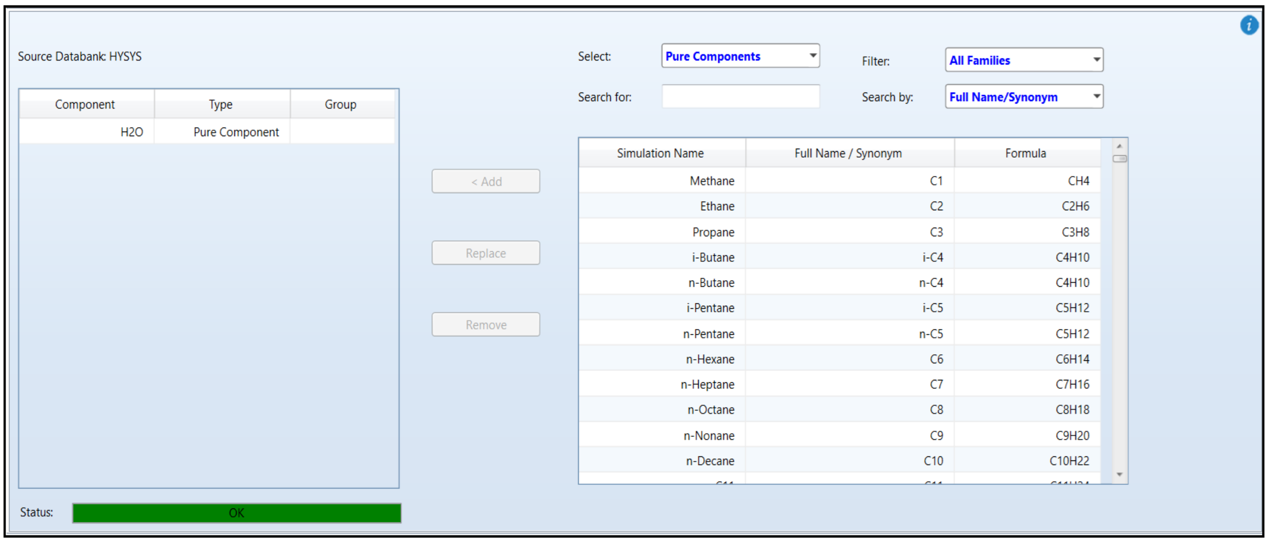
Educational Institute for Equipment and Process Design

Heat Exchanger Simulation

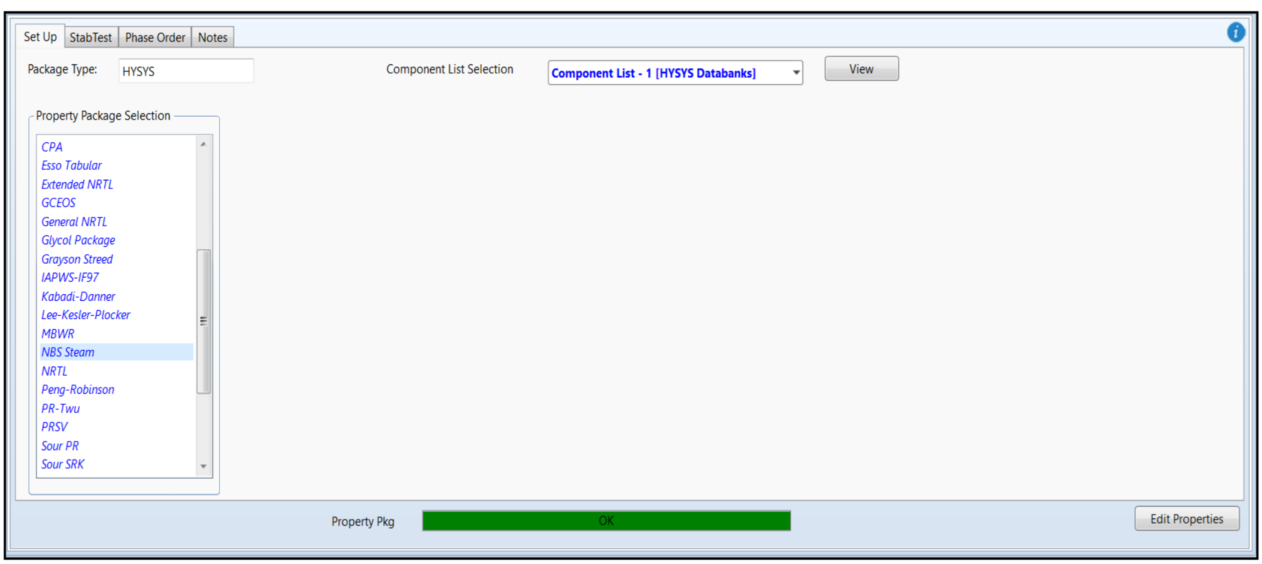
Example 1: 47200 kg/hr. of process condensate with operating pressure of 1.5 barg and operating temperature of 100C should be cooled to 65C. Using Aspen Hysys, calculate the duty of the heat exchanger used for such application.

How to simulate:

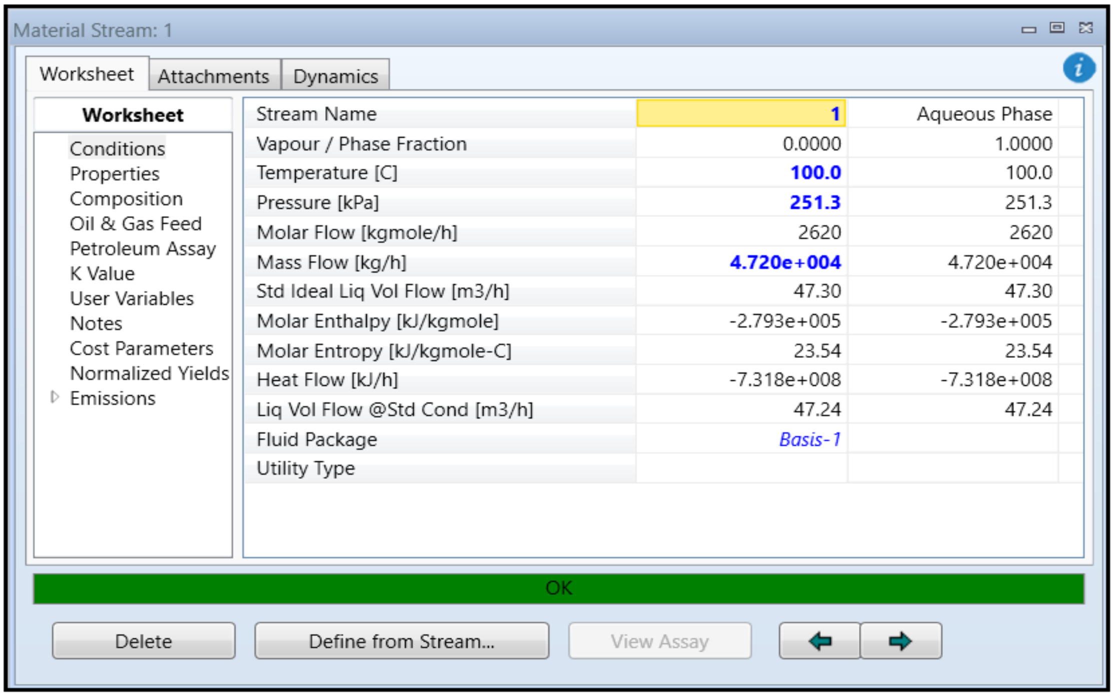
1.Add water in component list



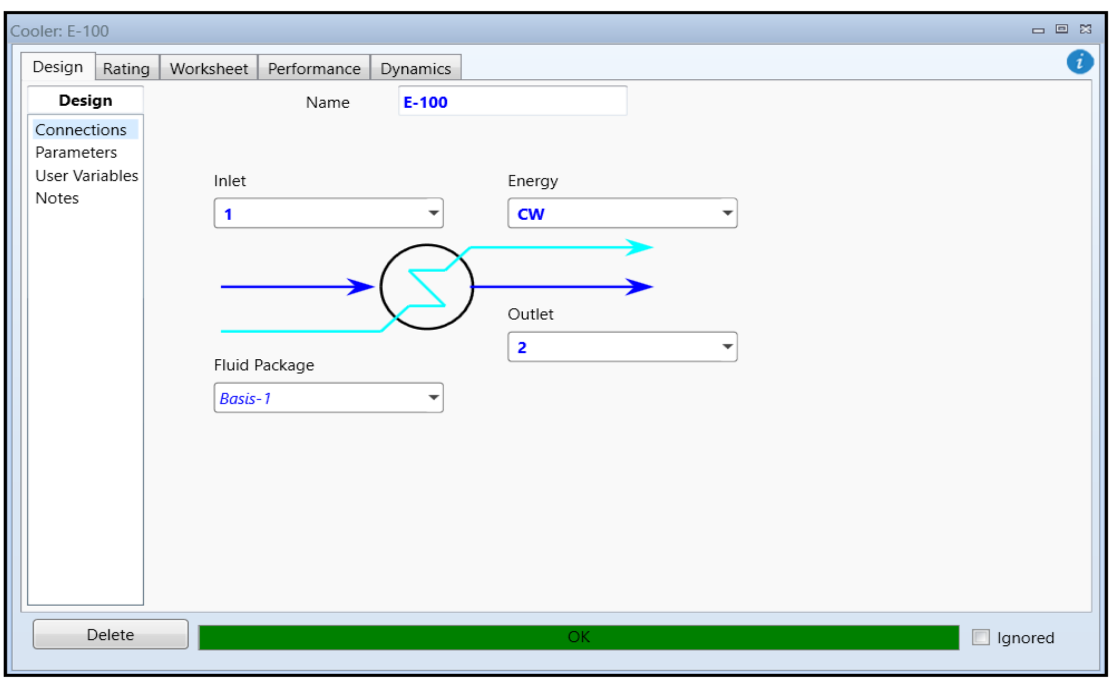
2.Select NBS as Fluid Package



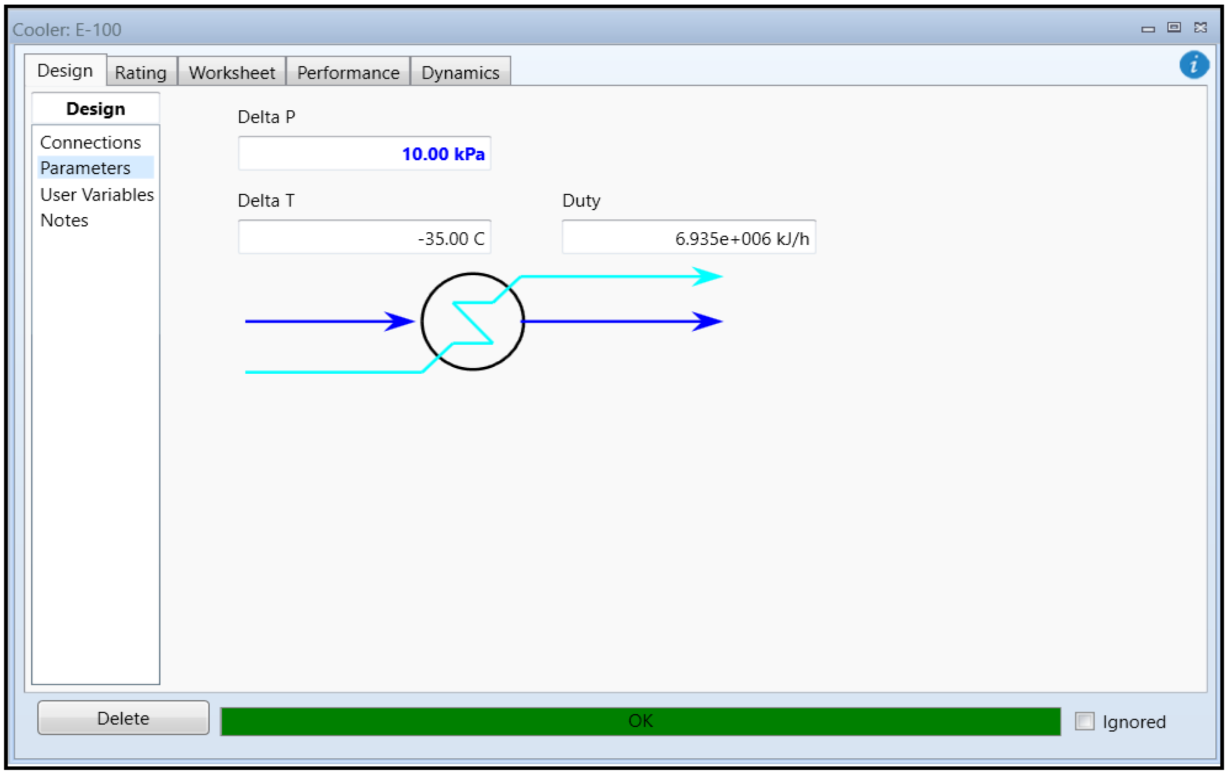
3.Enter Simulation Environment and define stream 1 with aforementioned operating conditions:

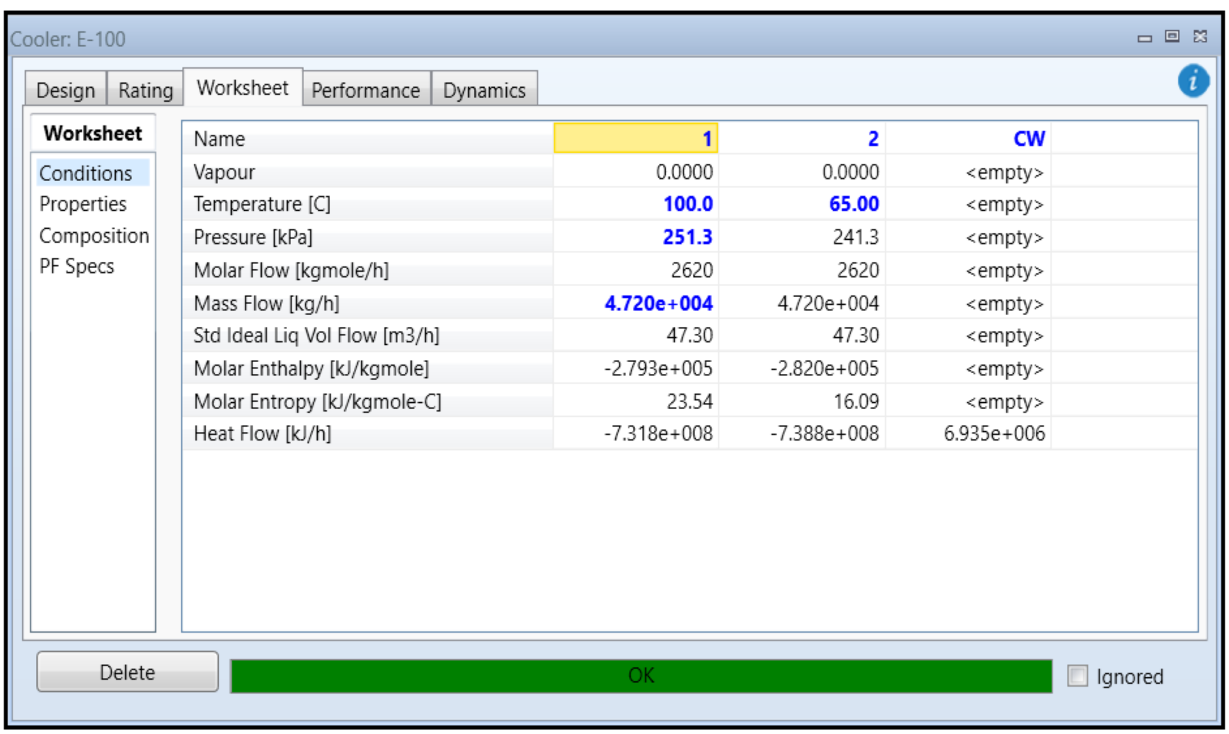


4.Select a cooler from Model Pallete/ Heat Exchanger. Connect stream 1 to its inlet and define stream 2 as the outlet stream.



5. Under Design/ Parameter, set pressure drop to 0.1 bar.



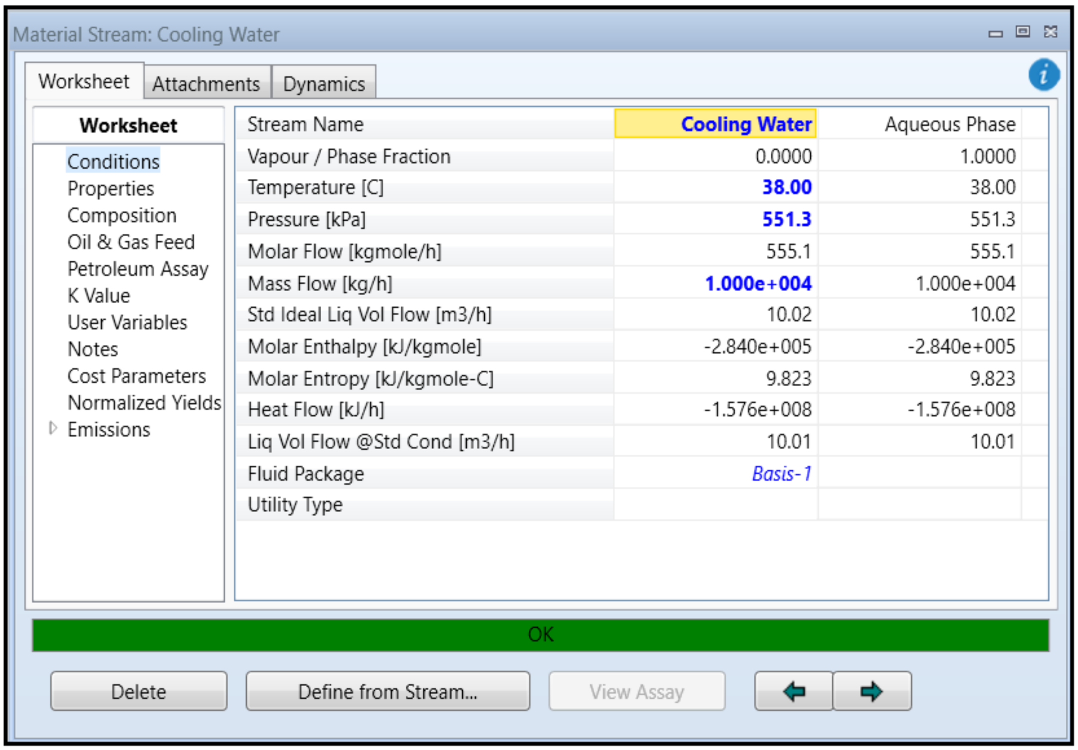


6.Based on the result, the cooling duty required is 6.935×10^6 kJ/h.

Example 2: Regarding the first example, calculate the exact value of cooling water needed. Cooling water has an inlet temperature of 38C and outlet temperature of 48C. The operating pressure is 4.5 barg and consider 0.6 pressure drop throughout the heat exchanger.

How to simulate:

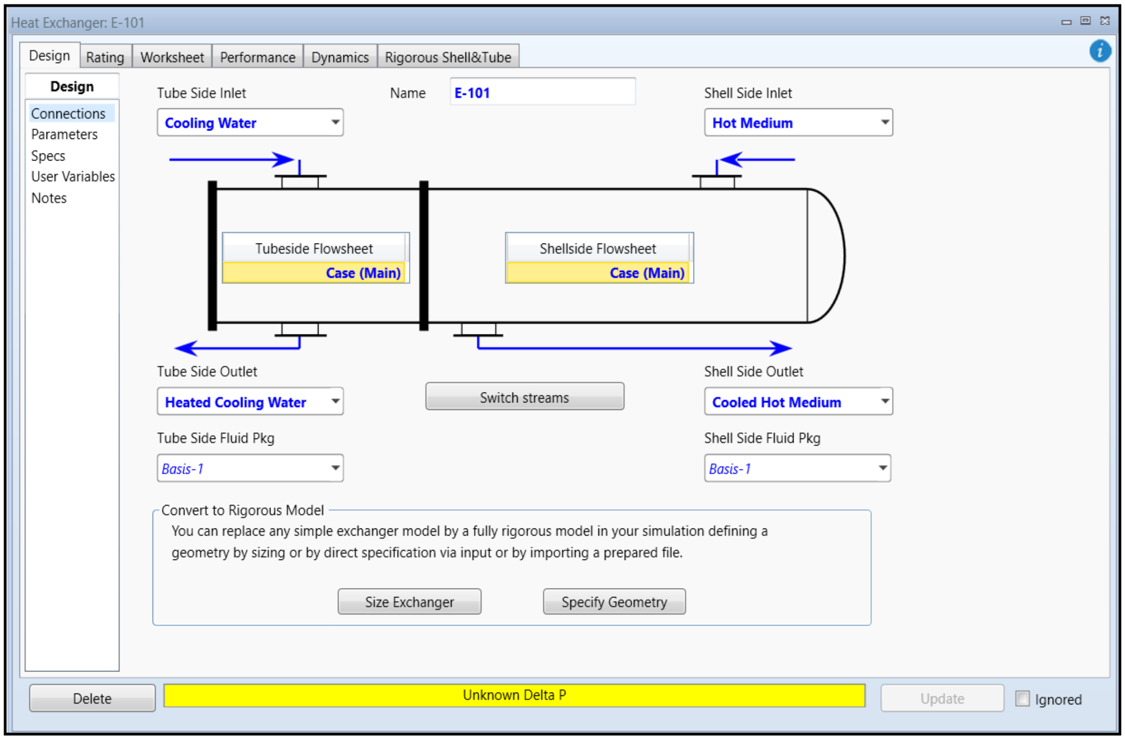
1.Define Cooling Water stream and for the Hot Medium which should be cooled from 100C to 65C, copy paste it from last simulation.

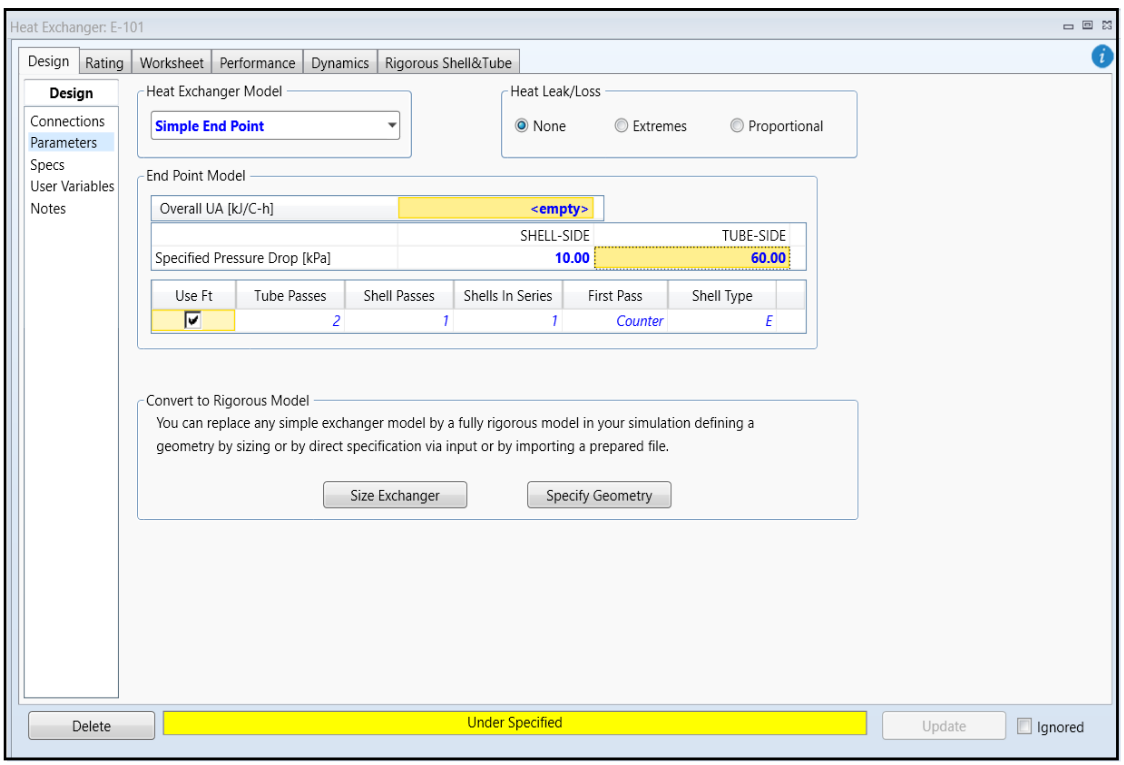


We don't know about the flowrate of cooling water, so for now we start with 10000 kg/hr.

2.Select a heat exchanger from Model Pallete/Heat Exchanger and connect these streams to the heat exchanger. In order to increase water velocity, cooling water passes through tubes. Also, we define Heated Cooling Water and Cooled Hot Medium as the outlet stream.

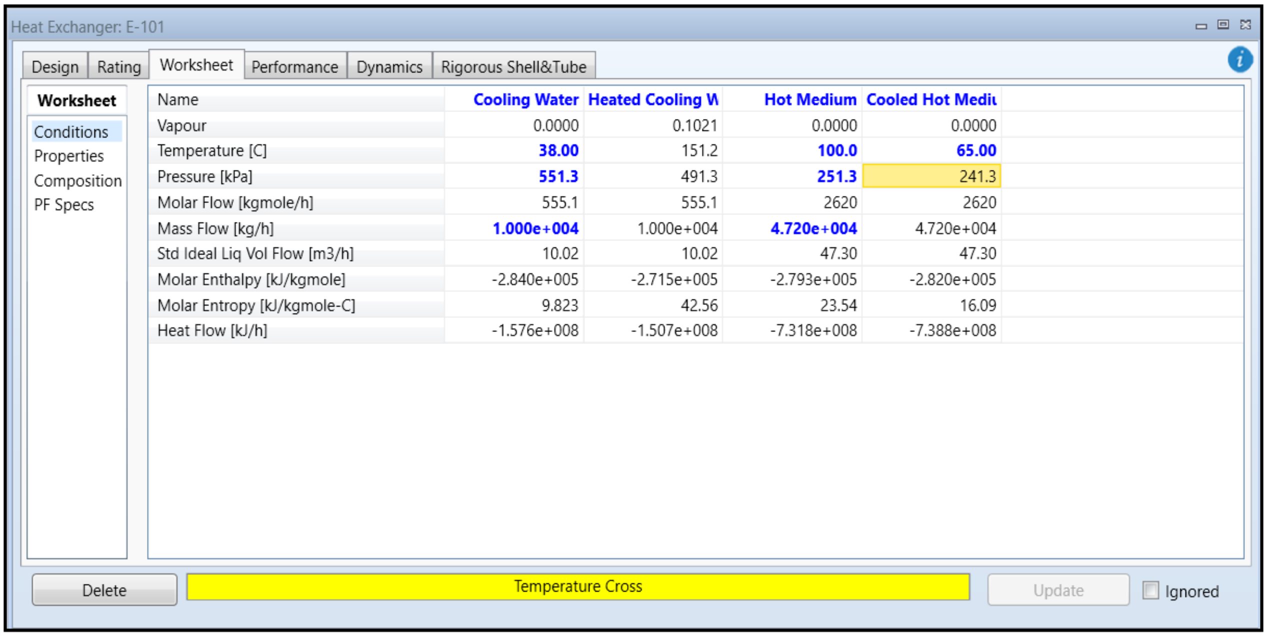
Under Design/Parameter specify 0.1 bar and 0.6 bar as the pressure drop of shell-side and tube-side respectively. As shown in the Parameter sheet, there are different types of heat exchanger model. Since no phase change is encountered in this simulation, simple end point is applied. Otherwise, simple weighted should be applied.


Heat Exchanger: E-101
Design
Rating
Worksheet
Performance
Dynamics
Rigorous Shell&Tube
Connections
Parameters
Specs
User Variables
Notes
Tube Side Inlet
Cooling Water
Name
E-101
Shell Side Inlet
Hot Medium
Tubeside Flowsheet
Case (Main)
Shellside Flowsheet
Case (Main)
Tube Side Outlet
Heated Cooling Water
Switch streams
Shell Side Outlet
Cooled Hot Medium
Tube Side Fluid Pkg
Basis-1
Shell Side Fluid Pkg
Basis-1
Convert to Rigorous Model
You can replace any simple exchanger model by a fully rigorous model in your simulation defining a geometry by sizing or by direct specification via input or by importing a prepared file.
Size Exchanger
Specify Geometry
Delete
Unknown Delta P
Update
Ignored


Heat Exchanger: E-101
Design
Rating
Worksheet
Performance
Dynamics
Rigorous Shell&Tube
Connections
Parameters
Specs
User Variables
Notes
Heat Exchanger Model
Simple End Point
Heat Leak/Loss
None
Extremes
Proportional
End Point Model
Overall UA [kJ/C-h]
<empty>
SHELL-SIDE
TUBE-SIDE
Specified Pressure Drop [kPa]
10.00
60.00
Use Ft
Tube Passes
Shell Passes
Shells In Series
First Pass
Shell Type
2
1
1
Counter
E
Convert to Rigorous Model
You can replace any simple exchanger model by a fully rigorous model in your simulation defining a geometry by sizing or by direct specification via input or by importing a prepared file.
Size Exchanger
Specify Geometry
Delete
Under Specified
Update
Ignored

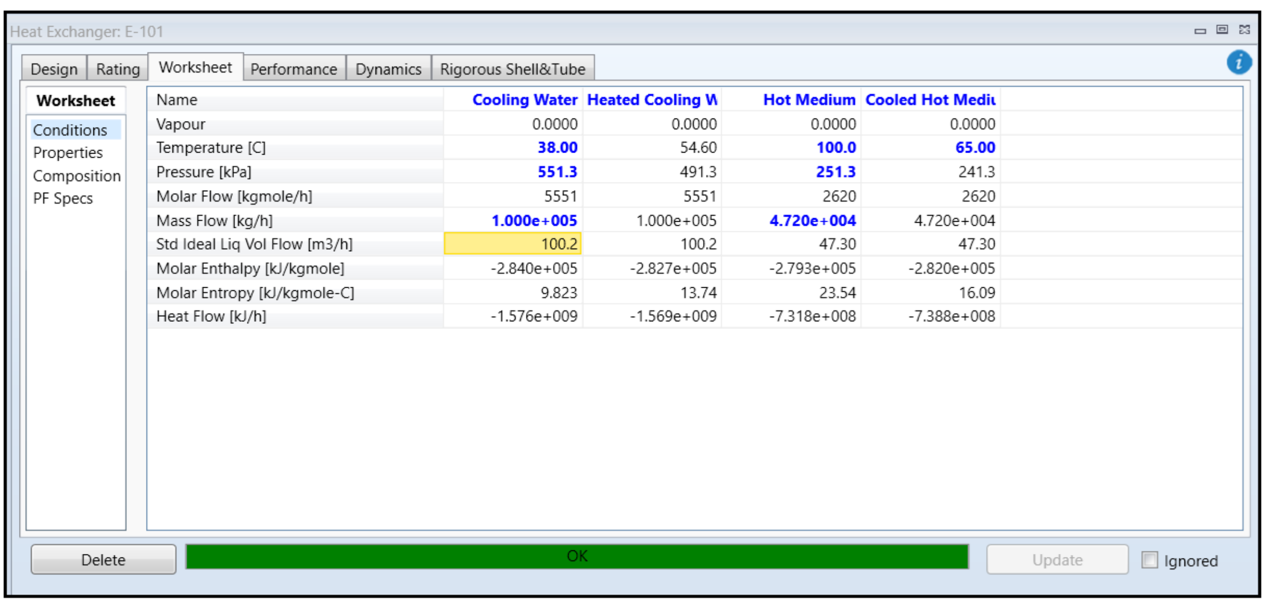
Remember we have two specs here, the first one being the outlet temperature of Hot medium to reach 65C and the second one, the cooling water outlet temperature to be 48C but the first one is more important.

So here at first, we specify that the hot medium outlet temperature should be 65C and then what the outlet temperature of cooling water is. If it is more than 48C then we increase the flow rate, if it is less than 48C, then we decrease the flowrate.



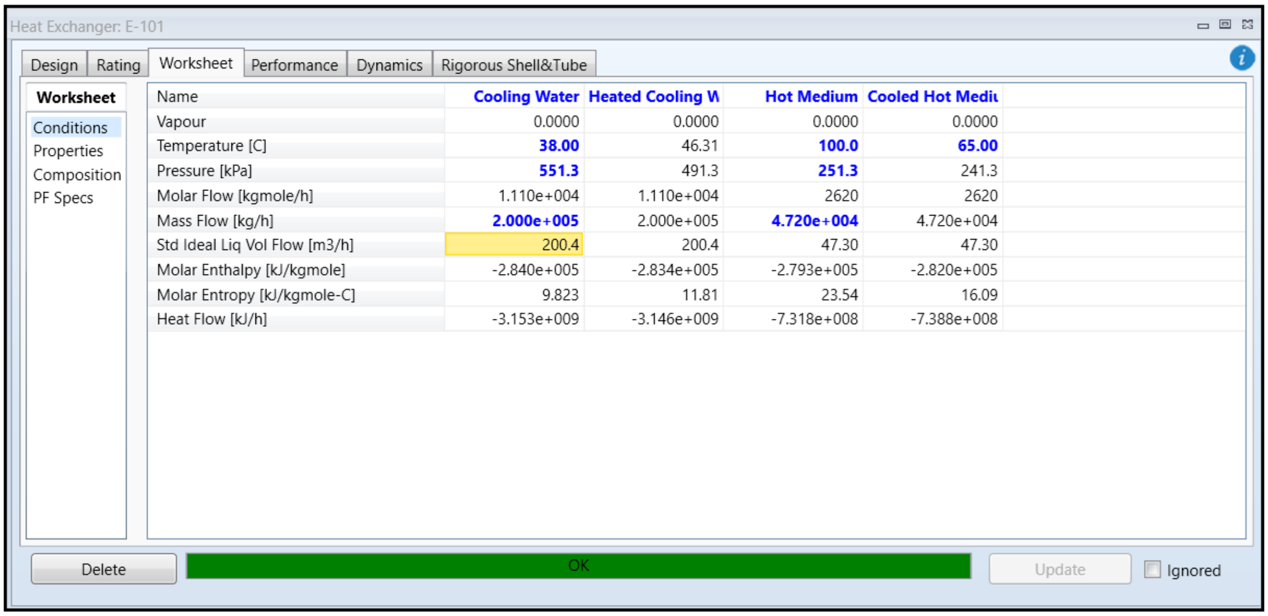
Name	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Mediu
Vapour	0.0000	0.1021	0.0000	0.0000
Temperature [C]	38.00	151.2	100.0	65.00
Pressure [kPa]	551.3	491.3	251.3	241.3
Molar Flow [kgmole/h]	555.1	555.1	2620	2620
Mass Flow [kg/h]	1.000e+004	1.000e+004	4.720e+004	4.720e+004
Std Ideal Liq Vol Flow [m3/h]	10.02	10.02	47.30	47.30
Molar Enthalpy [kJ/kgmole]	-2.840e+005	-2.715e+005	-2.793e+005	-2.820e+005
Molar Entropy [kJ/kgmole-C]	9.823	42.56	23.54	16.09
Heat Flow [kJ/h]	-1.576e+008	-1.507e+008	-7.318e+008	-7.388e+008

As shown above, the cooling water outlet temperature is 151C and a temperature cross has happened. So, at this stage the flowrate of cooling water is increased to 100000 kg/hr. to see how the outlet temperature changes.



Name	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Mediu
Vapour	0.0000	0.0000	0.0000	0.0000
Temperature [C]	38.00	54.60	100.0	65.00
Pressure [kPa]	551.3	491.3	251.3	241.3
Molar Flow [kgmole/h]	5551	5551	2620	2620
Mass Flow [kg/h]	1.000e+005	1.000e+005	4.720e+004	4.720e+004
Std Ideal Liq Vol Flow [m3/h]	100.2	100.2	47.30	47.30
Molar Enthalpy [kJ/kgmole]	-2.840e+005	-2.827e+005	-2.793e+005	-2.820e+005
Molar Entropy [kJ/kgmole-C]	9.823	13.74	23.54	16.09
Heat Flow [kJ/h]	-1.576e+009	-1.569e+009	-7.318e+008	-7.388e+008

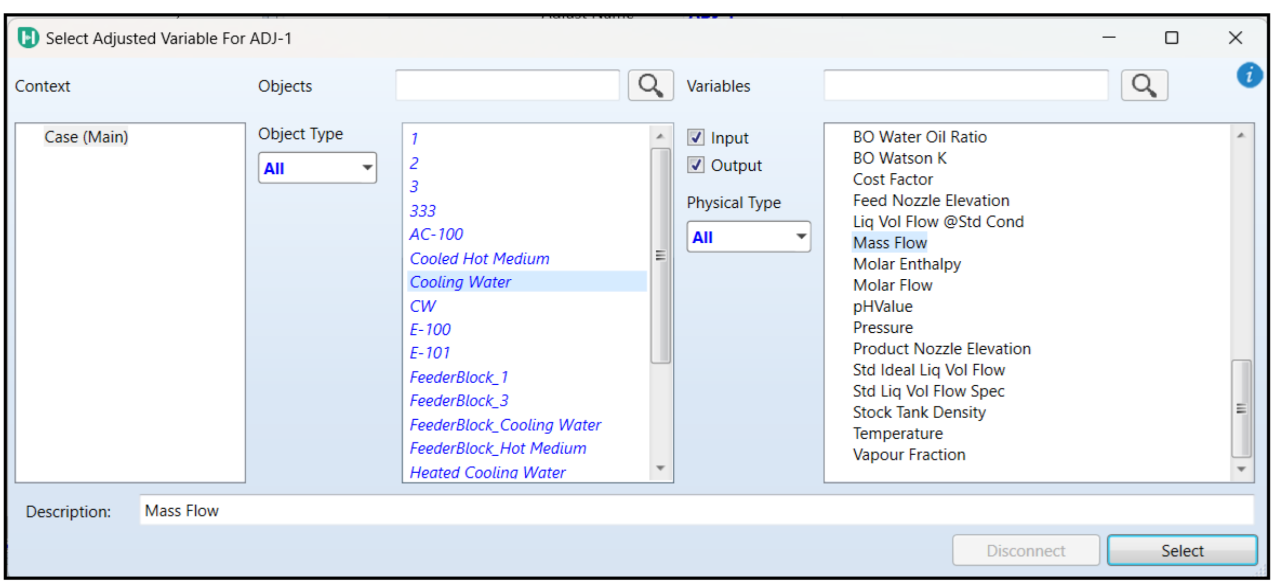
Let's increase it to 200000 kg/hr.

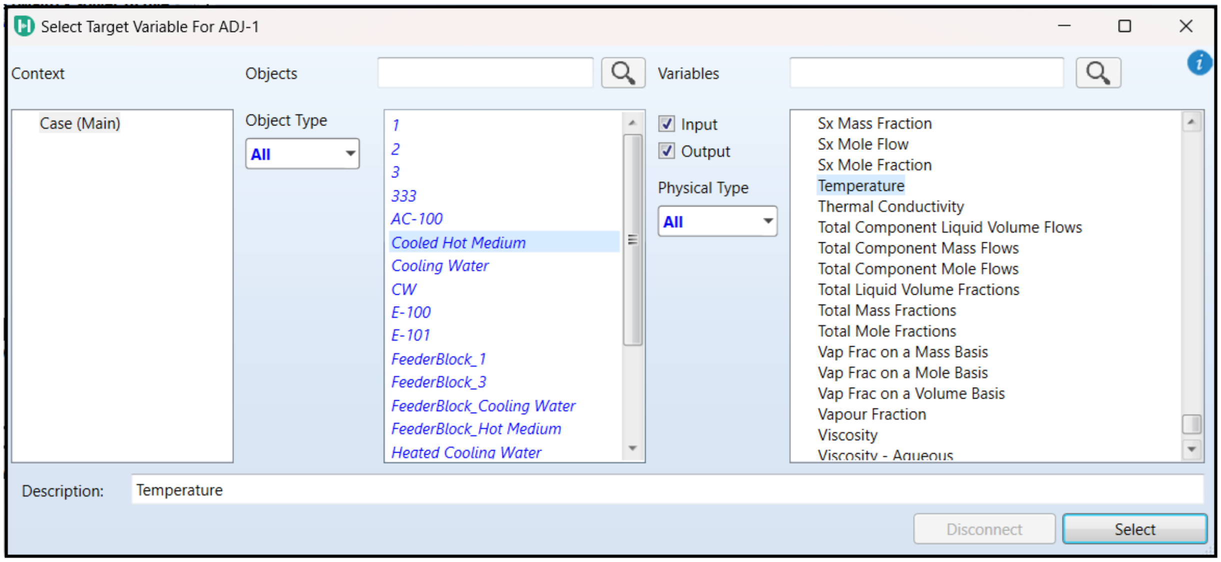


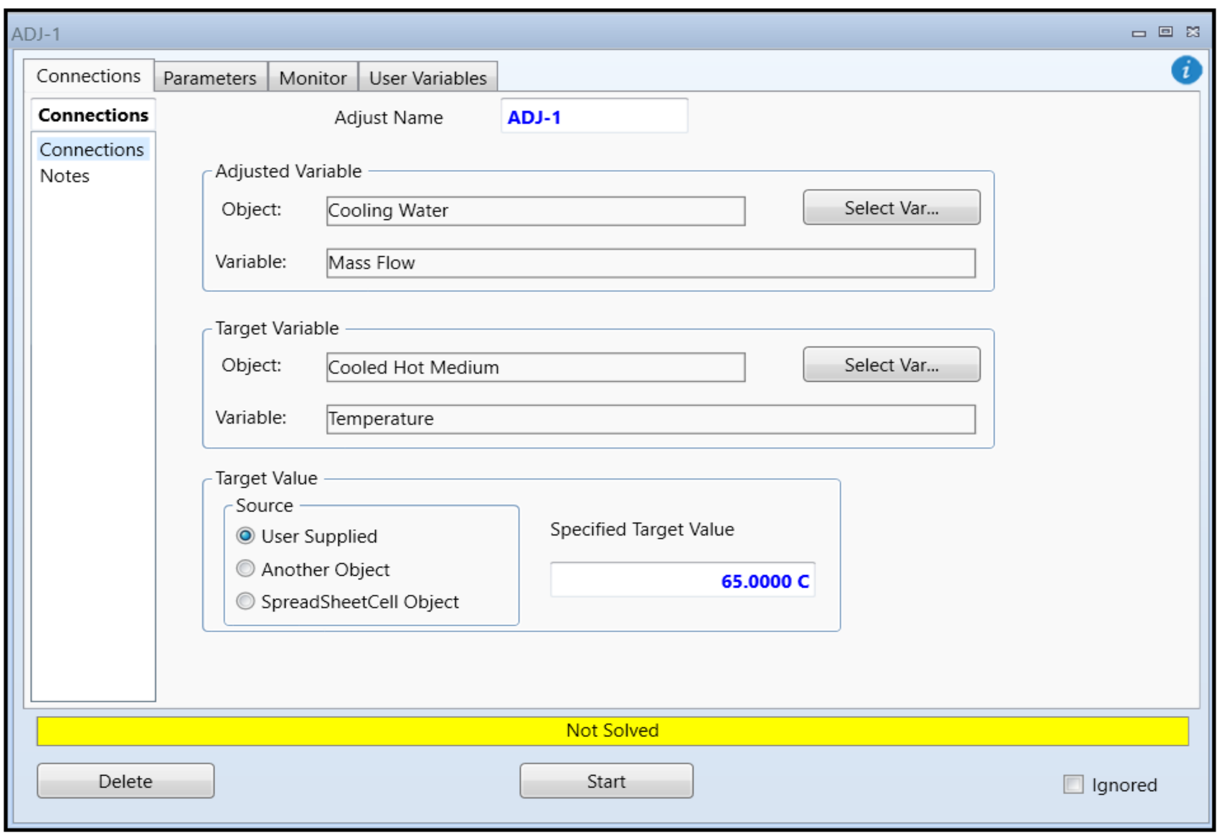
Name	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Mediu
Vapour	0.0000	0.0000	0.0000	0.0000
Temperature [C]	38.00	46.31	100.0	65.00
Pressure [kPa]	551.3	491.3	251.3	241.3
Molar Flow [kgmole/h]	1.110e+004	1.110e+004	2620	2620
Mass Flow [kg/h]	2.000e+005	2.000e+005	4.720e+004	4.720e+004
Std Ideal Liq Vol Flow [m3/h]	200.4	200.4	47.30	47.30
Molar Enthalpy [kJ/kgmole]	-2.840e+005	-2.834e+005	-2.793e+005	-2.820e+005
Molar Entropy [kJ/kgmole-C]	9.823	11.81	23.54	16.09
Heat Flow [kJ/h]	-3.153e+009	-3.146e+009	-7.318e+008	-7.388e+008

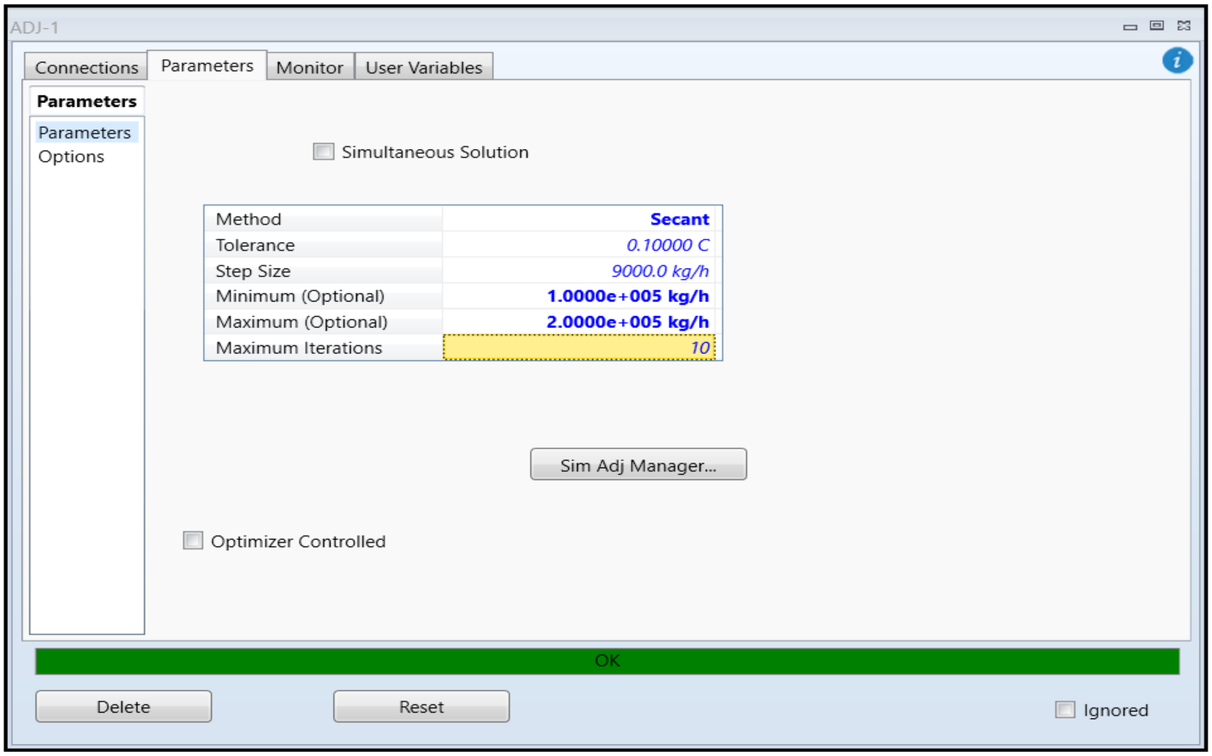
The outlet temperature is 46.3C. Our spec was 48C. Based on these two trials, we know that the cooling water flowrate should be between 100000 kg/hr. and 200000 kg/hr. since 46.3<48<54.6.

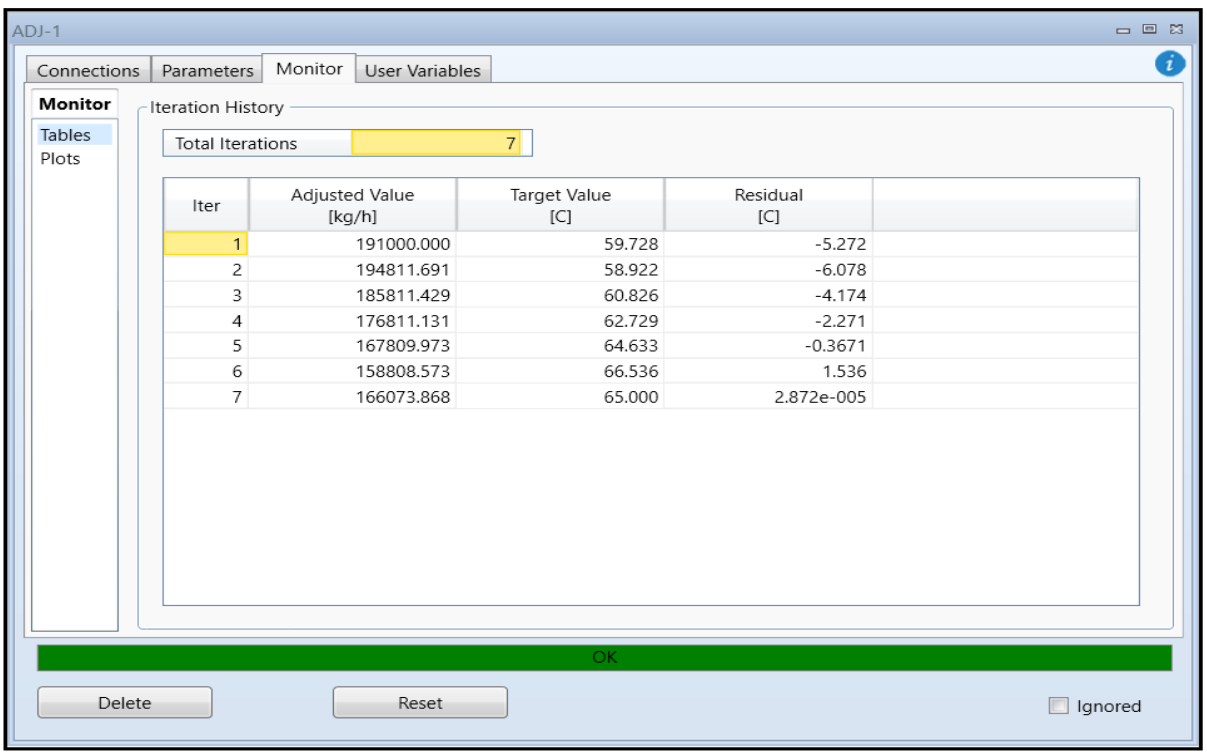
To find the exact value, Adjust could be used. Our adjusted variable is cooling water flowrate in the stream Cooling Water and our target variable is outlet temperature of hot medium in Cooled Hot Medium, which should be 65C. Also, it should be assumed that the outlet temperature of cooling water should be 48C.




Select Target Variable For ADJ-1
Context
Objects
Variables
Case (Main)
Object Type
All
1
2
3
333
AC-100
Cooled Hot Medium
Cooling Water
CW
E-100
E-101
FeederBlock_1
FeederBlock_3
FeederBlock_Cooling Water
FeederBlock_Hot Medium
Heated Cooling Water
Input
Output
Physical Type
All
Sx Mass Fraction
Sx Mole Flow
Sx Mole Fraction
Temperature
Thermal Conductivity
Total Component Liquid Volume Flows
Total Component Mass Flows
Total Component Mole Flows
Total Liquid Volume Fractions
Total Mass Fractions
Total Mole Fractions
Vap Frac on a Mass Basis
Vap Frac on a Mole Basis
Vap Frac on a Volume Basis
Vapour Fraction
Viscosity
Viscosity - Aqueous
Description:
Temperature
Disconnect
Select


ADJ-1
Connections
Parameters
Monitor
User Variables
Connections
Connections
Notes
Adjust Name
ADJ-1
Adjusted Variable
Object:
Cooling Water
Select Var...
Variable:
Mass Flow
Target Variable
Object:
Cooled Hot Medium
Select Var...
Variable:
Temperature
Target Value
Source
User Supplied
Another Object
SpreadSheetCell Object
Specified Target Value
65.0000 C
Not Solved
Delete
Start
Ignored


ADJ-1
Connections
Parameters
Monitor
User Variables
Parameters
Parameters
Options
Simultaneous Solution
Method Secant
Tolerance 0.10000 C
Step Size 9000.0 kg/h
Minimum (Optional) 1.0000e+005 kg/h
Maximum (Optional) 2.0000e+005 kg/h
Maximum Iterations 10
Sim Adj Manager...
Optimizer Controlled
OK
Delete
Reset
Ignored


ADJ-1
Connections
Parameters
Monitor
User Variables
Monitor
Tables
Plots
Iteration History
Total Iterations 7
Iter
Adjusted Value [kg/h]
Target Value [C]
Residual [C]
1 191000.000 59.728 -5.272
2 194811.691 58.922 -6.078
3 185811.429 60.826 -4.174
4 176811.131 62.729 -2.271
5 167809.973 64.633 -0.3671
6 158808.573 66.536 1.536
7 166073.868 65.000 2.872e-005
OK
Delete
Reset
Ignored

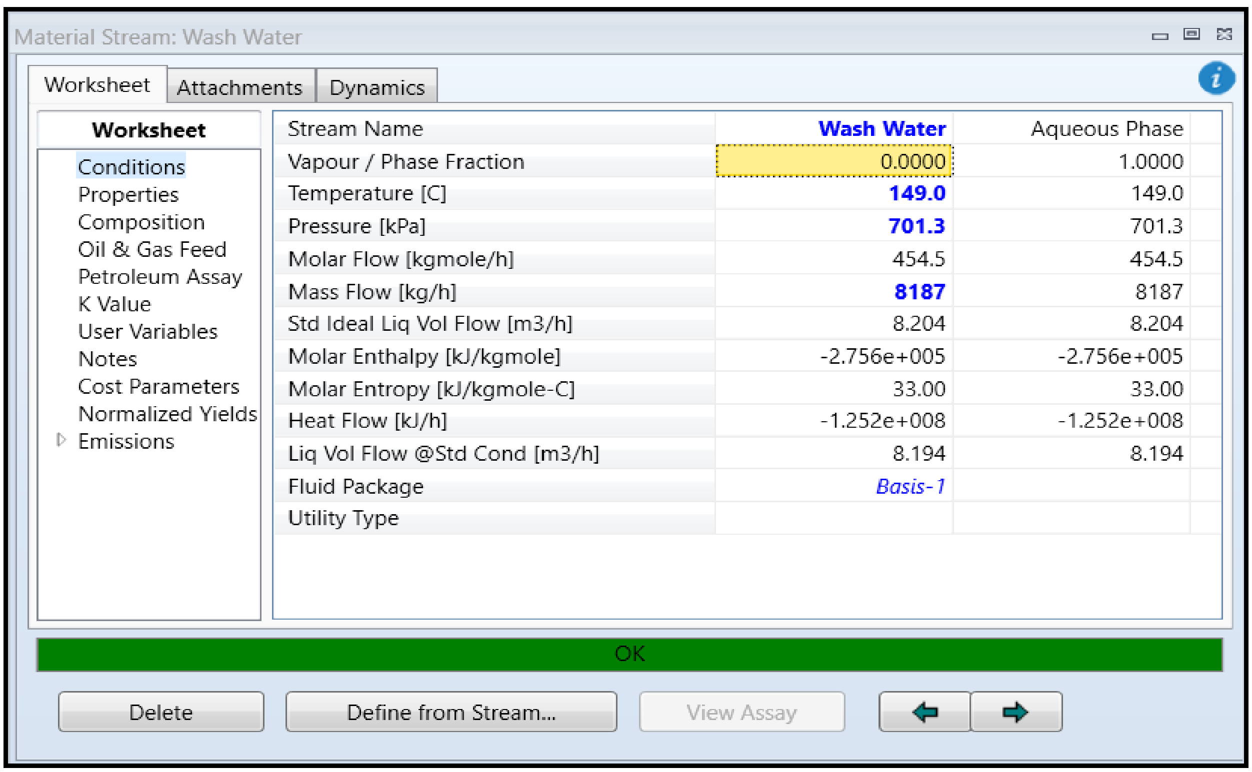
So, we need 166000 kg/hr. of cooling water to have the outlet temperature of 65C.

Example 3: In a process plant, it is decided to re-use a distillation column bottom which is approximately 100 % water, for a packed bed as washing water. The operating temperature is 48C. A typical rule in process engineering is that when a stream temperature is between 130-150C or generally more than 65C, an air-cooled heat exchanger is used. Note that on special cases, water-cooled might be used like previous example.

The hot water flowrate is 8187 kg/hr. The air-cooled heat exchanger is supposed to reduce wash water temperature from 149 to 65C and for cooling down more, a water-cooled heat exchanger is used. Determine how many fans are needed, provided that the maximum temperature of heated air reaches 48C.

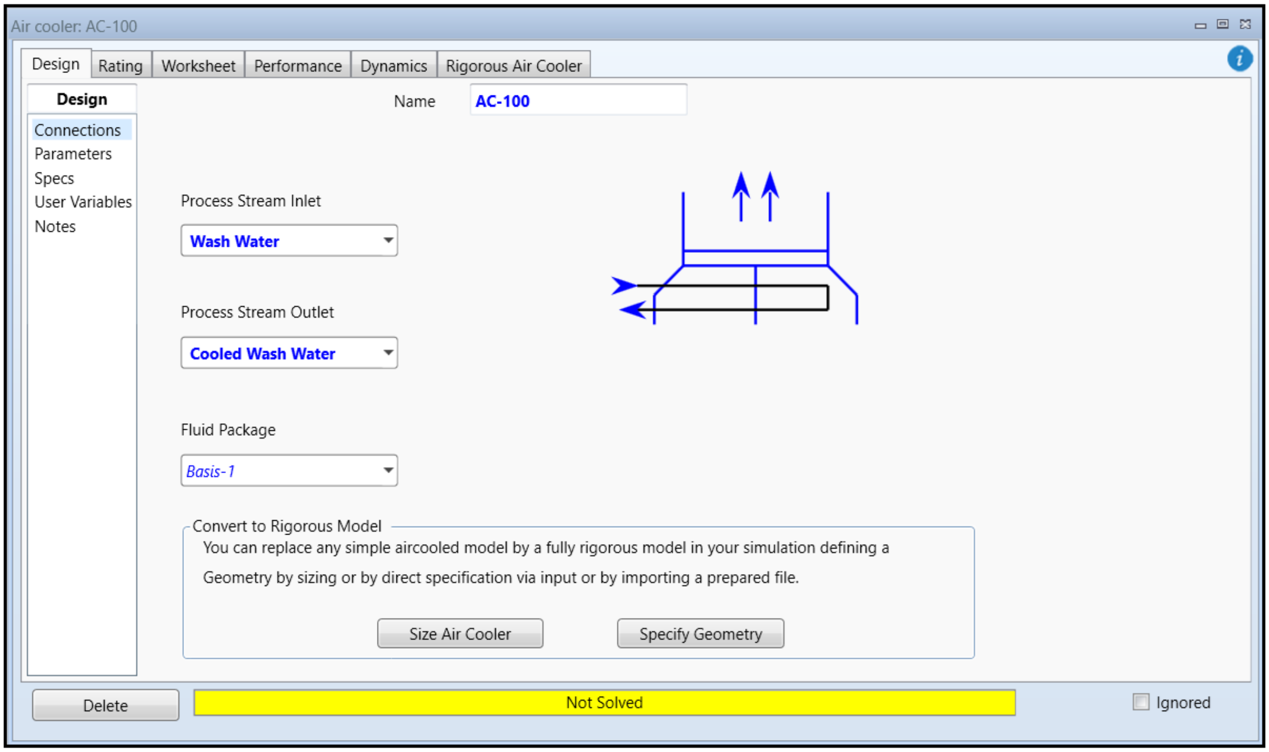
How to simulate:

1.Define Wash Water stream like below:

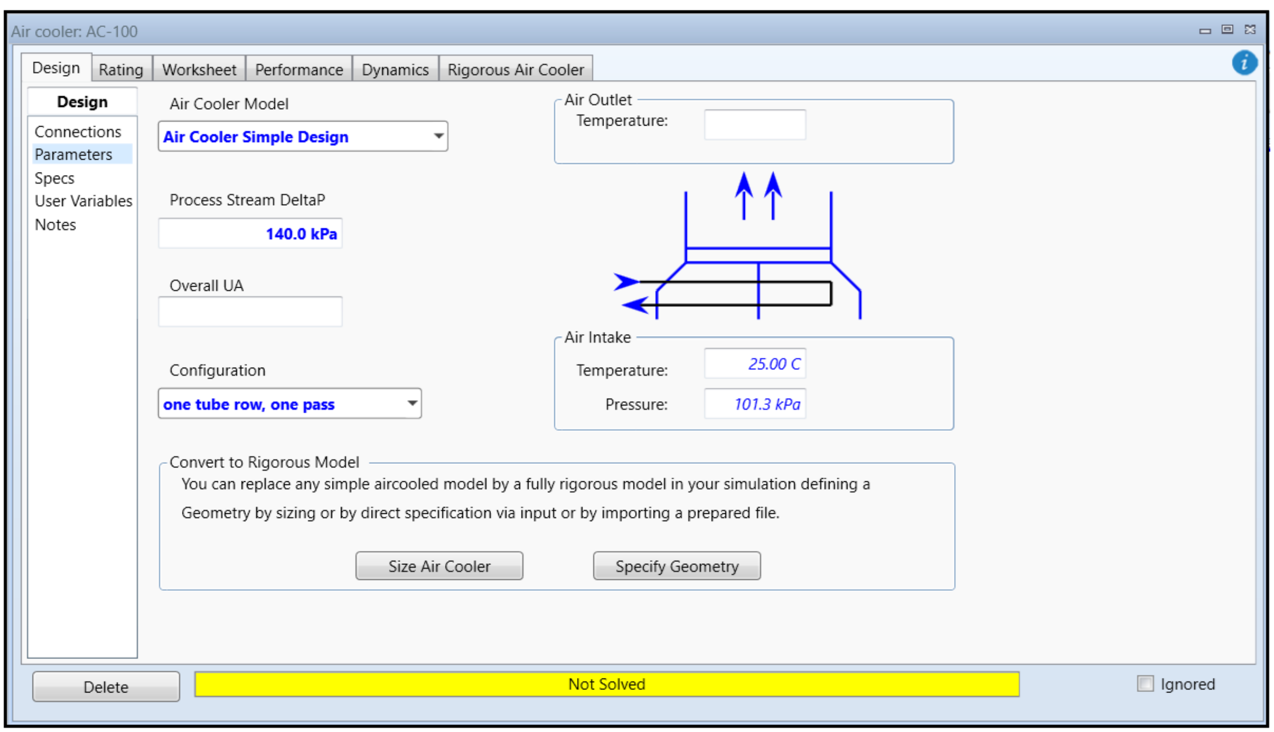


Stream Name	Wash Water	Aqueous Phase
Vapour / Phase Fraction	0.0000	1.0000
Temperature [C]	149.0	149.0
Pressure [kPa]	701.3	701.3
Molar Flow [kgmole/h]	454.5	454.5
Mass Flow [kg/h]	8187	8187
Std Ideal Liq Vol Flow [m3/h]	8.204	8.204
Molar Enthalpy [kJ/kgmole]	-2.756e+005	-2.756e+005
Molar Entropy [kJ/kgmole-C]	33.00	33.00
Heat Flow [kJ/h]	-1.252e+008	-1.252e+008
Liq Vol Flow @Std Cond [m3/h]	8.194	8.194
Fluid Package	Basis-1	
Utility Type		

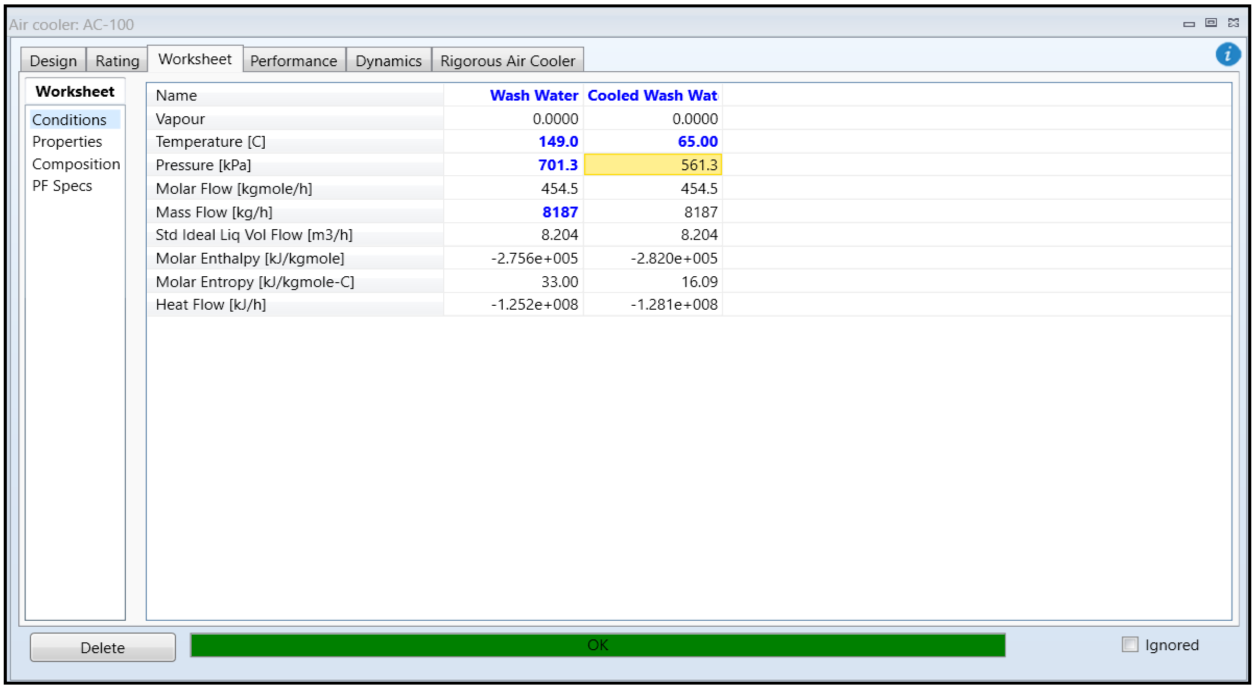
2.Select air-cooled heat exchanger from Model Pallete/ Heat Transfer and connect Wash Water to the inlet of the air cooler. Also define the stream Cooled Wash Water as the outlet stream.



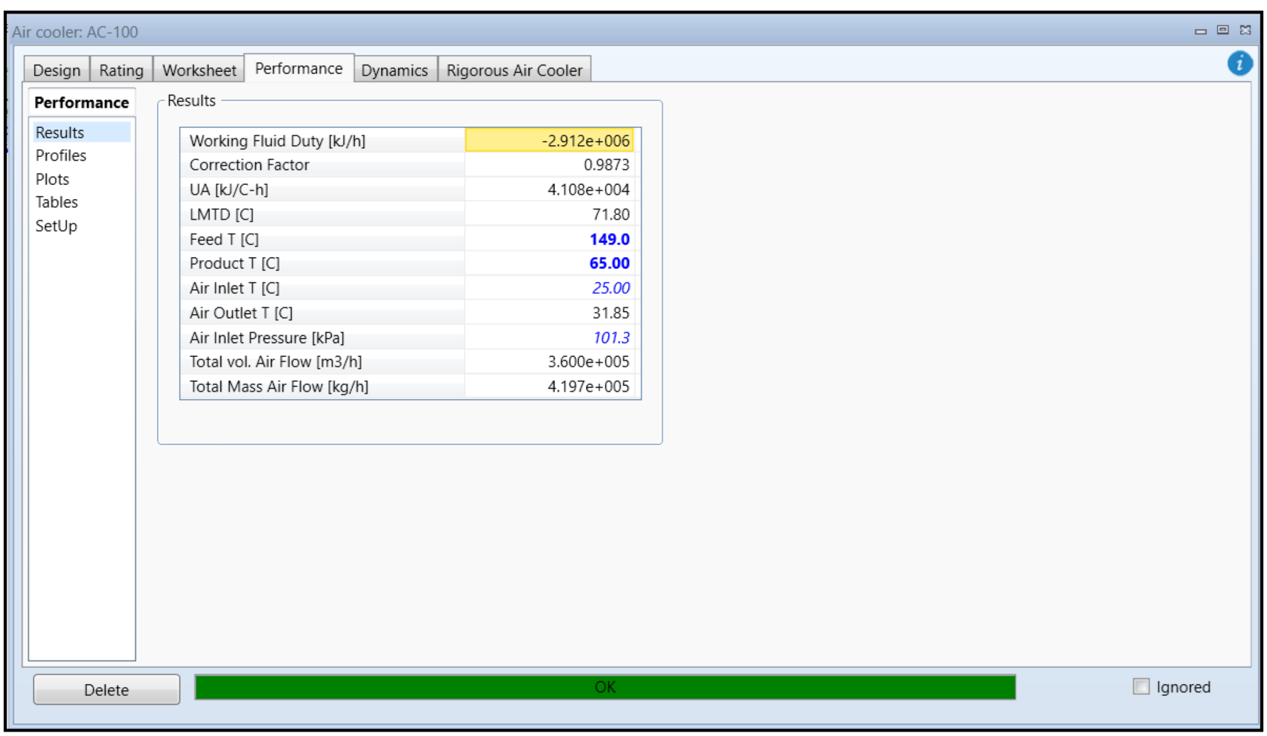
2.Under Design/Parameter, set pressure drop to 1.4 bar.



3.Specify 65C as the outlet temperature of Heated Wash Water.



4. To check the performance, Performance tab is selected.



5.Based on the result, Air Outlet T is 31.85 C, which is satisfactory. The software has so far selected one fan as default for this system. To change the number of fans, Rating tab shall be selected.