Unit Operations in HYSYS/HYSYS Derived Simulators

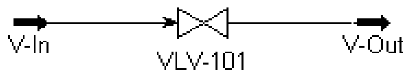
Revision 1.0

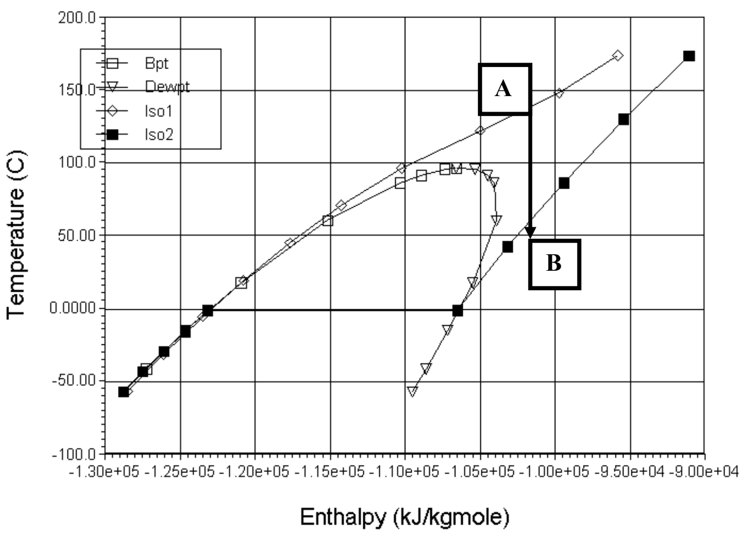
Valve

The valve is an **ISENTHALPIC** device. I.e., $H_{in} = H_{out}$. Assuming all the material specifications are provided, any **three** of the following can be specified.

- T_{in}
- P_{in}
- T_{out}
- P_{out}
- Delta_P_Valve

•An example path of this process is described by A-B in the T-H diagram. Iso1 and Iso2 are isobars.

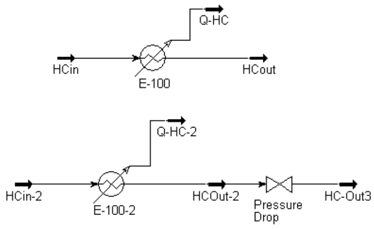




Simple Heater Cooler

The HYSYS simple heater and cooler are **<u>mathematically the same device</u>** with different conventions for the direction of heat flows.

The heater/cooler are fundamentally ISOBARIC processes. In order to better represent heat transfer equipment, the heater/cooler accepts a **pressure drop.** In which case, the ISOBARIC process is combined with an ISENTHALPIC pressure drop.



Streams								
		HCin	HCout	HCin-2	HCOut-2	HC-Out3	Q-HC	Q-HC-2
Vapour Fraction		1.0000	0.5000	1.0000	0.2879	0.5000		
Temperature	C	100.0	-42.48	100.0	1.798	-42.48		
Pressure	kPa	500.0	100.0	500.0	500.0	100.0		
Molar Flow	kgmole/h	1.000	1.000	1.000	1.000	1.000		
Mass Flow	kg/h	44.10	44.10	44.10	44.10	44.10		
Std Ideal Liq Vol Flow	m3/h	8.703e-002	8.703e-002	8.703e-002	8.703e-002	8.703e-002		
Heat Flow	kJ/h	-9.816e+004	-1.180e+005	-9.816e+004	-1.180e+005	-1.180e+005	1.987e+004	1.987e+004
Molar Enthalpy	kJ/kgmole	-9.816e+004	-1.180e+005	-9.816e+004	-1.180e+005	-1.180e+005		

<u>Typical Specifications</u>
Pressure Drop:
Pin, Pout Specified
Any three of the following:
Tin, Tout, Q and Flow

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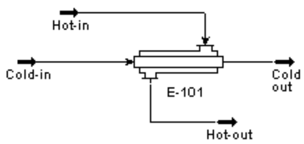
Heat Exchanger

Heat exchangers.
The heat exchanger modules in most simulators can be divided into the following types:

•Simple (no geometry)

•Detailed (using geometry to calculate heat transfer coefficients)



Streams					
		Cold-in	Cold out	Hot-in	Hot-out
Vapour Fraction		0.0000	0.0187	1.0000	0.0000
Temperature	C	100.0	191.0	222.7	218.9
Pressure	kPa	300.0	265.5	500.0	465.5
Molar Flow	kgmole/h	100.0	100.0	100.0	100.0
Mass Flow	kg/h	1.283e+004	1.283e+004	1.283e+004	1.283e+004
Std Ideal Liq Vol Flow	m3/h	17.81	17.81	17.81	17.81
Heat Flow	kJ/h	-2.525e+007	-2.206e+007	-1.785e+007	-2.104e+007
Molar Enthalpy	kJ/kgmole	-2.525e+005	-2.206e+005	-1.785e+005	-2.104e+005

Heat Exchanger - Simple

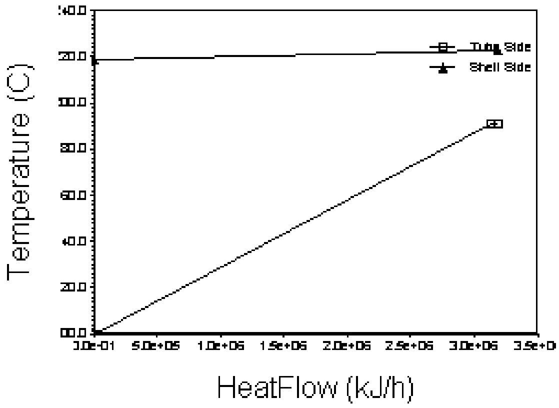
The simple heat exchanger models in most simulators does not rigorously rate the exchanger, I.e., pressure drops, shell and tube side heater transfer coefficients and fouling factors are not calculated.

The simple heat exchanger is represented by the basic design equation:

$Q = U_A\,(LMTD) f_t = H_{in} - H_{out}$

LMTD = (ΔToutlet – ΔTinlet)/ln(ΔToutlet/ΔTinlet)

Ft = correction factor



Given pressure drops and flowrates, **typical specifications** in this case are three of the following:

UA, T_{coldIn}, $T_{coldOut}$, T_{hotIn}, T_{hotOut}

Heat Exchanger - Rigorous

Most simulators have a “rigorous” or “rating mode” simulator. This representation allows the user to specify the geometry based on the TEMA design.

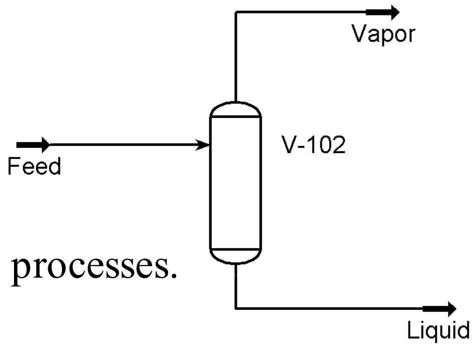
In this case, the user needs to specify the TEMA type and shell and tube geometry and layout.

This model calculates all the outlet conditions given fully defined inlet streams. Pressure drops, heat transfer coefficients are estimated from the TEMA type and geometry.

Separator

HYSYS has several types of separators:

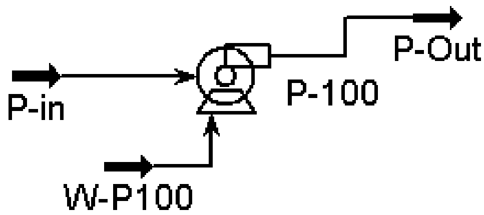
•Two Phase
•Three Phase and
•Tanks



Like the heater, the separator embodies several processes.

The most basic function is an adiabatic separation and phase disengagement device.
However, you can add a pressure drop and energy stream.
In that case, it becomes analogous to simple heater/cooler and adiabatic separation.

Pump



Pumps in most simulators are represented by:

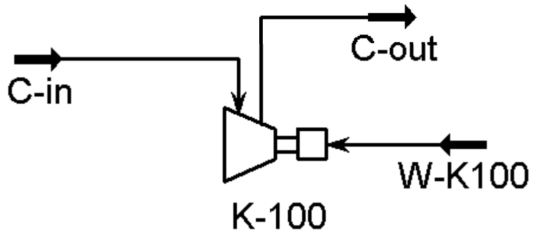
$$Power\ Required_{ideal} = \frac{(P_{out} - P_{in}) \times Flow\ Rate}{Liquid\ Density} \qquad Efficiency(\%) = \frac{Power\ Required_{ideal}}{Power\ Required_{actual}} \times 100\%$$

where: P_{out} = *pump outlet pressure*

P_{in} = *pump inlet pressure*

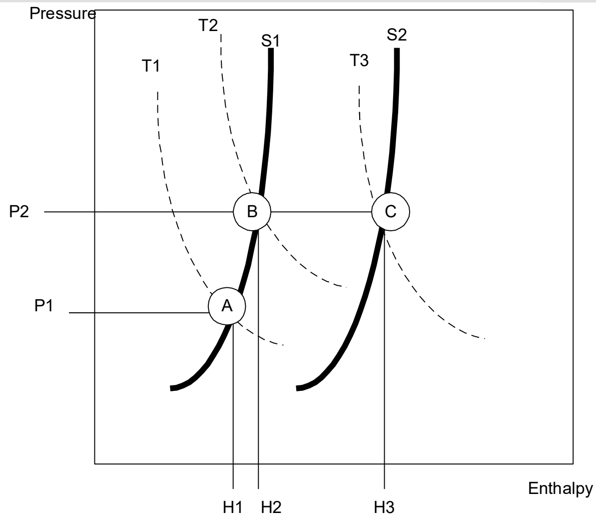
It is important to note that the pump is ONLY for **incompressible** liquids. If the liquid you are working with is **near critical** you should use a **compressor** instead.

Compressor/Expander



The compressor is a Polytropic device. The expander is essentially the reverse of a compressor

An actual compression is an **irreversible** process. Most simulators employ a **two step** procedure for this computation. First a reversible compression is used A-B, H2-H1 is the reversible work for this process.

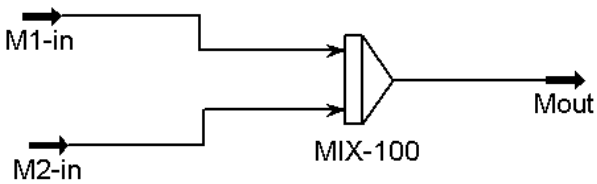


This work is then multiplied (or divided by an efficiency to give the actual work (point C). Total work = H3-H1. Adiabatic efficiency = (H2-H1)/(H3-H1)

Typical Specifications, 4 of the following:
Tin, Pin, Tout, Pout, Efficiency (adiabatic or polytropic), Work.

Mixer

The mixer unit is, solved as an adiabatic mixing. The temperature of the single outlet stream is computed for a specified outlet pressure with no heat gain or loss.

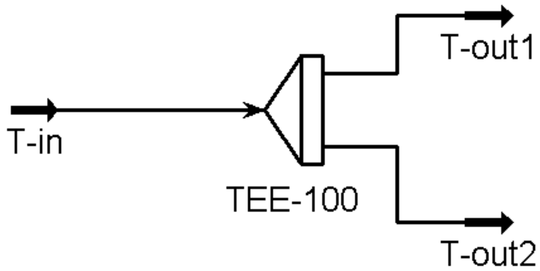


Compared to a real mixing device or a manifold, the mixer in most simulators are "dumb" devices. They **do not settle out pressures, there is no pressure-flow relationship** and the **outlet pressure MUST be specified**.

In HYSYS, the outlet pressure is specified in the following manner:
Set outlet P to lowest inlet – All inlet streams must have pressures. The lowest pressure is used for the outlet.
Equalize all – For n streams, only 1 stream is allowed to have a pressure, the other n-1 streams will be set to that pressure.

Splitter(Tee)

The computation for the Tee is similar to that of the mixer. It is an adiabatic device. The temperature, pressure and compositions of the outlet streams are set to be identical to that of the inlet stream



Compared to a real tee, the splitter in most simulators are “dumb” devices. They **do not settle out pressures, there is no pressure-flow relationship** and the **outlet pressure is always that of the inlet.**

For a splitter with **n** outlet streams, typical specifications are normally:

Split fractions for n-1 outlet streams.
Flow rates for n-1 outlet streams.