



## 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

Source Databank: HYSYS

Select: **Pure Components** Filter: **All Families**

Search for: Search by: **Full Name/Synonym**

Component	Type	Group
H2O	Pure Component	

< Add Replace Remove

Simulation Name	Full Name / Synonym	Formula
Methane	C1	CH4
Ethane	C2	C2H6
Propane	C3	C3H8
i-Butane	i-C4	C4H10
n-Butane	n-C4	C4H10
i-Pentane	i-C5	C5H12
n-Pentane	n-C5	C5H12
n-Hexane	C6	C6H14
n-Heptane	C7	C7H16
n-Octane	C8	C8H18
n-Nonane	C9	C9H20
n-Decane	C10	C10H22

Status: **OK**

### 2.Select NBS as Fluid Package

Set Up **StabTest** Phase Order Notes

Package Type: **HYSYS** Component List Selection: **Component List - 1 [HYSYS Databanks]** View

Property Package Selection

- CPA
- Esso Tabular
- Extended NRTL
- GCEOS
- General NRTL
- Glycol Package
- Grayson Streed
- IAPWS-IF97
- Kabadi-Danner
- Lee-Kesler-Plöcker
- MBWR
- NBS Steam**
- NRTL
- Peng-Robinson
- PR-Twu
- PRSV
- Sour PR
- Sour SRK

Property Pkg **OK** Edit Properties



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

Worksheet	Stream Name	1	Aqueous Phase
Conditions	Vapour / Phase Fraction	0.0000	1.0000
Properties	Temperature [C]	100.0	100.0
Composition	Pressure [kPa]	251.3	251.3
Oil & Gas Feed	Molar Flow [kgmole/h]	2620	2620
Petroleum Assay	Mass Flow [kg/h]	4.720e+004	4.720e+004
K Value	Std Ideal Liq Vol Flow [m3/h]	47.30	47.30
User Variables	Molar Enthalpy [kJ/kgmole]	-2.793e+005	-2.793e+005
Notes	Molar Entropy [kJ/kgmole-C]	23.54	23.54
Cost Parameters	Heat Flow [kJ/h]	-7.318e+008	-7.318e+008
Normalized Yields	Liq Vol Flow @Std Cond [m3/h]	47.24	47.24
Emissions	Fluid Package	Basis-1	
	Utility Type		

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

Design Rating Worksheet Performance Dynamics

Name: E-100

Inlet: 1

Energy: CW

Outlet: 2

Fluid Package: Basis-1



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

Design Rating Worksheet Performance Dynamics

**Design**

Connections  
Parameters  
User Variables  
Notes

Delta P  
10.00 kPa

Delta T  
-35.00 C

Duty  
6.935e+006 kJ/h

Delete OK Ignored

Design Rating Worksheet Performance Dynamics

**Worksheet**

Name	1	2	CW
Vapour	0.0000	0.0000	<empty>
Temperature [C]	100.0	65.00	<empty>
Pressure [kPa]	251.3	241.3	<empty>
Molar Flow [kgmole/h]	2620	2620	<empty>
Mass Flow [kg/h]	4.720e+004	4.720e+004	<empty>
Std Ideal Liq Vol Flow [m3/h]	47.30	47.30	<empty>
Molar Enthalpy [kJ/kgmole]	-2.793e+005	-2.820e+005	<empty>
Molar Entropy [kJ/kgmole-C]	23.54	16.09	<empty>
Heat Flow [kJ/h]	-7.318e+008	-7.388e+008	6.935e+006

Delete OK Ignored



6. Based on the result, the cooling duty required is  $6.935 \times 10^6$  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.

Worksheet	Stream Name	Cooling Water	Aqueous Phase
Conditions	Vapour / Phase Fraction	0.0000	1.0000
Properties	Temperature [C]	38.00	38.00
Composition	Pressure [kPa]	551.3	551.3
Oil & Gas Feed	Molar Flow [kgmole/h]	555.1	555.1
Petroleum Assay	Mass Flow [kg/h]	1.000e+004	1.000e+004
K Value	Std Ideal Liq Vol Flow [m3/h]	10.02	10.02
User Variables	Molar Enthalpy [kJ/kgmole]	-2.840e+005	-2.840e+005
Notes	Molar Entropy [kJ/kgmole-C]	9.823	9.823
Cost Parameters	Heat Flow [kJ/h]	-1.576e+008	-1.576e+008
Normalized Yields	Liq Vol Flow @Std Cond [m3/h]	10.01	10.01
Emissions	Fluid Package	Basis-1	
	Utility Type		

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 Palette/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

**Design**

Connections Parameters Specs User Variables Notes

Tube Side Inlet Name **E-101** Shell Side Inlet

Cooling Water Hot Medium

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

**Design**

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
<input checked="" type="checkbox"/>	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.

	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Medi
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.

	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Medi
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.

Heat Exchanger: E-101

	Cooling Water	Heated Cooling W	Hot Medium	Cooled Hot Medi
Name				
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 Adjusted Variable For ADJ-1

Context: Case (Main)

Object Type: All

Variables:

- BO Water Oil Ratio
- BO Watson K
- Cost Factor
- Feed Nozzle Elevation
- Liq Vol Flow @Std Cond
- Mass Flow
- Molar Enthalpy
- Molar Flow
- pHValue
- Pressure
- Product Nozzle Elevation
- Std Ideal Liq Vol Flow
- Std Liq Vol Flow Spec
- Stock Tank Density
- Temperature
- Vapour Fraction

Description: Mass Flow

Buttons: Disconnect, Select



Select Target Variable For ADJ-1

Context: Case (Main)

Objects: 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

Variables: 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

Buttons: Disconnect, Select

ADJ-1

Connections Parameters Monitor User Variables

Adjust Name: ADJ-1

Adjusted Variable

Object: Cooling Water

Variable: Mass Flow

Target Variable

Object: Cooled Hot Medium

Variable: Temperature

Target Value

Source:  User Supplied,  Another Object,  SpreadsheetCell Object

Specified Target Value: 65.0000 C

Not Solved

Buttons: 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

Optimizer Controlled

Sim Adj Manager...

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:

Worksheet	Attachments	Dynamics	
<b>Worksheet</b>			
Conditions	Stream Name	<b>Wash Water</b>	Aqueous Phase
Properties	Vapour / Phase Fraction	0.0000	1.0000
Composition	Temperature [C]	149.0	149.0
Oil & Gas Feed	Pressure [kPa]	701.3	701.3
Petroleum Assay	Molar Flow [kgmole/h]	454.5	454.5
K Value	Mass Flow [kg/h]	8187	8187
User Variables	Std Ideal Liq Vol Flow [m3/h]	8.204	8.204
Notes	Molar Enthalpy [kJ/kgmole]	-2.756e+005	-2.756e+005
Cost Parameters	Molar Entropy [kJ/kgmole-C]	33.00	33.00
Normalized Yields	Heat Flow [kJ/h]	-1.252e+008	-1.252e+008
▾ Emissions	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 Palette/ Heat Transfer and connect Wash Water to the inlet of the air cooler. Also define the stream Cooled Wash Water as the outlet stream.



Air cooler: AC-100

Design Rating Worksheet Performance Dynamics Rigorous Air Cooler

**Design** Name: AC-100

Connections  
Parameters  
Specs  
User Variables  
Notes

Process Stream Inlet: Wash Water

Process Stream Outlet: Cooled Wash Water

Fluid Package: Basis-1

Convert to Rigorous Model  
You can replace any simple aircooled 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 Air Cooler Specify Geometry

Delete Not Solved Ignored

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

Air cooler: AC-100

Design Rating Worksheet Performance Dynamics Rigorous Air Cooler

**Design** Air Cooler Model: Air Cooler Simple Design

Process Stream DeltaP: 140.0 kPa

Overall UA: [Empty]

Configuration: one tube row, one pass

Air Outlet Temperature: [Empty]

Air Intake Temperature: 25.00 C  
Air Intake Pressure: 101.3 kPa

Convert to Rigorous Model  
You can replace any simple aircooled 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 Air Cooler Specify Geometry

Delete Not Solved Ignored



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

	Wash Water	Cooled Wash Wat
Vapour	0.0000	0.0000
Temperature [C]	149.0	65.00
Pressure [kPa]	701.3	561.3
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	-2.820e+005
Molar Entropy [kJ/kgmole-C]	33.00	16.09
Heat Flow [kJ/h]	-1.252e+008	-1.281e+008

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

Results	
Working Fluid Duty [kJ/h]	-2.912e+006
Correction Factor	0.9873
UA [kJ/C-h]	4.108e+004
LMTD [C]	71.80
Feed T [C]	149.0
Product T [C]	65.00
Air Inlet T [C]	25.00
Air Outlet T [C]	31.85
Air Inlet Pressure [kPa]	101.3
Total vol. Air Flow [m3/h]	3.600e+005
Total Mass Air Flow [kg/h]	4.197e+005



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.

The screenshot shows the 'Rating' tab of the 'Air cooler: AC-100' software. The 'Number of Fans' is set to 1. The table below lists the specifications for 'Fan 0':

Fan	Fan 0
Speed [rpm]	60.00
Demanded speed [rpm]	60.00
Max Acceleration per sec [rpm]	<no limit>
Design speed [rpm]	60.00
Design air flow [ACT_m3/h]	3.600e+005
Current air flow [ACT_m3/h]	3.600e+005
Fan Is On	<input checked="" type="checkbox"/>