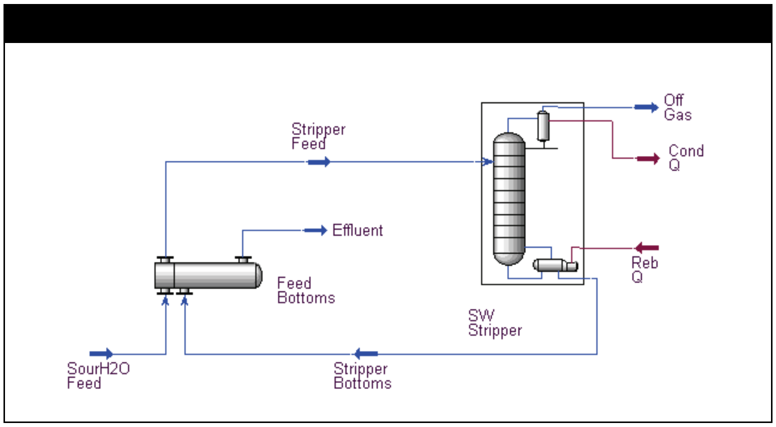
R2 Sour Water Stripper

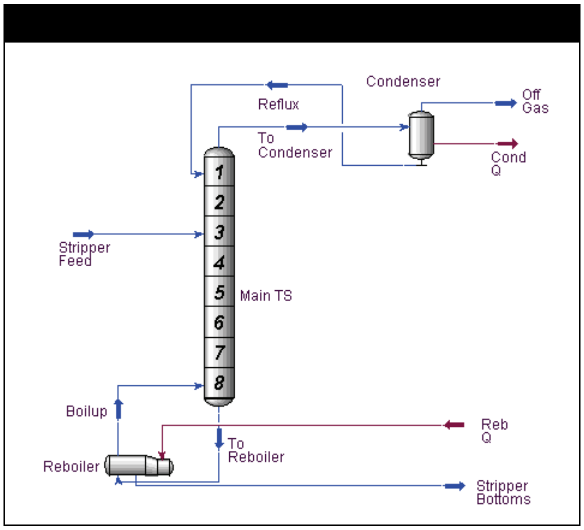
R2.1 Process Description



To see this case completely solved, see your UniSim Design\Samples\ directory and open the R-2.usc file.

The sour water stripper configuration shown in the above PFD is a common unit in refineries. It processes sour water that comes from a variety of sources including hydrotreaters, reformers, hydrocrackers, and crude units. The sour water is often stored in crude tanks, thereby eliminating the need for special vapour recovery systems.

A sour water stripper either uses the direct application of stripping steam (usually low quality, low pressure) or a steam-fired reboiler as a heat source.



The intent is to drive as much H2S and NH3 overhead in the stripper as possible. The sizing of a sour water stripper is very important since its capacity must equal or exceed the normal production rates of sour water from multiple sources in the refinery. Often, refiners find their strippers undersized due to a lack of allowance for handling large amounts of sour water, which can result from upset conditions (like start-up and shutdown). Consequently, there is often a backlog of sour water waiting to be processed in the stripper. With the increasing importance of environmental restrictions, the sour water stripper plays a greater role in the overall pollution reduction program of refiners.

The Sour Water feed stream goes through a feed/effluent exchanger where it recovers heat from the tower bottoms stream (Stripper Bottoms). This new stream (Stripper Feed) enters on tray 3 of an 8 tray distillation tower with a reboiler and a total reflux condenser. A quality specification of 10 ppm wt. ammonia on the tower bottoms (Stripper Bottoms) is specified. The tower bottoms, Stripper Bottoms, exchanges heat with the incoming feed and exits as Effluent.

There are two basic steps in this process simulation:

1. **Setup**. This case uses the Sour Peng-Robinson package and the following components: H2S, NH3 and H2O.
2. **Steady State Simulation**. The case will consist of an 8 stage stripper, used to separate H2S and NH3, and a heat exchanger to minimize heat loss.

R2.2 Setup

1. In the Session Preferences view, set the unit set to **Field** units.
2. In the Component List view, select the following components: **H2S**, **NH3** and **H2O**.
3. In the Fluid Package view, select the **Sour PR** property package.

   Sour Peng-Robinson combines the PR equation of state and Wilson's API-Sour model for handling sour water systems.

R2.3 Steady State Simulation

The following general steps will be taken to setup this case in steady state:

1. **Installing the SW Stripper.** An 8 stage distillation column will be used to strip the sour components from the feed stream. The liquid leaving the bottom of the column heats the incoming feed stream in a heat exchanger.
2. **Case Study.** A case study will be performed to obtain steady state solutions for a range of stripper feed temperatures.

R2.3.1 Installing the SW Stripper

Feed Stream

Specify the feed stream as shown below.

In this cell...	**Enter...**
Temperature	100°F
Pressure	40 psia
Std Ideal Liq Vol Flow	50,000 barrel/day
Comp Mass Frac [H2S]	0.0070
Comp Mass Frac [NH3]	0.0050
Comp Mass Frac [H2O]	0.9880

Operations

1. Install and specify the Heat Exchanger as shown below.

Heat Exchanger [Feed Bottoms]		
Tab[Page]	**In this cell...**	**Enter...**
Design [Connections]	Tube Side Inlet	Sour H2O Feed
	Tube Side Outlet	Stripper Feed
	Shell Side Inlet	Stripper Bottoms
	Shell Side Outlet	Effluent
Design [Parameters]	Heat Exchanger Model	Exchanger Design (Weighted)
	Tube Side Delta P	10 psi
	Shell Side Delta P	10 psi
Worksheet [Conditions]	Temperature (Stripper Feed)	200°F

2. Install a Distillation Column. This column will have both a reboiler and an overhead condenser.

If messages appear regarding loading an older case or installing property sets, click the **OK** button. They will not affect the case.

3. Define the Column configuration as shown below.

Page	In this cell...	Enter...
Connections	No. of Stages	8
	Inlet Stream	Stripper Feed
	Inlet Stage	3
	Condenser Type	Full Reflux
	Ovhd Vapour	Off Gas
	Bottoms Liquid	Stripper Bottoms
	Reboiler Energy Stream	Q-Reb
	Condenser Energy Steam	Q-Cond
Pressure Profile	Condenser Pressure	28.7 psia
	Reboiler Pressure	32.7 psia

4. In the Column property view, click the **Design** tab, then select the **Monitor** page.

   In the present configuration, the column has two degrees of freedom. For this example, the two specifications used will be a quality specification and a reflux ratio.

5. Modify the existing specification based on the information below:

Column [SW Stripper]		
Tab [Page]	**Variable Spec**	**Modify**
Design [Specs]	Ovhd Vap Rate	Active = uncheck
	Reflux Ratio	Active = checked Spec Value = 10 Molar

To add a new specification, click the **Add Spec** button.

6. Add a **Component Fraction** specification, and enter the following information in the **Comp Frac Spec** view:

Tab	In this cell...	Enter...
Parameters	Name	NH3 Mass Frac (Reboiler)
	Stage	Reboiler
	Spec Value	0.000010
	Component	Ammonia
Summary	Active	Checked
	Reflux Ratio Spec Value	Active 10 Molar

For more information on which damping factor is recommended for different systems, refer to **Chapter 8 - Column** of the **UniSim Design Operations Guide**.

7. Click the **Parameters** tab, then select the **Solver** page. Change the Fixed Damping Factor to **0.4**.

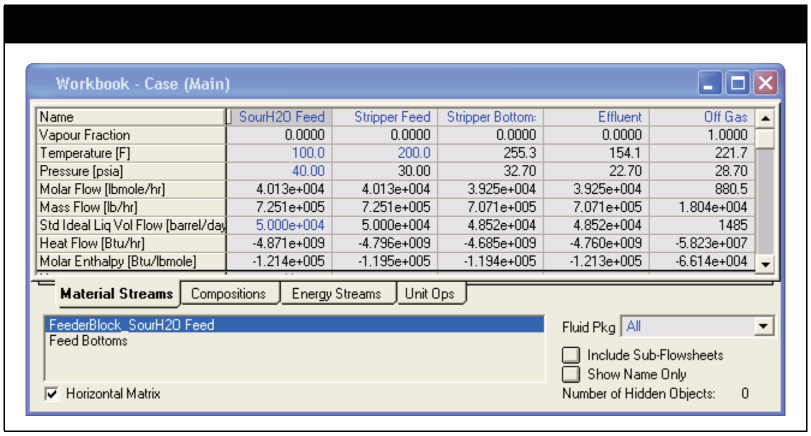
   A damping factor will speed up tower convergence and reduce the effects of any oscillations in the calculations (the default value is 1.0).

8. Run the column to calculate the values by clicking the **Run** button.

R2.4 Results

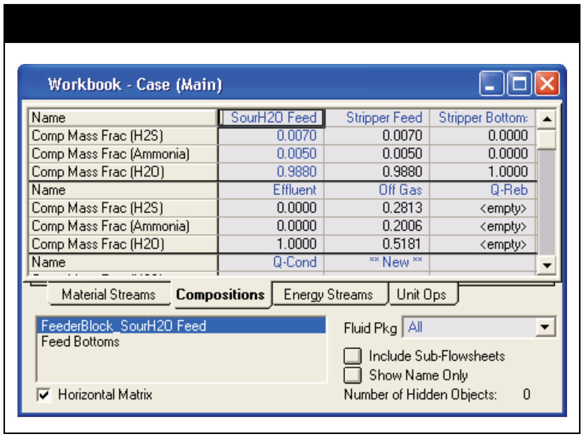
Workbook Case (Main)

Materials Streams Tab

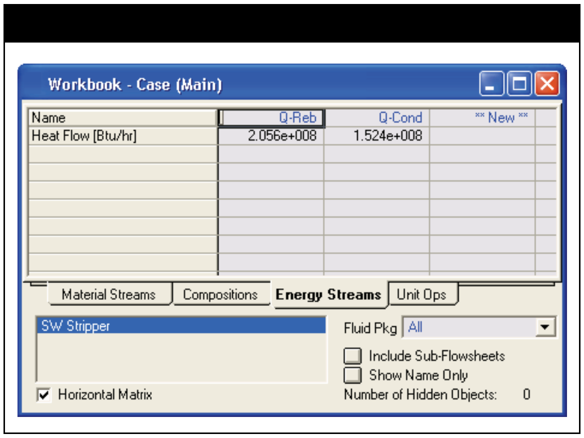


Name	SourH2O Feed	Stripper Feed	Stripper Bottom:	Effluent	Off Gas
Vapour Fraction	0.0000	0.0000	0.0000	0.0000	1.0000
Temperature [F]	100.0	200.0	255.3	154.1	221.7
Pressure [psia]	40.00	30.00	32.70	22.70	28.70
Molar Flow [lbmole/hr]	4.013e+004	4.013e+004	3.925e+004	3.925e+004	880.5
Mass Flow [lb/hr]	7.251e+005	7.251e+005	7.071e+005	7.071e+005	1.804e+004
Std Ideal Liq Vol Flow [barrel/day	5.000e+004	5.000e+004	4.852e+004	4.852e+004	1485
Heat Flow [Btu/hr]	-4.871e+009	-4.796e+009	-4.685e+009	-4.760e+009	-5.823e+007
Molar Enthalpy [Btu/lbmole]	-1.214e+005	-1.195e+005	-1.194e+005	-1.213e+005	-6.614e+004

Compositions Tab



Energy Streams Tab



R2.5 Case Study

The simulation can be run for a range of Stripper Feed temperatures (e.g., 190°F through 210°F in 5 degree increments) by changing the temperature specified for Stripper Feed in the worksheet.

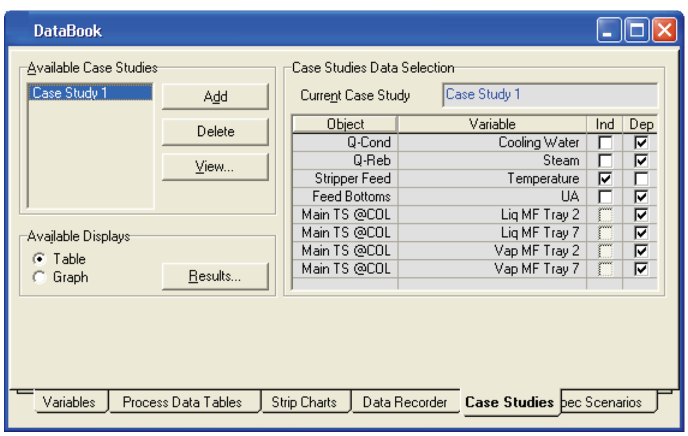
You can automate these changes by using the Case Studies feature in the DataBook.

1. Open the DataBook property view (Tools menu).
2. On the **Variables** tab, enter the variables as shown below.

	Object	Variables	Variables Description
Case	Q-Cond	Heat Flow	Cooling Water
	Q-Reb	Heat Flow	Steam
	Stripper Feed	Temperature	Temperature
	Feed Bottoms	UA	UA
T-100 SW Stripper	Main TS	Stage Liq Net Mass Flow (2__Main TS)	Liq MF Tray 2
	Main TS	Stage Liq Net Mass Flow (7__Main TS)	Liq MF Tray 7
	Main TS	Stage Vap Net Mass Flow (2__Main TS)	Vap MF Tray 2
	Main TS	Stage Vap Net Mass Flow (7__Main TS)	Vap MF Tray 7

3. Click the **Case Studies** tab.
4. In the Available Case Studies group, click the **Add** button to create Case Study 1.
5. Check the Independent and Dependent Variables as shown below.

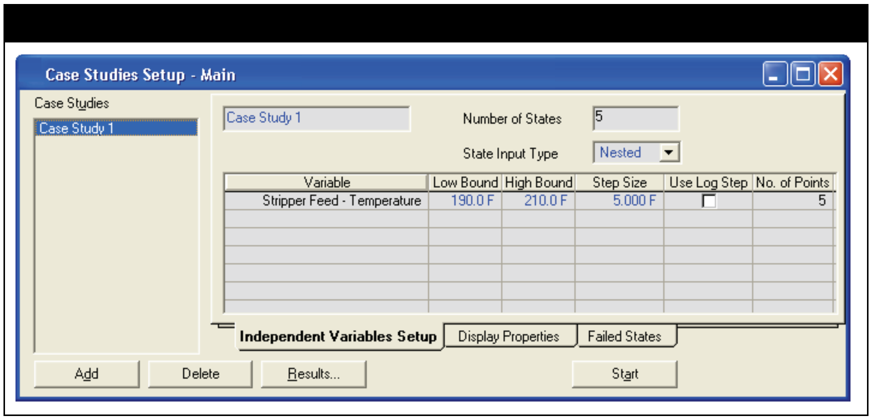
Figure R2.6



To automate the study, the Independent Variable range and Step Size must be given.

Temperature values are given in °F.

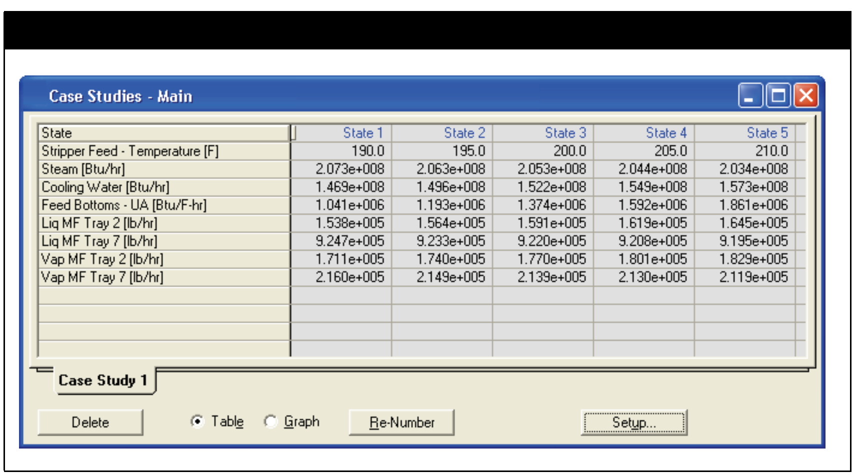
6. Click the **View** button to access the Case Studies Setup view. Define the range and step size for the Stripper Feed Temperature as shown below.



7. To begin the Study, click the **Start** button.
8. Click the **Results** button to view the variables. If the results are in graphical form, click the **Table** radio button on the Case Studies view.

R2.5.1 Results

The results of this study appear below.



State	State 1	State 2	State 3	State 4	State 5
Stripper Feed - Temperature [F]	190.0	195.0	200.0	205.0	210.0
Steam [Btu/hr]	2.073e+008	2.063e+008	2.053e+008	2.044e+008	2.034e+008
Cooling Water [Btu/hr]	1.469e+008	1.496e+008	1.522e+008	1.549e+008	1.573e+008
Feed Bottoms - UA [Btu/F-hr]	1.041e+006	1.193e+006	1.374e+006	1.592e+006	1.861e+006
Liq MF Tray 2 [lb/hr]	1.538e+005	1.564e+005	1.591e+005	1.619e+005	1.645e+005
Liq MF Tray 7 [lb/hr]	9.247e+005	9.233e+005	9.220e+005	9.208e+005	9.195e+005
Vap MF Tray 2 [lb/hr]	1.711e+005	1.740e+005	1.770e+005	1.801e+005	1.829e+005
Vap MF Tray 7 [lb/hr]	2.160e+005	2.149e+005	2.139e+005	2.130e+005	2.119e+005