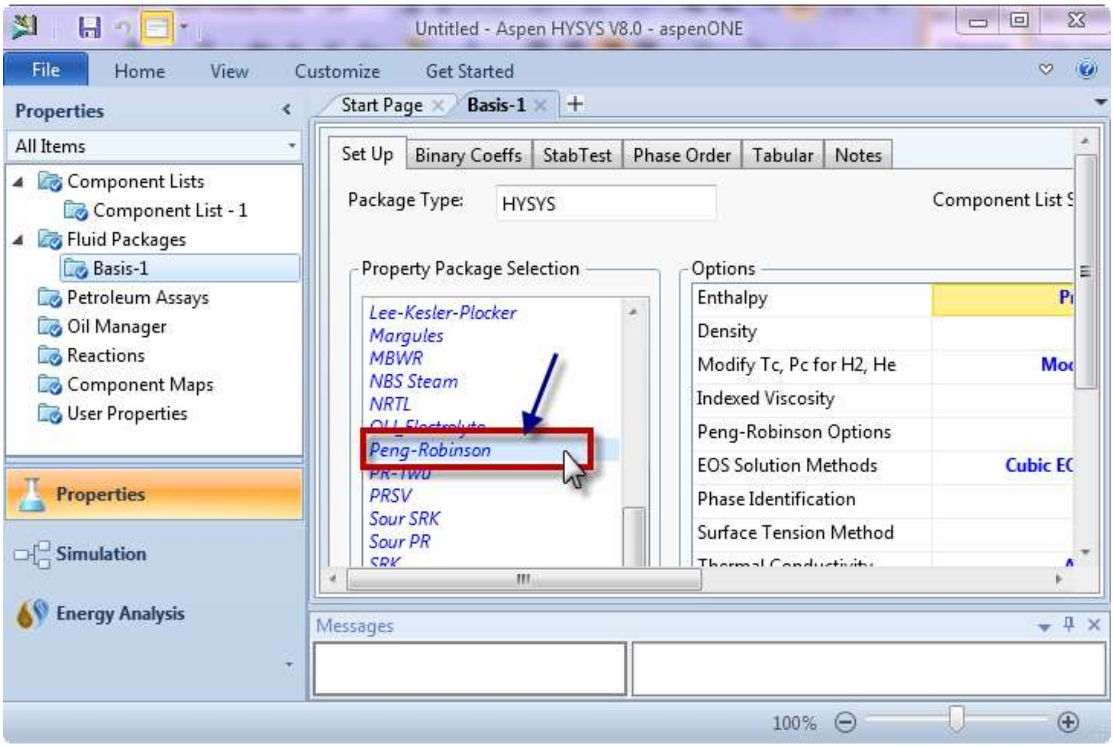


Add the pure components (C1, C2, C3, n-C4, i-C4, n-C5, i-C5, H_2O)

Now, select the suitable fluid package



In this case, select Peng-Robinson

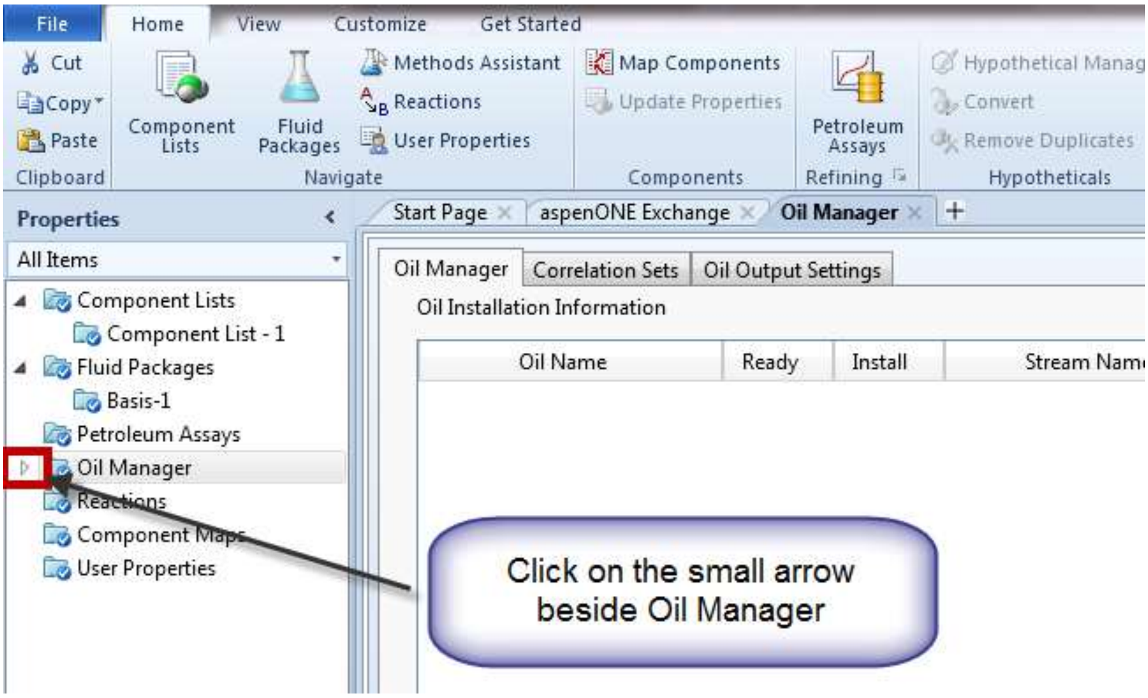


Characterize the Assay

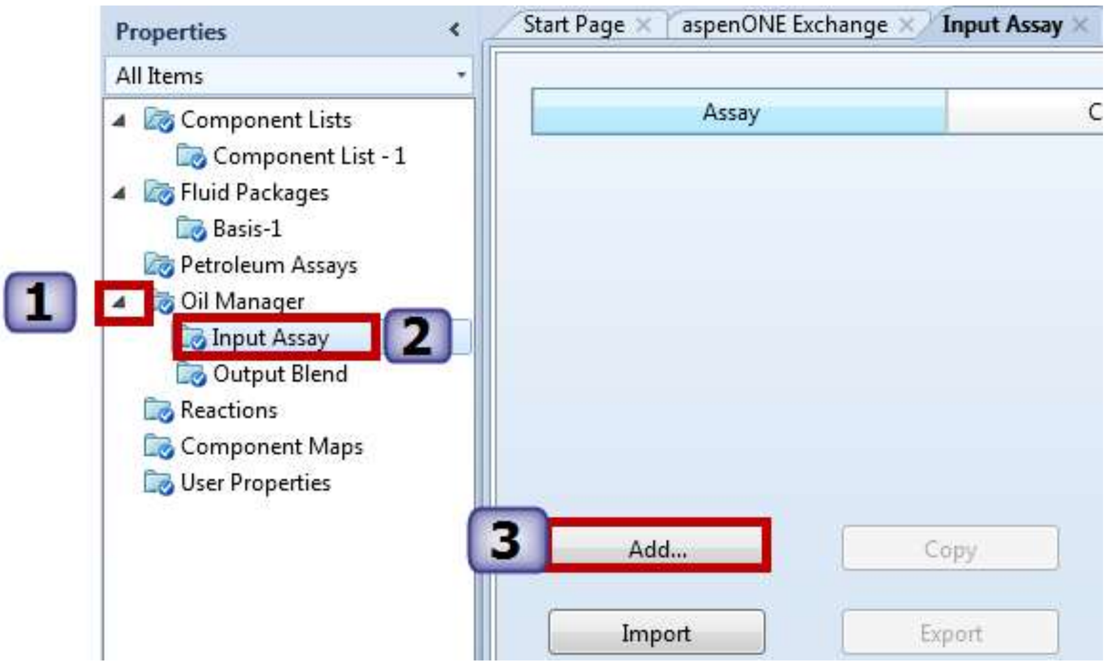
The assay contains all of the petroleum laboratory data, boiling point curves, light ends, property curves and bulk properties. HYSYS uses the supplied Assay data to generate internal TBP, molecular weight, density and viscosity curves, referred to as Working Curves.

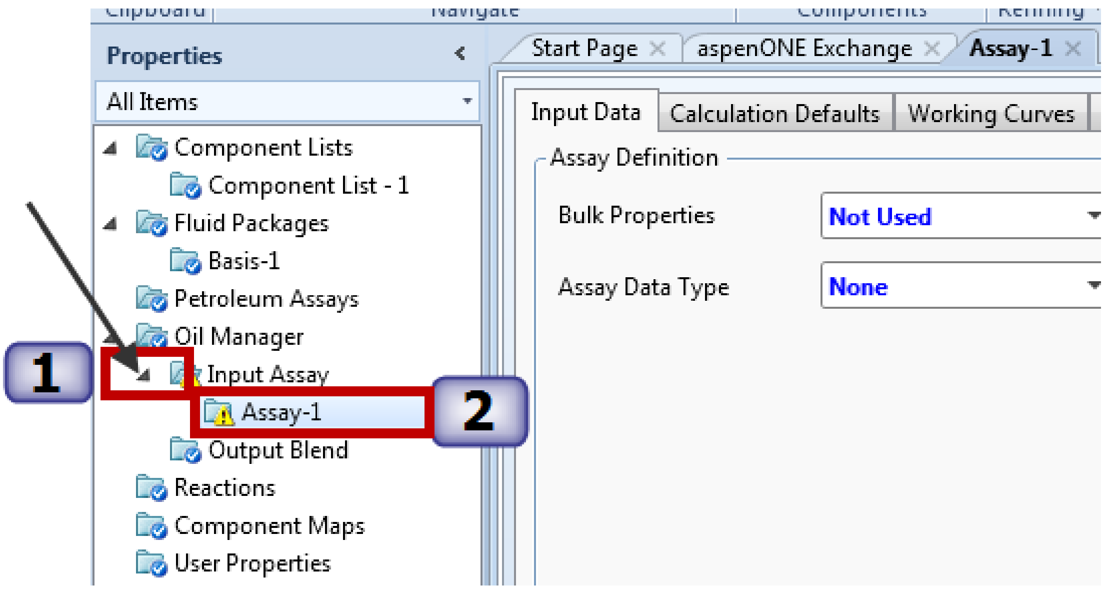
To characterize the assay follow the following steps:

1- Go to Oil Manager.



2- Click on Input Assay & then Click Add button:





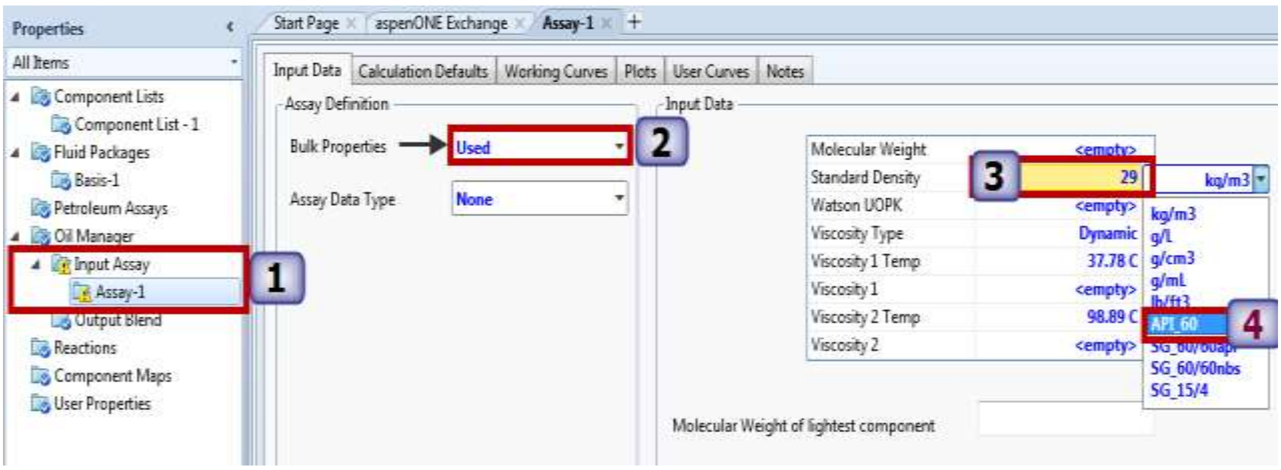
Bulk Properties

Bulk Properties for the sample may also be supplied. The bulk properties are optional if a distillation curve or chromatograph have been supplied

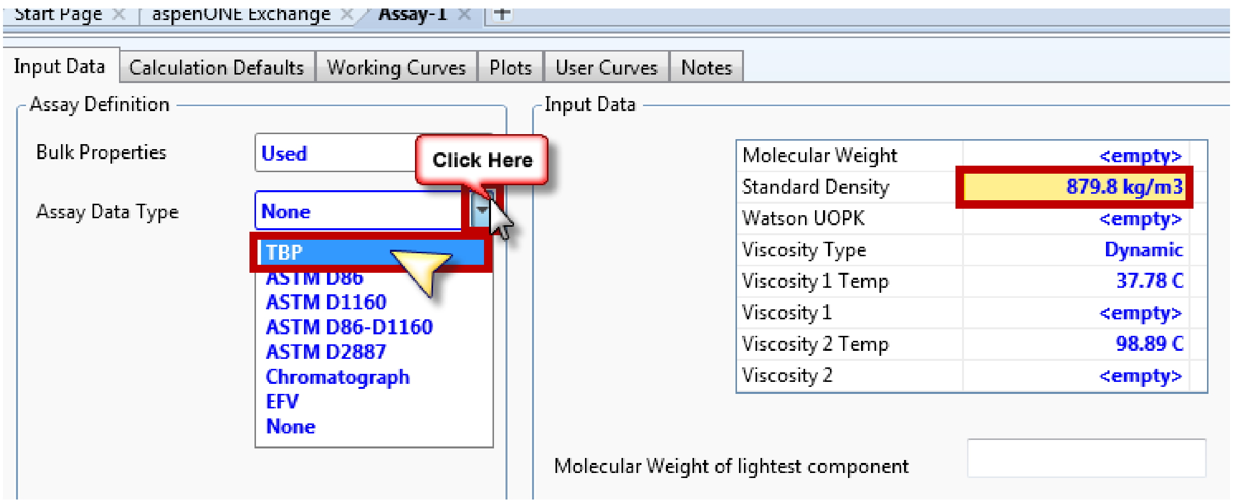
Change the bulk properties from **Not used** to **Used** and add the value for standard Density = 29 API_60

Note:

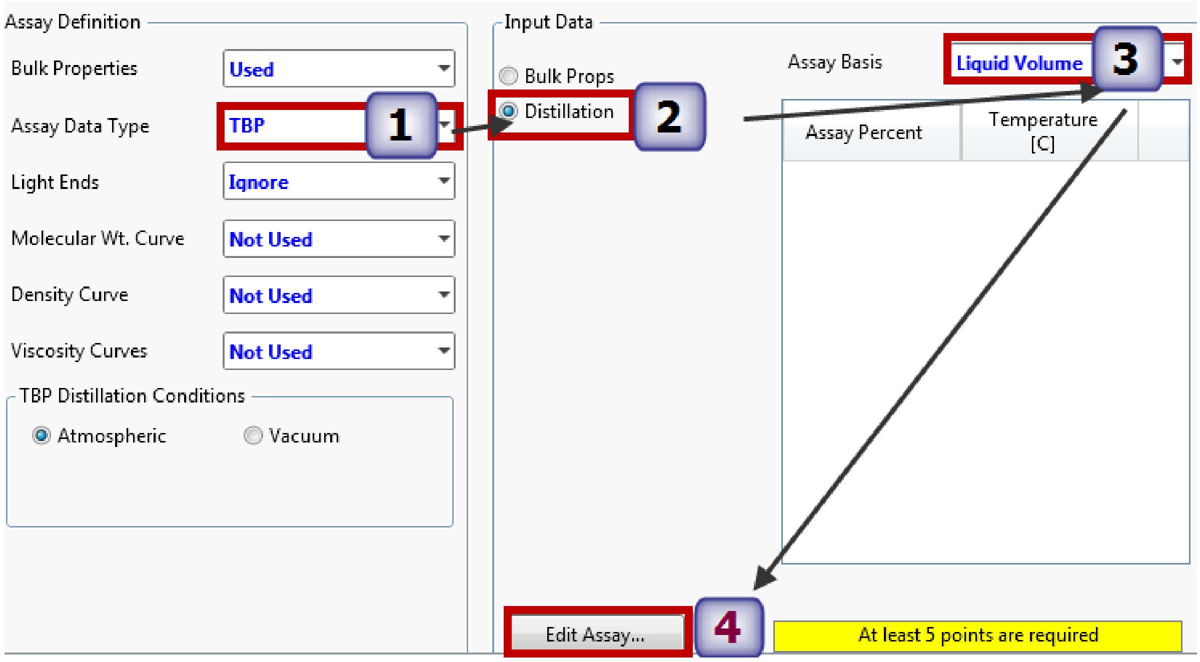
$$\text{API} = \frac{141.5}{SG} - 131.5$$



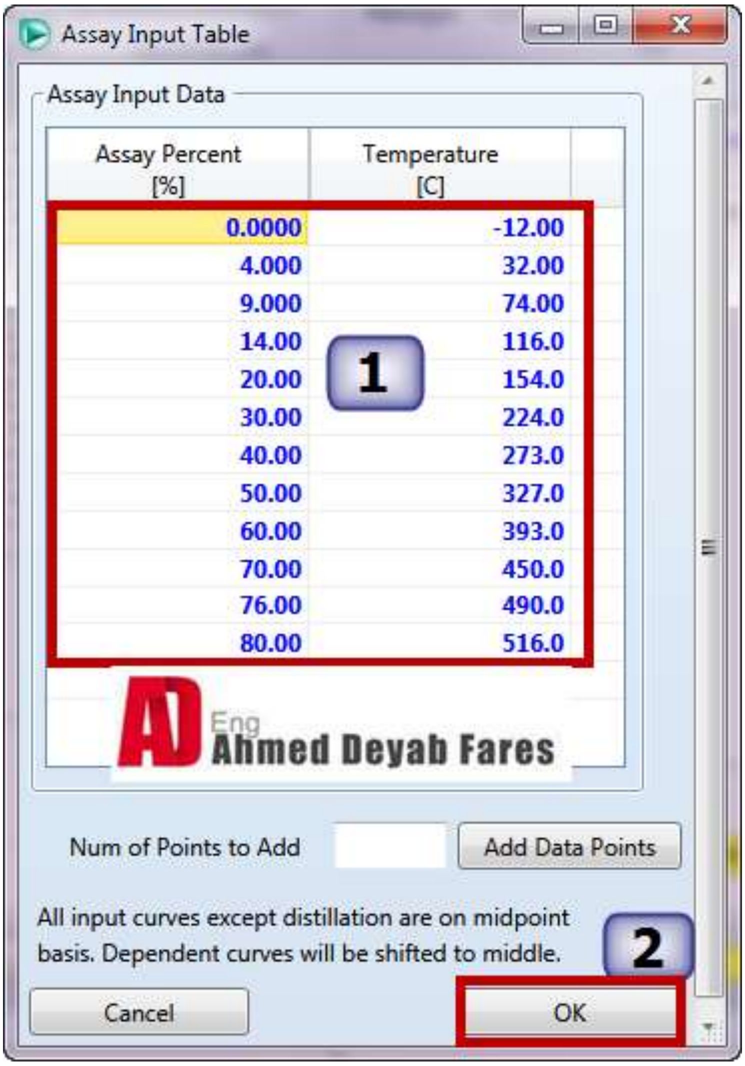
Select the Assay Data Type >> TBP



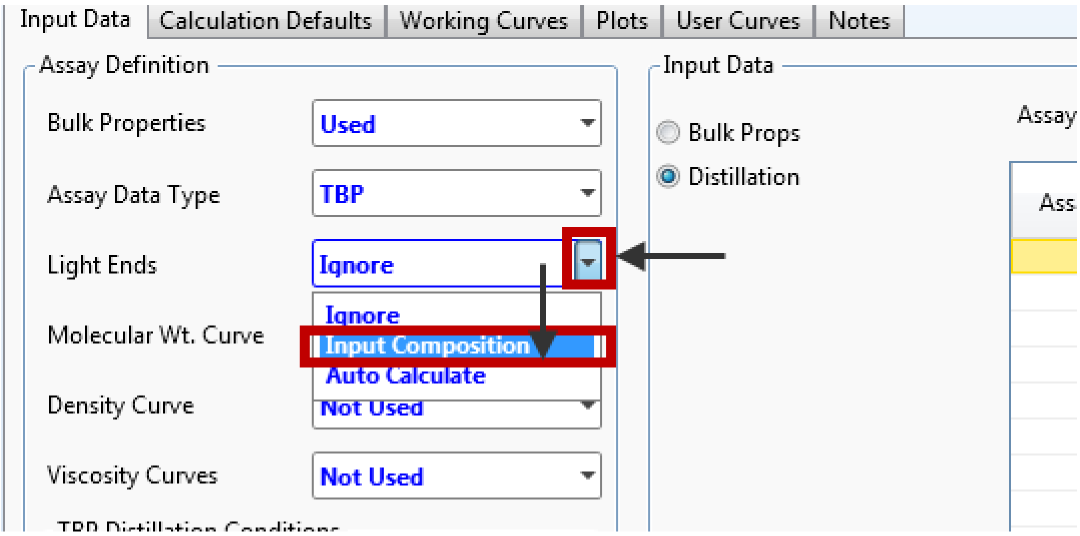
- Select the Distillation radio button in the Input Data group box.
- Select the Assay Basis as Liquid Volume (use the drop-down menu).
- Click the Edit Assay button; this will allow you to enter the assay information below.



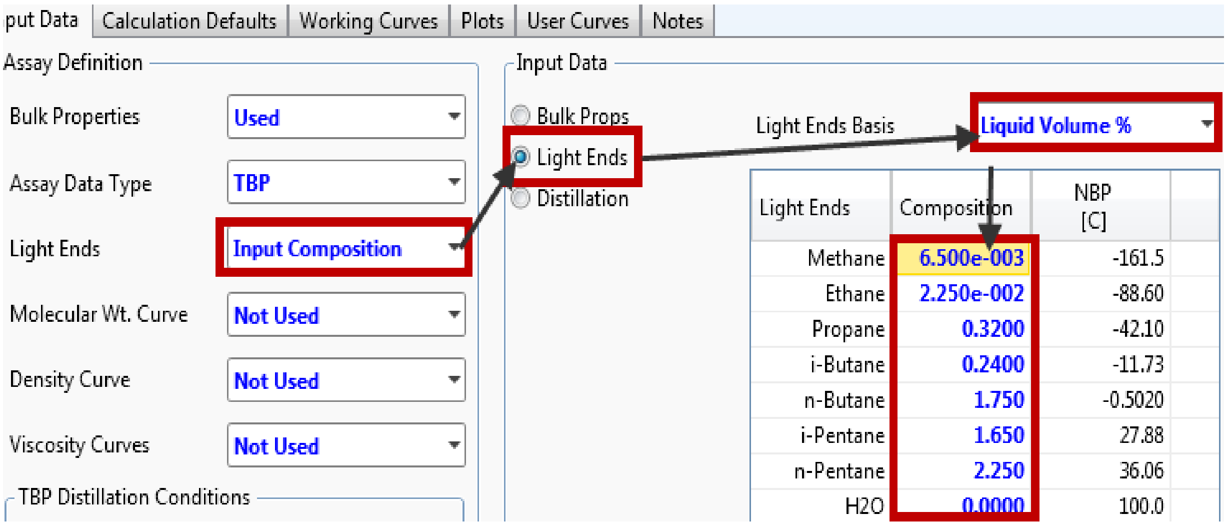
Add the assay data:



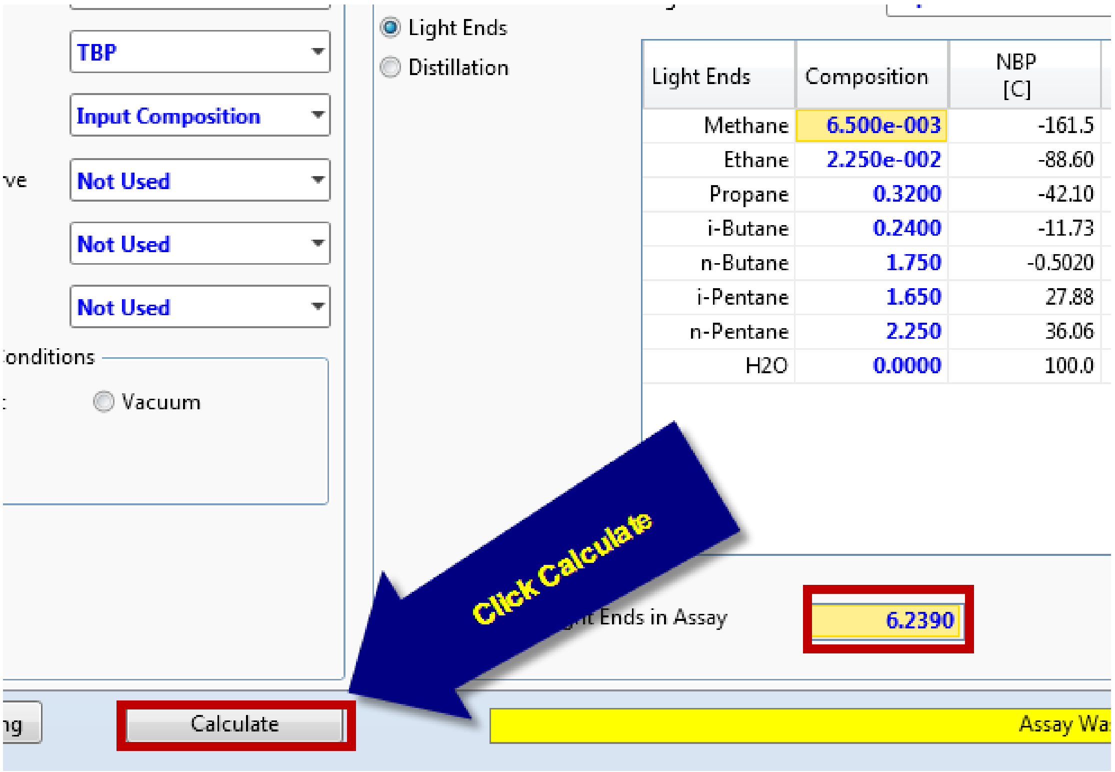
Use the drop-down lists to select **Input Composition** for **Light Ends**



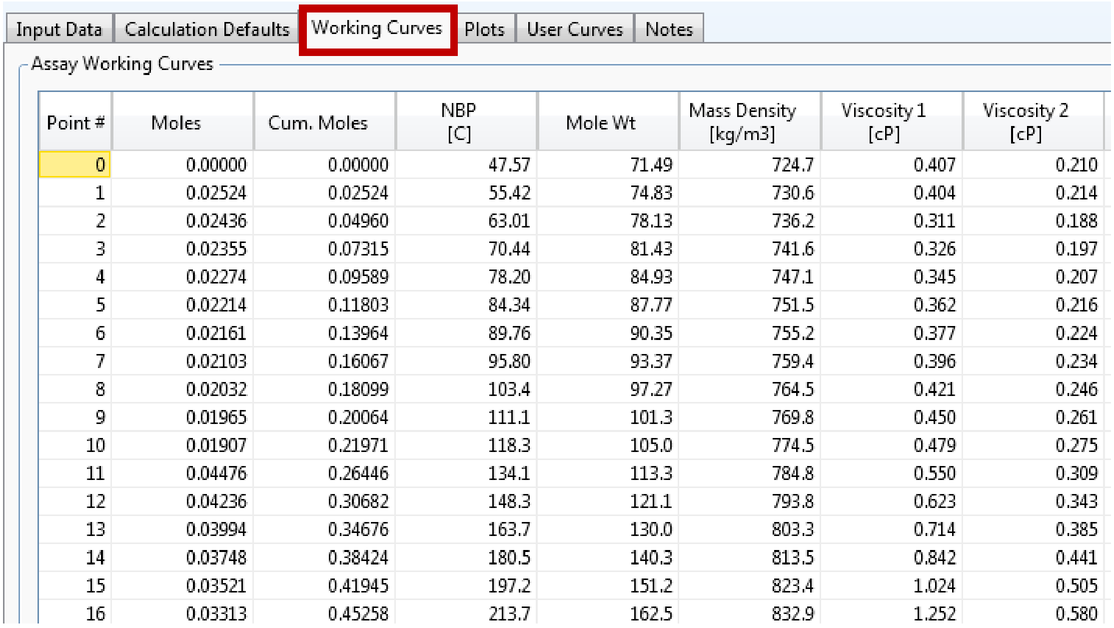
Select the **Light Ends** radio button and enter the data given from **Input Data**



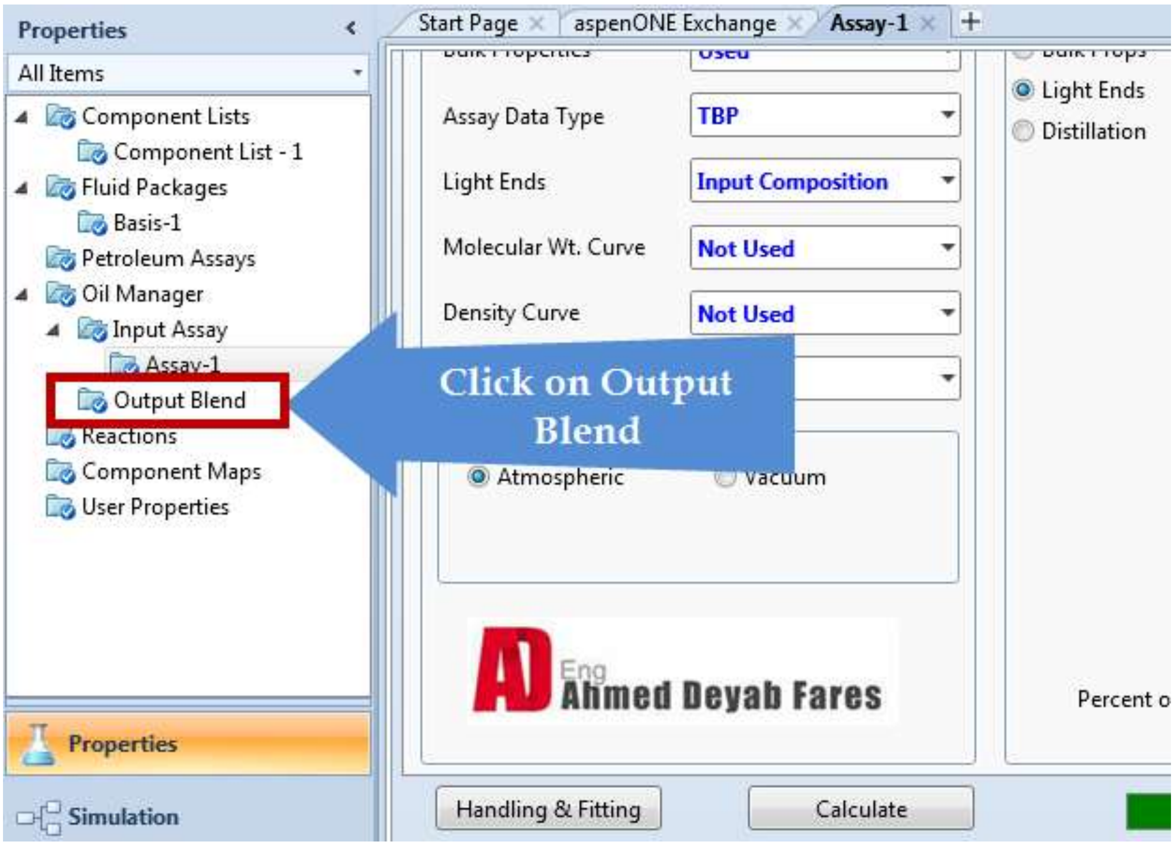
Once you have entered all of the data, click the Calculate button. The status message at the bottom of the Assay view will display Assay Was Calculated.



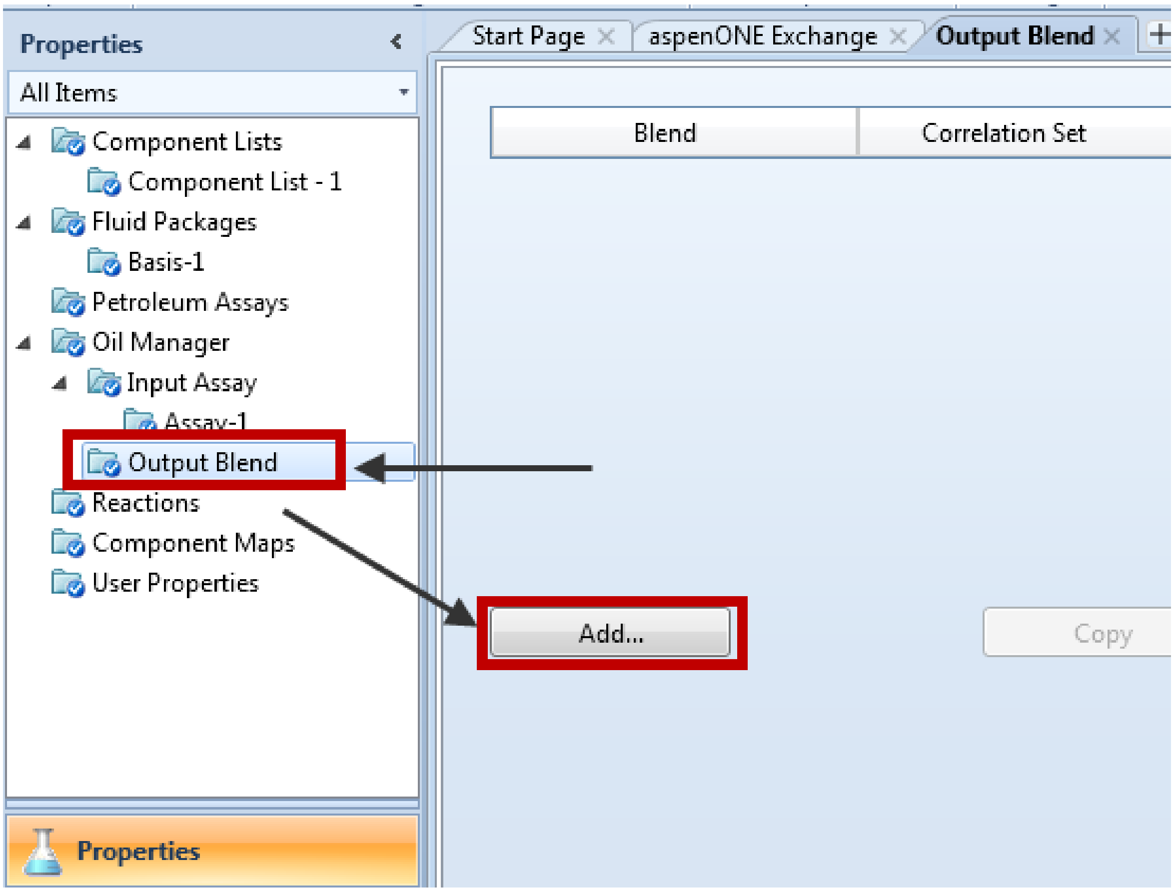
Once the Assay is calculated, the working curves are displayed on the **Plots** and **Working Curves** tabs. The working curves are regressed and extrapolated from the Assay input. From the user-supplied data, HYSYS generates curves for NBP, molecular weight, mass density, and viscosity. These working curves are used in determining the properties of the hypo components generated in the Blend step.

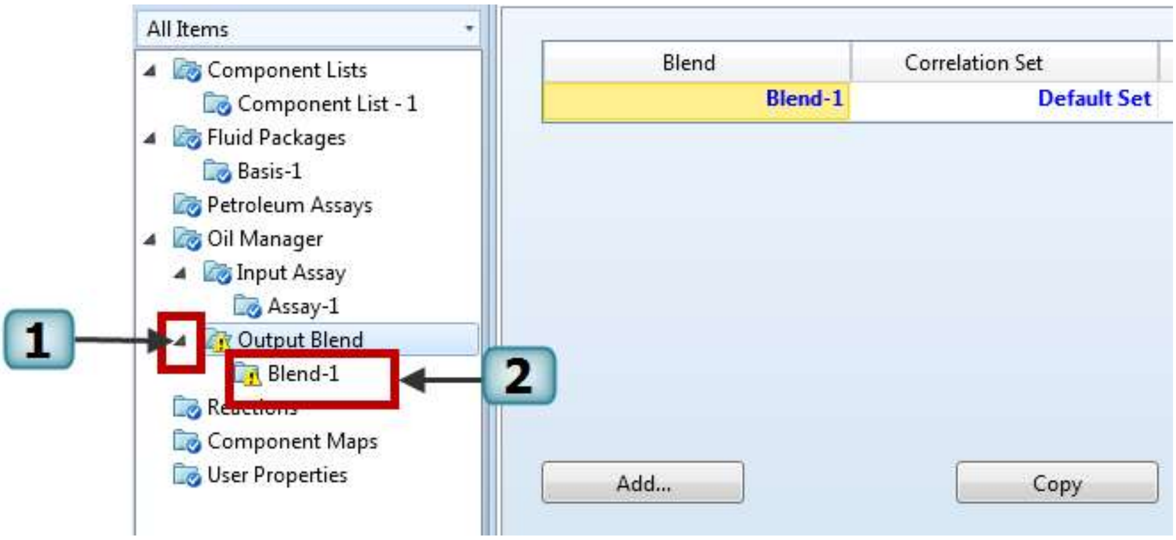


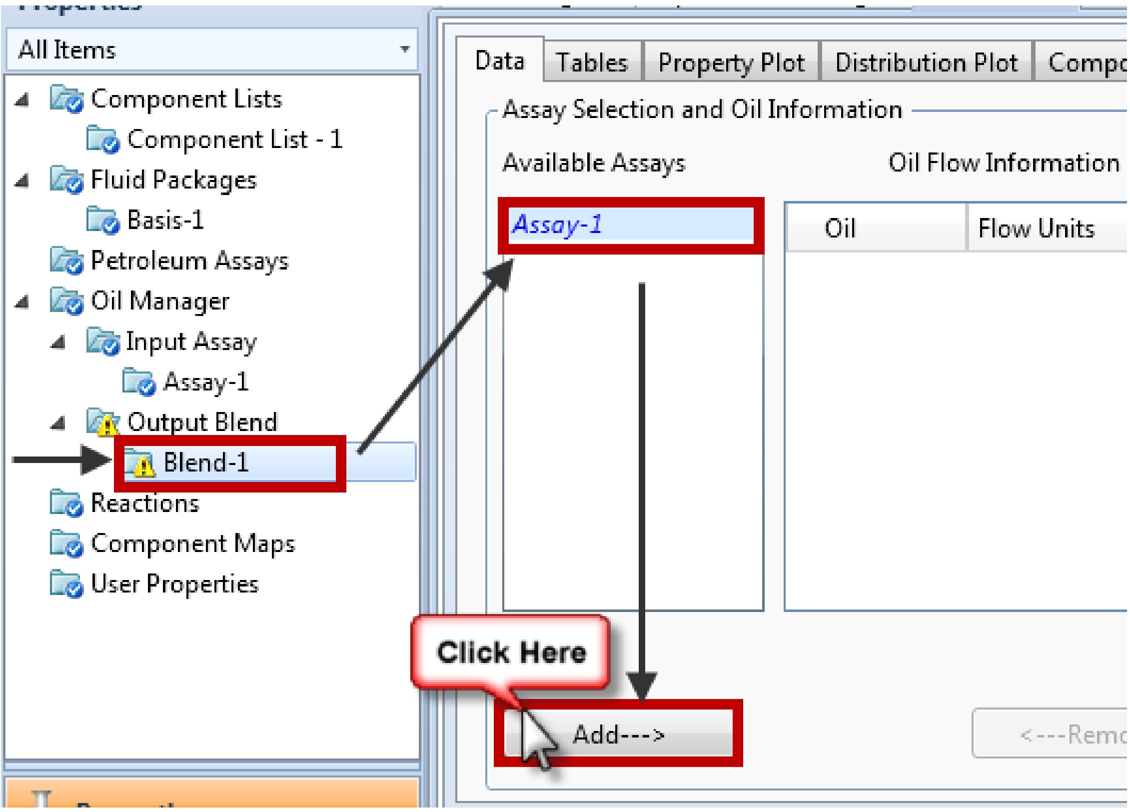
Point #	Moles	Cum. Moles	NBP [C]	Mole Wt	Mass Density [kg/m3]	Viscosity 1 [cP]	Viscosity 2 [cP]
0	0.00000	0.00000	47.57	71.49	724.7	0.407	0.210
1	0.02524	0.02524	55.42	74.83	730.6	0.404	0.214
2	0.02436	0.04960	63.01	78.13	736.2	0.311	0.188
3	0.02355	0.07315	70.44	81.43	741.6	0.326	0.197
4	0.02274	0.09589	78.20	84.93	747.1	0.345	0.207
5	0.02214	0.11803	84.34	87.77	751.5	0.362	0.216
6	0.02161	0.13964	89.76	90.35	755.2	0.377	0.224
7	0.02103	0.16067	95.80	93.37	759.4	0.396	0.234
8	0.02032	0.18099	103.4	97.27	764.5	0.421	0.246
9	0.01965	0.20064	111.1	101.3	769.8	0.450	0.261
10	0.01907	0.21971	118.3	105.0	774.5	0.479	0.275
11	0.04476	0.26446	134.1	113.3	784.8	0.550	0.309
12	0.04236	0.30682	148.3	121.1	793.8	0.623	0.343
13	0.03994	0.34676	163.7	130.0	803.3	0.714	0.385
14	0.03748	0.38424	180.5	140.3	813.5	0.842	0.441
15	0.03521	0.41945	197.2	151.2	823.4	1.024	0.505
16	0.03313	0.45258	213.7	162.5	832.9	1.252	0.580



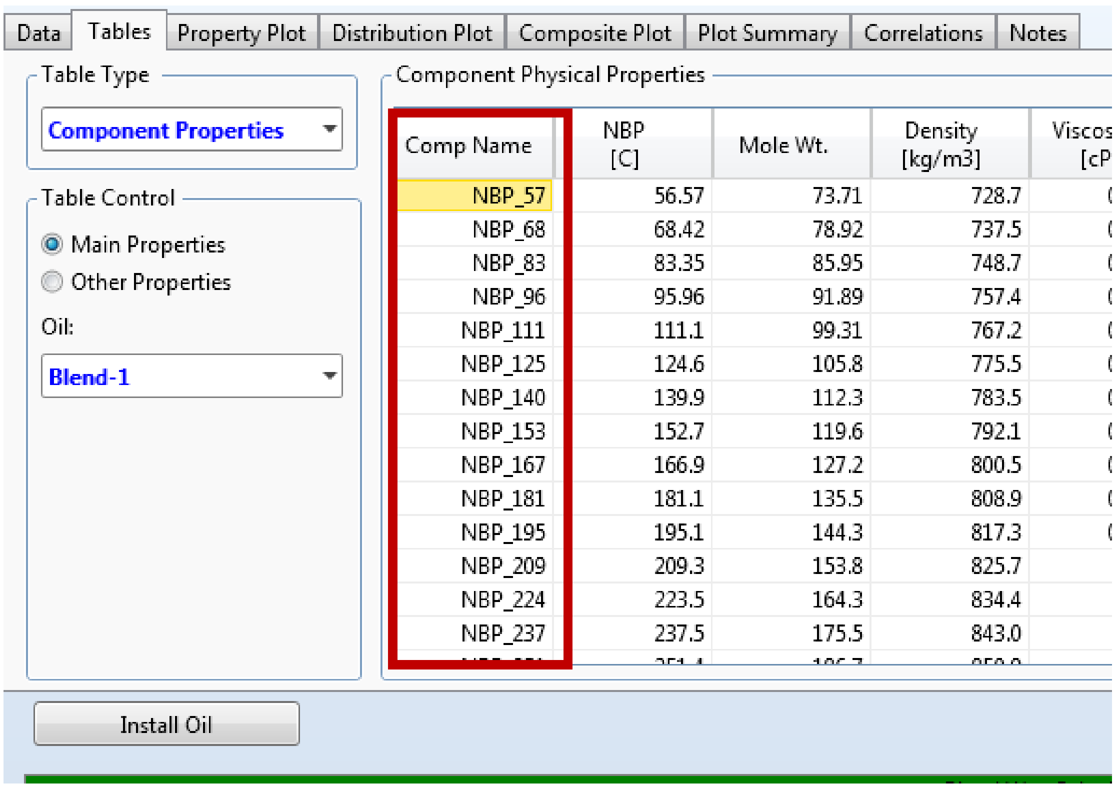
The Output Blend characterization in HYSYS splits the internal working curves for one or more assays into hypo components. The Blend tab of the Oil Characterization view provides two functions, cutting the Oil into Hypo components and Blending two or more Assays into one set of hypo components.

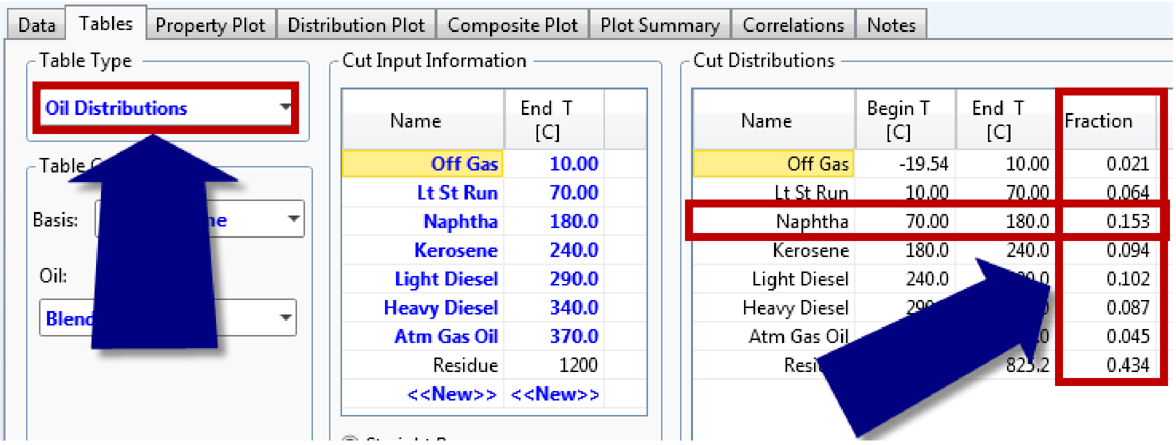

Properties
All Items
Component Lists
Component List - 1
Fluid Packages
Basis-1
Petroleum Assays
Oil Manager
Input Assay
Assay-1
Output Blend
Reactions
Component Maps
User Properties
Start Page
aspenONE Exchange
Output Blend
Blend
Correlation Set
Add...
Copy


All Items
Component Lists
Component List - 1
Fluid Packages
Basis-1
Petroleum Assays
Oil Manager
Input Assay
Assay-1
Output Blend
Blend-1
Component Maps
User Properties
1
2
Blend
Correlation Set
Blend-1
Default Set
Add...
Copy

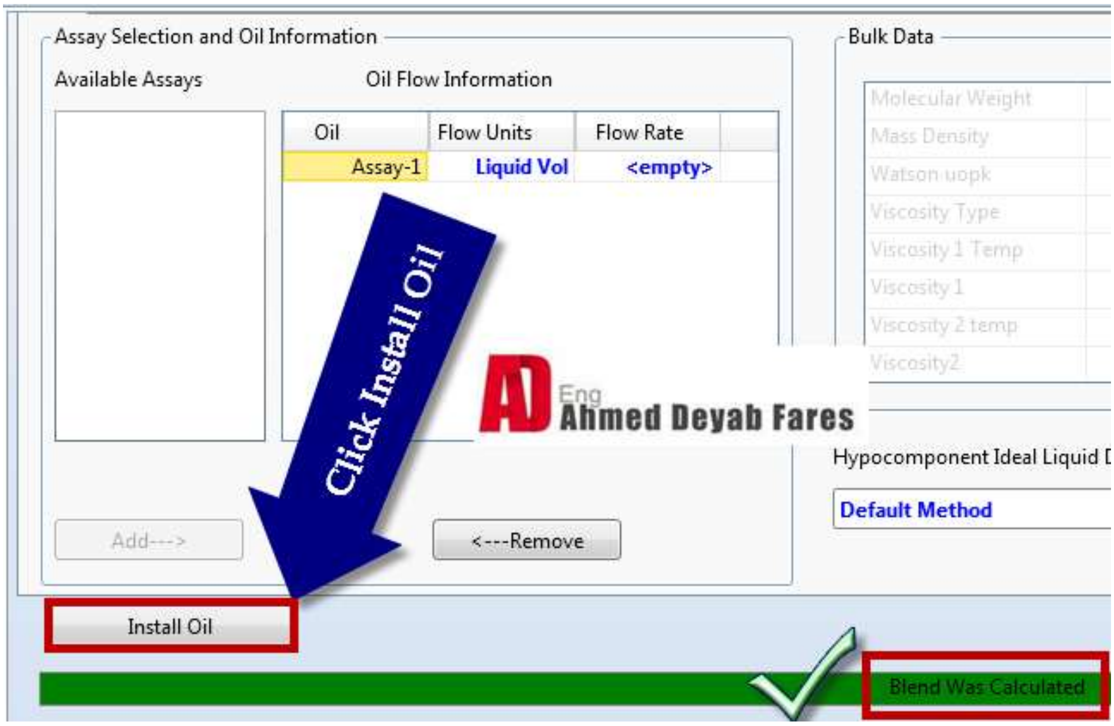


The results of the calculation can be viewed on the Tables tab

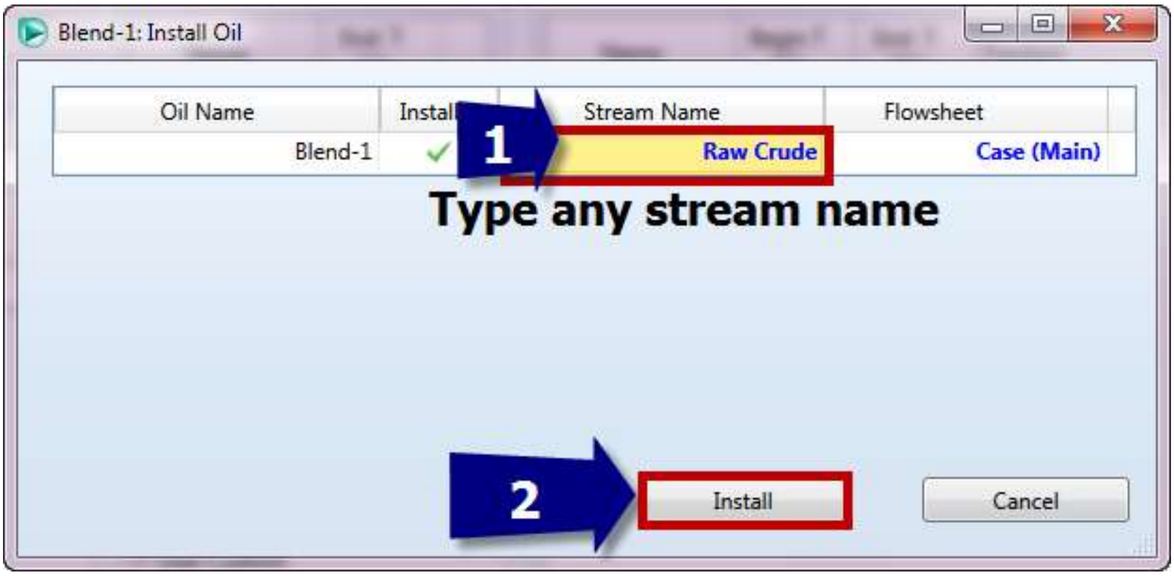




The final step of the characterization is to transfer the hypo component information into the Flowsheet.

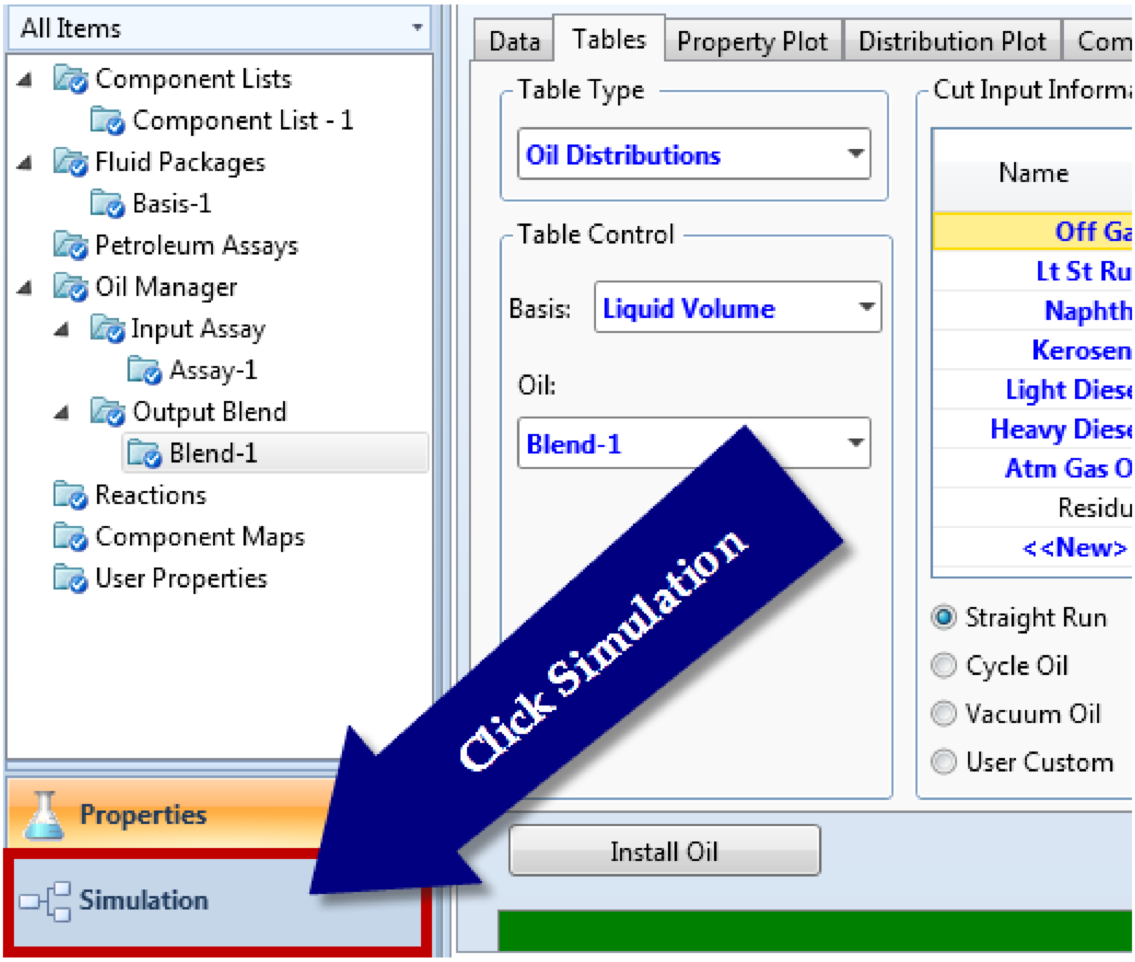


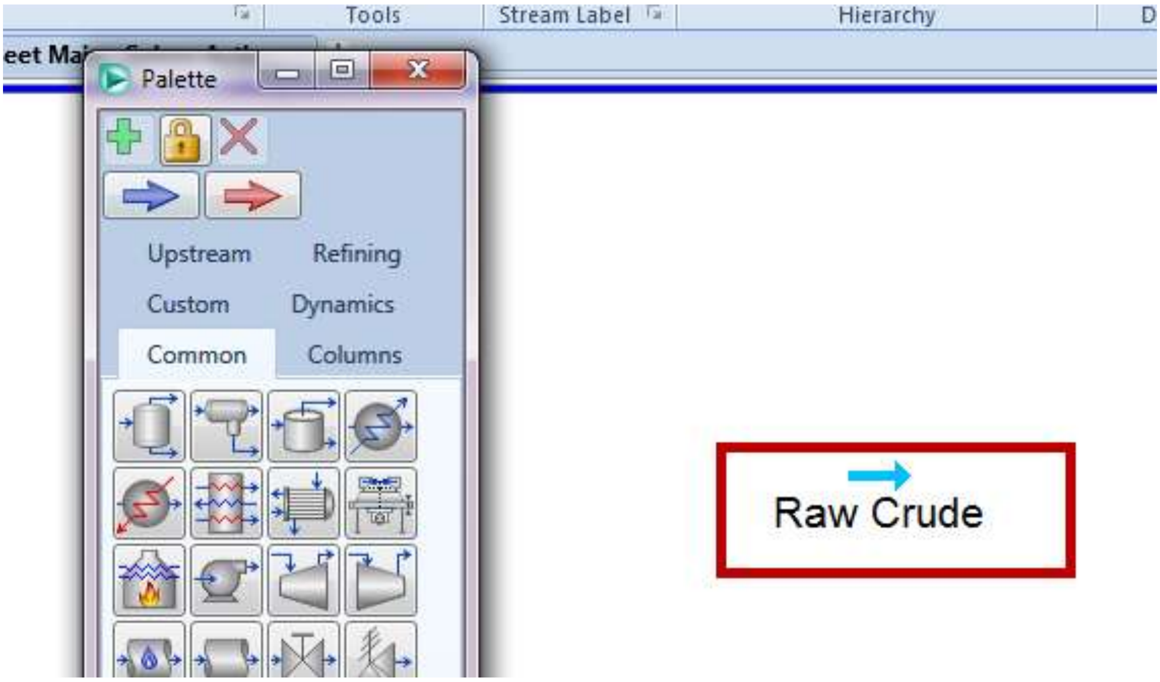
In the Stream Name column, enter the name **Raw Crude** to which the oil composition will be transferred.

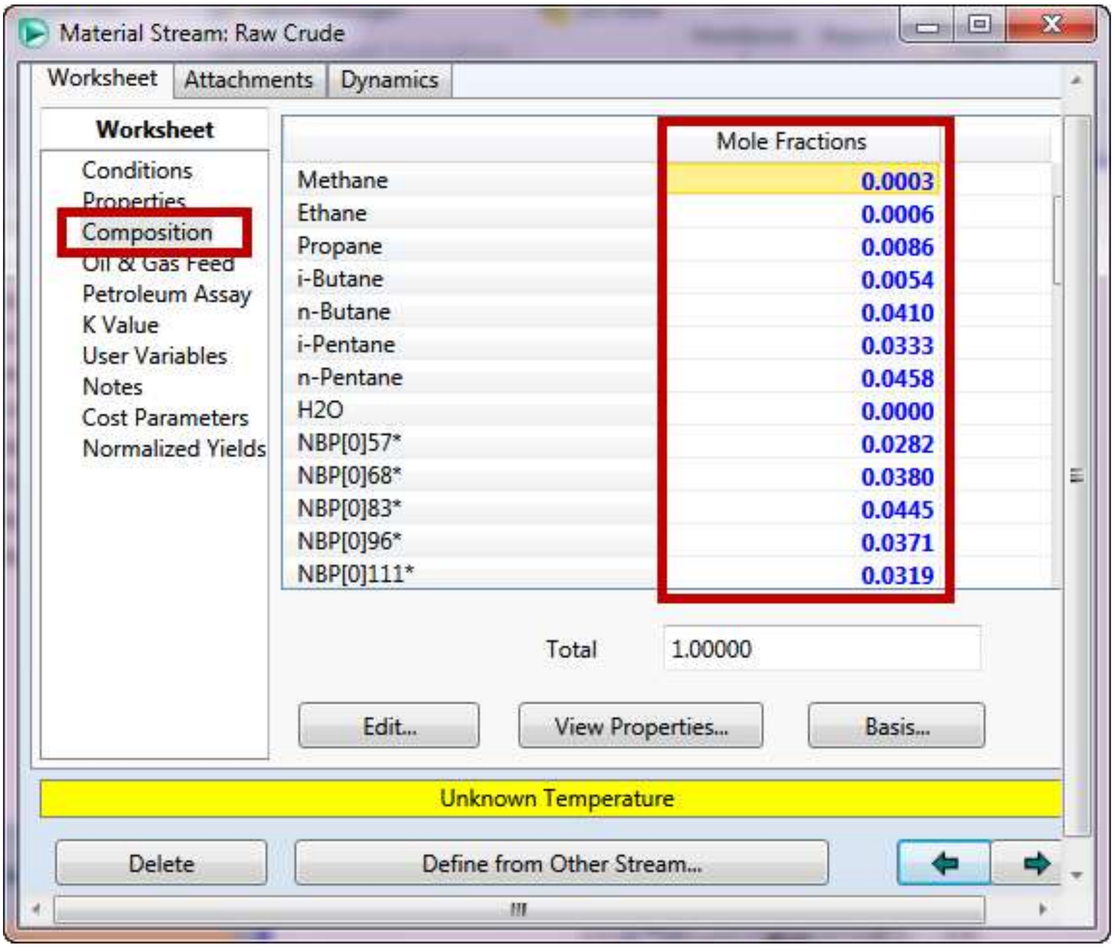


HYSYS will assign the composition of your calculated Oil and Light Ends into this stream, completing the characterization process.

Now you can return to the Simulation environment to see the stream (Raw Crude) with a full composition:







Save Your Case!

Atmospheric Distillation

6

Workshop

Atmospheric Crude Columns are one of the most important pieces of equipment in the petroleum refining industry. Typically located after the Desalter and the Crude Furnace, the Atmospheric Tower serves to distil the crude oil into several different cuts. These include naphtha, kerosene, light diesel, heavy diesel and AGO.

In this module, you will construct, run, analyze and manipulate an Atmospheric Crude Column simulation. You will begin by building a simple column and continue by adding side operations to the column.

Learning Objectives

- *Build and converge an Atmospheric Crude Column.*
- *Use HYSYS to analyze and predict the behavior of a simulated column.*
- *Add side operations to a column to improve operation and efficiency.*
- *Add cut point specifications to increase side product quality and quantity.*

Pre-Heat Train

A crude stream at 15°C, 1000 kPa and flowrate of 6×10^5 kg/hr is mixed with a stream of water at 15°C, 1000 kPa and flowrate of 21600 kg/hr using a Mixer, the outlet from the mixer is then heated to 65°C through a Heater (Δp=50 kPa), the heater outlet is fed to the tube side of a Shell & Tube Heat Exchanger, where it's heated using a Shell inlet stream having the same composition as the crude feed stream and enters the shell of the heat exchanger at 180°C, 200 kPa and flowrate of 175m^3/hr. The pressure drops for the Tube and Shell sides, will be 35 kPa and 5 kPa, respectively. The tube outlet from the HX is then sent to a desalter which is simply modeled as Three Phase Separator where desalted water, oil and gas is separated. The oil stream (light liquid) from the desalter is then heated to 175°C through a Heater (Pressure drop=375 kPa) and then sent to a Preflash (Separator) to reduce the light components in the feed. The liquid product from the separator is then heated to 400°C inside a Heater (Pressure drop=250 kPa) before entering the Atmospheric Column.

Heat Exchanger Specification:

- Use Simple weighted model
- Min Approach = 30°C (54°F). This is the minimum temperature difference between the hot and the cold stream.

Calculate:

- The vapor fraction of the product stream before entering the Atmospheric column.
- The Shell side outlet Temperature.
- The vapor molar flow rate from the Preflash.

Atmospheric Distillation

A feed stream from the pre-heat train is fed to the 28th tray of a ***Refluxed Absorber*** with 29 trays and a partial condenser to separate Off Gases, Naphtha and Bottom Residue. A steam stream (vapor fraction =1.0, pressure =1380 kPa and flowrate=3400 kg/hr) is fed to the bottom of the tower to provide the necessary heat. A water draw stream is required to remove the condensed steam from the overhead condenser. The tower is operated with the following conditions:

Condenser Pressure	140 kPa	Condenser Temperature	40 °C
Condenser Pressure Drop	60 kPa	Top Stage Temperature	120 °C
Bottom Stage Pressure	230 kPa	Bottom Stage Temperature	340 °C

Specifications:

Overhead vapor rate	0.0 kgmole/hr
Distillate rate (Naphtha rate)	………………..

What is the flow rate of?

Naphtha ________________ Residue ______________________

Wastewater _____________

Side Strippers & Pump Arounds

Side Strippers are added to the column in order to improve the quality of the three main products (Kerosene, Diesel, and AGO). There are two types of side strippers available in HYSYS: Reboiled and Steam Stripped. We will install one reboiled side stripper and two steam stripped.

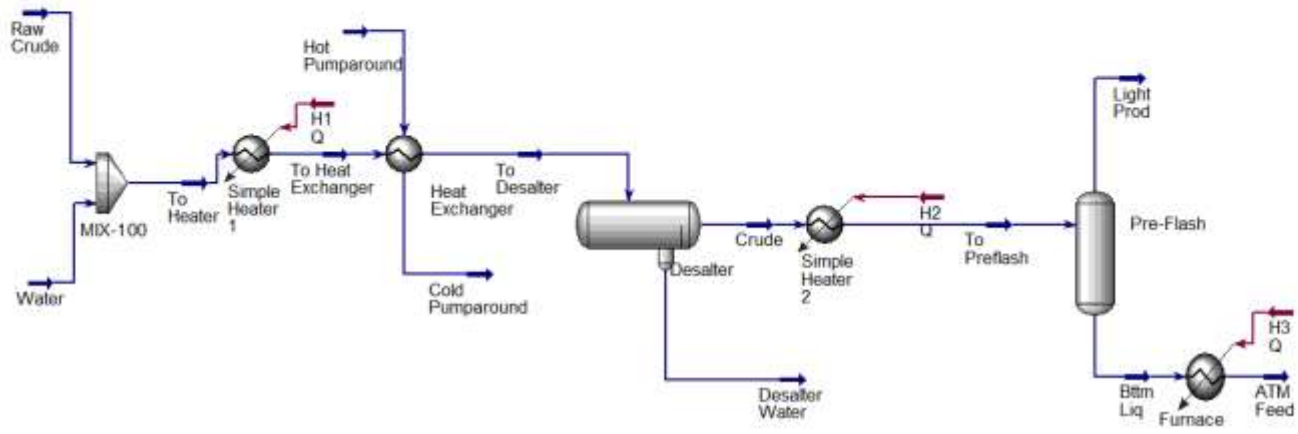
	AGO SS	Diesel SS	Kerosene SS
Draw Stage	22	17	9
Return Stage	21	16	8
Configuration	Steam Stripped	Steam Stripped	Reboiled
Product flow	………….	………….	………….

	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr

Pump Arounds help to improve the column's efficiency. They operate by drawing a liquid stream from one stage cooling it, and pumping it into a higher stage. In effect, this process adds to the reflux between these two stages.

	AGO PA	Diesel PA	Kerosene PA
Draw Stage	22	17	9
Return Stage	21	16	8
Flowrate	200 m^3/h	200 m^3/h	330 m^3/h
Duty	-3.7e7 kJ/h	-3.7e7 kJ/h	-4.5e7 kJ/h

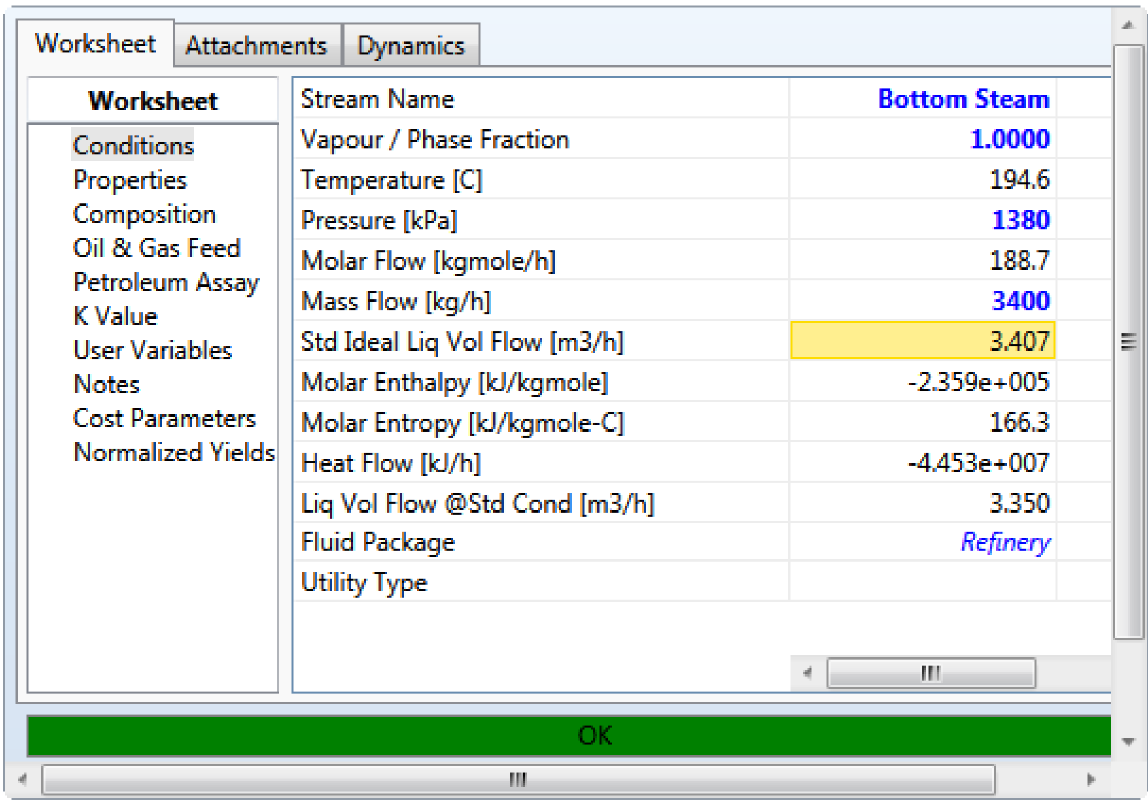
Load your Pre-Heat Train case from the Pre-Heat Train module.



Add a steam stream to provide the heating effect to the bottom of the tower instead of using a reboiler:

Vapor fraction =1.0, pressure =1380 kPa and flowrate=3400 kg/hr

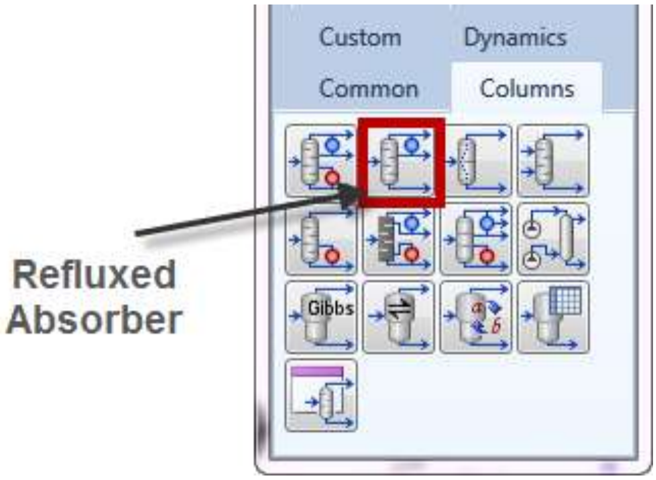
Composition (100% water)



ADDING THE ATMOSPHERIC COLUMN

The atmospheric column is modeled as a refluxed absorber,

- Double-click on the **Refluxed Absorber** icon on the Object Palette.



The tower (29 trays) is operated with the following conditions:

Condenser Pressure	140 kPa
Condenser Pressure Drop	60 kPa
Bottom Stage Pressure	230 kPa

Condenser Temperature	40 °C
Top Stage Temperature	120 °C
Bottom Stage Temperature	340 °C

Specifications:

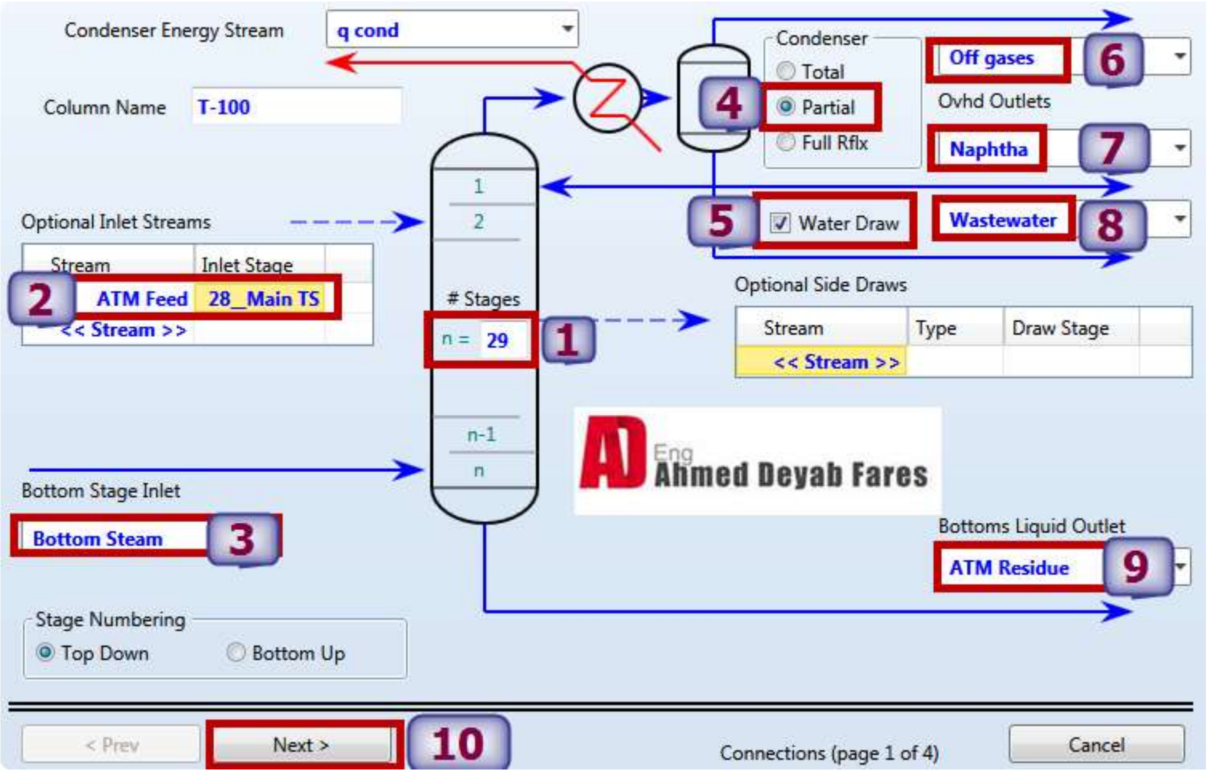
Overhead vapor rate	0.0 kgmole/hr
Distillate rate (Naphtha rate)	***0.153*** × 681.9 m^3/hr = 104.3 m^3/hr

Cut Input Information

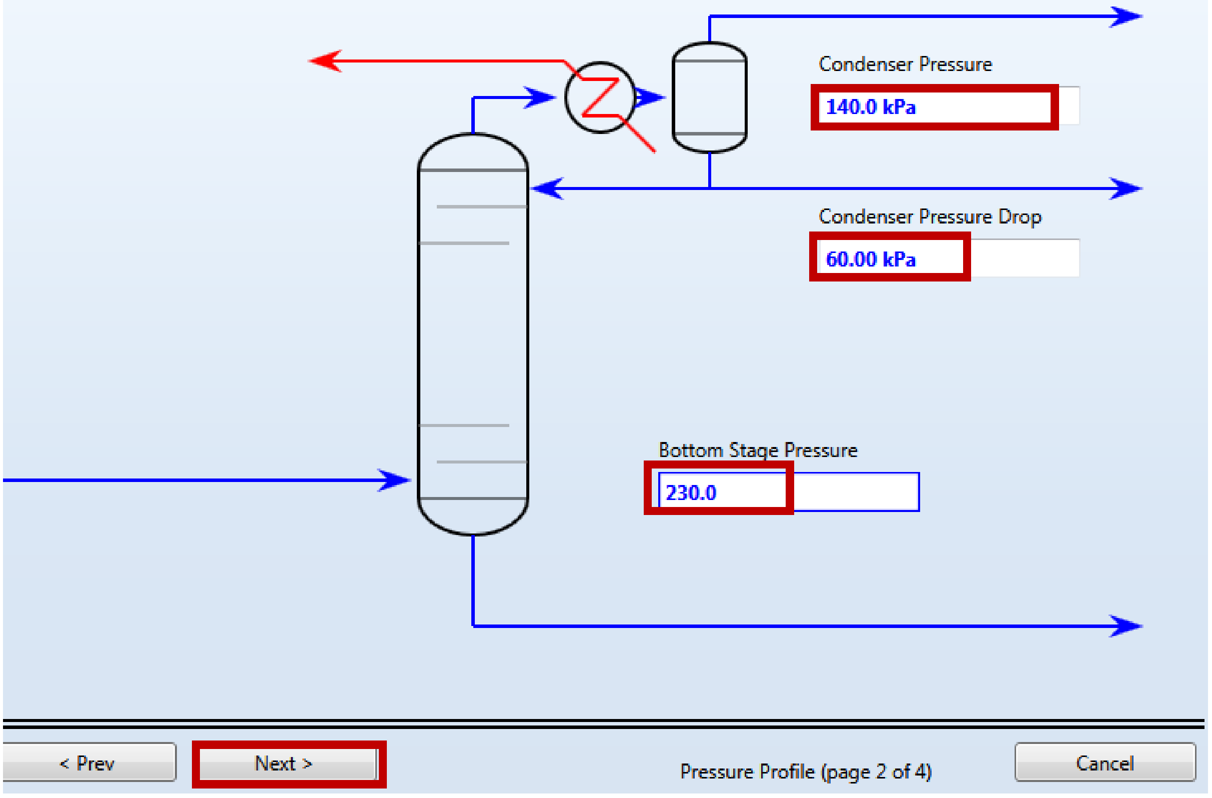
Name	End T [C]
Off Gas	10.00
Lt St Run	70.00
Naphtha	180.0
Kerosene	240.0
Light Diesel	290.0
Heavy Diesel	340.0
Atm Gas Oil	370.0
Residue	1200

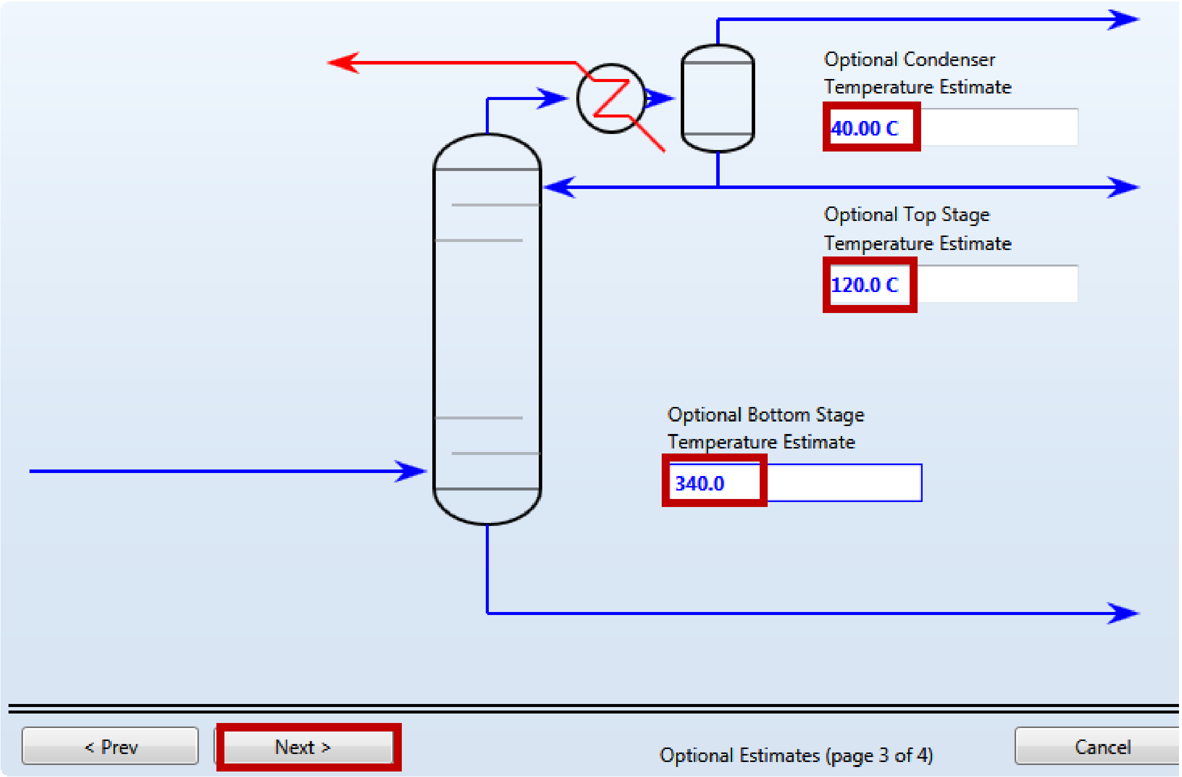
Cut Distributions

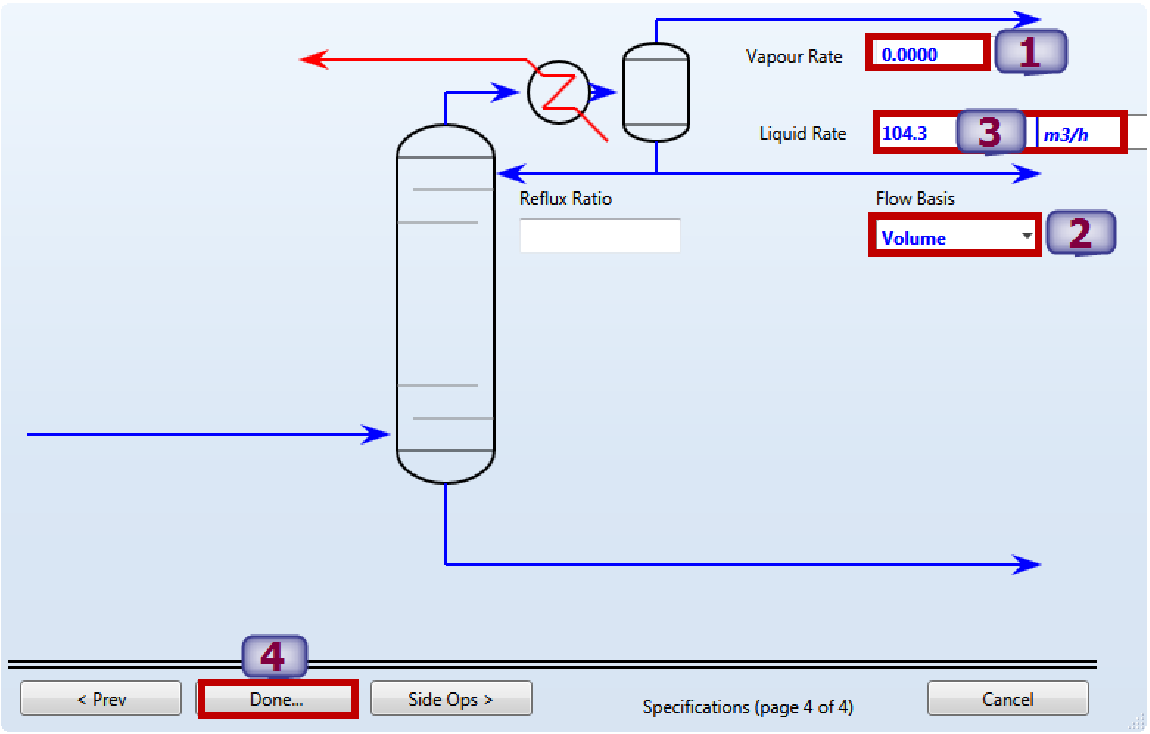
Name	Begin T [C]	End T [C]	Fraction
Off Gas	-19.54	10.00	0.021
Lt St Run	10.00	70.00	0.064
Naphtha	70.00	180.0	0.153
Kerosene	180.0	240.0	0.094
Light Diesel	240.0	290.0	0.102
Heavy Diesel	290.0	340.0	0.087
Atm Gas Oil	340.0	370.0	0.045
Residue	370.0	825.2	0.434

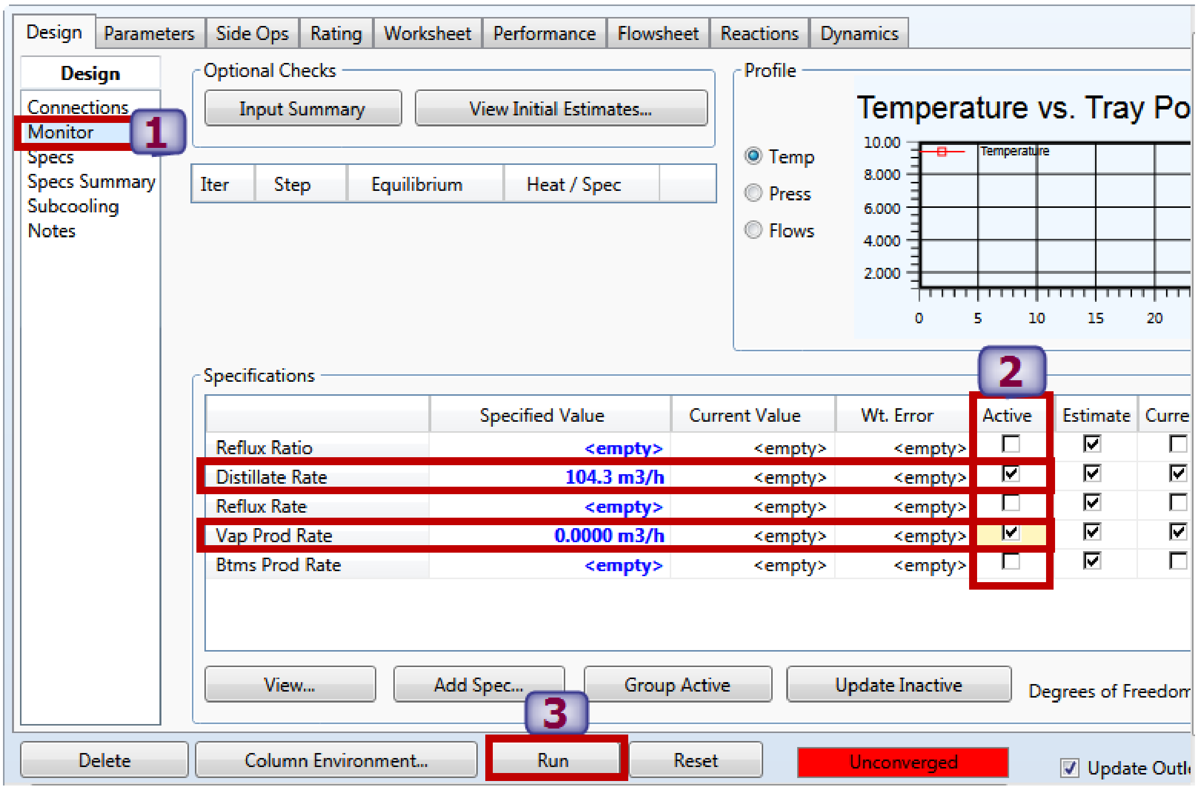


The Water Draw checkbox must be checked to prevent two liquid phases being formed in the column.




Optional Condenser
Temperature Estimate
40.00 C
Optional Top Stage
Temperature Estimate
120.0 C
Optional Bottom Stage
Temperature Estimate
340.0
< Prev
Next >
Optional Estimates (page 3 of 4)
Cancel


Vapour Rate
0.0000
1
Liquid Rate
104.3
3
m3/h
Reflux Ratio
Flow Basis
Volume
2
4
< Prev
Done...
Side Ops >
Specifications (page 4 of 4)
Cancel

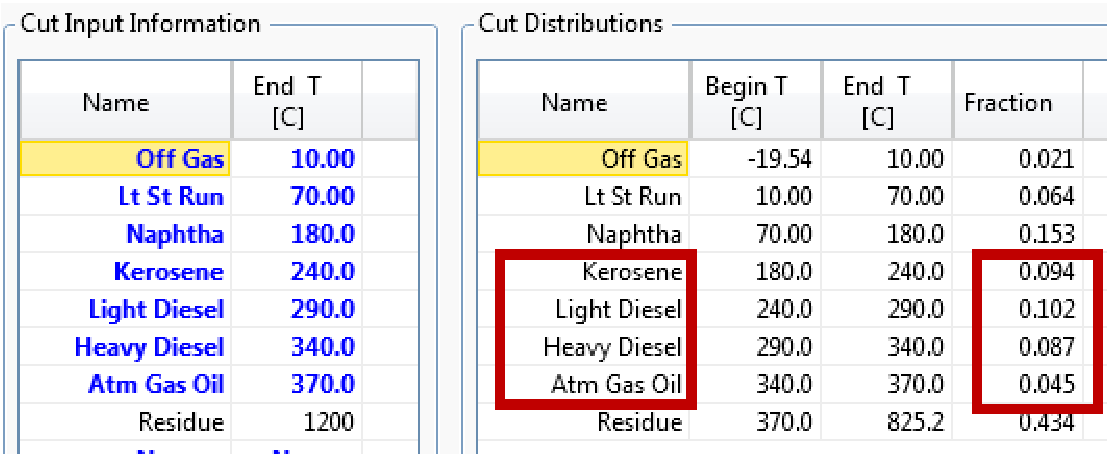


Run the column

Adding Side Strippers

Side Strippers are added to the column in order to improve the quality of the three main products (Kerosene, Diesel, and AGO). There are two types of side strippers available in HYSYS: Reboiled and Steam Stripped. We will install one reboiled side stripper and two steam stripped.

	AGO SS	Diesel SS	Kerosene SS
Draw Stage	22	17	9
Return Stage	21	16	8
Configuration	Steam Stripped	Steam Stripped	Reboiled
Product flow	0.045× 681.9 m^3/hr = 30.69 m^3/hr	(0.102+0.087)× 681.9 = 128.88 m^3/hr	0.094× 681.9 m^3/hr = 64.1 m^3/hr


Cut Input Information

Name	End T [C]
Off Gas	10.00
Lt St Run	70.00
Naphtha	180.0
Kerosene	240.0
Light Diesel	290.0
Heavy Diesel	340.0
Atm Gas Oil	370.0
Residue	1200

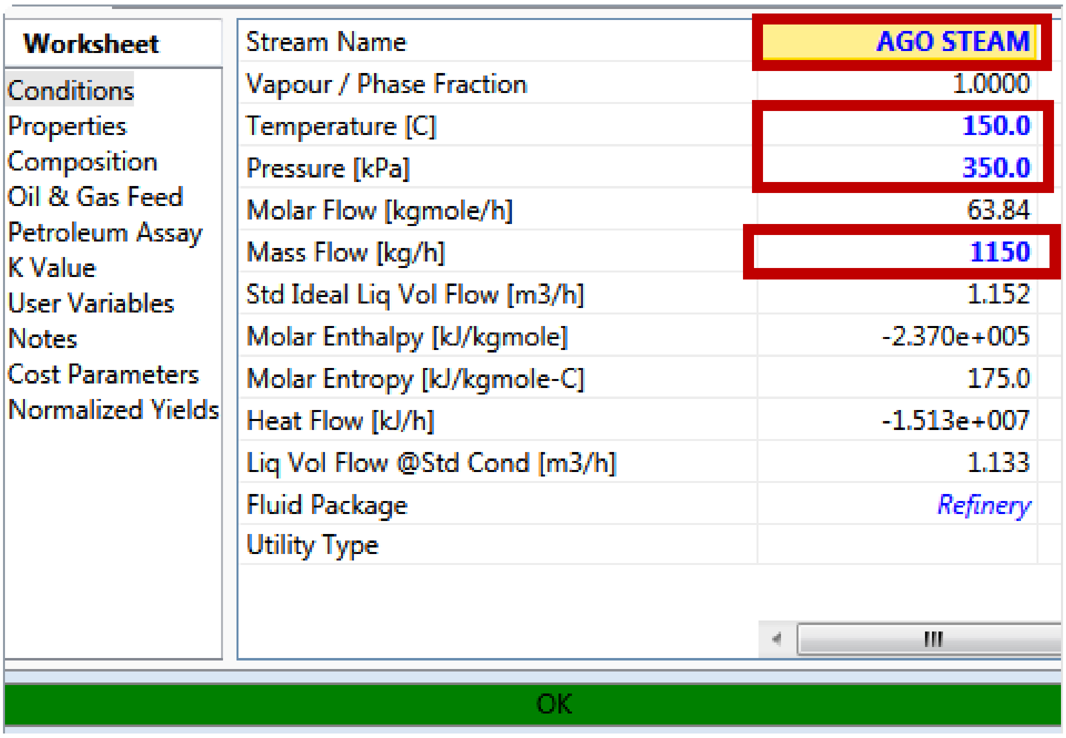
Cut Distributions

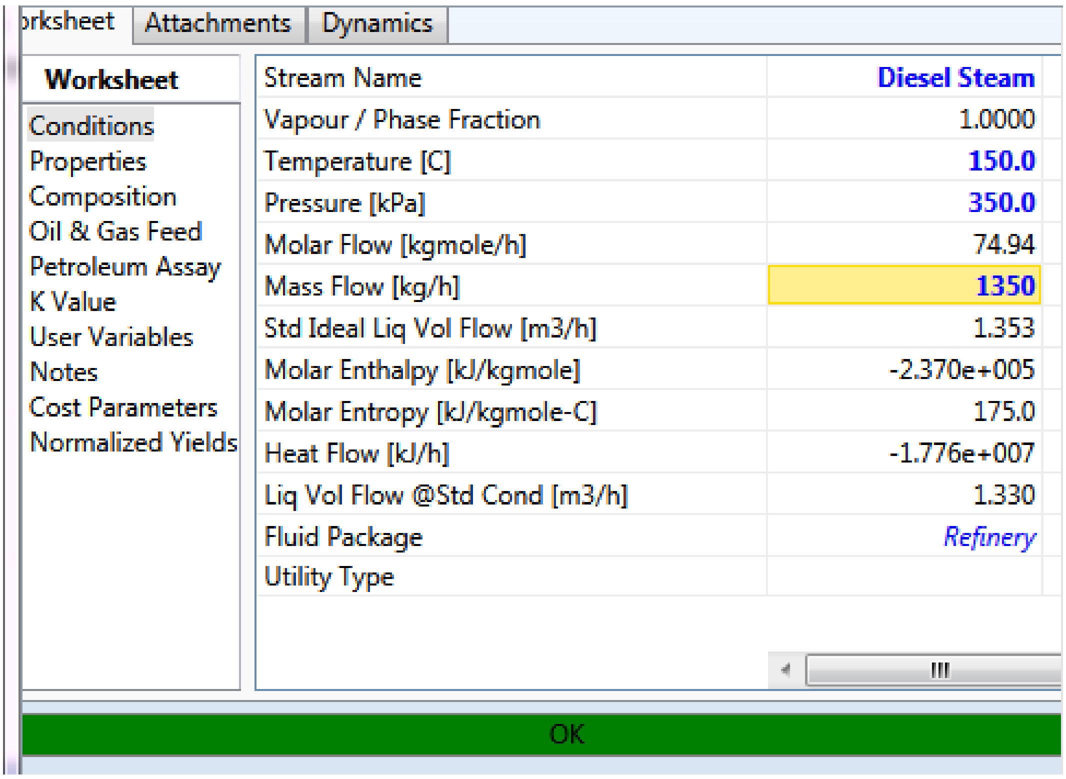
Name	Begin T [C]	End T [C]	Fraction
Off Gas	-19.54	10.00	0.021
Lt St Run	10.00	70.00	0.064
Naphtha	70.00	180.0	0.153
Kerosene	180.0	240.0	0.094
Light Diesel	240.0	290.0	0.102
Heavy Diesel	290.0	340.0	0.087
Atm Gas Oil	340.0	370.0	0.045
Residue	370.0	825.2	0.434

	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr

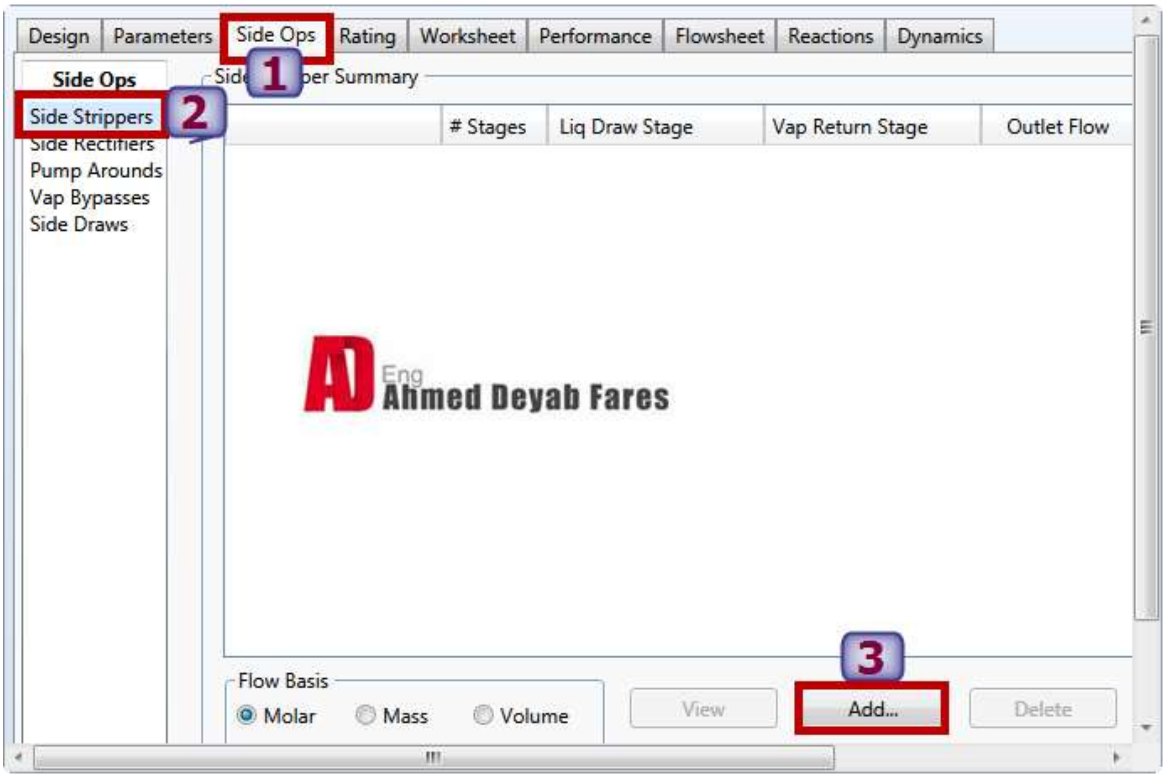
First we need to add two steam streams to provide the heating effect for both AGO & Diesel Side Strippers

	Temperature	Pressure	Flowrate
AGO Steam	150 °C	350 kPa	1150 kg/hr
Diesel Steam	150 °C	350 kPa	1350 kg/hr

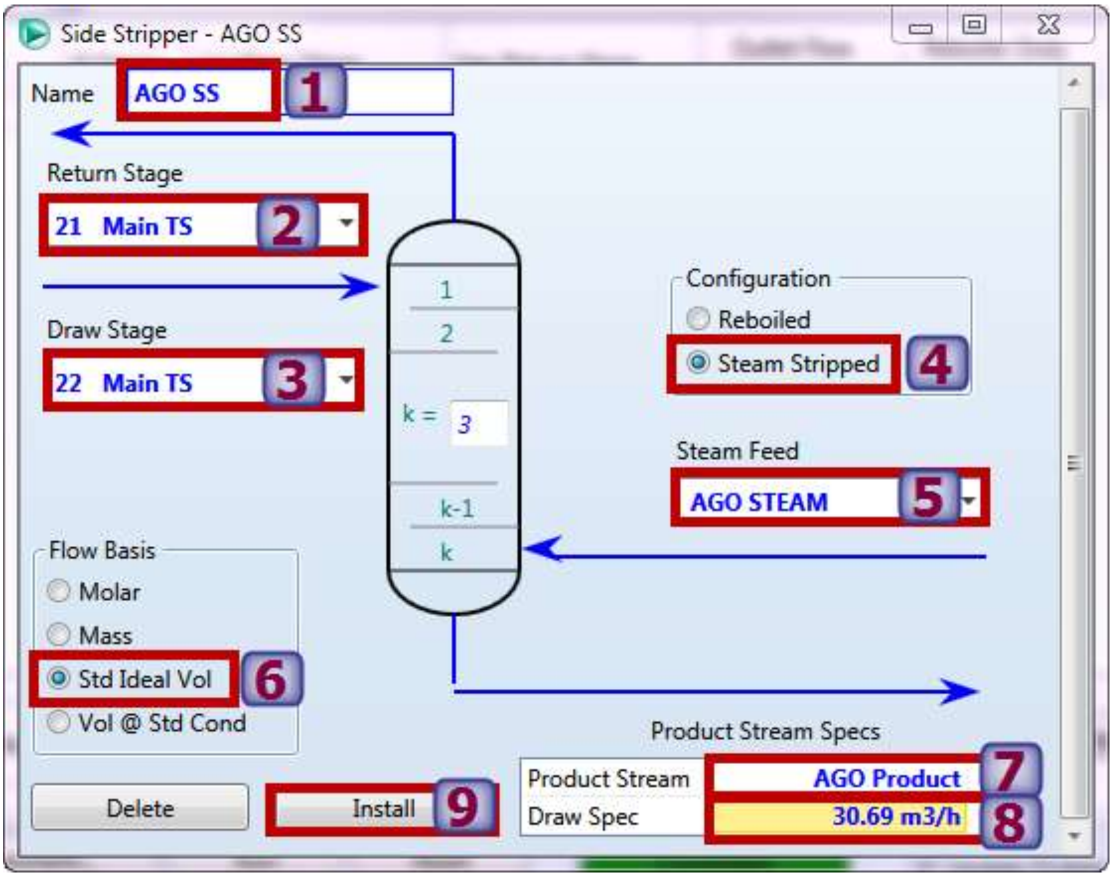


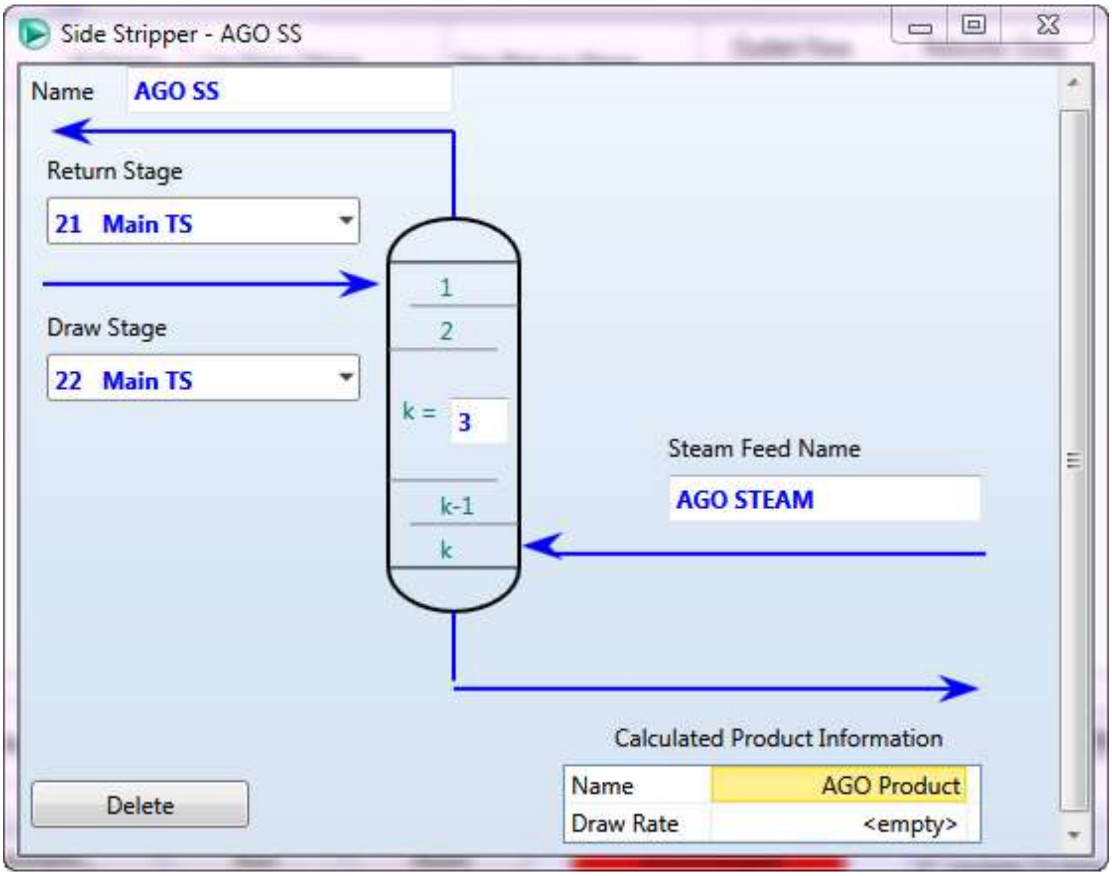


Go to the ***Side Ops*** tab inside the atmospheric tower to ***add*** the three side stripers:



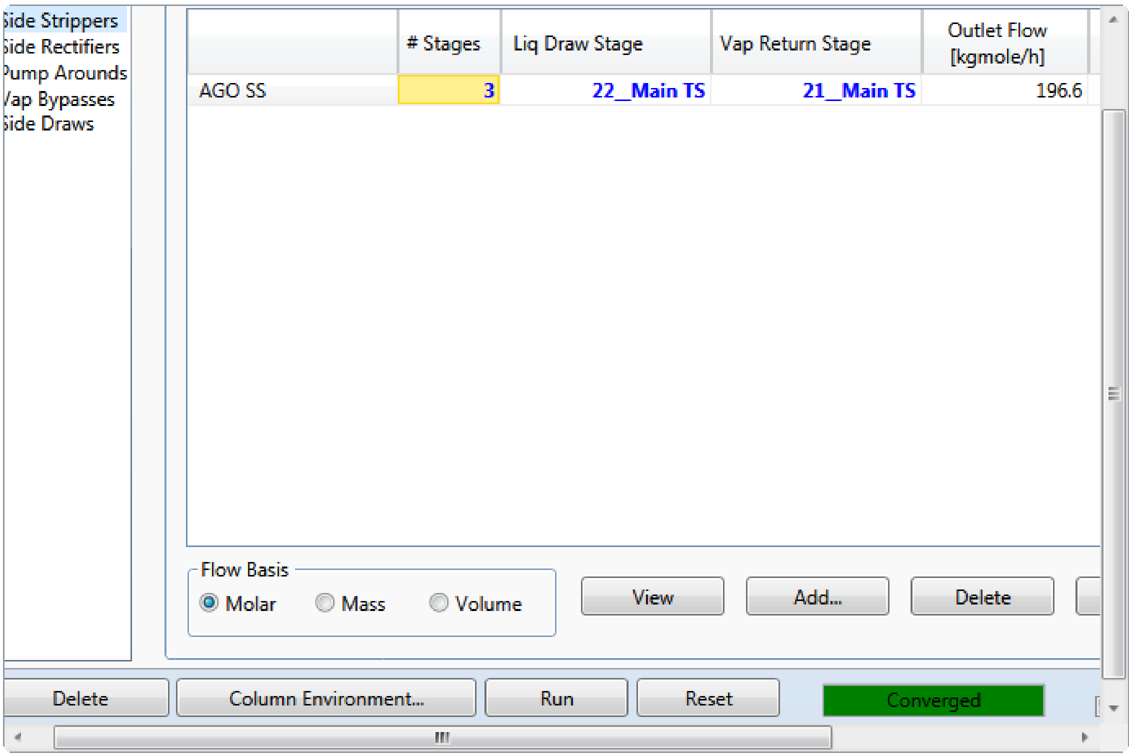
First add the AGO Side Stripper



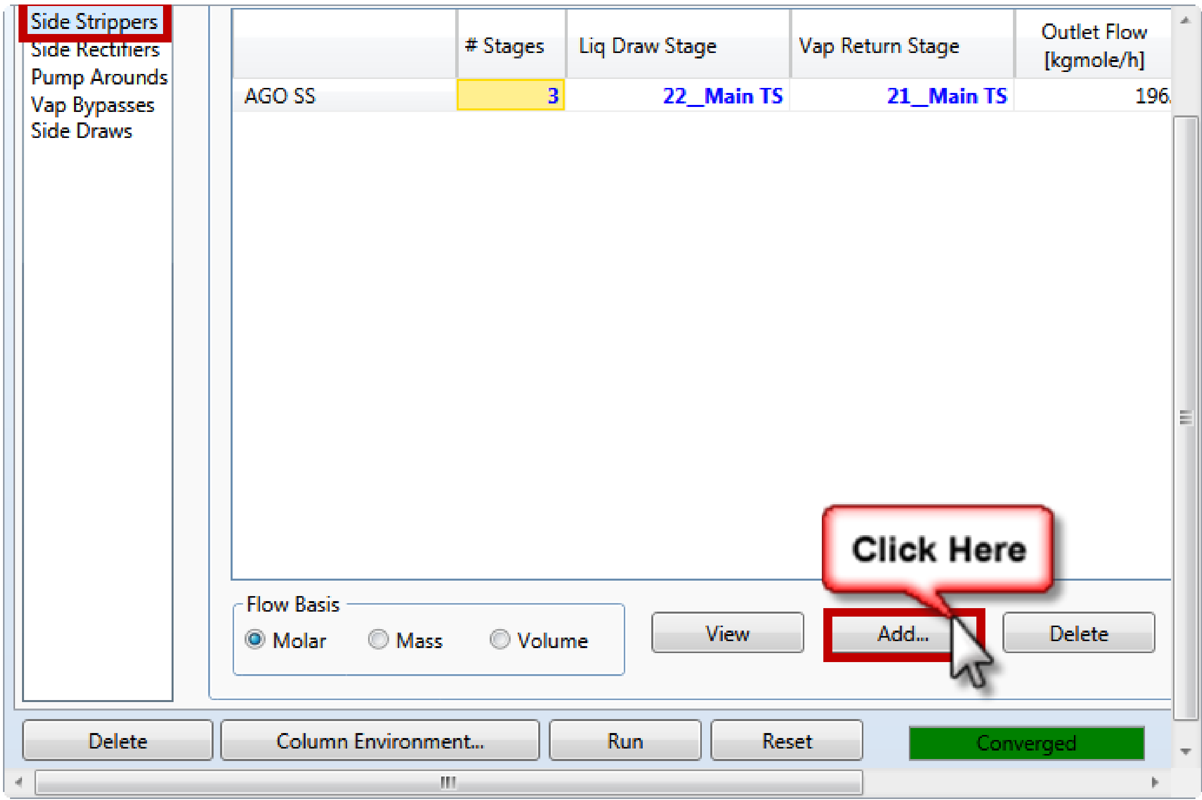


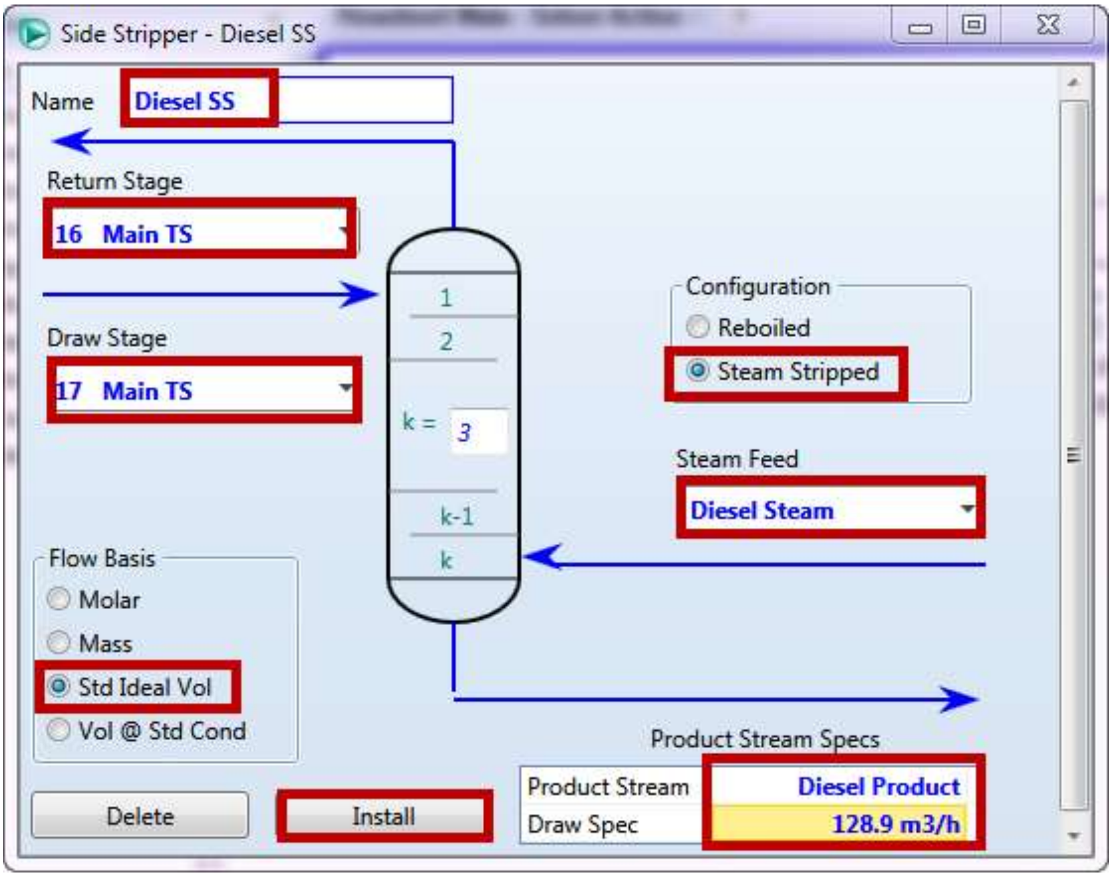
Close the window and run the column

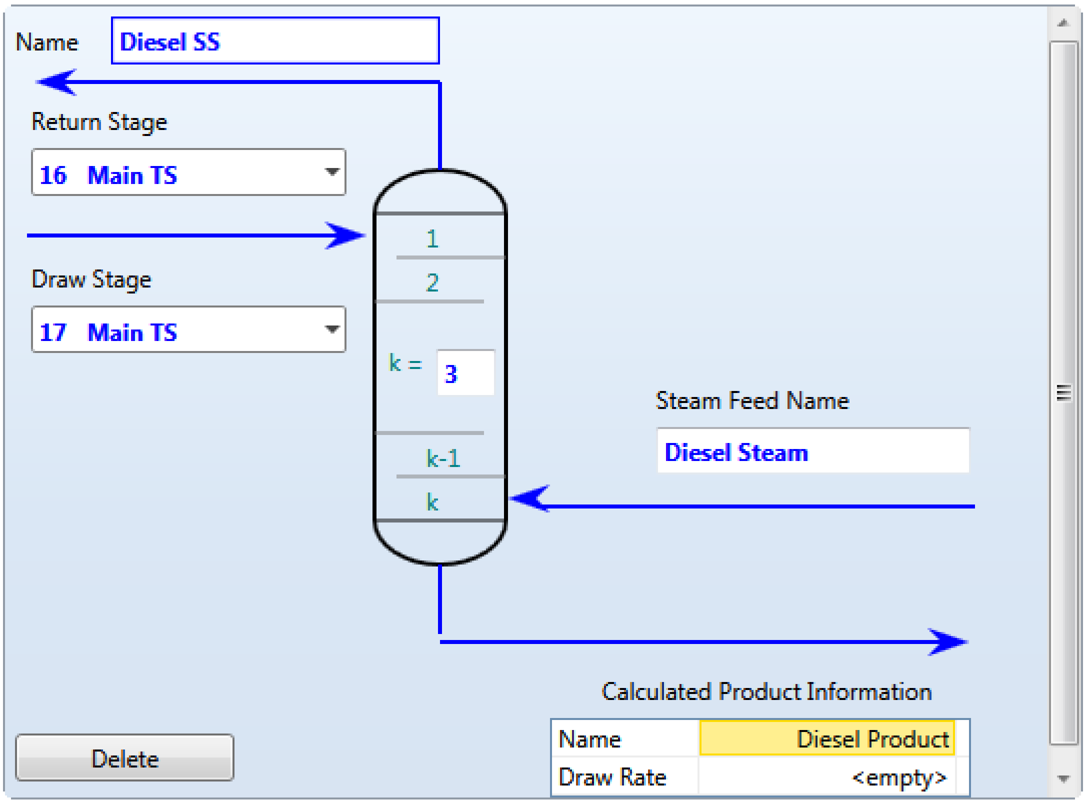
Make sure that the column is converged



Add the Diesel Side stripper:

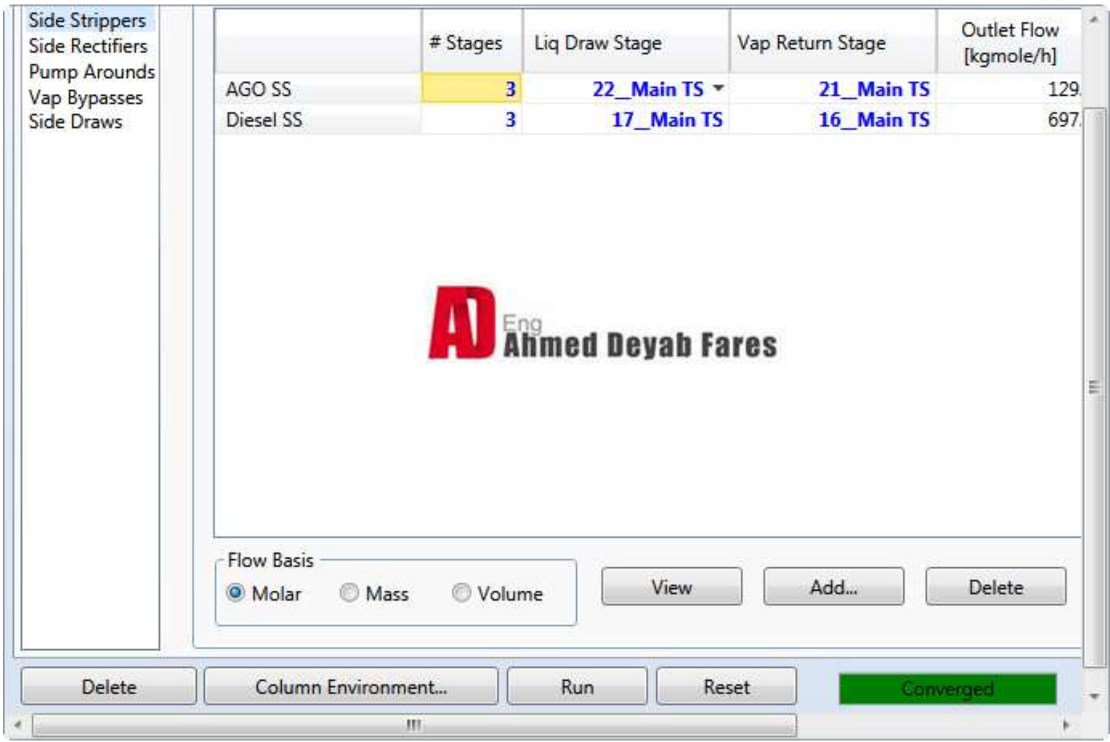




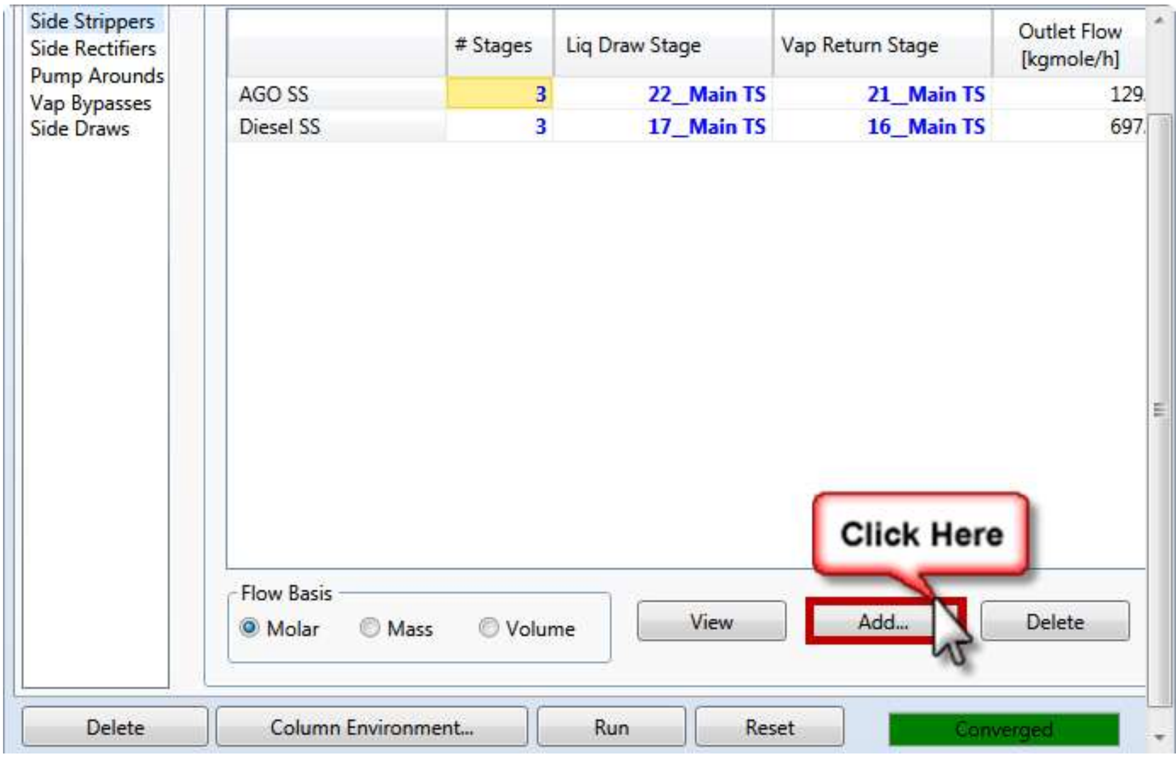


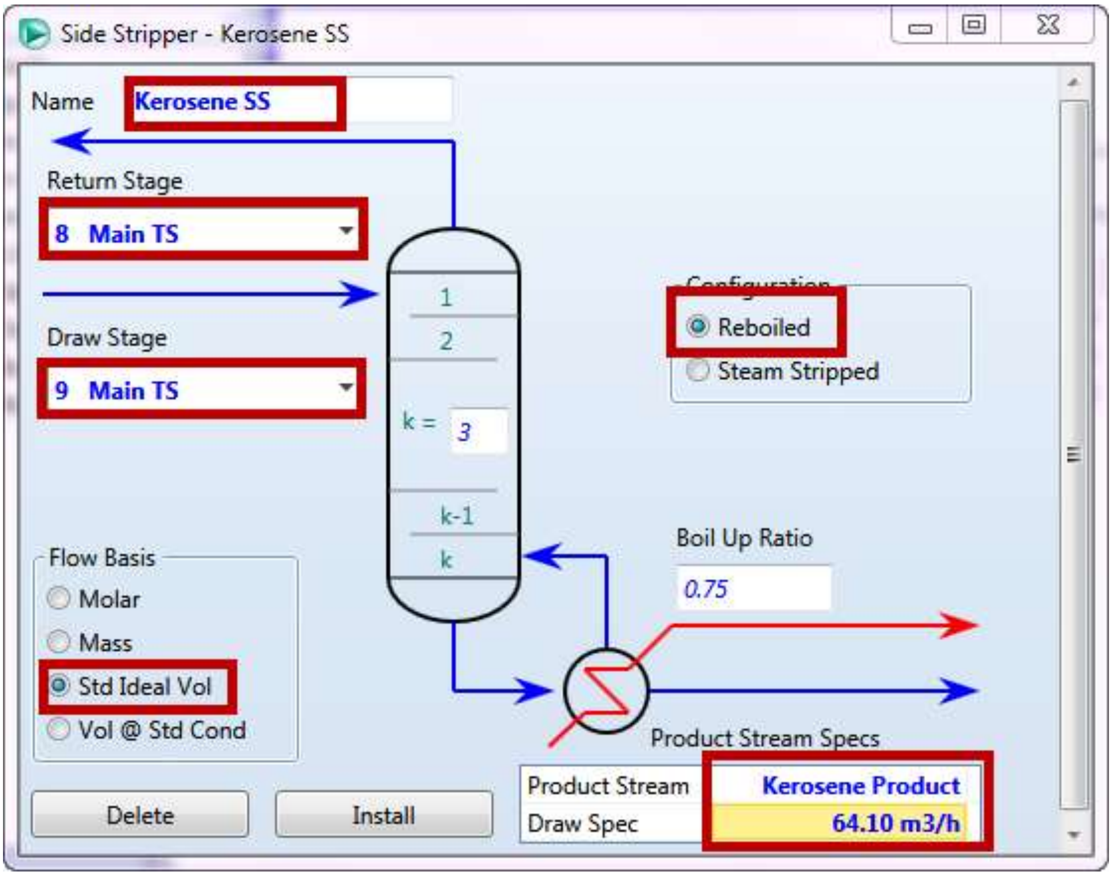
Close the window and run the column

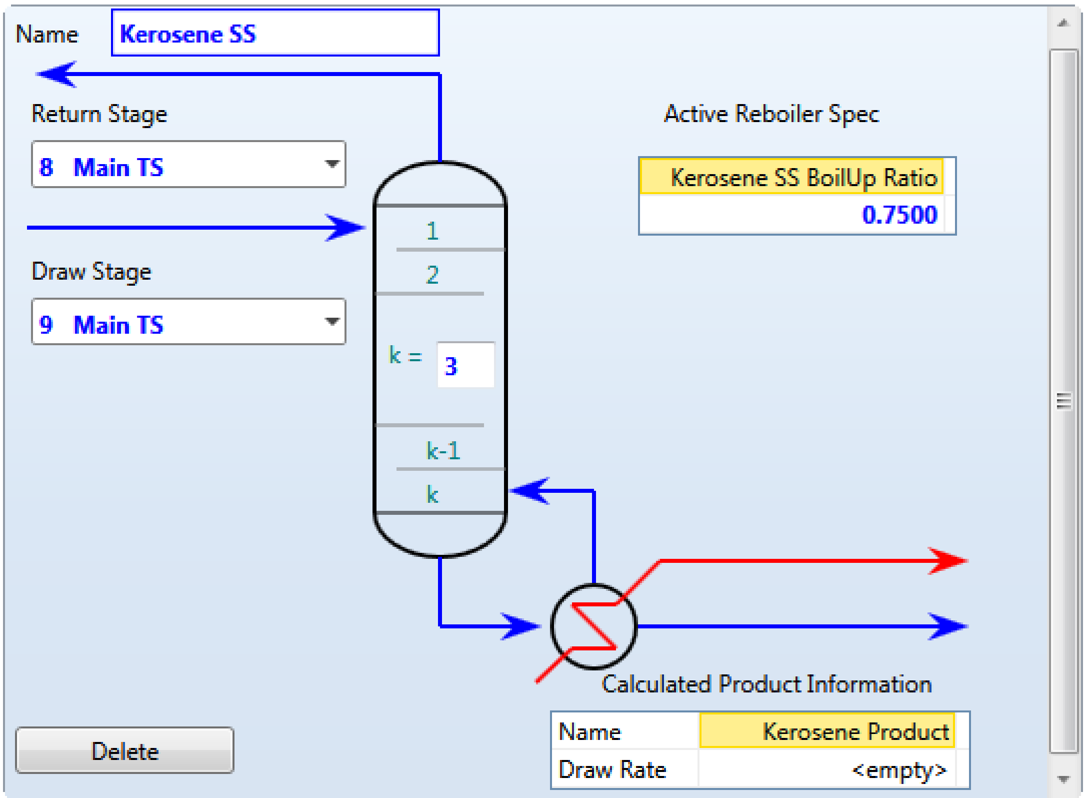
Make sure that the column is converged



Add the Kerosene Side stripper:

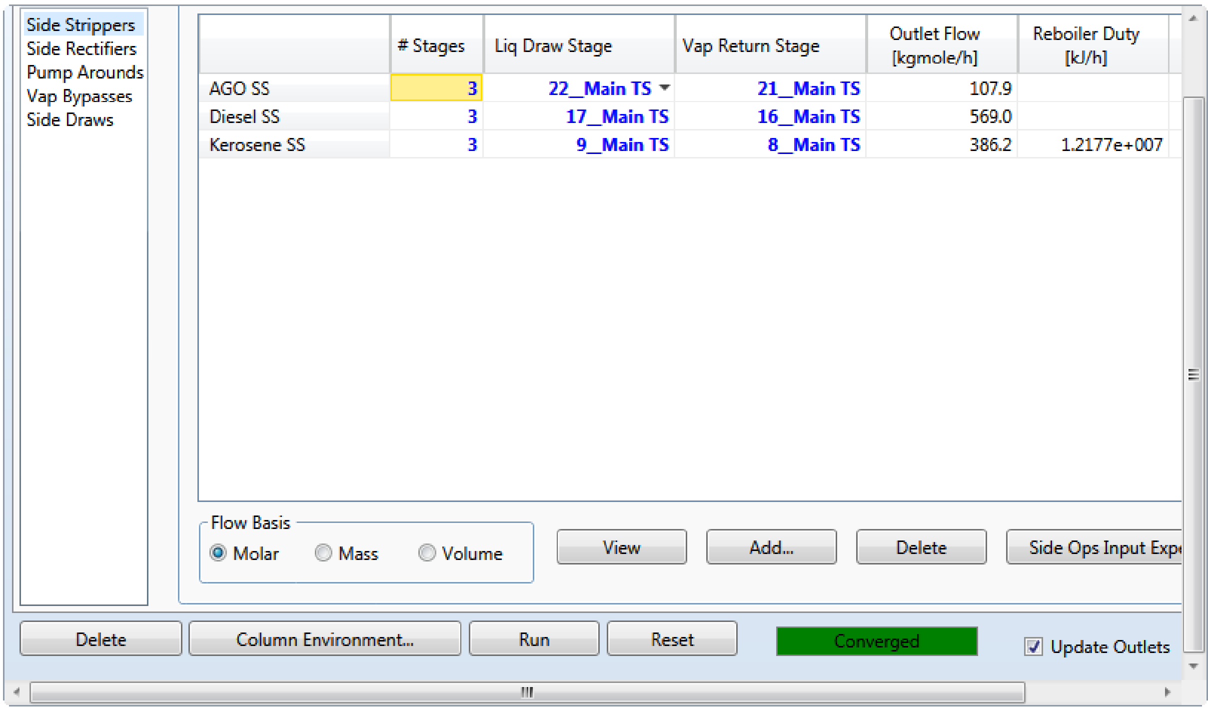






Close the window and run the column

Make sure that the column is converged

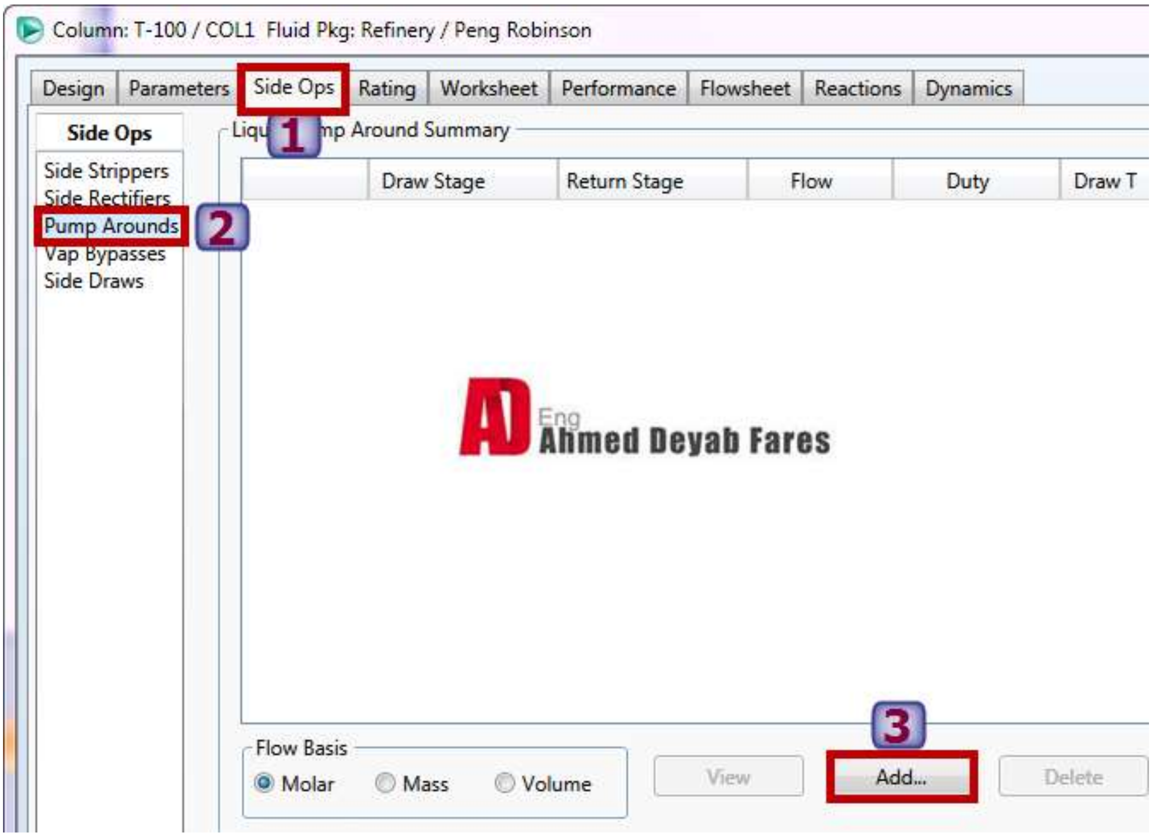


Adding Pump Arounds

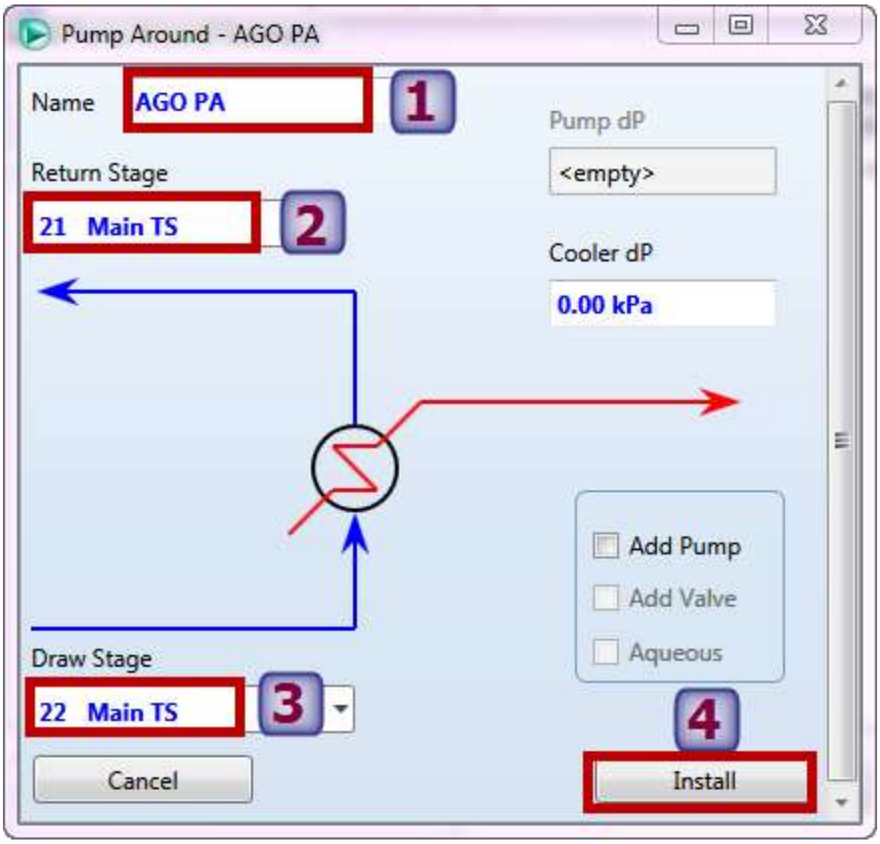
Pump Arounds help to improve the column's efficiency. They operate by drawing a liquid stream from one stage cooling it, and pumping it into a higher stage. In effect, this process adds to the reflux between these two stages.

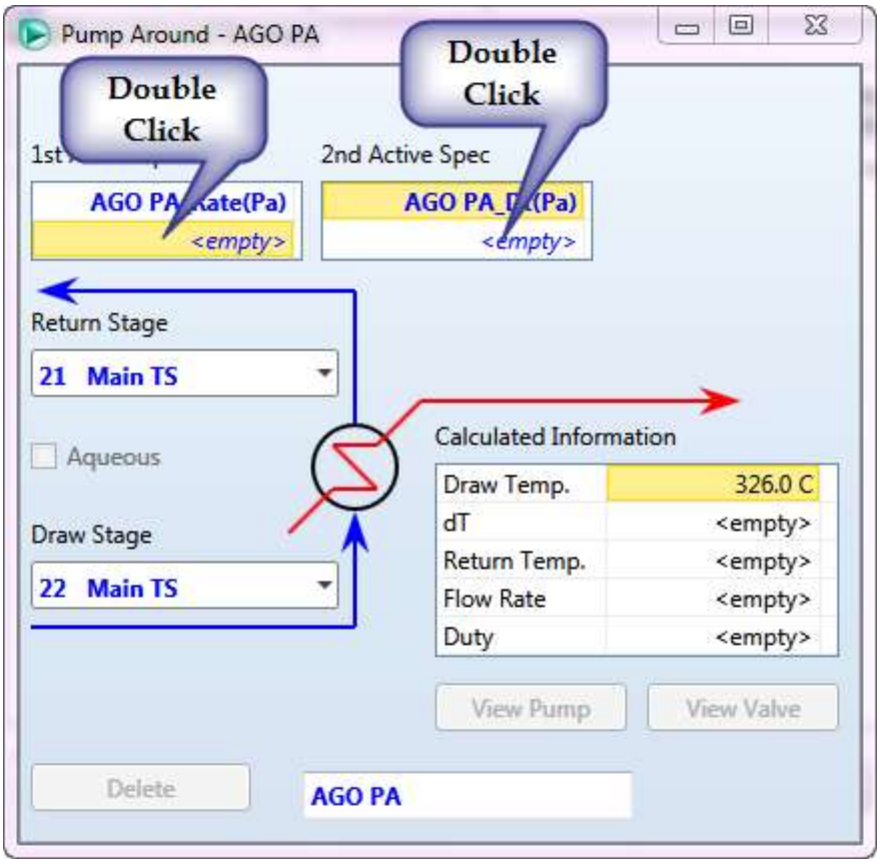
	AGO PA	Diesel PA	Kerosene PA
Draw Stage	22	17	9
Return Stage	21	16	8
Flowrate	200 m^3/h	200 m^3/h	330 m^3/h
Duty	-3.7e7 kJ/h	-3.7e7 kJ/h	-4.5e7 kJ/h

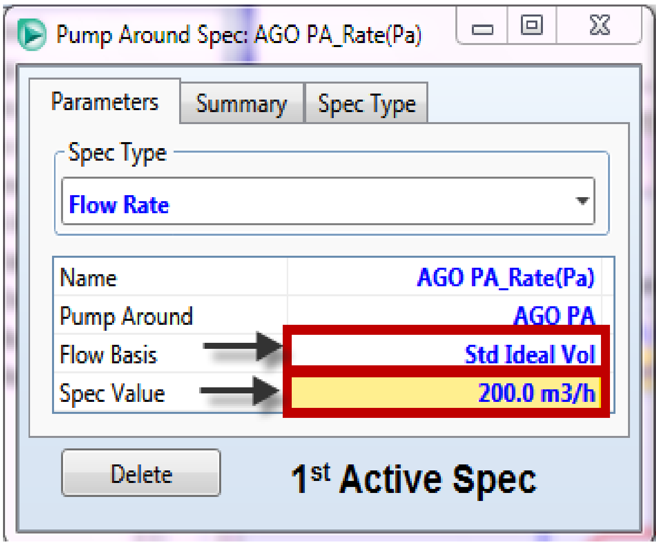
Go to the ***Side Ops*** tab inside the atmospheric tower to ***add*** the three Pump Arounds:

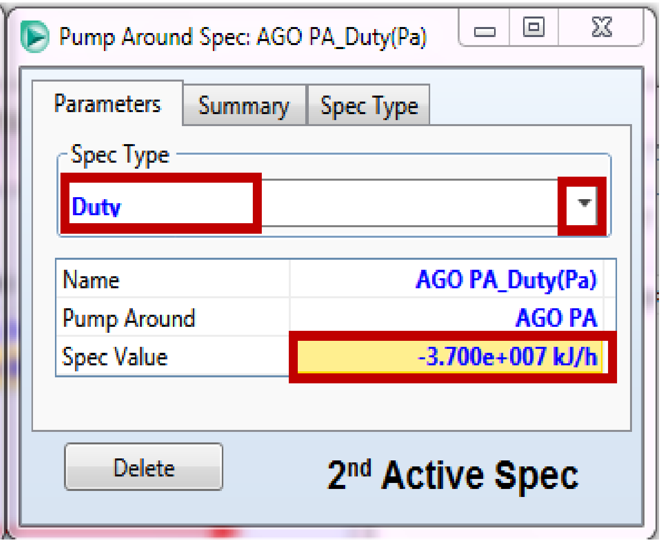


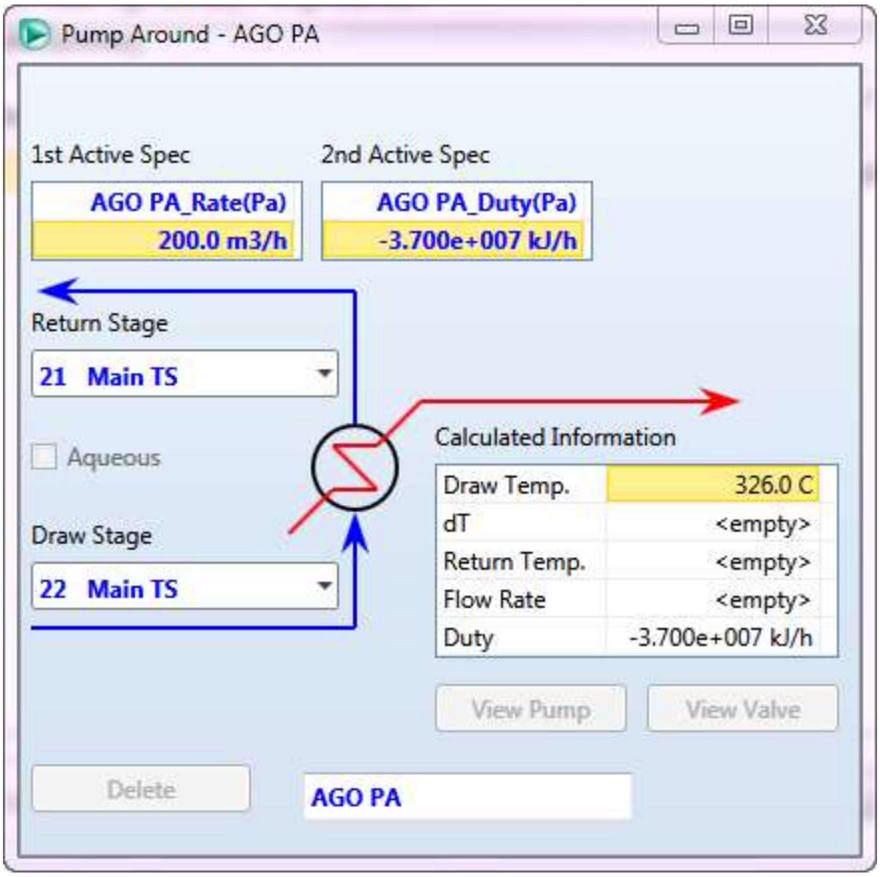
Add the AGO Pump Around (PA)







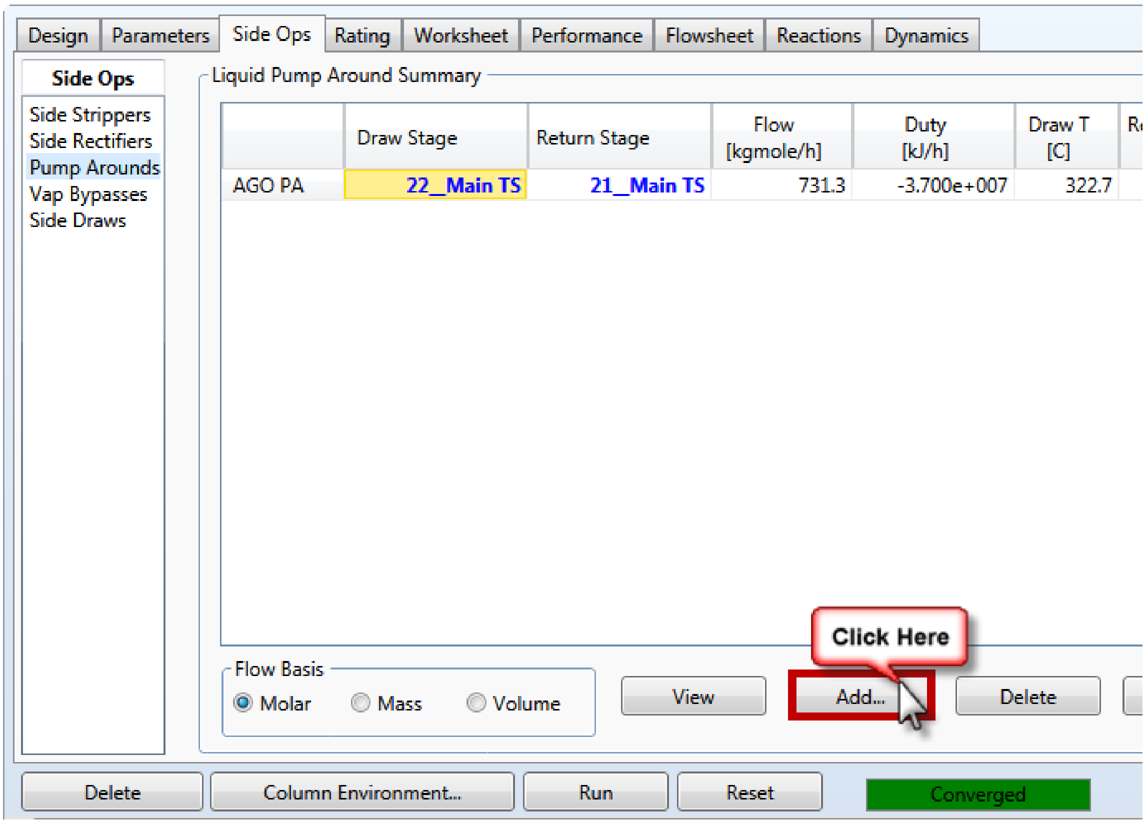


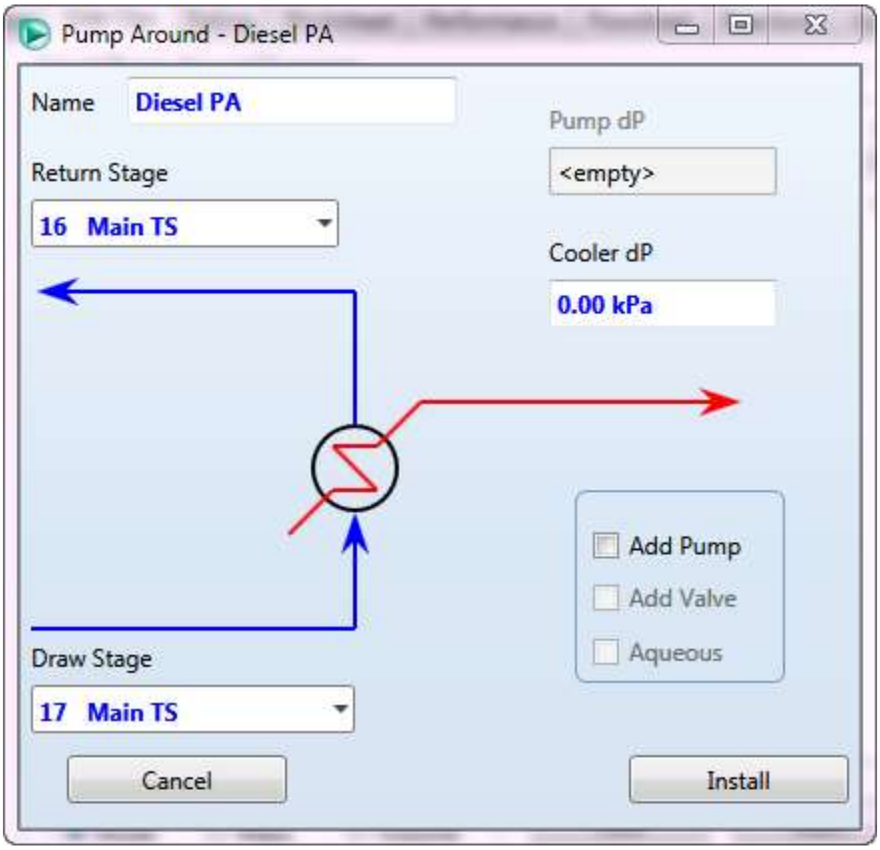


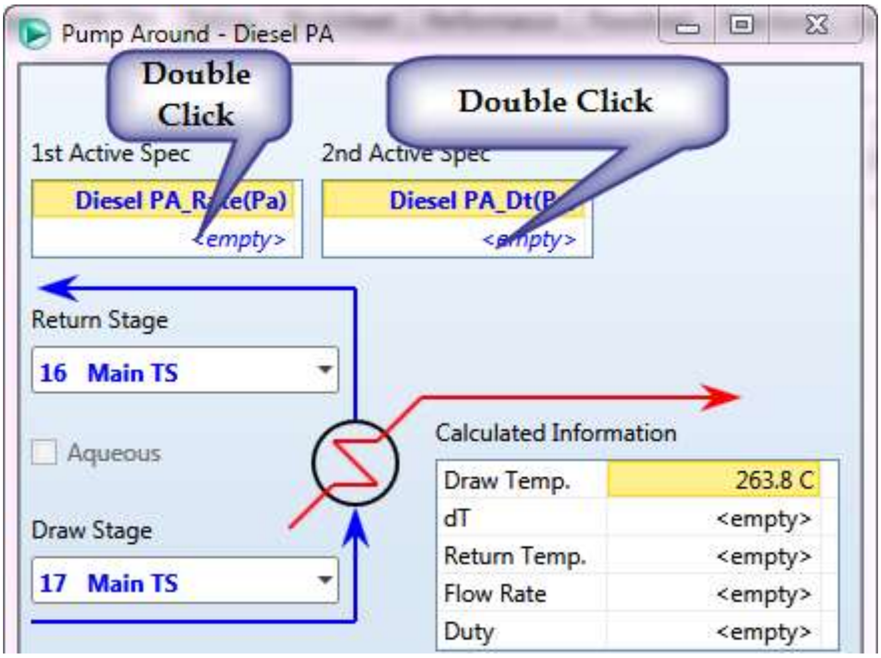
Close the window and run the column

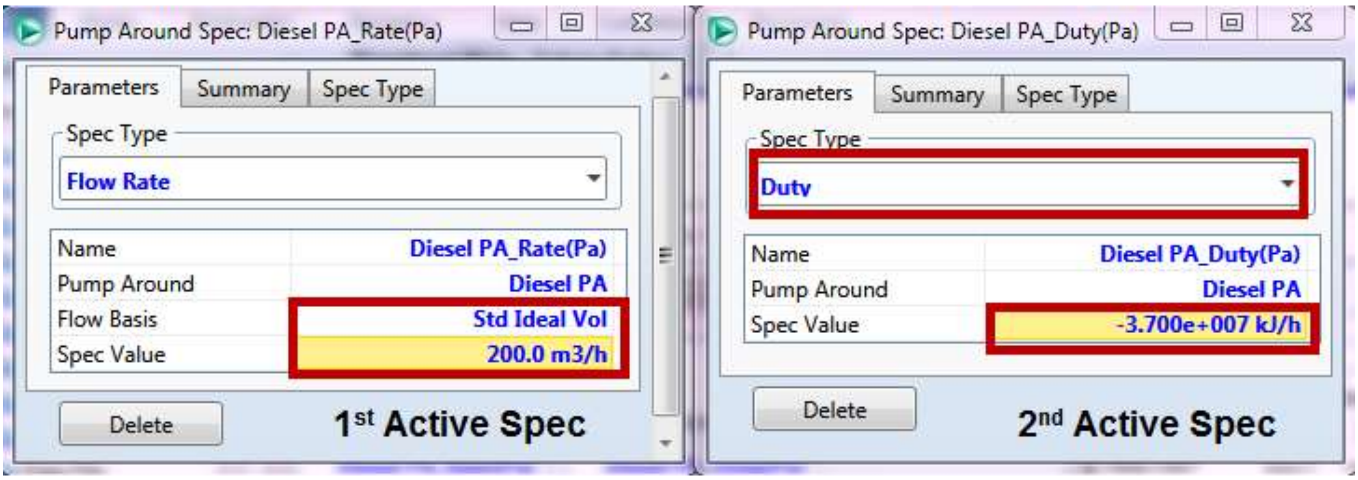
Make sure that the column is converged

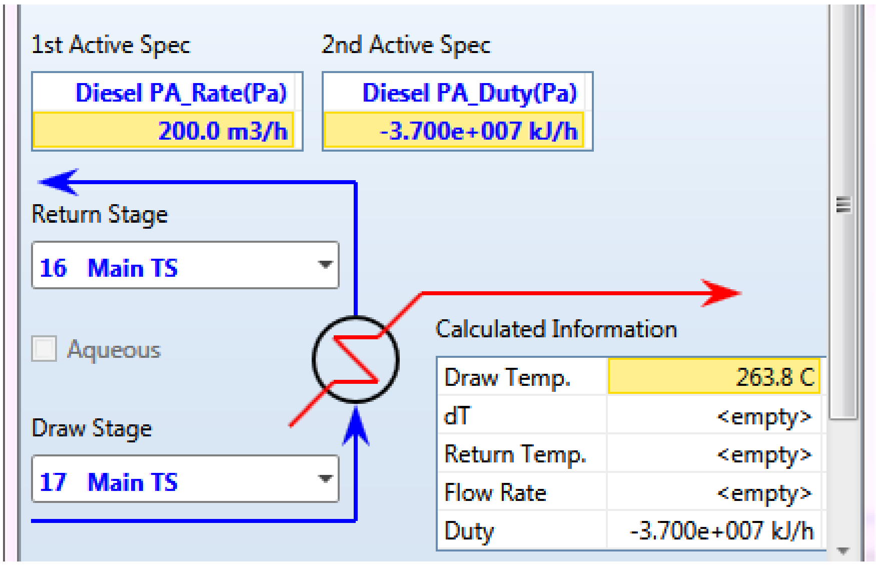
Add the Diesel Pump Around





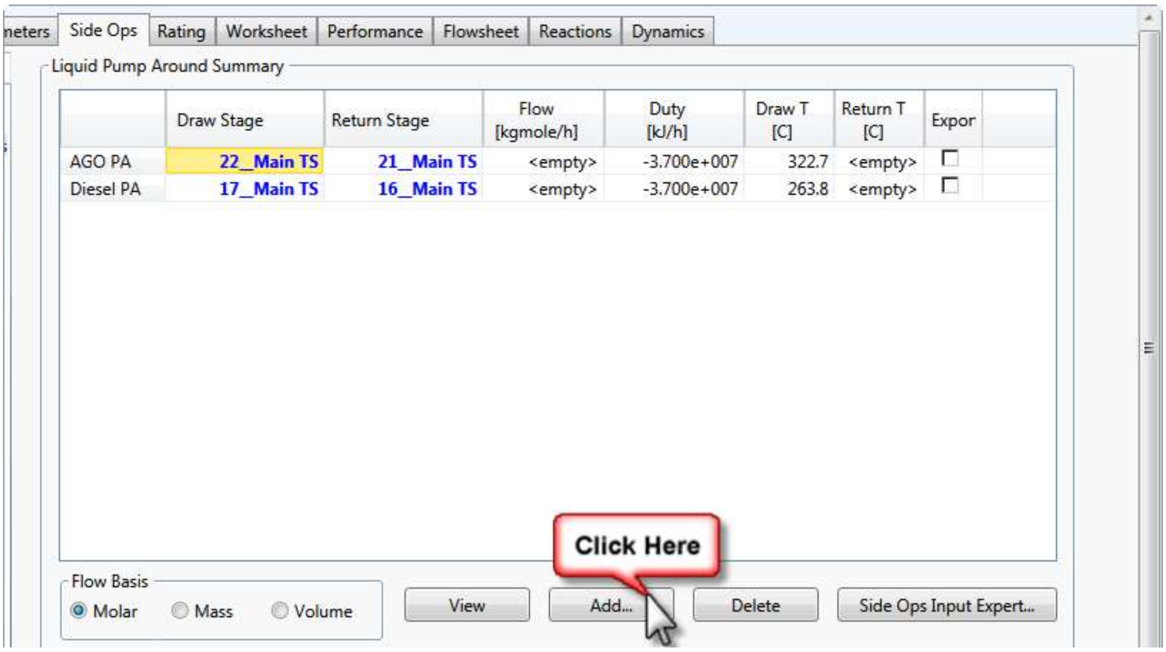


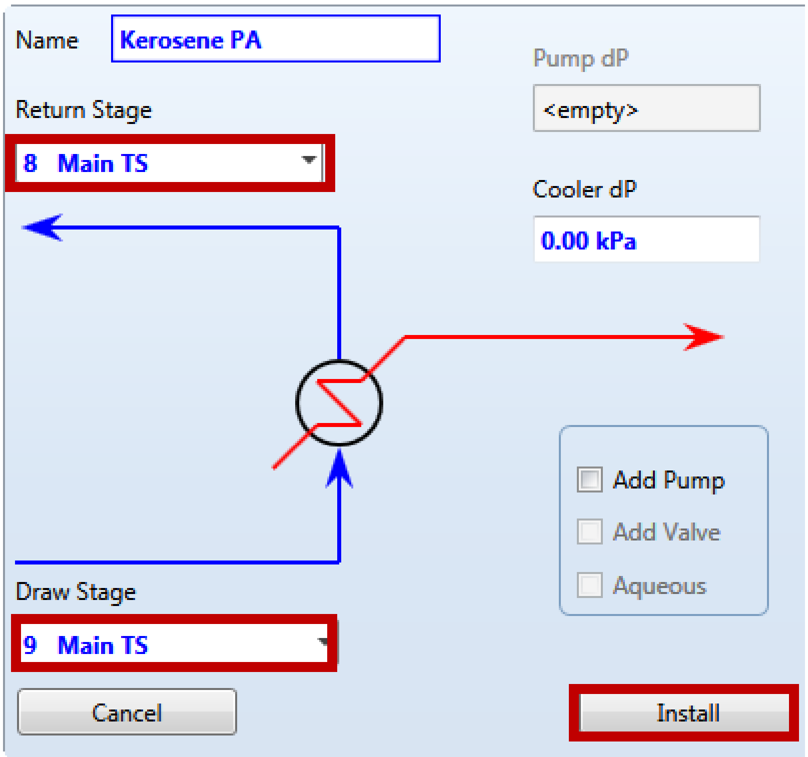


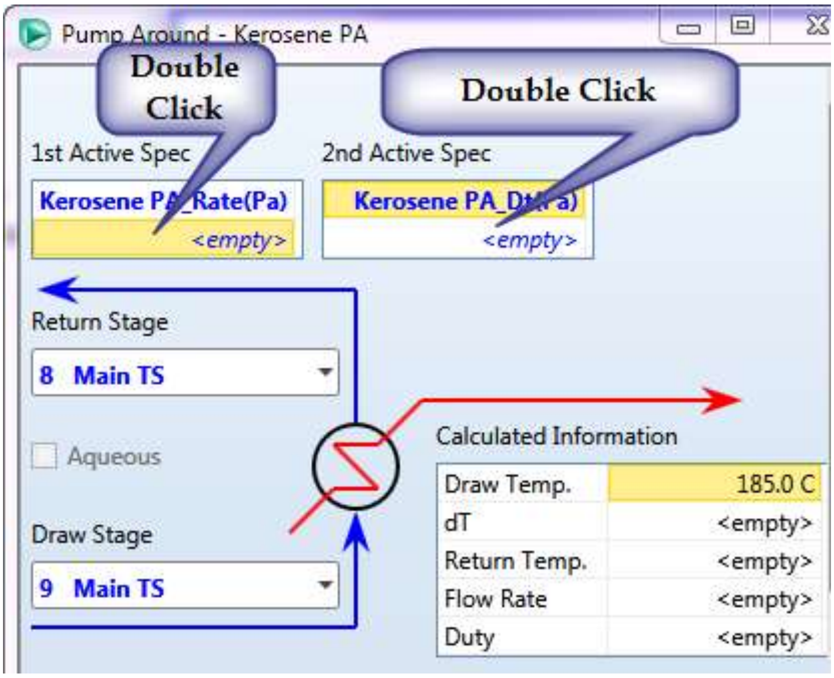


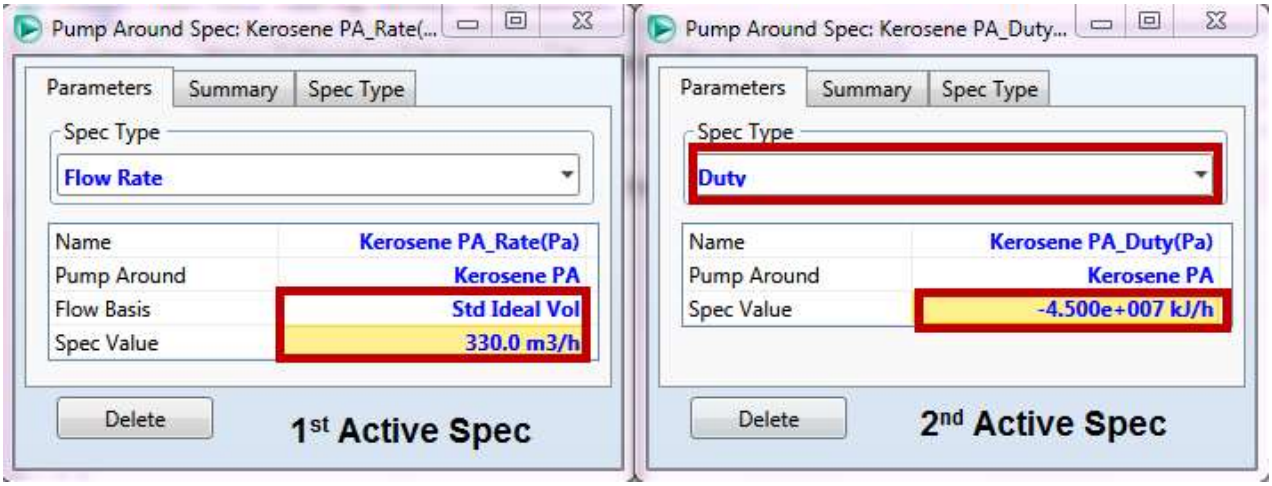
Close the window and run the column
Make sure that the column is converged

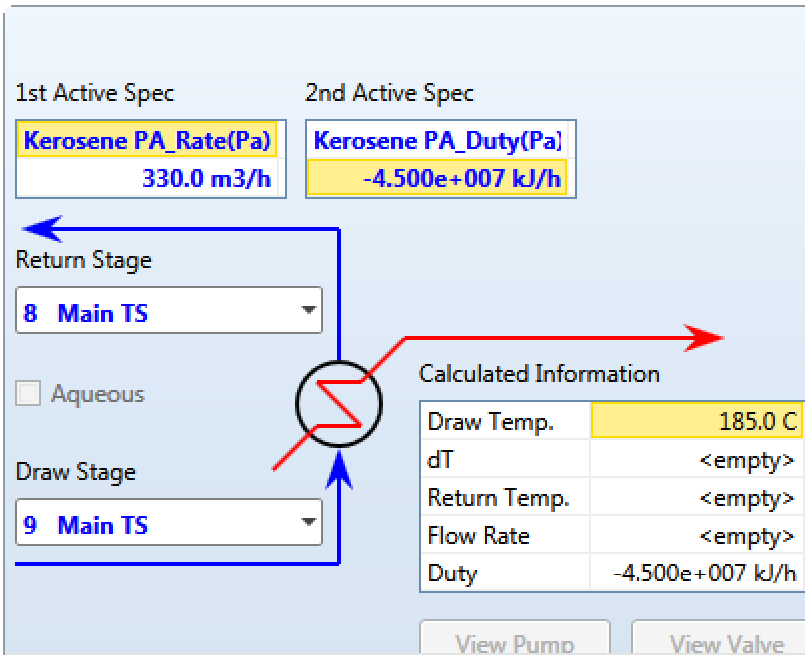
Add the Kerosene Pump Around





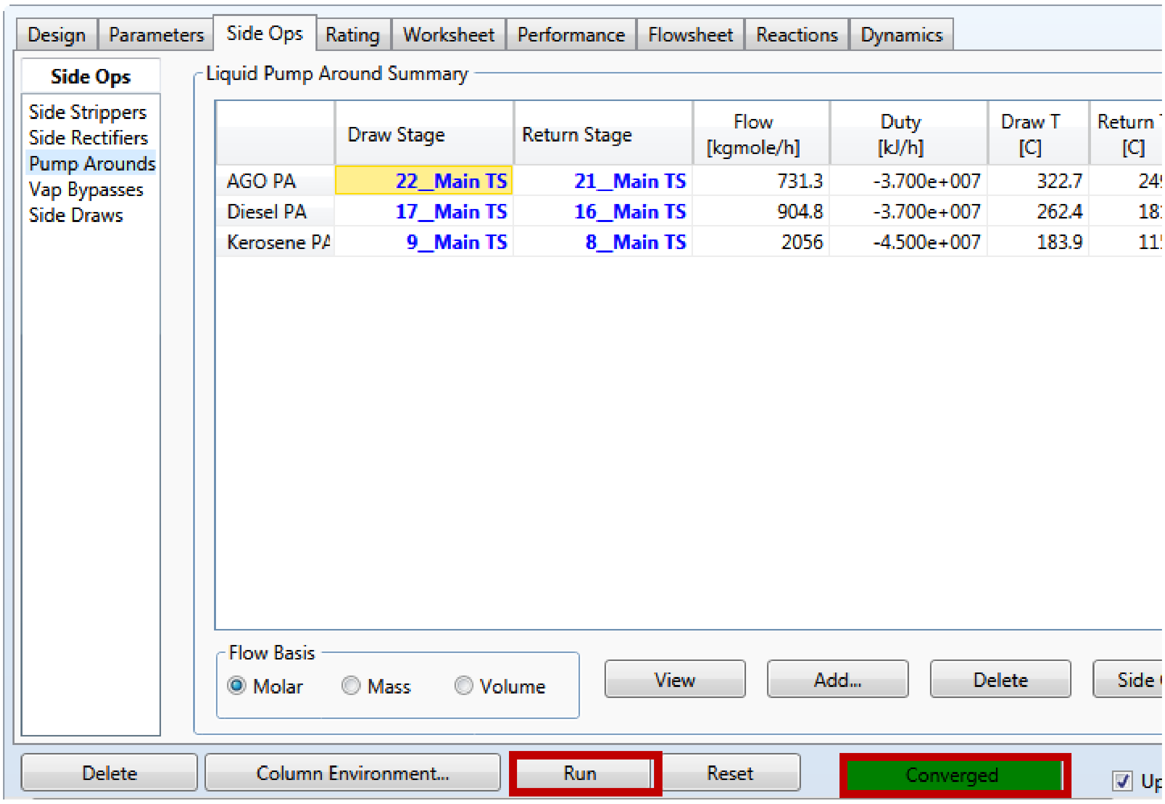

Pump Around - Kerosene PA
Double Click
Double Click
1st Active Spec
2nd Active Spec
Kerosene PA_Rate(Pa)
<empty>
Kerosene PA_Dt(Pa)
<empty>
Return Stage
8 Main TS
Aqueous
Draw Stage
9 Main TS
Calculated Information
Draw Temp. 185.0 C
dT <empty>
Return Temp. <empty>
Flow Rate <empty>
Duty <empty>


Pump Around Spec: Kerosene PA_Rate(...
Parameters
Summary
Spec Type
Spec Type
Flow Rate
Name Kerosene PA_Rate(Pa)
Pump Around Kerosene PA
Flow Basis Std Ideal Vol
Spec Value 330.0 m3/h
Delete
1st Active Spec
Pump Around Spec: Kerosene PA_Duty...
Parameters
Summary
Spec Type
Spec Type
Duty
Name Kerosene PA_Duty(Pa)
Pump Around Kerosene PA
Spec Value -4.500e+007 kJ/h
Delete
2nd Active Spec

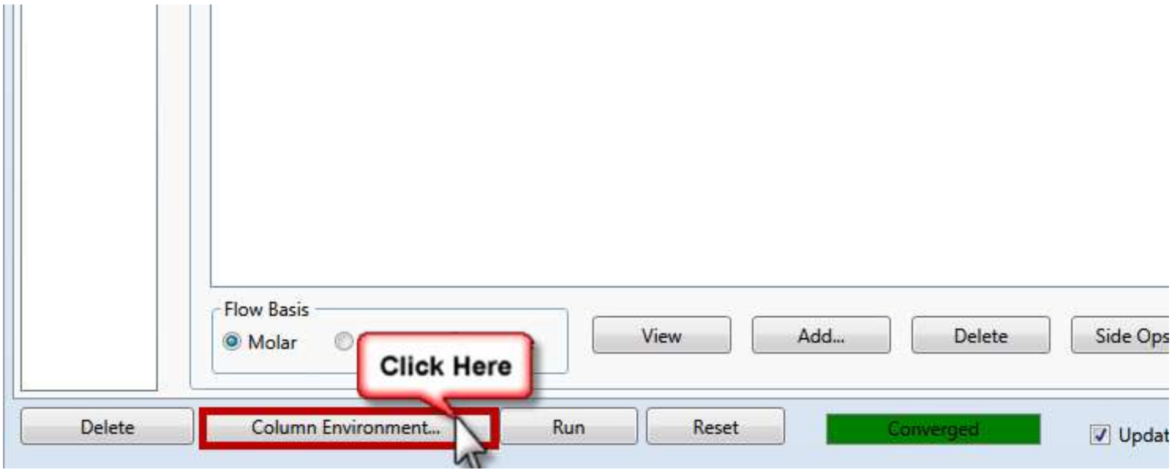

1st Active Spec
2nd Active Spec
Kerosene PA_Rate(Pa)
330.0 m3/h
Kerosene PA_Duty(Pa)
-4.500e+007 kJ/h
Return Stage
8 Main TS
Aqueous
Draw Stage
9 Main TS
Calculated Information
Draw Temp. 185.0 C
dT <empty>
Return Temp. <empty>
Flow Rate <empty>
Duty -4.500e+007 kJ/h
View Pump
View Valve

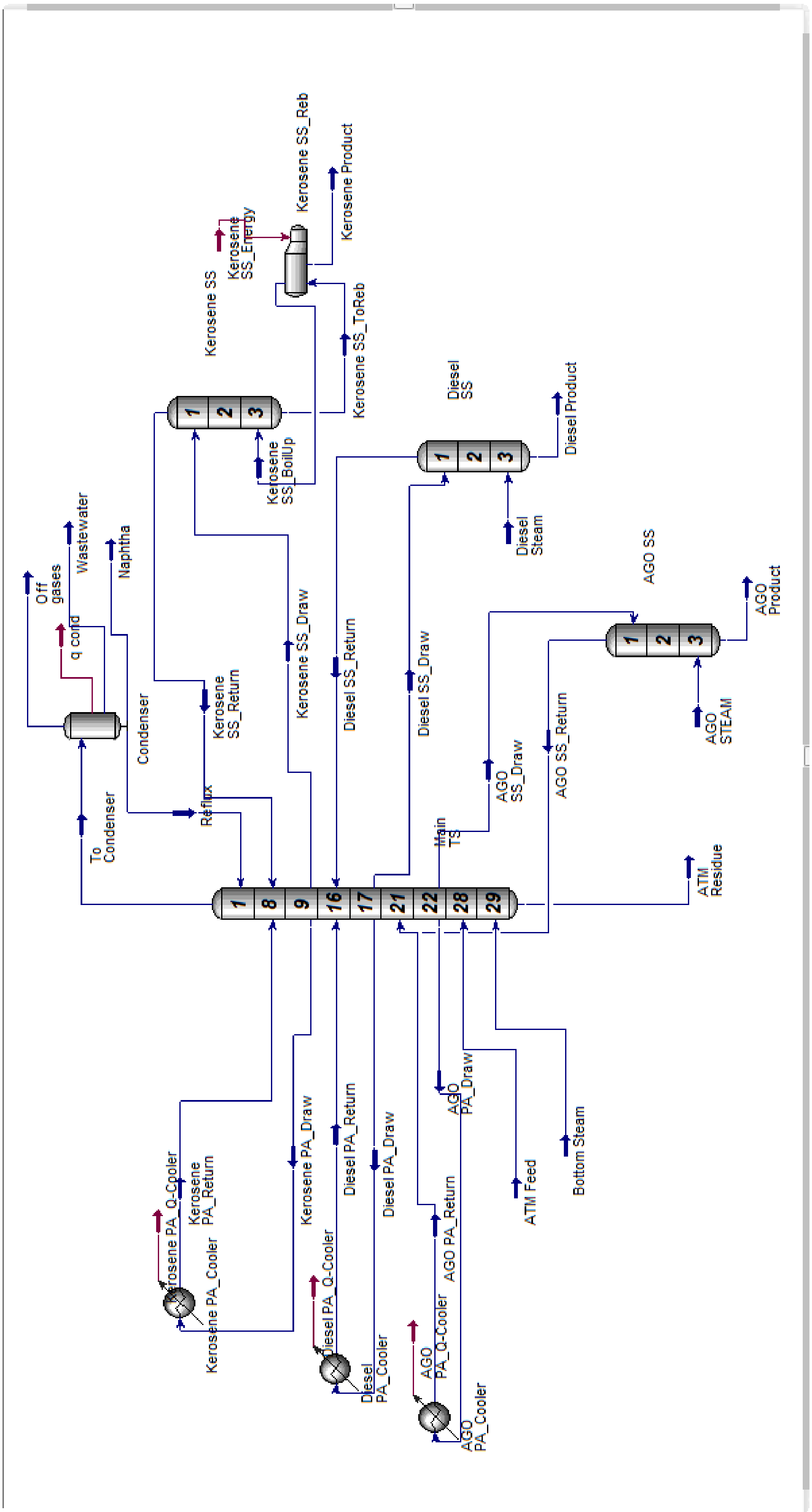
Close the window and run the column

Make sure that the column is converged

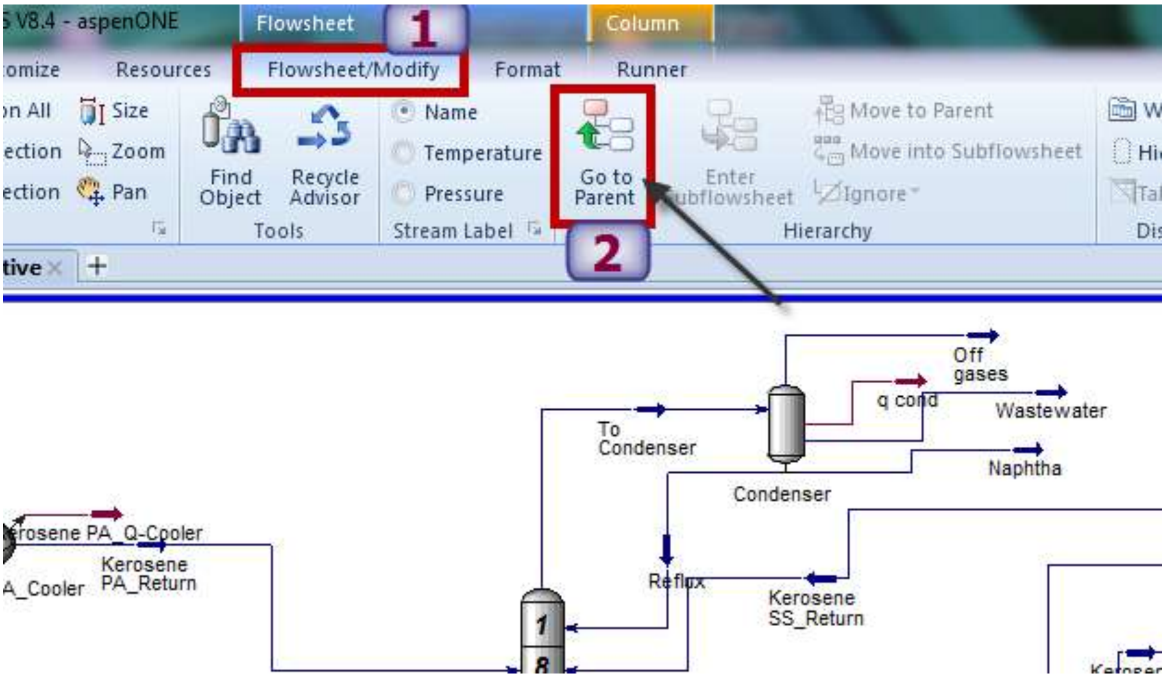


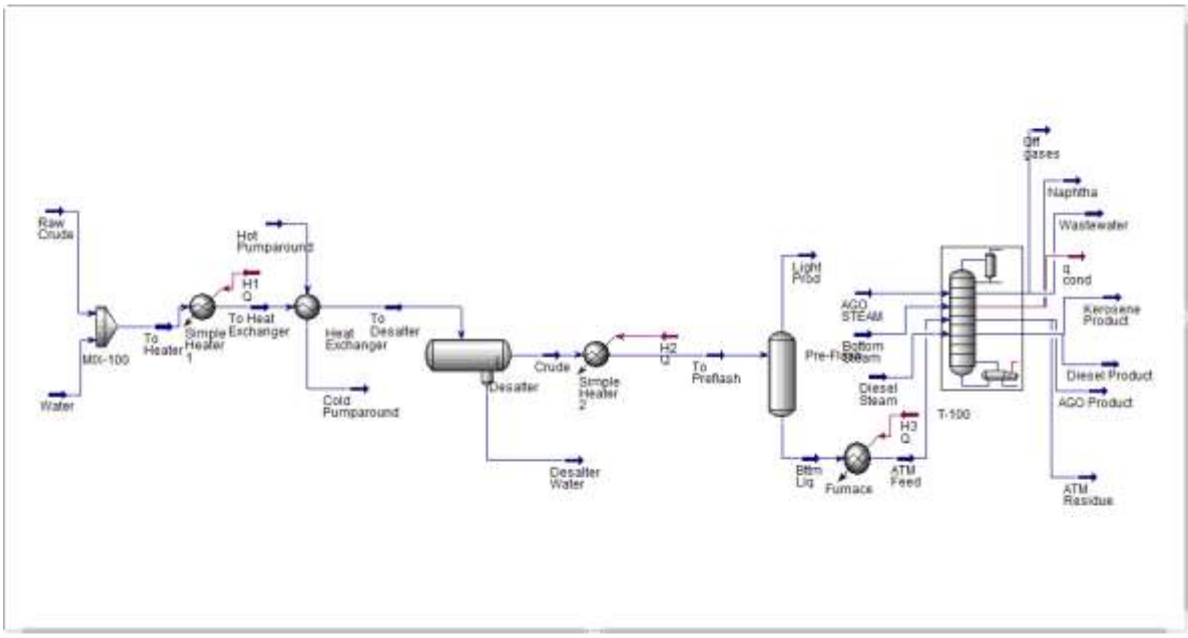
You can find the detailed flow sheet by entering the *Column Environment*




Kerosene SS_Reb
Kerosene Product
Kerosene SS_Energy
Kerosene SS
Kerosene SS_ToReb
Kerosene SS_BoilUp
Diesel SS
Diesel Product
Diesel Steam
AGO SS
AGO Product
AGO STEAM
Off gases
Wastewater
Naphtha
q cond
Condenser
To Condenser
Reflux
Kerosene SS_Return
Kerosene SS_Draw
Diesel SS_Return
Diesel SS_Draw
AGO SS_Draw
AGO SS_Return
Main TS
ATM Residue
Kerosene PA_Q-Cooler
Kerosene PA_Return
Kerosene PA_Cooler
Kerosene PA_Draw
Diesel PA_Return
Diesel PA_Draw
Diesel PA_Q-Cooler
Diesel PA_Cooler
AGO PA_Draw
AGO PA_Return
AGO PA_Q-Cooler
AGO PA_Cooler
ATM Feed
Bottom Steam

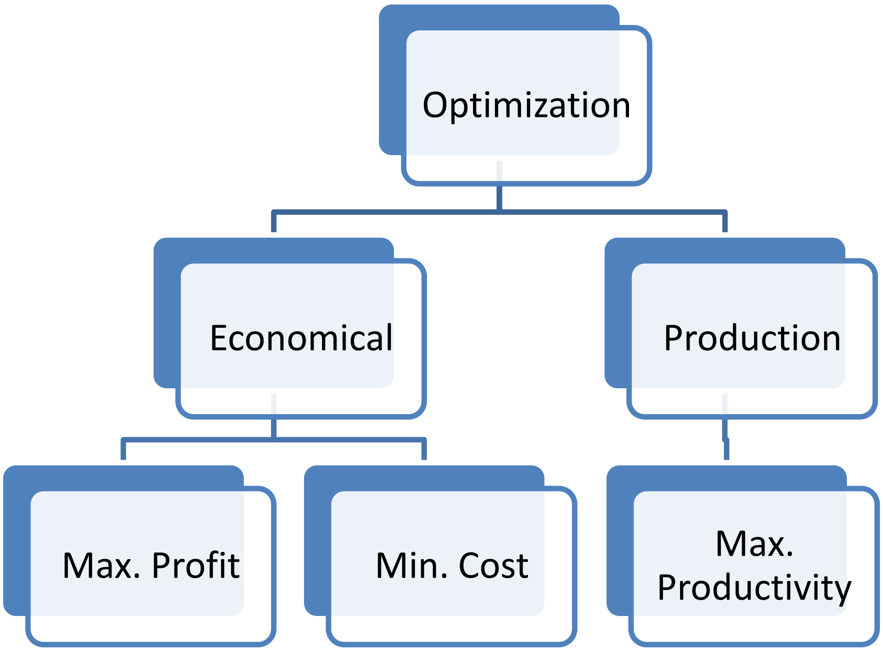
To return to the main environment:





Save Your Case!

Optimization



7

Workshop

In this example, a simple distillation column to separate Tetrahydrofuran (THF) from Toluene is simulated. The object of the exercise is to select the product specifications such that profit is maximized. A special tool in HYSYS, the Optimizer, will be used to find the optimum operating conditions.

HYSYS includes additional modelling and decision support tools that can be used to enhance the usability of your models. In this module, you will use the HYSYS optimization tool available in HYSYS to investigate the debottlenecking and optimization of a crude column.

Learning Objectives

Once you have completed this section, you will be able to:

• Use the Optimizer tool in HYSYS to optimize flowsheets

• Use the Spreadsheet to perform calculations

Example:

3700 kg/hr mixture of tetrahydrofuran & toluene (**44 mass% THF**) at **10°C** and **140 kPa** is to be separated by distillation to get each of them with purity of 99.5 mass% of THF & 94 mass% of Toluene (THF is the more volatile component).

- Use **Wilson** fluid package

<u>The column specifications are:</u>

- The condenser & reboiler pressure are 103 kPa & 107 kPa.
- The condenser works on **total condensation** conditions.
- **Number of stages = 10**.
- Feed enters from the 5th tray.

Calculate:

The reflux ratio and the distillate rate under the specified conditions.

Reflux Ratio	………………………
Distillate Rate	……………………… k_{gmol}/hr

Data:

- Feed price= 0.05 $/kg.
- Pure toluene selling price= 0.136 $/kg
- Pure THF selling price= 0.333 $/ kg
- Cooling Cost= 0.471 $/ kw.hr
- Heating Cost= 0.737 $/kw.hr

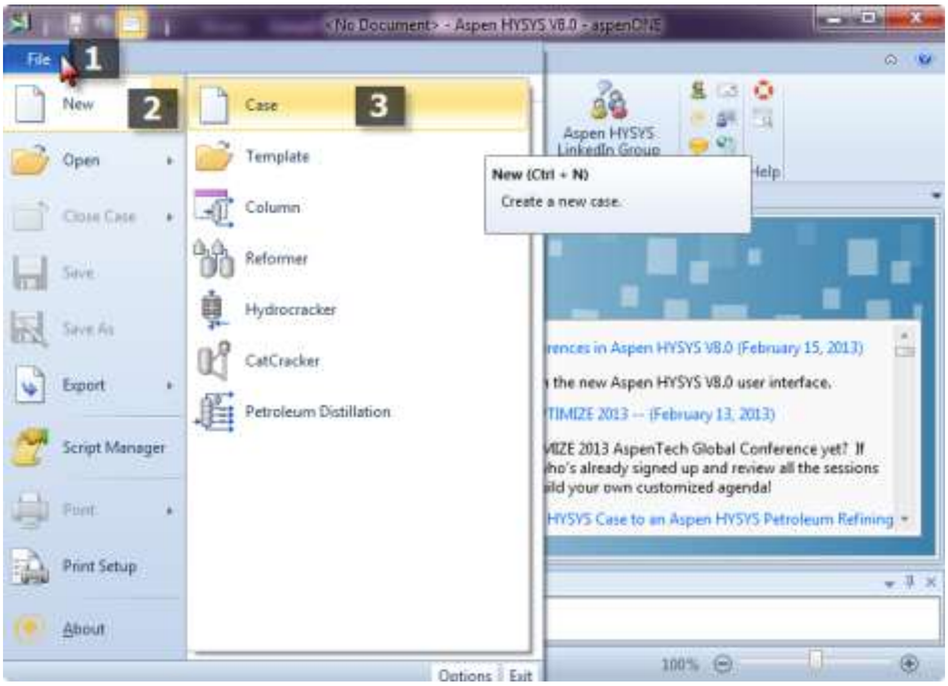
Note:

Profit = (Total Toluene selling price + Total THF selling price) - (Feed cost + Heating cost + Cooling Cost)

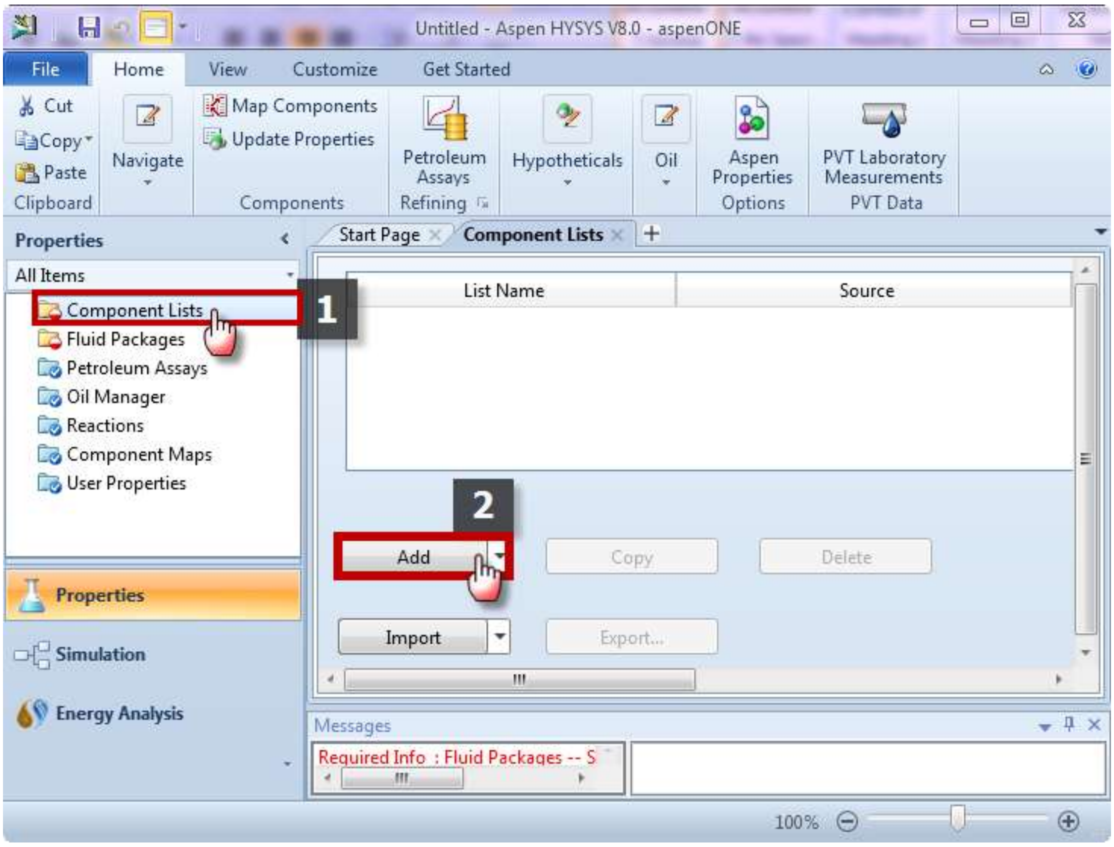
•Use a range of 0.99 to 0.999 for THF limit & 0.9 to 0.99 for the toluene.

To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.0 >>>> Aspen HYSYS >> Aspen HYSYS

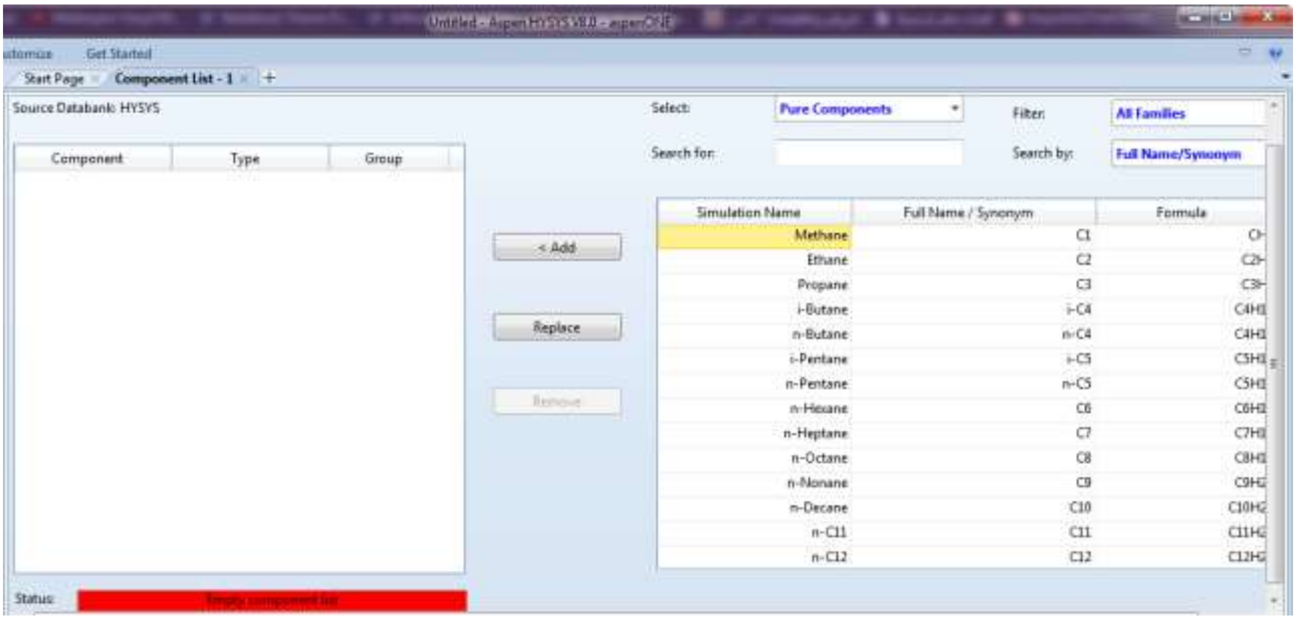
5- First, Start a new case



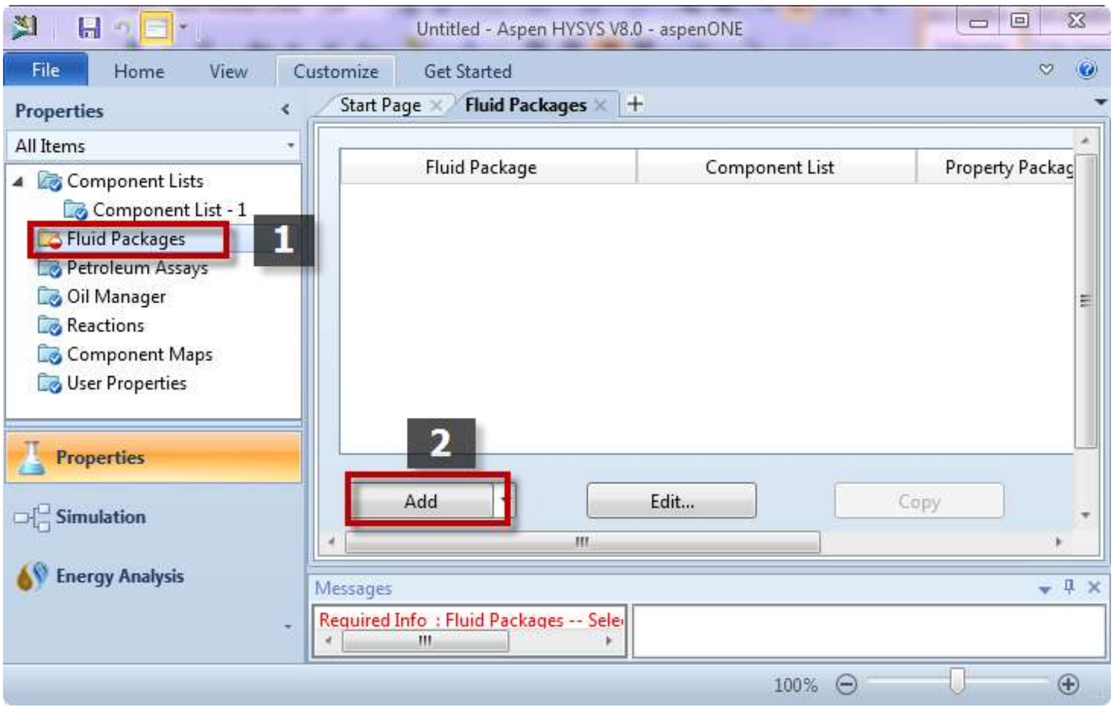
6- Add the Components



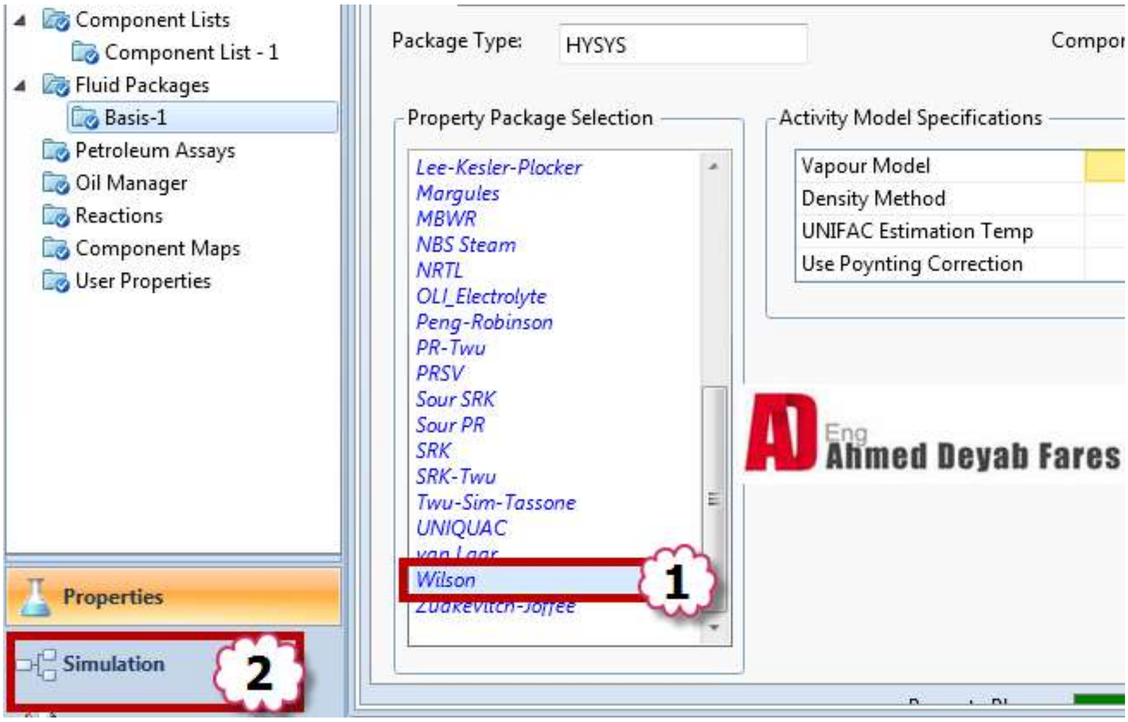
7- Choose the system components from the databank:



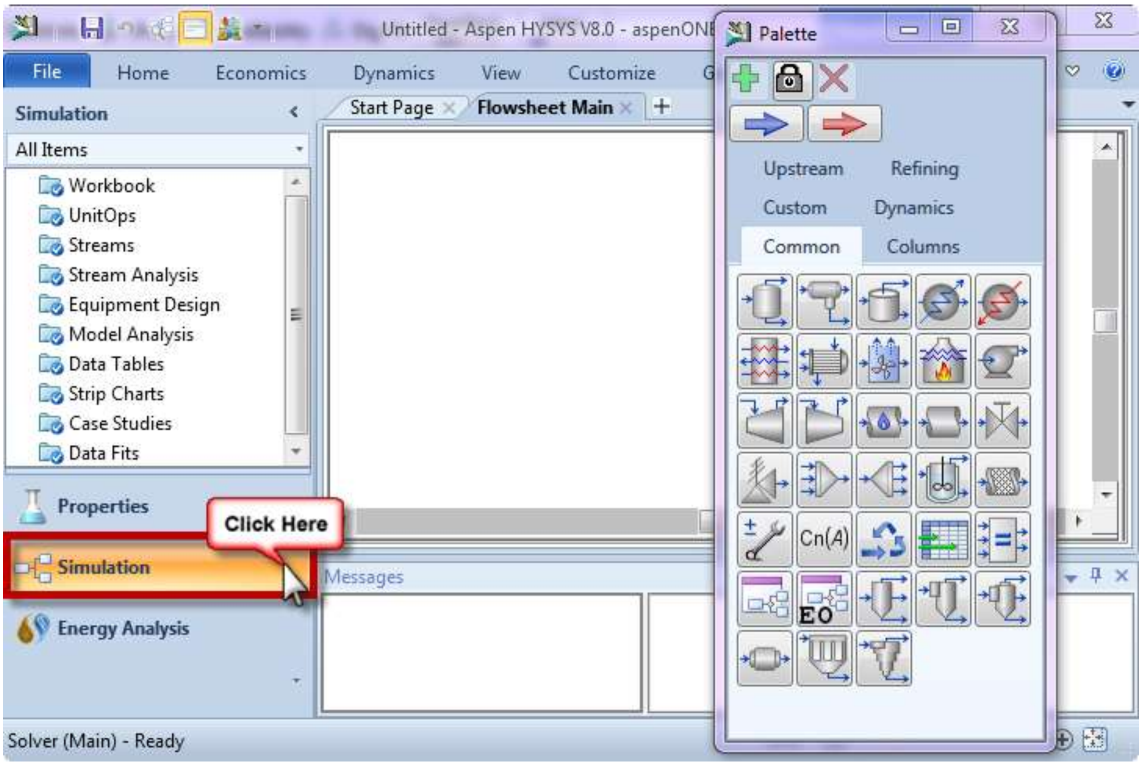
Now, select the suitable fluid package



In this case, select Wilson

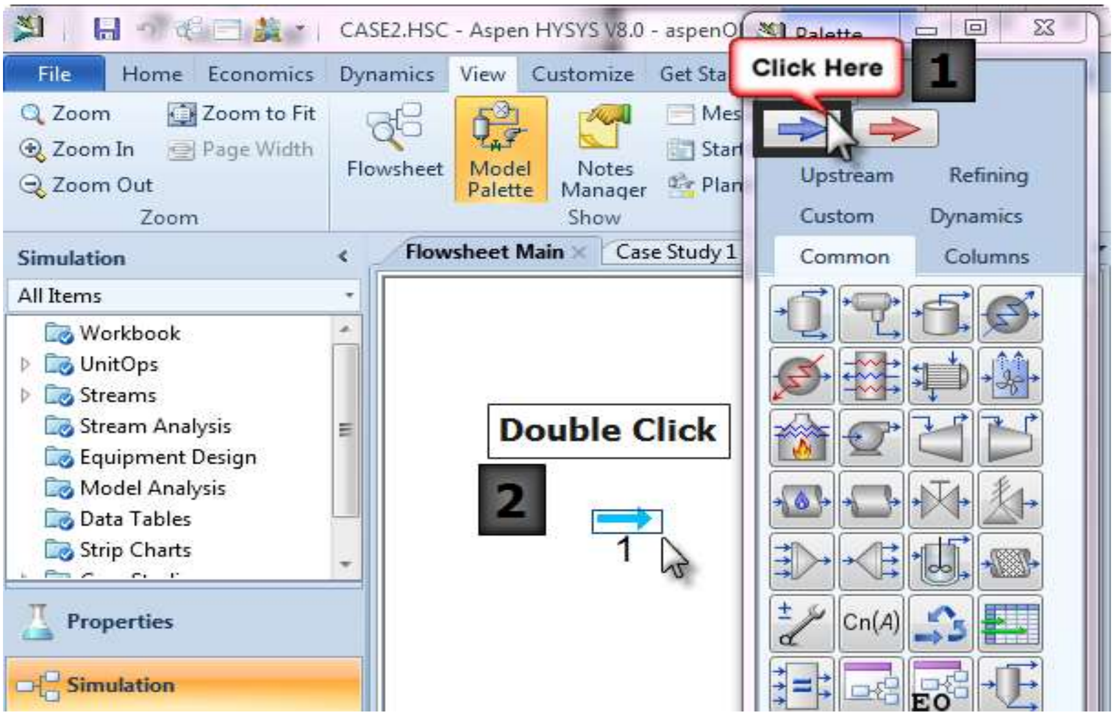


Now you can start drawing the flow sheet for the process by clicking the Simulation button:

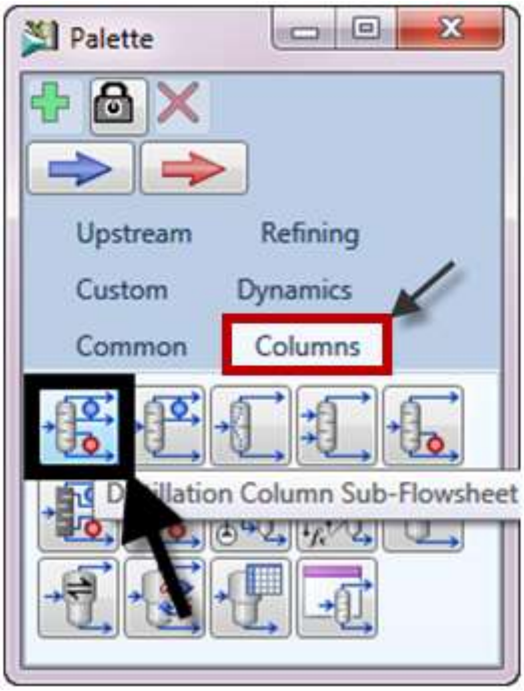


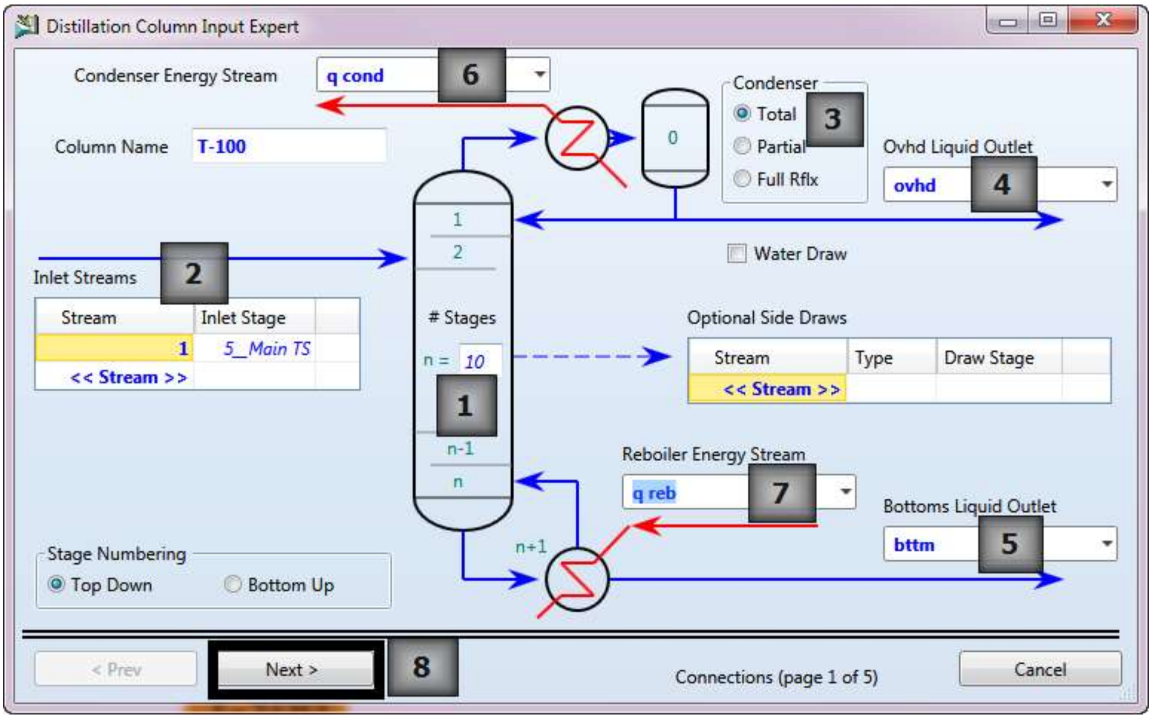
Now add a material stream to define the composition and the conditions of the feed stream

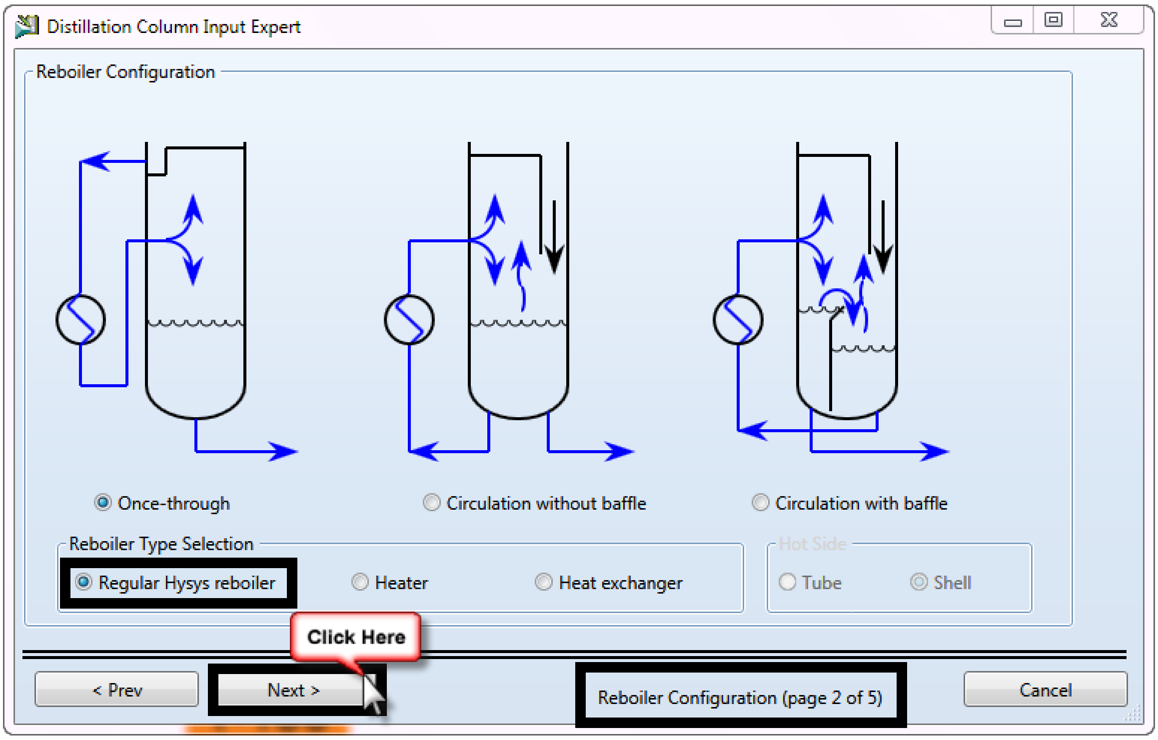
From the palette:

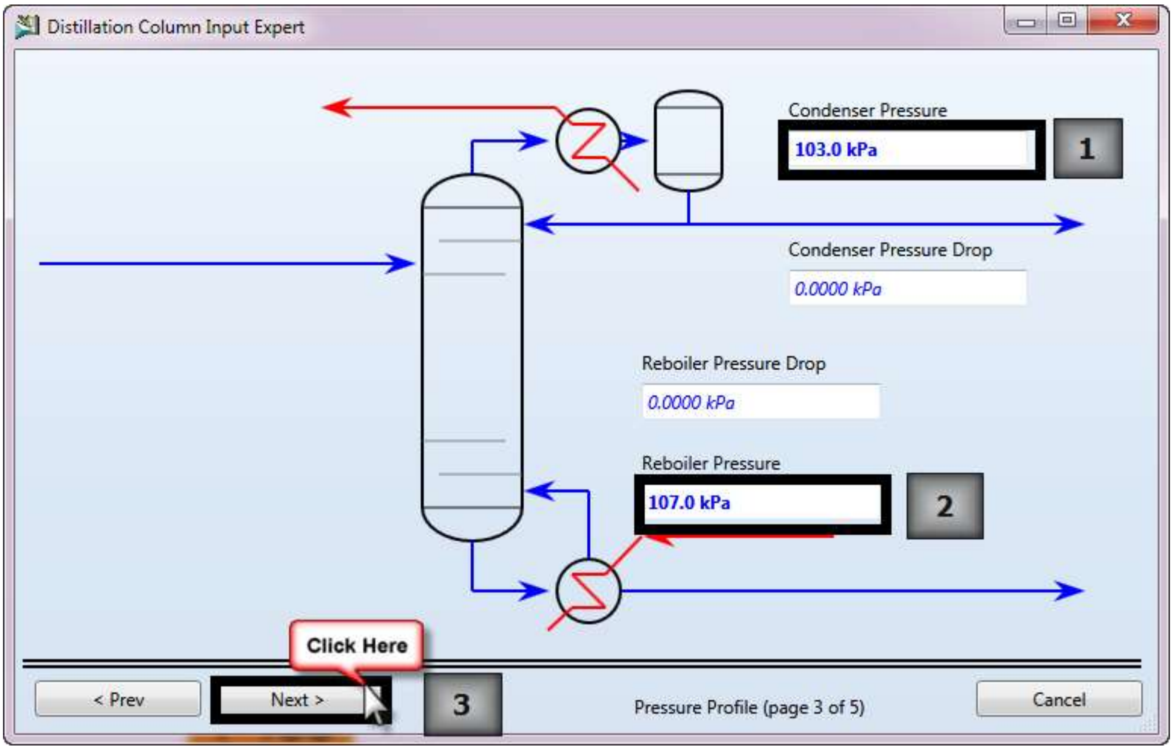


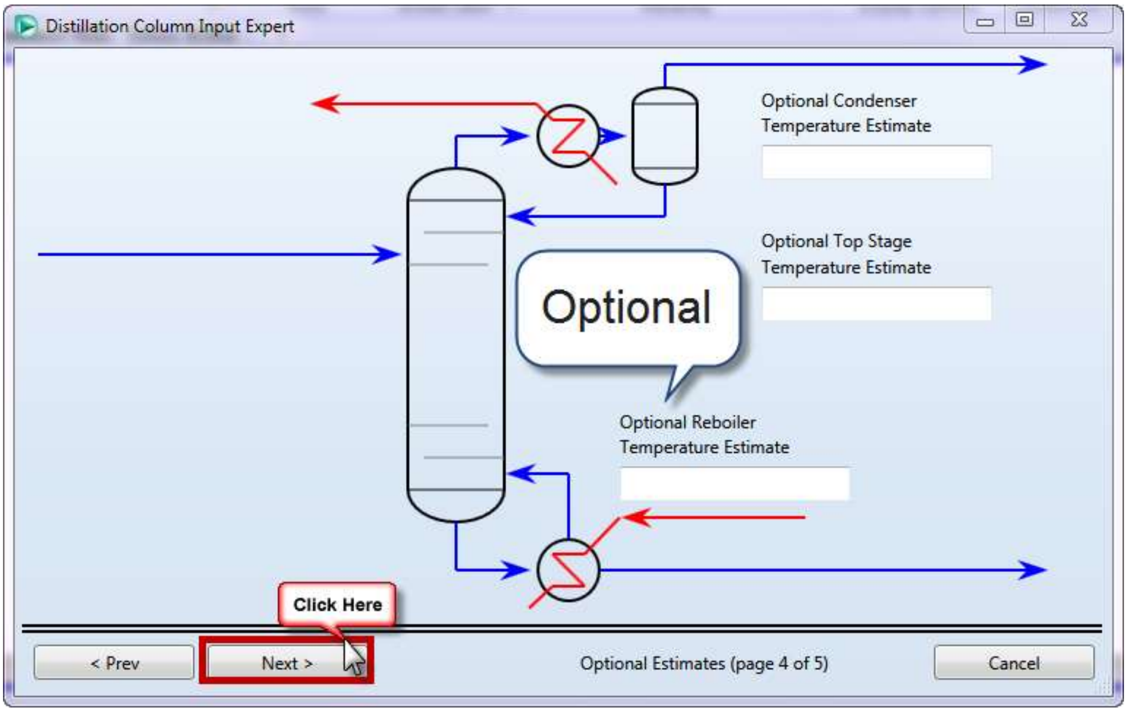
Add a distillation tower:

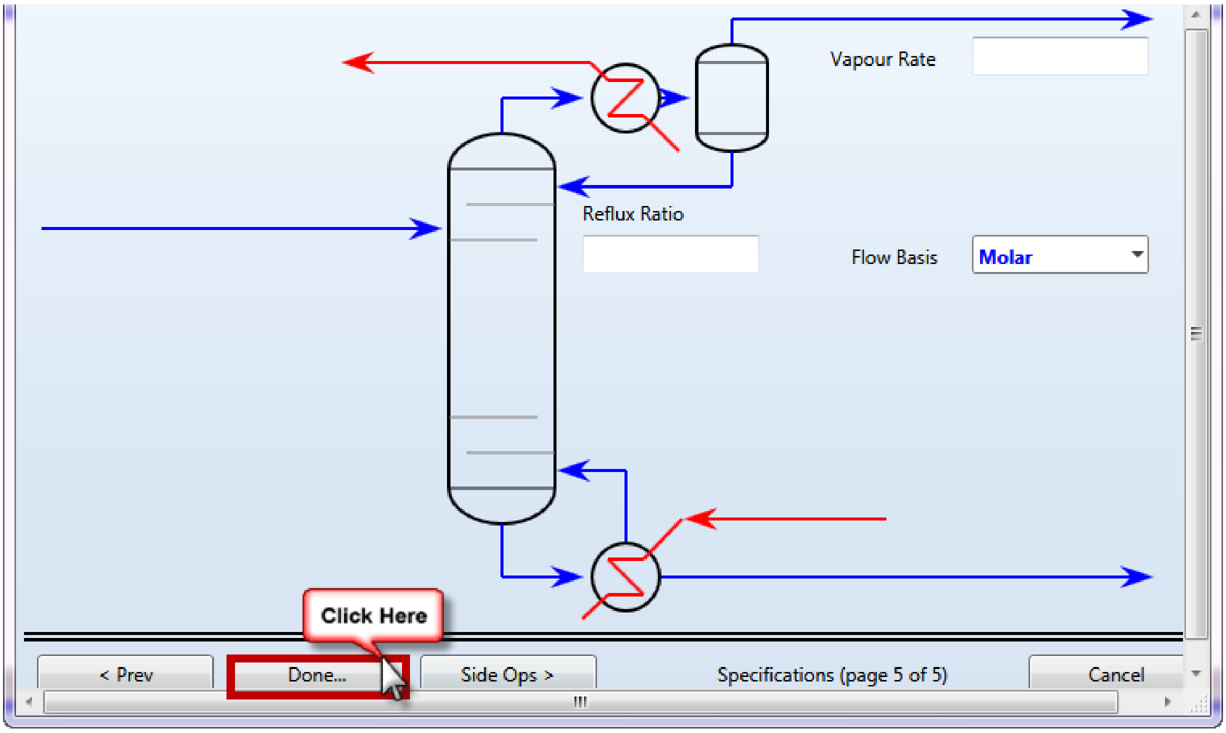


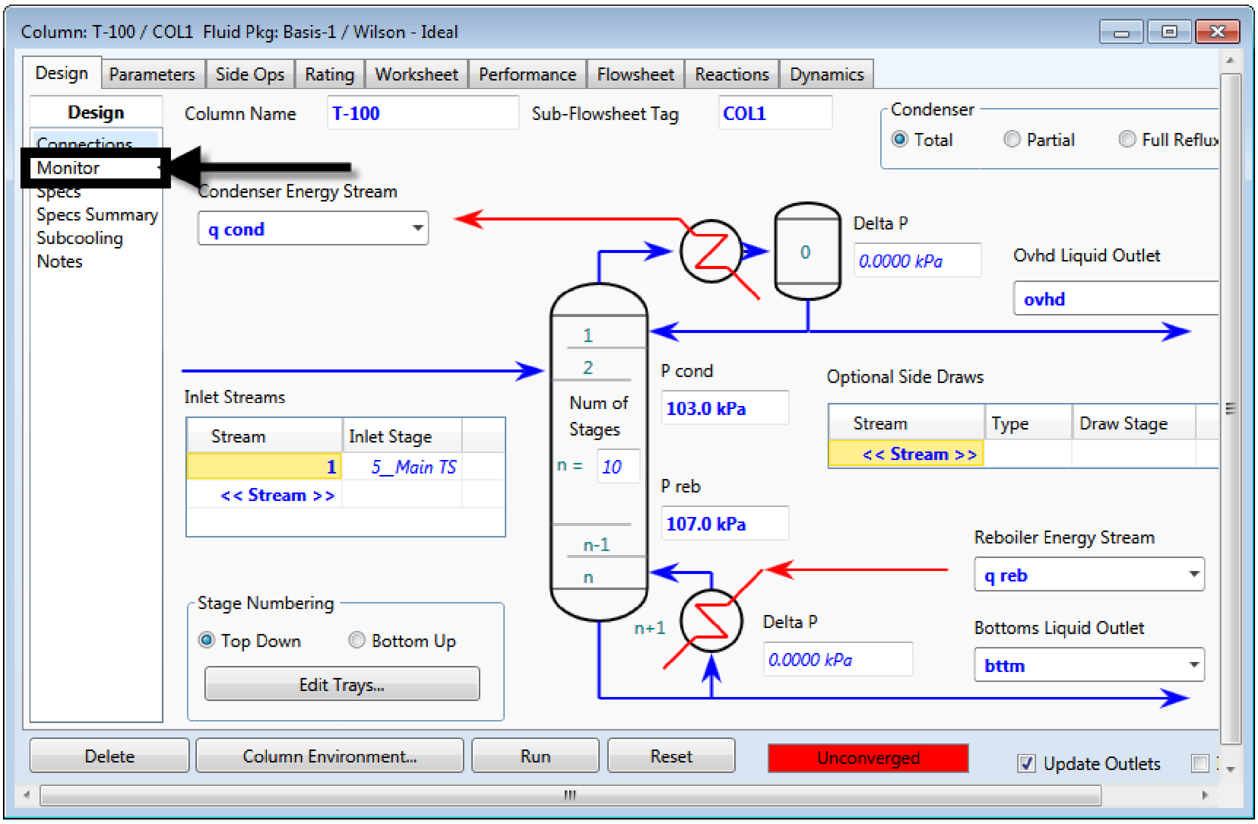

Distillation Column Input Expert
Condenser Energy Stream
q cond
6
Column Name
T-100
Condenser
Total
Partial
Full Rflx
3
Ovhd Liquid Outlet
ovhd
4
Water Draw
Inlet Streams
2
Stream
Inlet Stage
1
5_Main TS
<< Stream >>
# Stages
n = 10
1
Optional Side Draws
Stream
Type
Draw Stage
<< Stream >>
Reboiler Energy Stream
q reb
7
Bottoms Liquid Outlet
bttm
5
Stage Numbering
Top Down
Bottom Up
< Prev
Next >
8
Connections (page 1 of 5)
Cancel

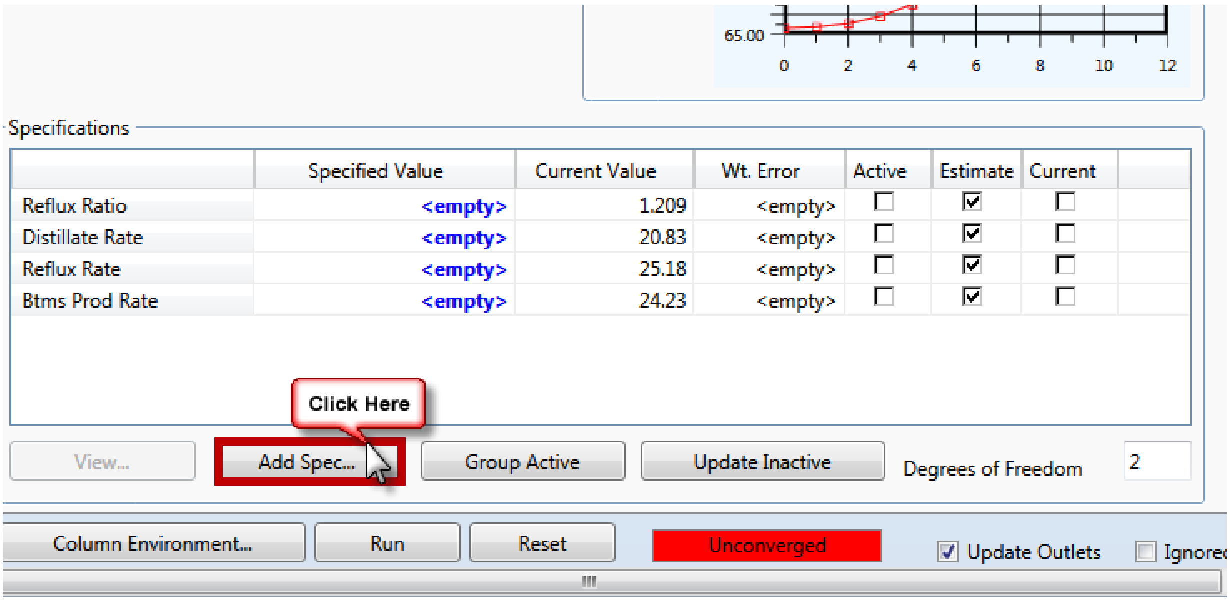

Distillation Column Input Expert
Reboiler Configuration
Once-through
Circulation without baffle
Circulation with baffle
Reboiler Type Selection
Regular Hysys reboiler
Heater
Heat exchanger
Hot Side
Tube
Shell
Click Here
< Prev
Next >
Reboiler Configuration (page 2 of 5)
Cancel

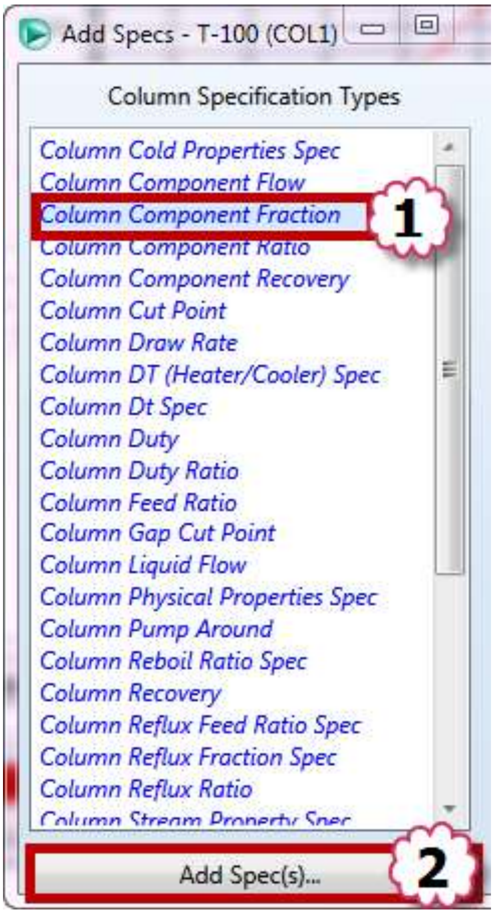

Distillation Column Input Expert
Condenser Pressure
103.0 kPa
1
Condenser Pressure Drop
0.0000 kPa
Reboiler Pressure Drop
0.0000 kPa
Reboiler Pressure
107.0 kPa
2
Click Here
< Prev
Next >
3
Pressure Profile (page 3 of 5)
Cancel

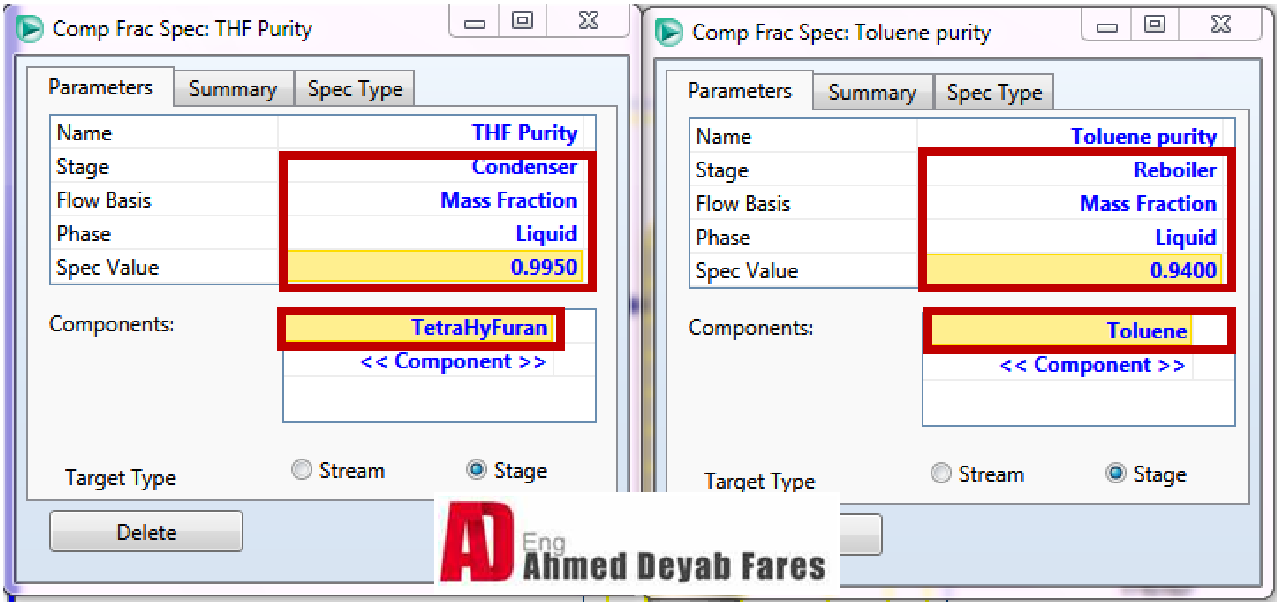

Distillation Column Input Expert
Optional Condenser Temperature Estimate
Optional Top Stage Temperature Estimate
Optional
Optional Reboiler Temperature Estimate
Click Here
< Prev
Next >
Optional Estimates (page 4 of 5)
Cancel

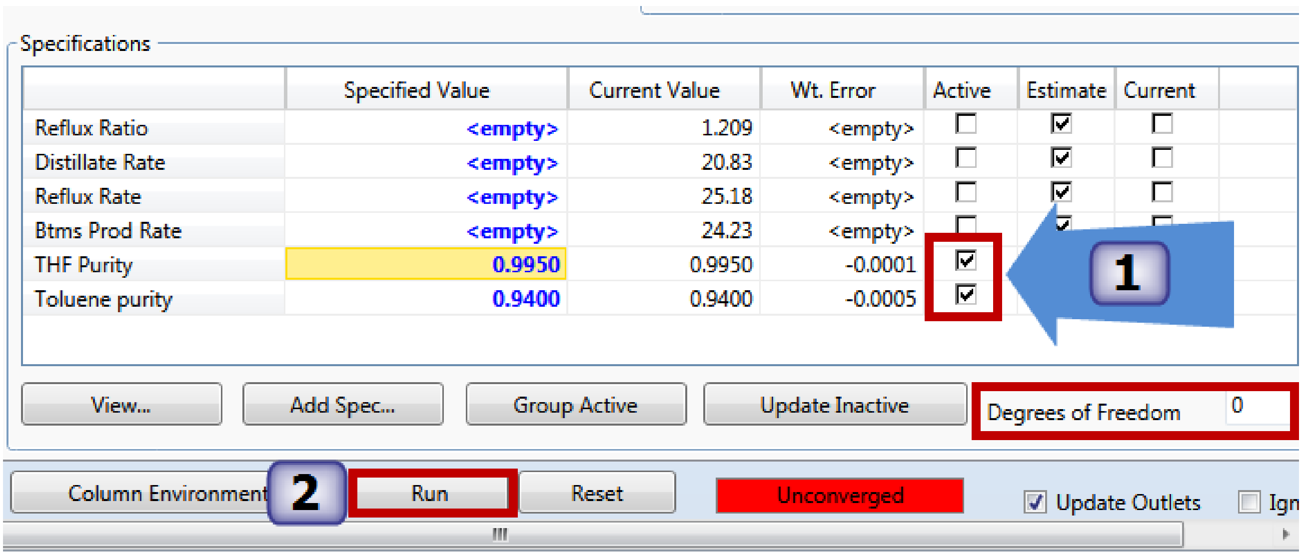

Vapour Rate
Reflux Ratio
Flow Basis
Molar
Click Here
< Prev
Done...
Side Ops >
Specifications (page 5 of 5)
Cancel


Column: T-100 / COL1 Fluid Pkg: Basis-1 / Wilson - Ideal
Design
Parameters
Side Ops
Rating
Worksheet
Performance
Flowsheet
Reactions
Dynamics
Design
Connections
Monitor
Specs
Specs Summary
Subcooling
Notes
Column Name
T-100
Sub-Flowsheet Tag
COL1
Condenser
Total
Partial
Full Reflux
Condenser Energy Stream
q cond
Delta P
0.0000 kPa
Ovhd Liquid Outlet
ovhd
Inlet Streams
Stream
Inlet Stage
1
5_Main TS
<< Stream >>
Num of Stages
n = 10
P cond
103.0 kPa
P reb
107.0 kPa
Optional Side Draws
Type
Draw Stage
Reboiler Energy Stream
q reb
Bottoms Liquid Outlet
bttm
Stage Numbering
Top Down
Bottom Up
Edit Trays...
Delete
Column Environment...
Run
Reset
Unconverged
Update Outlets


65.00
0
2
4
6
8
10
12
Specifications
Specified Value
Current Value
Wt. Error
Active
Estimate
Current
Reflux Ratio
<empty>
1.209
<empty>
Distillate Rate
<empty>
20.83
<empty>
Reflux Rate
<empty>
25.18
<empty>
Btms Prod Rate
<empty>
24.23
<empty>
Click Here
View...
Add Spec...
Group Active
Update Inactive
Degrees of Freedom
2
Column Environment...
Run
Reset
Unconverged
Update Outlets


Add Specs - T-100 (COL1)
Column Specification Types
Column Cold Properties Spec
Column Component Flow
Column Component Fraction
1
Column Component Ratio
Column Component Recovery
Column Cut Point
Column Draw Rate
Column DT (Heater/Cooler) Spec
Column Dt Spec
Column Duty
Column Duty Ratio
Column Feed Ratio
Column Gap Cut Point
Column Liquid Flow
Column Physical Properties Spec
Column Pump Around
Column Reboil Ratio Spec
Column Recovery
Column Reflux Feed Ratio Spec
Column Reflux Fraction Spec
Column Reflux Ratio
Add Spec(s)...
2


Comp Frac Spec: THF Purity
Parameters
Summary
Spec Type
Name THF Purity
Stage Condenser
Flow Basis Mass Fraction
Phase Liquid
Spec Value 0.9950
Components: TetraHyFuran
<< Component >>
Target Type
Stream
Stage
Delete
Comp Frac Spec: Toluene purity
Parameters
Summary
Spec Type
Name Toluene purity
Stage Reboiler
Flow Basis Mass Fraction
Phase Liquid
Spec Value 0.9400
Components: Toluene
<< Component >>
Target Type
Stream
Stage
Eng Ahmed Deyab Fares

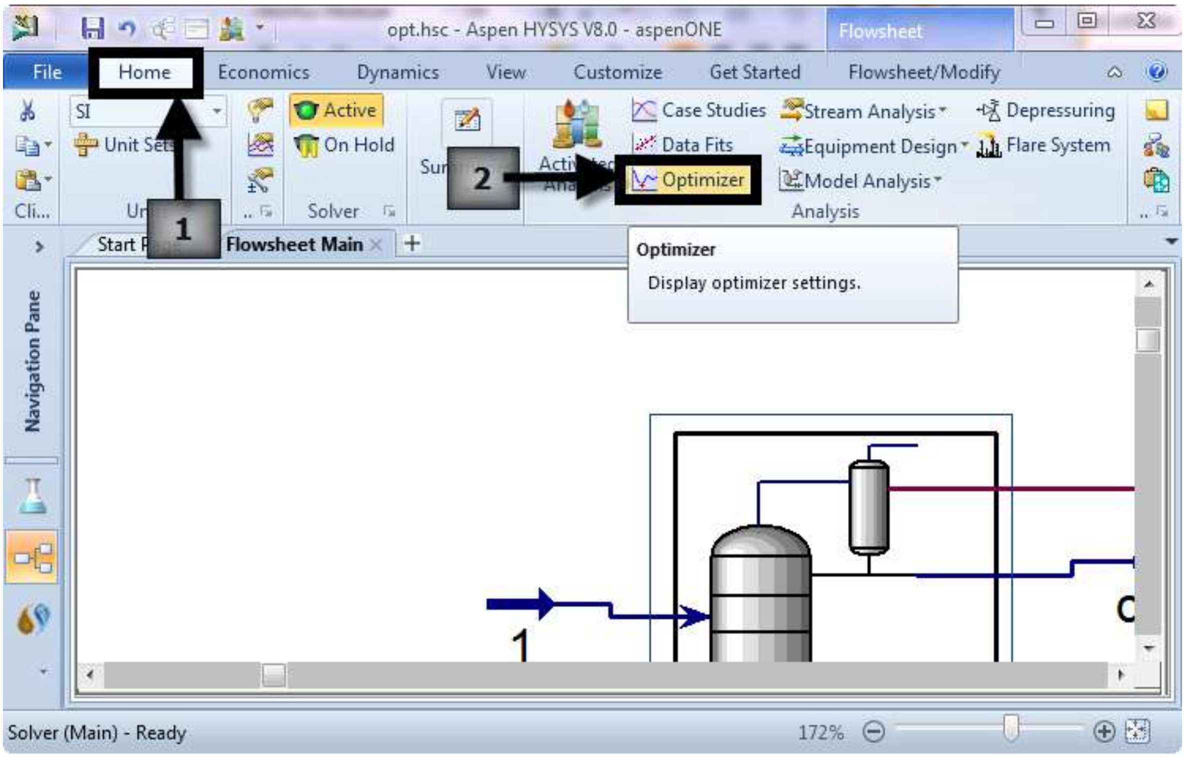

Specifications
Specified Value
Current Value
Wt. Error
Active
Estimate
Current
Reflux Ratio <empty> 1.209 <empty>
Distillate Rate <empty> 20.83 <empty>
Reflux Rate <empty> 25.18 <empty>
Btms Prod Rate <empty> 24.23 <empty>
THF Purity 0.9950 0.9950 -0.0001
Toluene purity 0.9400 0.9400 -0.0005
1
View...
Add Spec...
Group Active
Update Inactive
Degrees of Freedom 0
Column Environment
2
Run
Reset
Unconverged
Update Outlets
Ign

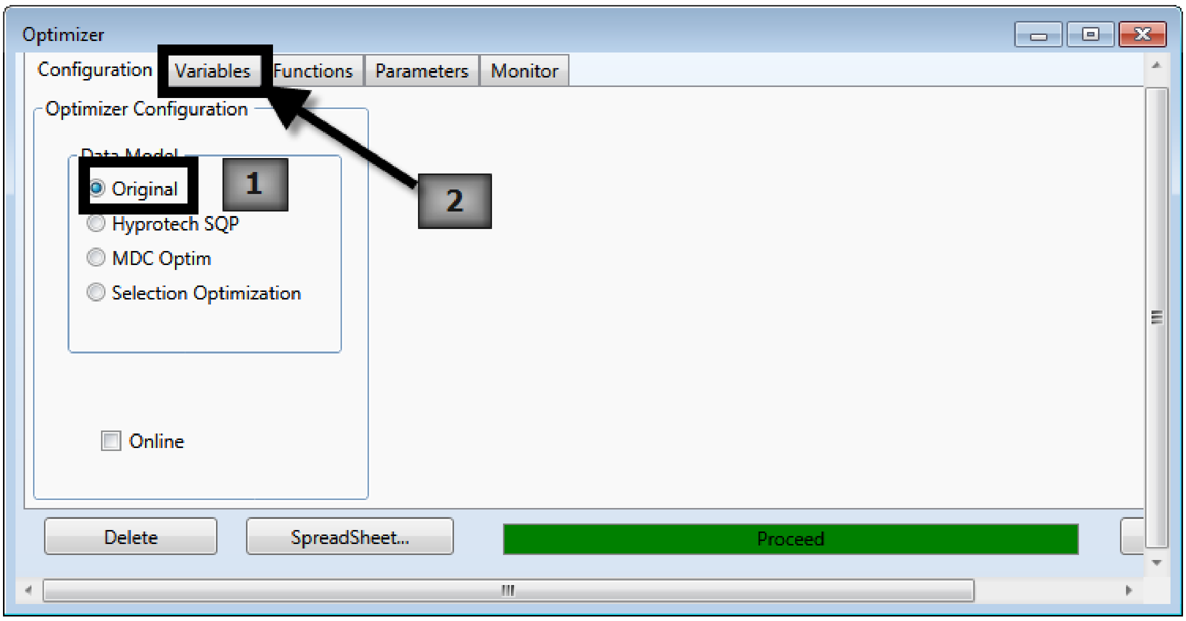
Optimization

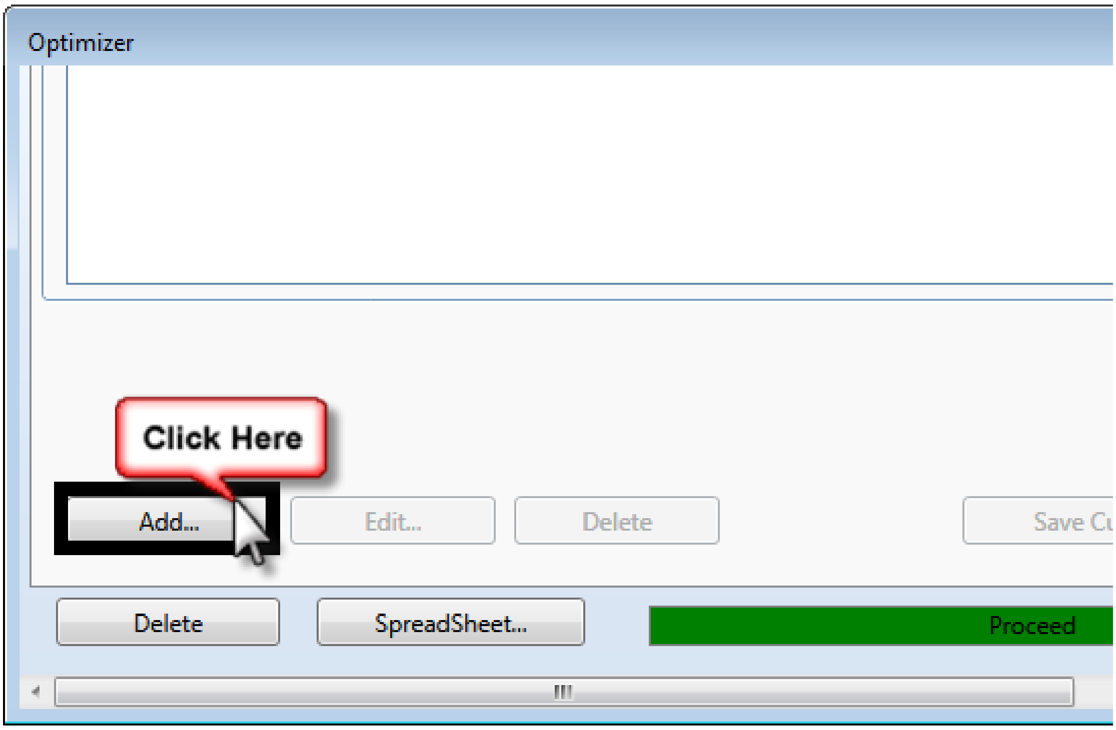
We need to check if the operating conditions are optimum or not.

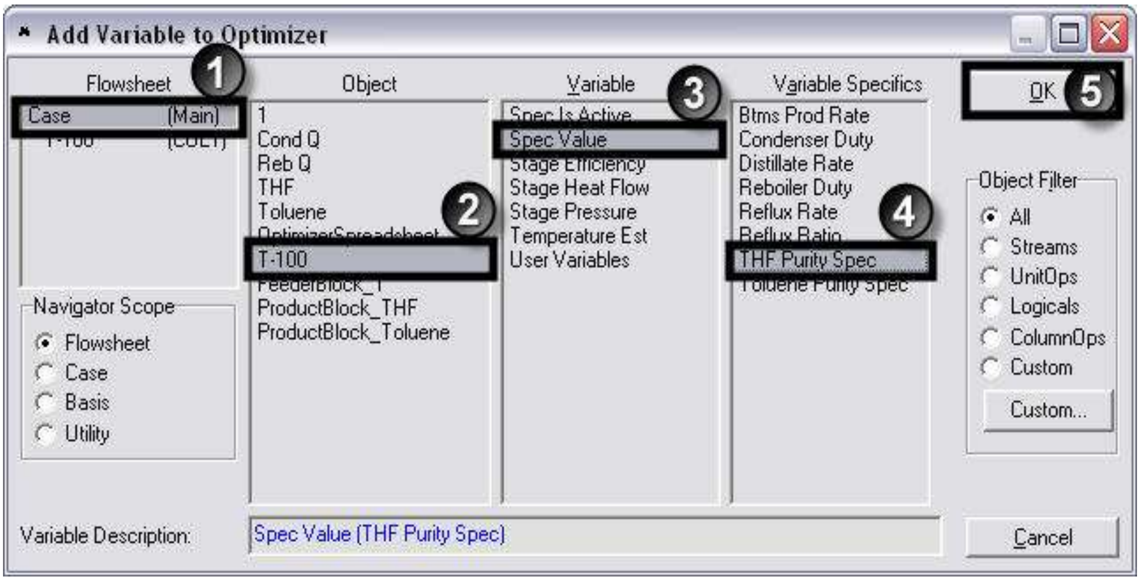
The Variables to check are: THF Purity & Toluene Purity

Using the Optimizer tool:



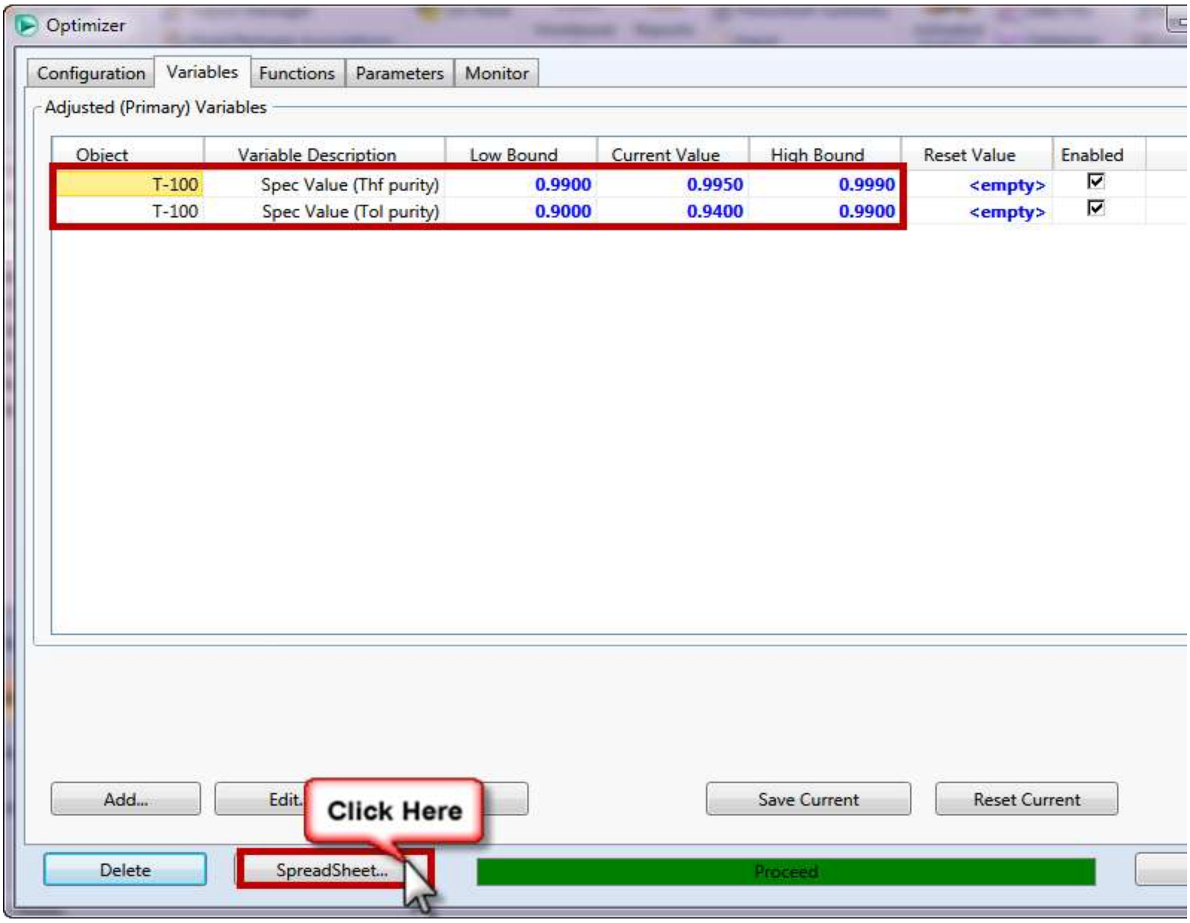




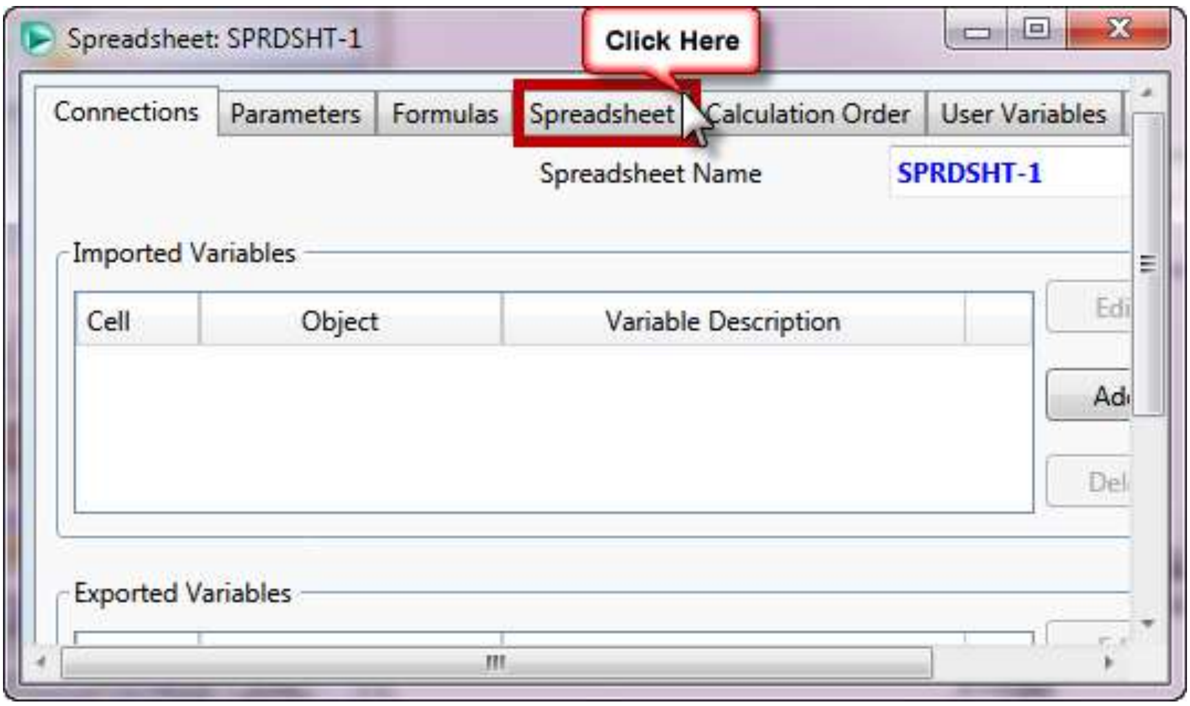


And do the same steps to add the other variable

Use a range of 0.99 to 0.999 for THF limit & 0.9 to 0.99 for the toluene.

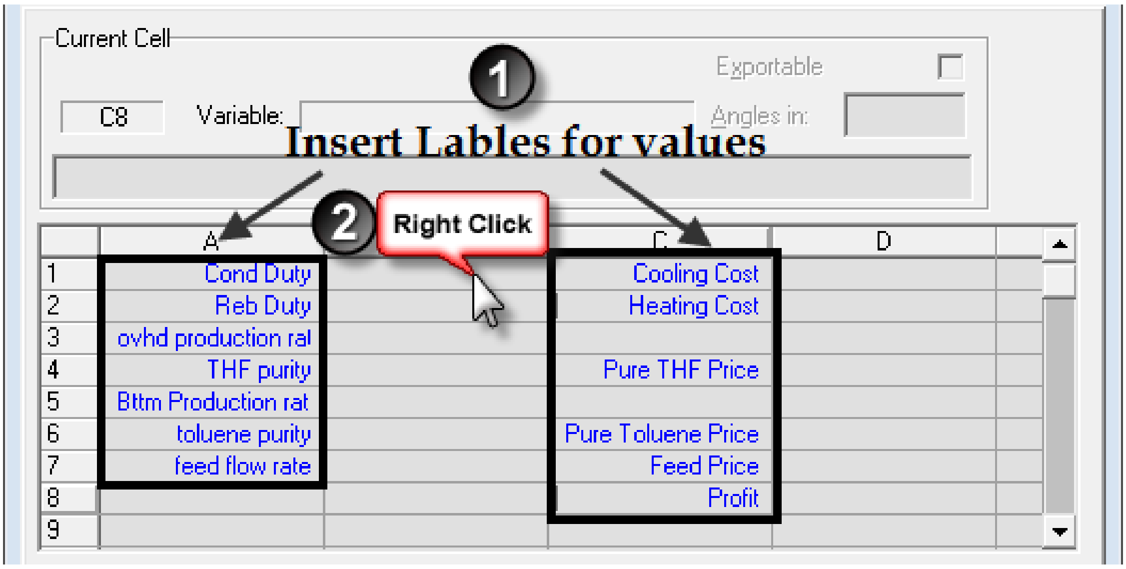


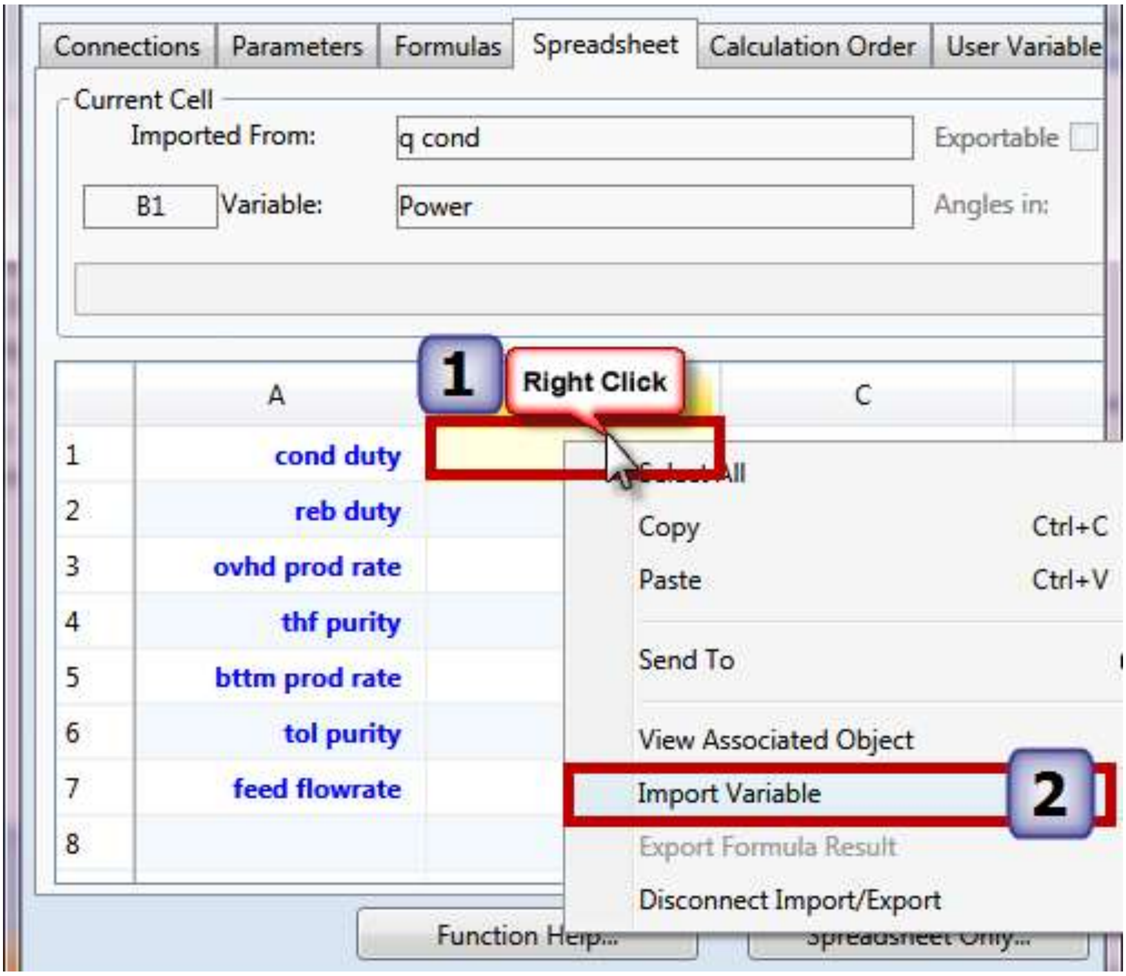
Now we have to start building the profit module using the spreadsheet operation:

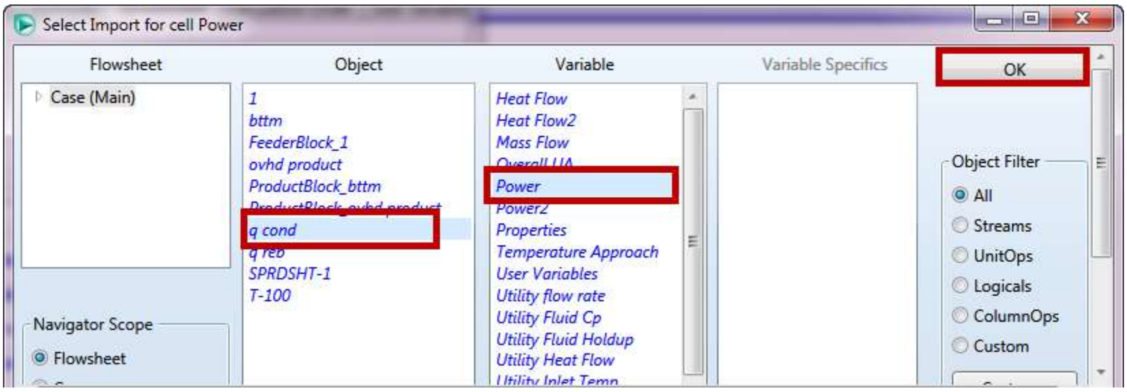


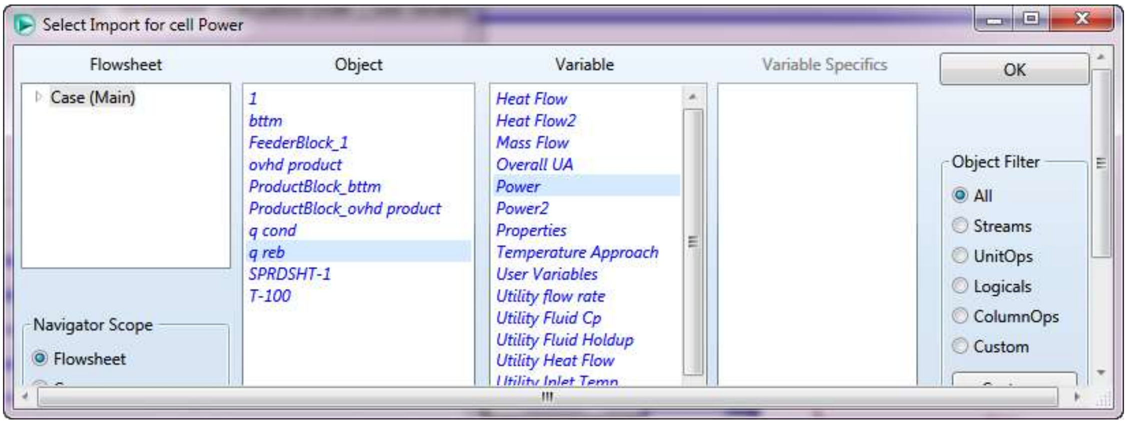
Profit= Income - Cost

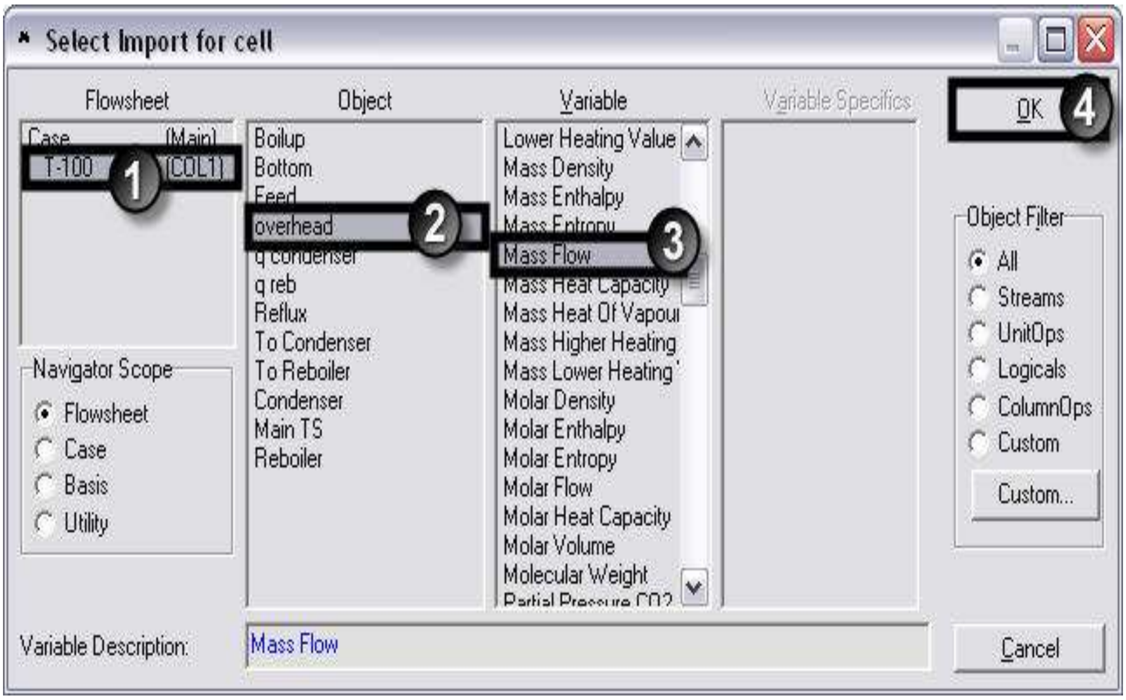
Profit = (Total Toluene selling price + Total THF selling price) - (Feed cost + Heating cost + Cooling Cost)

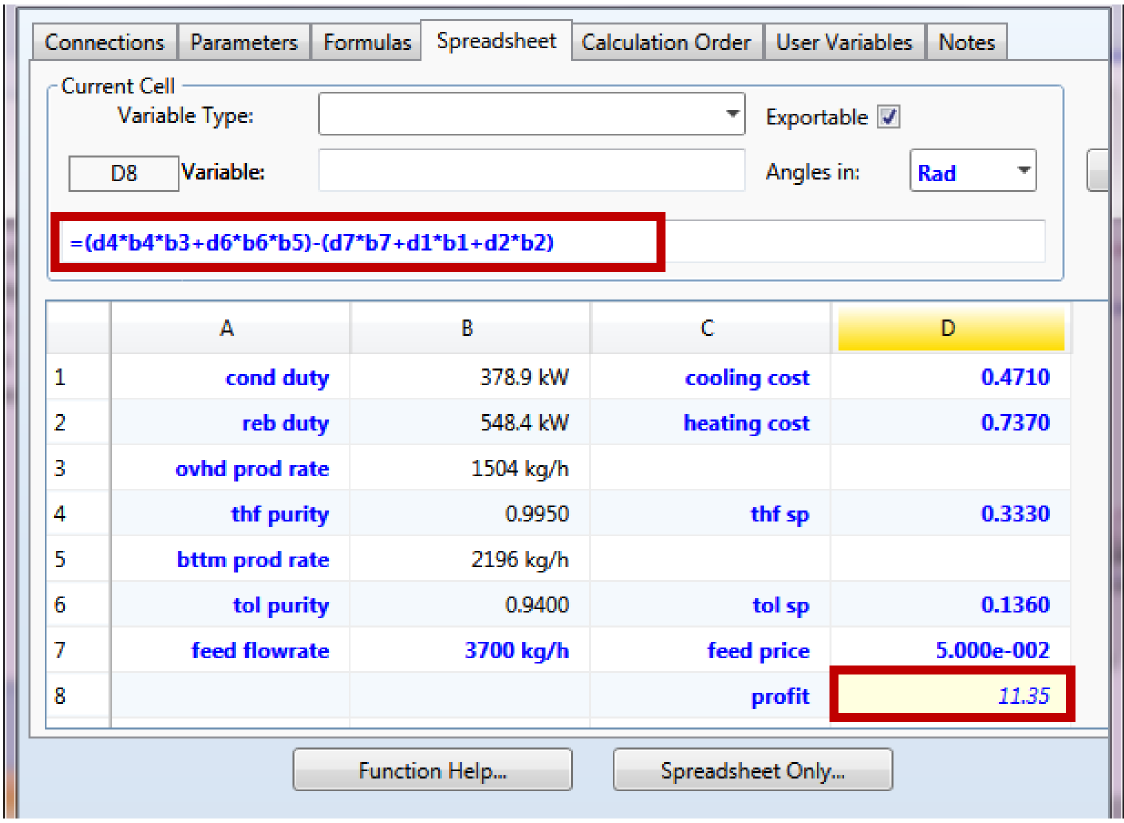





Select Import for cell Power
Flowsheet
Object
Variable
Variable Specifics
OK
Case (Main)
1
bttm
FeederBlock_1
ovhd product
ProductBlock_bttm
q cond
SPRDSHT-1
T-100
Heat Flow
Heat Flow2
Mass Flow
Power
Properties
Temperature Approach
User Variables
Utility flow rate
Utility Fluid Cp
Utility Fluid Holdup
Utility Heat Flow
Object Filter
All
Streams
UnitOps
Logicals
ColumnOps
Custom
Navigator Scope
Flowsheet

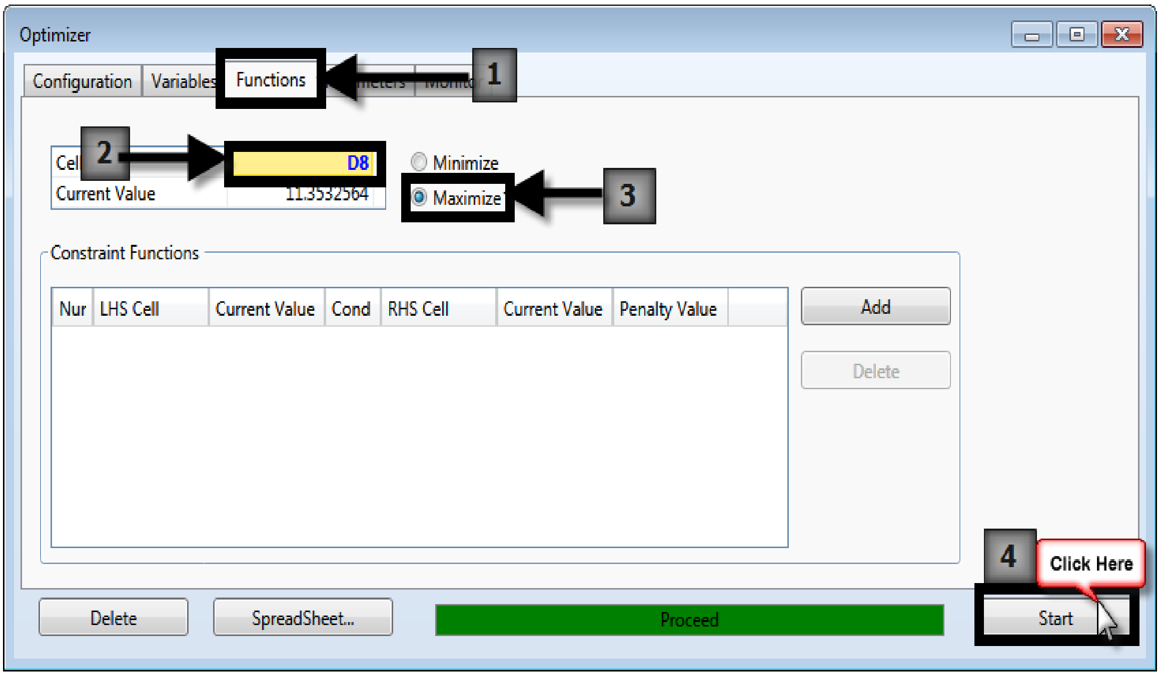

Select Import for cell Power
Flowsheet
Object
Variable
Variable Specifics
OK
Case (Main)
1
bttm
FeederBlock_1
ovhd product
ProductBlock_bttm
ProductBlock_ovhd product
q cond
q reb
SPRDSHT-1
T-100
Heat Flow
Heat Flow2
Mass Flow
Overall UA
Power
Power2
Properties
Temperature Approach
User Variables
Utility flow rate
Utility Fluid Cp
Utility Fluid Holdup
Utility Heat Flow
Object Filter
All
Streams
UnitOps
Logicals
ColumnOps
Custom
Navigator Scope
Flowsheet

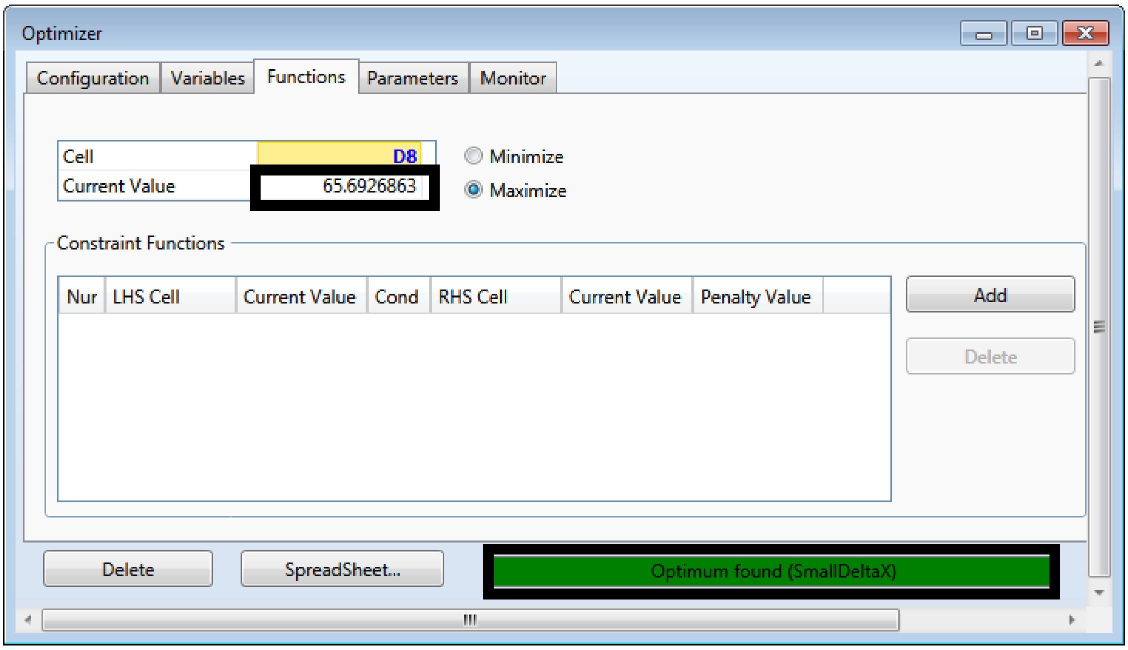

Select Import for cell
Flowsheet
Object
Variable
Variable Specifics
OK
4
Case (Main)
T-100 (COL1)
1
Boilup
Bottom
Feed
overhead
2
q reb
Reflux
To Condenser
To Reboiler
Condenser
Main TS
Reboiler
Lower Heating Value
Mass Density
Mass Enthalpy
Mass Flow
3
Mass Heat Of Vapour
Mass Higher Heating
Molar Density
Molar Enthalpy
Molar Entropy
Molar Flow
Molar Heat Capacity
Molar Volume
Molecular Weight
Object Filter
All
Streams
UnitOps
Logicals
ColumnOps
Custom
Custom...
Navigator Scope
Flowsheet
Case
Basis
Utility
Variable Description:
Mass Flow
Cancel



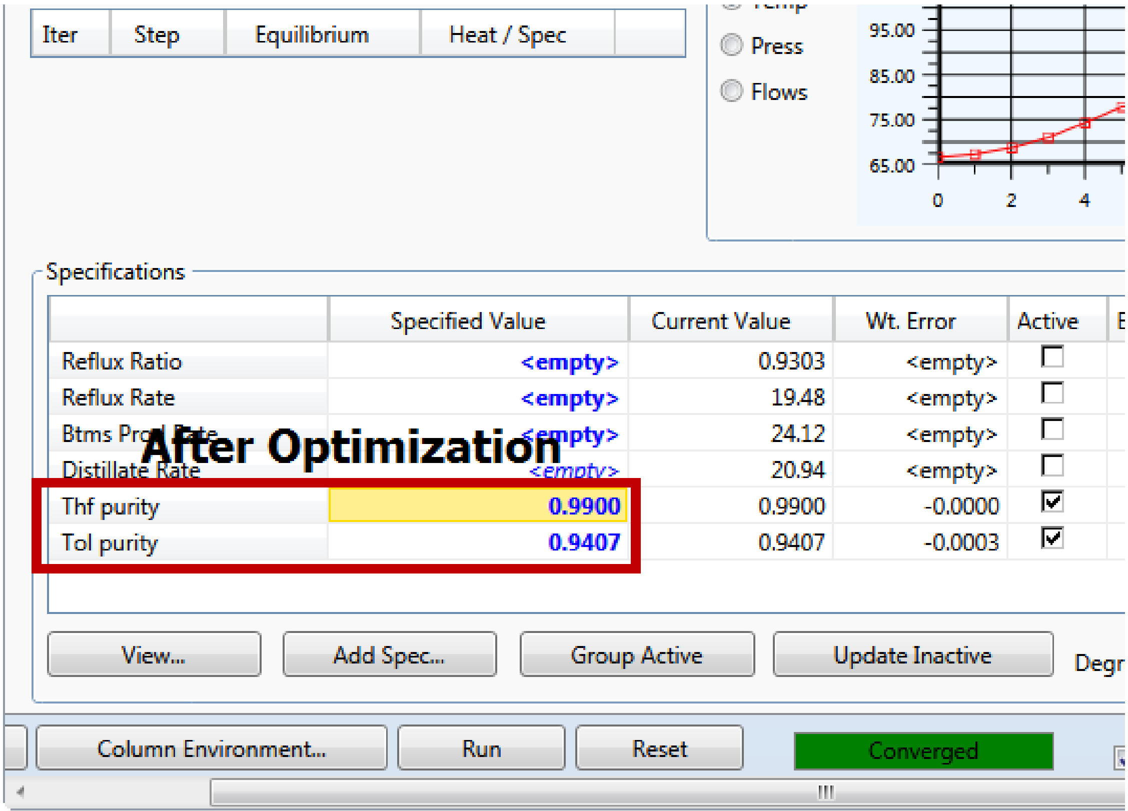
The profit formula will be in D8:

= (d3*b3*b4+d5*b5*b6)-(d1*b1+d2*b2+d7*b7)



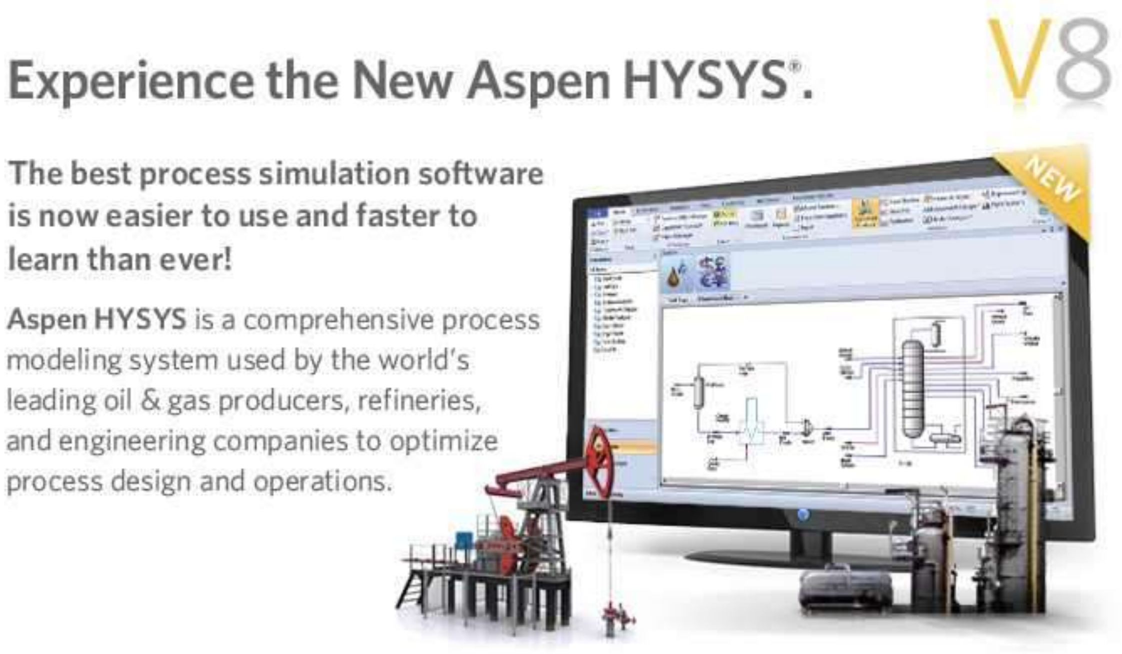


Now you can go to the monitor tab inside the column to see the optimum values for the THF & Toluene purities.



Save Your Case!

Gas Gathering



8

Workshop

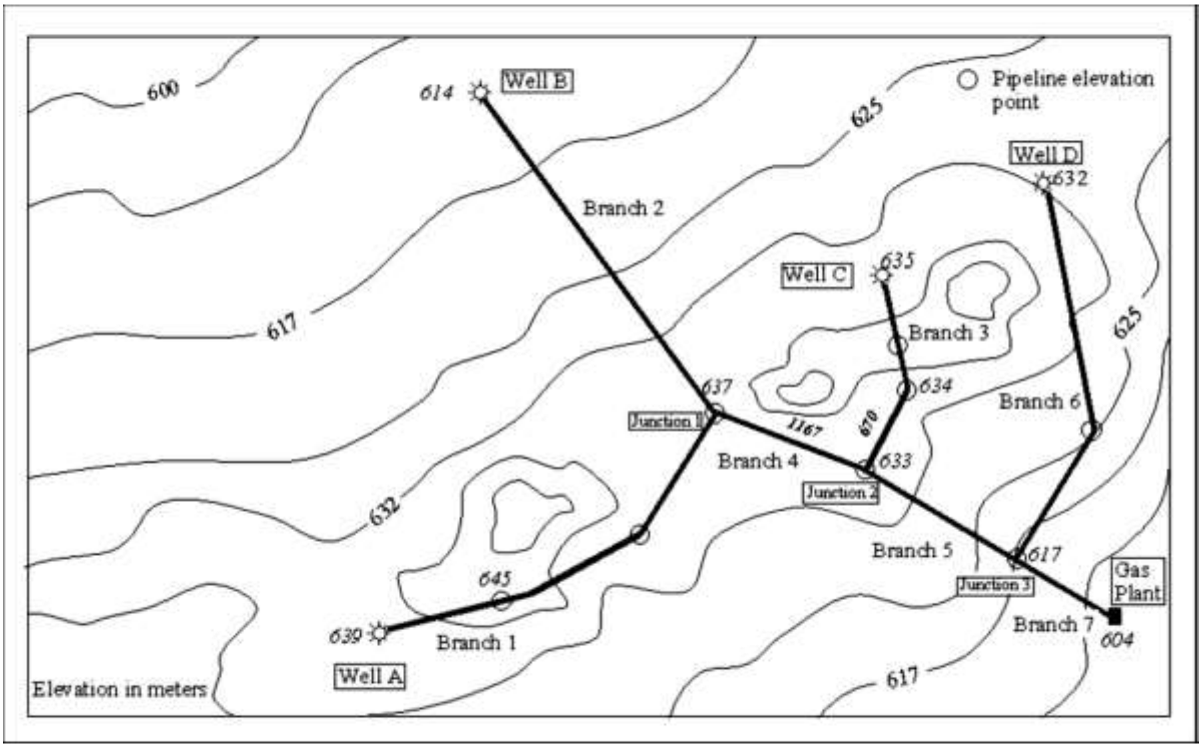
In this example, a gas gathering system located on varied terrain is simulated using the steady state capabilities of HYSYS. The following figure shows the physical configuration of this system superimposed on a topographic map. The system consists of four wells distributed over an area of approximately 2.0 square km, connected to a gas plant via a network of pipelines.

Learning Objectives

Once you have completed this module, you will be able to use the Pipe Segment in HYSYS to model pipelines.

Example:

There are 4 gas wells, we need to gather the gas from the wells and transfer it to the plant through pipe lines shown below:



The composition of the four wells is the same:

Component	Mole Fraction	Component	Mole Fraction
Methane	0.6230	**n-pentane**	0.00405
Ethane	0.2800	**n-hexane**	0.00659
Propane	0.0163	**C7+**	0.00992
i-butane	0.00433	**N_2**	0.00554
n-butane	0.00821	**CO_2**	0.0225
i-pentane	0.00416	**H_2S**	0.0154

C7+: MW=122, ρ=47.45 lb/ft^3

	GasWell 1	GasWell 2	GasWell 3	GasWell 4
Temperature °C (°F)	40 (105)	45 (115)	45 (115)	35 (95)
Pressure kPa (psia)	4135 (600)	3450 (500)	<empty>	<empty>
Flow kgmole/h (lbmole/hr)	425 (935)	375 (825)	575 (1270)	545 (1200)

<u>The pipe segments data are given below:</u>

Branch	Segment	Length meters	Elevation meters	Elevation Change meters
Branch 1	GasWell 1		639	
	1	150	645	6
	2	125	636.5	-8.5
	3	100	637	0.5
Branch 2	GasWell 2			614
	1	200	637	23
Branch 3	GasWell 3		635.5	
	1	160	648	12.5
	2	100	634	-14
	3	205	633	-1
Branch 4	Branch 1 & 2		637	
	1	355	633	-4
Branch 5	Branch 3 & 4		633	633
	1	300	617	-16
Branch 6	GasWell 4		632.5	
	1	180	625	-7.5
	2	165	617	-8
Branch 7	Branch 5 & 6		617	
	1	340	604	-13

Pipe Branch	Diameter
Branch 1	76.2 mm (3")
Branch 2	101.6 mm (4")
Branch 3	76.2 mm (3")
Branch 4	101.6 mm (4")
Branch 5	152 mm (6")
Branch 6	76.2 mm (3")
Branch 7	152 mm (6")

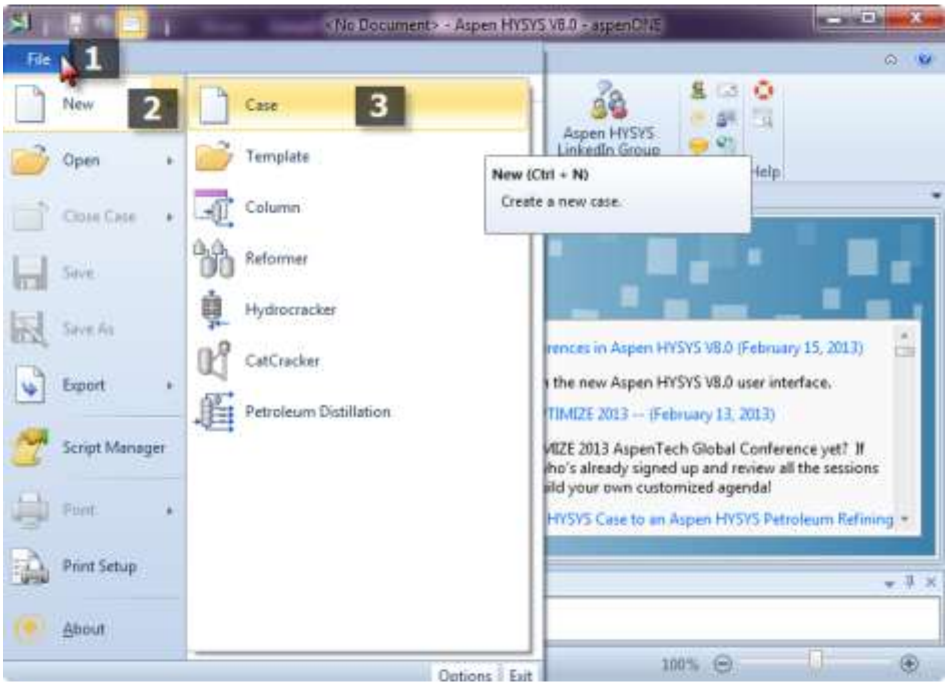
Schedule 40 steel pipes is used throughout and all branches are buried at a depth of 1 m (3 ft). All pipes are uninsulated

Consider inner and outer HTC and the pipe wall in heat transfer estimation. (Ambient Temperature=5ºC)

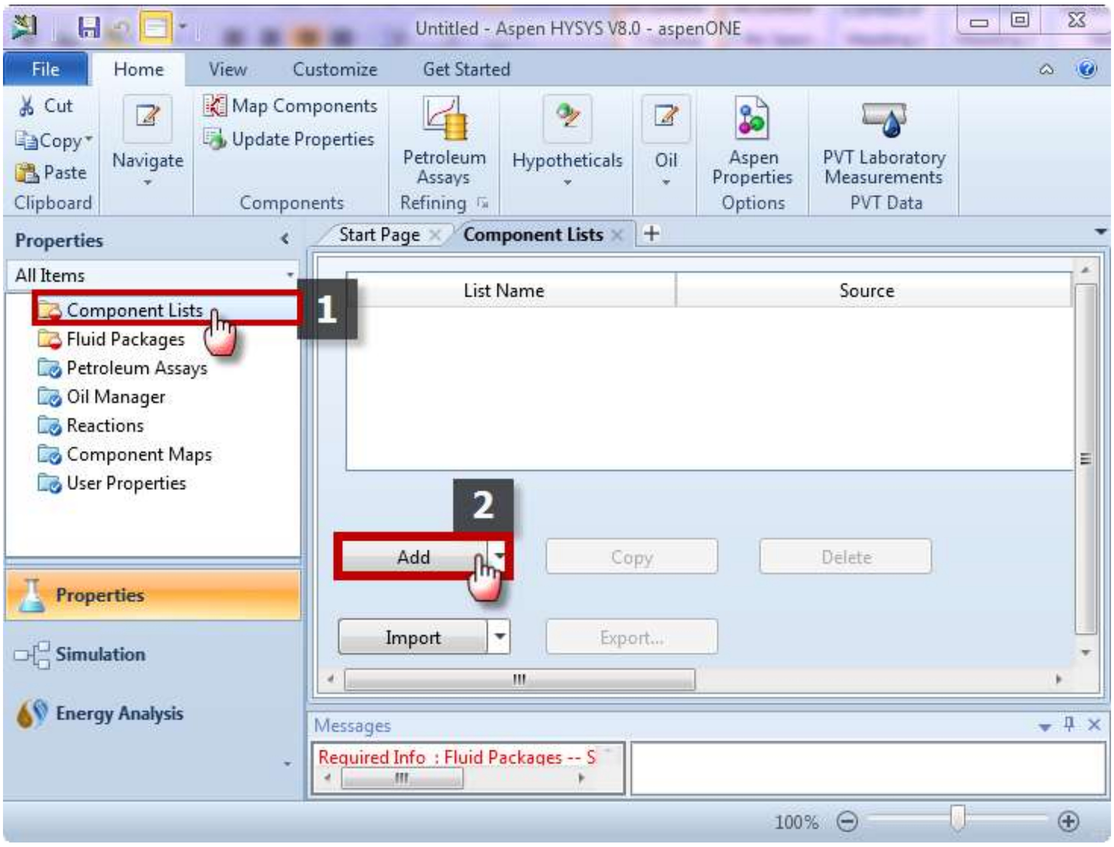
- Calculate the pressure drop and the heat loses inside each branch.

To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS

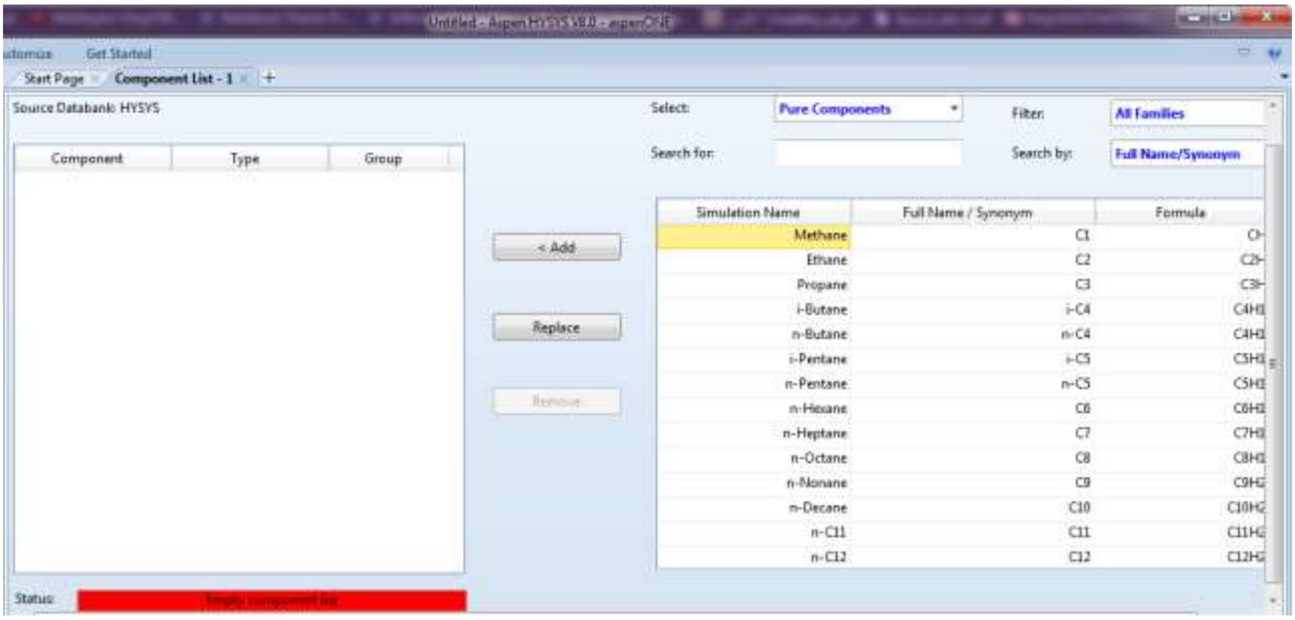
8- First, Start a new case

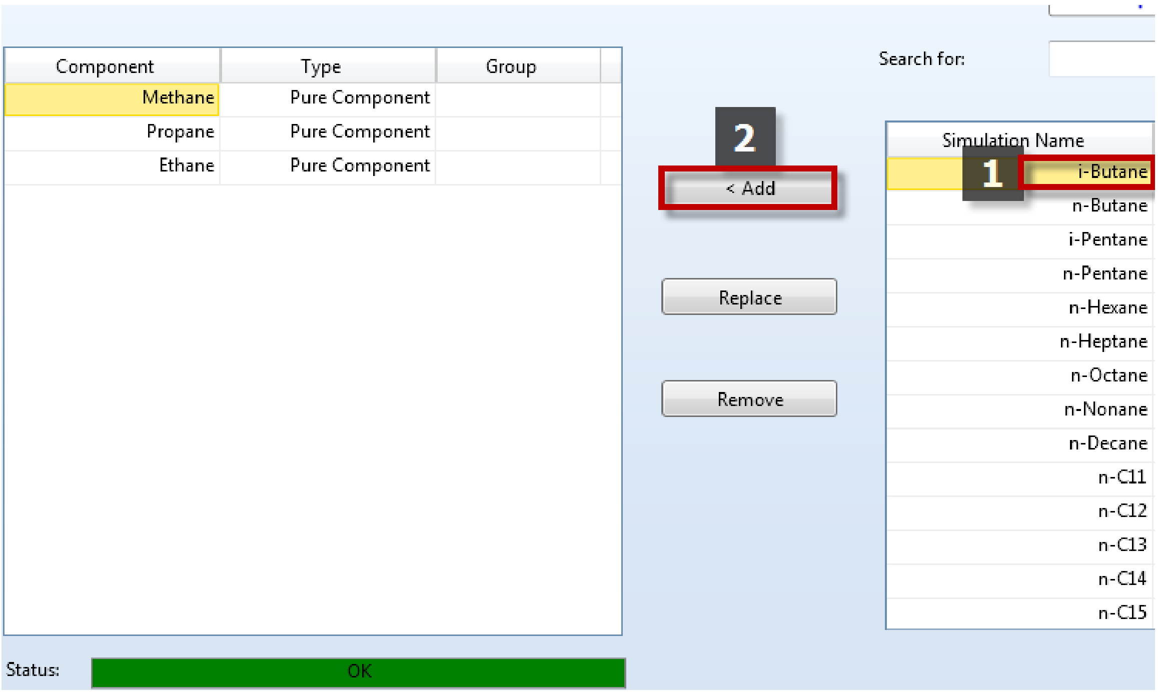


9- Add the Components



10- Choose the system components from the databank:

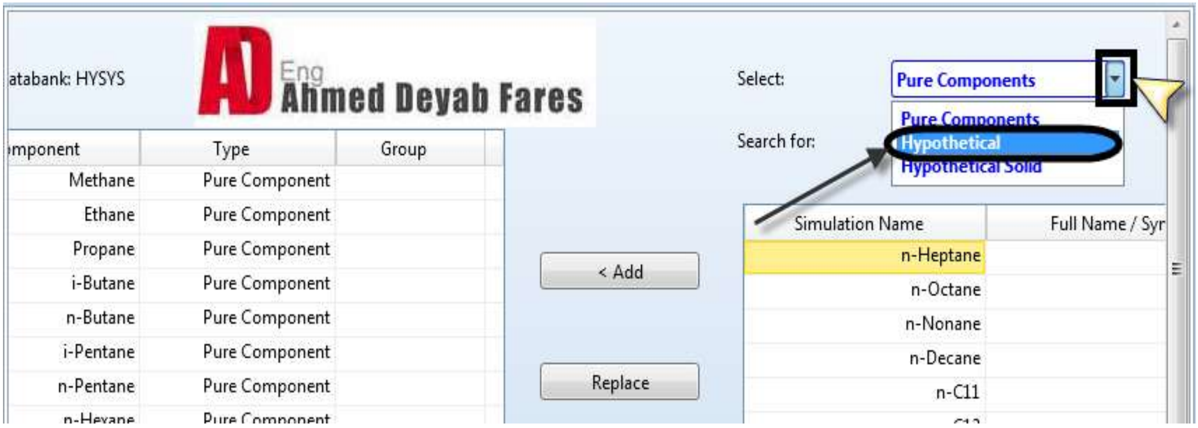




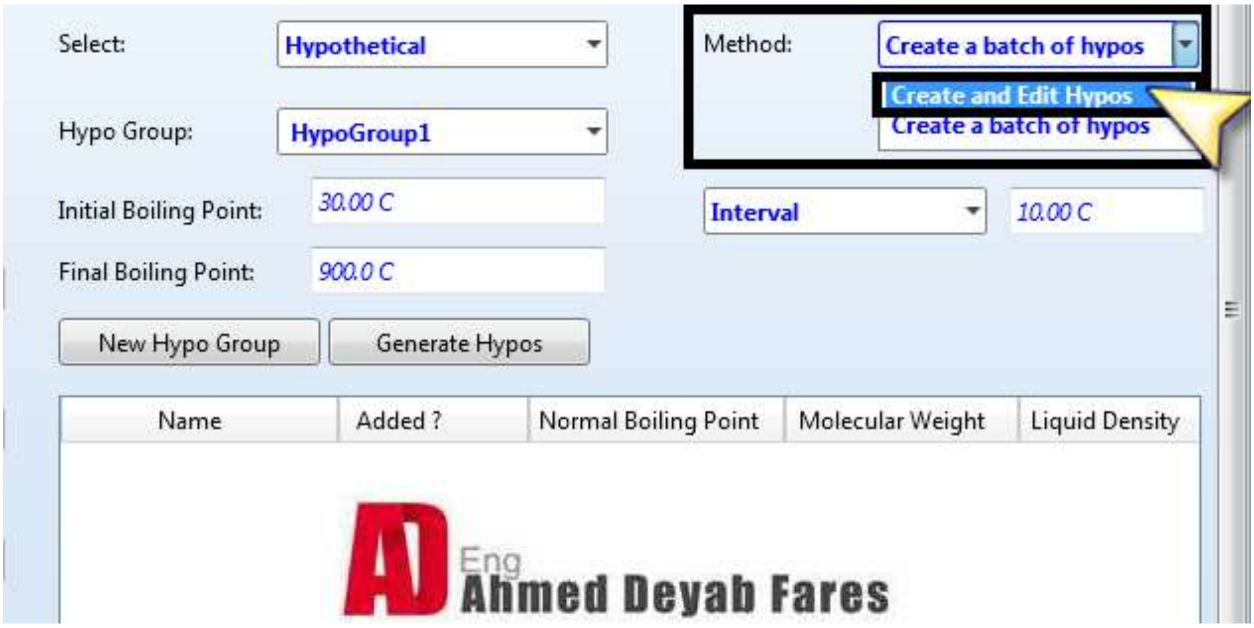
After adding the pure components (N_2, H_2S, CO_2, C1, C2, C3, n-C4, i-C4, n-C5, i-C5, n-C6, H_2O) we have to add the last component ($C7^+$) which is not a pure component as it represents all components above C7 including C7 in the feed.

To define C7+ we have to create it as a hypothetical component as the following:

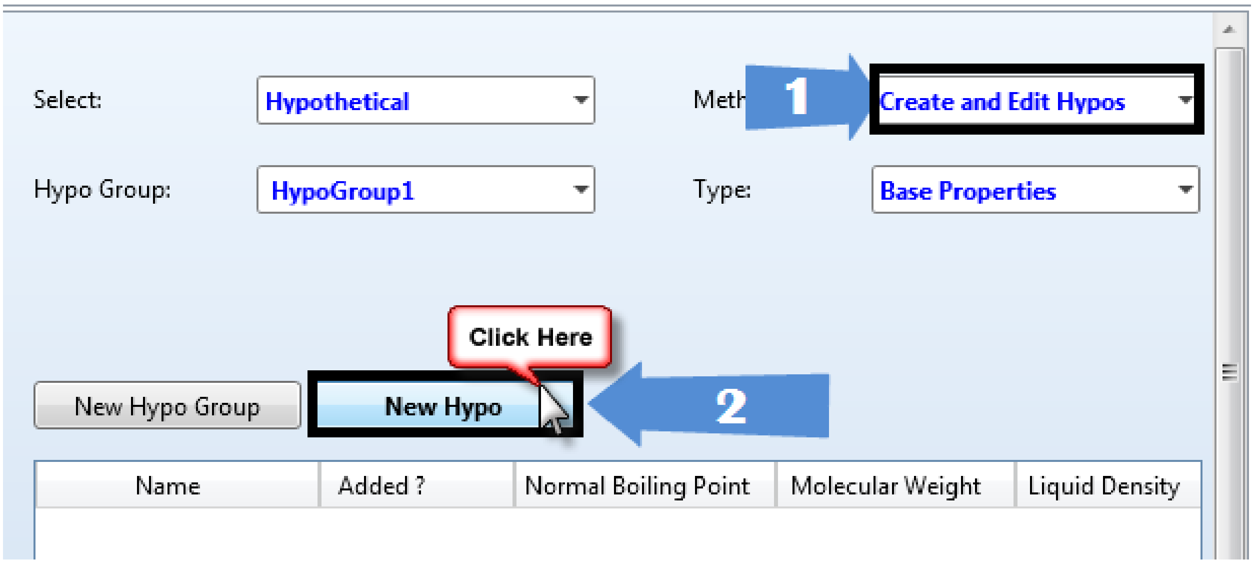
From the drop menu select Hypothetical instead of pure components



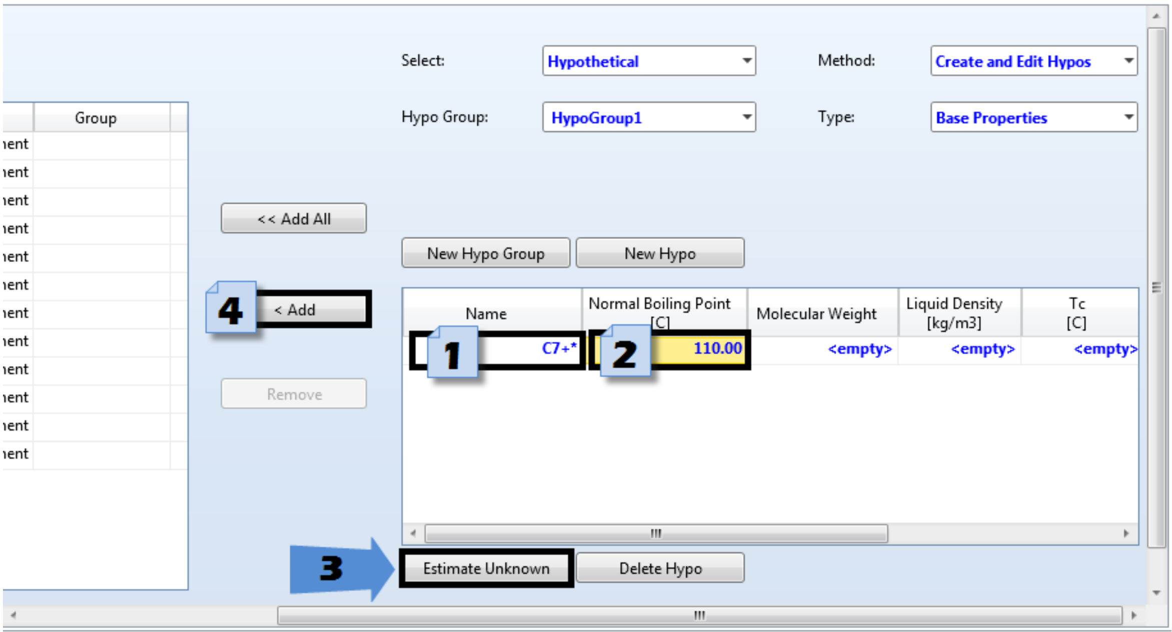
Select create and edit hypos



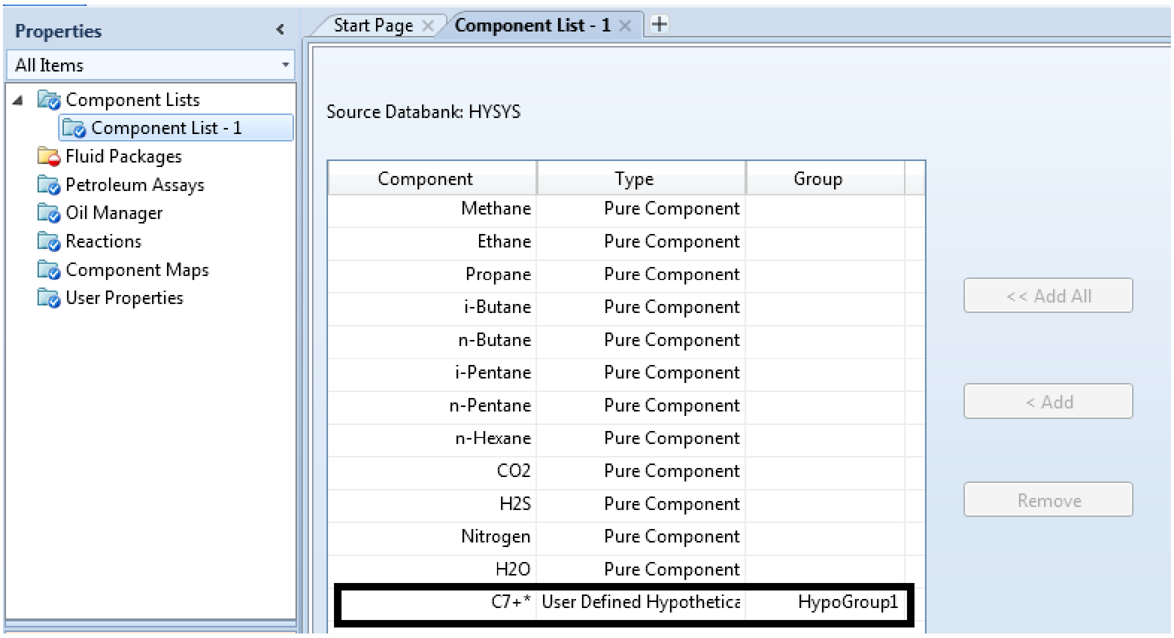
Click on New Hypo



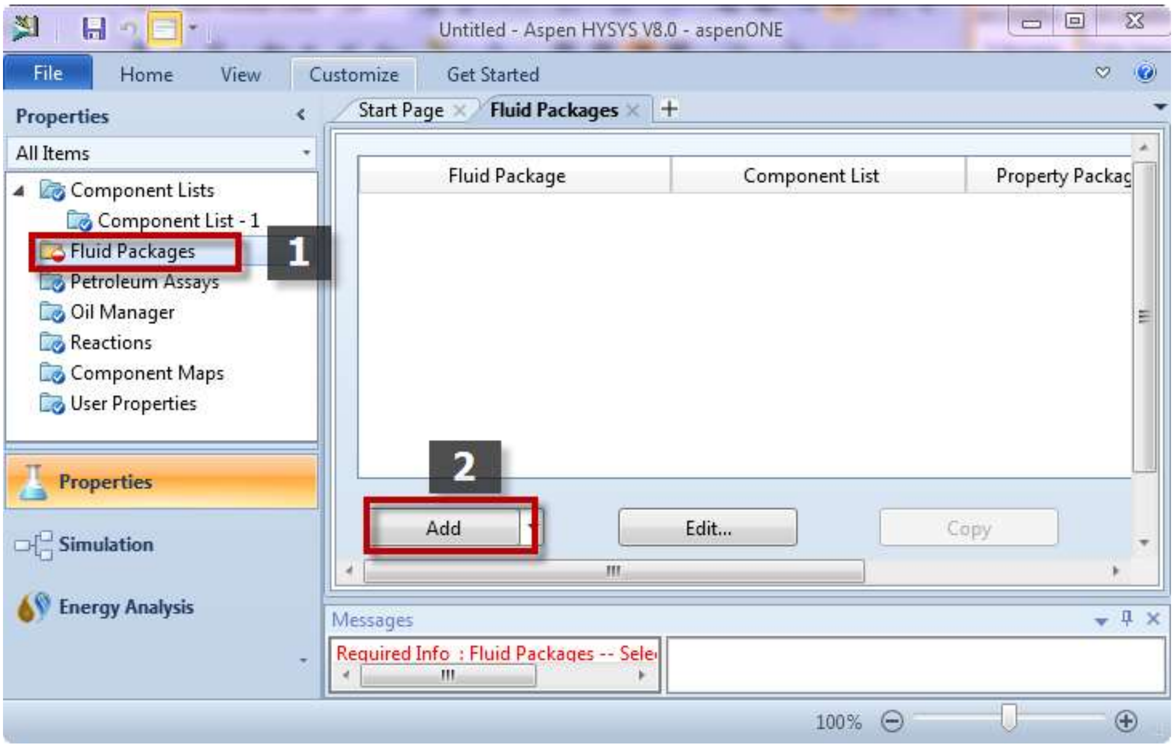
After adding a hypo component you can edit the name, add the properties you have, and estimate the unknown properties as follows:



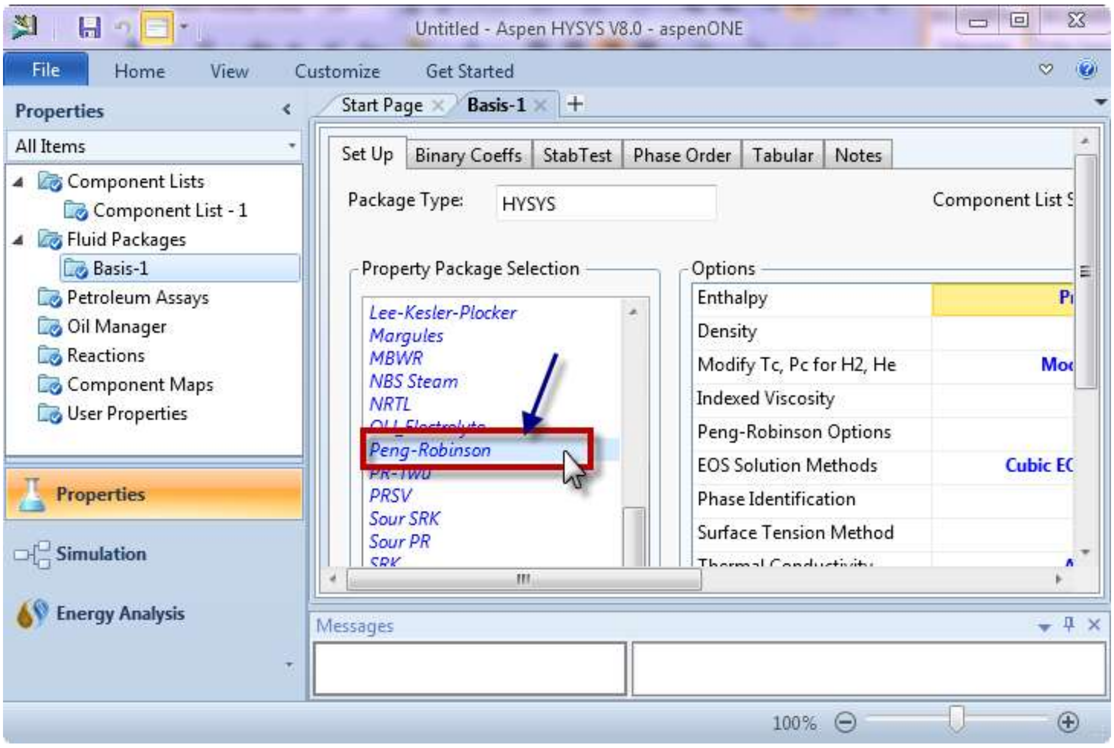
Finally add the hypo component to the component list



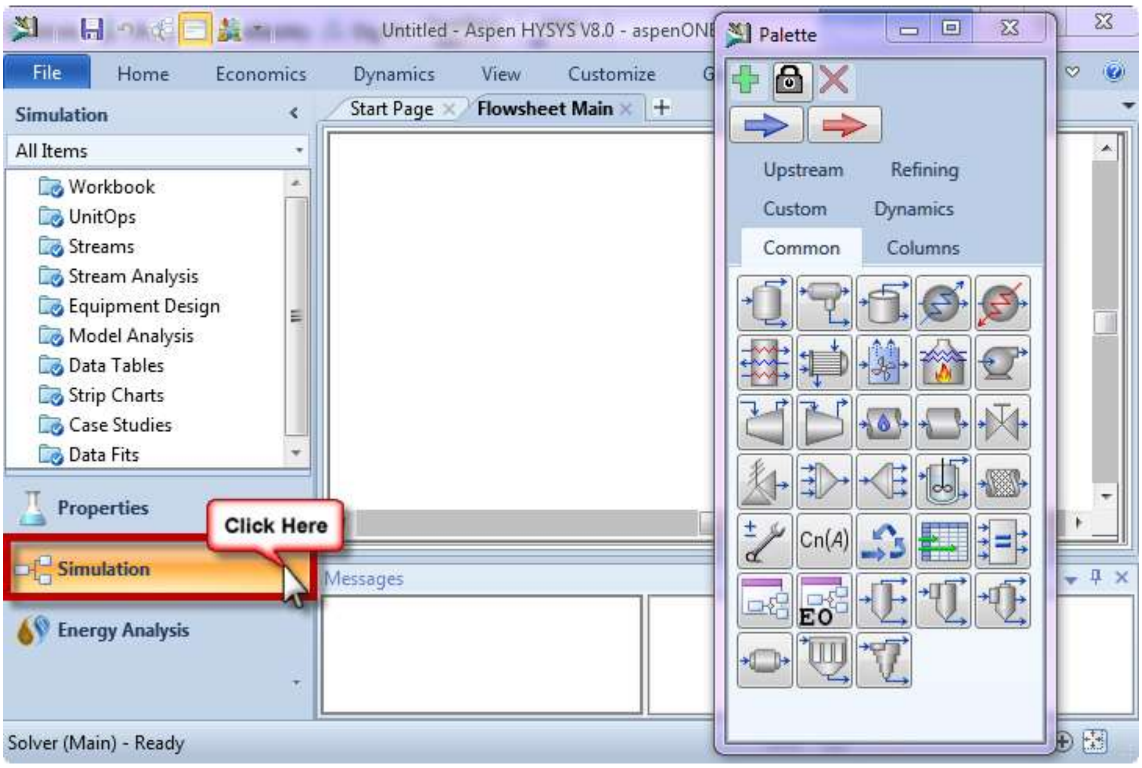
Now, select the suitable fluid package



In this case, select Peng-Robinson

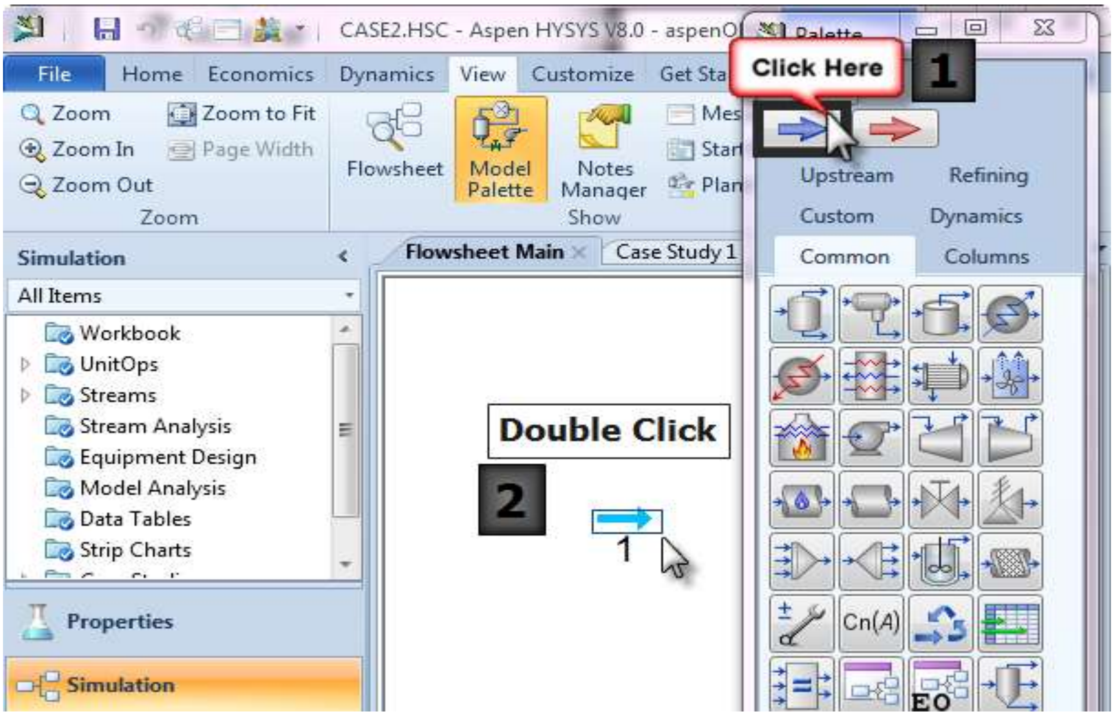


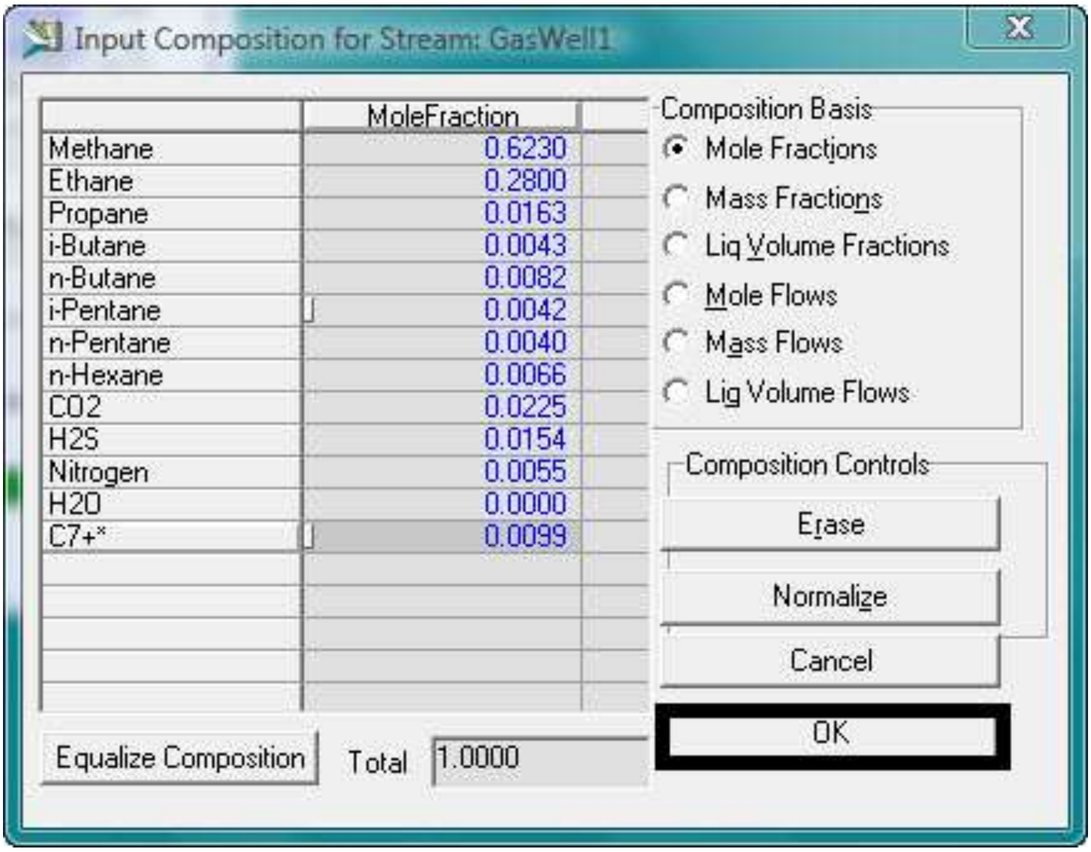
Now you can start drawing the flow sheet for the process by clicking the Simulation button:



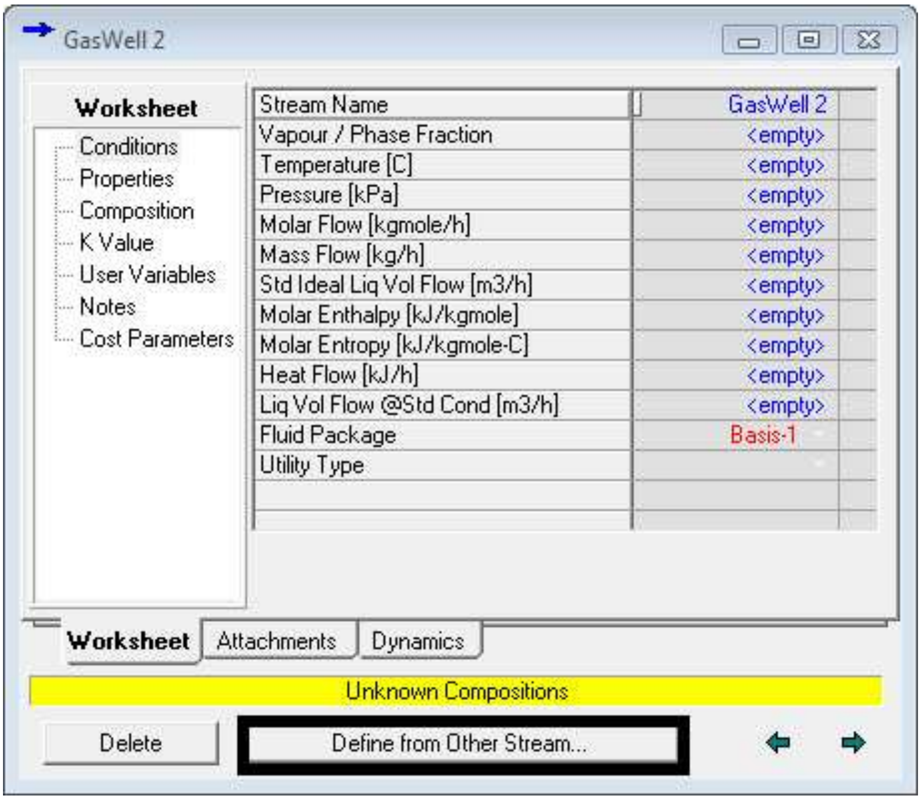
Now add a material stream to define the composition and the conditions of the feed stream

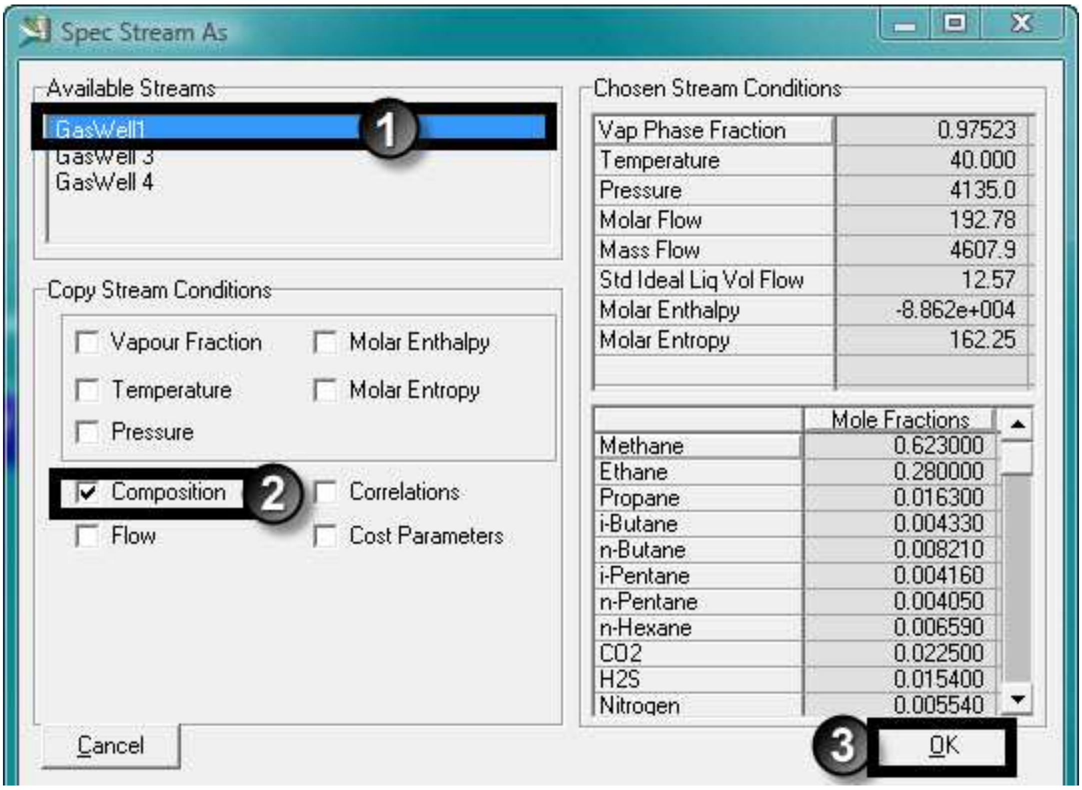
From the palette:



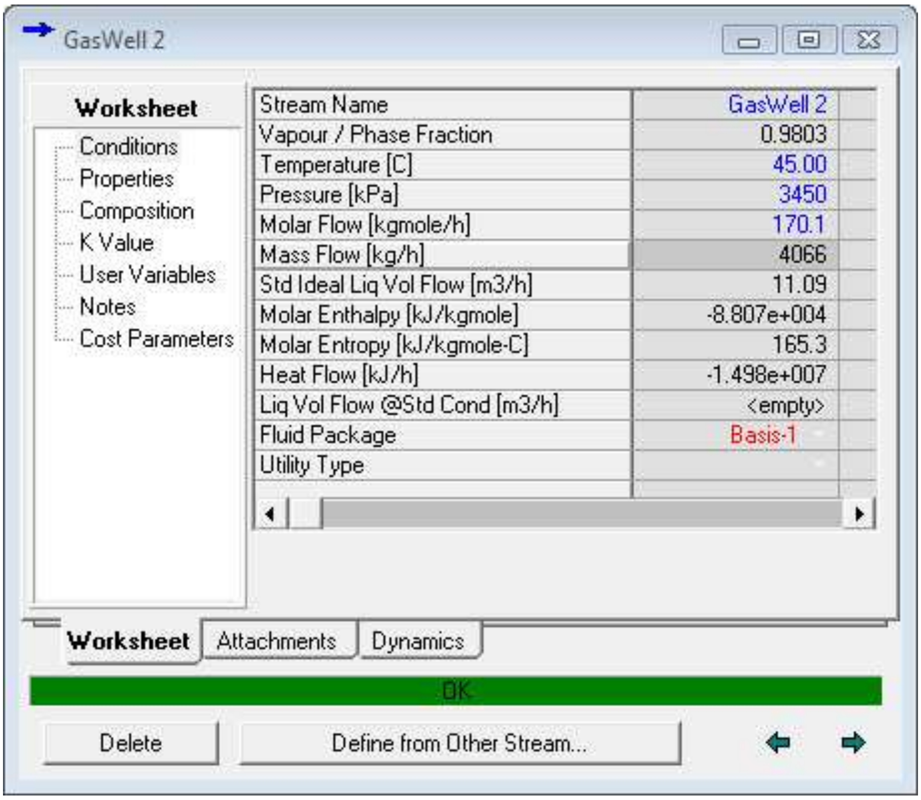


After adding the compositions and the conditions for the first well, add another stream for well 2 and define the composition from the first stream as follows:



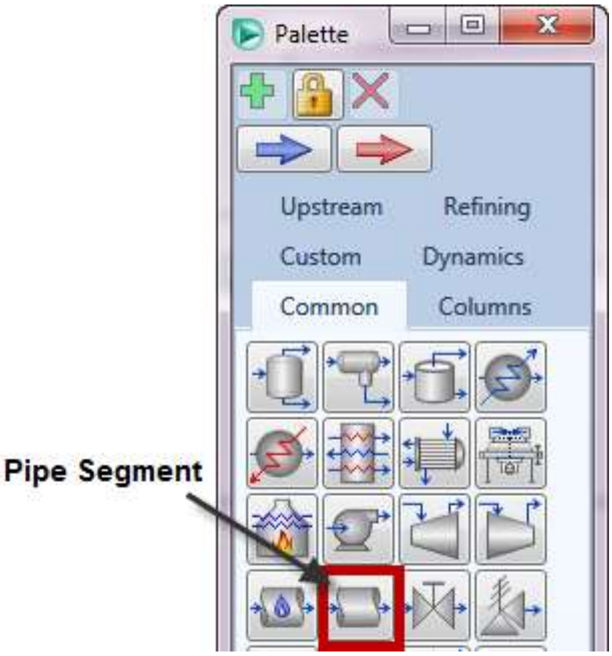


Add the conditions for the second stream

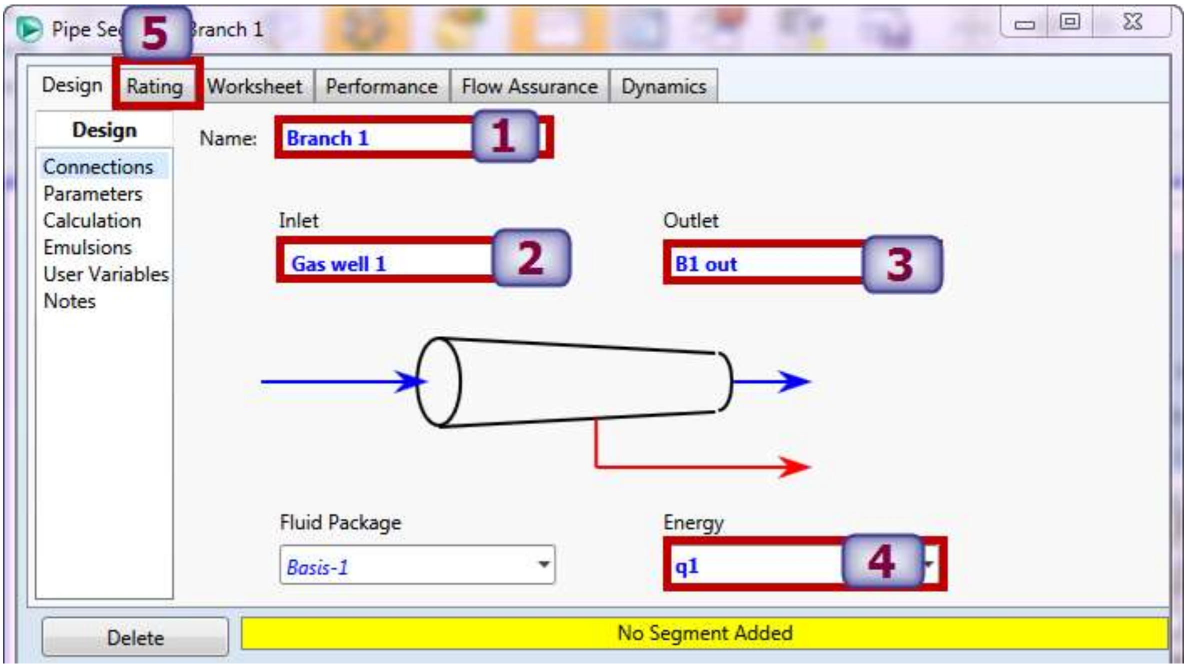


Add the conditions & Compositions for the other two streams as above

Now, Add a **Pipe Segment** from the palette

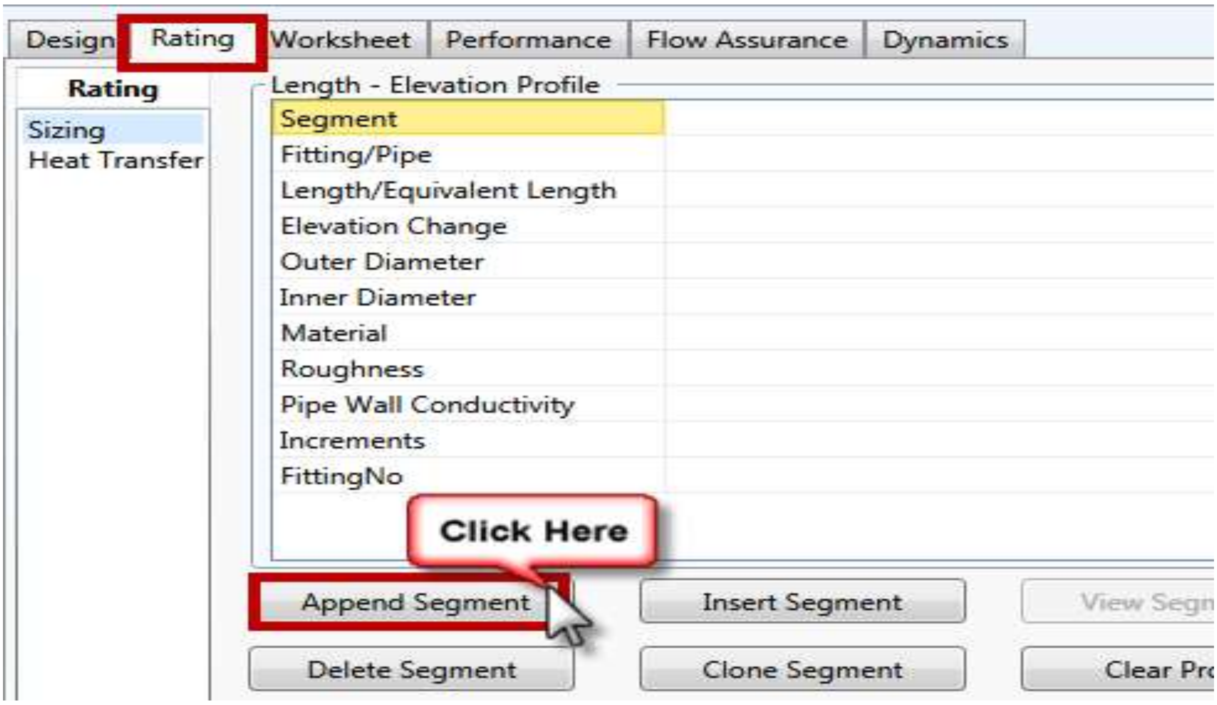


The pipe segment is used to simulate a wide variety of piping situations ranging from single/multiphase plant piping with rigorous heat transfer estimation, to large capacity looped pipeline problems



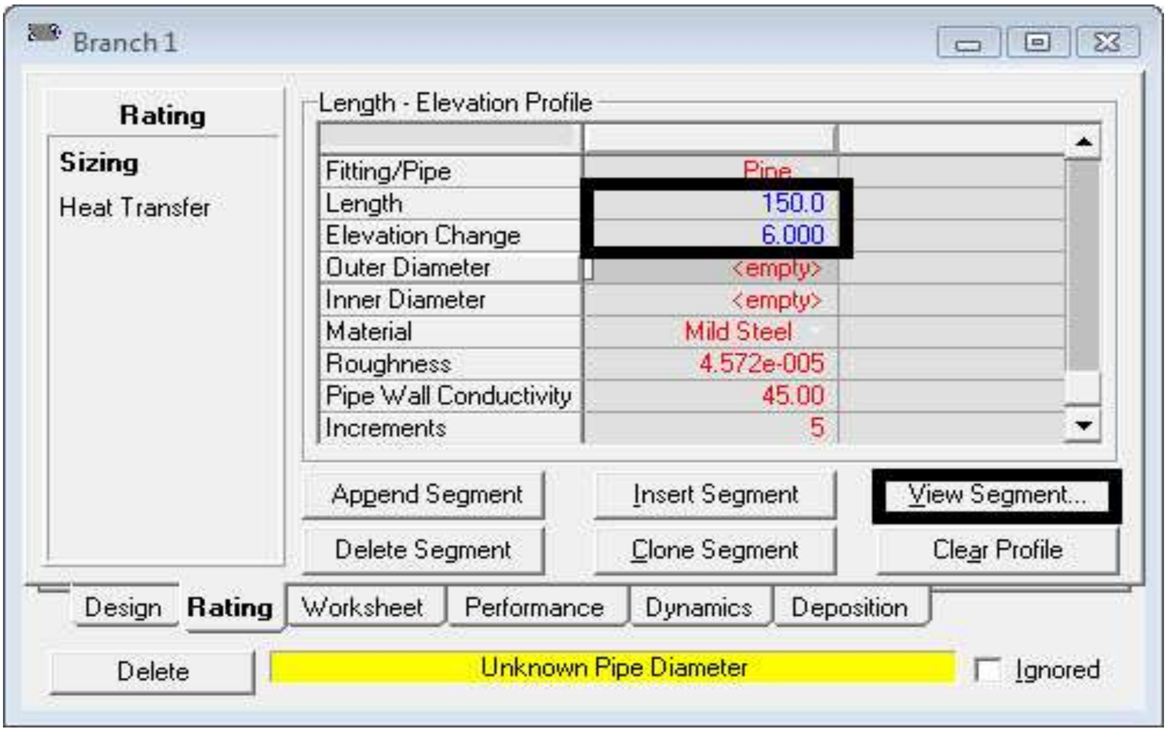
On the **Sizing** page, you construct the length-elevation profile for the Pipe Segment. Each pipe section and fitting is labeled as a segment. To fully define the pipe sections segments, you must also specify pipe schedule, diameters, pipe material and a number of increments.

- The first pipe, Branch 1 is broken into three segments.



- Add the first segment to the pipe unit operation by clicking the **Append Segment** button. Specify the following information for the segment.

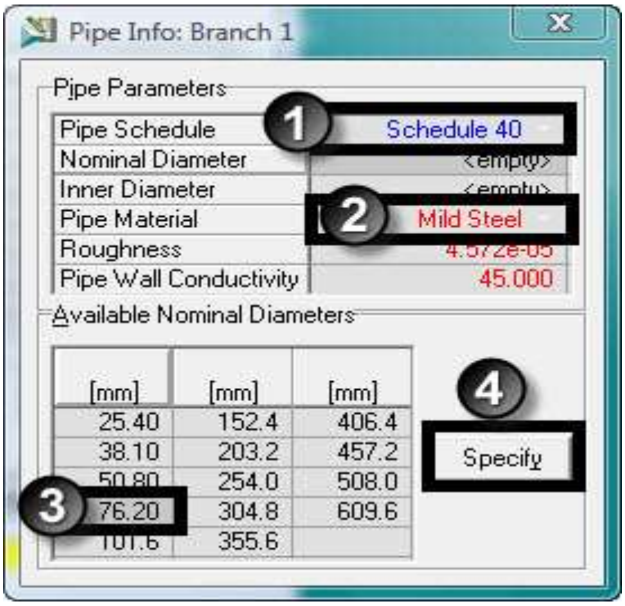
- To specify the diameter, click the **View Segment** button.



- Select **Schedule 40** as the Pipe Schedule.

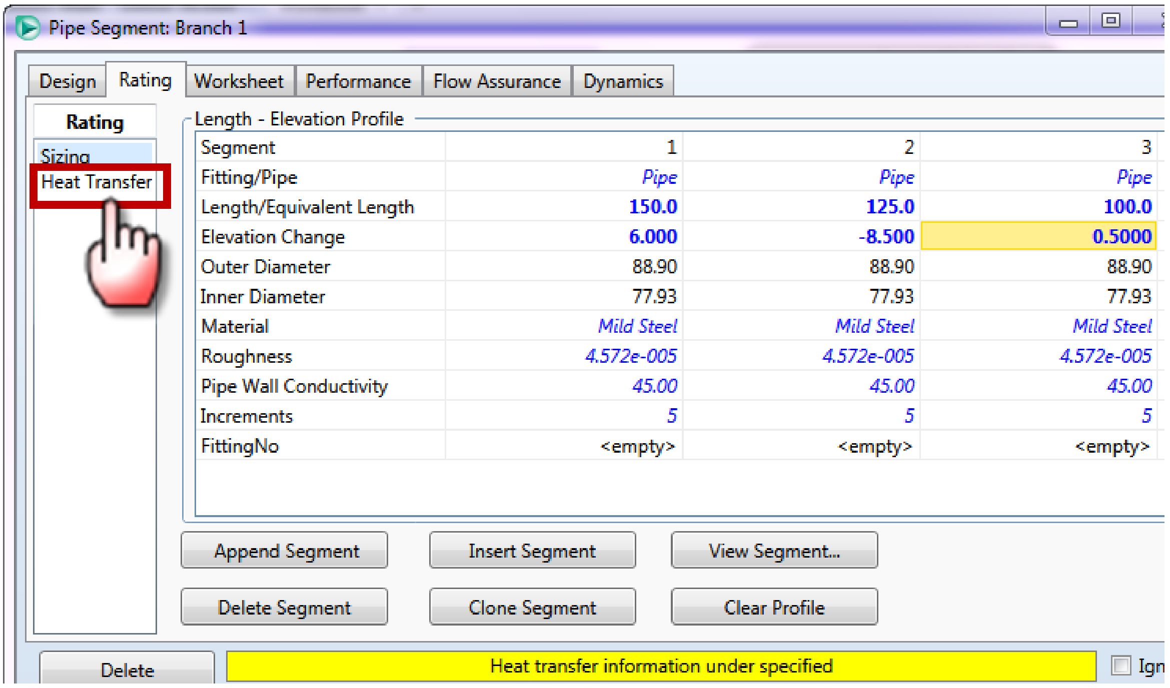
- From the Available Nominal Diameters group, select **76.20 mm (3 inch)** diameter pipe and click the **Specify** button. The Outer and Inner Diameter will be calculated by HYSYS.

- Use the default Pipe Material, Mild Steel



- Two more segments are needed to complete the branch.

In this cell...	Enter...	Enter...
Segment	2	3
Fitting/Pipe	Pipe	Pipe
Length	125 m (410 ft)	100 m (325 ft)
Elevation	-6.5 m (-21 ft)	0.5 m (1 ft)
Schedule	40	40
Nominal Diameter	76.2 mm (3 inch)	76.2 mm (3 inch)

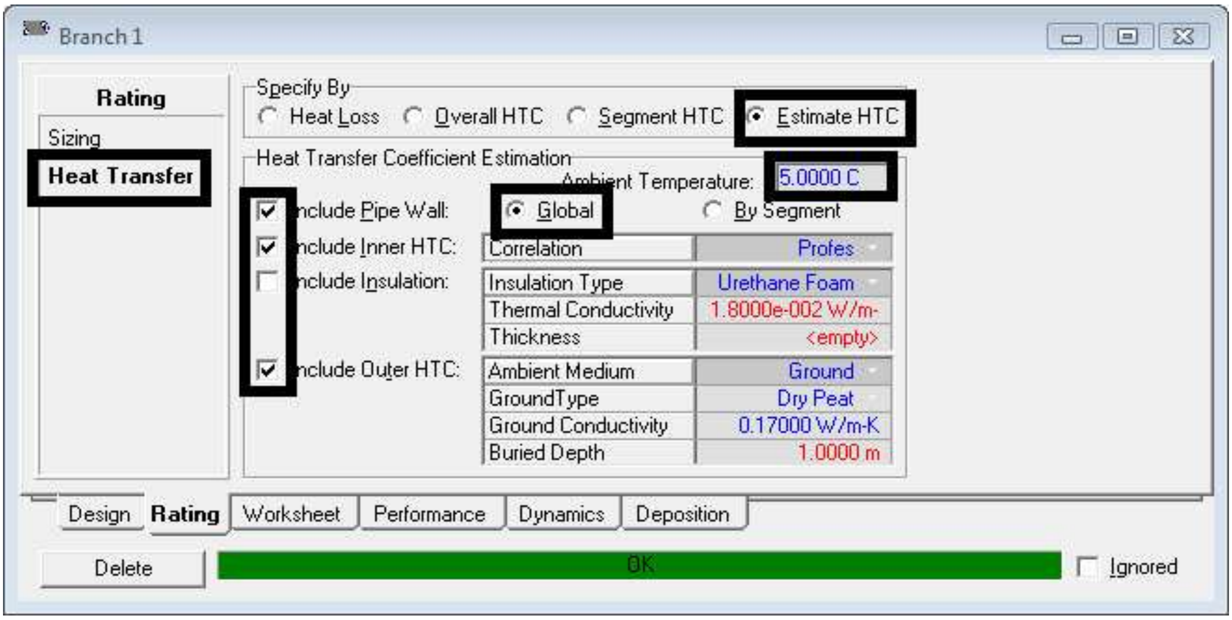


The Pipe Segment is not yet able to solve because we have not specified any information about the heat transfer properties of the pipe.

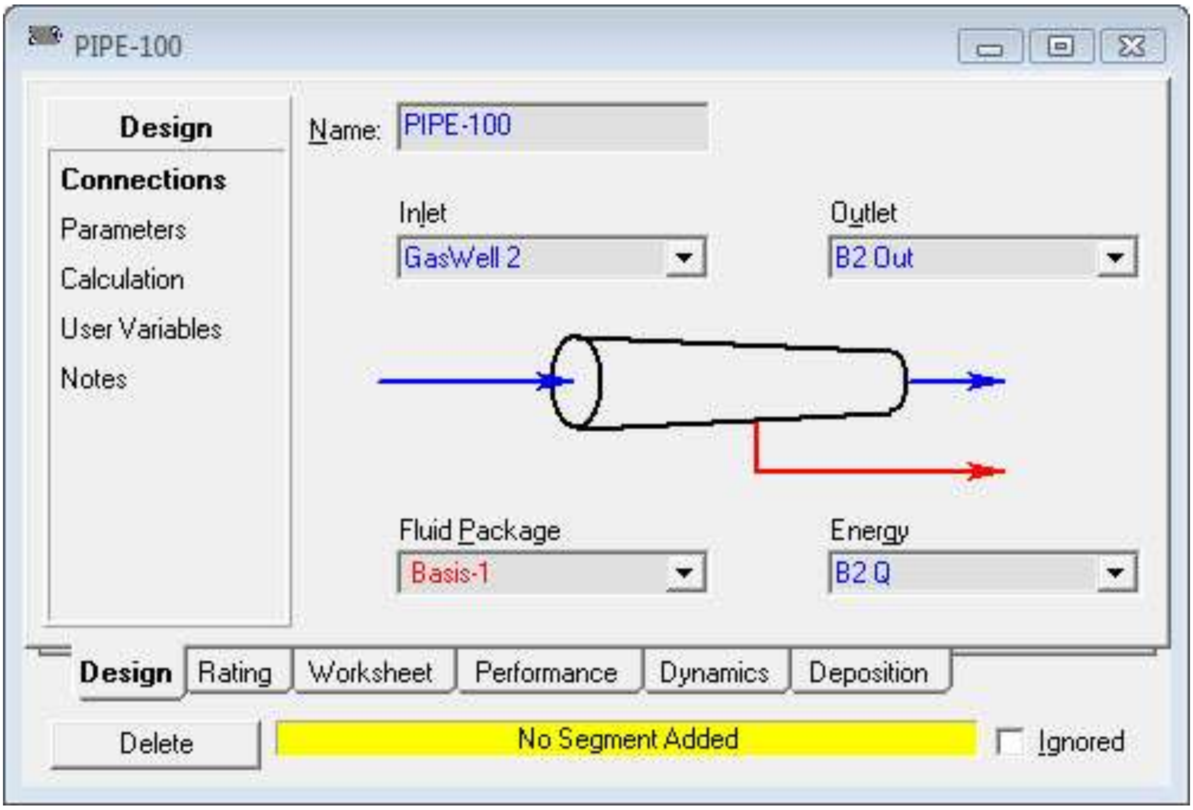
Heat Transfer page

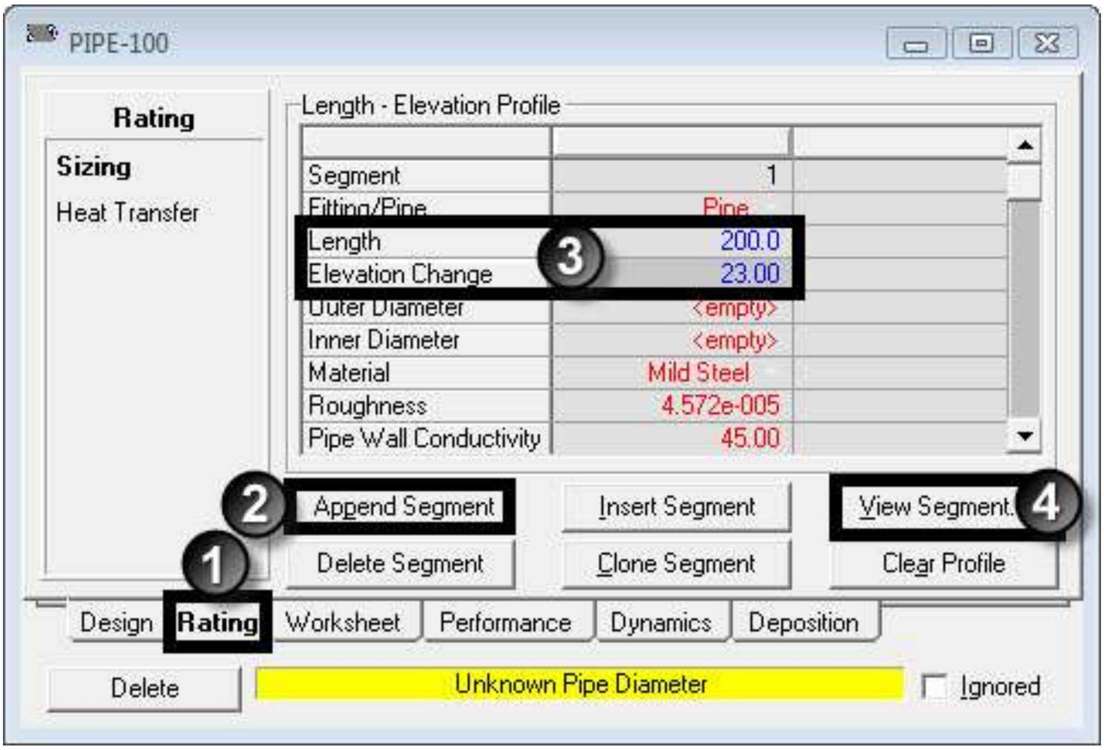
On this page, you select the method that HYSYS will use for the heat transfer calculations.

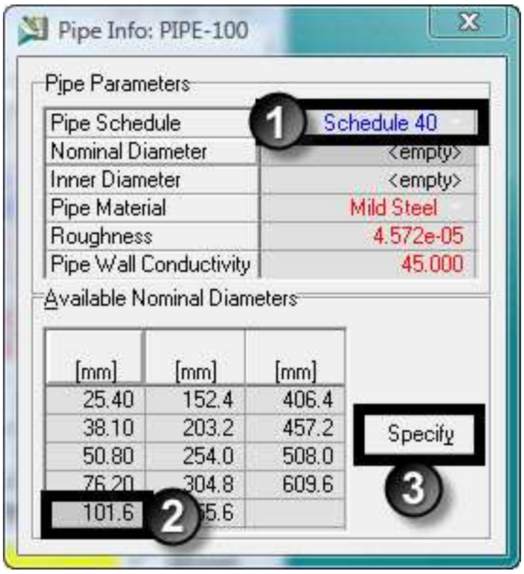
For all pipes in this simulation, use the Estimate HTC method.

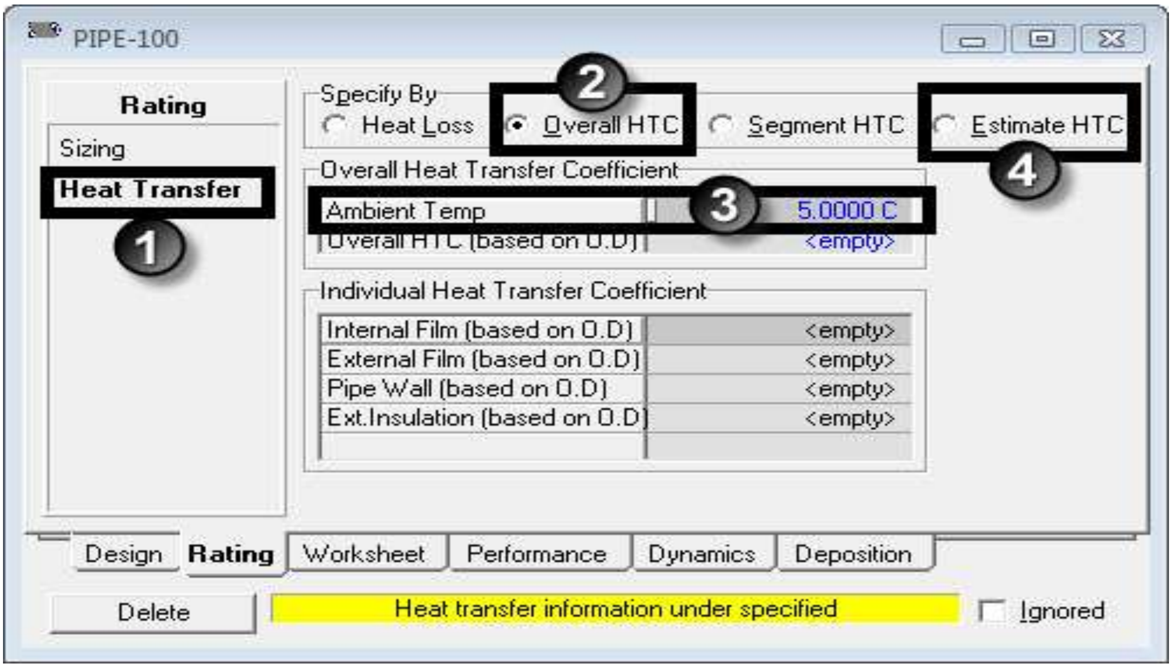


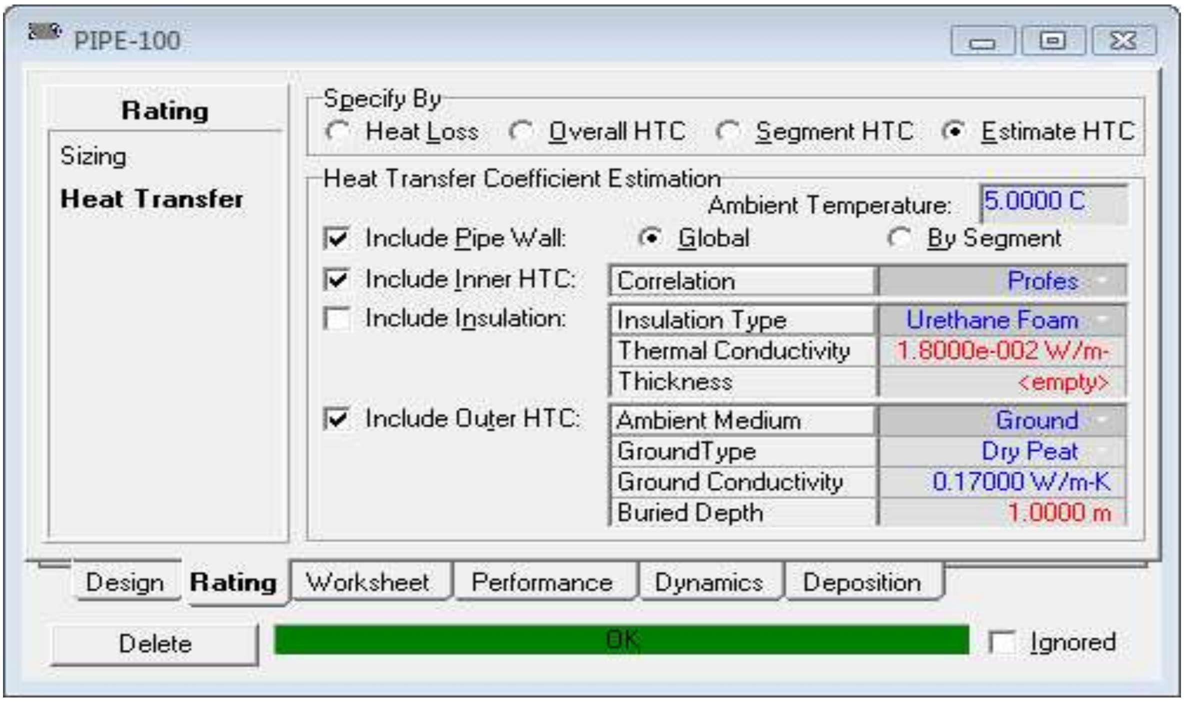
Now add the remaining unit operations to your case.

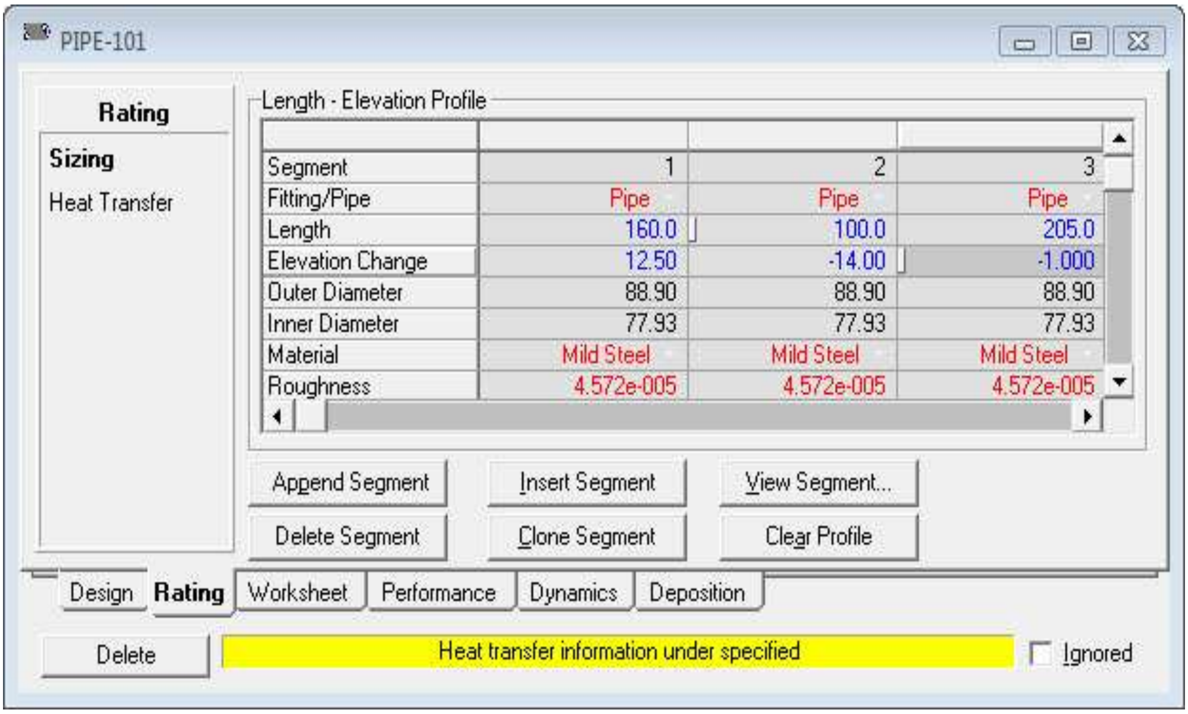


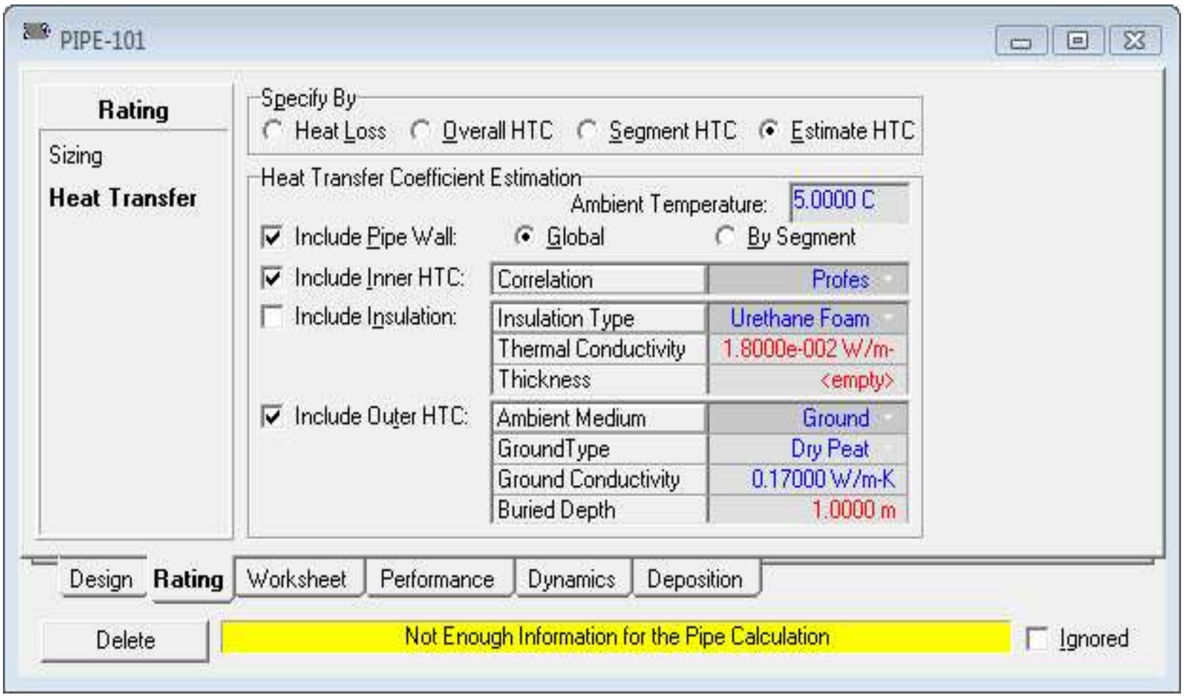

PIPE-100
Rating
Sizing
Heat Transfer
Length - Elevation Profile
Segment
1
Fitting/Pipe
Pipe
Length
200.0
Elevation Change
23.00
Outer Diameter
<empty>
Inner Diameter
<empty>
Material
Mild Steel
Roughness
4.572e-005
Pipe Wall Conductivity
45.00
Append Segment
Insert Segment
View Segment
Delete Segment
Clone Segment
Clear Profile
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
Unknown Pipe Diameter
Ignored
1
2
3
4


Pipe Info: PIPE-100
Pipe Parameters
Pipe Schedule
Schedule 40
Nominal Diameter
<empty>
Inner Diameter
<empty>
Pipe Material
Mild Steel
Roughness
4.572e-05
Pipe Wall Conductivity
45.000
Available Nominal Diameters
[mm]
[mm]
[mm]
25.40
152.4
406.4
38.10
203.2
457.2
50.80
254.0
508.0
76.20
304.8
609.6
101.6
Specify
1
2
3

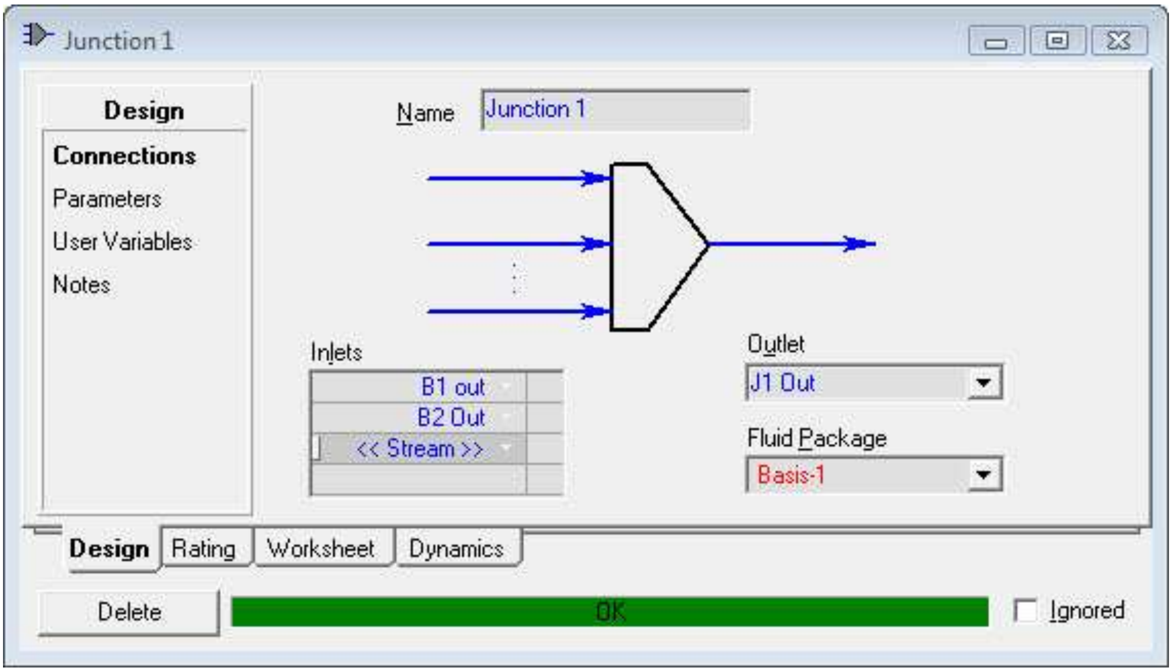

PIPE-100
Rating
Sizing
Heat Transfer
Specify By
Heat Loss
Overall HTC
Segment HTC
Estimate HTC
Overall Heat Transfer Coefficient
Ambient Temp
5.0000 C
Overall HTC (based on O.D)
<empty>
Individual Heat Transfer Coefficient
Internal Film (based on O.D)
External Film (based on O.D)
Pipe Wall (based on O.D)
Ext.Insulation (based on O.D)
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
Heat transfer information under specified
Ignored

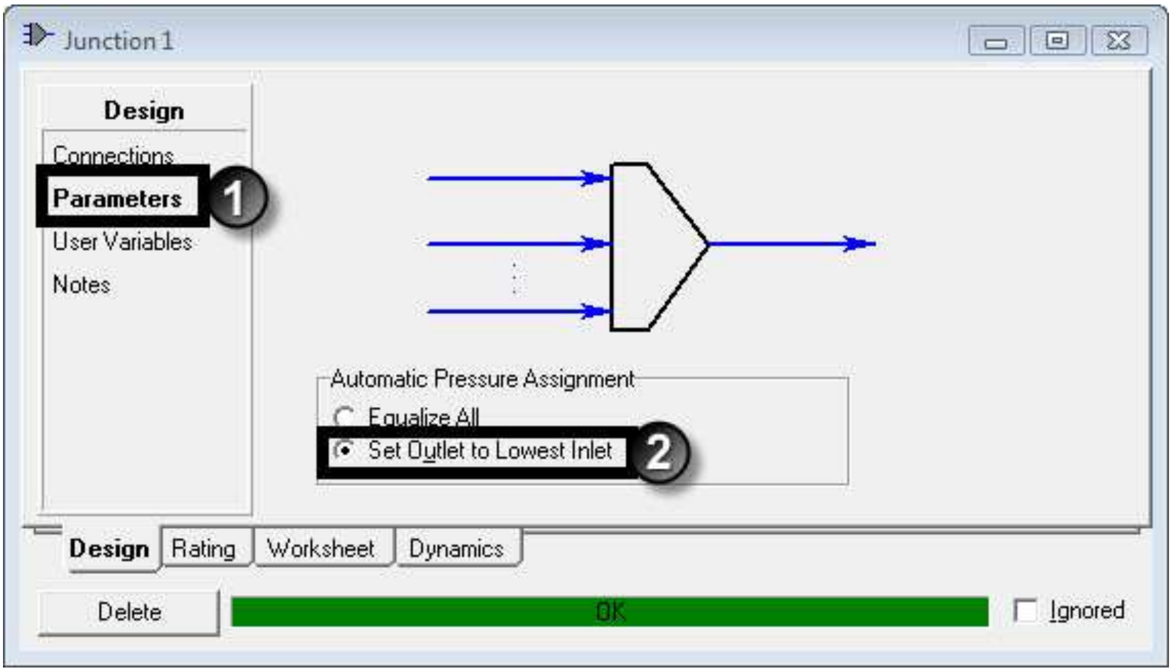

PIPE-100
Rating
Sizing
Heat Transfer
Specify By
Heat Loss
Overall HTC
Segment HTC
Estimate HTC
Heat Transfer Coefficient Estimation
Ambient Temperature:
5.0000 C
Include Pipe Wall:
Global
By Segment
Include Inner HTC:
Correlation
Profes
Include Insulation:
Insulation Type
Urethane Foam
Thermal Conductivity
1.8000e-002 W/m-
Thickness
<empty>
Include Outer HTC:
Ambient Medium
Ground
GroundType
Dry Peat
Ground Conductivity
0.17000 W/m-K
Buried Depth
1.0000 m
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
OK
Ignored

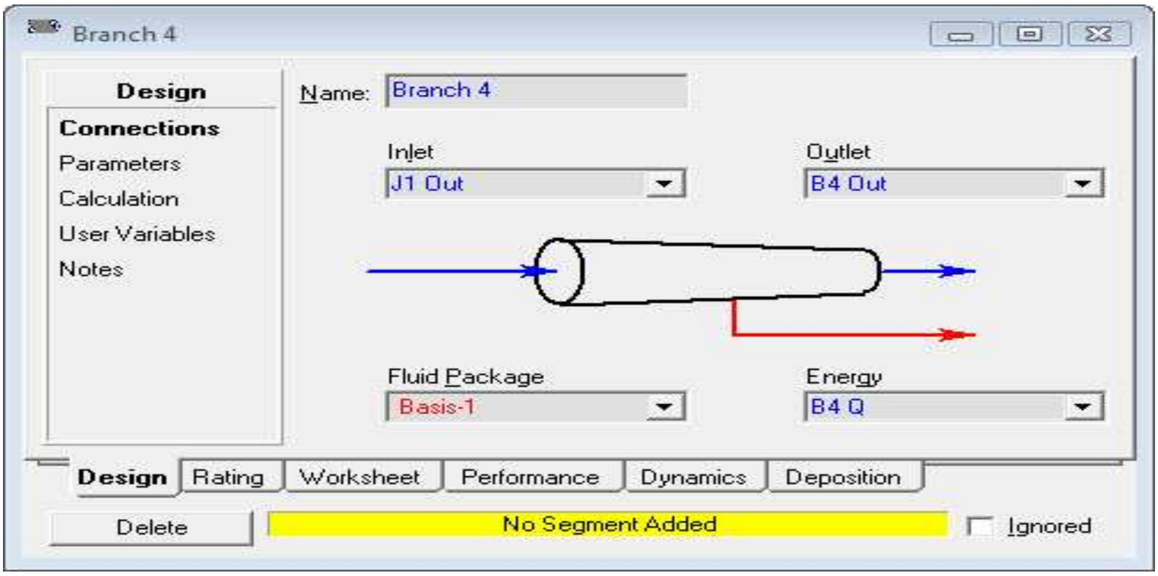


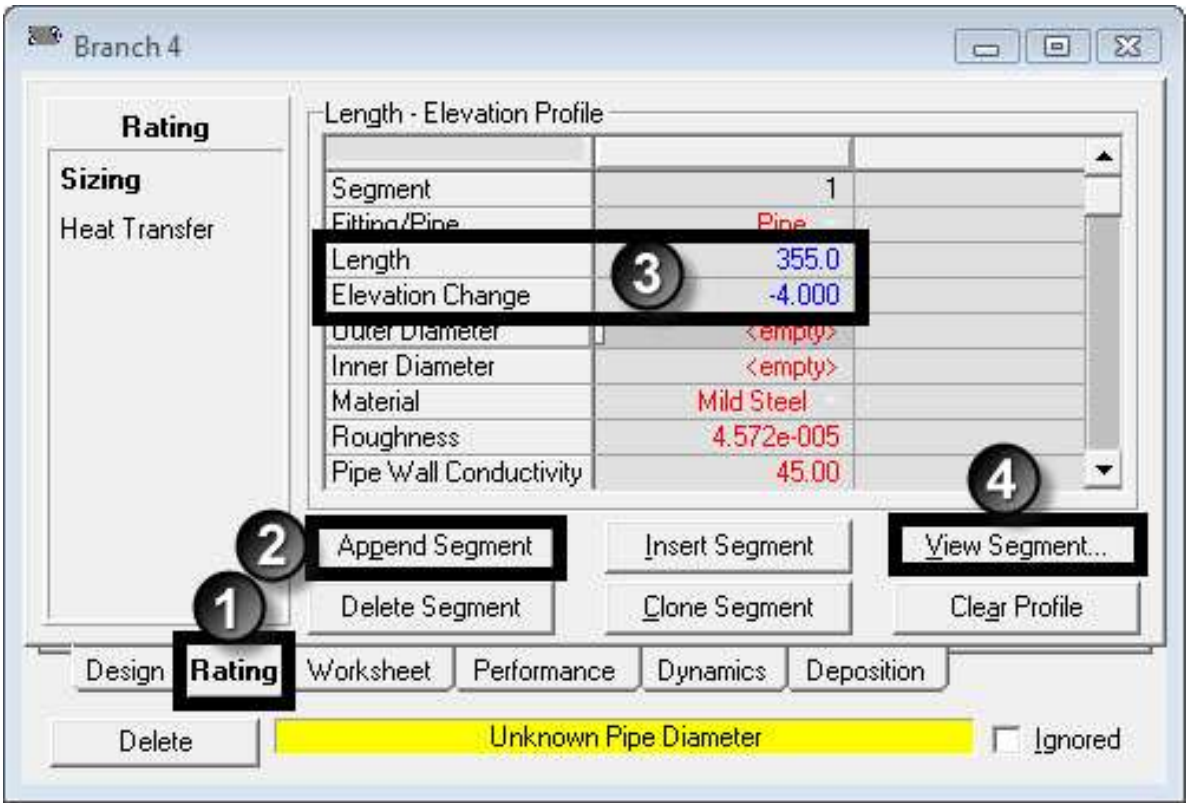


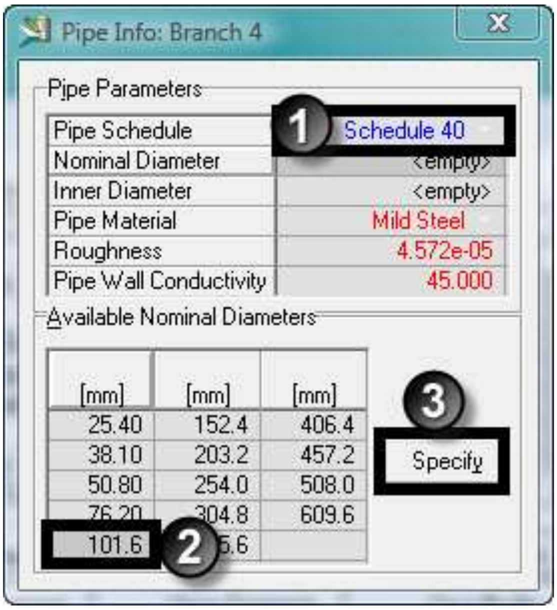
Now, add a mixer operation to mix the outlet streams from both branch 1 & branch 2

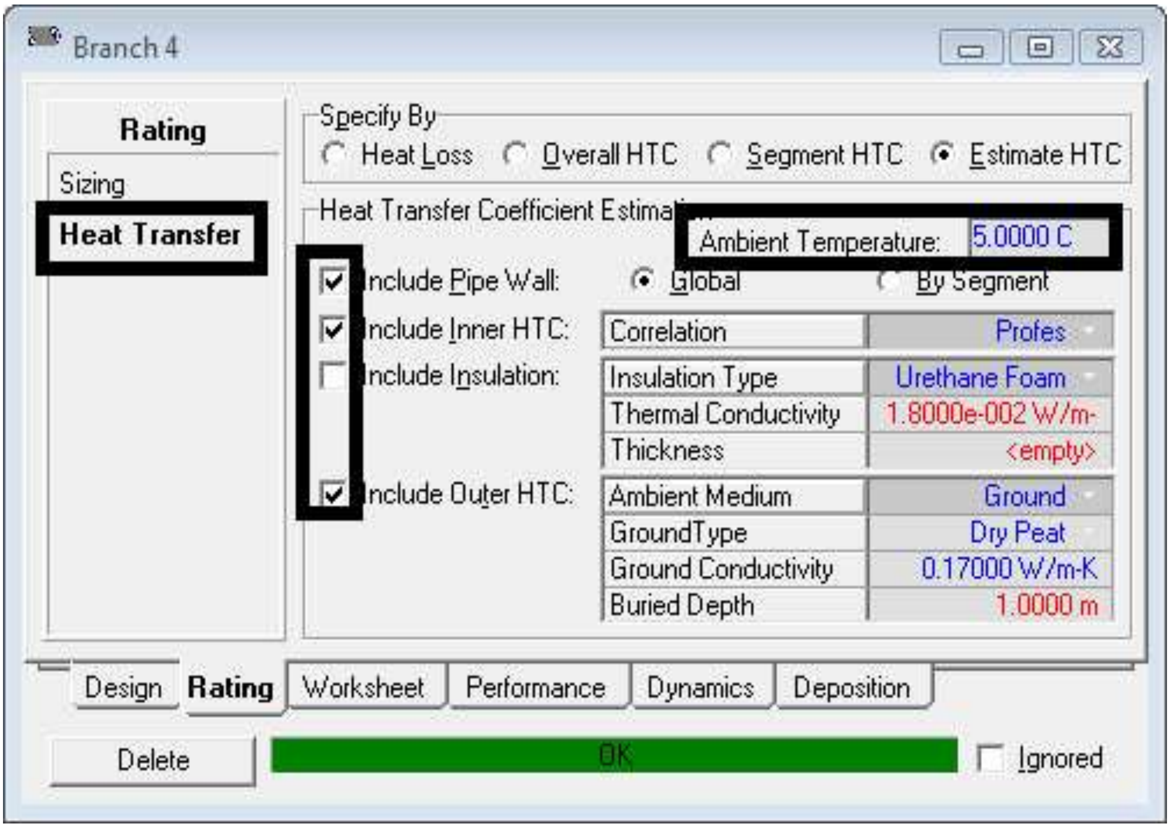

Junction 1
Design
Connections
Parameters
User Variables
Notes
Name
Junction 1
Inlets
B1 out
B2 Out
<< Stream >>
Outlet
J1 Out
Fluid Package
Basis-1
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored

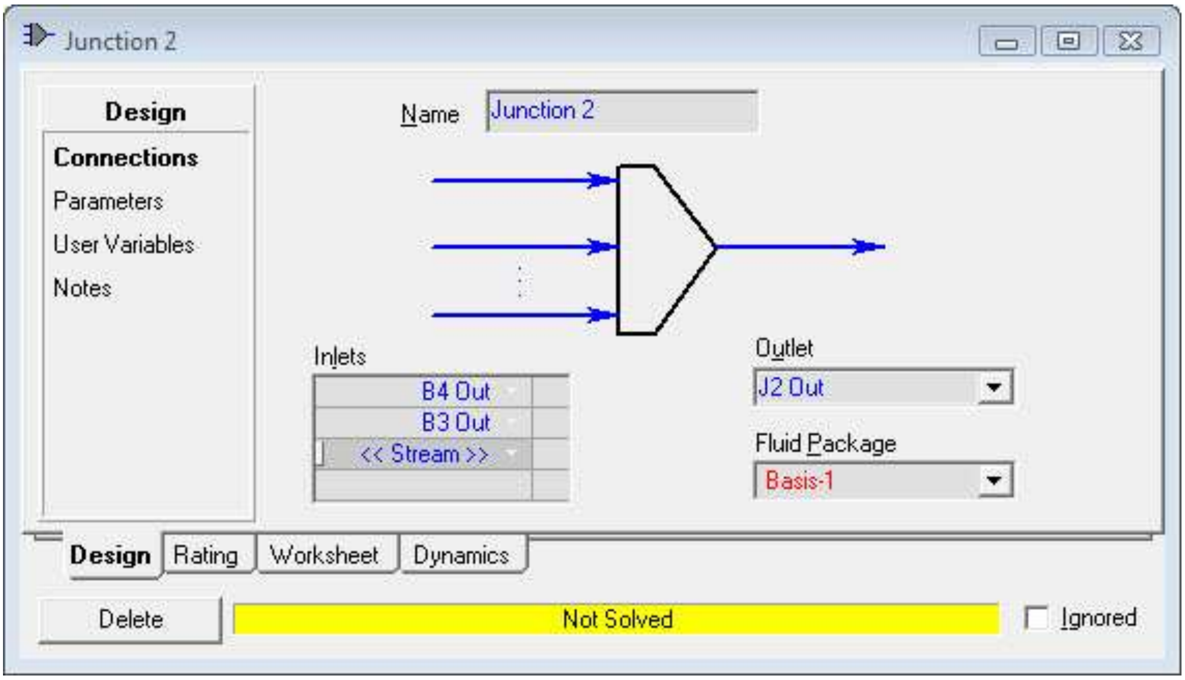

Junction 1
Design
Connections
Parameters
1
User Variables
Notes
Automatic Pressure Assignment
Equalize All
Set Outlet to Lowest Inlet
2
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored

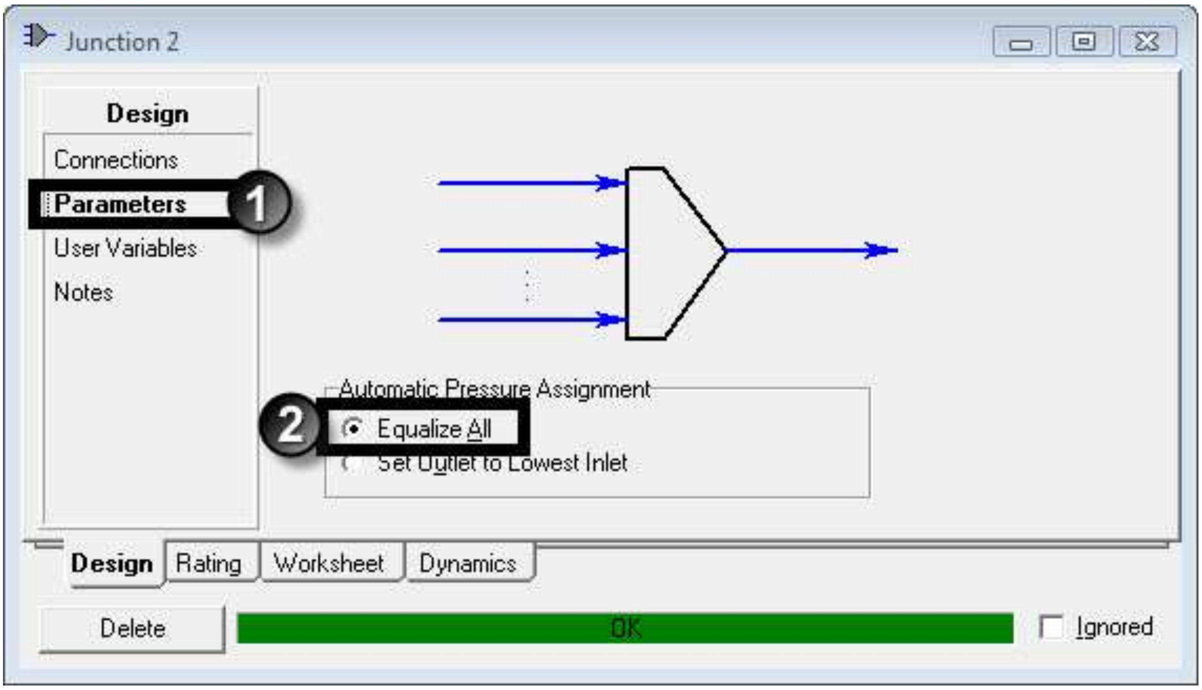

Branch 4
Design
Connections
Parameters
Calculation
User Variables
Notes
Name: Branch 4
Inlet
J1 Out
Outlet
B4 Out
Fluid Package
Basis-1
Energy
B4 Q
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
No Segment Added
Ignored

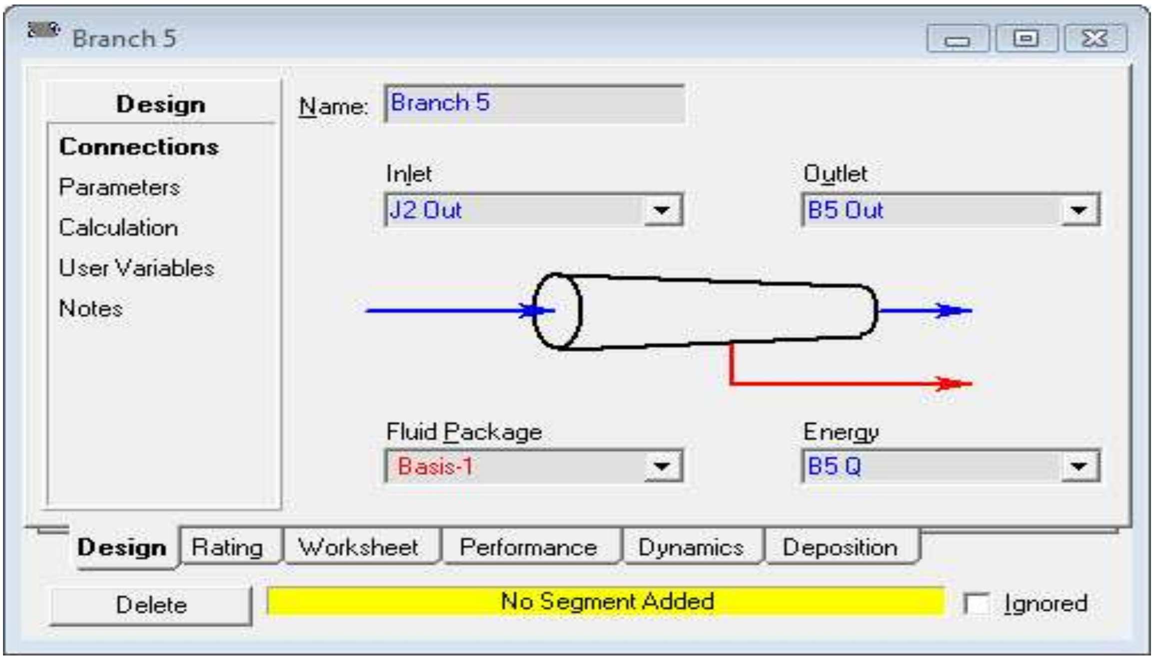

Branch 4
Rating
Sizing
Heat Transfer
Length - Elevation Profile
Segment 1
Fitting/Pipe Pipe
Length 355.0
Elevation Change -4.000
Outer Diameter <empty>
Inner Diameter <empty>
Material Mild Steel
Roughness 4.572e-005
Pipe Wall Conductivity 45.00
1
2
3
4
Append Segment
Insert Segment
View Segment...
Delete Segment
Clone Segment
Clear Profile
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
Unknown Pipe Diameter
Ignored

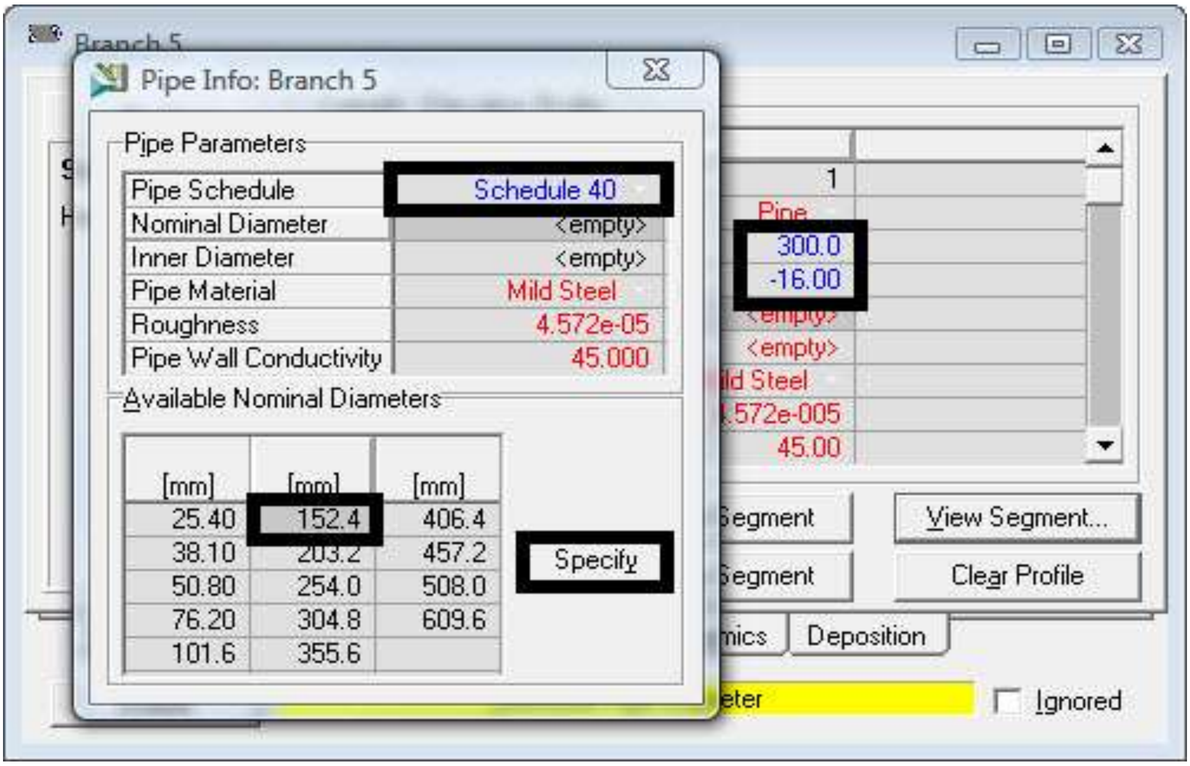

Pipe Info: Branch 4
Pipe Parameters
Pipe Schedule
Schedule 40
Nominal Diameter
<empty>
Inner Diameter
<empty>
Pipe Material
Mild Steel
Roughness
4.572e-05
Pipe Wall Conductivity
45.000
Available Nominal Diameters
[mm]
[mm]
[mm]
25.40
152.4
406.4
38.10
203.2
457.2
50.80
254.0
508.0
609.6
101.6
1
2
3
Specify

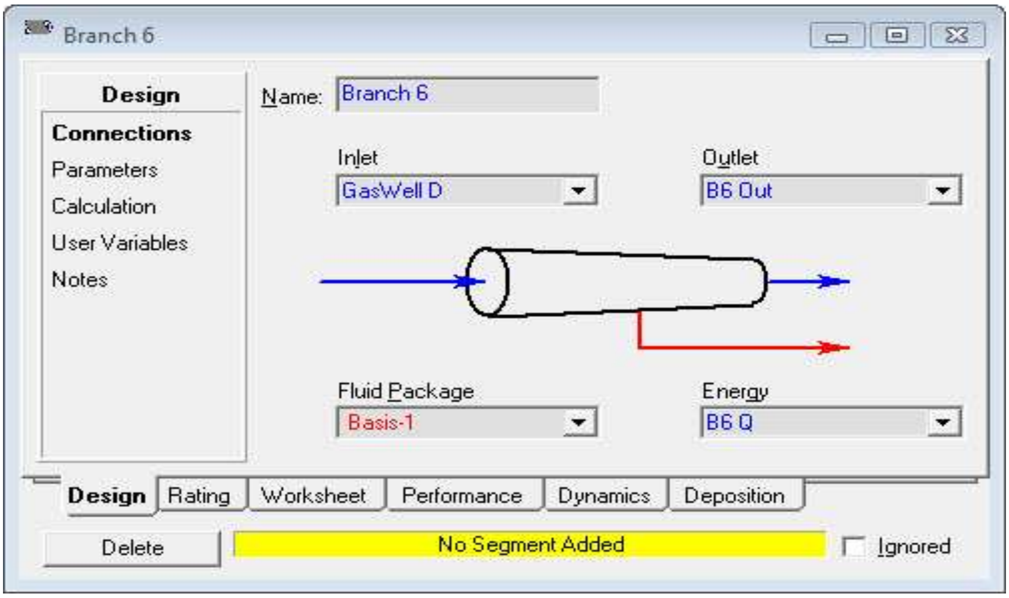

Branch 4
Rating
Sizing
Heat Transfer
Specify By
Heat Loss
Overall HTC
Segment HTC
Estimate HTC
Heat Transfer Coefficient Estima
Ambient Temperature:
5.0000 C
Include Pipe Wall:
Global
By Segment
Include Inner HTC:
Correlation
Profes
Include Insulation:
Insulation Type
Urethane Foam
Thermal Conductivity
1.8000e-002 W/m-
Thickness
<empty>
Include Outer HTC:
Ambient Medium
Ground
GroundType
Dry Peat
Ground Conductivity
0.17000 W/m-K
Buried Depth
1.0000 m
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
OK
Ignored

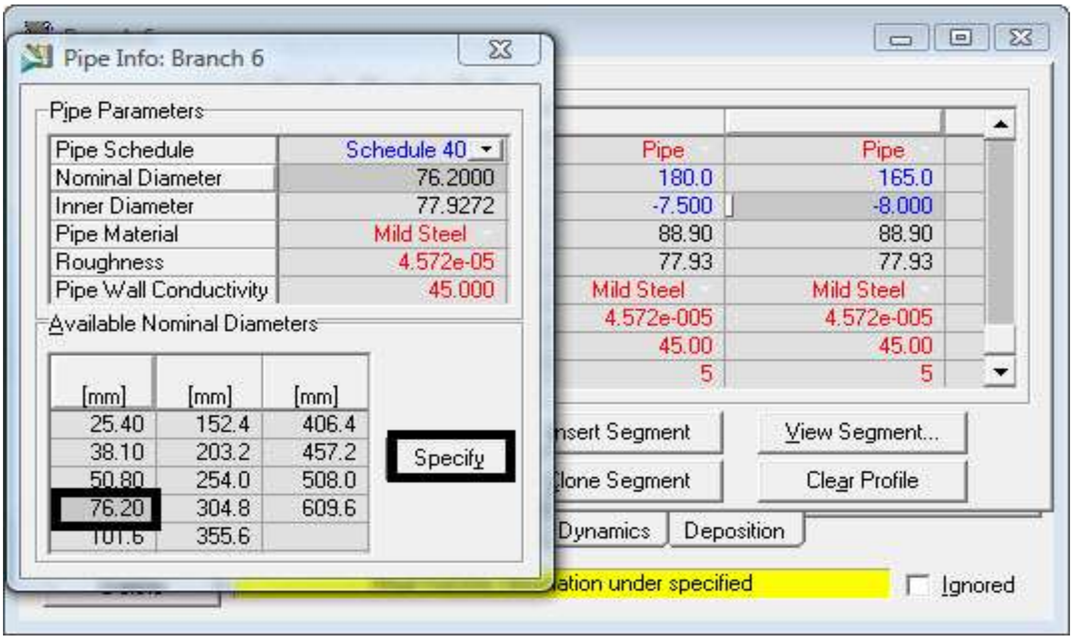

Junction 2
Design
Connections
Parameters
User Variables
Notes
Name
Junction 2
Inlets
B4 Out
B3 Out
<< Stream >>
Outlet
J2 Out
Fluid Package
Basis-1
Design
Rating
Worksheet
Dynamics
Delete
Not Solved
Ignored

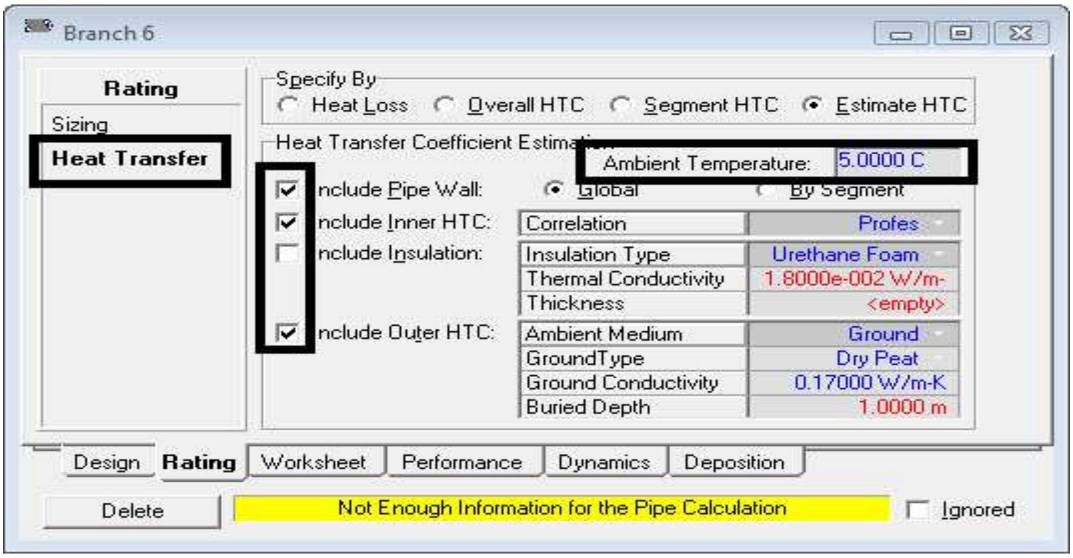

Junction 2
Design
Connections
Parameters
1
User Variables
Notes
Automatic Pressure Assignment
2
Equalize All
Set Outlet to Lowest Inlet
Design
Rating
Worksheet
Dynamics
Delete
OK
Ignored


Branch 5
Design
Connections
Parameters
Calculation
User Variables
Notes
Name: Branch 5
Inlet
J2 Out
Outlet
B5 Out
Fluid Package
Basis-1
Energy
B5 Q
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
No Segment Added
Ignored

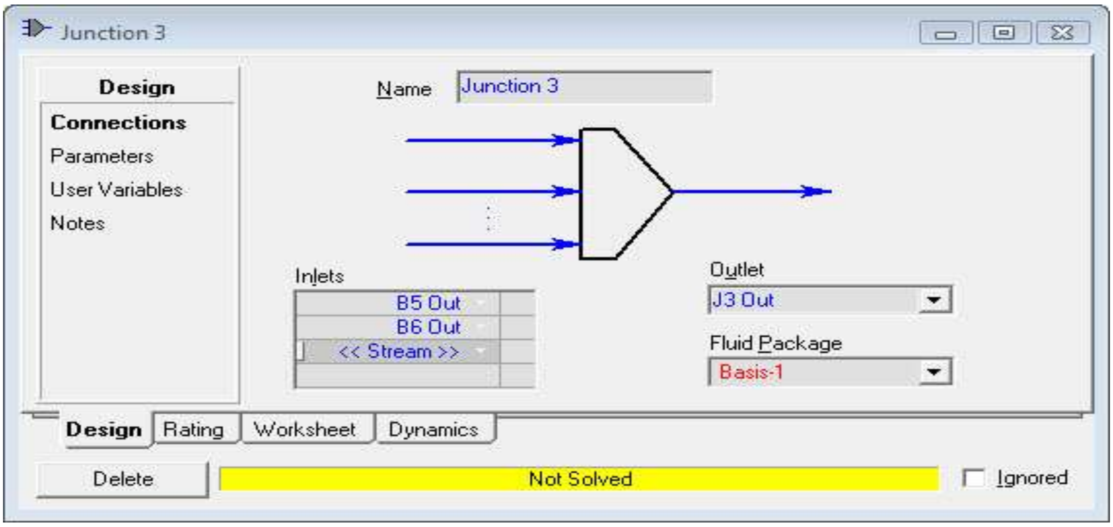

Pipe Info: Branch 5
Pipe Parameters
Pipe Schedule
Schedule 40
Nominal Diameter
<empty>
Inner Diameter
<empty>
Pipe Material
Mild Steel
Roughness
4.572e-05
Pipe Wall Conductivity
45.000
Available Nominal Diameters
[mm]
[mm]
[mm]
25.40
152.4
406.4
38.10
203.2
457.2
50.80
254.0
508.0
76.20
304.8
609.6
101.6
355.6
Specify
300.0
-16.00
View Segment...
Clear Profile
Deposition
Ignored

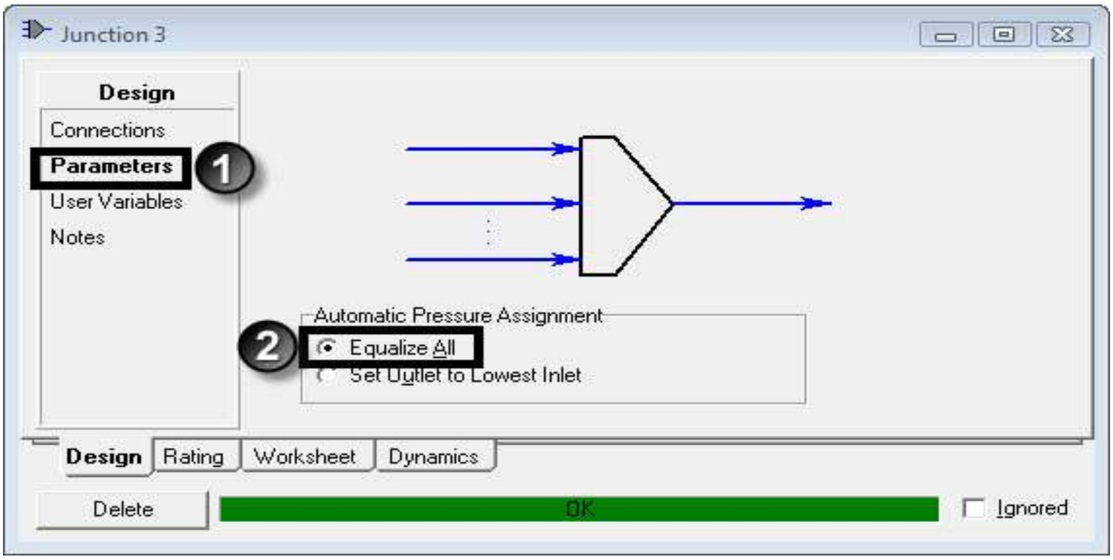

Branch 6
Design
Connections
Parameters
Calculation
User Variables
Notes
Name: Branch 6
Inlet
GasWell D
Outlet
B6 Out
Fluid Package
Basis-1
Energy
B6 Q
Design Rating Worksheet Performance Dynamics Deposition
Delete
No Segment Added
Ignored


Pipe Info: Branch 6
Pipe Parameters
Pipe Schedule Schedule 40
Nominal Diameter 76.2000
Inner Diameter 77.9272
Pipe Material Mild Steel
Roughness 4.572e-05
Pipe Wall Conductivity 45.000
Available Nominal Diameters
[mm] [mm] [mm]
25.40 152.4 406.4
38.10 203.2 457.2
50.80 254.0 508.0
76.20 304.8 609.6
101.6 355.6
Specify
Pipe Pipe
180.0 165.0
-7.500 -8.000
88.90 88.90
77.93 77.93
Mild Steel Mild Steel
4.572e-005 4.572e-005
45.00 45.00
5 5
View Segment...
Clear Profile
Dynamics Deposition
Ignored

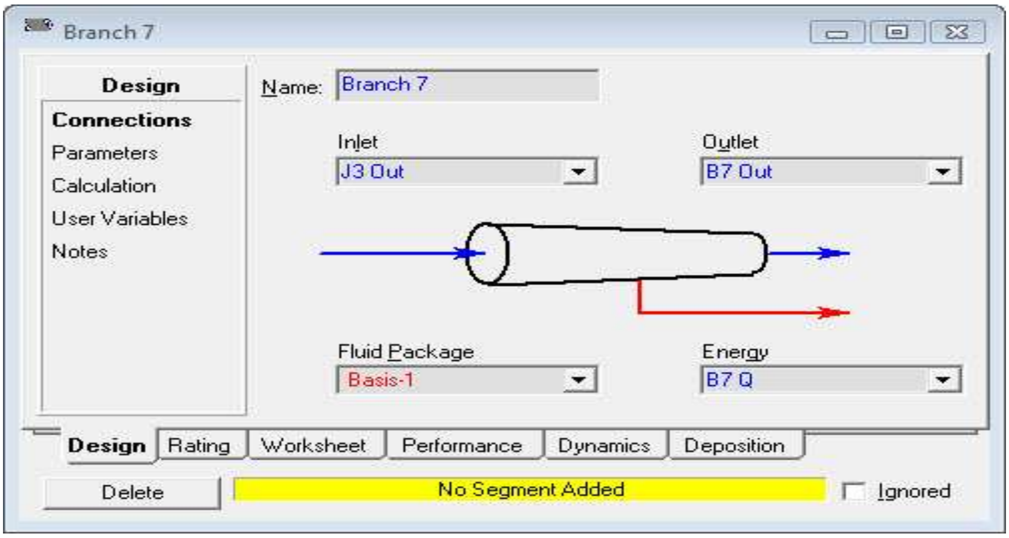

Branch 6
Rating
Sizing
Heat Transfer
Specify By
Heat Loss
Overall HTC
Segment HTC
Estimate HTC
Ambient Temperature: 5.0000 C
Include Pipe Wall:
Global
By Segment
Include Inner HTC:
Correlation Profes
Include Insulation:
Insulation Type Urethane Foam
Thermal Conductivity 1.8000e-002 W/m-
Thickness <empty>
Include Outer HTC:
Ambient Medium Ground
GroundType Dry Peat
Ground Conductivity 0.17000 W/m-K
Buried Depth 1.0000 m
Design Rating Worksheet Performance Dynamics Deposition
Delete
Not Enough Information for the Pipe Calculation
Ignored

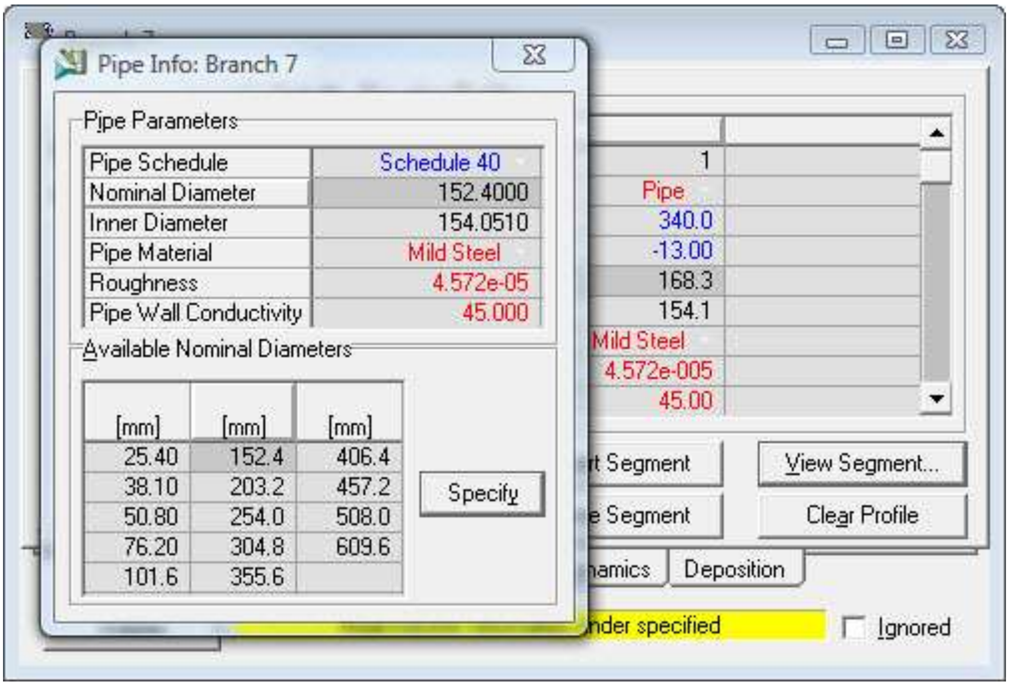
Mix the outlet from both branch 5 & branch 6

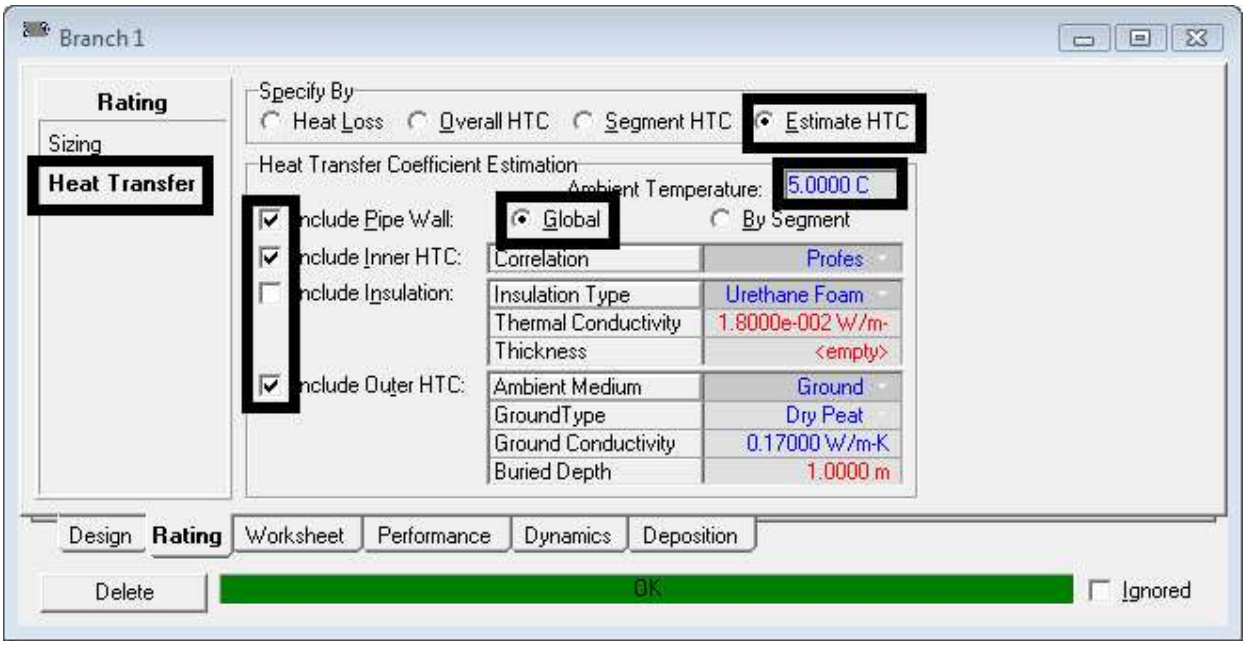


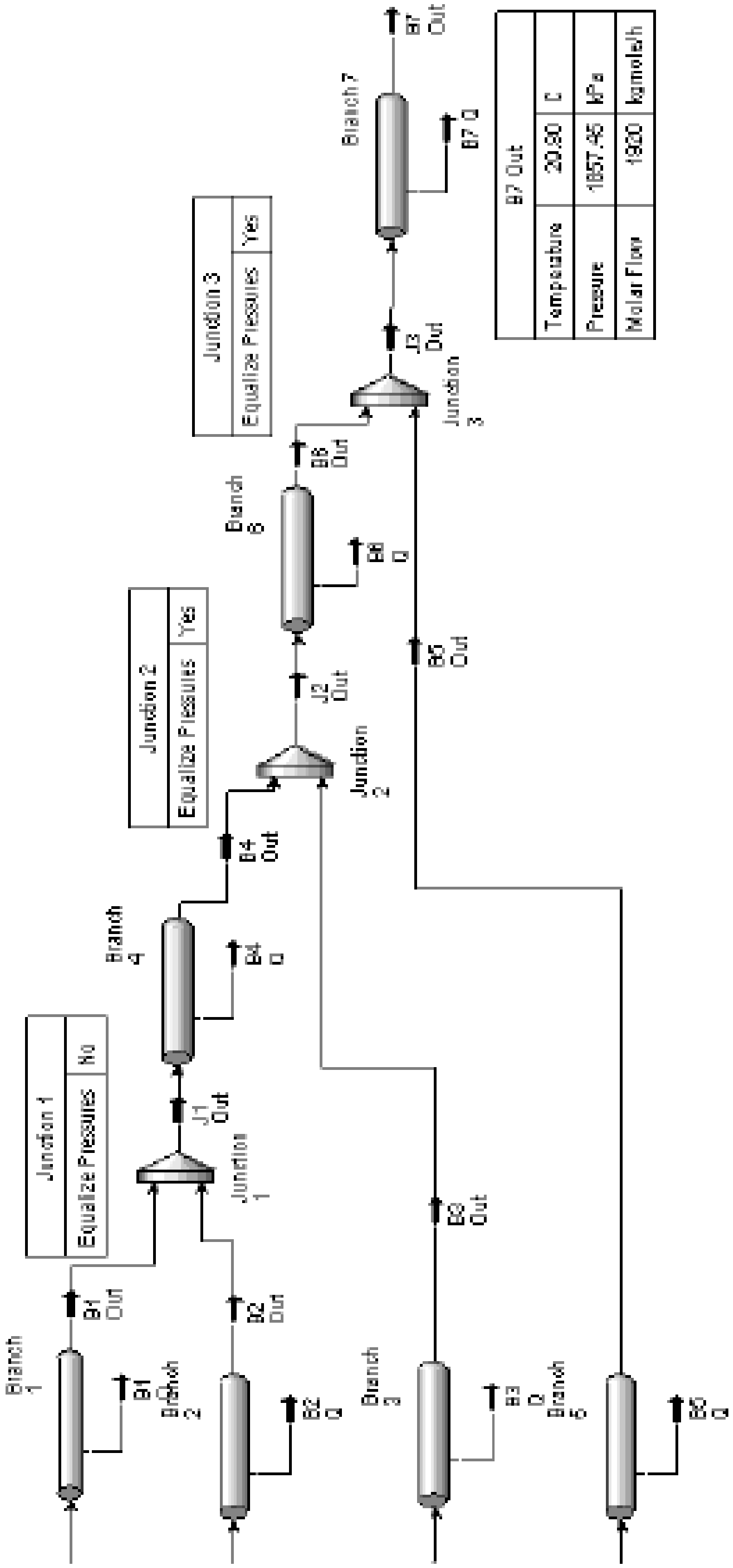


The last branch

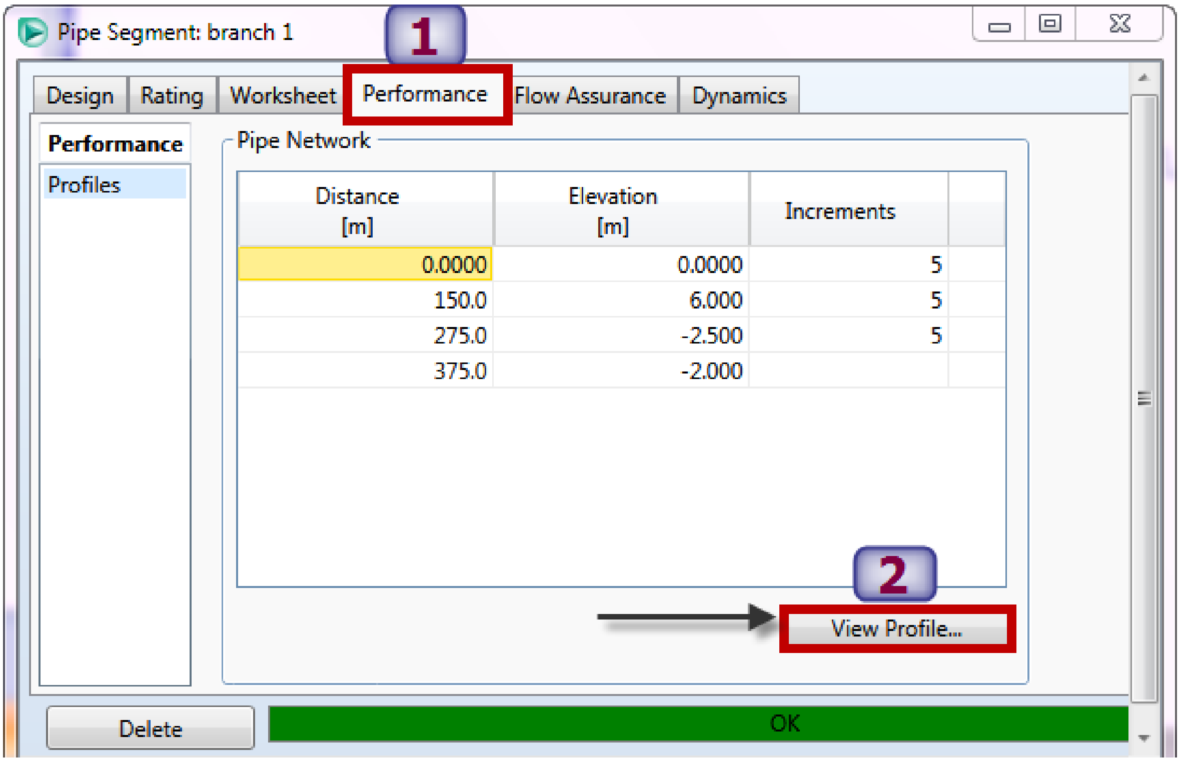


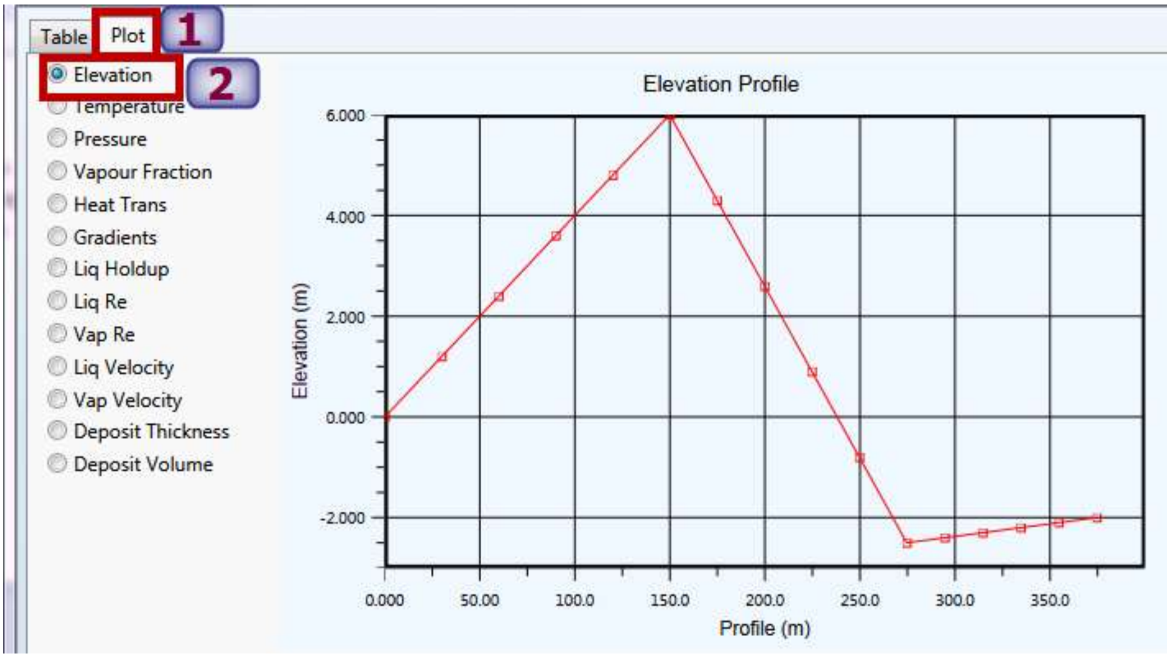

Pipe Info: Branch 7
Pipe Parameters
Pipe Schedule
Schedule 40
Nominal Diameter
152.4000
Inner Diameter
154.0510
Pipe Material
Mild Steel
Roughness
4.572e-05
Pipe Wall Conductivity
45.000
Available Nominal Diameters
[mm]
25.40
38.10
50.80
76.20
101.6
152.4
203.2
254.0
304.8
355.6
406.4
457.2
508.0
609.6
Specify
View Segment...
Clear Profile
Deposition
Ignored

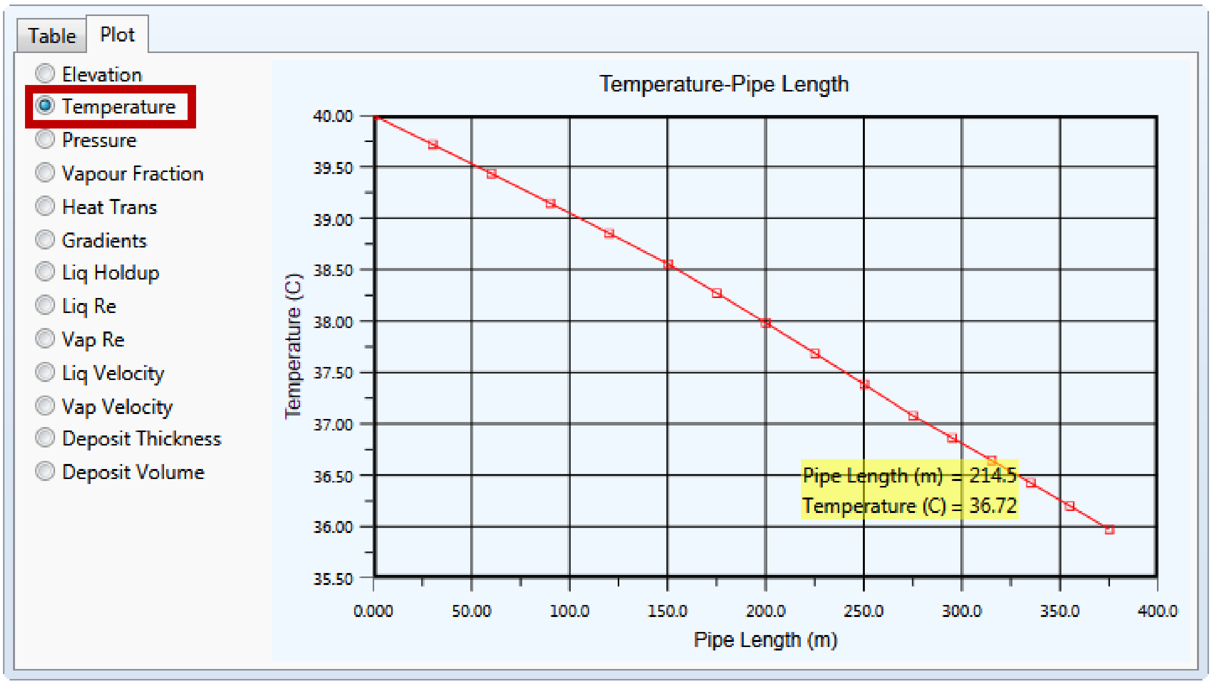

Branch 1
Rating
Sizing
Heat Transfer
Specify By
Heat Loss
Overall HTC
Segment HTC
Estimate HTC
Heat Transfer Coefficient Estimation
Ambient Temperature:
5.0000 C
Include Pipe Wall:
Global
By Segment
Include Inner HTC:
Correlation
Profes
Include Insulation:
Insulation Type
Urethane Foam
Thermal Conductivity
1.8000e-002 W/m-
Thickness
<empty>
Include Outer HTC:
Ambient Medium
Ground
GroundType
Dry Peat
Ground Conductivity
0.17000 W/m-K
Buried Depth
1.0000 m
Design
Rating
Worksheet
Performance
Dynamics
Deposition
Delete
OK
Ignored

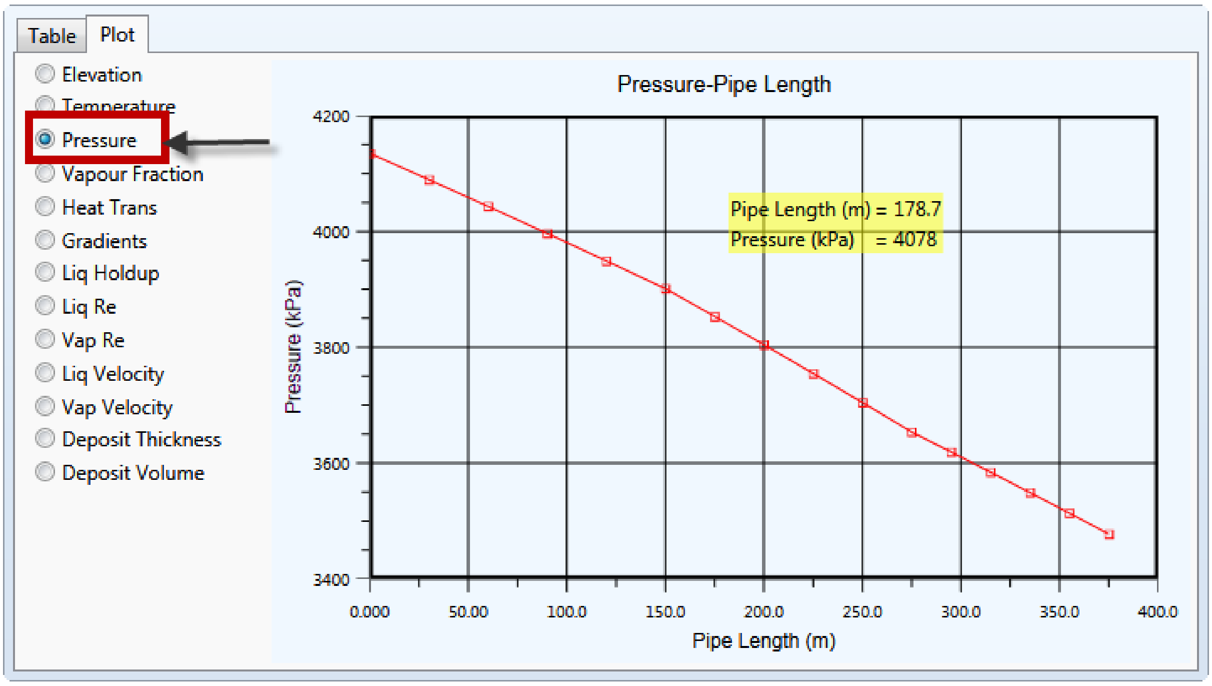

Branch 1
B1 Out
B1 Q
Branch 2
B2 Out
B2 Q
Branch 3
B3 Out
B3 Q
Branch 5
B5 Out
B5 Q
Junction 1
Equalize Pressures
No
J1 Out
Branch 4
B4 Out
B4 Q
Junction 2
Equalize Pressures
Yes
J2 Out
Branch 6
B6 Out
B6 Q
Junction 3
Equalize Pressures
Yes
J3 Out
Branch 7
B7 Out
B7 Q
B7 Out
Temperature
20.80
C
Pressure
1857.45
kPa
Molar Flow
1920
kgmole/h

You can go to the performance tab inside each segment to view the profile

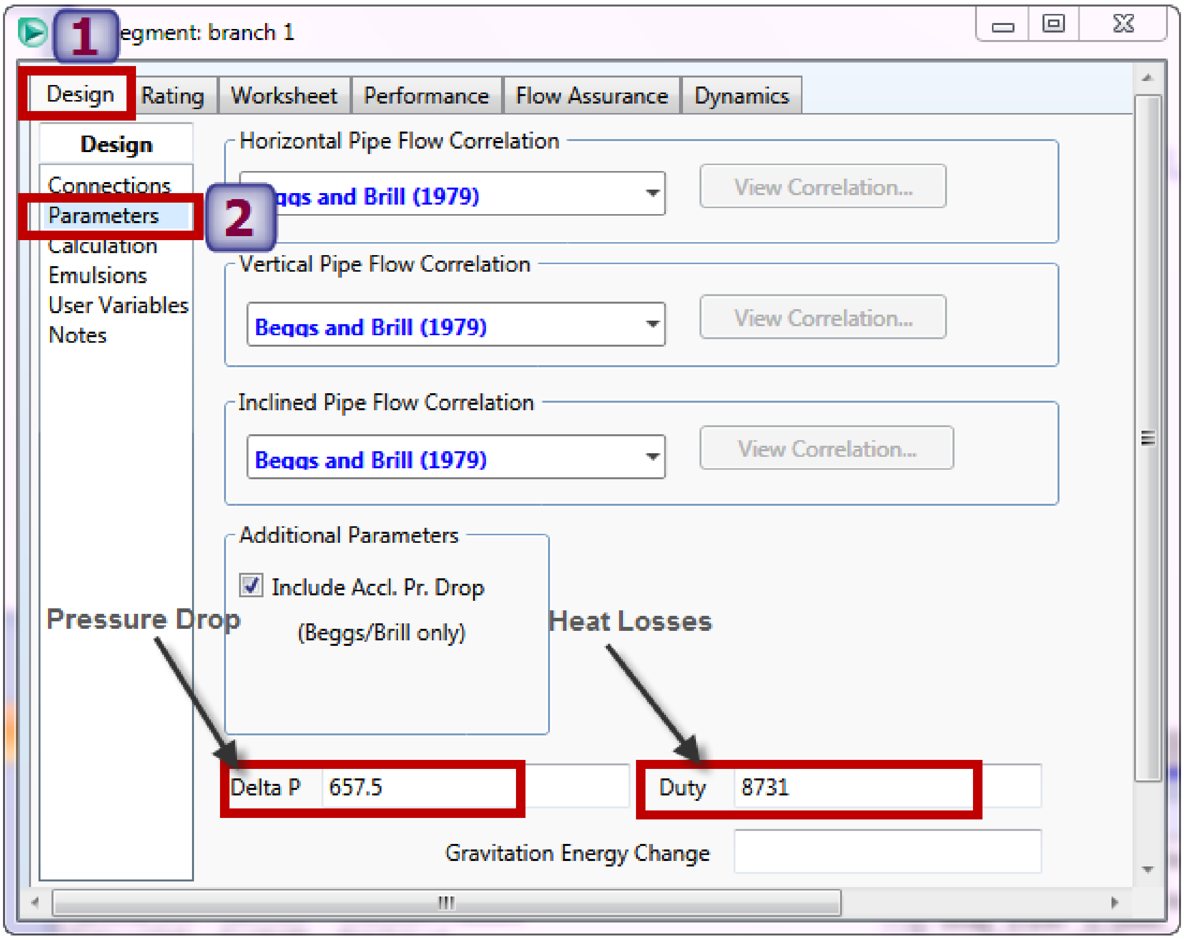








You can also go to the parameters page to see the pressure drop & heat losses inside each branch:



Save Your Case!

NGL Fractionation

9

Workshop

Recovery of natural-gas liquids (NGL) from natural gas is quite common in natural gas processing. Recovery is usually done to:

- *Produce transportable gas (free from heavier hydrocarbons which may condense in the pipeline).*
- *Meet a sales gas specification.*
- *Maximize liquid recovery (when liquid products are more valuable than gas).*

Aspen HYSYS can model a wide range of different column configurations. In this simulation, an NGL Plant will be constructed, consisting of three columns:

- *De-Methanizer (operated and modeled as a Reboiled Absorber column)*
- *De-Ethanizer (Distillation column)*
- *De-Propanizer (Distillation column)*

Learning Objectives

Once you have completed this section, you will be able to:

- *Add columns using the Input Experts.*
- *Add extra specifications to columns.*

NGL Fractionation Train

It's required to process a crude natural gas to remove the heavier hydrocarbons from it thus the composition of it would be suitable for transportation by passing the crude gas which comes from two different wells to three towers: De-Methanizer, De-Ethanizer and De-Propanizer.

The first well at (-140 oF, 330 psia and flow rate of 3575 lbmol/hr) have the following conditions and compositions: (**Fluid Package: Peng Robinson**)

Component	Mol frac	Component	Mol frac
N_2	0.0025	n-C4	0.0085
CO_2	0.0048	i-C5	0.0036
C1	0.7041	n-C5	0.002
C2	0.1921	n-C6	0.0003
C3	0.0706	n-C7	0.0002
i-C4	0.0112	n-C8	0.0001

The second one at (-120 ^{o}F, 332 psia and flow rate of 475 lbmol/hr) have the following conditions and composition

Component	Mol frac	Component	Mol frac
N_2	0.0057	n-C4	0.0197
CO_2	0.0029	i-C5	0.0147
C1	0.7227	n-C5	0.0102
C2	0.1176	n-C6	0.0037
C3	0.075	n-C7	0.0047
i-C4	0.0204	n-C8	0.0027

There's also an energy supplied to the De-Methanizer of (2e6 BTU/hr) which is used to improve the efficiency of the separation.

The De-Methanizer (reboiled absorber) has the following specifications:

- Feed 1 Material Stream enters the column from the top stage inlet

- Feed 2 Material stream enters from the 2nd stage

- Ex-duty Energy Stream enters from the 4th stage

- Number of stages = 10

- Top Stage pressure = 330 psia & Reboiler pressure = 335 psia

- Top Stage temperature = -125^{o}F & Reboiler temperature = 80 ^{o}F

- Ovhd Prod Rate = 2950 lbmole/hr (1338 Kg/hr)

After running the column with the above specifications, the <u>design is then modified to ensure that the overhead molar fraction of the methane is 0.96</u>

Most of methane is removed from the top of the tower and the bottom stream is pumped to 2790 kpa then it enters to the De-Ethanizer (distillation Column) where most of the ethane in the crude is taken as an overhead product then it is processed to use in different applications.

The de-ethanizer has the following specifications:

Connections	
Name	DC2
No. of Stages	14
Inlet Stream/Stage	DC2 Feed/6
Condenser Type	Partial
Overhead Vapour Product	DC2 Ovhd
Overhead Liquid Product	DC2 Dist
Bottoms Liquid Outlet	DC2 Btm
Reboiler Duty Energy Stream	DC2 Reb Q
Condenser Duty Energy Stream	DC2 Cond Q
Pressures	
Condenser	2725 kPa (395 psia)
Condenser Delta P	35 kPa (5 psi)
Reboiler	2792 kPa (405 psia)
Temperature Estimates	
Condenser	-4°C (25°F)
Reboiler	95°C (200°F)
Specifications	
Overhead Vapour Rate	320 kgmole/h (700 lbmole/hr)
Distillate Rate	0 kgmole/h
Reflux Ratio	2.5 (Molar)

After running the column with the above specifications, the design is modified to ensure that the bottom stream has ratio between C_2/C_3 = 0.01

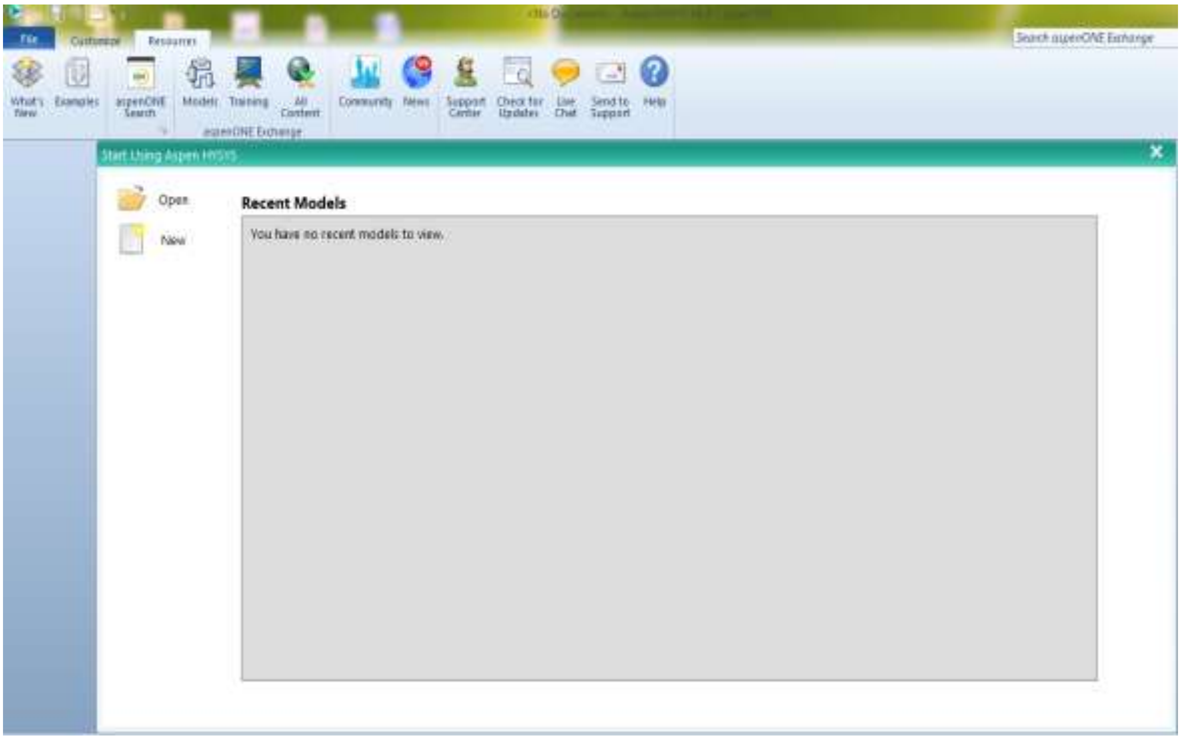
Then the bottom product is sent to a valve where the pressure of it decrease to 1690 kpa, the outlet flow from the valve is sent to a de-propanizer (distillation Column) where most of propane is removed from the top and the heavier hydrocarbons is removed from the bottom

The specifications of the de-propanizer are:

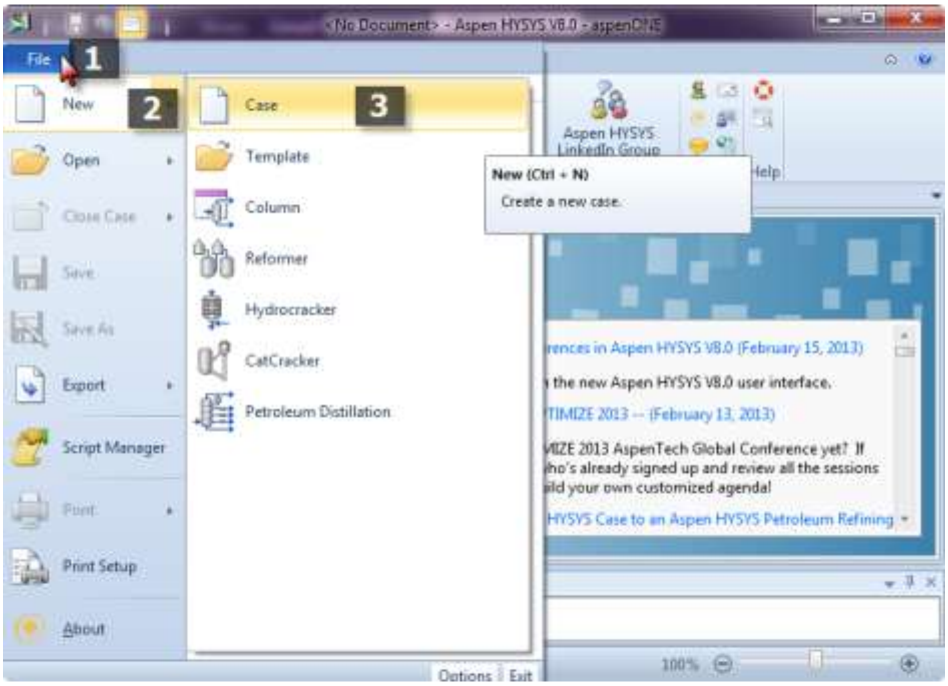
In this cell...	Enter...
Connections	
Name	DC3
No. of Stages	24
Inlet Streams/Stage	DC3 Feed/11
Condenser Type	Total
Ovhd Liquid Outlet	DC3 Dist
Bottom Liquid Outlet	DC3 Btm
Reboiler Duty Energy Stream	DC3 Reb Q
Condenser Duty Energy Stream	DC3 Cond Q
Pressures	
Condenser	1585 kPa (230 psia)
Condenser Delta P	35 kPa (5 psi)
Reboiler	1655 kPa (240 psia)
Temperature Estimates	
Condenser	38°C (100°F)
Reboiler	120°C (250°F)
Specifications	
Liquid Rate	110 kgmole/h (240 lbmole/hr)
Reflux Ratio	1.0 Molar

After running the column with the above specifications, the design is modified to ensure that the overhead molar fraction of the i-C4 & n-C4 =0.15 *AND* propane bottom product molar fraction = 0.02

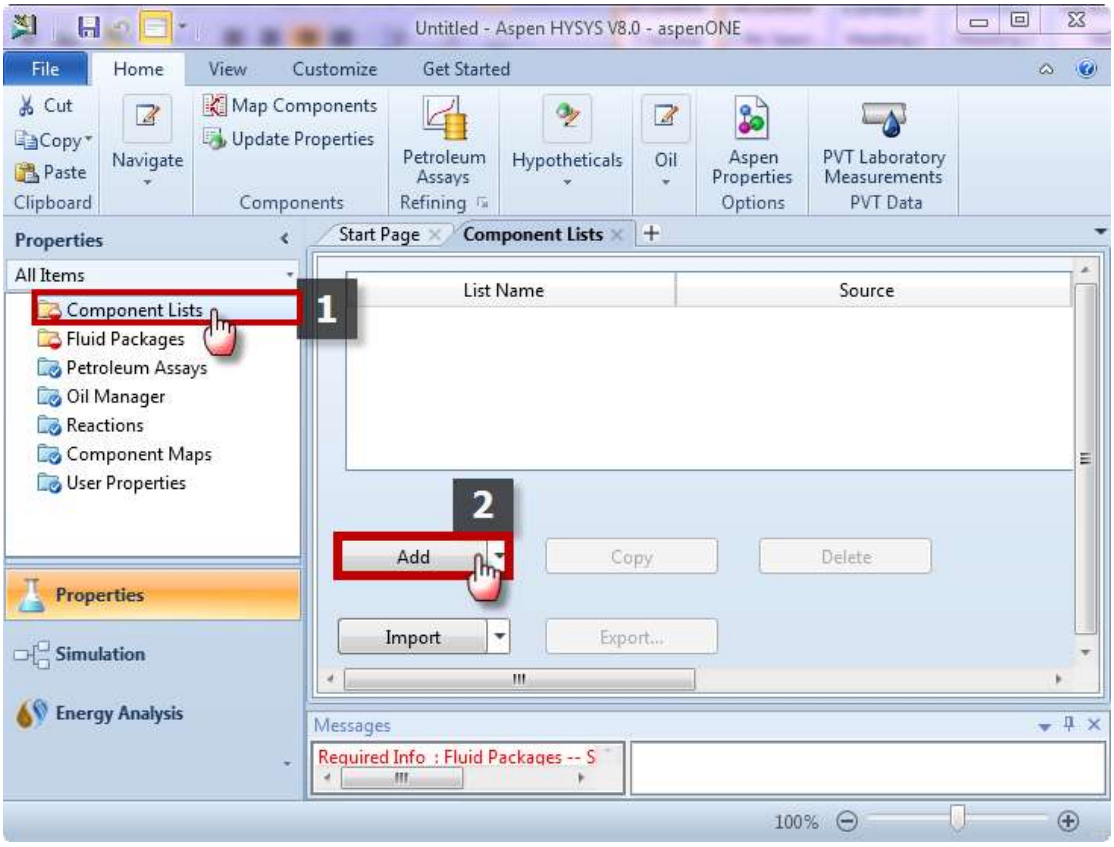
To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8.x >>>> Aspen HYSYS >> Aspen HYSYS



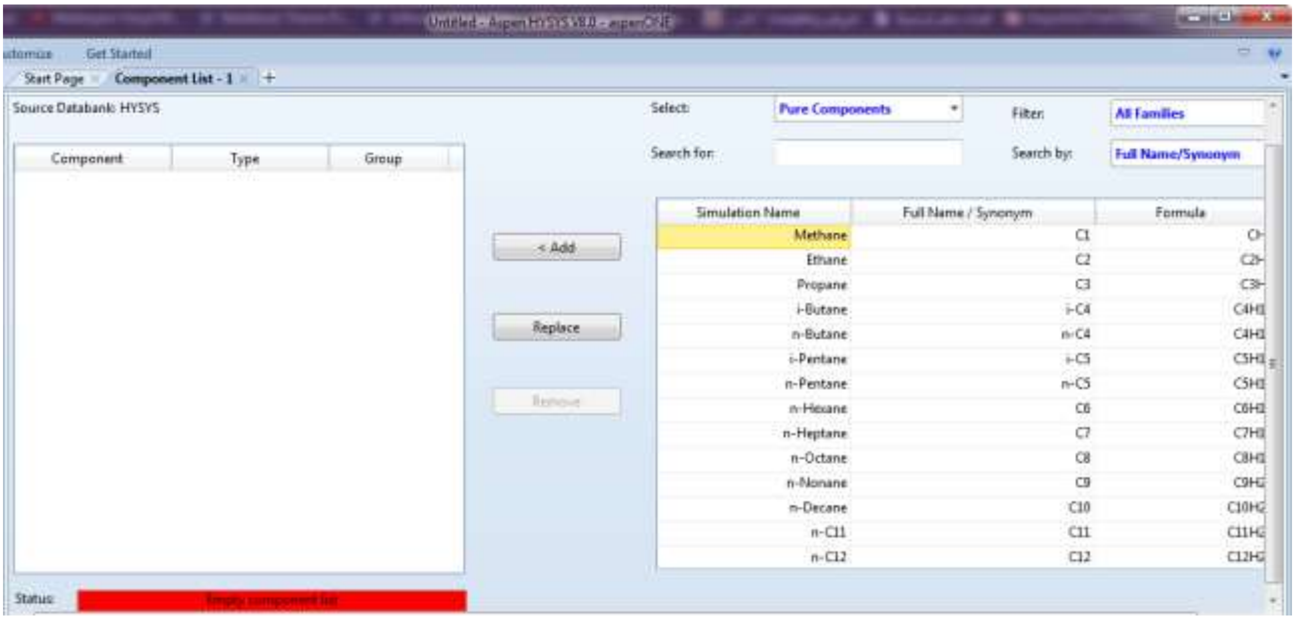
11- First, Start a new case

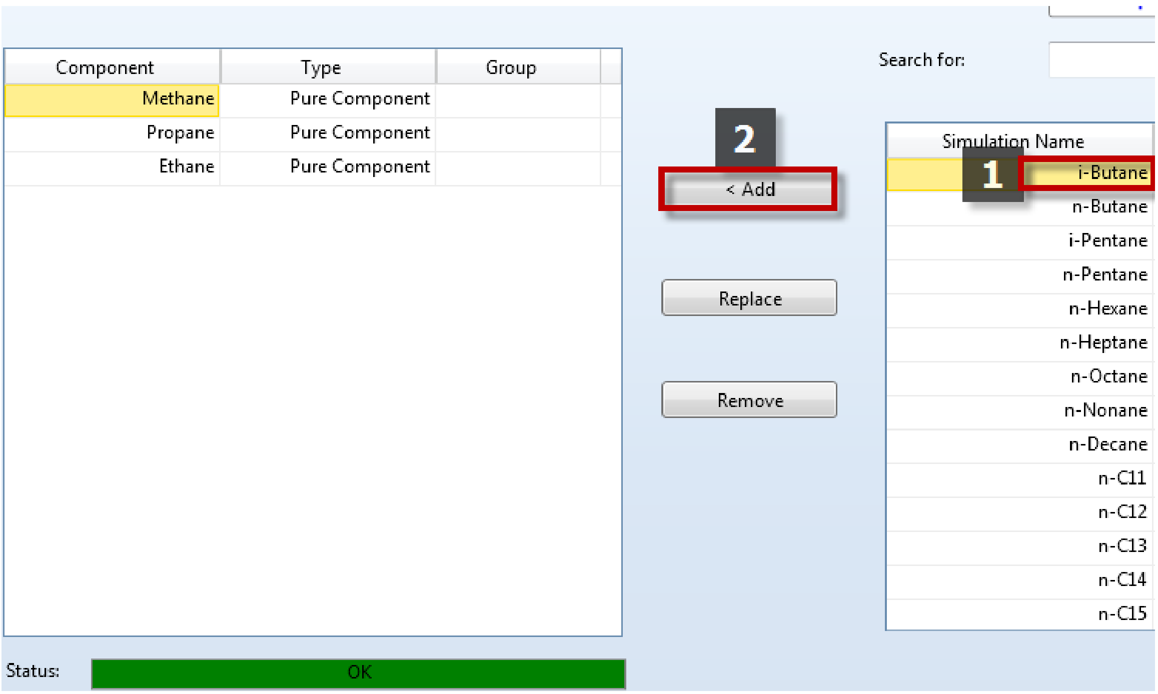


12- Add the Components



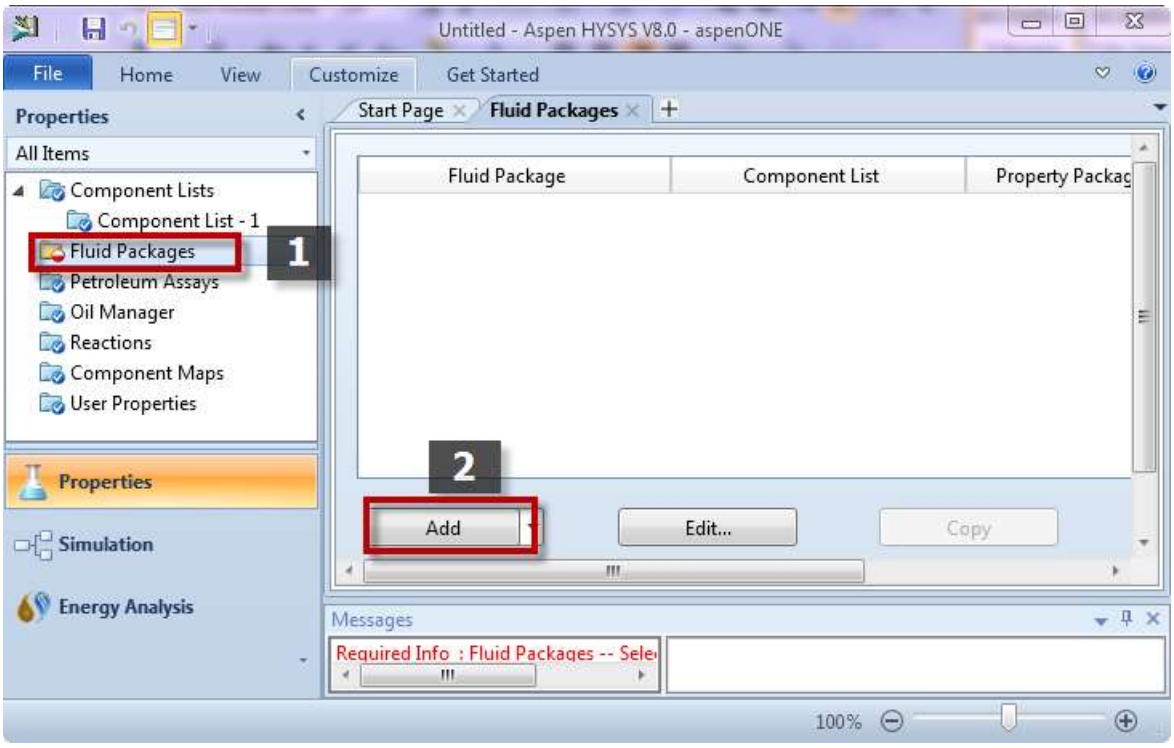
13- Choose the system components from the databank:



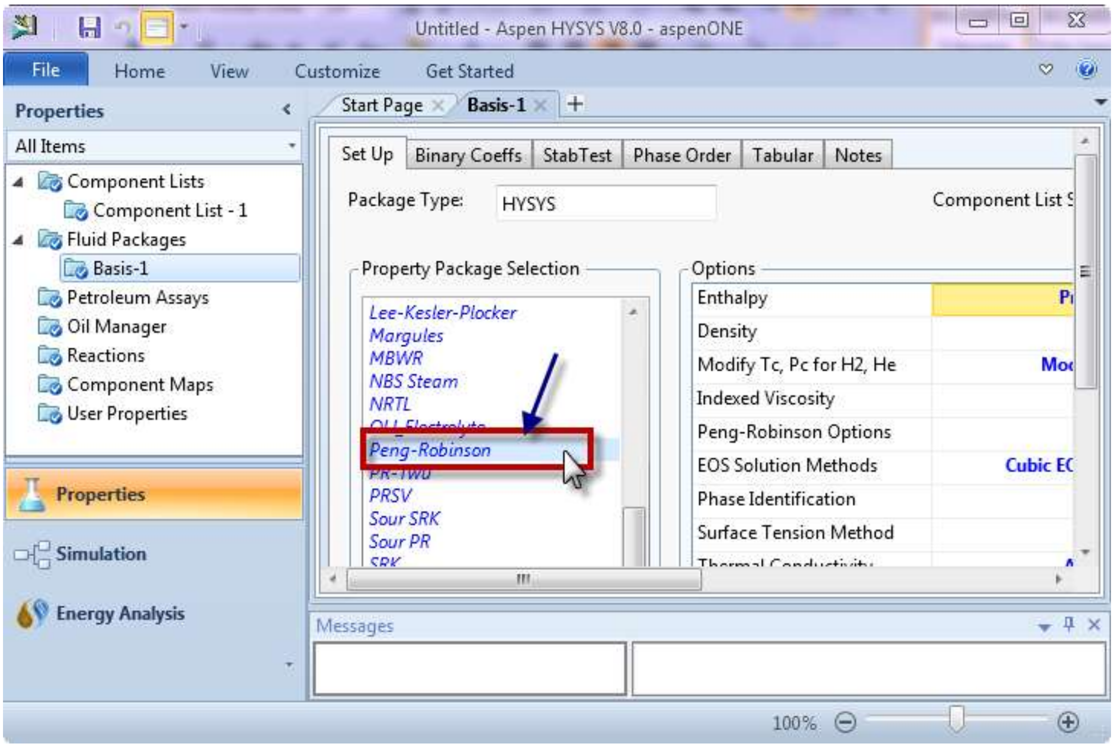


After adding the pure components (N_2, CO_2, C1, C2, C3, n-C4, i-C4, n-C5, i-C5, n-C6, C7, C8)

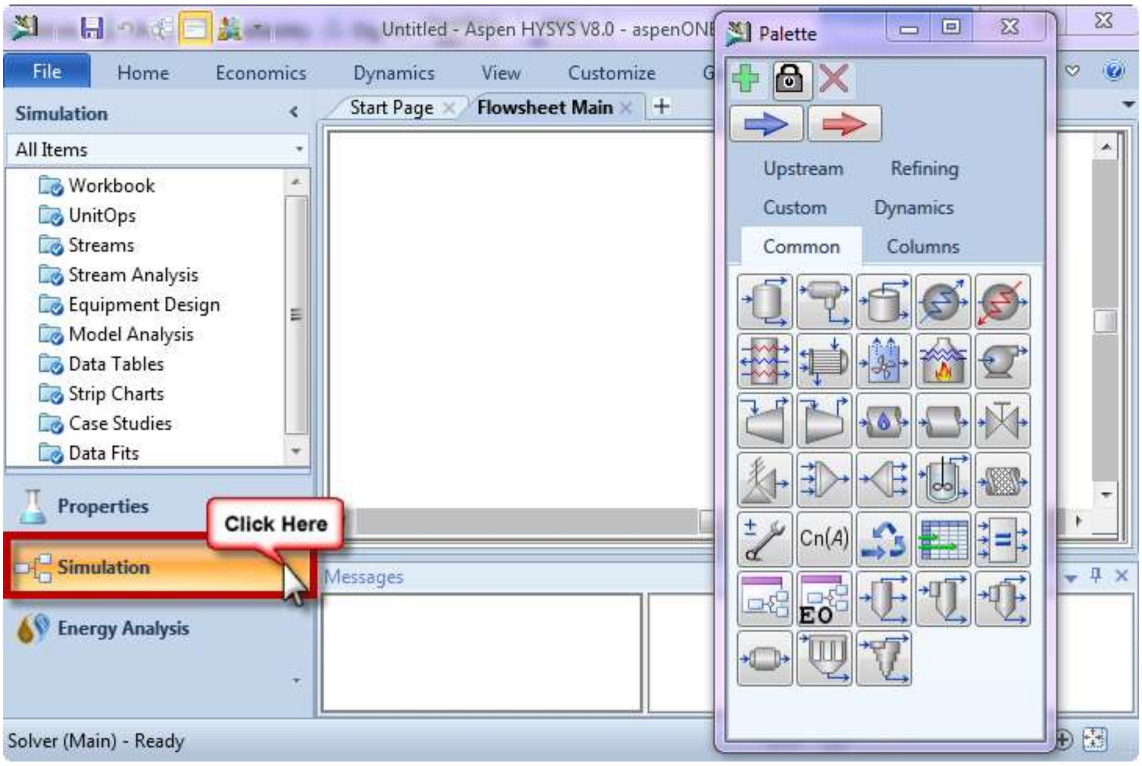
Now, select the suitable fluid package



In this case, select Peng-Robinson

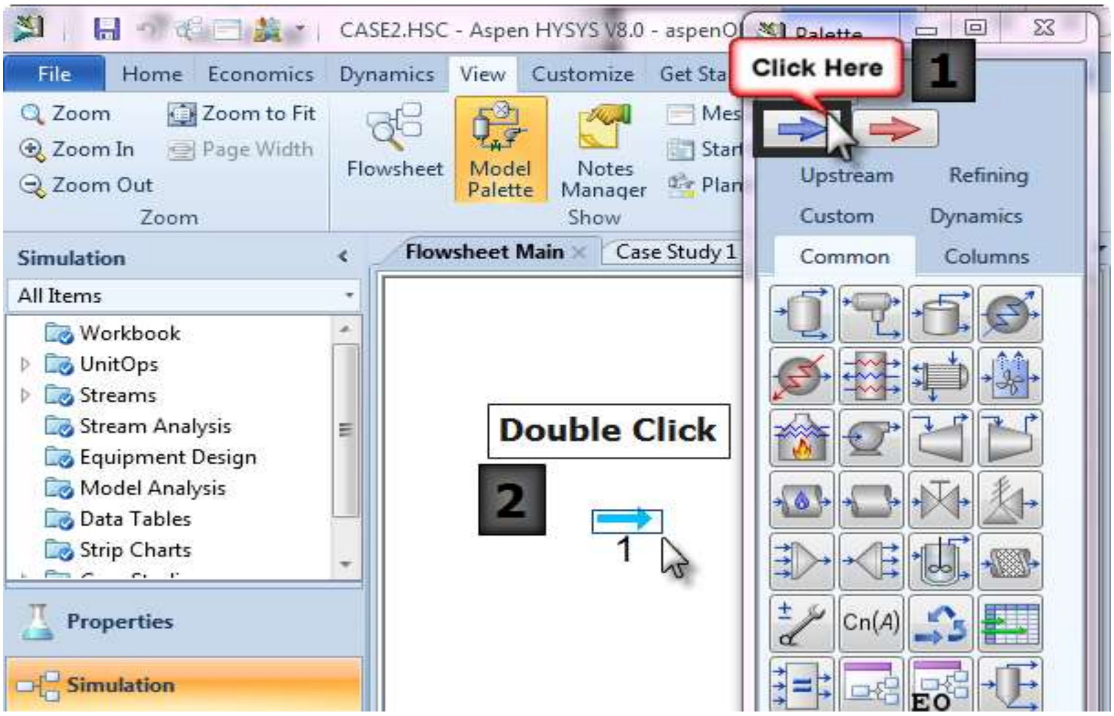


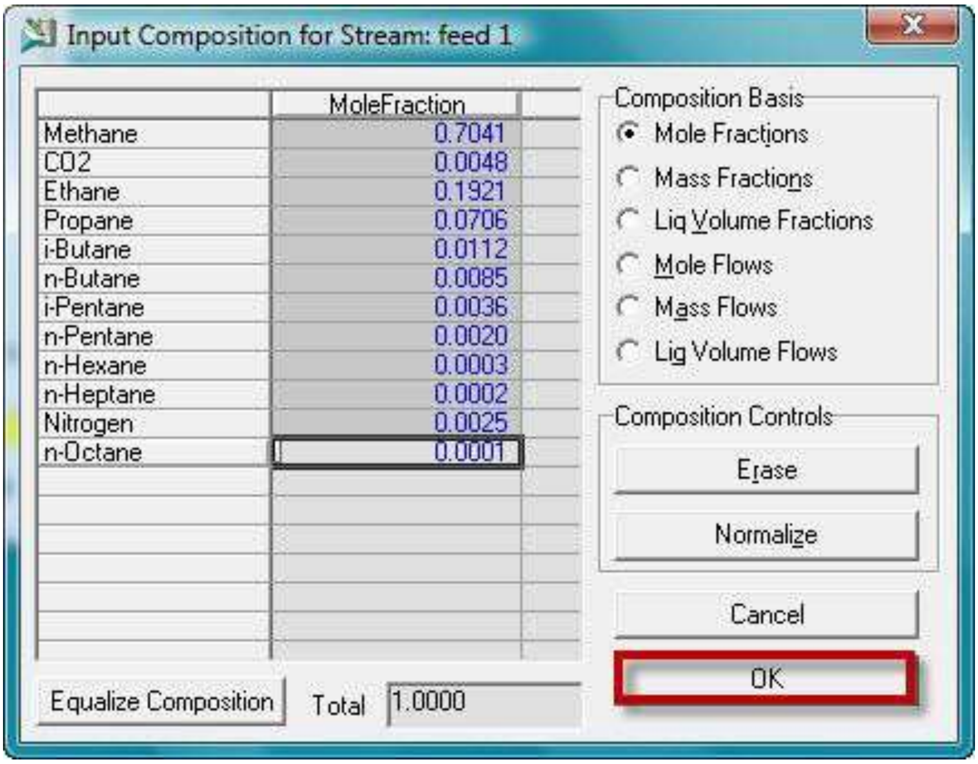
Now you can start drawing the flow sheet for the process by clicking the Simulation button:



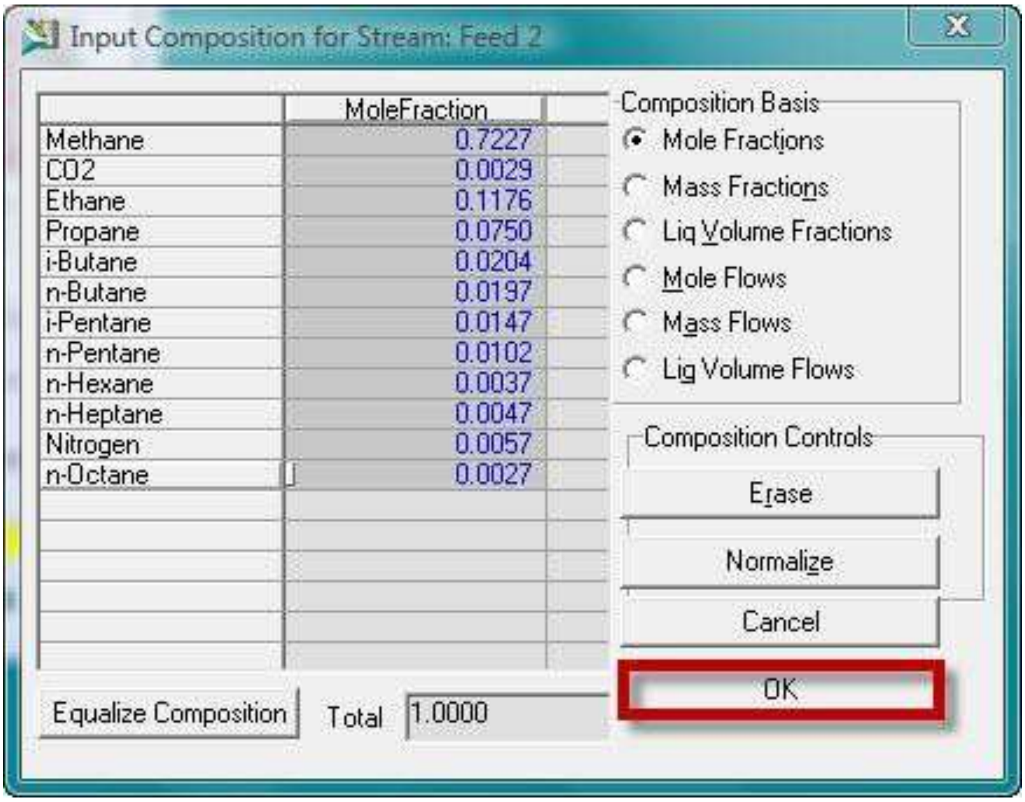
Now add a material stream to define the composition and the conditions of the feed stream

From the palette:





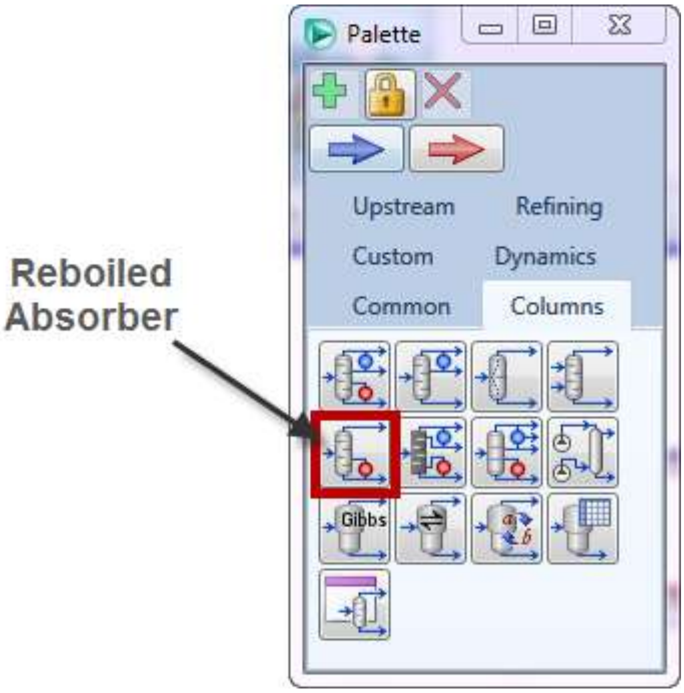
After adding the compositions and the conditions for the first stream, add another stream for feed 2:



PART 1: DE- METHANIZER COLUMN

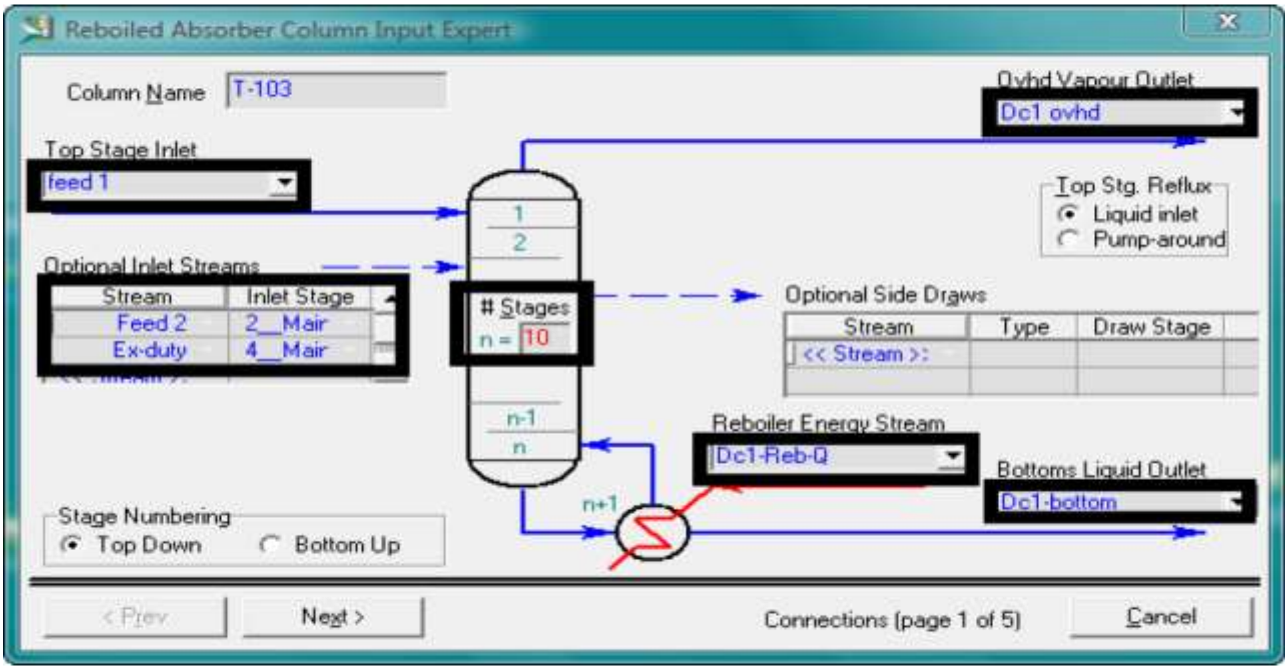
The De-Methanizer is modeled as a reboiled absorber operation, with two feed streams and an energy stream feed, which represents a side heater on the column.

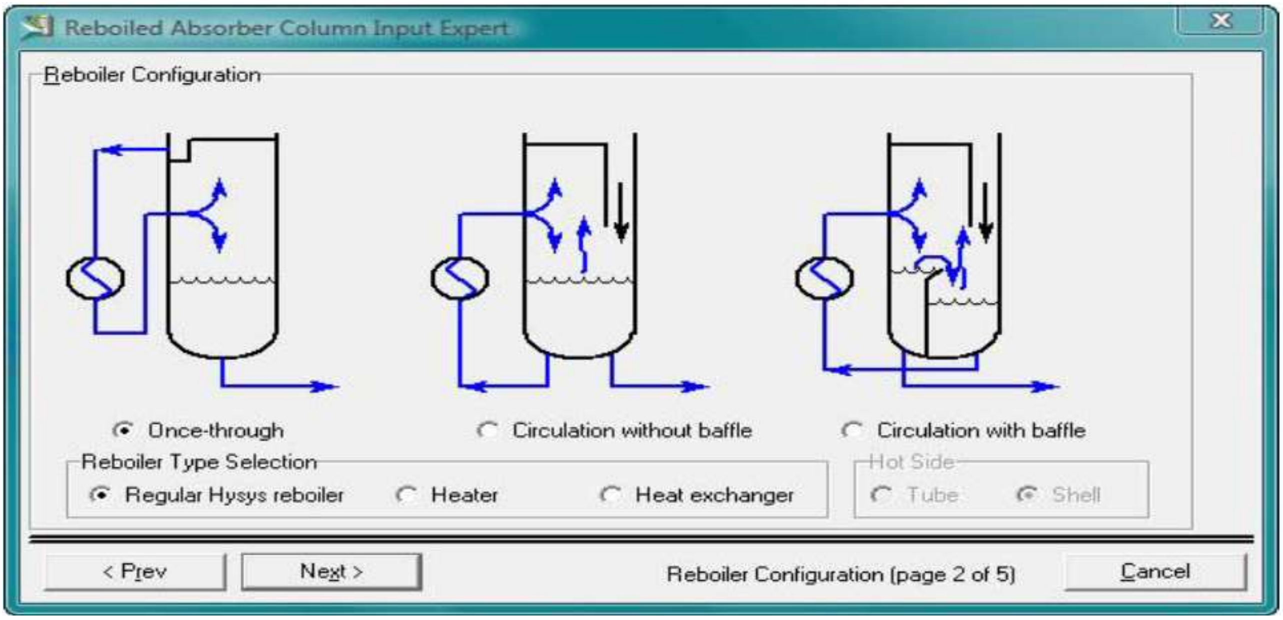
- Add an **Energy** stream with the duty = 2.1 e6 kJ/hr
- Double-click on the **Reboiled Absorber** icon on the Object Palette.

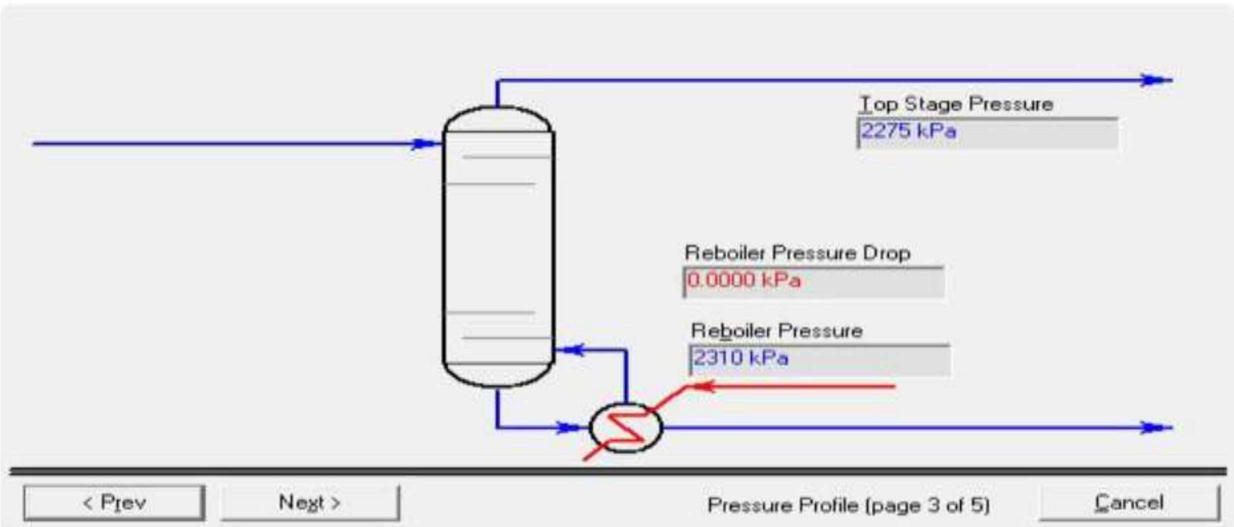


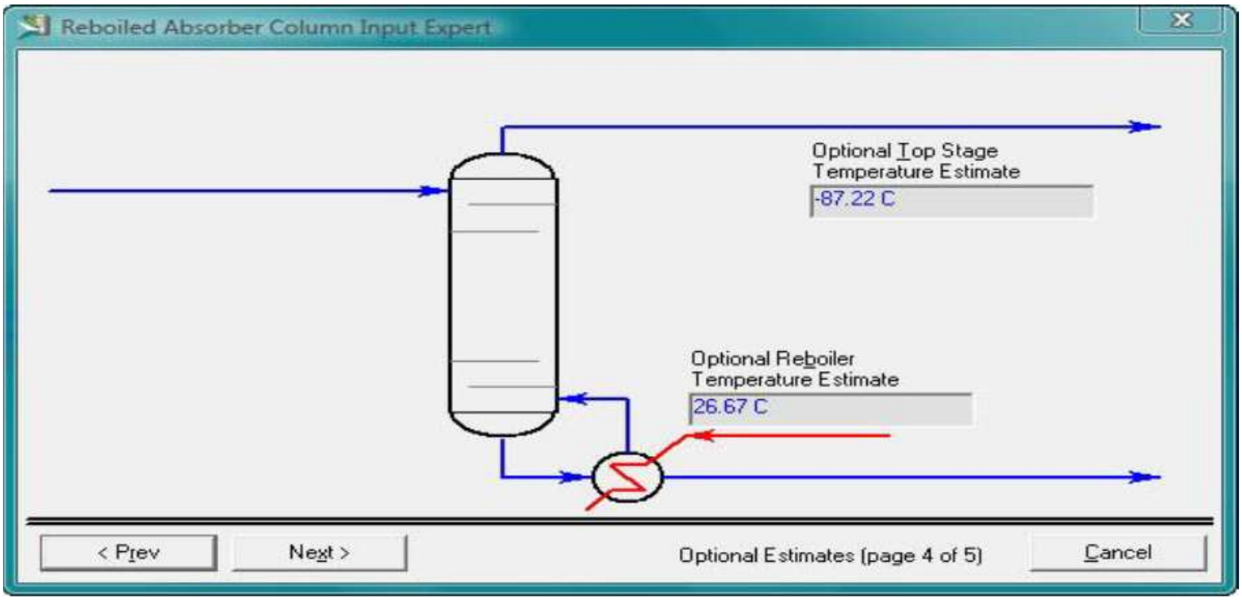
De-Methanizer Specs:

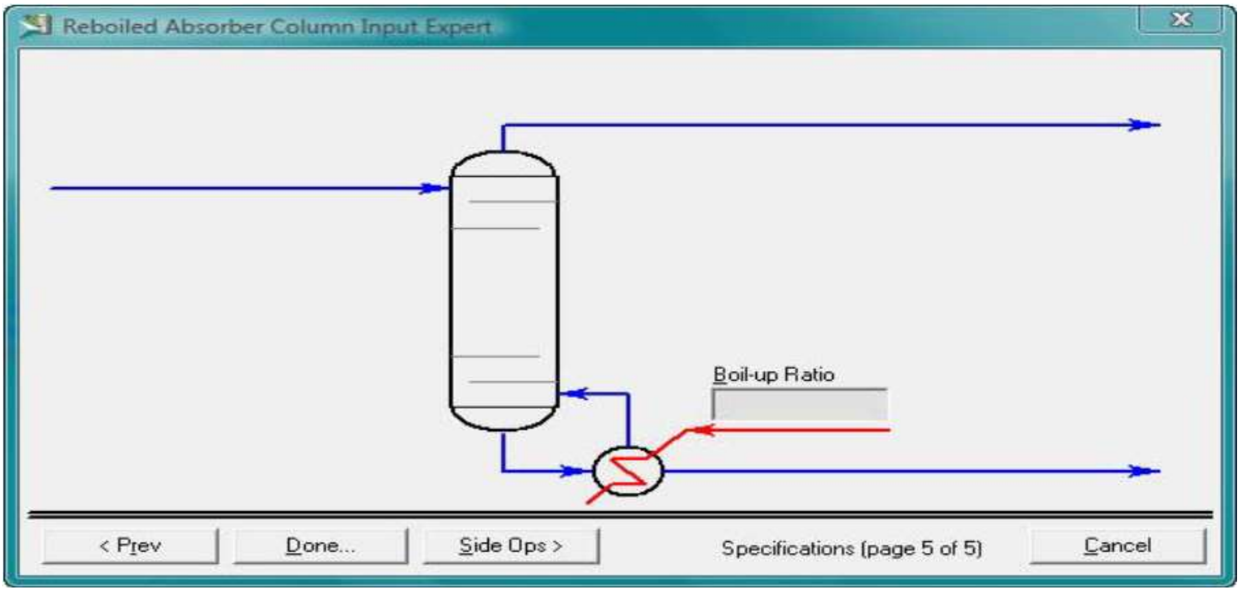
- Feed 1 Material Stream enters the column from the top stage inlet
- Feed 2 Material stream enters from the 2nd stage
- Ex-duty Energy Stream enters from the 4th stage
- Number of stages = 10
- Top Stage pressure = 330 psia
- Reboiler pressure = 335 psia
- Top Stage temperature = -125°F
- Reboiler temperature = 80 °F
- Ovhd Prod Rate = 2950 lbmole/hr (1338 Kg/hr)
- C1 fraction in the Ovhd stream = 0.96

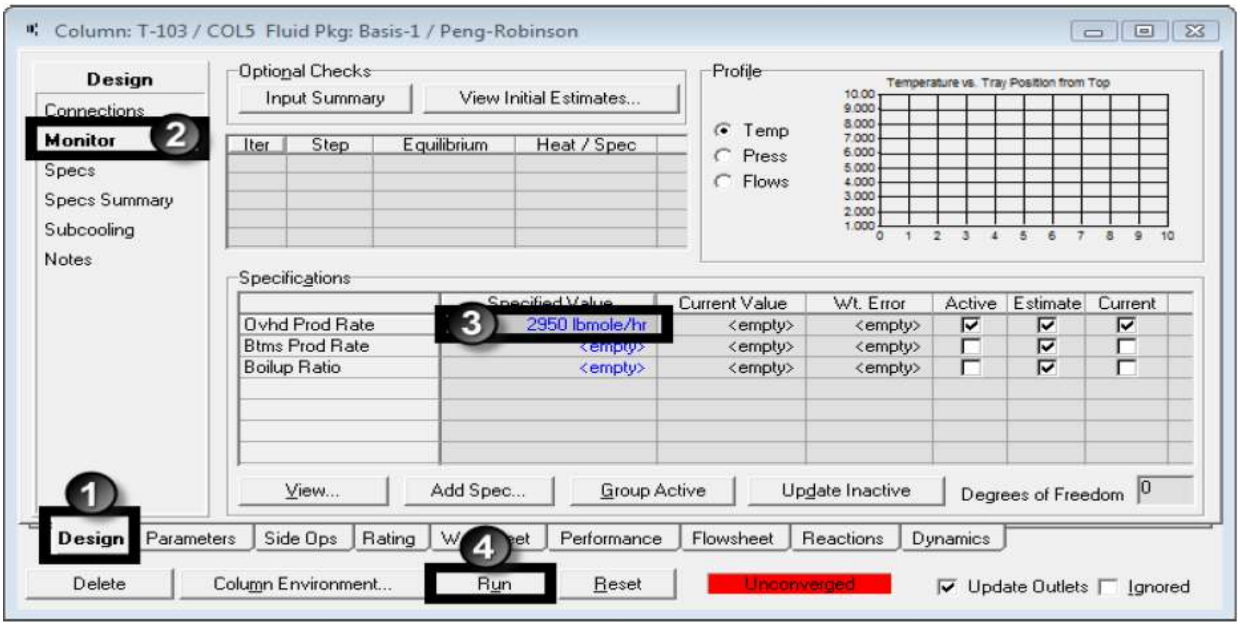

Reboiled Absorber Column Input Expert
Column Name
T-103
Ovhd Vapour Outlet
Dc1 ovhd
Top Stage Inlet
feed 1
Top Stg. Reflux
Liquid inlet
Pump-around
Optional Inlet Streams
Stream
Inlet Stage
Feed 2
2__Main
Ex-duty
4__Main
# Stages
n = 10
Optional Side Draws
Stream
Type
Draw Stage
<< Stream >>
1
2
n-1
n
n+1
Reboiler Energy Stream
Dc1-Reb-Q
Bottoms Liquid Outlet
Dc1-bottom
Stage Numbering
Top Down
Bottom Up
< Prev
Next >
Connections (page 1 of 5)
Cancel


Reboiled Absorber Column Input Expert
Reboiler Configuration
Once-through
Circulation without baffle
Circulation with baffle
Reboiler Type Selection
Regular Hysys reboiler
Heater
Heat exchanger
Hot Side
Tube
Shell
< Prev
Next >
Reboiler Configuration (page 2 of 5)
Cancel


Top Stage Pressure
2275 kPa
Reboiler Pressure Drop
0.0000 kPa
Reboiler Pressure
2310 kPa
< Prev
Next >
Pressure Profile (page 3 of 5)
Cancel

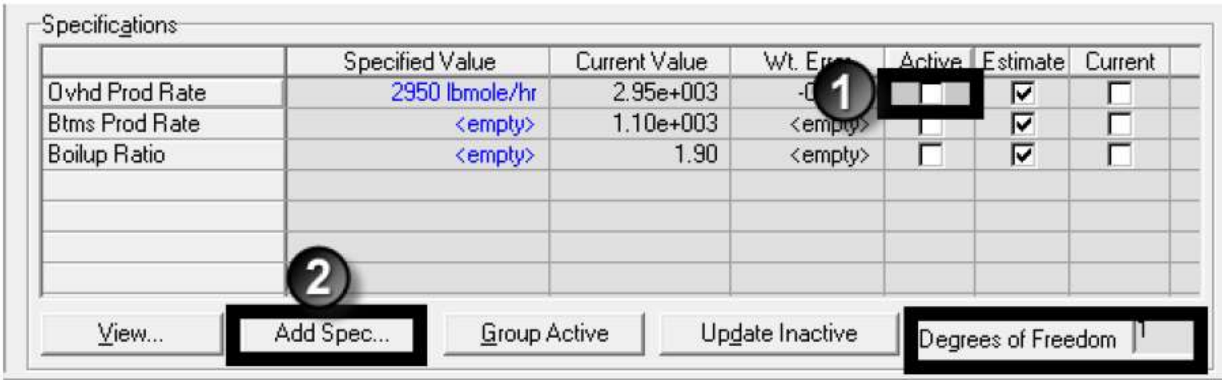

Reboiled Absorber Column Input Expert
Optional Top Stage Temperature Estimate
-87.22 C
Optional Reboiler Temperature Estimate
26.67 C
< Prev
Next >
Optional Estimates (page 4 of 5)
Cancel

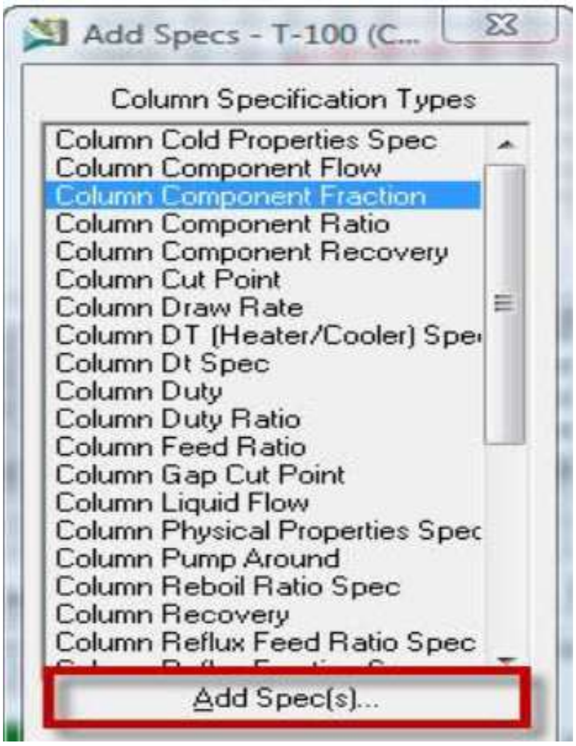

Reboiled Absorber Column Input Expert
Boil-up Ratio
< Prev
Done...
Side Ops >
Specifications (page 5 of 5)
Cancel

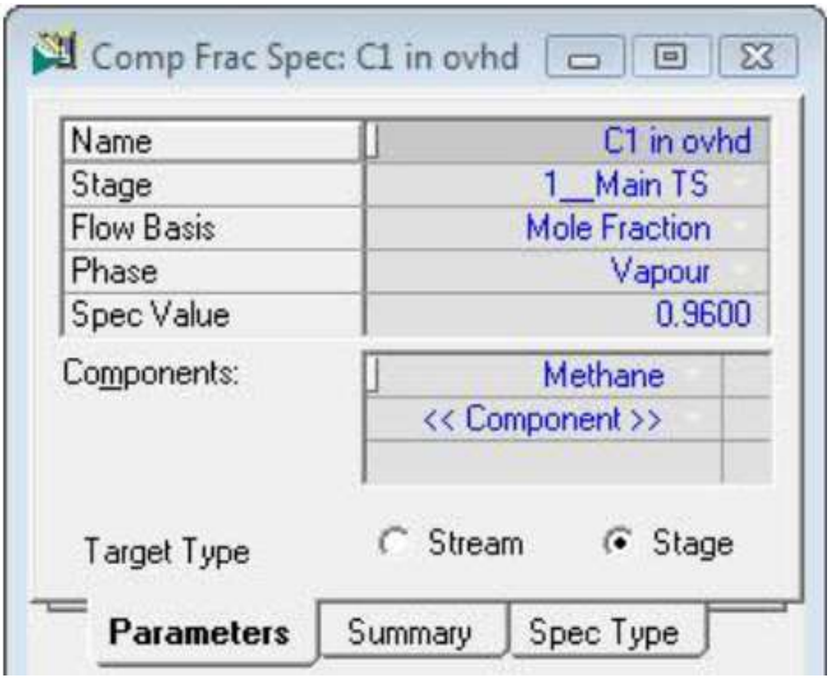

Column: T-103 / COL5 Fluid Pkg: Basis-1 / Peng-Robinson
Design
Connections
Monitor
Specs
Specs Summary
Subcooling
Notes
Optional Checks
Input Summary
View Initial Estimates...
Iter
Step
Equilibrium
Heat / Spec
Profile
Temp
Press
Flows
Temperature vs. Tray Position from Top
Specifications
Specified Value
Current Value
Wt. Error
Active
Estimate
Current
Ovhd Prod Rate
2950 lbmole/hr
Btms Prod Rate
Boilup Ratio
View...
Add Spec...
Group Active
Update Inactive
Degrees of Freedom
0
Design
Parameters
Side Ops
Rating
Performance
Flowsheet
Reactions
Dynamics
Delete
Column Environment...
Run
Reset
Unconverged
Update Outlets
Ignored
1
2
3
4

Although the column is converged, it is not always practical to have flow rate specifications. These specifications can result in columns which cannot be converged or that produce product streams with undesirable properties if the column feed conditions change.

An alternative approach is to specify either component fractions or component recoveries for the column product streams.

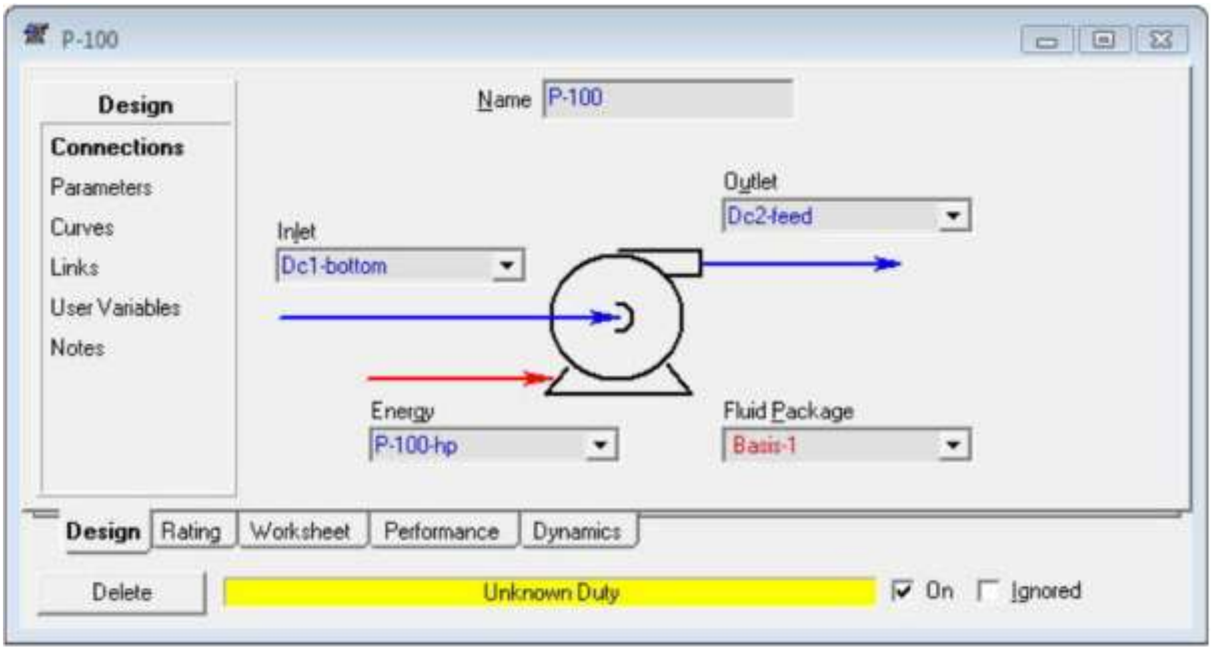




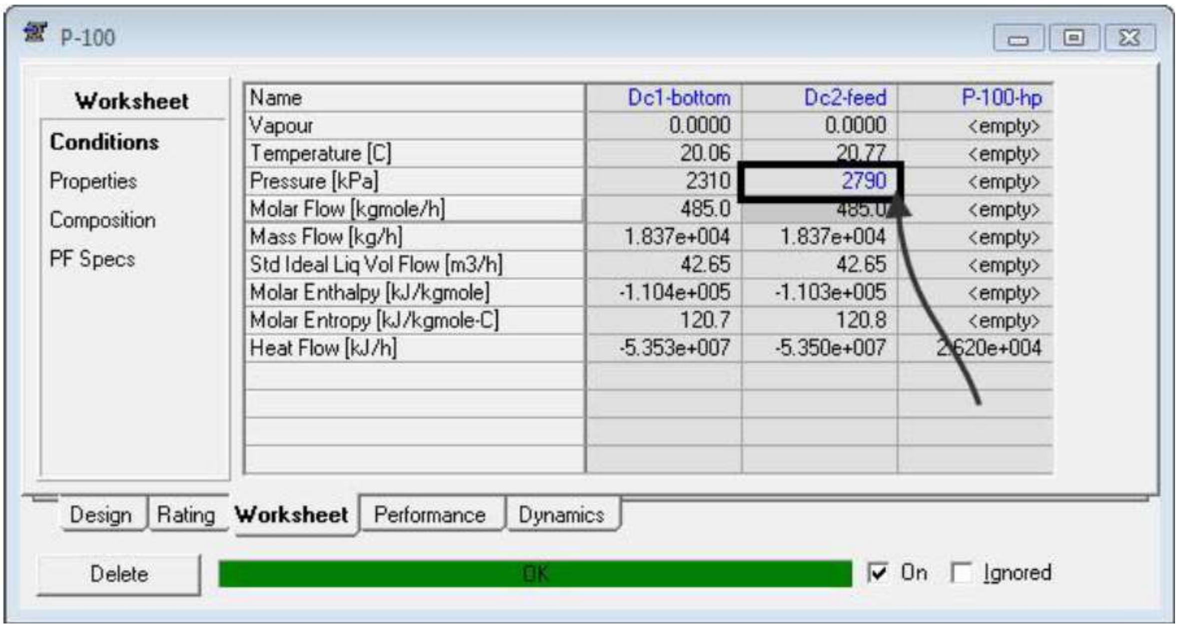


Run the column:

After running the column, add a pump to transfer the bottom liquid to the De-ethanizer:

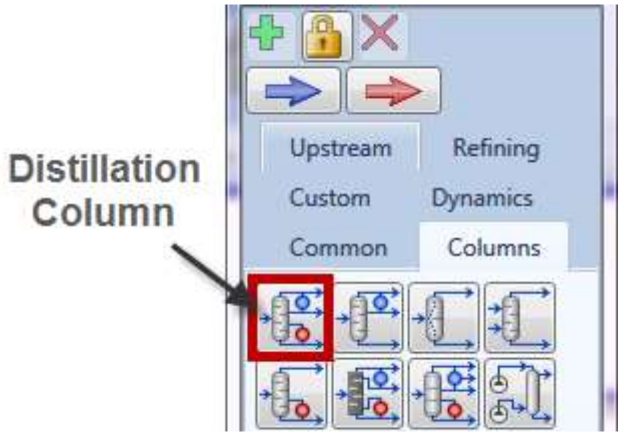


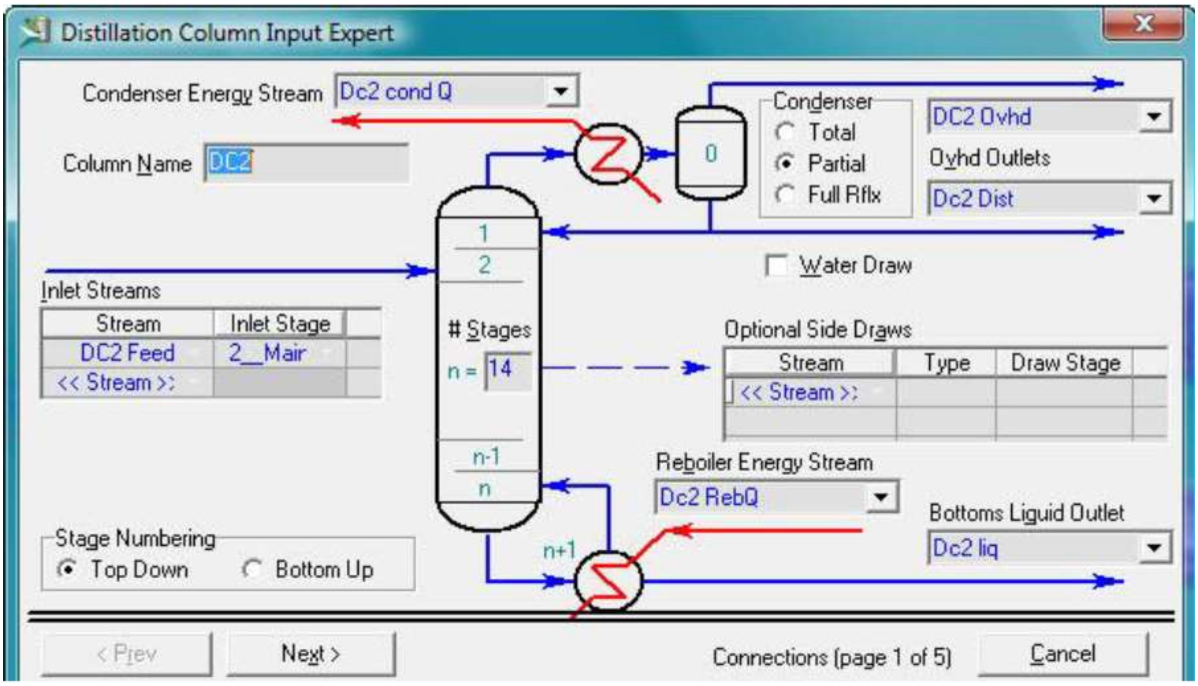
The pump outlet pressure is 2790 kPa (from Worksheet)

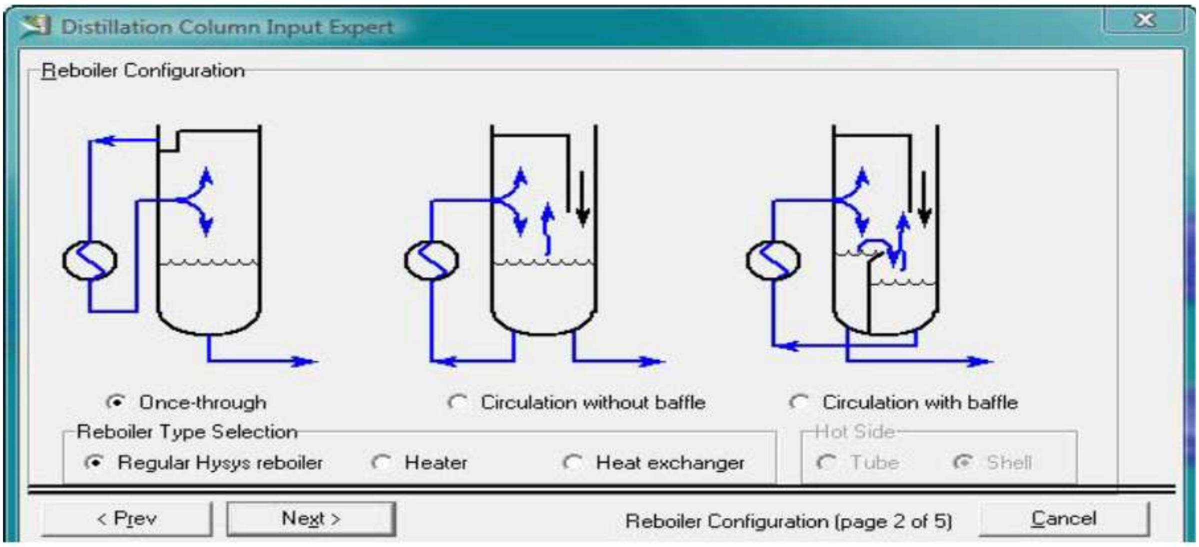


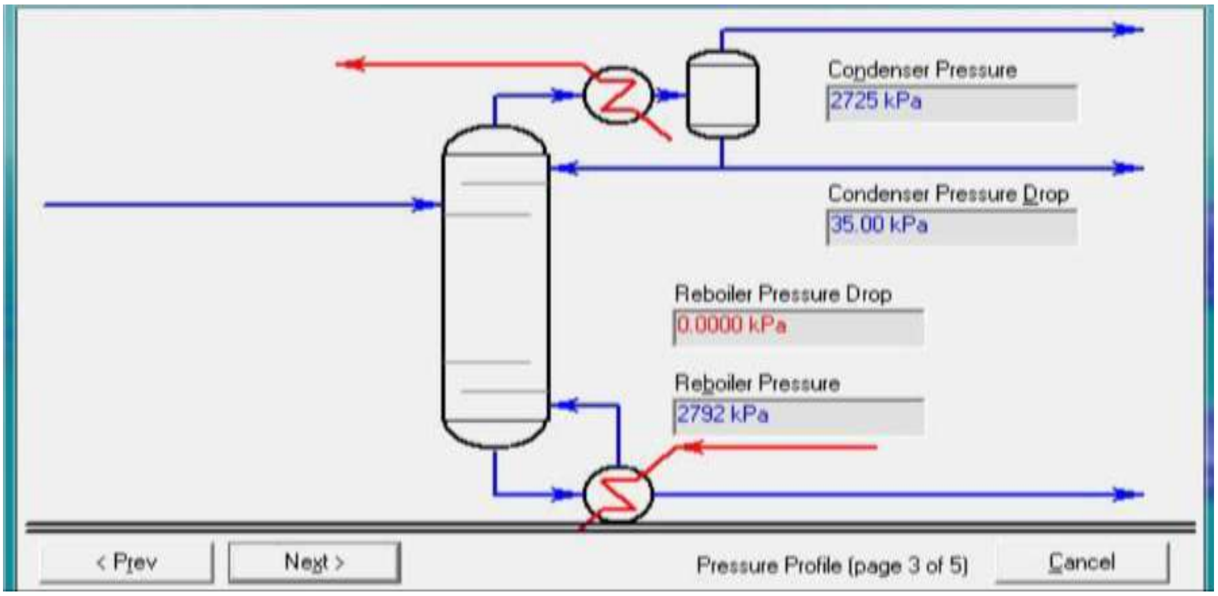
Part 2: De- Ethanizer Column

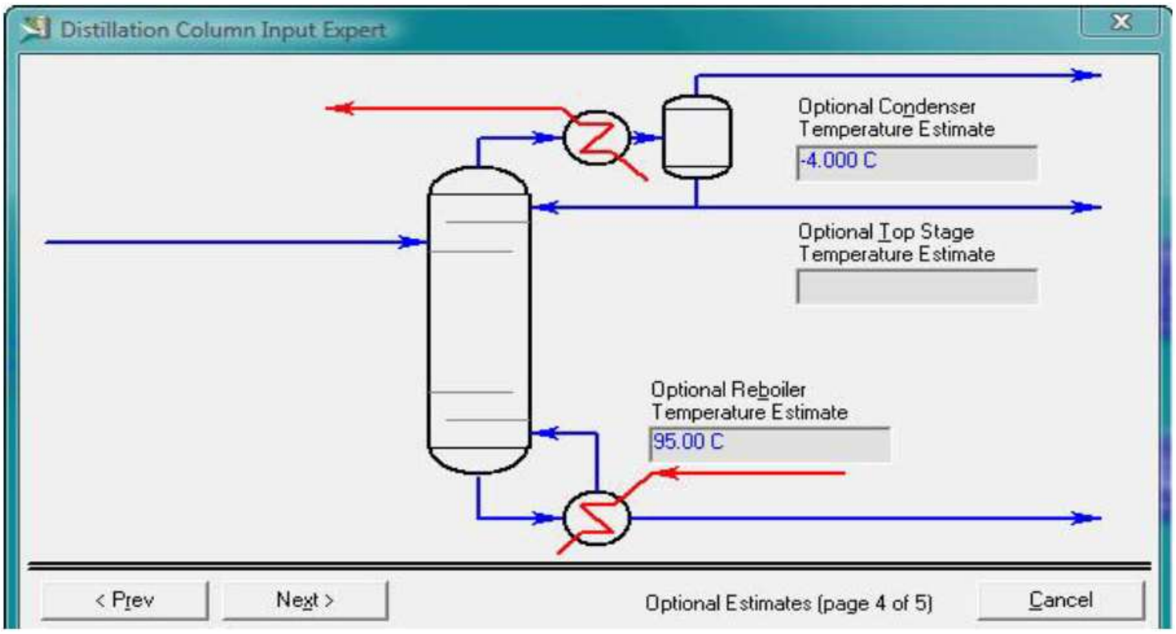
The outlet from the pump is then fed to the de-ethanizer:

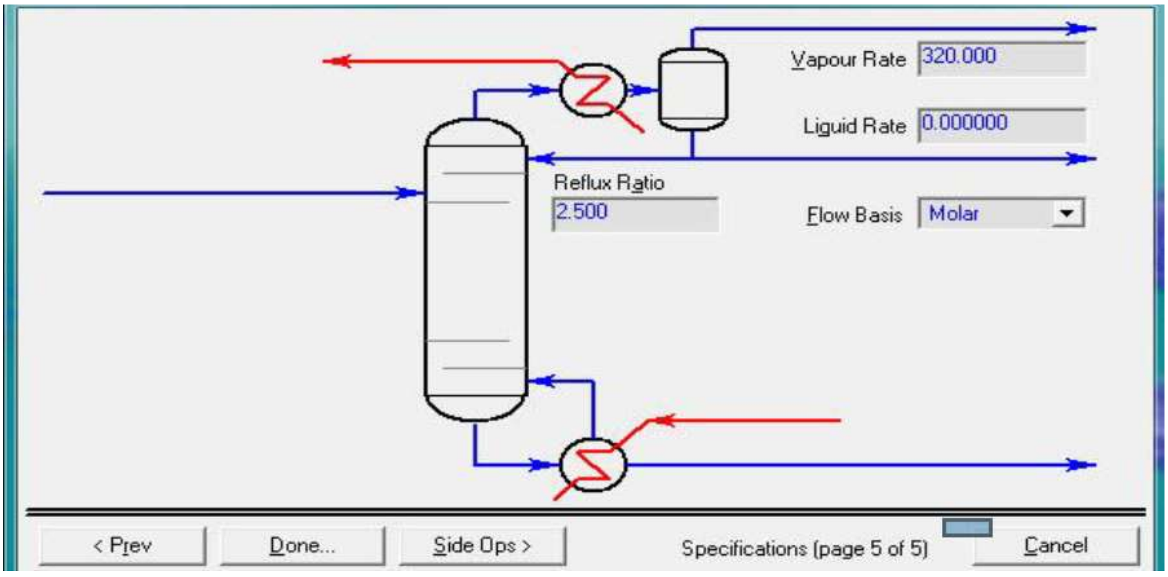


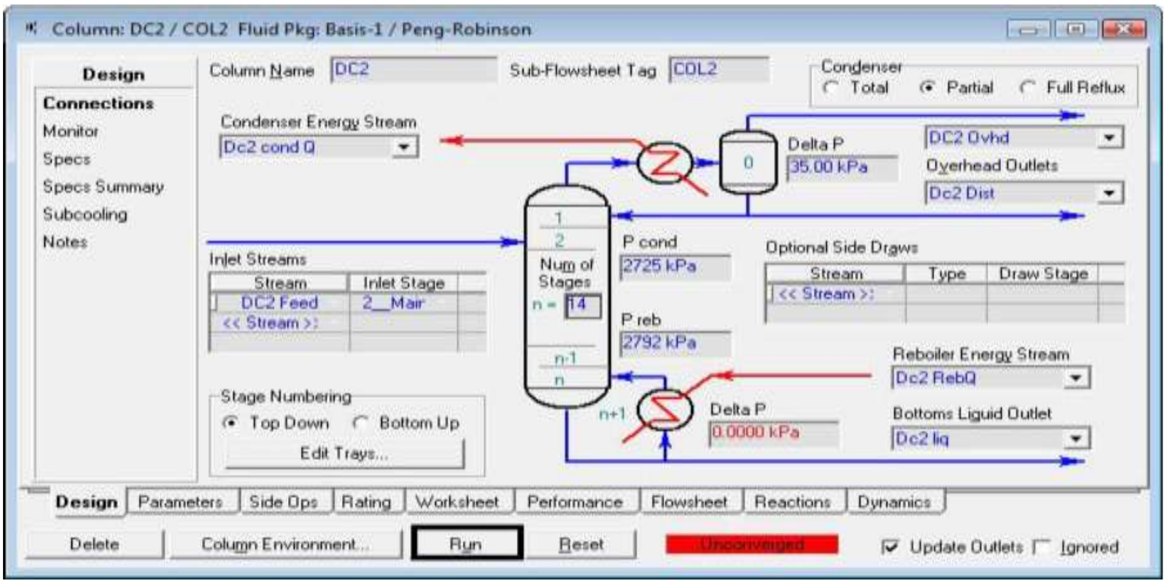




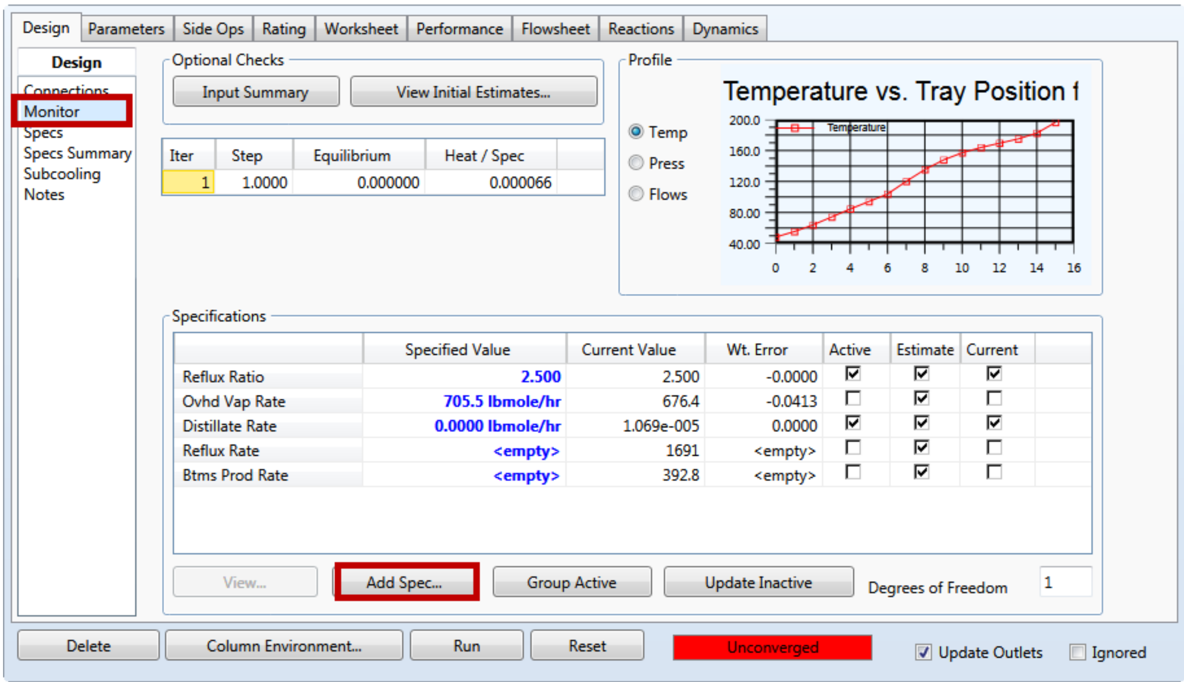

Condenser Pressure
2725 kPa
Condenser Pressure Drop
35.00 kPa
Reboiler Pressure Drop
0.0000 kPa
Reboiler Pressure
2792 kPa
< Prev
Next >
Pressure Profile (page 3 of 5)
Cancel

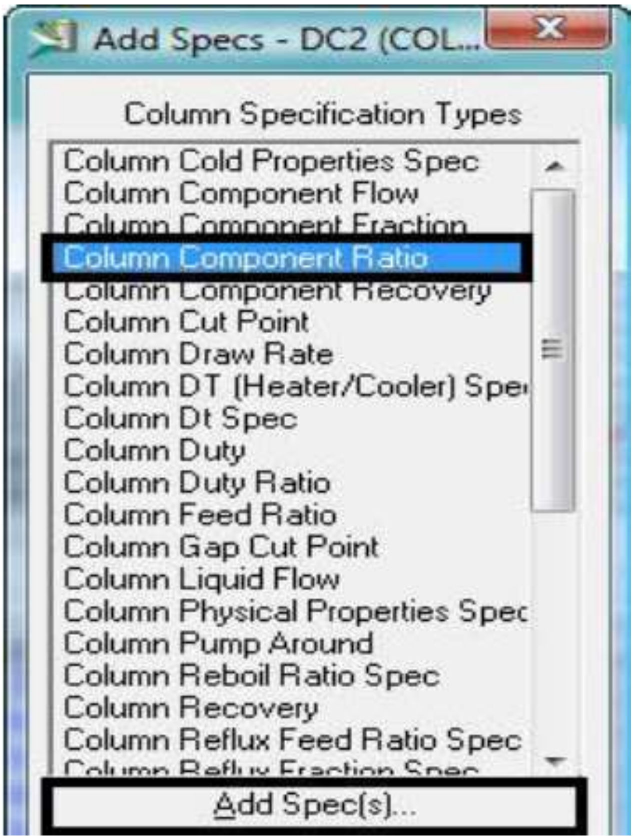

Distillation Column Input Expert
Optional Condenser Temperature Estimate
-4.000 C
Optional Top Stage Temperature Estimate
Optional Reboiler Temperature Estimate
95.00 C
< Prev
Next >
Optional Estimates (page 4 of 5)
Cancel

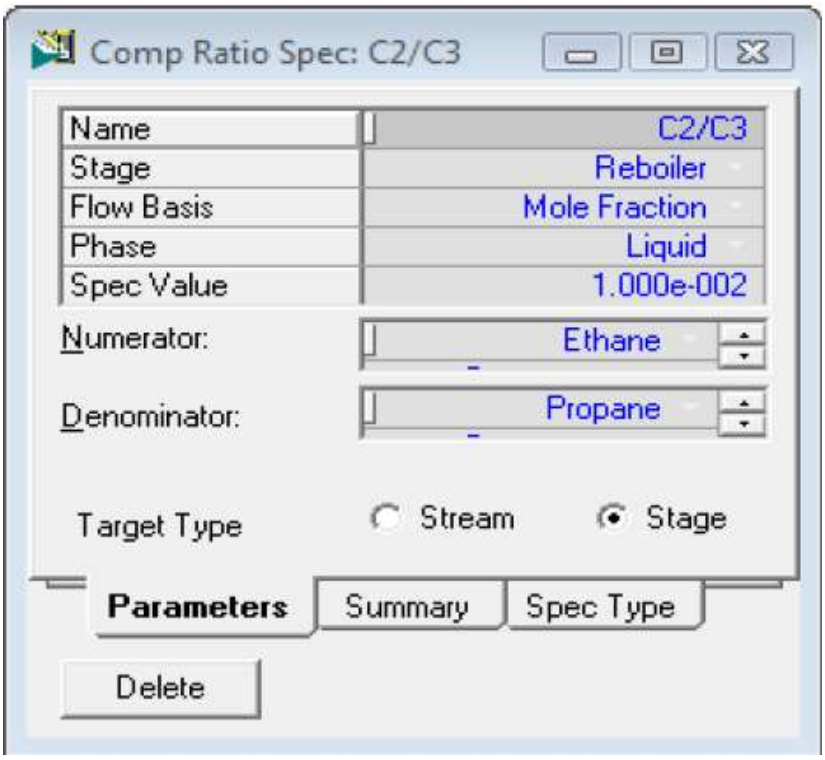

Vapour Rate
320.000
Liquid Rate
0.000000
Reflux Ratio
2.500
Flow Basis
Molar
< Prev
Done...
Side Ops >
Specifications (page 5 of 5)
Cancel



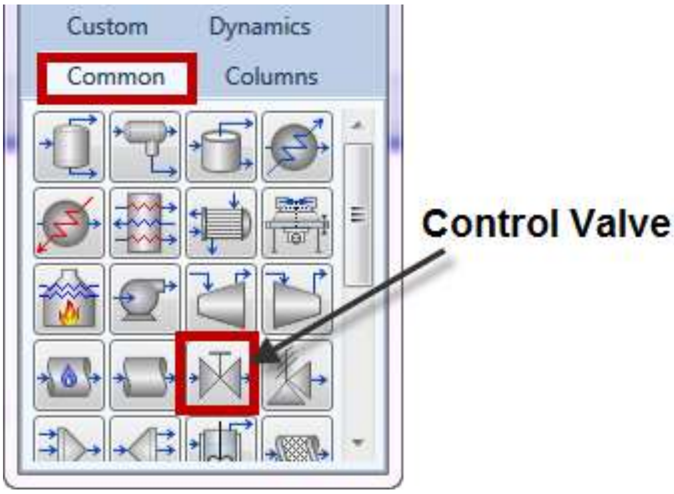
Add the Column component ratio from the monitor page as follows:

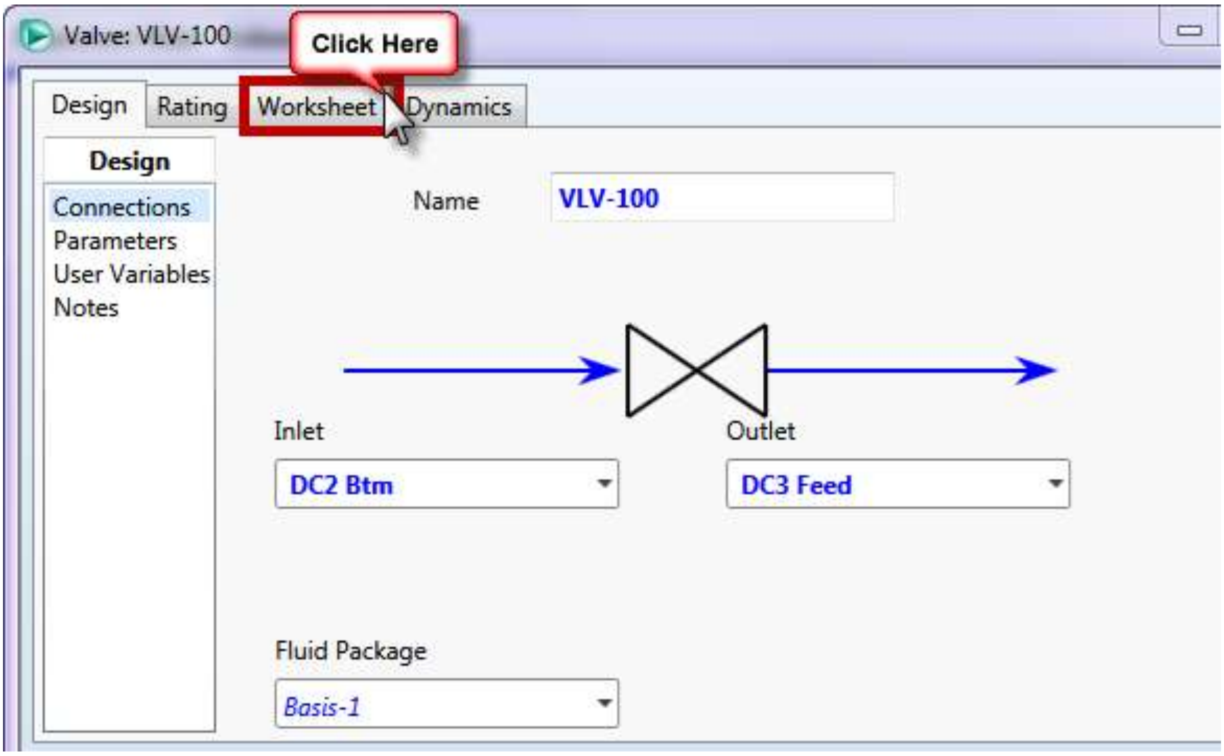



Add Specs - DC2 (COL...
Column Specification Types
Column Cold Properties Spec
Column Component Flow
Column Component Fraction
Column Component Ratio
Column Component Recovery
Column Cut Point
Column Draw Rate
Column DT (Heater/Cooler) Spe
Column Dt Spec
Column Duty
Column Duty Ratio
Column Feed Ratio
Column Gap Cut Point
Column Liquid Flow
Column Physical Properties Spec
Column Pump Around
Column Reboil Ratio Spec
Column Recovery
Column Reflux Feed Ratio Spec
Add Spec(s)...

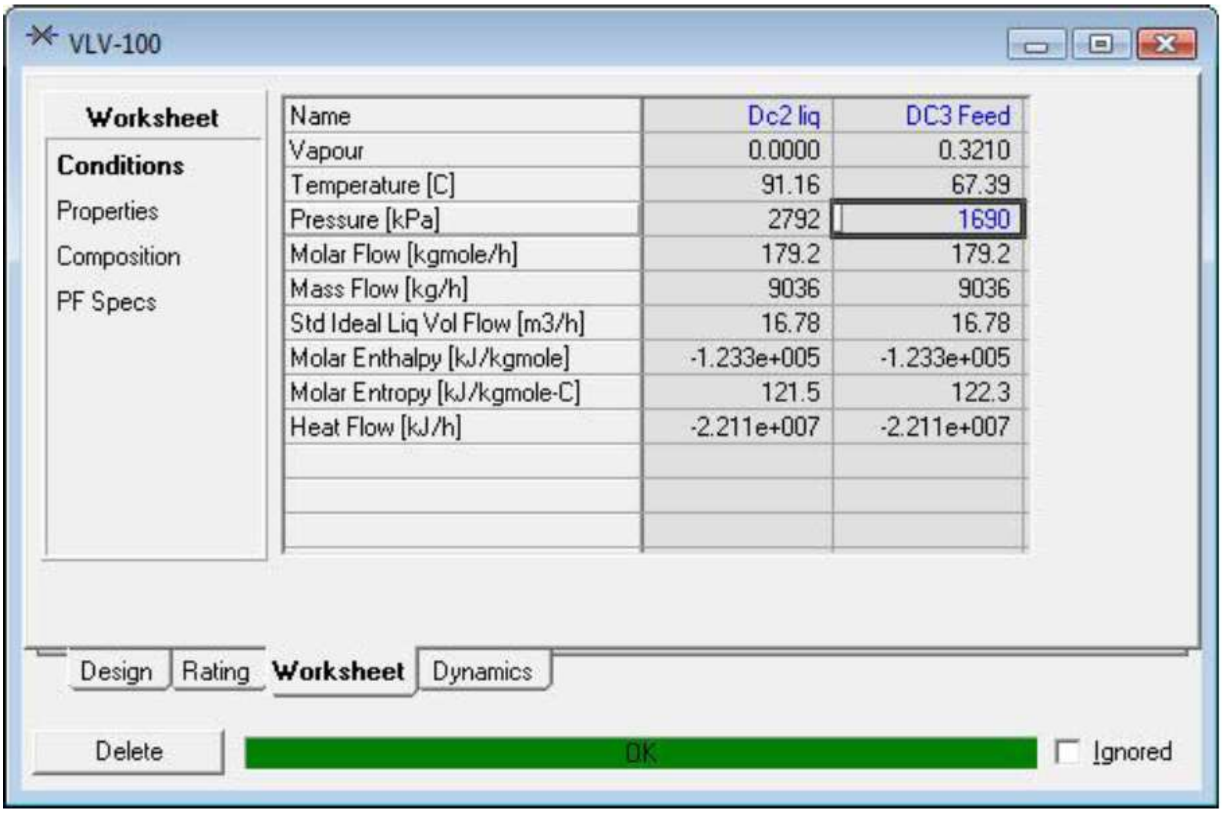

Comp Ratio Spec: C2/C3
Name
C2/C3
Stage
Reboiler
Flow Basis
Mole Fraction
Phase
Liquid
Spec Value
1.000e-002
Numerator:
Ethane
Denominator:
Propane
Target Type
Stream
Stage
Parameters
Summary
Spec Type
Delete

Add a valve on the bottom liquid stream:





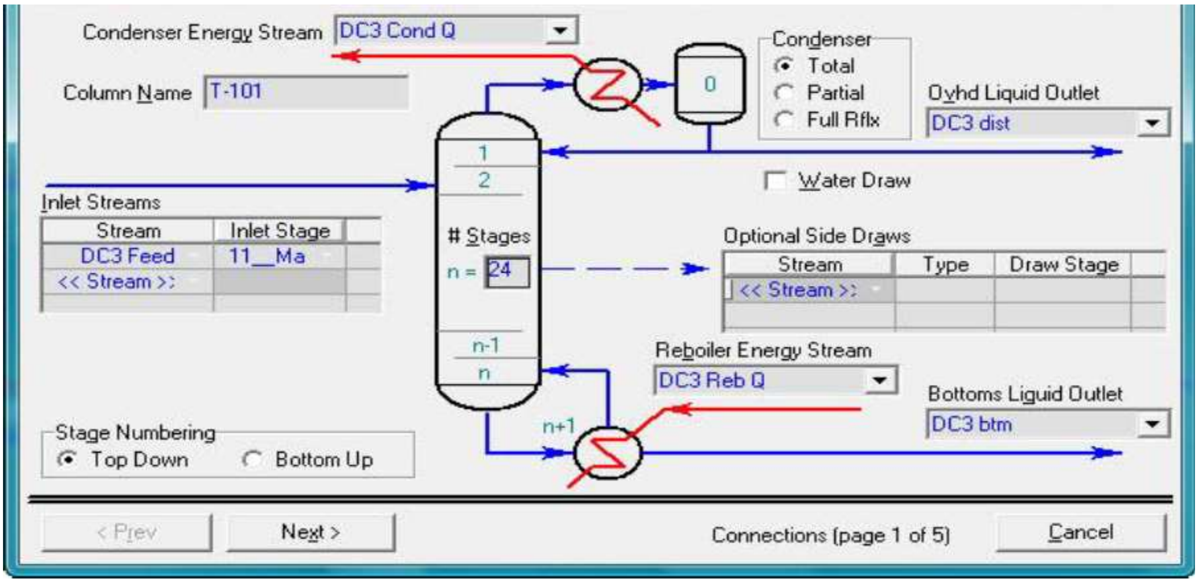
Outlet pressure from the valve = 1690 kPa (from the **Worksheet** tab)

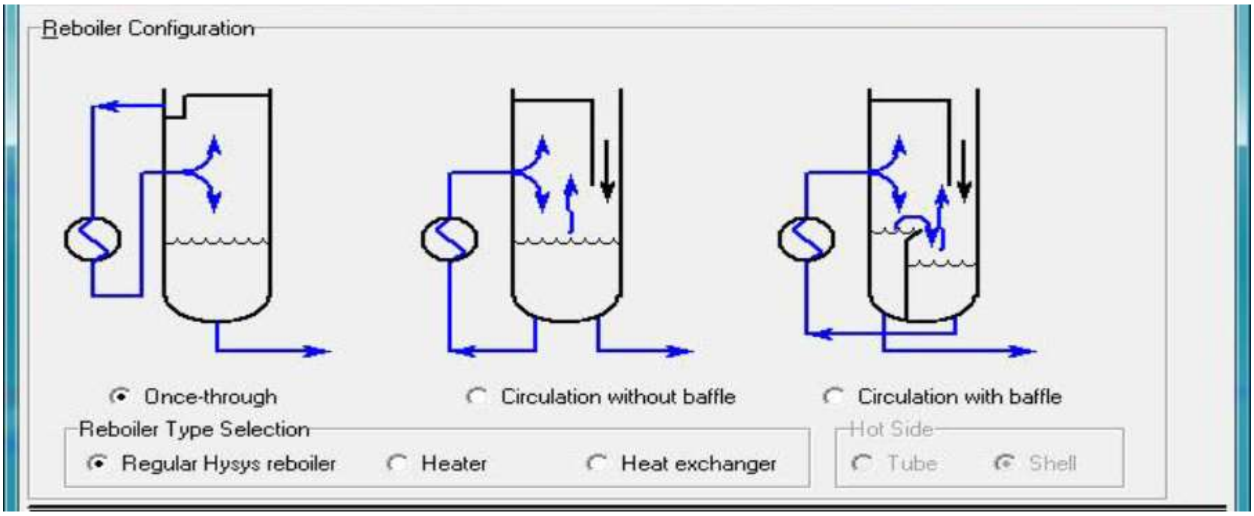


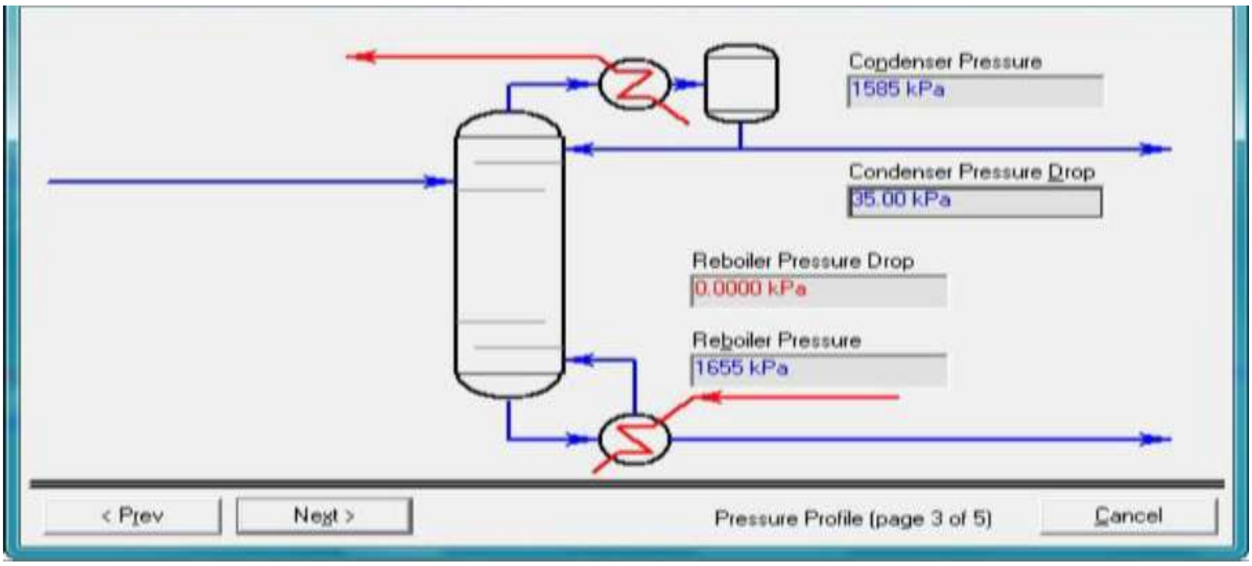
Name	Dc2 liq	DC3 Feed
Vapour	0.0000	0.3210
Temperature [C]	91.16	67.39
Pressure [kPa]	2792	1690
Molar Flow [kgmole/h]	179.2	179.2
Mass Flow [kg/h]	9036	9036
Std Ideal Liq Vol Flow [m3/h]	16.78	16.78
Molar Enthalpy [kJ/kgmole]	-1.233e+005	-1.233e+005
Molar Entropy [kJ/kgmole-C]	121.5	122.3
Heat Flow [kJ/h]	-2.211e+007	-2.211e+007

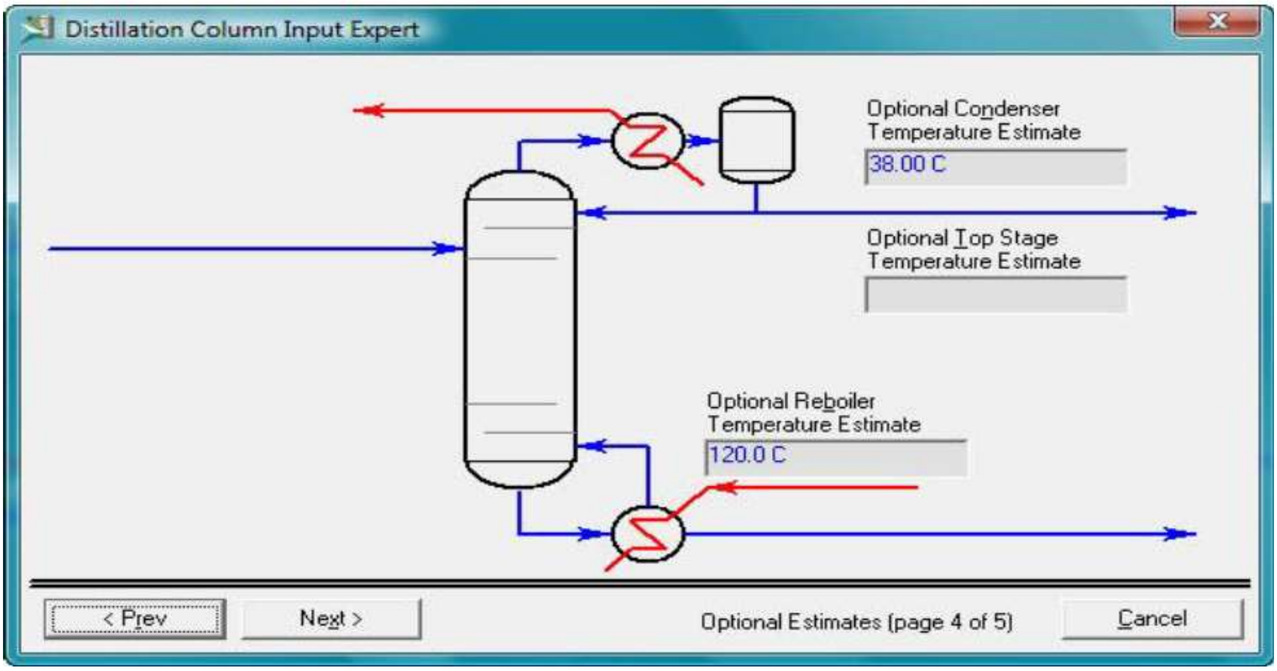
PART 3: DE- PROPANIZER COLUMN

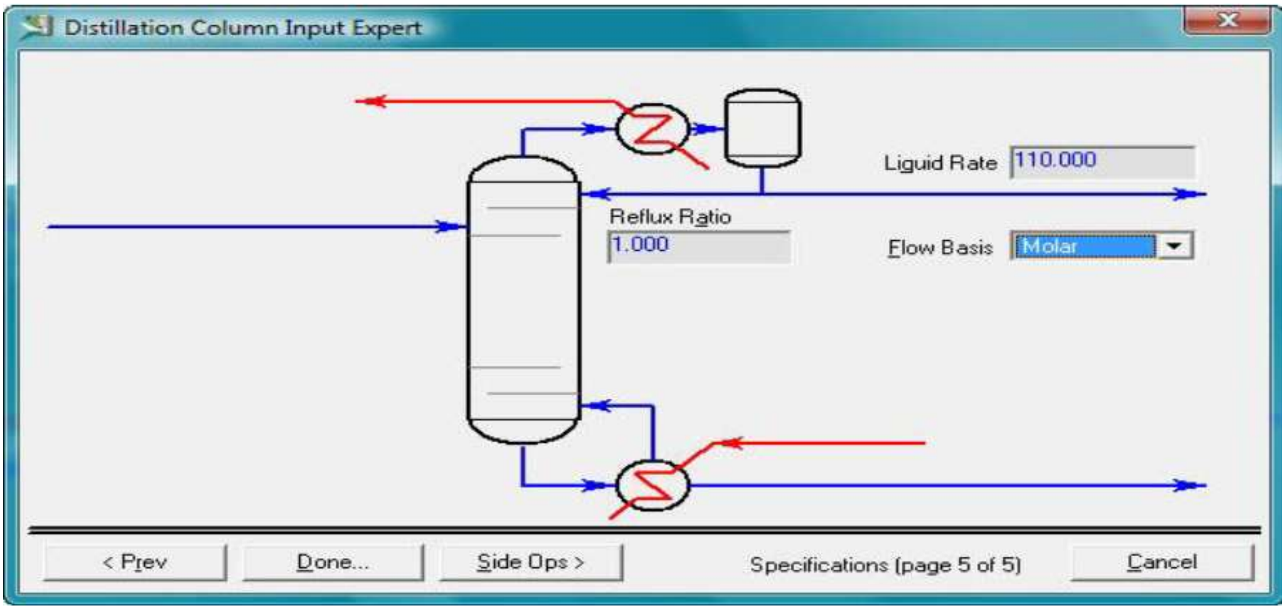
Add a distillation column (De-propanizer):

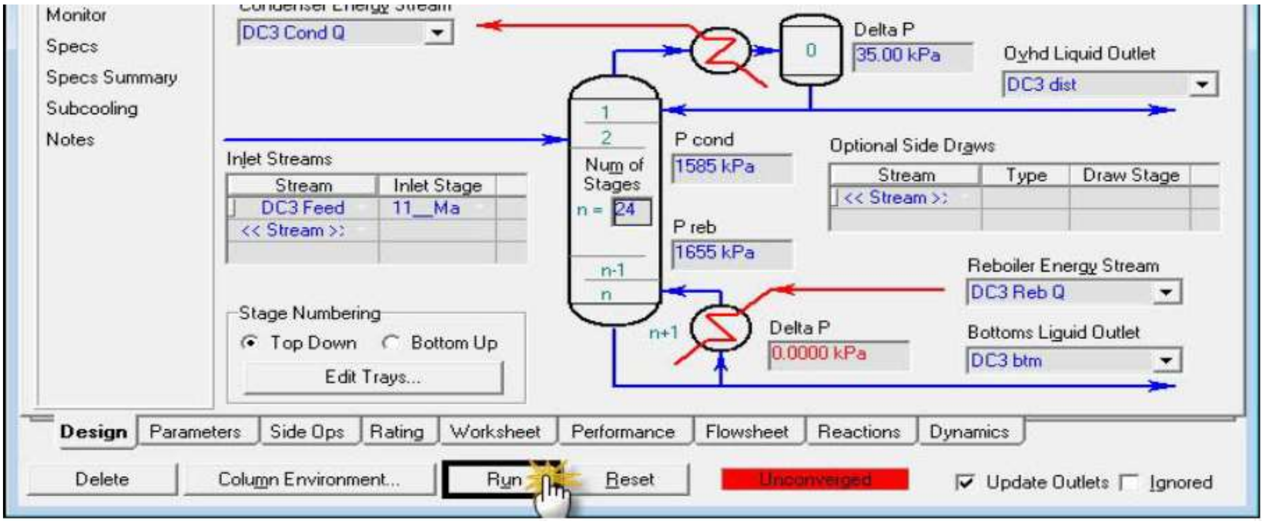




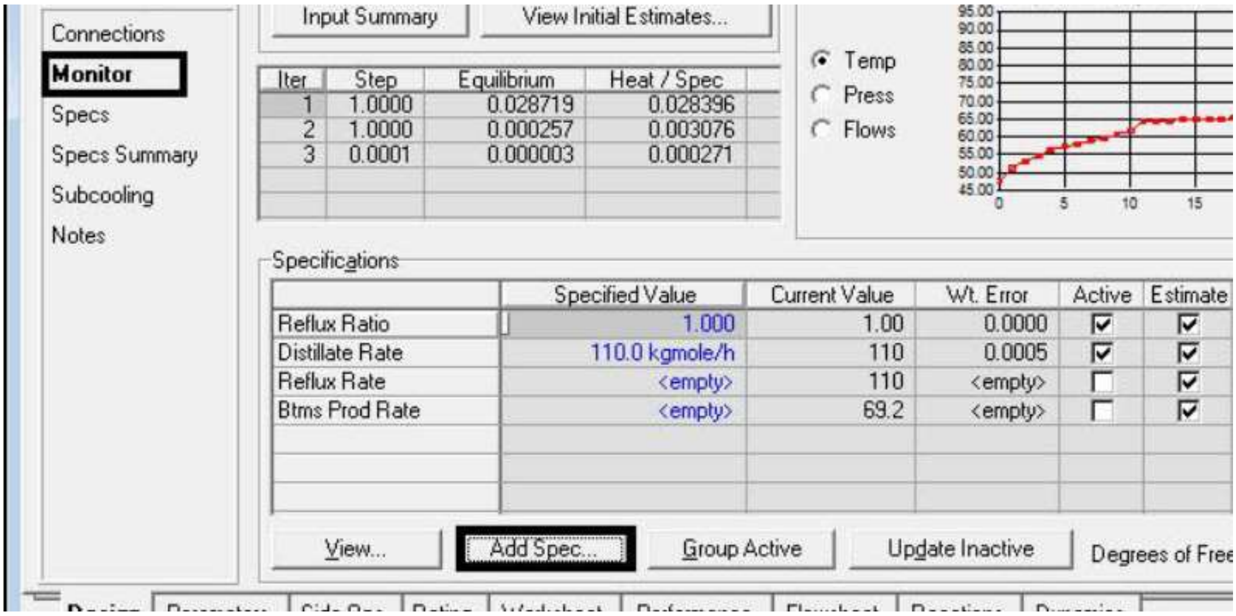


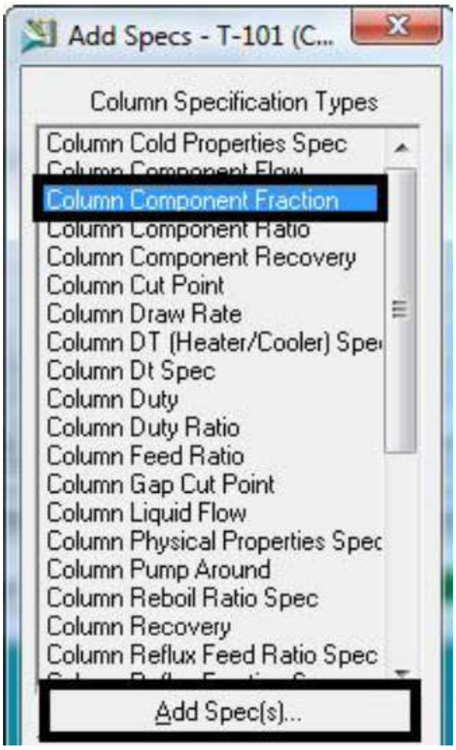

Distillation Column Input Expert
Optional Condenser Temperature Estimate
38.00 C
Optional Top Stage Temperature Estimate
Optional Reboiler Temperature Estimate
120.0 C
< Prev
Next >
Optional Estimates (page 4 of 5)
Cancel

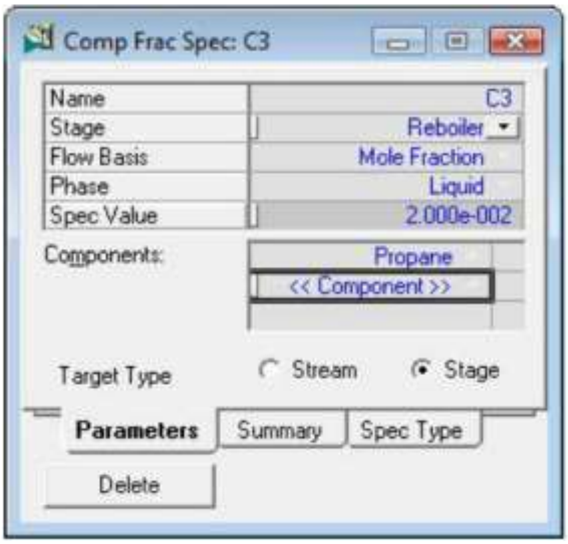

Distillation Column Input Expert
Liquid Rate
110.000
Reflux Ratio
1.000
Flow Basis
Molar
< Prev
Done...
Side Ops >
Specifications (page 5 of 5)
Cancel

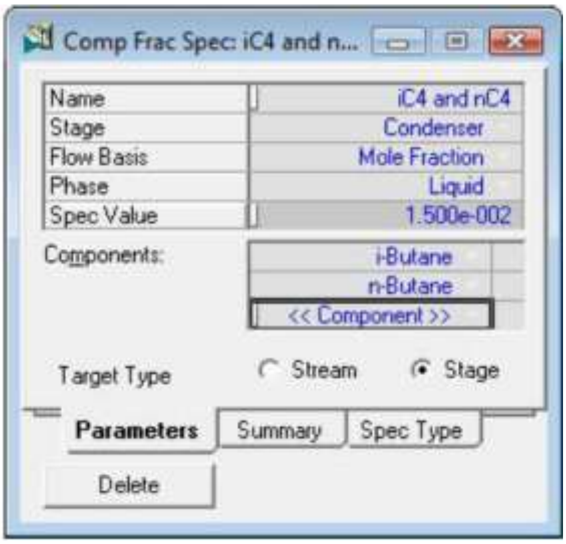

Monitor
Specs
Specs Summary
Subcooling
Notes
DC3 Cond Q
Delta P
35.00 kPa
Ovhd Liquid Outlet
DC3 dist
Inlet Streams
Stream
Inlet Stage
DC3 Feed
11__Ma
<< Stream >>
P cond
1585 kPa
Num of Stages
n = 24
P reb
1655 kPa
Optional Side Draws
Type
Draw Stage
Reboiler Energy Stream
DC3 Reb Q
Delta P
0.0000 kPa
Bottoms Liquid Outlet
DC3 btm
Stage Numbering
Top Down
Bottom Up
Edit Trays...
Design
Parameters
Side Ops
Rating
Worksheet
Performance
Flowsheet
Reactions
Dynamics
Delete
Column Environment...
Run
Reset
Unconverged
Update Outlets
Ignored

Now, let's add a new 2 specifications instead of the current:

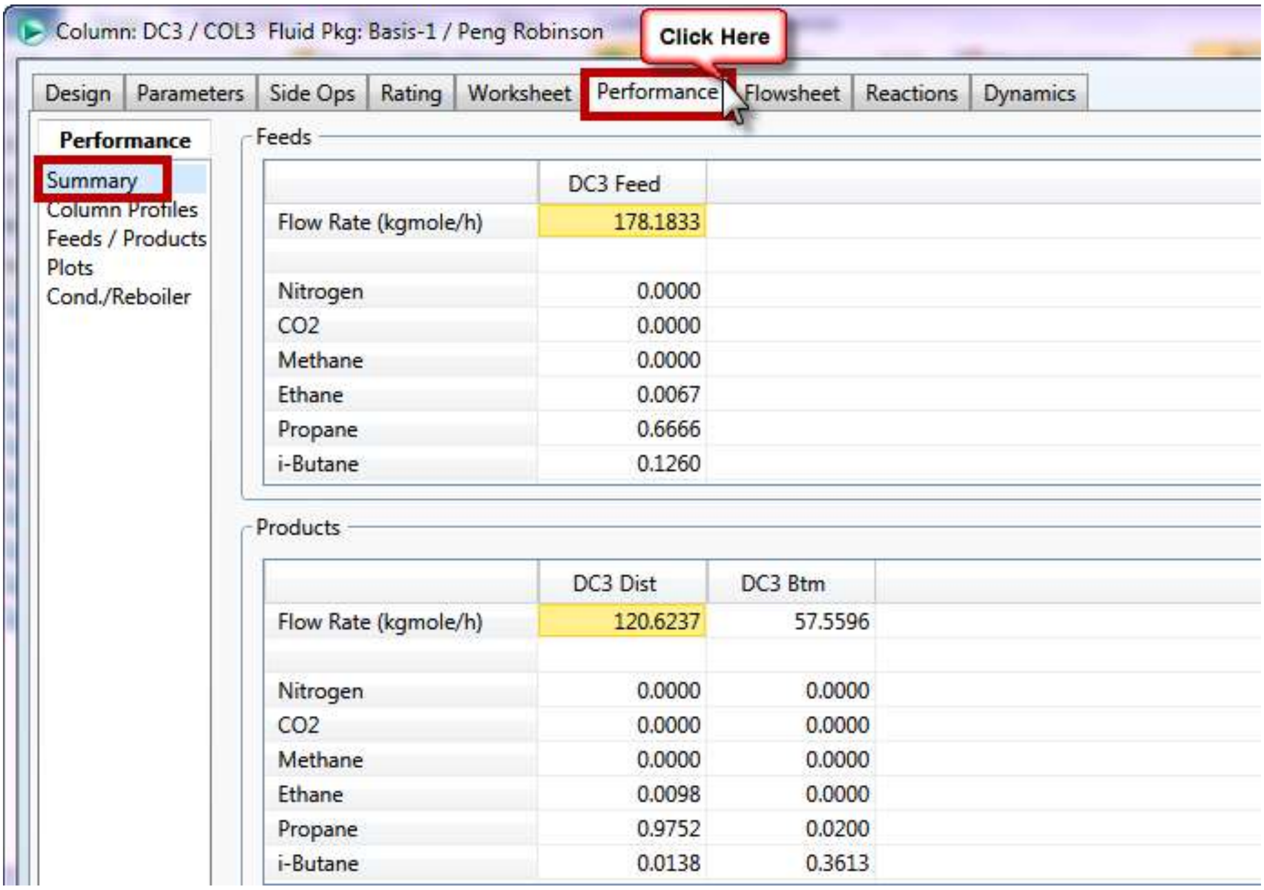


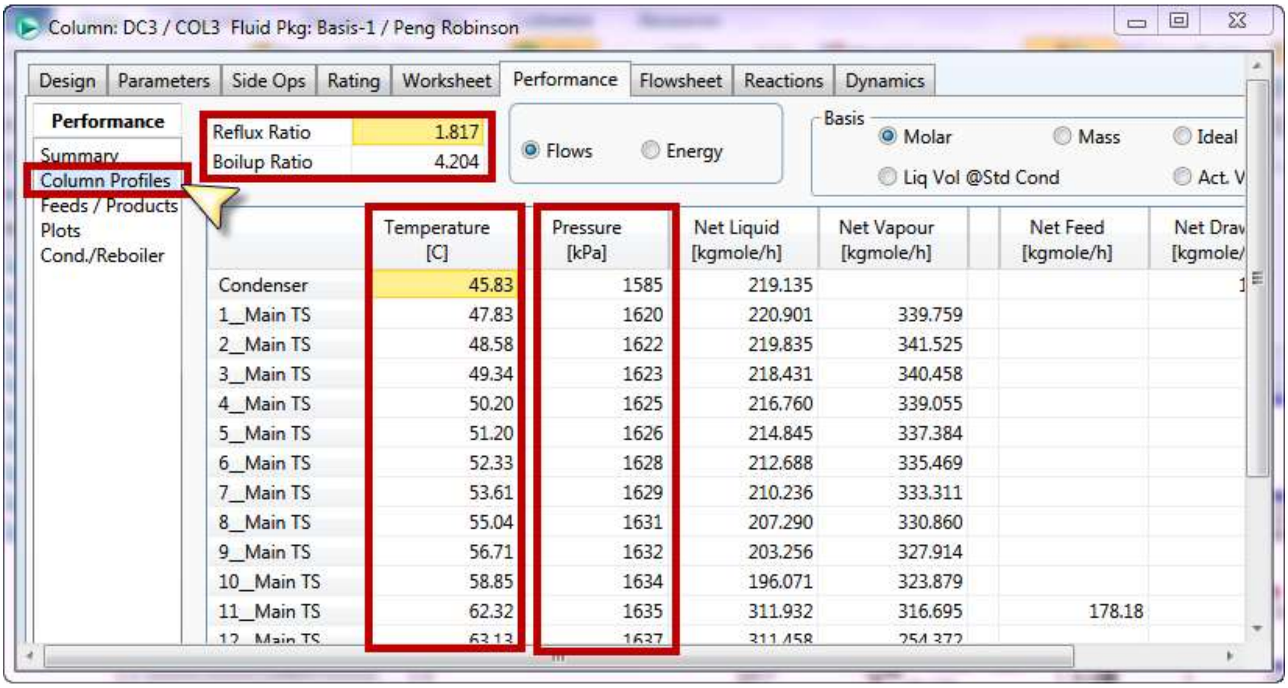


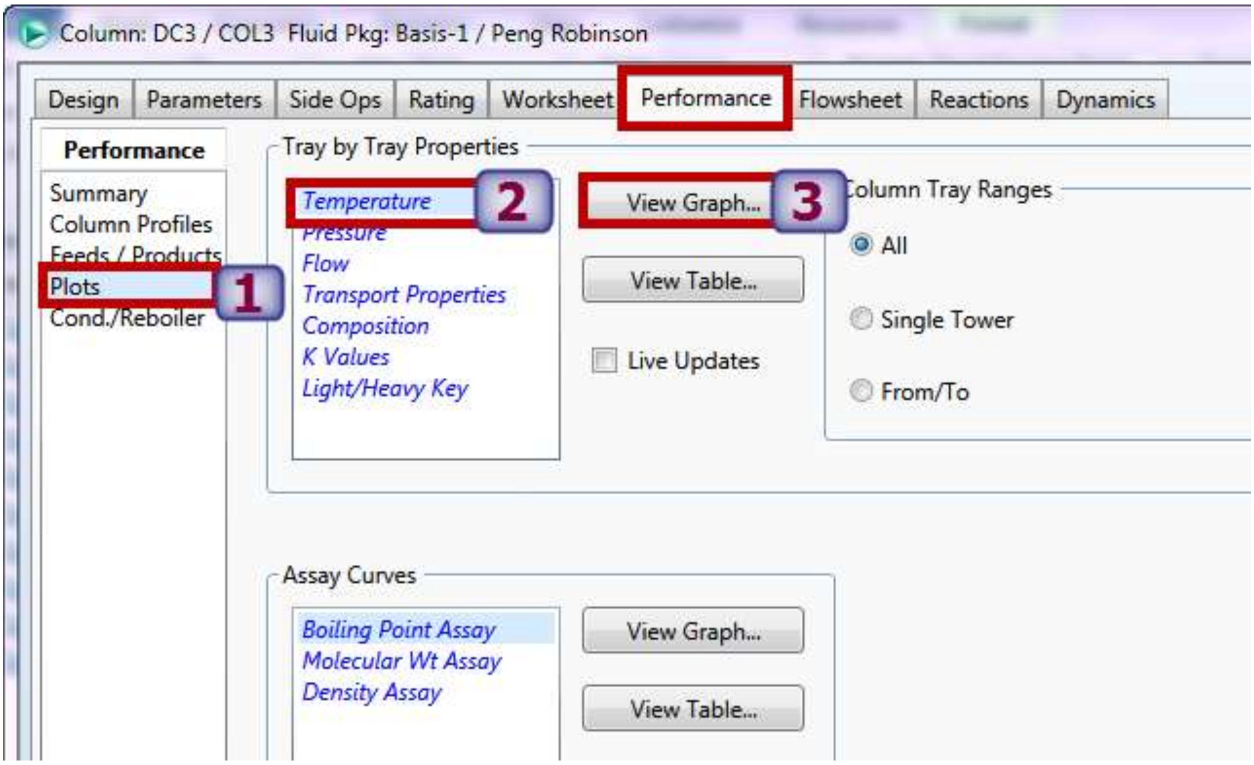


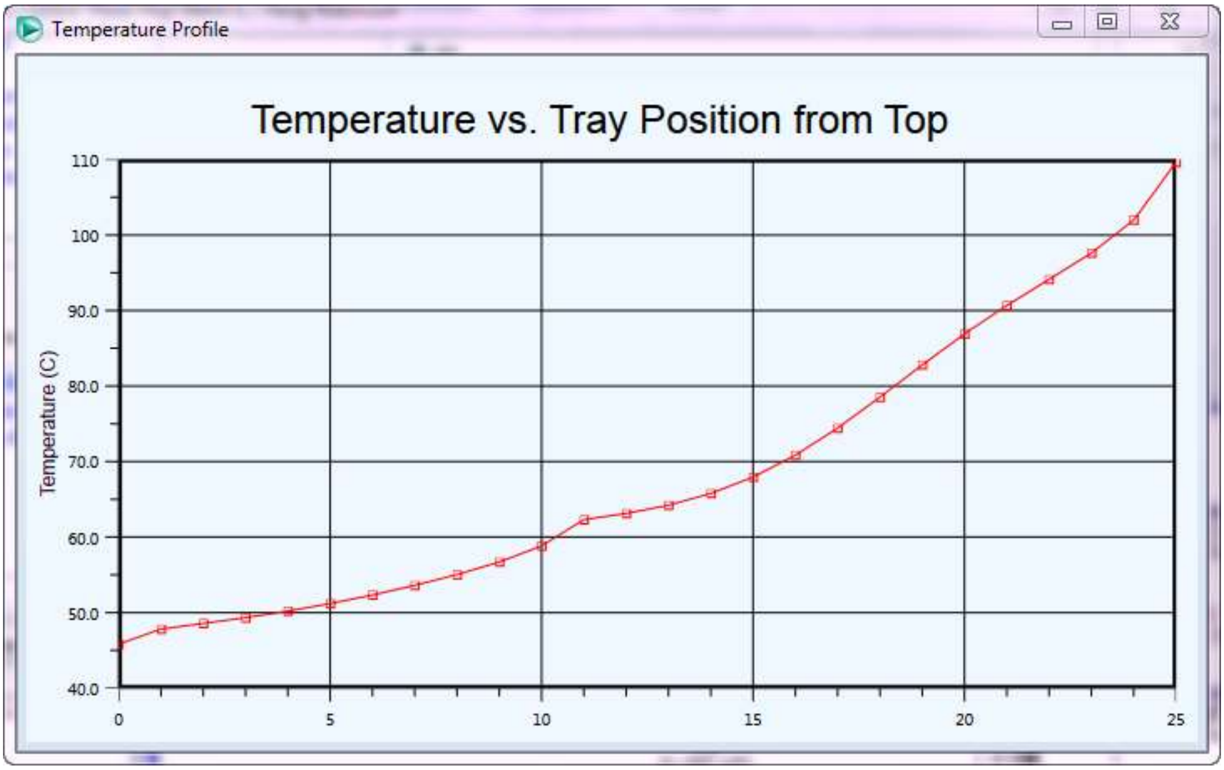


After running the column, you can view the results from the **Performance** page (for any column)

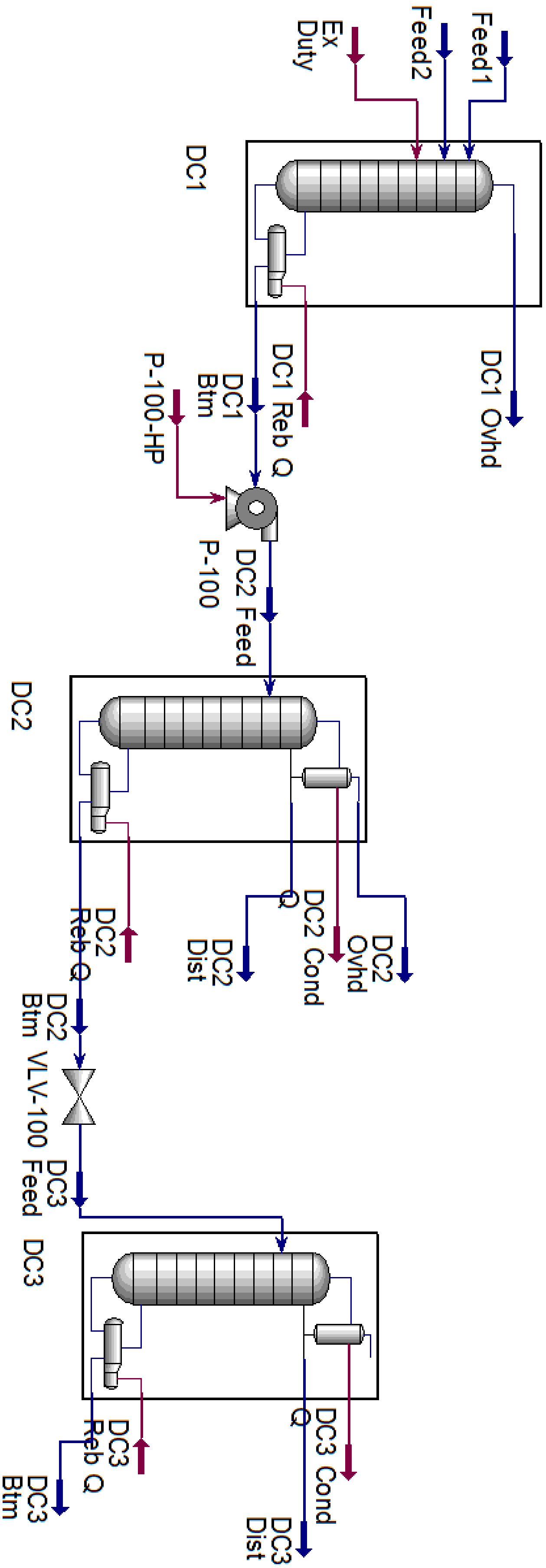

Column: DC3 / COL3 Fluid Pkg: Basis-1 / Peng Robinson
Click Here
Design Parameters Side Ops Rating Worksheet Performance Flowsheet Reactions Dynamics
Performance
Summary
Column Profiles
Feeds / Products
Plots
Cond./Reboiler
Feeds
DC3 Feed
Flow Rate (kgmole/h) 178.1833
Nitrogen 0.0000
CO2 0.0000
Methane 0.0000
Ethane 0.0067
Propane 0.6666
i-Butane 0.1260
Products
DC3 Dist DC3 Btm
Flow Rate (kgmole/h) 120.6237 57.5596
Nitrogen 0.0000 0.0000
CO2 0.0000 0.0000
Methane 0.0000 0.0000
Ethane 0.0098 0.0000
Propane 0.9752 0.0200
i-Butane 0.0138 0.3613


Column: DC3 / COL3 Fluid Pkg: Basis-1 / Peng Robinson
Design Parameters Side Ops Rating Worksheet Performance Flowsheet Reactions Dynamics
Performance
Summary
Column Profiles
Feeds / Products
Plots
Cond./Reboiler
Reflux Ratio 1.817
Boilup Ratio 4.204
Flows Energy
Basis Molar Mass Ideal Liq Vol @Std Cond
Temperature [C] Pressure [kPa] Net Liquid [kgmole/h] Net Vapour [kgmole/h] Net Feed [kgmole/h]
Condenser 45.83 1585 219.135
1_Main TS 47.83 1620 220.901 339.759
2_Main TS 48.58 1622 219.835 341.525
3_Main TS 49.34 1623 218.431 340.458
4_Main TS 50.20 1625 216.760 339.055
5_Main TS 51.20 1626 214.845 337.384
6_Main TS 52.33 1628 212.688 335.469
7_Main TS 53.61 1629 210.236 333.311
8_Main TS 55.04 1631 207.290 330.860
9_Main TS 56.71 1632 203.256 327.914
10_Main TS 58.85 1634 196.071 323.879
11_Main TS 62.32 1635 311.932 316.695 178.18





Save Your Case!


Ex Duty
Feed2
Feed1
DC1
DC1 Ovhd
DC1 Reb Q
DC1 Btm
P-100-HP
P-100
DC2 Feed
DC2
Q
DC2 Cond
DC2 Ovhd
DC2 Dist
DC2 Reb Q
DC2 Btm
VLV-100
DC3 Feed
DC3
Q
DC3 Cond
DC3 Dist
DC3 Reb Q
DC3 Btm

Oil Stabilization Optimization

Workshop

A poor-boy stabilization scheme is used to separate an oil and gas mixture into a stabilized oil and a saleable gas. A simple three-stage separation with heating between each stage is used and the object of the exercise is to select the let-down pressure and temperatures such that the products revenue less the utilities cost is maximized. A special tool in HYSYS, the Optimizer, will be used to find the optimum operating conditions. HYSYS includes additional modelling and decision support tools that can be used to enhance the usability of your models. In this module, you will use the HYSYS optimization tool available in HYSYS to investigate the debottlenecking and optimization of a crude column.

Learning Objectives

Once you have completed this section, you will be able to:

• Use the Optimizer tool in HYSYS to optimize flowsheets

• Use the Spreadsheet to perform calculations

Oil Stabilization

A feed stream @ 10°C, 4125 kPa with a flowrate of 1 MMSCFD is fed to a heater (duty=4.25*10^5 kJ/hr) before entering the first separator where the separated liquid is heated in a second heater (duty=3.15*10^5 kJ/hr). The outlet from the heater is then sent to a letdown valve in order to decrease the pressure to 2050 kPa before entering the second separator where the separated liquid is heated through a third heater (duty=1.13*10^5 kJ/hr). The outlet from the third heater is then throttled through a valve (outlet pressure = 350 kPa) and then fed to a third separator to obtain the final liquid oil product.

Each gas stream from the 2nd & 3rd separators is fed to a separate compressor to raise the pressure to 4125 kPa and then mixed (using a mixer) with the gas stream from the 1st separator to get the final gas product stream.

Notes:

- Pressure drop across all heaters and separators are 0.0.

Comp	Mol frac	Comp	Mol frac
C1	0. 316	n-C5	0.053
C2	0.158	C6	0.027
C3	0.105	C7	0.026
i-C4	0.105	C8	0.026
n-C4	0.105	C9	0.026
i-C5	0.053		

Calculate:

- The total liquid product = …………………… barrel/hr
- The total gas product = ………………… m^3_gas/hr

Oil Stabilization Optimization

In this case, we want to maximize the total operating profit while achieving an RVP of Liquid Product less than 96.5 kPa. The incomes from the Plant are both the Gas and Liquid Products. The operating costs are the Steam Costs for each Heater plus the Power Cost for each Compressor.

Profit = Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)

Prices & costs:

Oil Price= 15 $/bbl

Gas Price =0.106 $/m^3_gas

Steam Cost= 0.682 $/kW-h

Compression Cost=0.1 $/kW-h

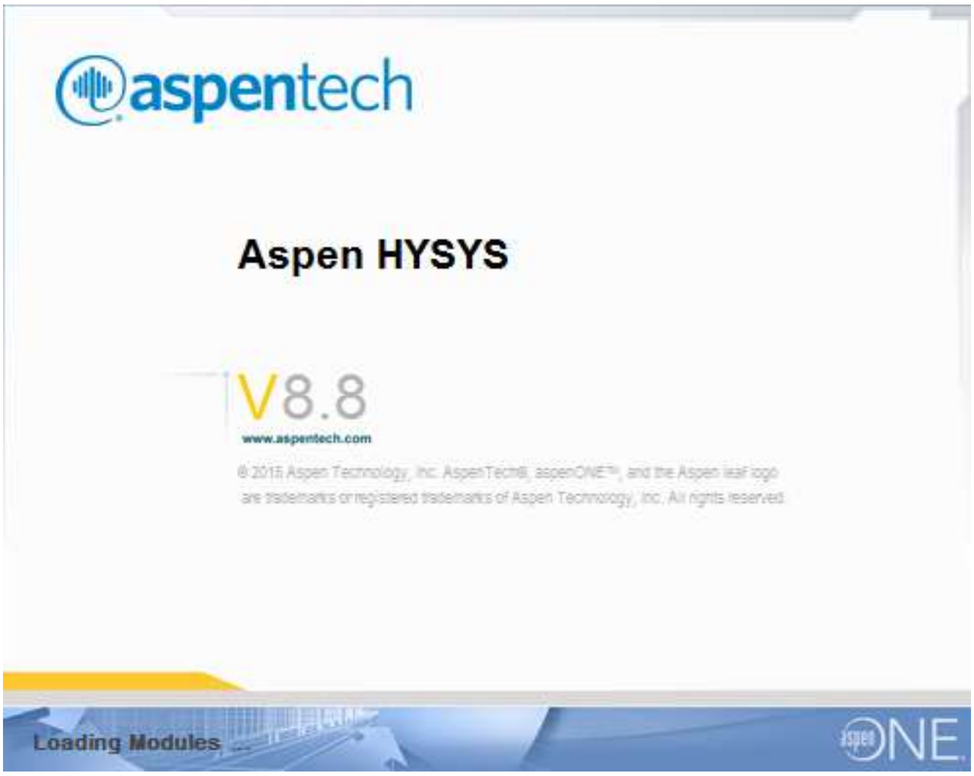
The variables to be adjusted:

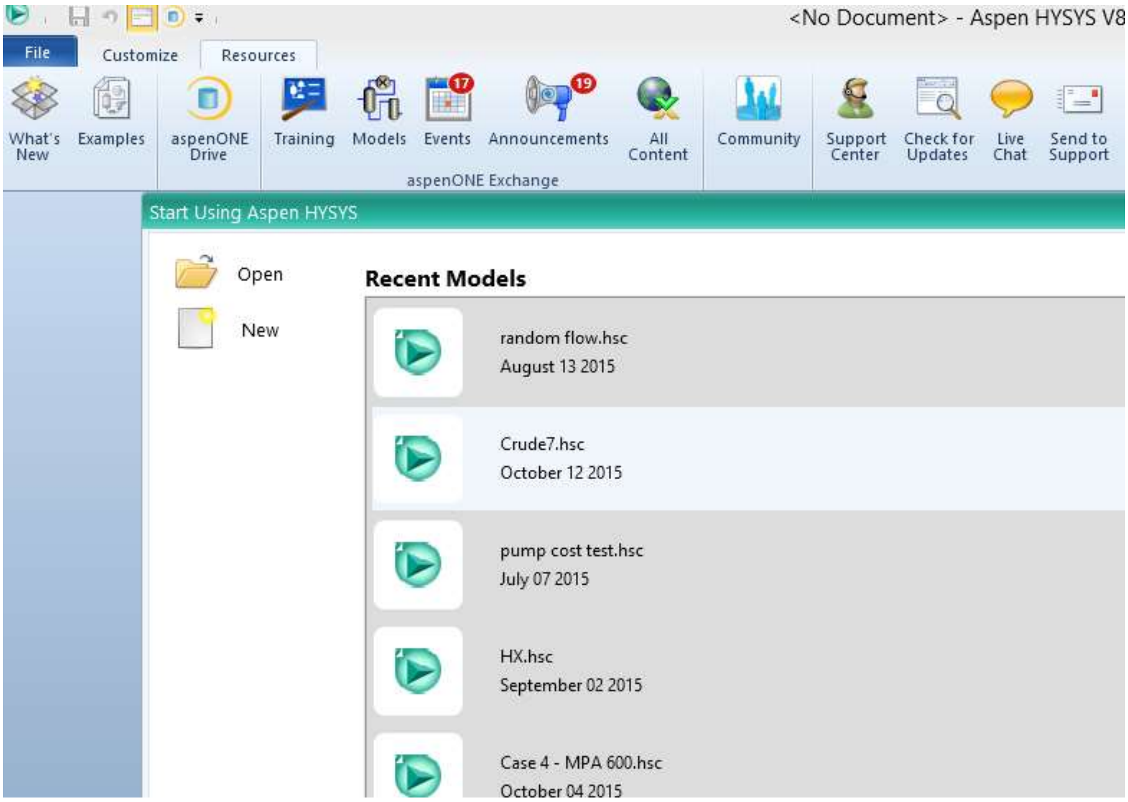
- Heater duties (for the 3 heaters). Use range of 0 – 1e6 kJ/hr
- Valves outlet pressures.
    - Use range of 650 – 3500 kPa for the first valve
    - Use range of 70 – 1000 kPa for the second valve

Calculate:

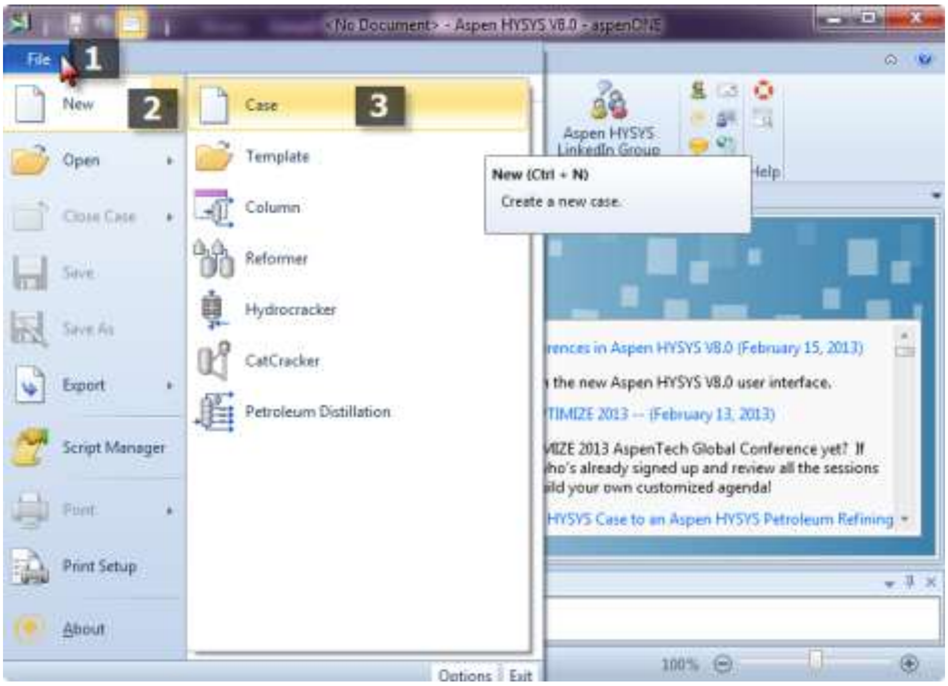
- The optimum values for the adjusted variables
- The maximum profit .... $/hr

To start the program, From Start Menu, Select All Programs >> Aspen Tech >> Process Modeling V8 >>>> Aspen HYSYS >> Aspen HYSYS

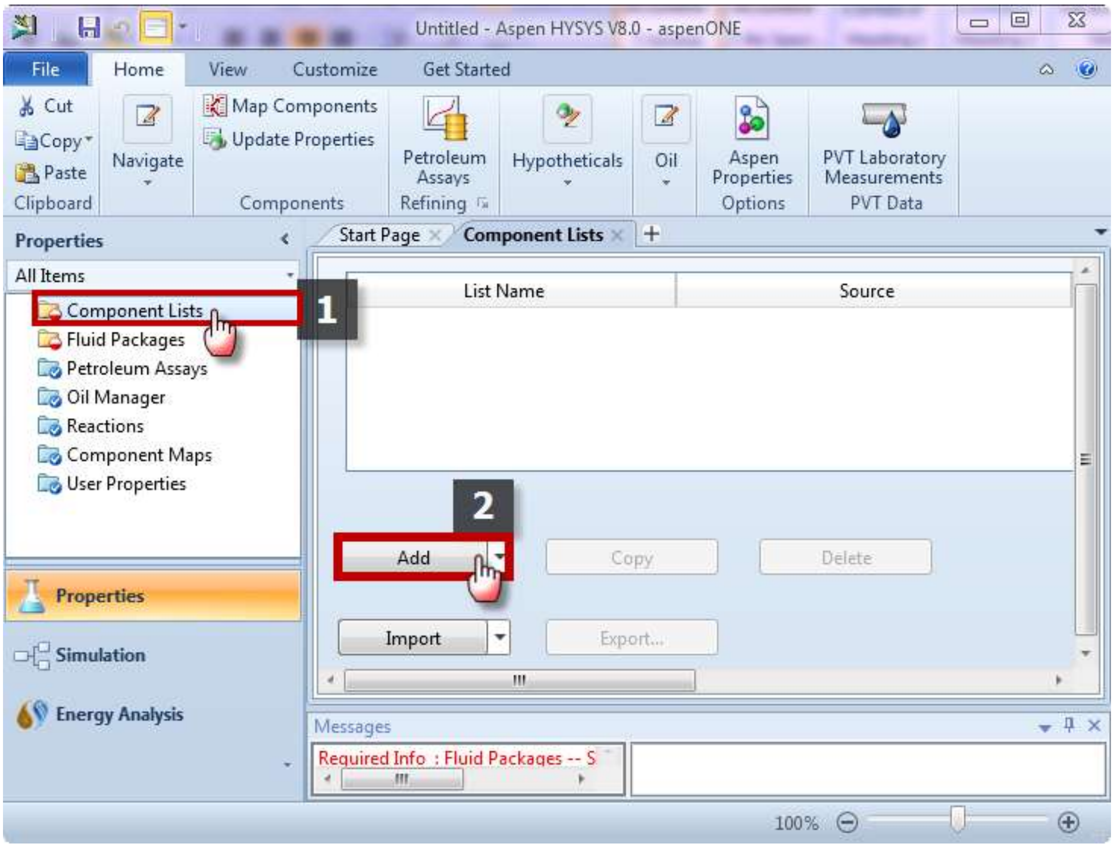




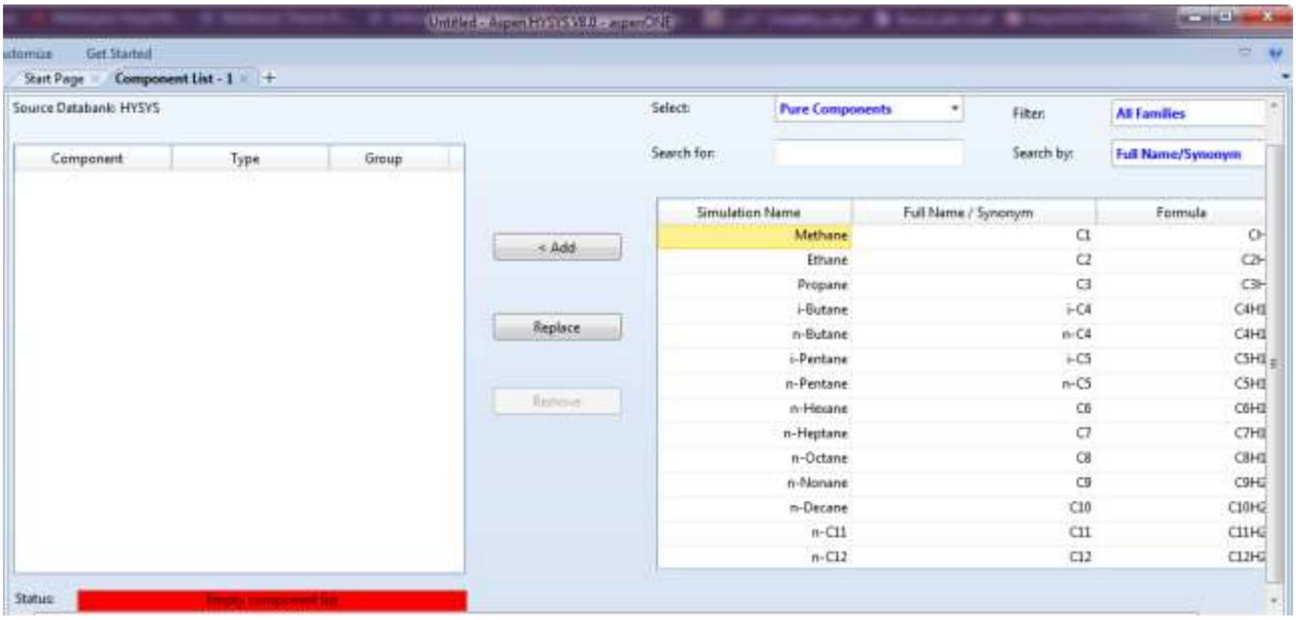
10- First, Start a new case



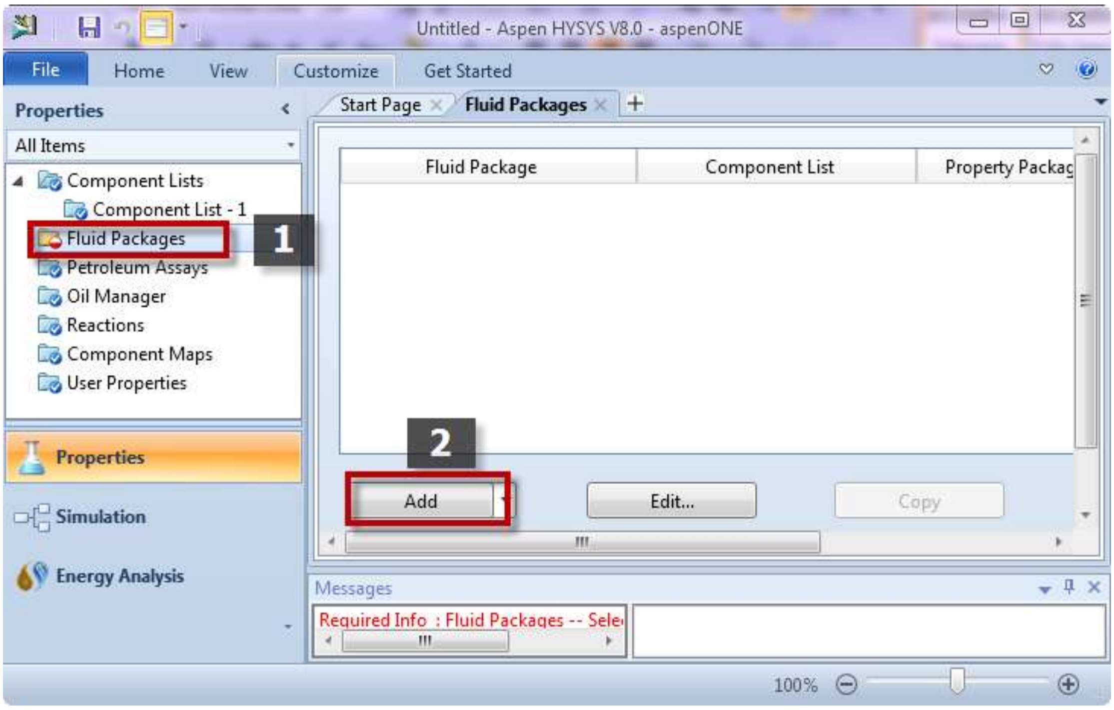
11- Add the Components



12- Choose the system components from the databank:

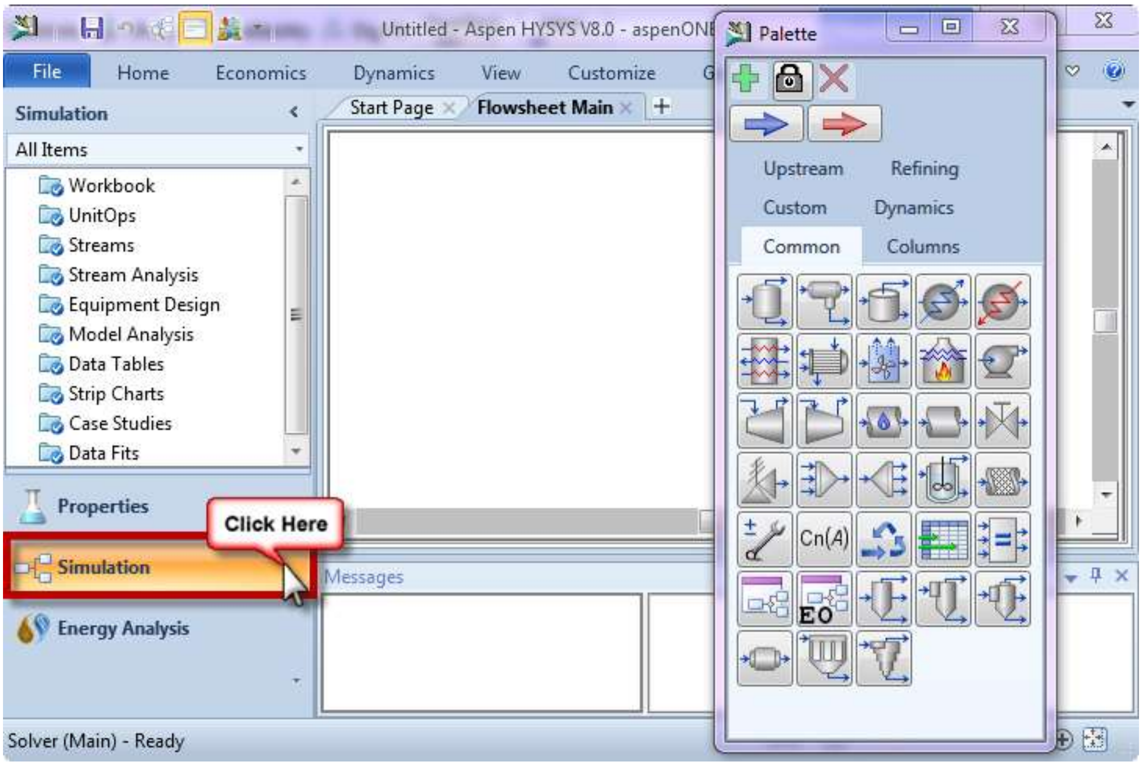


Now, select the suitable fluid package



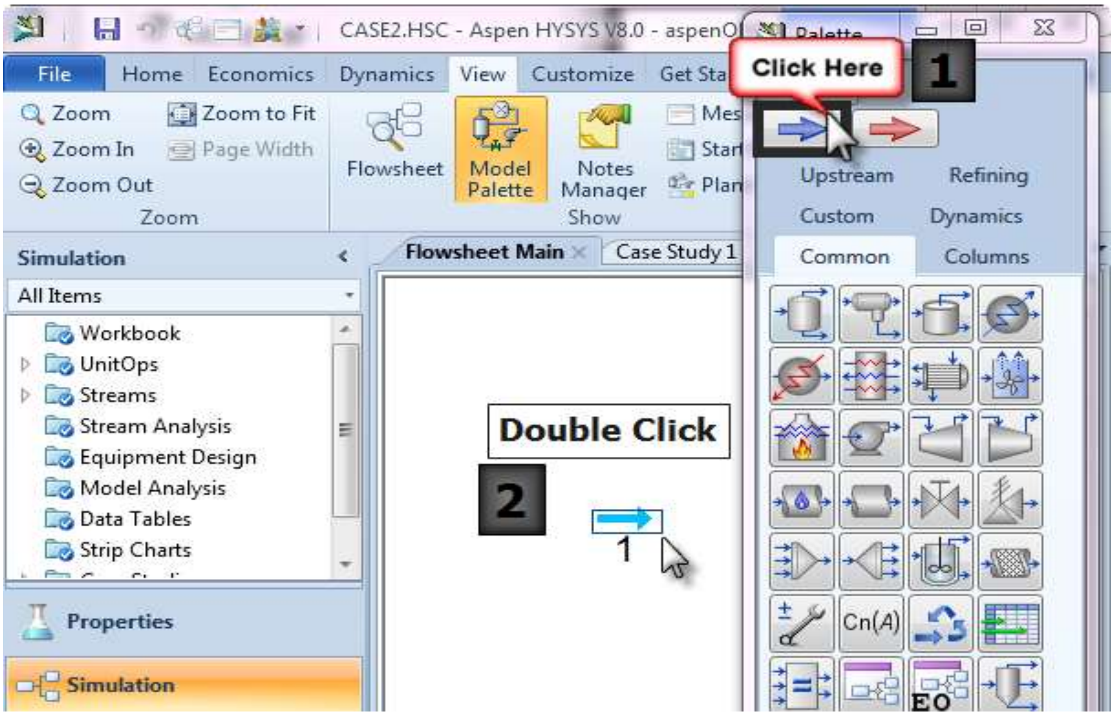
In this case, select Peng-Robinson

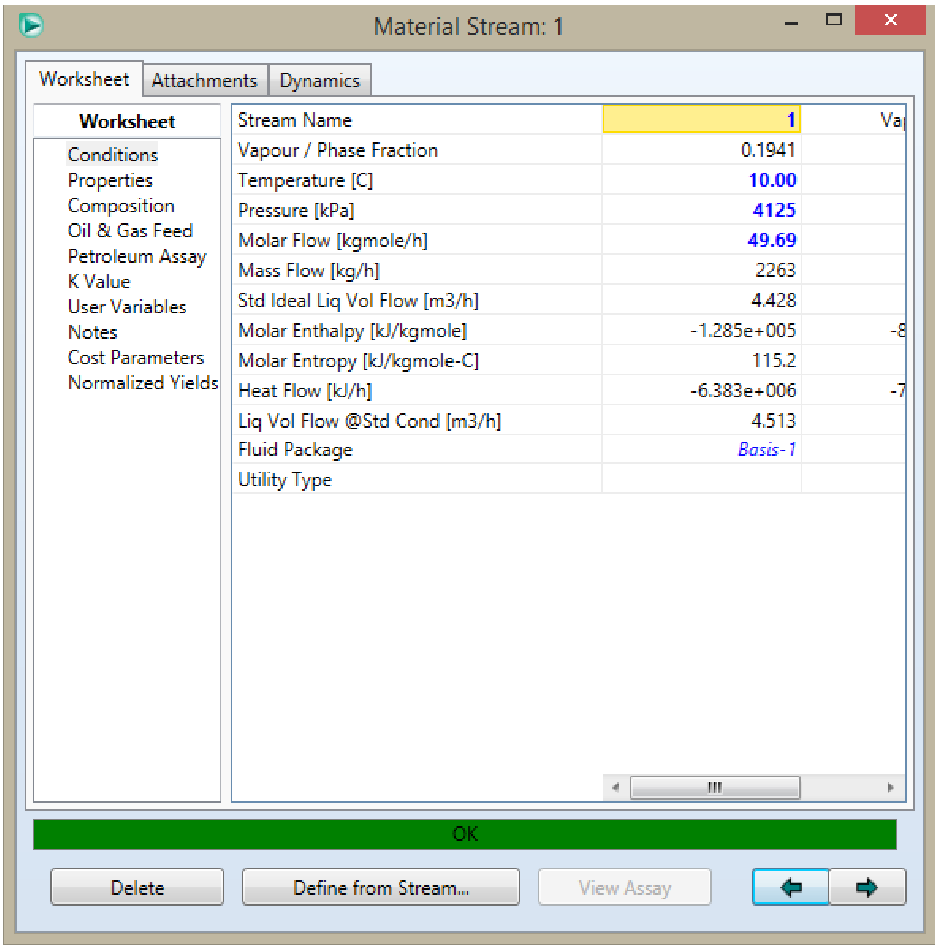
Now you can start drawing the flow sheet for the process by clicking the Simulation button:



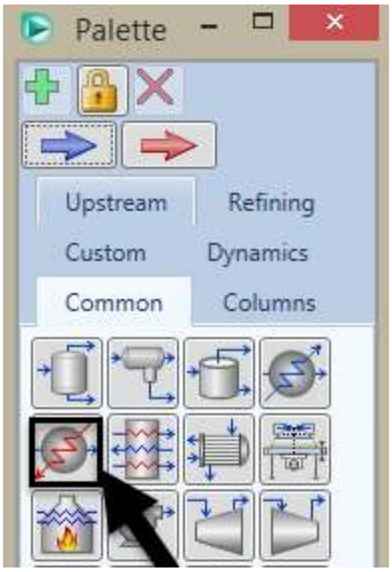
Now add a material stream to define the feed stream composition and conditions

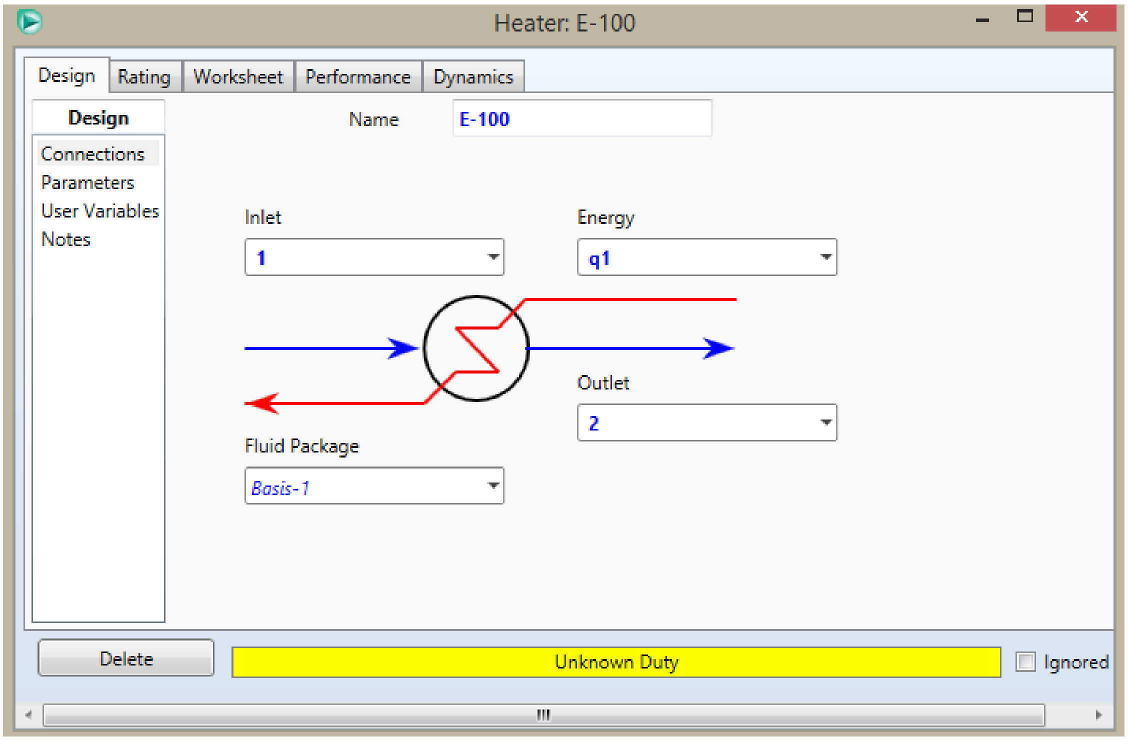
From the palette:

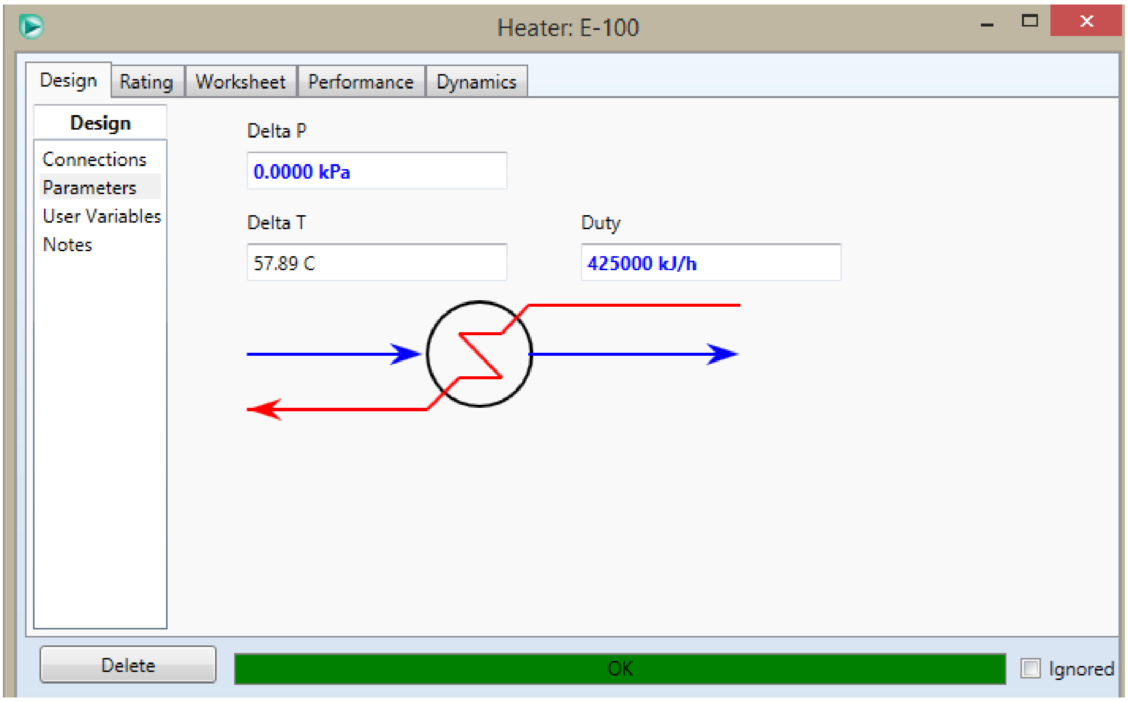




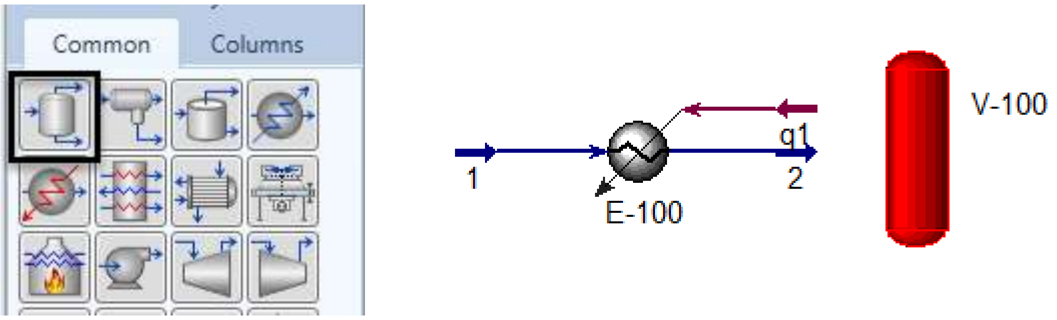
Add a heater with a duty of 4.25 * 10^5 kJ/hr and pressure drop of 0.0

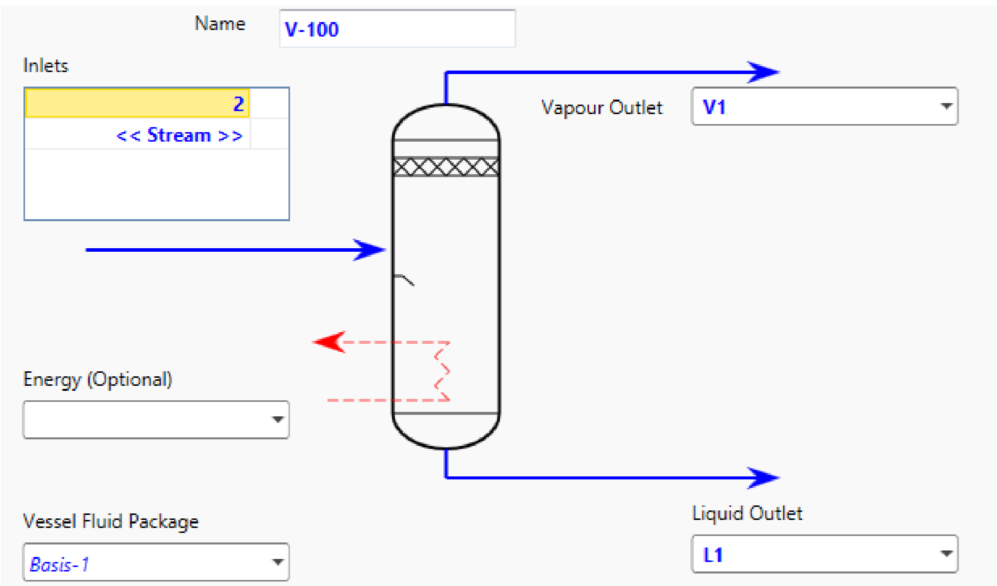




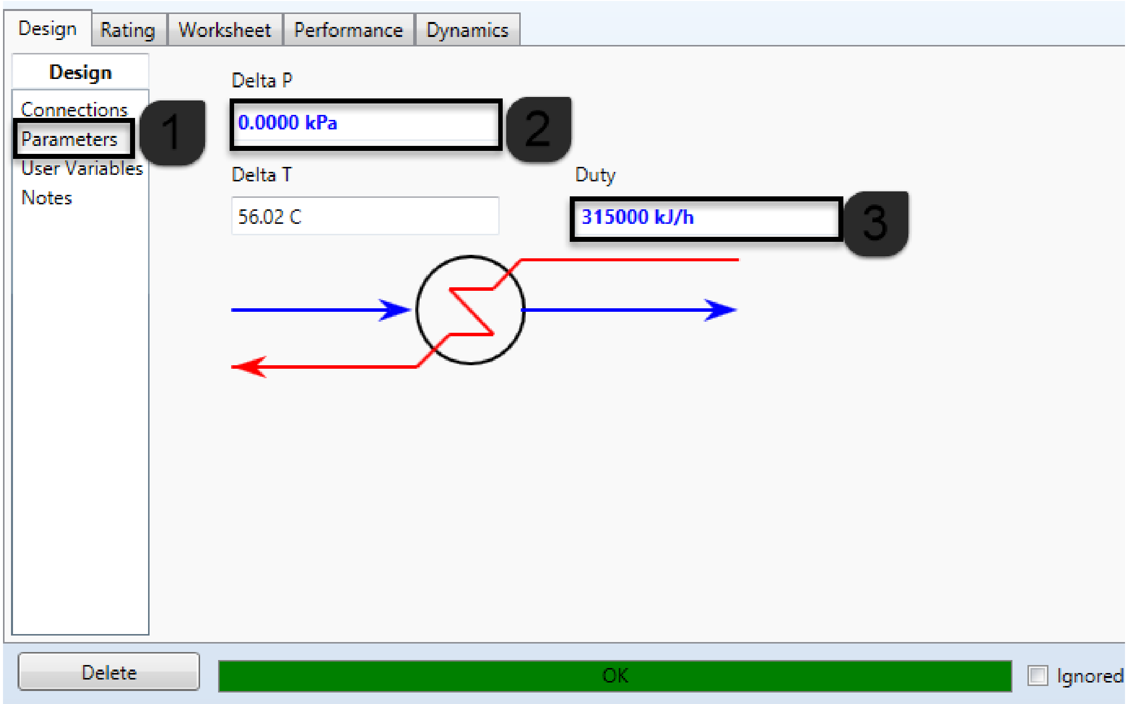


Add the first separator

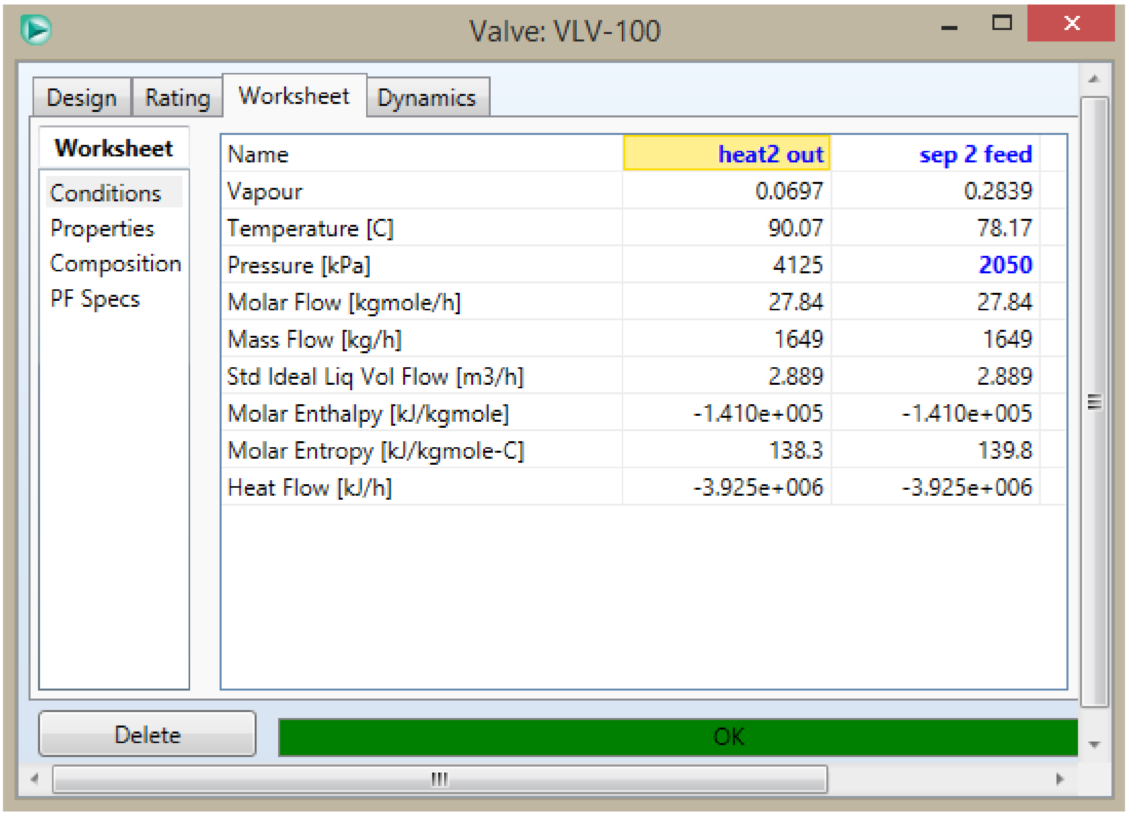




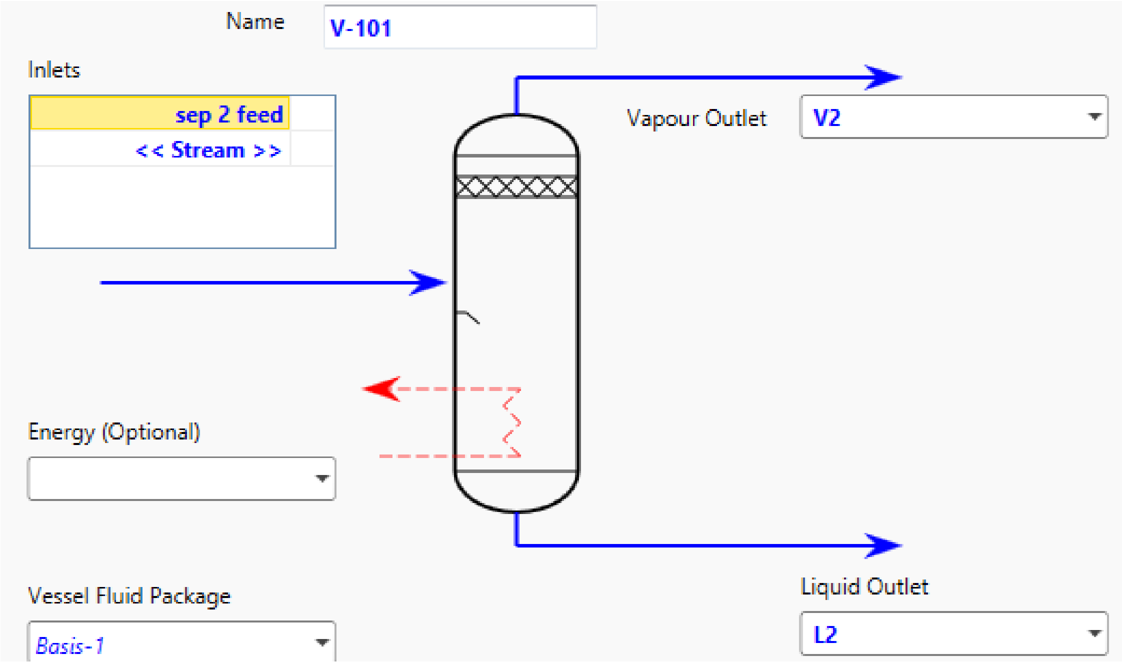
The ***liquid*** stream is then heated, add a second heater with a pressure drop of 0.0 & duty of $3.15 * 10^5$



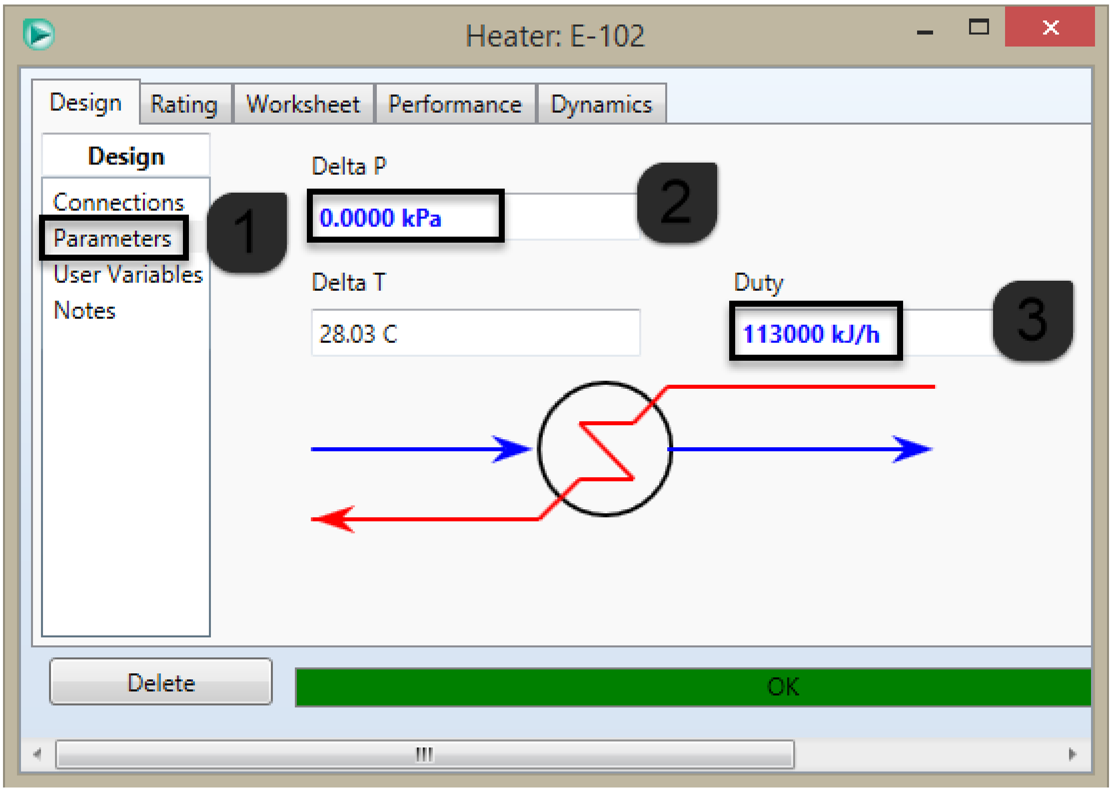
Add a valve with outlet pressure of 2050 kPa



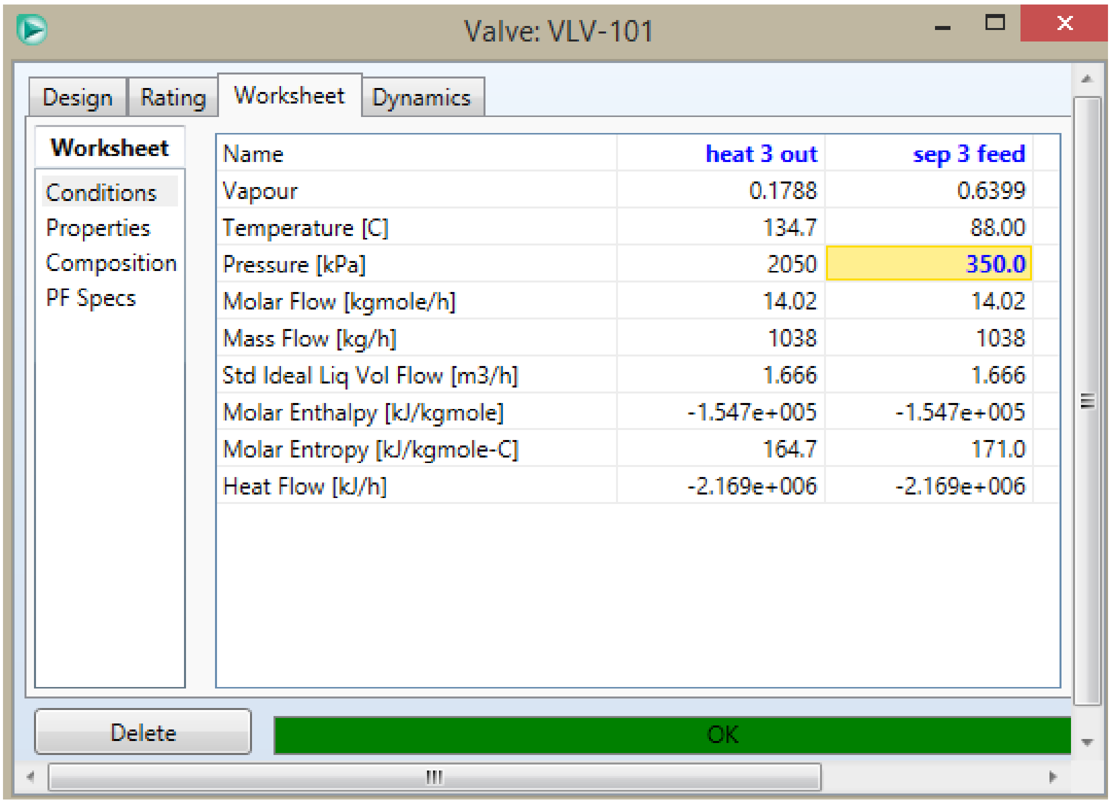
Add the second separator



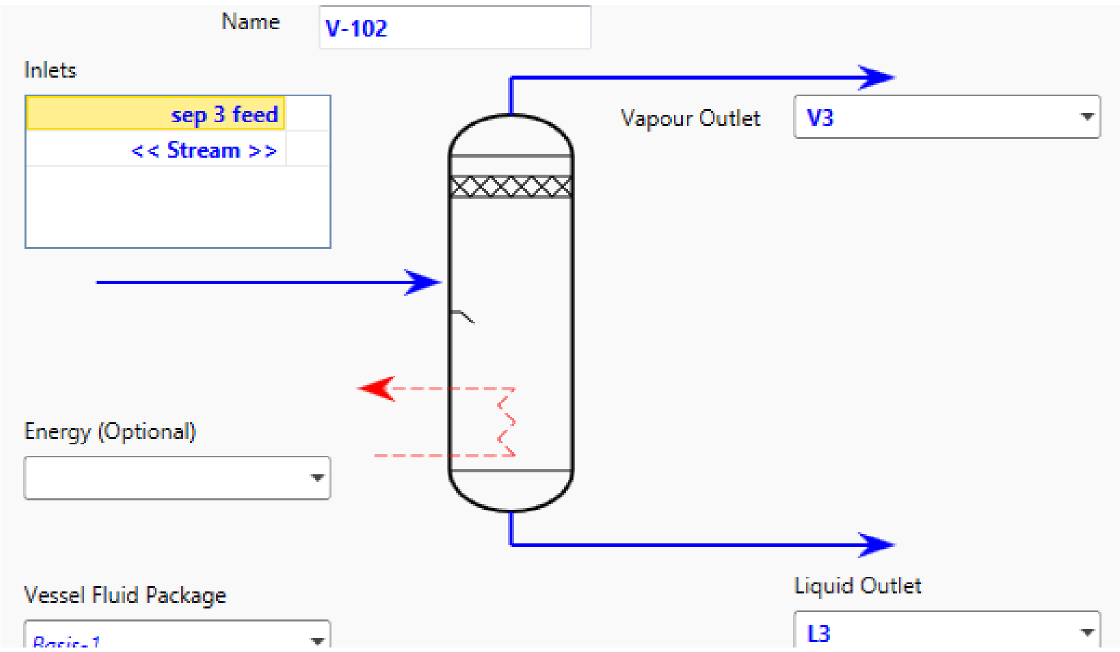
The liquid from the second separator is now fed to a third heater with a pressure drop of 0.0 & duty of 1.13 * 10^5



Add a second valve with an outlet pressure of 350 kPa

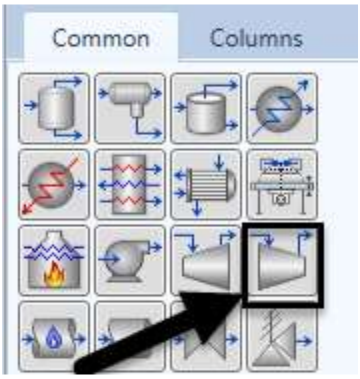


Add the third separator



The ***vapor*** from the ***second separator*** is fed to a compressor to raise the pressure to 4125 kPa

Add a compressor from the palette



Design | Rating | Worksheet | Performance | Dynamics

Worksheet: Conditions, Properties, Composition, PF Specs

Name	V2	comp 1 out	comp p1
Vapour	1.0000	1.0000	<empty>
Temperature [C]	106.7	145.9	<empty>
Pressure [kPa]	2050	4125	<empty>
Molar Flow [kgmole/h]	13.82	13.82	<empty>
Mass Flow [kg/h]	611.4	611.4	<empty>
LiqVol Flow [m3/h]	1.223	1.223	<empty>
Molar Enthalpy [kJ/kgmole]	-1.043e+005	-1.019e+005	<empty>
Molar Entropy [kJ/kgmole-C]	175.2	176.6	<empty>
Heat Flow [kJ/h]	-1.441e+006	-1.408e+006	3.313e+004

The ***vapor*** from the ***third separator*** is fed to a second compressor to raise the pressure to 4125 kPa

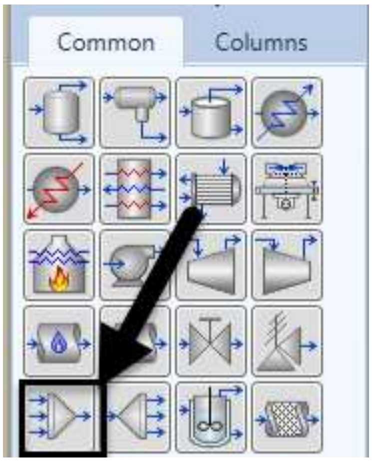
Add a **second** compressor with an outlet pressure of 4125kPa

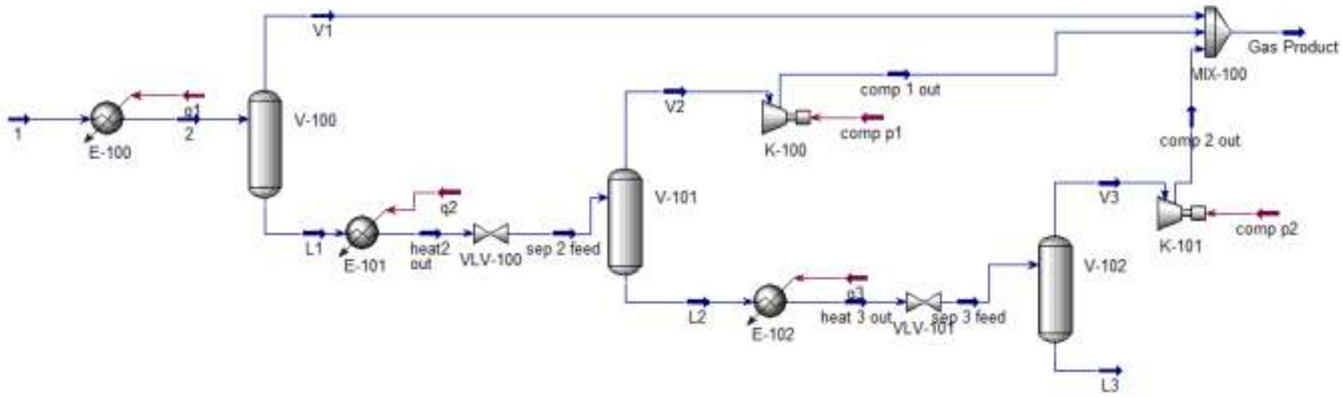
Design | Rating | Worksheet (1) | Performance | Dynamics

Worksheet: Conditions, Properties, Composition, PF Specs

Name	V3	comp 2 out	comp p2
Vapour	1.0000	1.0000	<empty>
Temperature [C]	88.00	191.0	<empty>
Pressure [kPa]	350.0	4125 (2)	<empty>
Molar Flow [kgmole/h]	8.970	8.970	<empty>
Mass Flow [kg/h]	549.9	549.9	<empty>
LiqVol Flow [m3/h]	0.9460	0.9460	<empty>
Molar Enthalpy [kJ/kgmole]	-1.270e+005	-1.183e+005	<empty>
Molar Entropy [kJ/kgmole-C]	183.1	187.8	<empty>
Heat Flow [kJ/h]	-1.139e+006	-1.061e+006	7.753e+004

The three vapor streams will be mixed using a mixer

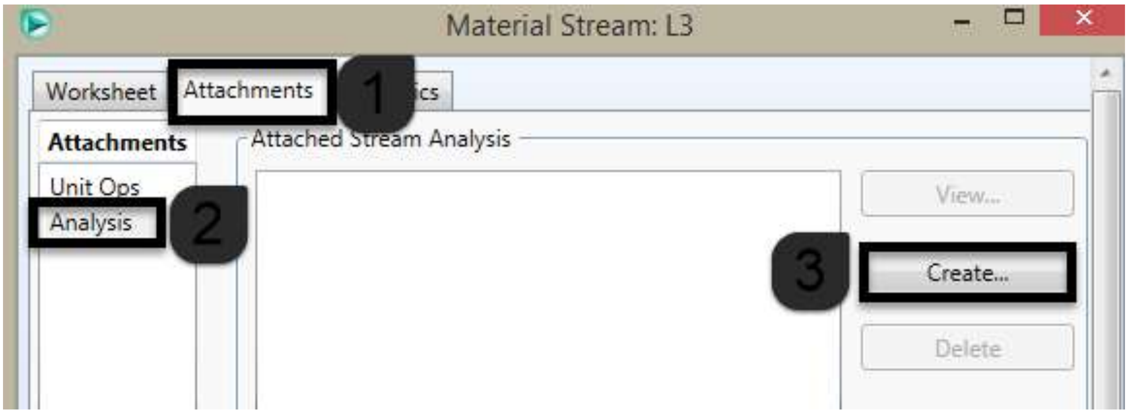


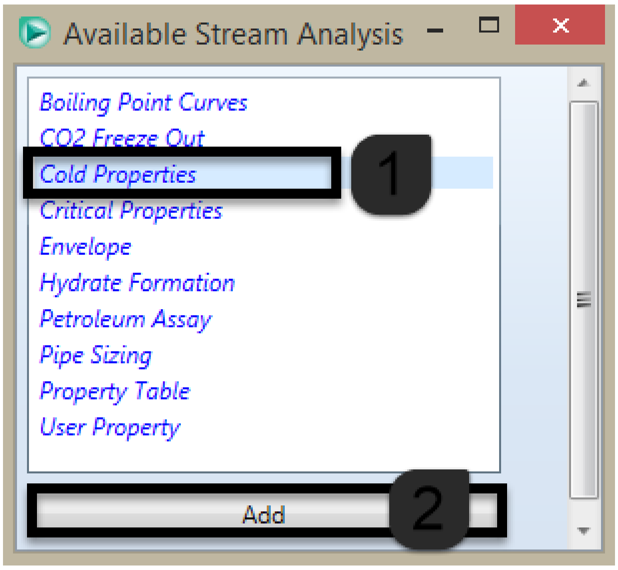


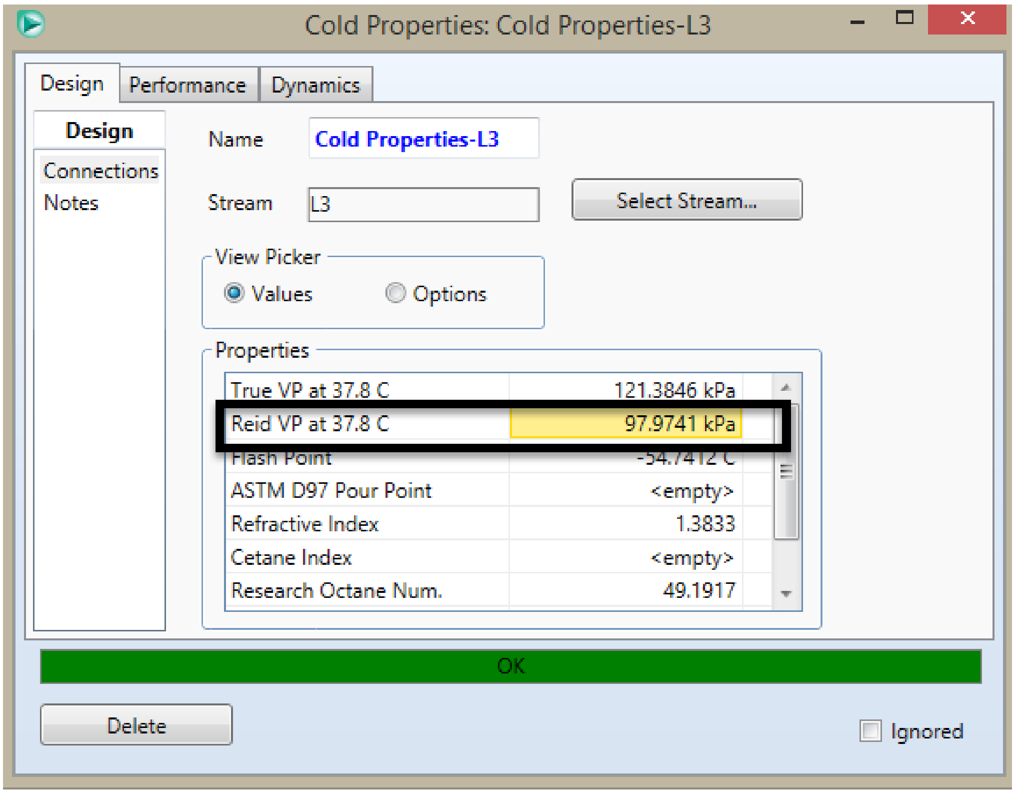
The RVP of the Liquid Product stream should be about 96.5 kPa to satisfy the pipeline criterion.

Use ***cold properties*** analysis to see the current Reid Vapor Pressure for the liquid product from the third separator:

From the attachments tab, select Analysis and then Create:


Material Stream: L3
Worksheet
Attachments
Attachments
Unit Ops
Analysis
Attached Stream Analysis
View...
Create...
Delete
1
2
3


Available Stream Analysis
Boiling Point Curves
CO2 Freeze Out
Cold Properties
Critical Properties
Envelope
Hydrate Formation
Petroleum Assay
Pipe Sizing
Property Table
User Property
Add
1
2


Cold Properties: Cold Properties-L3
Design
Performance
Dynamics
Design
Connections
Notes
Name
Cold Properties-L3
Stream
L3
Select Stream...
View Picker
Values
Options
Properties
True VP at 37.8 C
121.3846 kPa
Reid VP at 37.8 C
97.9741 kPa
Flash Point
-54.7412 C
ASTM D97 Pour Point
<empty>
Refractive Index
1.3833
Cetane Index
<empty>
Research Octane Num.
49.1917
OK
Delete
Ignored

Changing the Units

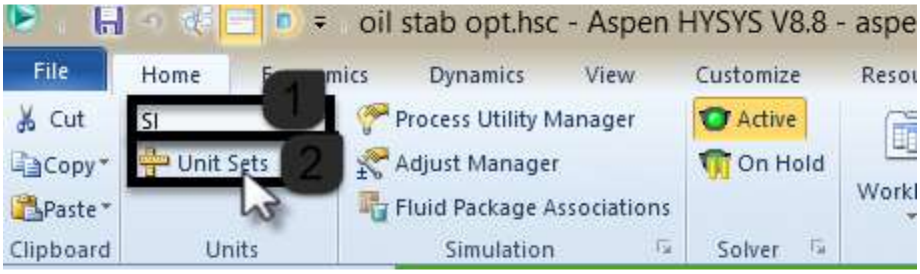
We need to change the default unit set to fit this case

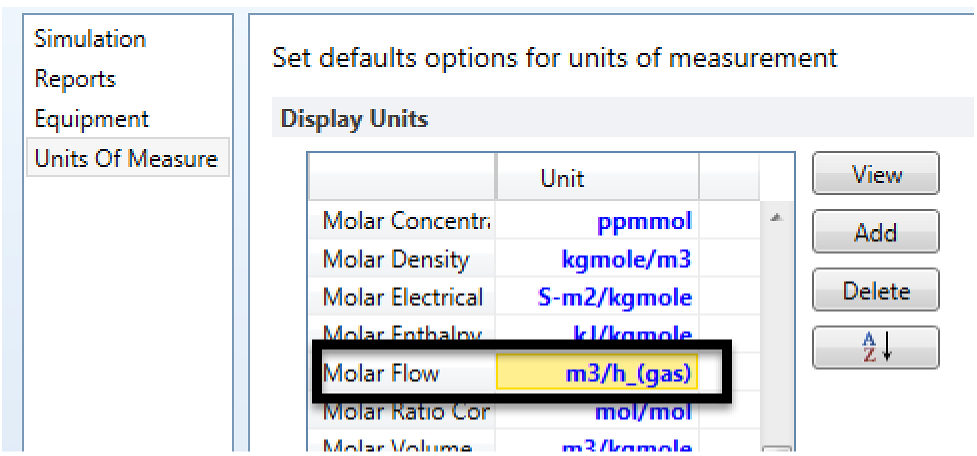
Change the units as follows:

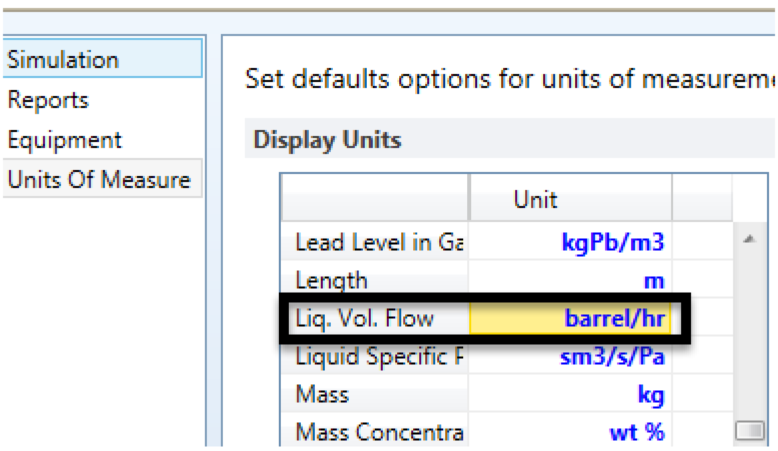
Molar flow: m^3_gas/hr

Liq. Vol. Flow: barrel/hr

Std. Vol. Flow: barrel/hr







Optimization

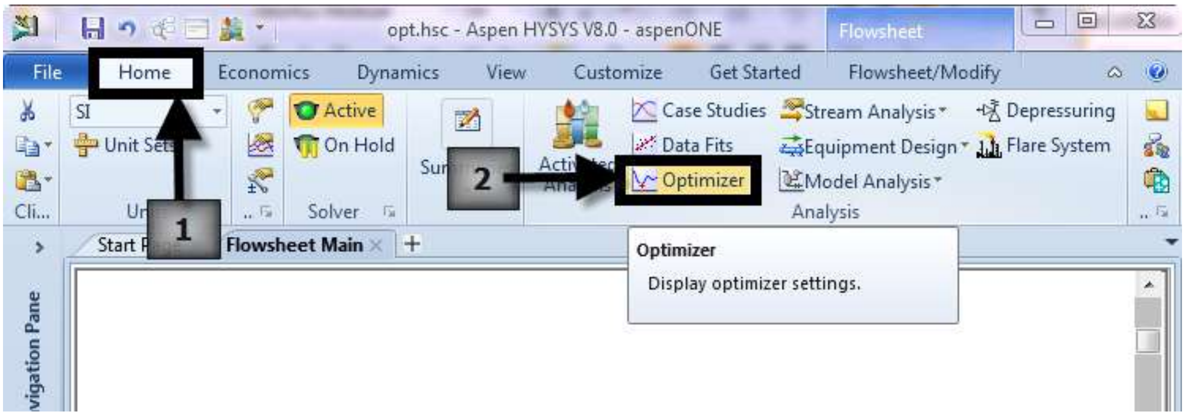
HYSYS contains a multi-variable Steady State Optimizer. Once your flowsheet has been built and converged, you can use the Optimizer tool to find the operating conditions which minimize or maximize an Objective Function. The Optimizer owns its own Spreadsheet for defining the Objective Functions as well as any constraint expressions to be used. This allows you to construct Objective Functions which maximize profit, minimize utilities or minimize exchanger UA.

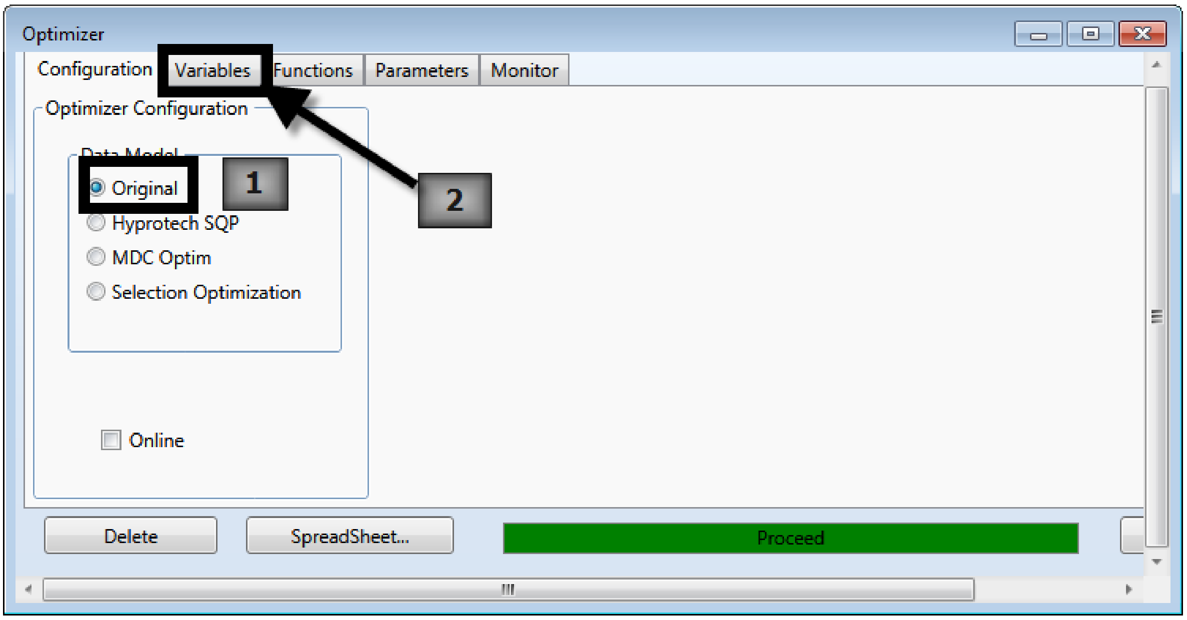
In this case, we want to maximize the total operating profit while achieving an RVP of Liquid Product less than 96.5 kPa. The incomes from the Plant are both the Gas and Liquid Products. The operating costs are the Steam Costs for each Heater plus the Power Cost for each Compressor.

Profit = Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)

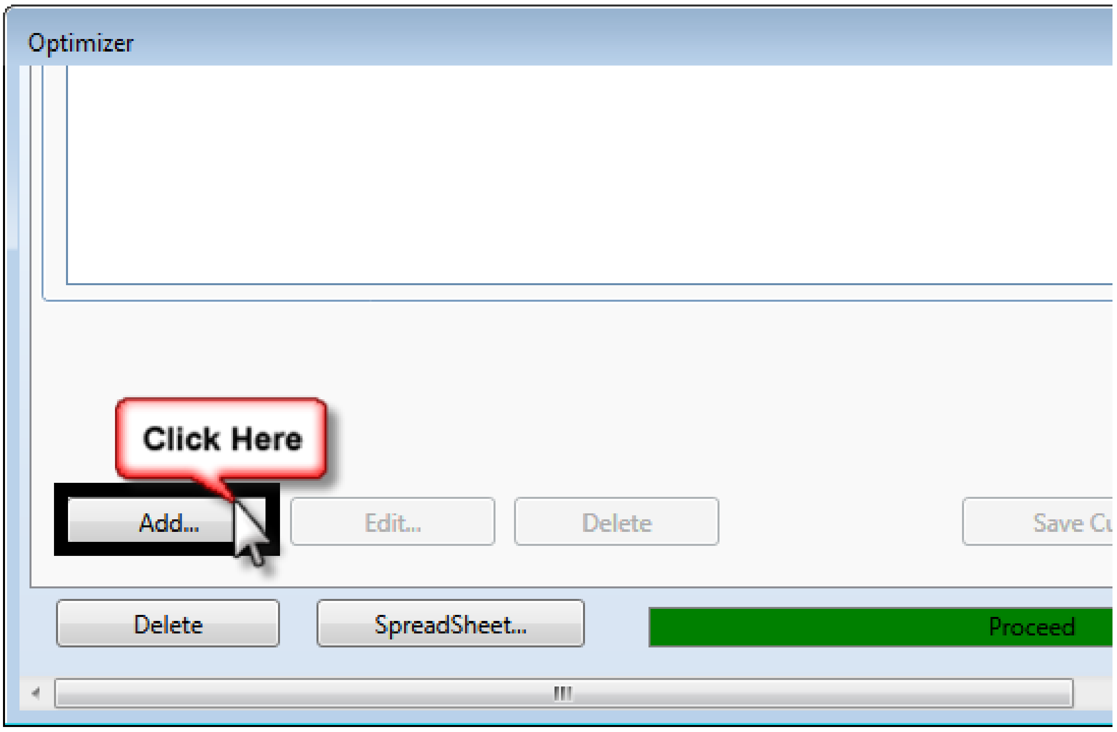
Use the Optimizer tool:

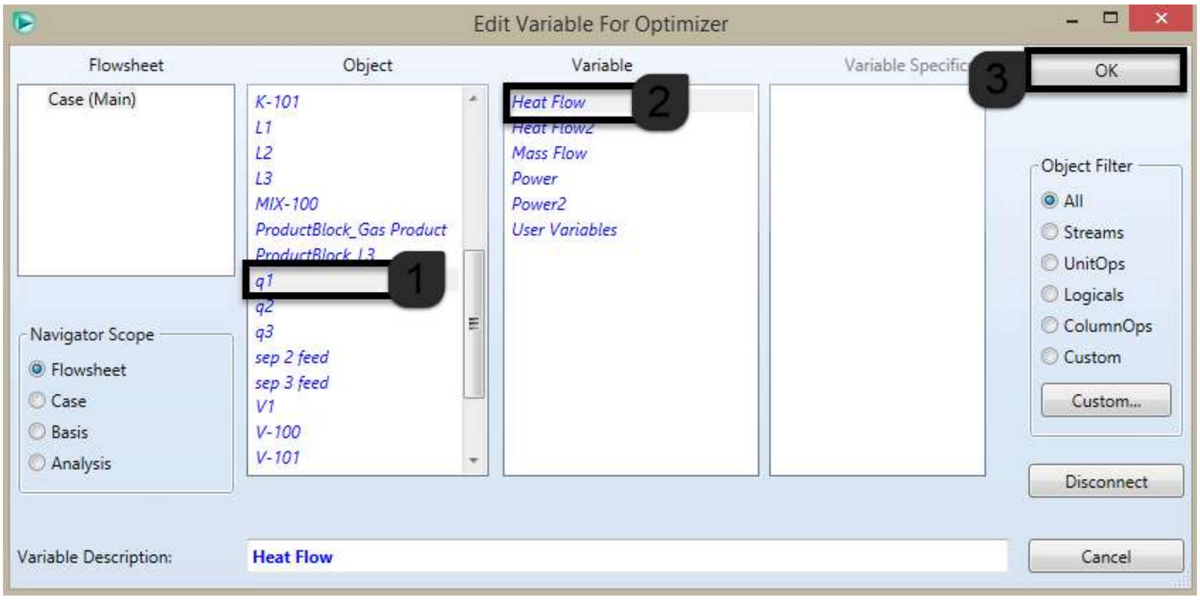




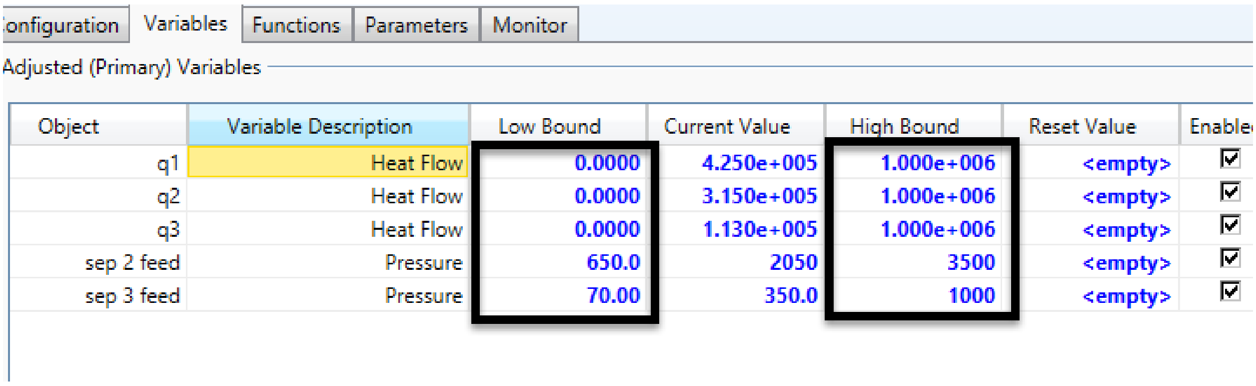
The variables to be optimized in order to maximize the profit should be added now, these variables are:

The 3 Heaters' duties and Valves outlet pressures





After adding all the 5 variables, set the upper and lower ranges for each variable as follows:



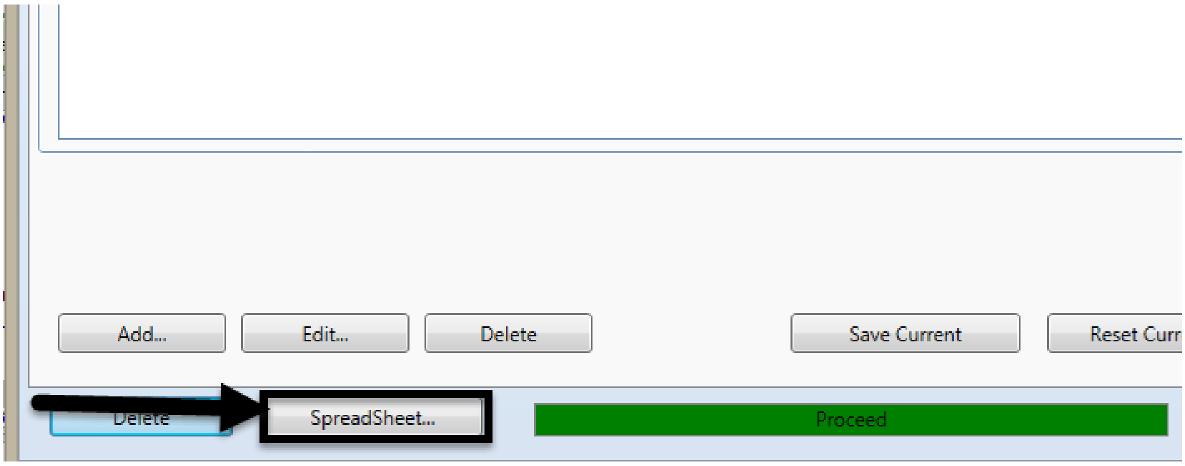
Configuration | Variables | Functions | Parameters | Monitor

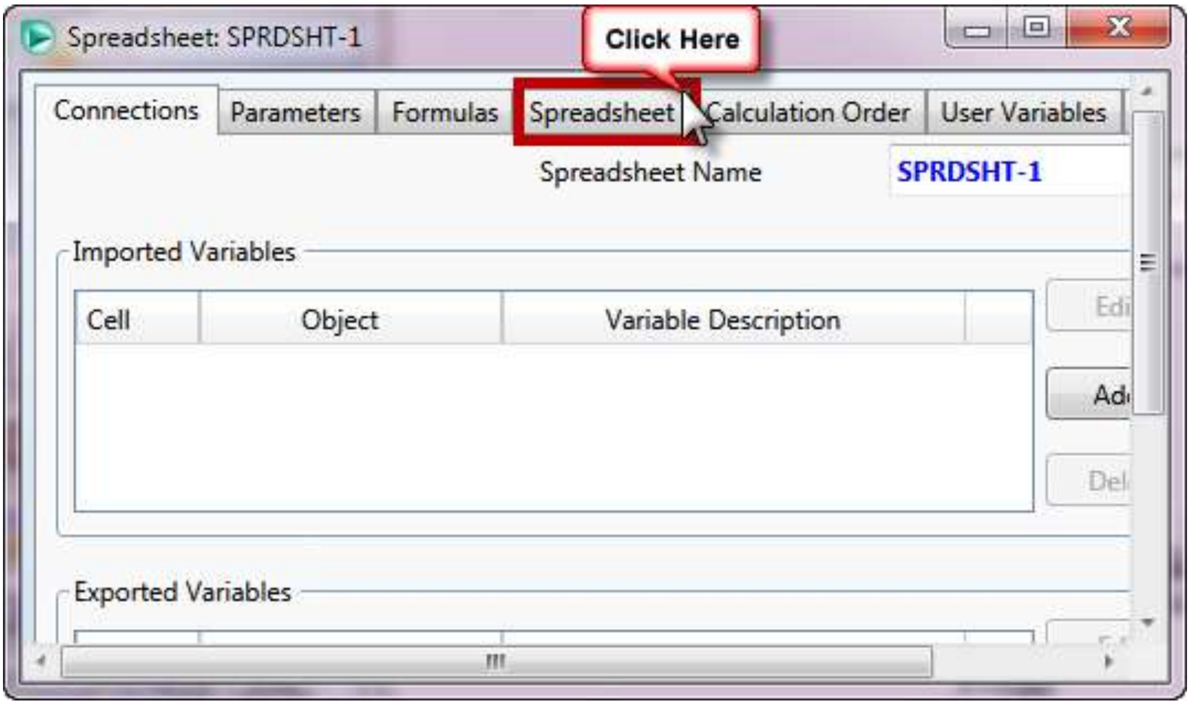
Adjusted (Primary) Variables

Object	Variable Description	Low Bound	Current Value	High Bound	Reset Value	Enable
q1	Heat Flow	0.0000	4.250e+005	1.000e+006	<empty>	☑
q2	Heat Flow	0.0000	3.150e+005	1.000e+006	<empty>	☑
q3	Heat Flow	0.0000	1.130e+005	1.000e+006	<empty>	☑
sep 2 feed	Pressure	650.0	2050	3500	<empty>	☑
sep 3 feed	Pressure	70.00	350.0	1000	<empty>	☑

The Optimizer has its own Spreadsheet for defining the Objective and Constraint functions.

Now we have to start building the profit module using the spreadsheet operation:





Profit= Income - Cost

Profit= (Gas Product + Liquid Product) – (Steam Costs + Compression Cost)

Prices & costs:

Oil Price= 15 $/bbl

Gas Price =0.106 $/m^3_gas

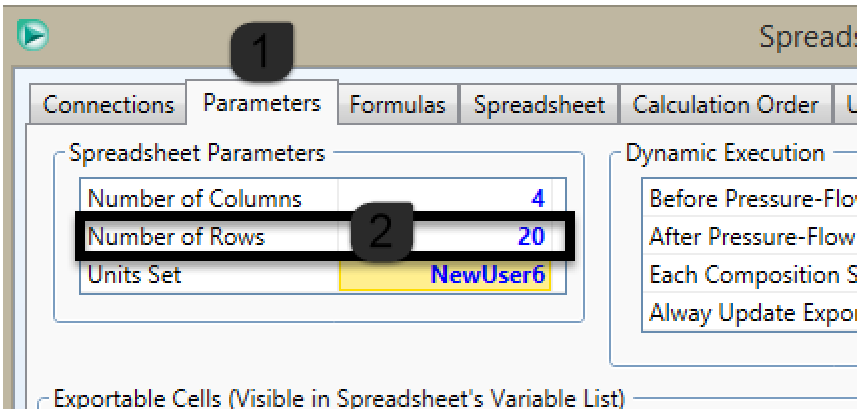
Steam Cost= 0.682 $/kW-h

Compression Cost=0.1 $/kW-h

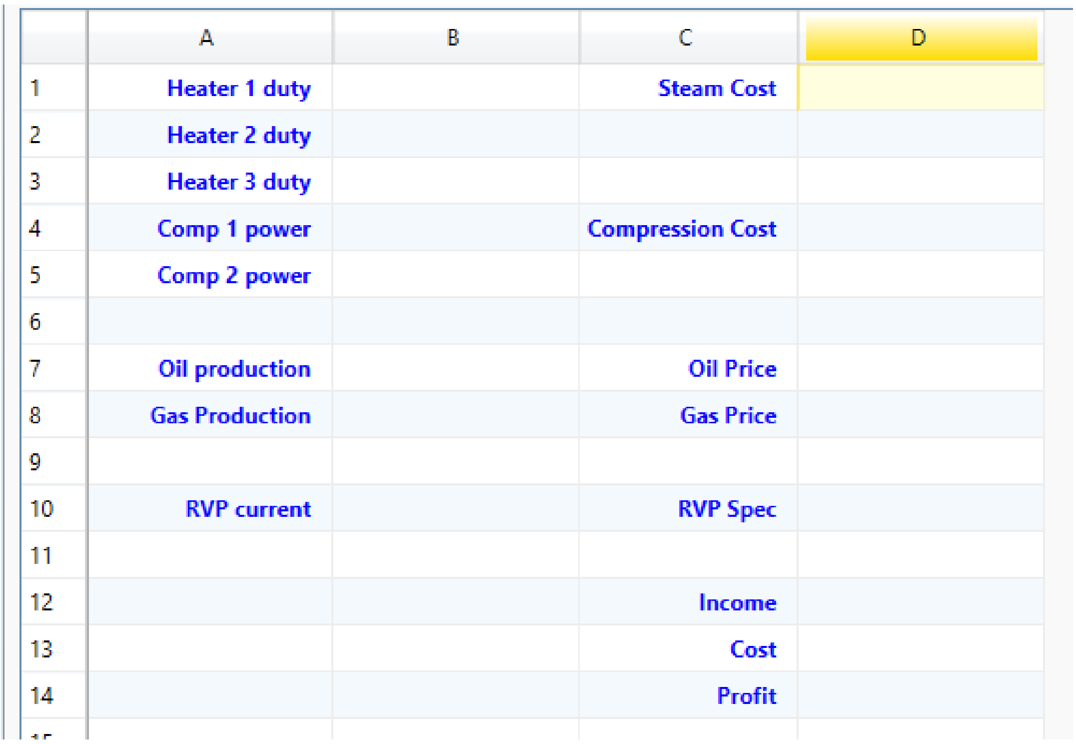
The RVP spec for the liquid should be added in the spread sheet in order to use it as a constraint.

RVP spec= 96.5 kPa

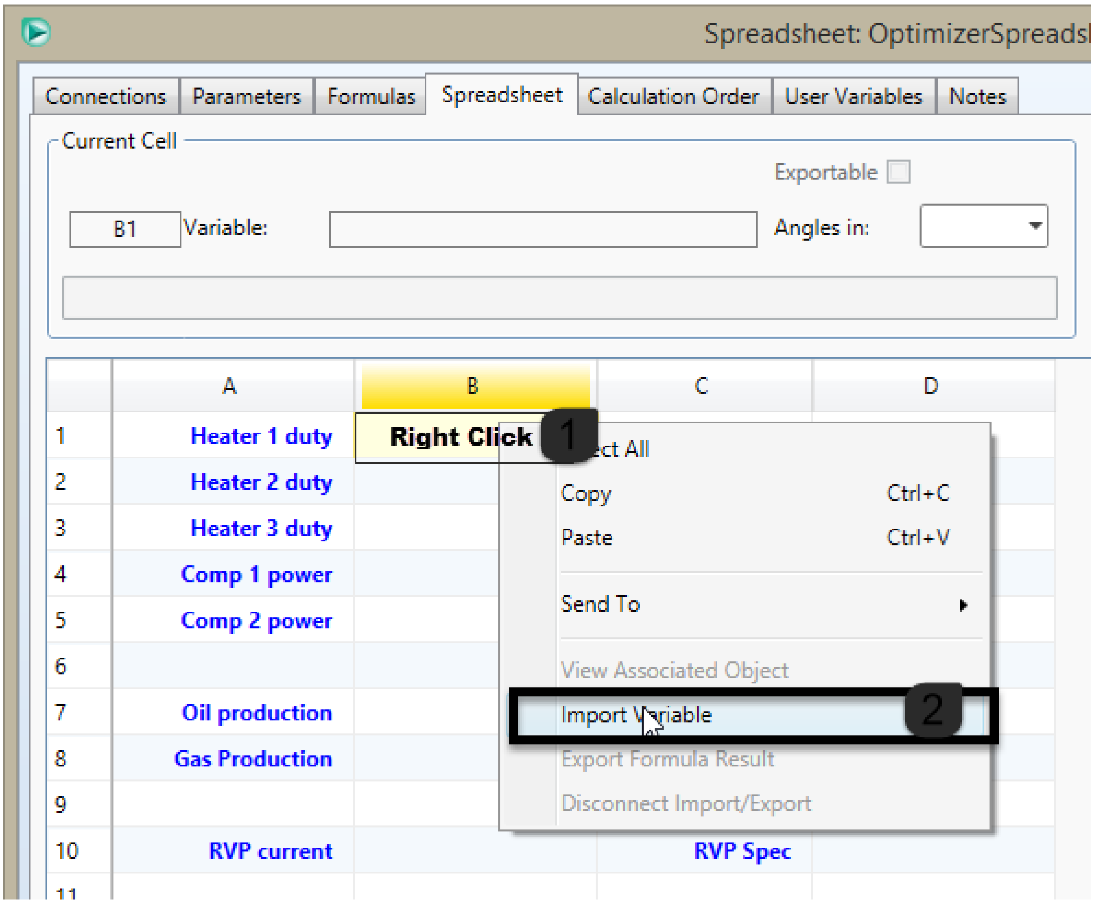
First we need to increase the number of rows in the spread sheet to be 20 from the parameters tab:

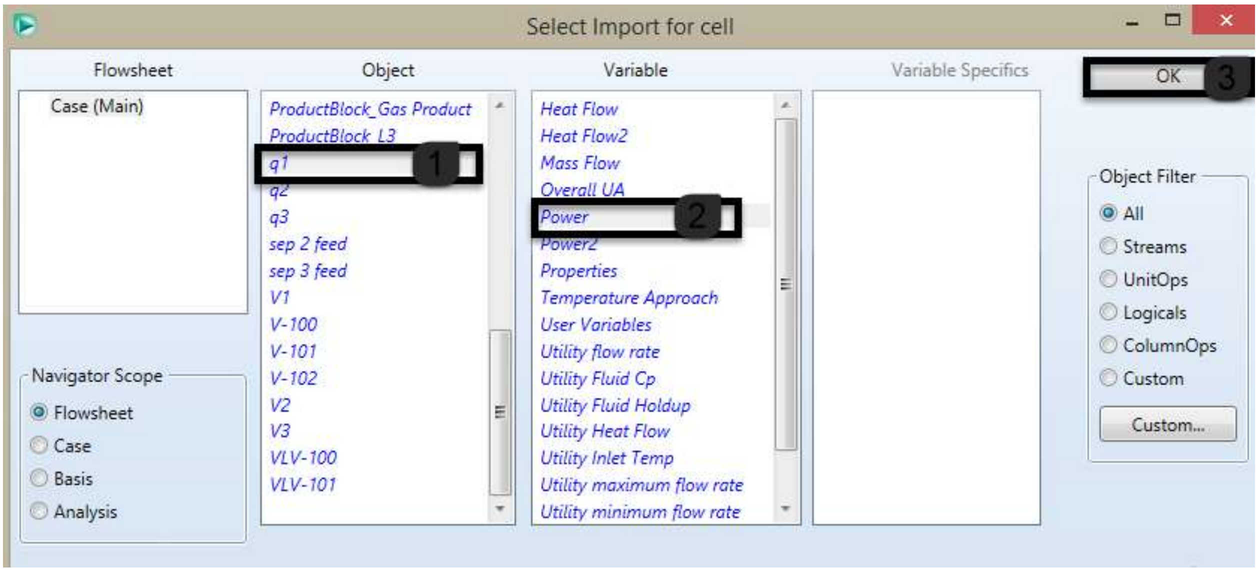


Now return to the spreadsheet tab again and add all the profit equation parameters & variables.



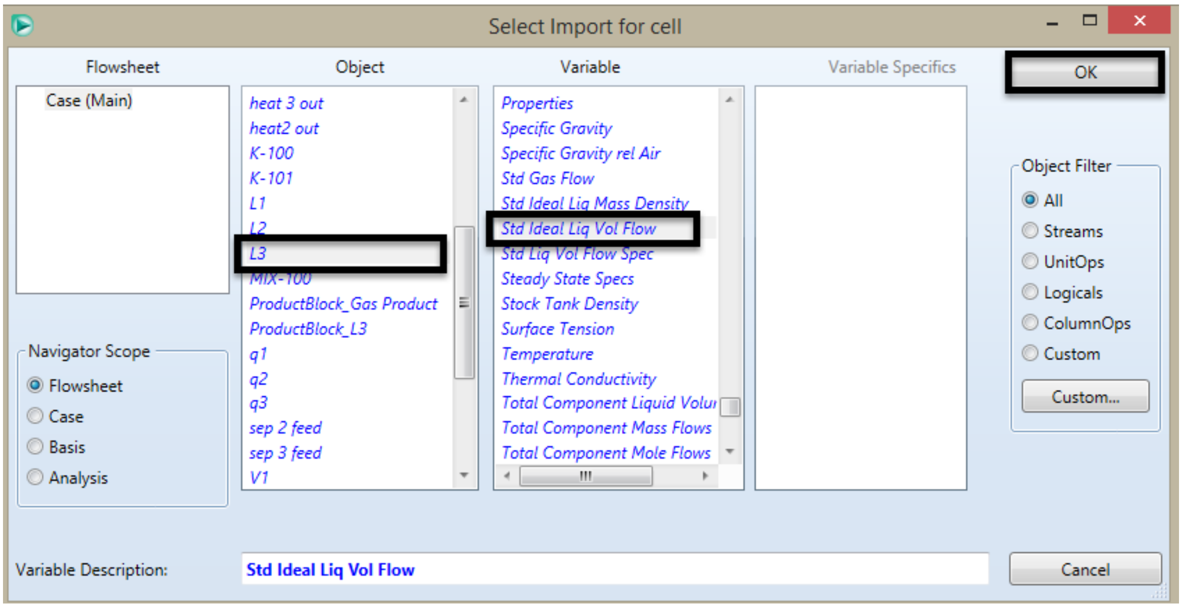
After adding the labels, import the variables in each labeled cell:

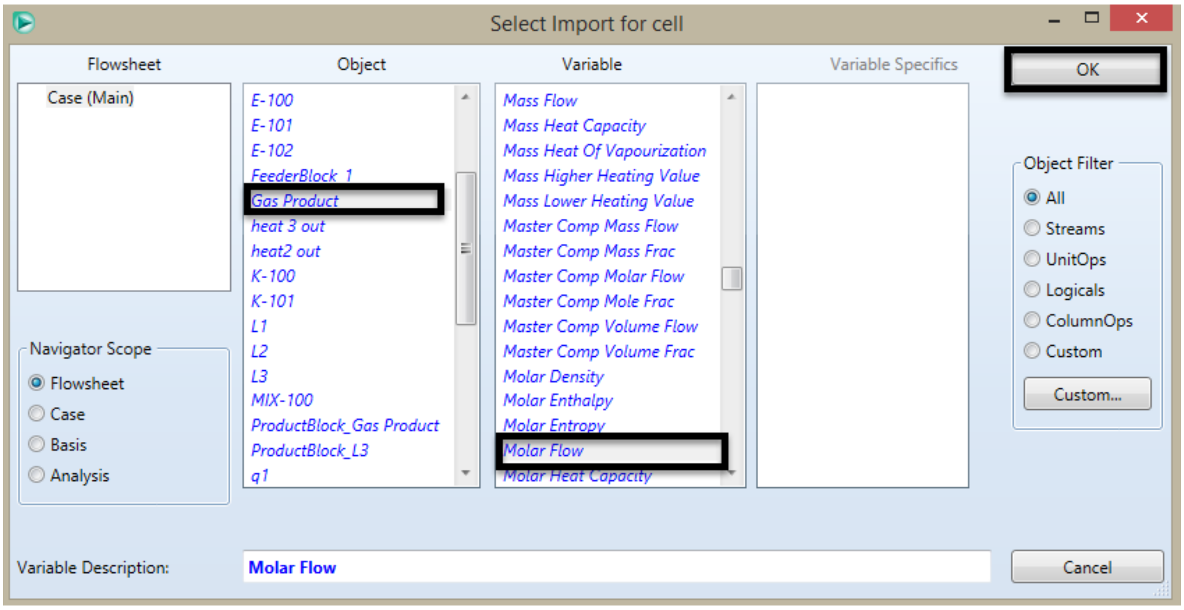




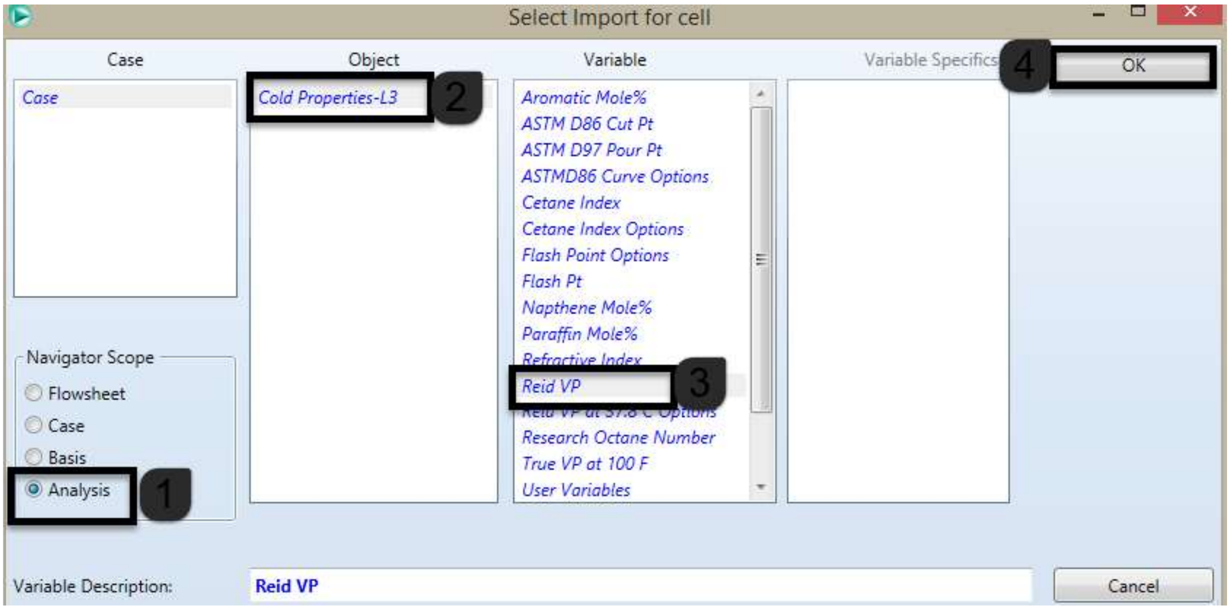
Add all duties for heaters & compressors the same way as we did in the previous step.

Do the same for Oil & gas production flow rates





The RVP current value should be imported from the Analysis:



The Prices should now added manually without importing it

	A	B	C	D
1	Heater 1 duty	118.1 kW	Steam Cost ($/kW-h)	0.6820
2	Heater 2 duty	87.50 kW		
3	Heater 3 duty	31.39 kW		
4	Comp 1 power	9.203 kW	Compression Cost ($/kW-h)	0.1000
5	Comp 2 power	21.54 kW		
6				
7	Oil production	4.530 barrel/hr	Oil Price ($/bbl)	15.00
8	Gas Production	1056 m3/h_(gas)	Gas Price ($/m3_gas)	0.1060
9				
10	RVP current	97.97 kPa	RVP Spec (kPa)	96.50
11				
12			Income	
13			Cost	
14			Profit	

Calculate the Income, Cost & Profit using the current formulas:

Income: =d7*b7+d8*b8

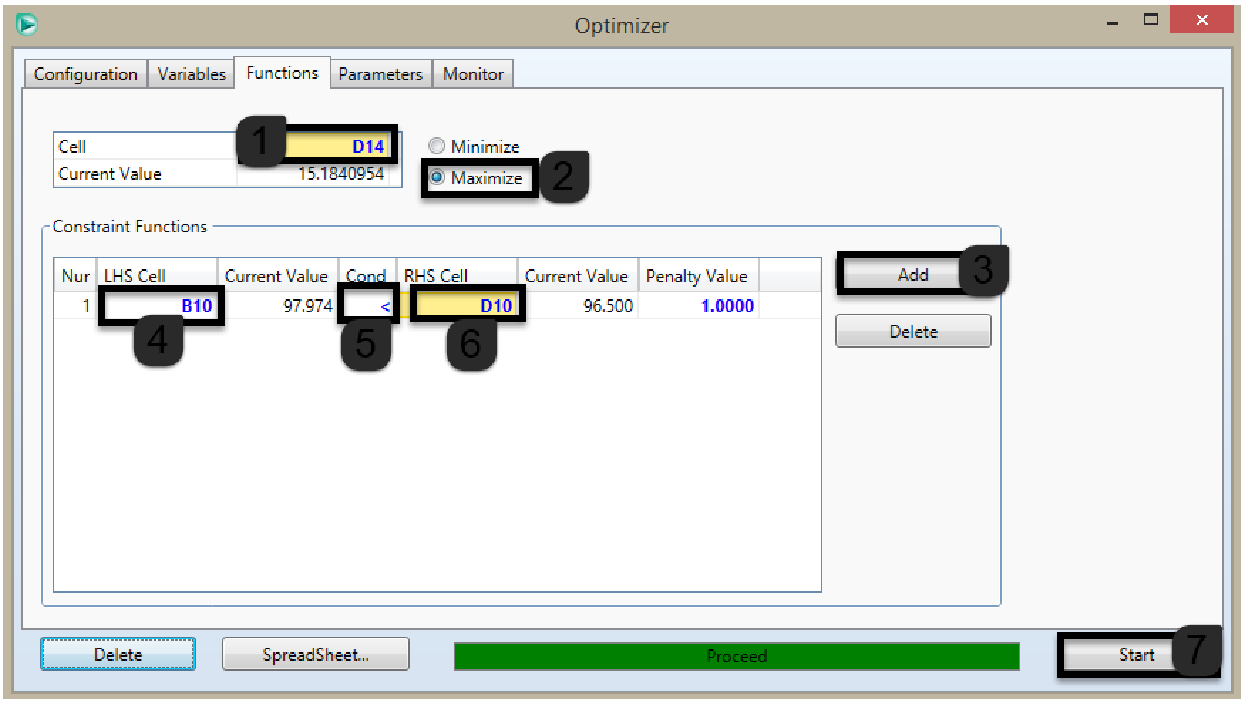
Cost: =(b1+b2+b3)*d1+(b4+b5)*d4

Profit: =d12-d13

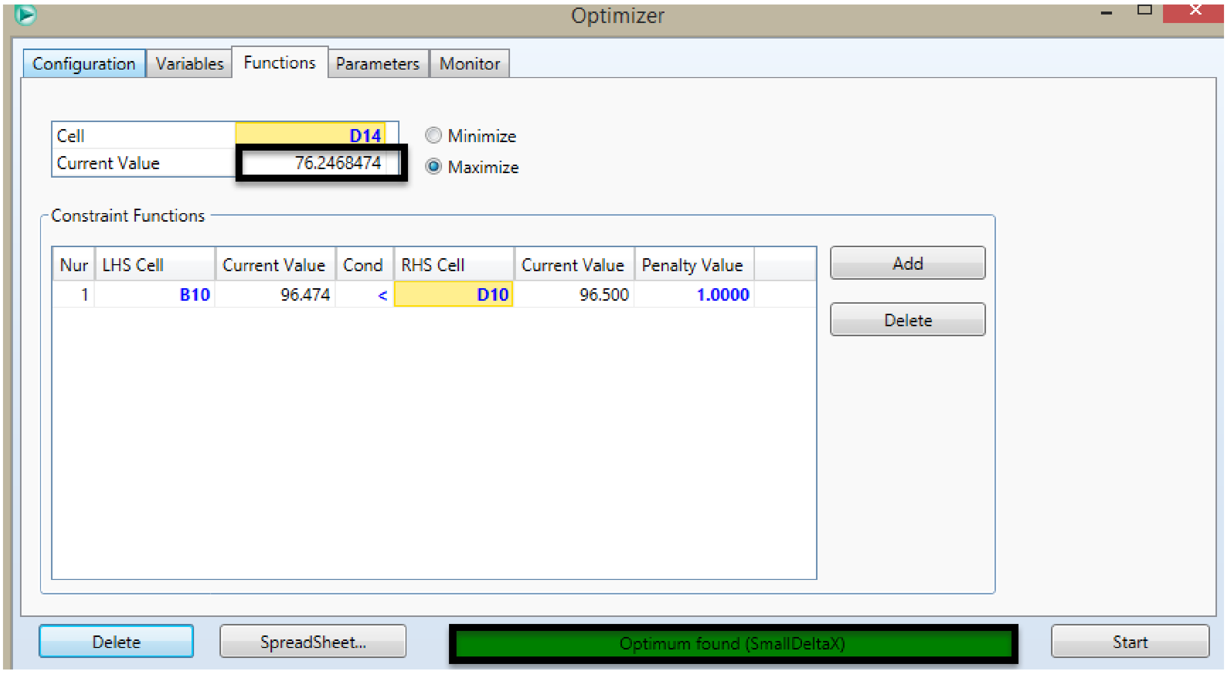
	A	B	C	D
1	Heater 1 duty	118.1 kW	Steam Cost ($/kW-h)	0.6820
2	Heater 2 duty	87.50 kW		
3	Heater 3 duty	31.39 kW		
4	Comp 1 power	9.203 kW	Compression Cost ($/kW-h)	0.1000
5	Comp 2 power	21.54 kW		
6				
7	Oil production	4.530 barrel/hr	Oil Price ($/bbl)	15.00
8	Gas Production	1056 m3/h_(gas)	Gas Price ($/m3_gas)	0.1060
9				
10	RVP current	97.97 kPa	RVP Spec (kPa)	96.50
11				
12			Income ($/hr)	179.9
13			Cost ($/hr)	164.7 kW
14			Profit ($/hr)	15.18 kW

After calculating the operating profit @ current conditions, use the optimizer to maximize the profit by changing the 5 variables which we added before

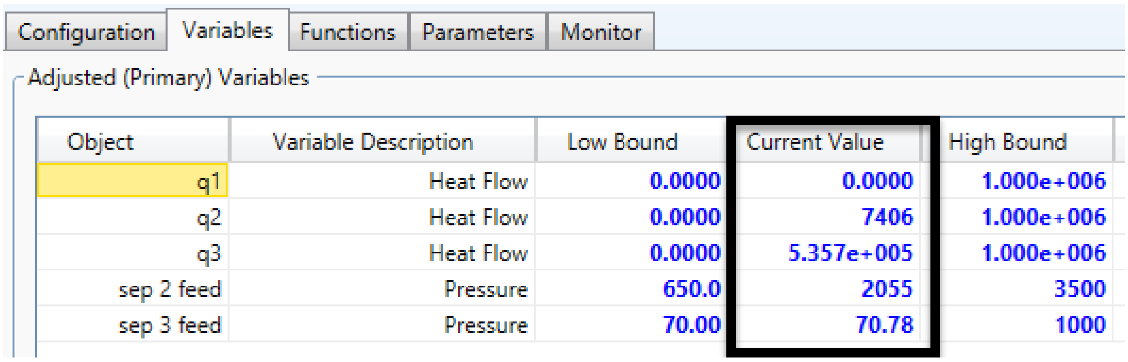
Open the optimizer and go to Functions tab:



You may need to press the Start button 2 or 3 times to ensure reaching the optimum solution as follows:

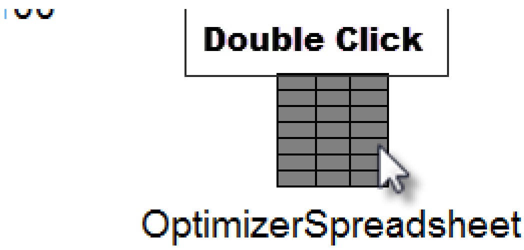


You may see the new values for the variables from the Variables tab:



Object	Variable Description	Low Bound	Current Value	High Bound
q1	Heat Flow	0.0000	0.0000	1.000e+006
q2	Heat Flow	0.0000	7406	1.000e+006
q3	Heat Flow	0.0000	5.357e+005	1.000e+006
sep 2 feed	Pressure	650.0	2055	3500
sep 3 feed	Pressure	70.00	70.78	1000

Now you can return back to the spreadsheet to observe the results:



	A	B	C	D
1	Heater 1 duty	0.0000 kW	Steam Cost ($/kW...	0.6820
2	Heater 2 duty	2.057 kW		
3	Heater 3 duty	148.8 kW		
4	Comp 1 power	3.797 kW	Compression Cost...	0.1000
5	Comp 2 power	109.4 kW		
6				
7	Oil production	5.403 barrel/hr	Oil Price ($/bbl)	15.00
8	Gas Production	1032 m3/h_(gas)	Gas Price ($/m3_g...	0.1060
9				
10	RVP current	96.47 kPa	RVP Spec (kPa)	96.50
11				
12			Income ($/hr)	190.5
13			Cost ($/hr)	114.2 kW
14			Profit ($/hr)	76.25 kW

Save Your Case!

Exercise:

One thing you may notice with the Optimized solution is that the Pressure of V3 has been decreased to 70 kPa (10 psia) which is less than atmospheric. This is not a desired condition for the inlet of a compressor. The inlet of the second compressor, cannot be less than 125 kPa (19 psia). What is the maximum profit if you adhere to this guideline?

You may check the website for more data & courses

http://www.adeyab.com

If you have any inquiry:

eng.a.deab@gmail.com

adeyab@adeyab.com

002 01227549943

00966544390045