Sulphur Condensers

In SulphurPro™, the SRU Condenser block is a specialized heat exchanger block which has one process inlet stream and two process outlet streams (vapor outlet and liquid Sulphur outlet). The utility side typically has one inlet stream and one outlet stream. The SRU Condenser block offers an optional rigorous sizing / rating heat transfer rate model integrated within the process simulation. Several utility side configuration options are available. This ProTips™ article will shed some light on the features of the SRU Condenser in SulphurPro™.

The SRU Condenser block is modelled with the process stream on the tube-side and (if included) the utility stream on the shell-side. One tube-side pass and one shell-side pass are assumed. The process side is modelled with the Sulphur Thermo Package which includes accurate H_2S/H_2S_x/SO_2 solubility in liquid Sulphur. Figure 1 shows a schematic of the SRU Condenser block in SulphurPro™. Figure 2 shows the basic data input required for the SRU Condenser block.
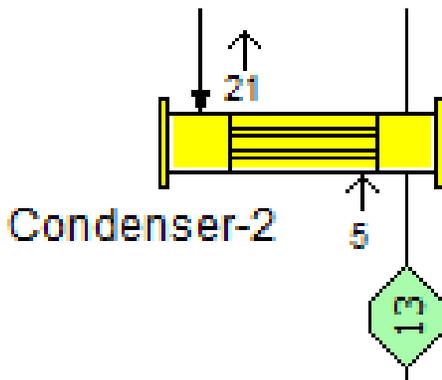

Figure 1. Sulphur Condenser Block in SulphurPro™

There are three calculation modes for the SRU Condenser block: Simple Energy Balance, Heat Transfer Sizing, and Heat Transfer Rating. Depending on the chosen calculation mode, other data tabs such as Heat Transfer, Equipment Data, and Cooling Medium may require simple or more elaborate inputs. The SRU Condenser block can be modelled as a series of segments divided into increments of equal temperature change or equal duty.

Figure 2. Basic Data Tab for Sulphur Condensers

The SRU Condenser has some unique reporting aspects. Figure 3 shows the overall reporting of the SRU Condenser block which contain details such as the overall heat duty, LMTD, equipment details, temperature, etc.

Condenser-2 [SulphurCondenser Block]		
Duty*	-3.758E+06	Btu/hr
LMTD*	103.864	Fahrenheit
Corrected LMTD*	103.864	Fahrenheit
Overall HTC*	16.931	Btu/hr-sqft-F
Overall Heat Flux*	-5547.491	W/m2
Total Area*	2136.893	sqft
Area Per Tube*	11.740	sqft
Tube Count*	182.025	
Tube ID	0.125	feet
Tube Length*	29.895	feet
Inlet Tube Velocity*	103.864	ft/s
Inlet Tube Mass Velocity	24.412	kg/m2-s
Process Inlet Pressure*	19.550	psia
Process Outlet Pressure (Spec'd)	19.150	psia
Process Outlet Pressure (Calc'd)		psia
Process Inlet Temperature*	585.357	Fahrenheit
Process Outlet Temperature	320.000	Fahrenheit
Utility Inlet Pressure*	64.696	psia
Utility Outlet Pressure	64.696	psia
Utility Inlet Temperature*	297.644	Fahrenheit
Utility Outlet Temperature*	297.644	Fahrenheit
Liquid Entrainment	100.694	lb/hr
Max Iterations Specified	100	
Iterations Used*		
Tolerance Specified	0.0001	
Tolerance Achieved*		

Figure 3. Sulphur Condenser Outputs

Figure 4 shows segment-wise reporting of the process side which includes segment data as well as cumulative data. Segment data includes duty, inside tube-wall temperatures, heat fluxes in each segment etc. These are useful in gaining a better understanding of how the exchanger is performing along the length of the tubes. The Process Side stream output is also reported here for the overall stream as well as the vapor and liquid phases.

🔳 View: Data

Segment		0	1	2
Duty	Btu/hr		-3.23E+05	-3.22E+05
Cumulative Duty	Btu/hr		-3.23E+05	-6.45E+05
Area	sqft		6.62E+01	7.25E+01
Cumulative Area	sqft		6.62E+01	1.39E+02
Tube Length	feet		9.26E-01	1.01E+00
Cumulative Tube Length	feet		9.26E-01	1.94E+00
LMTD	Fahrenheit		2.74E+02	2.48E+02
Corrected LMTD	Fahrenheit		2.74E+02	2.48E+02
Overall HTC	Btu/hr-sqft-F		1.78E+01	1.79E+01
Heat Flux	W/m2		-1.54E+04	-1.40E+04
Inside Tube Wall Temp.	Fahrenheit		3.25E+02	3.23E+02
Output for Process Side				
Overall Stream				
Temperature	Fahrenheit	5.85E+02	5.59E+02	5.32E+02
Pressure	psia	1.95E+01	1.95E+01	1.95E+01
Molec Wt		2.76E+01	2.76E+01	2.76E+01
Molar Flow	lbmol/hr	1.46E+03	1.46E+03	1.46E+03
Enthalpy	Btu/lb	-1.16E+03	-1.17E+03	-1.18E+03
Density	lb/cuft	4.81E-02	4.93E-02	5.05E-02
Vapor Phase				
Phase Fraction		1.00E+00	1.00E+00	1.00E+00
Molec Wt		2.76E+01	2.76E+01	2.76E+01
Molar Flow	lbmol/hr	1.46E+03	1.46E+03	1.46E+03
Enthalpy	Btu/lb	-1.19E+03	-1.17E+03	-1.18E+03
HeatCapacity	Btu/lb-R	3.01E-01	3.05E-01	3.03E-01
Density	lb/cuft	5.30E-02	4.93E-02	5.05E-02
Viscosity	cP	2.39E-02	2.54E-02	2.48E-02
Thermal Conductivity	Btu/hr-ft-F	2.12E-02	2.27E-02	2.21E-02
Cp/Cv		1.31E+00	1.31E+00	1.31E+00
ZFactor		1.00E+00	1.00E+00	1.00E+00
Liquid Phase				
Phase Fraction		1.00E-04		
Molec Wt		2.50E+02		
Molar Flow	lbmol/hr	1.46E-01		
Enthalpy	Btu/lb	1.17E+02		
HeatCapacity	Btu/lb-R	2.54E-01		

Figure 4. Phase-Wise Physical Property Reporting

📊 View: Data

Output for Utility Side			
Overall Stream			
Temperature	Celsius	1.40E+02	1.40E+02
Pressure	barg	2.62E+00	2.62E+00
Molec Wt		1.80E+01	1.80E+01
Molar Flow	kmol/hr	5.24E+01	5.24E+01
Enthalpy	cal/gm	4.91E+01	2.49E+01
Density	gm/cc	1.95E-03	2.05E-03
Vapor Phase			
Phase Fraction		1.00E+00	9.53E-01
Molec Wt		1.80E+01	1.80E+01
Molar Flow	kmol/hr	5.24E+01	5.00E+01
Enthalpy	cal/gm	4.91E+01	4.91E+01
HeatCapacity	cal/gm-K	4.70E-01	4.70E-01
Density	gm/cc	1.95E-03	1.95E-03
Viscosity	cP	1.37E-02	1.37E-02
Thermal Conductivity	W/m-K	2.78E-02	2.78E-02
Cp/Cv		1.34E+00	1.34E+00
ZFactor		9.76E-01	9.76E-01
Aqueous Phase			
Phase Fraction			4.68E-02
Molec Wt			1.80E+01
Molar Flow	kmol/hr		2.45E+00
Enthalpy	cal/gm		-4.68E+02
HeatCapacity	cal/gm-K		1.03E+00
Density	gm/cc		9.30E-01
Viscosity	cP		2.07E-01
Thermal Conductivity	W/m-K		6.88E-01
Surface Tension	N/m		5.07E-02
Vapor Pressure	bar		3.63E+00
pH			

Figure 5. Utility Stream Reporting

Figure 5 shows segment-wise reporting of the utility side of the condenser. This includes the overall utility stream as well as the vapor and liquid phases, similar to the process side reporting. As seen in Figure 1, SulphurPro has the option of creating automatically generated streams for the steam side calculations. These contain the boiler feed water make-up and steam flowrate values which will tell the user how much steam that particular exchanger is generating based on a boiler feed water temperature and generated steam pressure. An optional continuous blow-down stream specification is available.

PROTIP:
The segment-wise information of the process side can be very useful to a user and can aid in creating exchanger duty curves, Heat Flux profiles, inside tube wall temperature profiles, and phase fraction profiles; all of which can help gain a deeper understanding as to the performance and efficiency of the exchanger and also help make optimization move decisions. The Sulphur Condenser can also calculate the pressure drop based on user-provided information about the inlet and exit nozzles. In sizing mode, this calculated pressure drop will simply be a reported value and not actually used in the simulation. In rating mode, the calculated pressure drop value will be used directly in the simulation.

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