



UNIVERSITI MALAYSIA PERLIS (UniMAP)
Pusat Pengajian Kejuruteraan Bioproses

ERT 214

MATERIAL AND ENERGY BALANCE

HYSYS SIMULATION MANUAL

Pn Hafiza Shukor

Dr Ku Syahidah Ku Ismail

Cik Hafizah Mohd Johar

MODULE 1

INTRODUCTION TO HYSYS SIMULATION

1.0 OBJECTIVES

1.1 To familiarize students with HYSYS simulation.

1.2 To learn basic concepts required to model and analyze processes using HYSYS.

2.0 INTRODUCTION ON HYSYS

HYSYS is an interactive process engineering and simulation program. It is powerful software for simulation of chemical plants and oil refineries. It includes tools for estimation of physical properties and liquid-vapor phase equilibrium, heat and material balances, and simulation of many types of chemical engineering equipment.

As a user-friendly computer software package which is developed by Hyprotech, the package combines comprehensive data regression, thermodynamic database access (TRC, DIPPR, DDB, API, PDS) and the Mayflower distillation technology to enable the design and analysis of separation systems, including azeotropic and extractive distillation and non-ideal, heterogeneous and multiple liquid phase systems.

Although this software is user friendly, considerable effort must be expended to master it. HYSYS, which is built upon proven technologies with more than 25 years experience supplying process simulation tools to the oil & gas and refining industries. It provides an intuitive and interactive process modeling solution that enables engineers to create steady state and dynamic models for plant design, performance monitoring, troubleshooting, operational improvement, business planning and asset management.

Programs like HYSYS were usually used to design an entire process as completely and accurately as possible. Unlike Aspen, HYSYS does not wait until we have entered everything before beginning calculations. It always calculates as much as it can at all time and results are always available, even during calculations. Any changes of a data are automatically propagated throughout

the program to anywhere that entry appears and all necessary recalculations are instantly carried out. It tends to be a lot easier to catch errors this way as we build our simulation.

3.0 HYSYS FEATURES

In order to operate with maximum effectiveness and provide the necessary insights and knowledge, a steady state modeling tool must combine ease-of-use with robust engineering power. HYSYS will provide the following features:

i. Easy-to-Use Windows Environment.

Process Flow Diagram, PFDs provide a clear and concise graphical representation of the process flowsheet including productivity features such as cut, copy, paste, auto connection, and organizing large cases into sub-flowsheets.

ii. Comprehensive Thermodynamics Foundation.

Ensures accurate calculation of physical properties, transport properties, and phase behavior for the oil & gas and refining industries. Contains an extensive component database and the ability to add user components.

iii. Active X (OLE Automation) Compliance.

Permits the integration of user-created unit operations, proprietary reaction kinetic expressions, and specialized property packages. Interfaces easily with programs such as Microsoft Excel and Visual Basic.

iv. Comprehensive Unit Operations.

Includes distillation, reactions, heat transfer operations, rotating equipment, and logical operations in the steady state and dynamics environment. Proven to deliver quality realistic results and handle various situations such as vessel emptying or overflowing and reverse flow.

v. Detailed Heat Exchanger Design and Rating.

Users may optionally link to rigorous heat exchanger design and rating tools, such as TASC™ (shell and tube exchangers), MUSE™ (multi-pass exchangers) and ACOL™ (air coolers). This provides users with more rigour when needed without leaving the HYSYS environment.

vi. Economic Evaluation of Process Designs.

HYSYS simulation models can be exported to Aspen Icarus Process Evaluator™ or Aspen Icarus Project Manager™ for economic evaluation and project management of process designs. Aspen Icarus™ technology is used to perform unit operation and site-wide costing of processing equipment and facilities.

vii. Front-end Engineering Work.

HYSYS simulation models can be exported to Aspen Zyqad™ in order to streamline the front-end engineering work process. Using Aspen Zyqad throughout this process results in increased engineering efficiency, quality and reduced project cycle time.

4.0 ADVANTAGES USING HYSYS

HYSYS helps process industries improve productivity and profitability throughout the plant lifecycle. The powerful simulation and analysis tools, real-time applications and the integrated approach to the engineering solutions in HYSYS enables the companies to improve designs, optimize production and enhance decision-making. Some of the key business benefits offered by HYSYS are listed below:

I. Evaluates Process Operability, safety concern and Improved Process Designs

Engineers can rapidly evaluate the most profitable, reliable and safest design. It is estimated that on-site design changes made during commissioning constitute 7% of the capital cost of a project. HYSYS enables engineers to evaluate the impact of their design decisions earlier in the project. For new designs, HYSYS enables users to create models quickly to evaluate many scenarios. The interactive environment allows for easy ‘what-if’ studies and sensitivity analysis. Using powerful simulation and analysis tools, HYSYS can help us to improve design, optimize production, and enhance decision-making.

II. Equipment Performance Monitoring

Ensure optimal equipment performance, reveals sources of process problems and eliminates them. HYSYS allows users to determine rapidly whether equipment is performing below specification. For example, engineers troubleshooting or improving plant operations use HYSYS to assess equipment deficiencies such as heat exchanger fouling, column flooding, compressor and separation efficiencies. HYSYS also enables you to devise improved control strategies and assess their benefits before modify the actual process.

III. Reduced Engineering Costs.

Avoid manual and error-prone data re-entry by simulating with HYSYS. Process reduces engineering costs by creating models that can be leveraged throughout the plant lifecycle – from conceptual design to detailed design, rating, training, and optimization providing a work environment that ensures work is completed quickly and effectively. This avoids the time consuming and error-prone manual process of transferring, formatting and analyzing production and process data that can account for up to 30% of engineering man-hours.

PROCEDURE

1.Starting HYSYS

1.1 Click on Start → Aspen tech → Process Modelling V8.0 → Aspen HYSYS → Aspen HYSYS

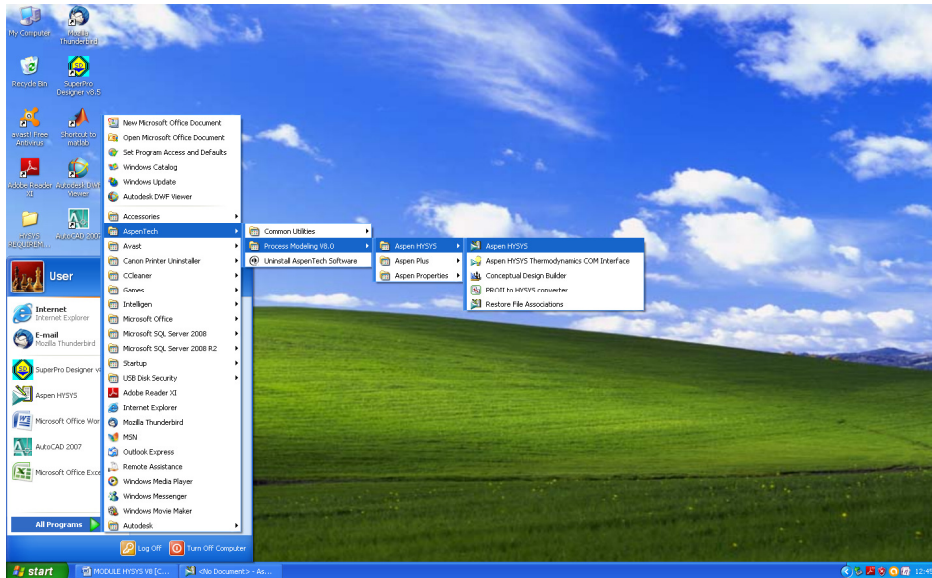


Figure 1: Windows Desktop

1.2 This box will appear.

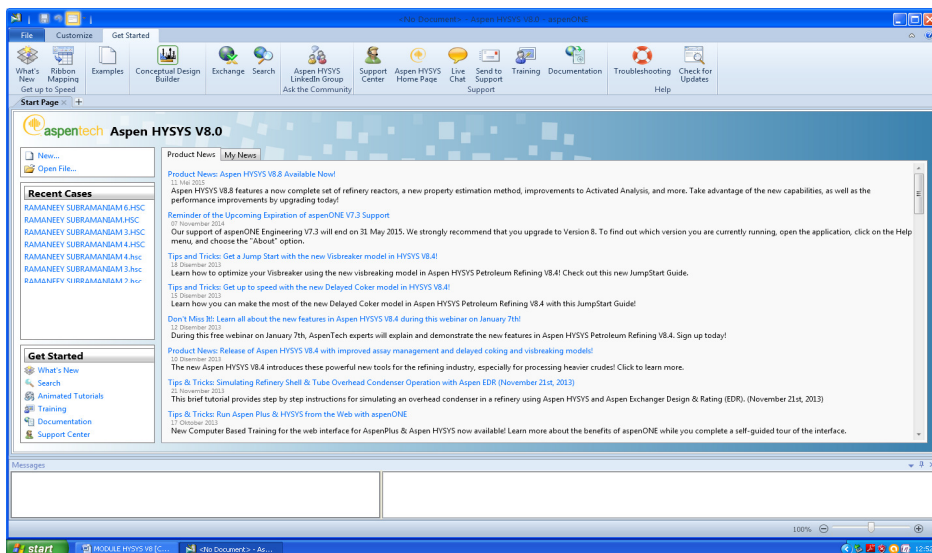


Figure 2: HYSYS Window

2. CREATING NEW SIMULATION

2.1 Select “**File/New/Case**” or press **Ctrl + N** to start new case.

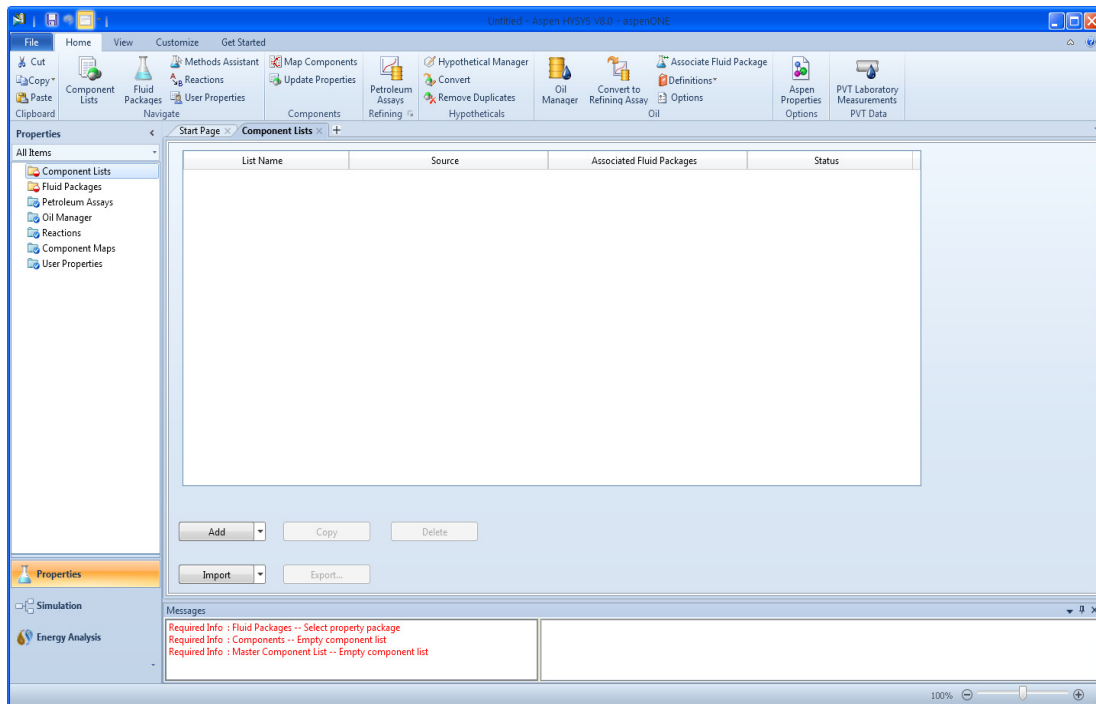


Figure 3: Open New File/Case

2.2 Before proceeding any further, save your file in appropriate location.

2.3 Once you have created the file, you will be in the simulation basis environment. It is here that you specify the chemical components that will be present in your simulation as well as the fluid (Thermodynamics) package that will be used to calculate the fluid properties of these components.

3. COMPONENTS

3.1 The first step in establishing the simulation basis is to set the chemical components which will be present in your simulation.

3.2 Select the “Component Lists” tab. Click the “Add” button to display a new component list as shown in Figure 4.

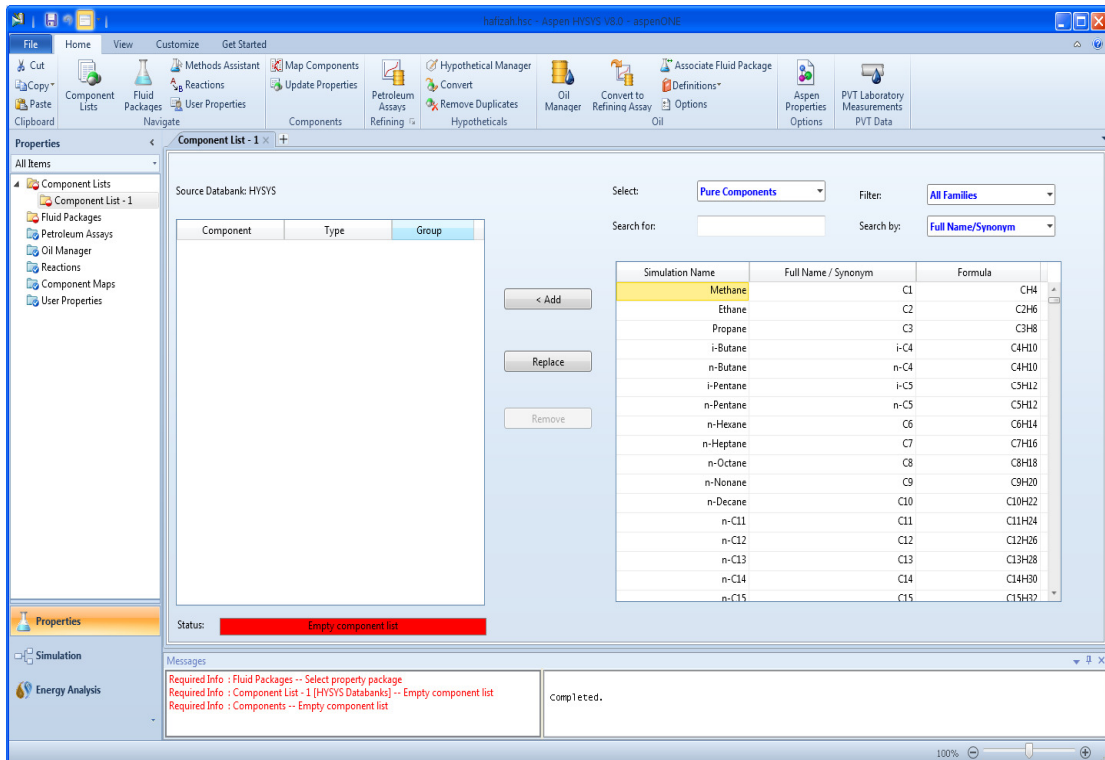


Figure 4: Component list view

3.3 Select the desired components for your simulation. You can search through the list of components in one of three ways which are **Simulation name**, **Full Name/Synonym**, or **Formula**.

Simulation Name	The name appearing within the simulation
Full Name/Synonym	IUPAC name (or similar), and synonyms for many components
Formula	The chemical formula of the component. This is useful when we are unsure the library name of a component, but know its formula

3.4 Select which match term you want of the three above types by selecting the corresponding button above the list of components. Then type in the name of the component you are looking for. For example, typing in “water” for a simulation name narrows the list down to a single component. If your search attempt does not yield the desired component, then either try another name or try searching under full name or formula.

3.5 Once you have located the desired components, either double click on the component or click “**Add**” button to add it to the list of components for the simulation.

3.6 You can give your component list a name by renaming it.

3.7 You can view the component property by double click on the component name. HYSYS will open the **property view** for the component you selected. The component property view only allows you to view the pure component information. You cannot modify any parameters for a library component. However, HYSYS allows you to clone a library component as a Hypothetical component which you can then modify as required.

3.8 Close the window to return to “**Simulation Basis Manager**”.

4. FLUID PACKAGES

4.1 Once you have specified the components present in your simulation, you can now set the fluid package for your simulation. The fluid package is used to calculate the fluid/thermodynamic properties of the components and mixtures in your simulation (such as enthalpy, entropy, density, vapor-liquid equilibrium etc.). Therefore, it is very important that you select the correct fluid package since this forms the basis for the results returned by your simulation.

4.2 From the simulation basis manager, select “**Fluid Packages**”.

4.3 Click the “**Add**” button to create new fluid package as shown in figure 5.

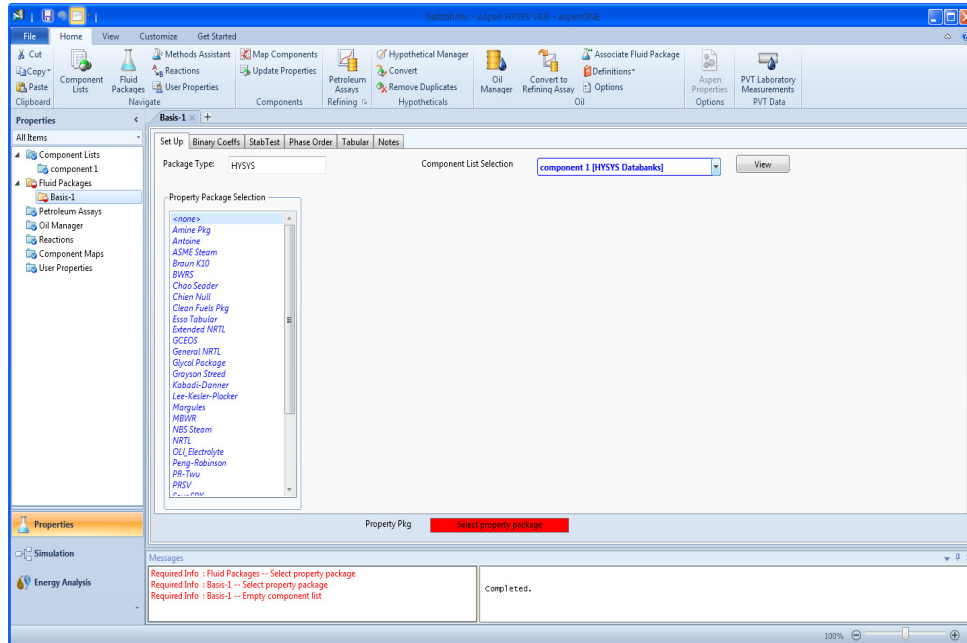


Figure 5: Fluid Package View

4.4 From the list of fluid packages, select the desired thermodynamic package.

4.5 Once the desired model has been located, select it by clicking on it once (no need to double click).

4.6 You can rename the fluid package as desired. Once this is done, close the window.

5. SIMULATION ENVIRONMENT

5.1 You are now completed all necessary input to begin your simulation. Click on the Simulation icon to begin the simulation. This icon is located at the bottom left of the screen.



5.2 You should see this screen appear (figure 6).

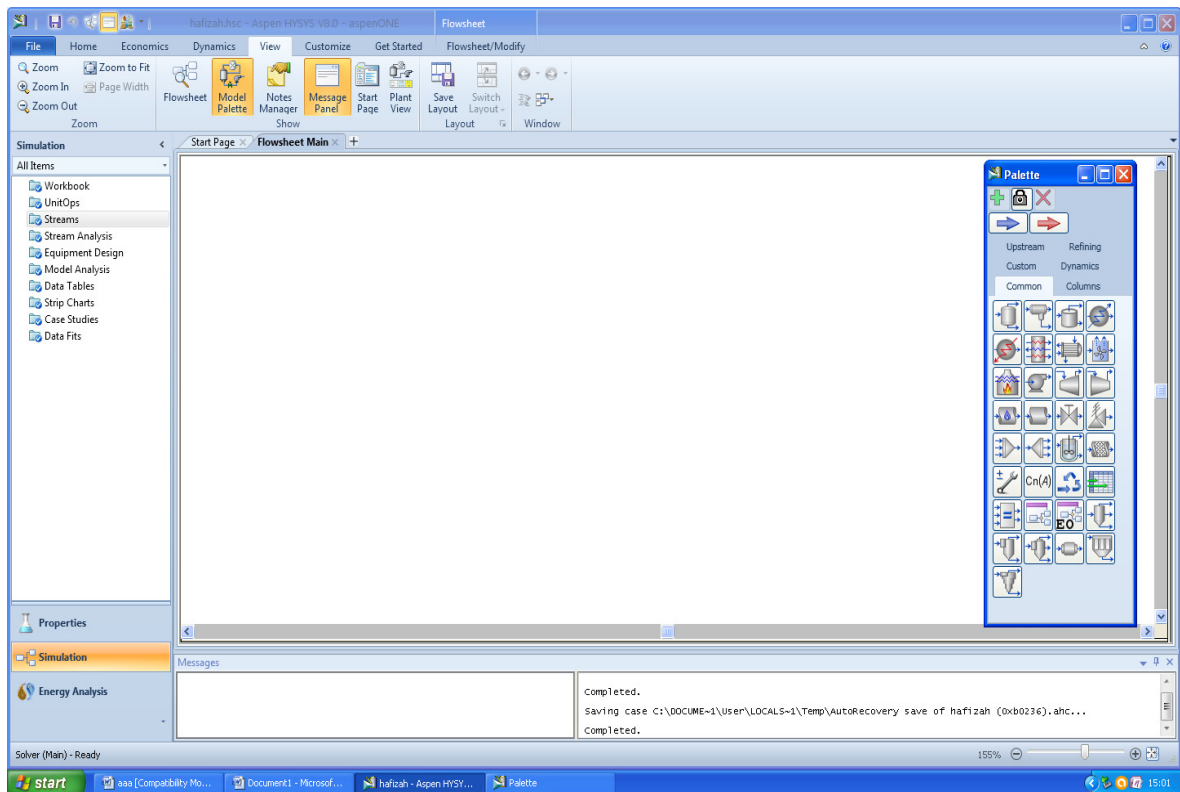



Figure 6: Simulation environment

5.3 A number of new items are now available in the menu bar and tool bar, and the PFD and Model Palette is open on the screen.

5.4 If the Model Palette does not appear on the screen, click on **View** at the toolbar, and then click on **Model Palette**. The Model palette should appear on the screen.

Objects	Descriptions
PFD	Graphical presentation of the flowsheet topology for a simulation case. The PFD view shows operations and streams and the connection between the objects. We can also attach information tables or annotations to the PFD.
Model Palette	A floating palette or button that can be used to add streams and unit operations.

5.5 Before proceeding, a few of the features of this simulation window and of HYSYS in general should be pointed out:

1. HYSYS, unlike the majority of other simulation packages, solves the flowsheet after each addition/change to the flowsheet. This feature can be disabled by clicking the “**On Hold**” button located in the toolbar. If this button is selected, then HYSYS will NOT solve the simulation and it will NOT provide any results. In order to allow HYSYS to return results, the “**Active**” (the “**GREEN light**” button ) must be selected.
2. Unlike most other process simulators, HYSYS is capable of solving for information both downstream AND upstream. Therefore, it is very important to pay close attention to your flowsheet specification to ensure that you are not providing HYSYS with conflicting information. Otherwise, you will get an error and the simulation will NOT solve.

6. STREAMS

6.1 There are **two** types of streams in HYSYS. **Material streams** and **Energy streams**. Material streams provide the information regarding the movement of material between unit operations. Energy streams provide the information regarding the flow of energy (heat or power) to or from unit operations. The following discussion will focus on the addition and manipulation of material streams since the majority of your work will use material streams. Energy streams will be discussed further within the context of unit operations.

6.2 Material streams.

6.2.1 A material stream can be added to the flowsheet by clicking on the “**blue arrow**” button on the Model Palette. Then click on the PFD. The HYSYS default names the streams in increasing numerical order. This name can be modified at any time.

6.2.2 To enter information about the material stream, double click on the stream. It is within the window that the user specifies the details regarding the material stream. Values shown in **blue** have been specified by the user while values shown in **black** have been calculated by HYSYS.

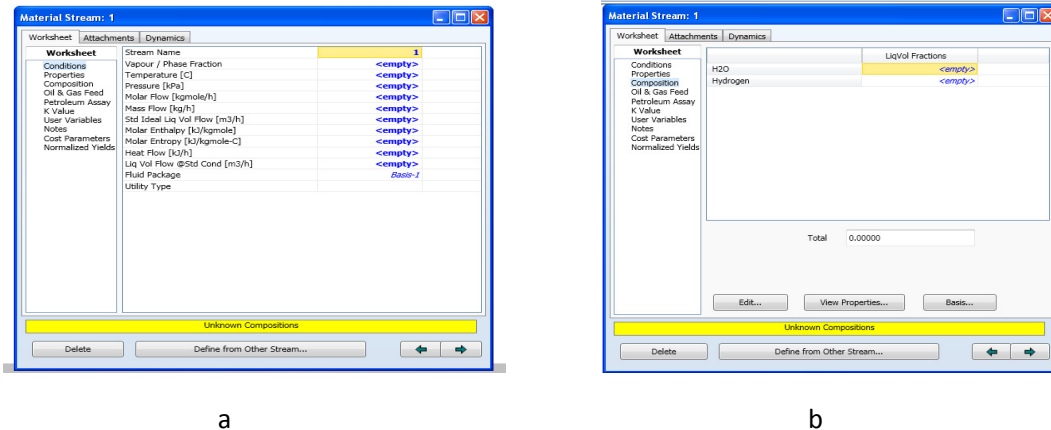


Figure 7: Material stream input

6.2.3 When entering the conditions for the stream, it is not necessary to enter the values in the default units provided. When the user begins to enter a value in one of the cells, a drop down arrow appears in the unit's box next to the cell. By clicking on this drop down arrow, the user can specify any unit for the corresponding value and HYSYS will automatically convert the value to the default unit set.

6.2.4 Also note that in figure 7(a), that there is a list of options along the left hand side of the window. In order to specify the composition of the stream, select the “**Composition**” option from this list (figure 7(b)). Note that only the components that you specify in the simulation basis manager will appear in the list. You can specify the composition in many different ways by clicking on the “**Basis**” button. The HYSYS default is mole fractions; however the user can also specify mass fractions, liquid volume fractions, or flows of each component. If the user is specifying fractions, all fractions must add up to 1.

6.2.5 Once all of the stream information has been entered, HYSYS will calculate the remaining properties and data provided it has enough information from the rest of the flowsheet. Once a stream has enough information to be completely characterized, a green message bar appears at the bottom of the window within the stream input view indicating that everything is “**OK**”. Otherwise, the input window will have a yellow message bar indicating what information is missing.

6.2.6 The following color code for material streams on the flowsheet indicates whether HYSYS has enough information to completely characterize the stream:

Royal blue	Properly specified and completely solved
Light blue	Incompletely specified, properties not solved

6.2.7 At any time, the specifications and calculated properties for a stream can be viewed and modified by simply double clicking on the desired stream.

7. UNIT OPERATIONS

7.1 CREATING UNIT OPERATIONS

7.1.1 Unit operations take material streams as inputs and perform processing operations on them. There are many different operations available in HYSYS and they can be added to the flowsheet via the following steps:

- a) Click on the unit operation that you want on the **Model Palette**.
- b) Then click on PFD.

7.2 CONNECTING MATERIAL STREAMS TO UNIT OPERATIONS

7.2.1 Material streams can be connected to the unit operations by simply double clicking on the unit operations and select the desired stream to be connected on the stream icon. You have to select the inlet and outlet stream for that particular unit operation.

7.3 INSTALLING UNIT OPERATION

7.3.1 As most commands in HYSYS, installing an operation can be accomplished in a numbers of ways. One method is through the Unit Operations tab of the Workbook.

7.3.2 Click on “**Workbook**” icon at the toolbar. The workbook will appear as shown in figure 9.

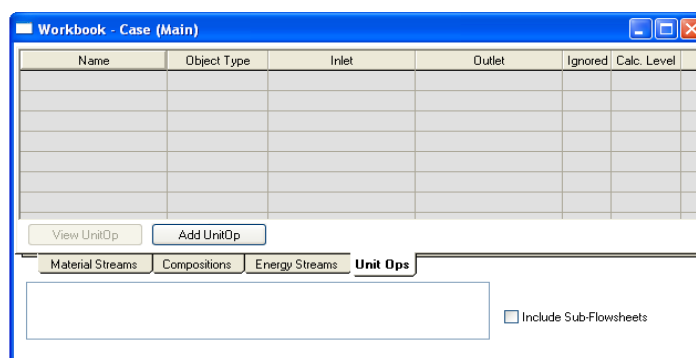


Figure 8: Workbook

7.3.3 Click the “Unit Ops” tab of the workbook.

7.3.4 Click the “Add UnitOp” button. The UnitOp view will appear listing all available unit operations as shown in figure 9.

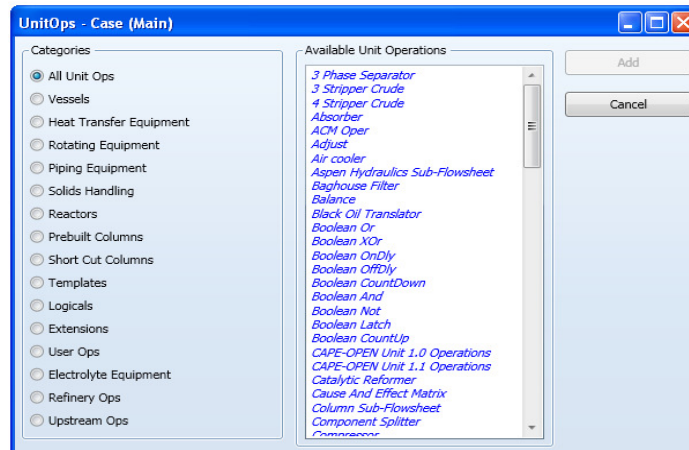


Figure 9: UnitOp window

7.3.5 For instance, select mixer by doing one of the following:

- Start typing “mixer” on the “Available Unit Operations” icon.
- Press the “Down arrow” key to scroll down the list of available operations to Mixer.
- “Scroll down” the list using the vertical scroll bar and click on “Mixer”.

With mixer selected, click the “Add” button or press the “Enter key”.

7.3.6 We can also use the filters to find and add an operation. For the mixer operation, select **Piping Equipment** button under the **Categories** . A filtered list appears in the **Available Unit Operations** group. Double click to install it. The mixer property view will appear as shown in Figure 10.

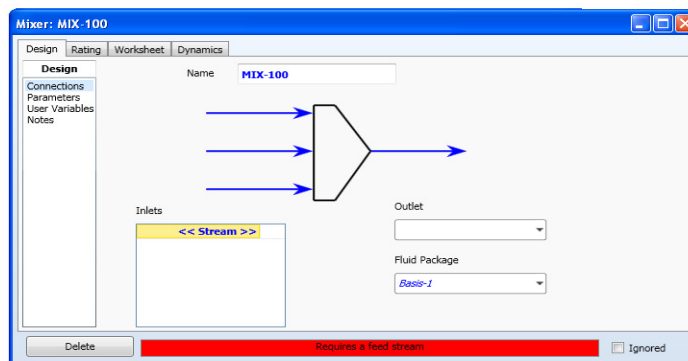


Figure 10: Mixer Property View

7.3.7 Click the “stream” cell to ensure the inlets table is active. The status bar at the bottom of the view shows that the operation requires a feed stream.

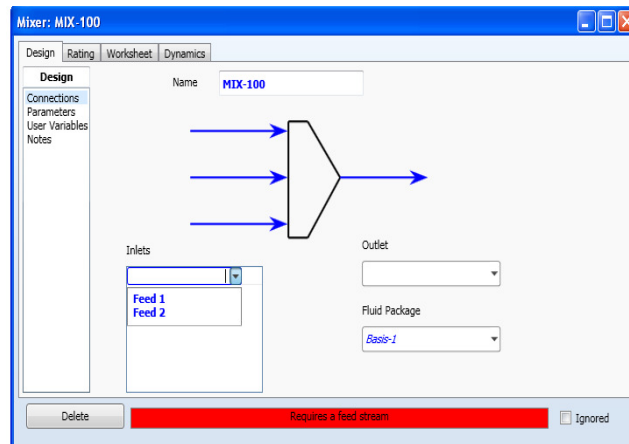


Figure 11: Open the “stream” part in mixer property view

7.3.8 Select “**Feed 1**” from the list. The stream is transferred to the list of “inlet” and “stream” is automatically moved down to a new empty cell. Or you can just type in the stream name “Feed 1” in the cell if you don’t have establish any stream in the PFD.

7.3.9 Repeat step 7.3.7 to 7.3.8 to connect the other stream, “**Feed 2**”.

7.3.10 The status indicator now displays “**Requires product stream**”. Next you will assign a product stream.

7.3.11 Move to the “Outlet” field. Type the “**Mixer out**” in the cell and press “**ENTER**”. The status indicator now displays a green “**OK**”, indicating that the operation and attached streams are completely calculated.

7.3.12 Click the “**Parameter**” page. In the “**Automatic Pressure Assignment**” group, leave the default setting at “**Set Outlet to Lowest Inlet**”.

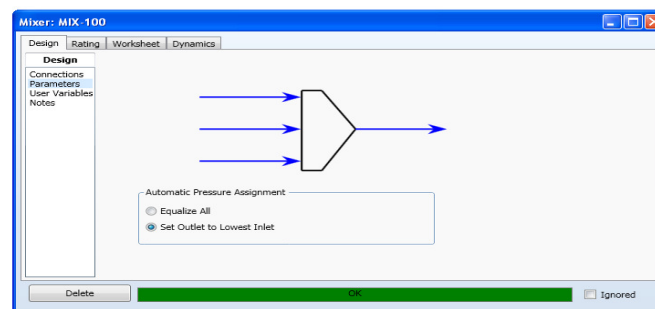


Figure 12: Automatic Pressure Assignment group

7.3.13 To view the calculated outlet stream, click the “Worksheet” tab, and then click on the “Conditions” page (Figure 13).

	Feed 1	Feed 2	Mixer Out
Name	0.3436	0.5726	0.4957
Vapour			
Temperature [C]	25.00	25.00	25.00
Pressure [kPa]	25.00	25.00	25.00
Molar Flow [kgmole/h]	7.567	14.98	22.54
Mass Flow [kg/h]	100.0	150.0	250.0
Std Ideal Liq Vol Flow [m3/h]	0.1611	0.3513	0.5124
Molar Enthalpy [kJ/kgmole]	-1.975e+005	-1.393e+005	-1.588e+005
Molar Entropy [kJ/kgmole-C]	64.02	102.3	89.47
Heat Flow [kJ/h]	-1.495e+006	-2.086e+006	-3.580e+006

Figure 13: Conditions page on Worksheet

7.3.14 Now the mixer is completely known, close the view to return to the “Workbook”. The new operations appear in the table on the “UnitOp” tab of the workbook (Figure 14).

Name	Object Type	Inlet	Outlet	Ignored	Calc. Level
MIX-100	Mixer	Feed1 Feed 2	Mixer Out	<input type="checkbox"/>	500

Figure 14: New Operation on Unit Ops Workbook

7.3.15 To open the property view for one of the streams attached to the Mixer, do one of the following.

- a) Double click on “**Feed 1**” in the box at the bottom of the workbook.
- b) Double click on the “**Inlet**” cell for MIX-100. The property view for the first listed feed stream, in the case “Feed 1”, appears.

7.3.16 The mixer can be renamed (from the default MIX-100) to any suitable name.

8. INTRODUCTION ON UNIT OPERATIONS

8.1 FLASH SEPARATORS

The flash separator unit operation takes any number of input streams and separates the resulting mixture into a vapour and liquid stream. The input screen for this unit operation is shown in Figure 16, where stream 10 is being flashed into a vapour stream (stream 11) and a liquid stream (Stream 12). If there is no liquid present in the inlet streams, then the vapour stream will simply have no flow and the calculated composition will be the bubble point composition of the mixture.

NOTE: It is NOT necessary to specify that the phase fraction of the vapour outlet be 1 and the phase fraction of the liquid outlet be 0. This is automatically set by HYSYS since this unit operation is an equilibrium flash. Therefore, the 2 outlet streams will automatically be saturated phases (if the feed streams are saturated mixtures).

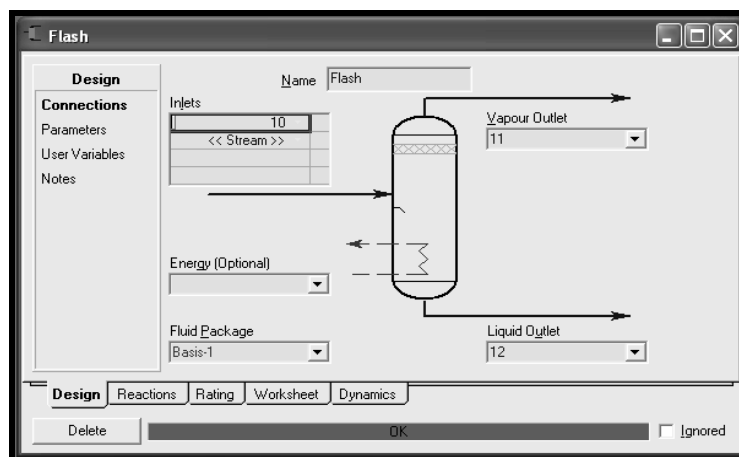


Figure 15: Flash Separator Input Screen

In the rare cases where an energy input into the flash drum is desired, an energy stream can be specified on the inlet page. This can be any energy stream and allows the user to add or remove heat from the drum. To installing the inlet separator,

1. Click the **“Add UnitOp”** button. The UnitOps view appears. In the Categories group, select the **“Vessels”** button.
2. In the list of Available Unit Operations, choose **“Separator”**.
3. Click the **“Add”** button. The separator property view appears, displaying the connection page on the Design tab.
4. In the name cell, changes the name to **“Inlet Sep”**, and then press **“ENTER”**.
5. Move to the Inlet list by clicking on the **“Streams”** cell.
6. Open the drop-down list of available feed streams.
7. Select the stream Mixer Out by doing one of the following;
 - Click on the **“stream name”** in the drop-down list
 - Press the **“Down arrow key”** to highlight the stream name, and then press **“ENTER”**.
8. Move to the Vapour Outlet cell by clicking on the **“Vapour Outlet”** cell.
9. To create the vapour outlet stream, types **“SepVap”**, then press **“ENTER”**.
10. Click on the **“Liquid Outlet”** cell, type the name **“SepLiq”**, then press **“ENTER”**. The completed Connections page will appears as shown in Figure 16.

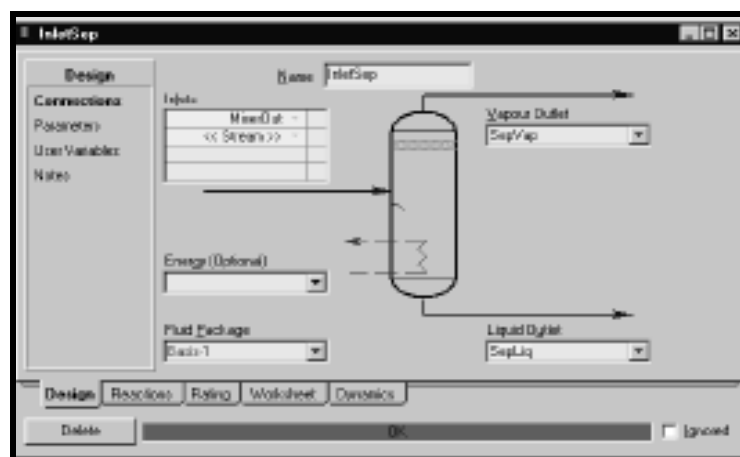


Figure 16: Completed Connection Page

- Select the **“Parameters”** page. The current default values for Delta P, Volume, Liquid Volume, and Liquid Level are acceptable (Figure 17).

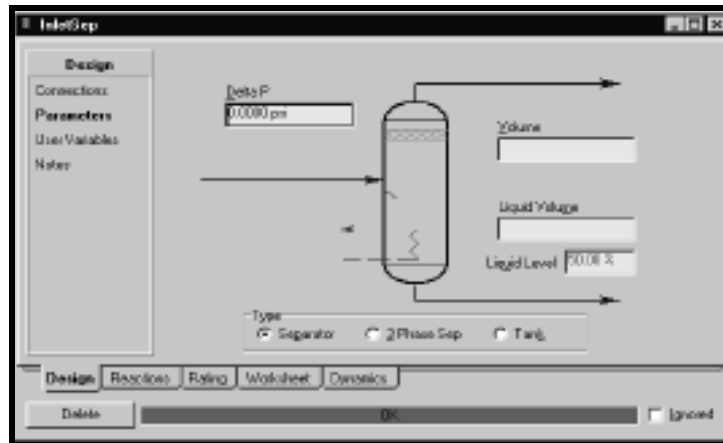


Figure 17: Select the “Parameter”

- To view the calculated outlet stream data, click the **“Worksheet tab”**, then select the **“Conditions”** page. The table will appear in this page.

Name	Flow/Out	Sep/Liq	Sep/Vap
Vapor	0.8898	0.0000	1.0000
Temperature (F)	60.00	60.00	60.00
Pressure (psia)	600.0	600.0	600.0
Molar Flow (MHS/CD)	11.00	1.024	8.976
Mass Flow (lb/hr)	2.775e+004	4564	2.318e+004
Std/Liqed Liq Vol Flow (gpm/Day)	4995	682.9	4342
Molar Entropy (Btu/lbmole-F)	-3.907e+008	-5.122e+008	-3.687e+008
Molar Entropy (Btu/lbmole-F)	39.65	29.87	39.77
Heat Flow (Btu/hr)	-4.160e+007	-5.756e+006	-3.606e+007

Figure 18: Condition Page

- When finishing, click the **“Close”** the separator property view.

8.2 HEAT EXCHANGER

Install heat exchanger unit as describe in previous section.

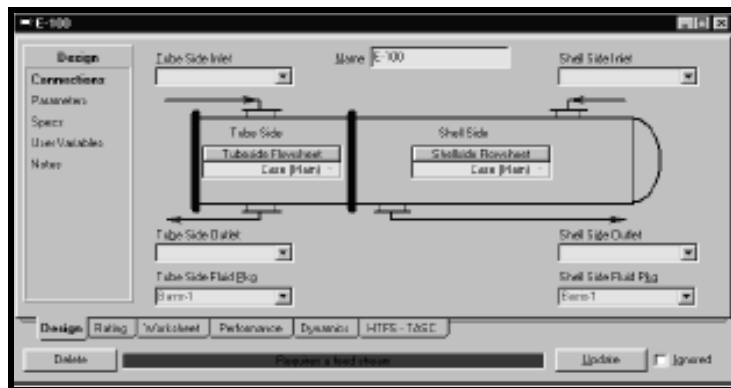


Figure 19: Heat Exchanger Property View

1. In the “**Name**” field, change the operation name from its default “**E-100**” to “**Gas/Gas**”.
2. Attach the “**inlet and outlet**” streams as shown, using the methods learned in the previous sections.

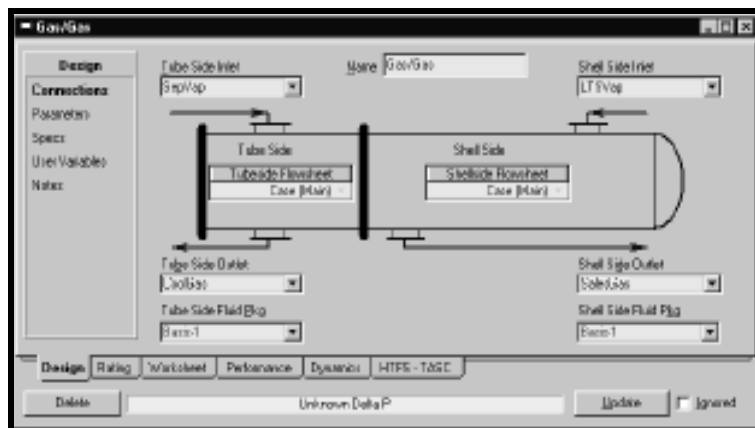


Figure 20: Attach Inlet and Outlet Streams

3. Click the “**Parameter**” page. The Exchanger Design End Point is the acceptable default setting for the Heat Exchanger Model for this class.
4. Enter a “**pressure drop**” for both the Tube Slide Delta P and Shell Side Delta P.

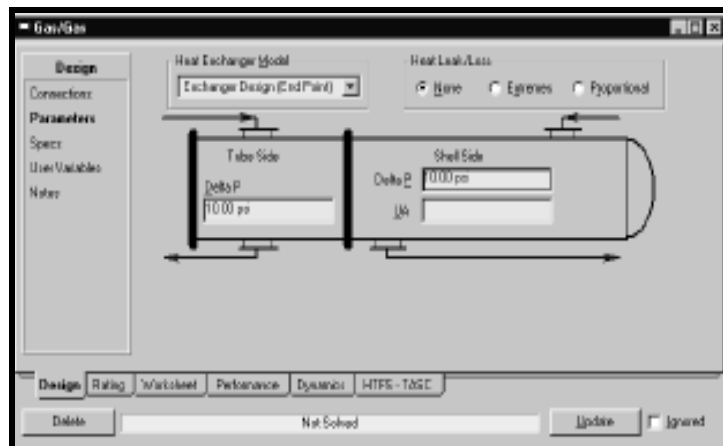


Figure 21: Enter the Pressure Drop

5. Click the **“Rating”** tab, and then select the **“Sizing”** page.
6. In the Configuration group, click in the **“Tube Passes per Shell”** cell, then change the value to **“1”**, to model **“Counter Current Flow”**.

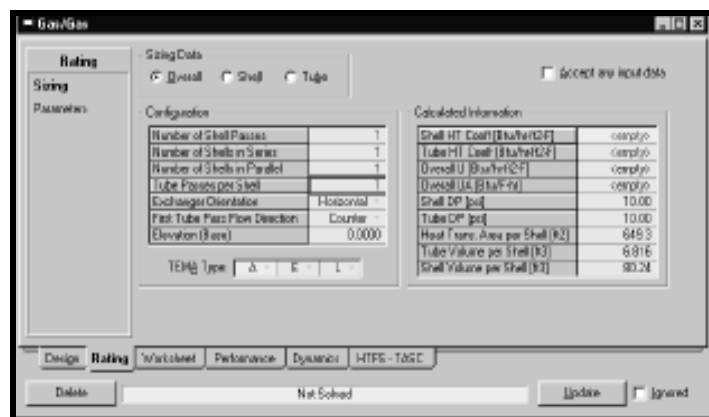


Figure 23: Configuration group

7. Close the Heat Exchanger property view to return to the **“Workbook”**.
8. Click the **“Material Streams”** tab of workbook.

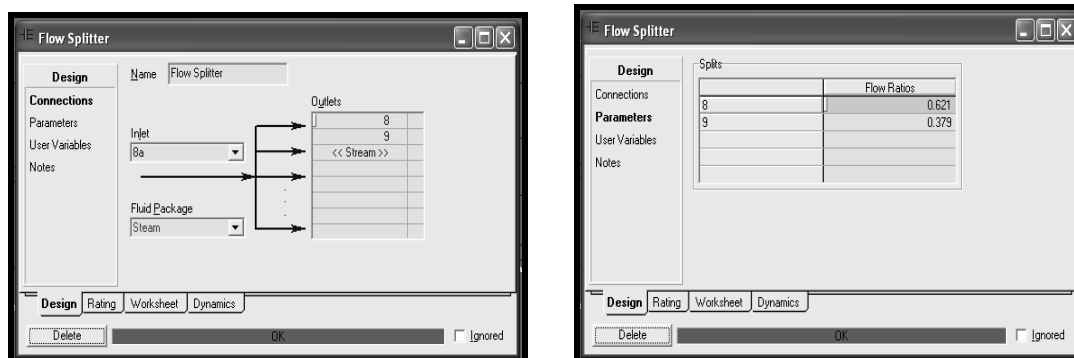
Stream Cool Gas has not yet been flashed, as its temperature is unknown. Cool Gas is flashed later when a temperature approach is specified for the Gas/Gas Exchanger (Figure 22).

Name	Feed 1	Feed 2	Mixer Out	Sep/Up
Vapor Fraction	0.8952	0.9013	0.8896	1.0000
Temperature [F]	60.08	68.00	60.00	60.00
Pressure [psia]	608.8	680.0	600.0	600.0
Molar Flow [lbmole/hr]	6.006	4.000	10.00	8.976
Mass Flow [lb/hr]	1.675e+004	1.100e+004	2.775e+004	2.318e+004
Liquid Volume Flow [cubic/Day]	3012	1983	4995	4342
Heat Flow [Btu/hr]	-2.553e+007	-1.622e+007	-4.188e+007	-3.685e+007
Name	Sep/Up	Cool/In	Water/In	L15/Up
Vapor Fraction	0.8008	<empty>	<empty>	<empty>
Temperature [F]	60.08	<empty>	<empty>	<empty>
Pressure [psia]	608.8	580.0	<empty>	<empty>
Molar Flow [lbmole/hr]	1.024	8.956	<empty>	<empty>
Mass Flow [lb/hr]	4954	2.318e+004	<empty>	<empty>
Liquid Volume Flow [cubic/Day]	652.5	4942	<empty>	<empty>
Heat Flow [Btu/hr]	-5.756e+006	<empty>	<empty>	<empty>

Figure 22: Workbook completed

8.3 TEE (SPLITTER)

The Tee unit operation takes a single input stream and splits it into any number of output streams as shown in Figure 23 (a), where the inlet stream 8a is split into 2 outlet streams (Streams 8 & 9).



(a)

(b)

Figure 23: Tee Unit Operation Input Screen

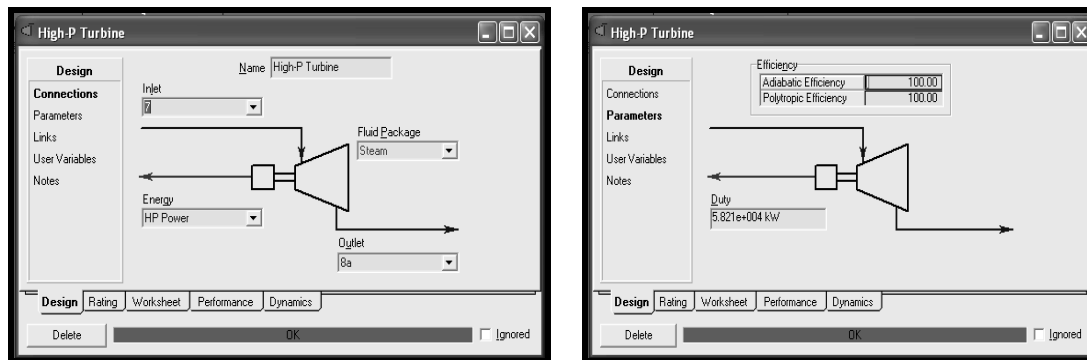
However, unlike the mixer unit operation, additional specs are required. Selecting the “Parameters” option in the list on the left side of the screen in Figure 23 (a) brings up the window shown in Figure 23 (b). It is here that the user inputs the proportion of the input stream which is split to each output stream. For example, in Figure 23 (b), 62.1% of the inlet stream goes to stream 8 while 37.9% goes to stream 9. The total fractions MUST sum to 1. In fact, once the user specifies all but one of the flow ratios, the last one is calculated by HYSYS automatically. For example, in Figure 23 (b), only the first flow ratio (0.621) is specified since it is

blue and the second value is calculated automatically (black). That is all of the information that is required by HYSYS to solve the tee unit operation. The user can also specify the flowrates of all but 1 of the connected streams and HYSYS will calculate the flowrate of the final stream as well as the split ratios.

6.3.5 EXPENDERS AND COMPRESSORS

The turbine and compressor unit operations take an inlet stream and either increases the pressure by putting in shaft work (compressor) or decreases the pressure by removing shaft work (expander). The input screens for the expander are shown in Figure 24.

Figure 24 (a) shows the connections page where the inlet, outlet, and energy streams are specified. An energy stream **MUST** be specified for this unit operation and it can be created within this input screen. For example, in Figure 24(a), stream 7 is being expanded to stream 8a with the energy stream “**HP Power**” representing the shaft work extracted by the expander.



(a)

(b)

Figure 24: Expander Input Screens

Once the inlet, outlet, and energy streams have been specified, the efficiency of the expander must be specified as shown in Figure 24 (b). An isentropic expander has an adiabatic efficiency of 100%, as shown in Figure 24 (Adiabatic efficiency is synonymous with isentropic efficiency).

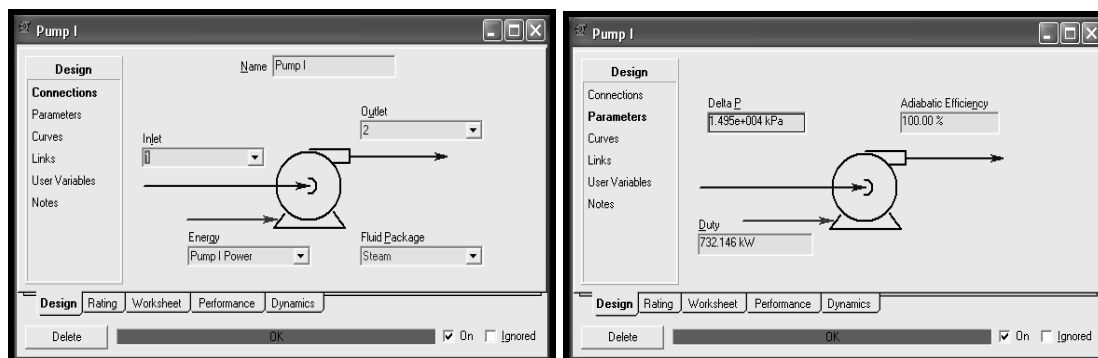
In order for the expander unit operation to solve, the flowrate through the expander must be known and the user must specify three of the four inlet and outlet pressure and temperatures. That is, one of the following combinations of specs:

1. Inlet pressure & temperature + the outlet pressure
2. Inlet pressure & temperature + the outlet temperature
3. Outlet pressure & temperature + the inlet pressure
4. Outlet pressure & temperature + the inlet temperature

The specifications for the compressor unit operation are identical to those for the expander. The only difference is that rather than decreasing the pressure, the compressor increases the pressure. Otherwise, the specifications required for solving as well as the algorithms used for the calculations are identical. Even the input screens are the same except for the graphic displaying the operation on the screen.

8.4 PUMPS

Pumps are very similar to compressors except that they handle liquids rather than gases. The input screens for the pump unit operation are shown below in Figure 25. Figure 25 (a) shows the connections page where the inlet, outlet, and energy streams are specified. Just like the expander and compressor, the pump MUST have an energy stream to solve. As well, the efficiency MUST be specified on the parameters page. Note that for the pump, it is also possible to specify the pressure drop (referred to as “Delta P”) within the unit operation. This is optional since the user can also specify the pressure drop by specifying the pressure of both the inlet and outlet streams. Figure 25 show a pump which takes stream 1 and increases the pressure by 14050 kPa to stream 2 with an isentropic (adiabatic) efficiency of 100%. The required power is given by the energy stream Pump I Power.



(a)

(b)

Figure 25: Pump Input Screens

8.5 COOLERS AND HEATER

The cooler and heater unit operations take an inlet stream and either increases the temperature by adding heat (heater) or decreases the temperature by removing heat (cooler). The input screens for the cooler are shown in Figure 26. Figure 26 (a) shows the connections page where the inlet, outlet, and energy streams are specified. An energy stream MUST be specified for this unit operation and it can be created within this input screen. For example, in Figure 26(a), stream 12 is being cooled to stream 12a by removing the energy stream “Condenser Duty” representing the energy removed by the cooler.



Figure 26: Cooler Input Screens

Once the inlet, outlet, and energy streams have been specified, the pressure drop of the cooler **MUST** be specified as shown in Figure 26 (b). For the problems you will encounter, always set this pressure drop to 0 unless otherwise instructed.

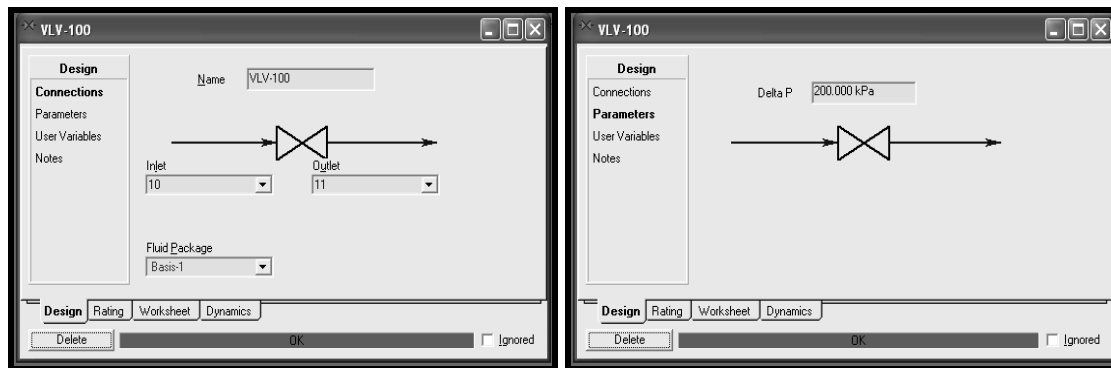
In order for the cooler unit operation to solve, the flowrate through the cooler must be known and the user must specify the inlet and outlet conditions as follows:

1. At least one of either the inlet or outlet pressure
2. At least one of either temperature or vapour fraction at the inlet
3. At least one of either temperature or vapour fraction at the outlet
4. OR in lieu of one of the temperature/vapour fractions above (either inlet or outlet) the user can also specify the amount of heat/energy removed under the “**Duty**” cell in Figure 26 (b)

The specifications for the heater unit operation are identical to those for the cooler. The only difference is that rather than decreasing the temperature, the heater increases the temperature. Otherwise, the specifications required for solving as well as the algorithms used for the calculations are identical. Even the input screens are the same except for the graphic displaying the operation on the screen.

8.6 VALVE (THROTTLE)

The valve unit operation takes an inlet stream and **adiabatically** throttles the stream down to the specified pressure (or by a specified pressure drop). The input screens for the valve are shown in Figure 27. Figure 27 (a) shows the connections page where the inlet and outlet streams are specified. No energy stream can be specified for this operation since the expansion is done adiabatically.



(a)

(b)

Figure 27: Valve Input Screen

Once the inlet and outlet streams have been chosen on the “**Connections**” page (Figure 27 (a)), the pressure drop for the valve can be specified on the “**Parameters**” page (Figure 27 (b)). Alternatively, the user can also specify the pressures of the inlet and outlet streams directly and HYSYS will calculate the pressure drop and temperature change. It is also possible (although not as useful) to specify the outlet conditions with an inlet pressure and have HYSYS calculate the inlet temperature.

9.0 WORKBOOK

*Workbook One final feature within HYSYS that is useful is the “**Workbook**”. The workbook is a spreadsheet containing all of the streams and unit operations in your entire simulation. This feature allows you to export all of the stream properties and compositions for use in other software packages, such as Microsoft® Excel.*

The workbook can be opened in one of the following ways:

1. Click on the “**Workbook**” icon 
2. Select the “**tools**” pull down menu and select “**Workbooks**”
3. Press “**Ctrl+W**”

Any of these commands will bring up the window shown below in Figure 30. Once the workbook is open, a new “**Workbook**” pull down menu will appear in the menu bar. From this menu the user can perform different operations on the workbook such as exporting or importing information. The user can also modify the layout and the information contained within the workbook under the “**Setup**” option within the “**workbook**” menu.

Workbook - Case (Main)							
Name	1	7	8a	8	9	10	11
Vapour Fraction	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Temperature [C]	81.34	600.0	197.0	197.0	197.0	600.0	183.7
Pressure [kPa]	50.00	1.500e+004	1000	1000	1000	1000	50.00
Molar Flow [kgmole/h]	9498	1.529e+004	1.529e+004	9498	5795	9498	9498
Mass Flow [kg/h]	1.711e+005	2.755e+005	2.755e+005	1.711e+005	1.044e+005	1.711e+005	1.711e+005
Std Ideal Liq Vol Flow [m3/h]	171.5	276.1	276.1	171.5	104.6	171.5	171.5
Heat Flow [kJ/h]	-2.667e+009	-3.401e+009	-3.611e+009	-2.242e+009	-1.368e+009	-2.092e+009	-2.243e+009
Molar Enthalpy [kJ/kgmole]	-2.808e+005	-2.224e+005	-2.361e+005	-2.361e+005	-2.361e+005	-2.203e+005	-2.361e+005
Name	12	2	3	4	5	6	5a
Vapour Fraction	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Temperature [C]	81.35	82.20	342.1	179.9	183.0	292.4	182.9
Pressure [kPa]	50.00	1.500e+004	1.500e+004	1000	1.500e+004	1.500e+004	1.500e+004
Molar Flow [kgmole/h]	9498	9498	9498	5795	5795	1.529e+004	5795
Mass Flow [kg/h]	1.711e+005	1.711e+005	1.711e+005	1.044e+005	1.044e+005	2.755e+005	1.044e+005
Std Ideal Liq Vol Flow [m3/h]	171.5	171.5	171.5	104.6	104.6	276.1	104.6
Heat Flow [kJ/h]	-2.272e+009	-2.664e+009	-2.449e+009	-1.583e+009	-1.581e+009	-4.030e+009	-1.581e+009
Molar Enthalpy [kJ/kgmole]	-2.392e+005	-2.805e+005	-2.579e+005	-2.732e+005	-2.728e+005	-2.635e+005	-2.728e+005
Name	12a	HP Power	LP Power	Condenser Duty	Pump II Power	Pump I Power	Process Duty
Vapour Fraction	0.0000	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Temperature [C]	81.34	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Pressure [kPa]	50.00	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Molar Flow [kgmole/h]	9498	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Mass Flow [kg/h]	1.711e+005	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Std Ideal Liq Vol Flow [m3/h]	171.5	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Heat Flow [kJ/h]	-2.667e+009	2.096e+008	1.504e+008	3.946e+008	2.198e+006	2.636e+006	2.952e+007
Molar Enthalpy [kJ/kgmole]	-2.808e+005	<empty>	<empty>	<empty>	<empty>	<empty>	<empty>
Name	HP Boiler Duty	LP Boiler Duty	Closed FwH (C)	Closed FwH (H)	** New **		
Vapour Fraction	<empty>	<empty>	<empty>	<empty>			
Temperature [C]	<empty>	<empty>	<empty>	<empty>			
Pressure [kPa]	<empty>	<empty>	<empty>	<empty>			
Molar Flow [kgmole/h]	<empty>	<empty>	<empty>	<empty>			
Mass Flow [kg/h]	<empty>	<empty>	<empty>	<empty>			
Std Ideal Liq Vol Flow [m3/h]	<empty>	<empty>	<empty>	<empty>			
Heat Flow [kJ/h]	6.290e+008	1.503e+008	2.148e+008	2.148e+008			
Molar Enthalpy [kJ/kgmole]	<empty>	<empty>	<empty>	<empty>			

Figure 28: HYSYS Workbook View