

Learn how to optimize air cooler designs using Aspen EDR

A self guided demo on designing an overhead air cooled condenser for a crude distillation column

Objective



This self-guided demo shows **how to design an air cooler** using Aspen EDR.

Additionally you would learn how to

- **Import necessary data** from an Aspen HYSYS model
- Find the **optimal air flow** for the air cooler
- **Export** the final air cooler model to Aspen HYSYS

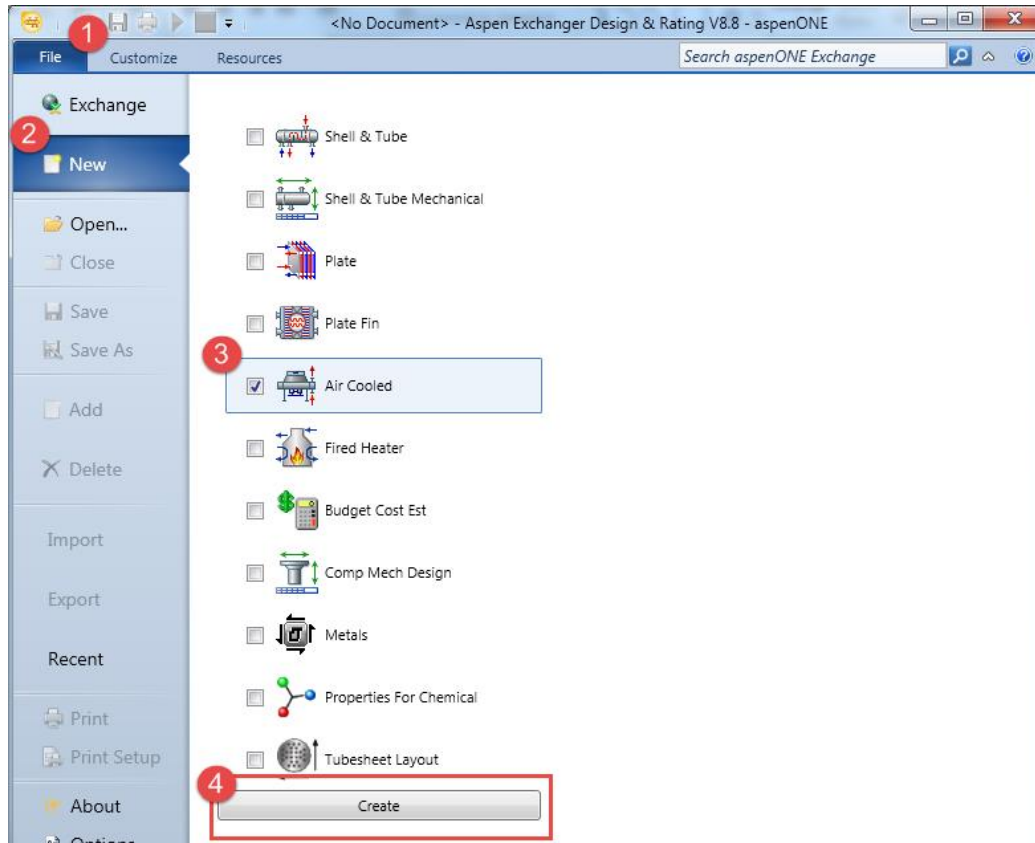
To download the required files for this exercise please visit Aspen Tech's customer support site.
(**Knowledge Base ID:144652** <http://support.aspentech.com/webteamasp/KB.asp?ID=144652>)

Context



A process engineer undertaking a revamp study on a crude distillation unit requires a preliminary design of air-cooled overhead condenser for the main atmospheric crude column.

Open Aspen EDR



Open a new case in
Aspen Air Cooled Exchanger

Import data from HYSYS file

1

File Home View Customize Resources

Exchange

New

Open...

Close

Save

Save As

Add

Delete

2

Import

Export

Recent

Print

Print Setup

Import from Aspen HYSYS

3

- Aspen HYSYS (Default)
- Aspen HYSYS V8.8
- Aspen HYSYS V8.6
- Aspen HYSYS V8.4
- Aspen HYSYS V8.3
- Aspen HYSYS V8.2
- Aspen HYSYS V8.0

Import from Aspen Plus

- Aspen Plus (Default)
- Aspen Plus V8.8
- Aspen Plus V8.6
- Aspen Plus V8.4
- Aspen Plus V8.2
- Aspen Plus V8.0
- Aspen Plus V7.3.2

Open

CDU

Search CDU

Name	Type	Size
EDR_CDU	HYSYS Simulation Case	1,865 KB

4

File name: EDR_CRUDE_UNIT1

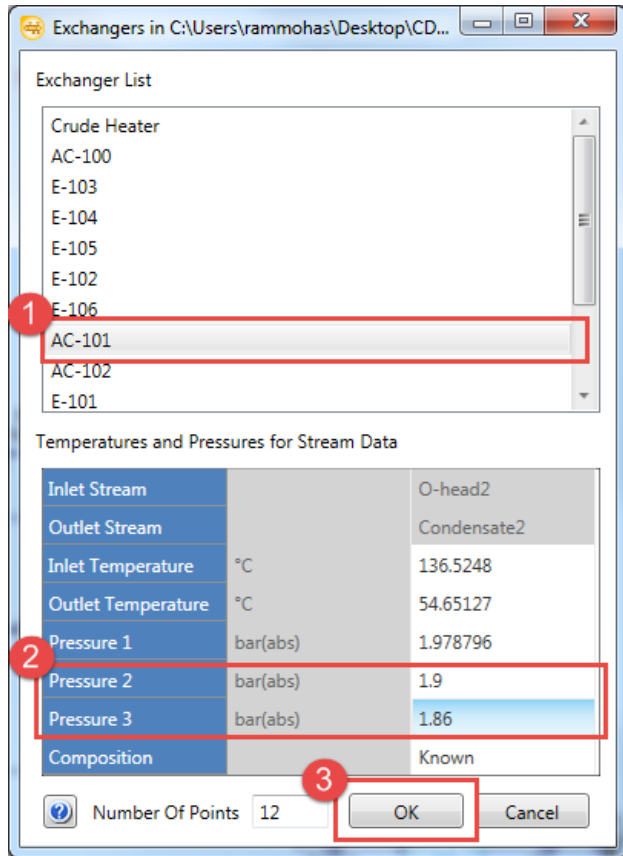
HYSYS File (*.hsc)

5

Open Cancel

Integration with Aspen HYSYS enables transfer of stream data directly from the process model and saves users from manual data transfer.

Import data from HYSYS file

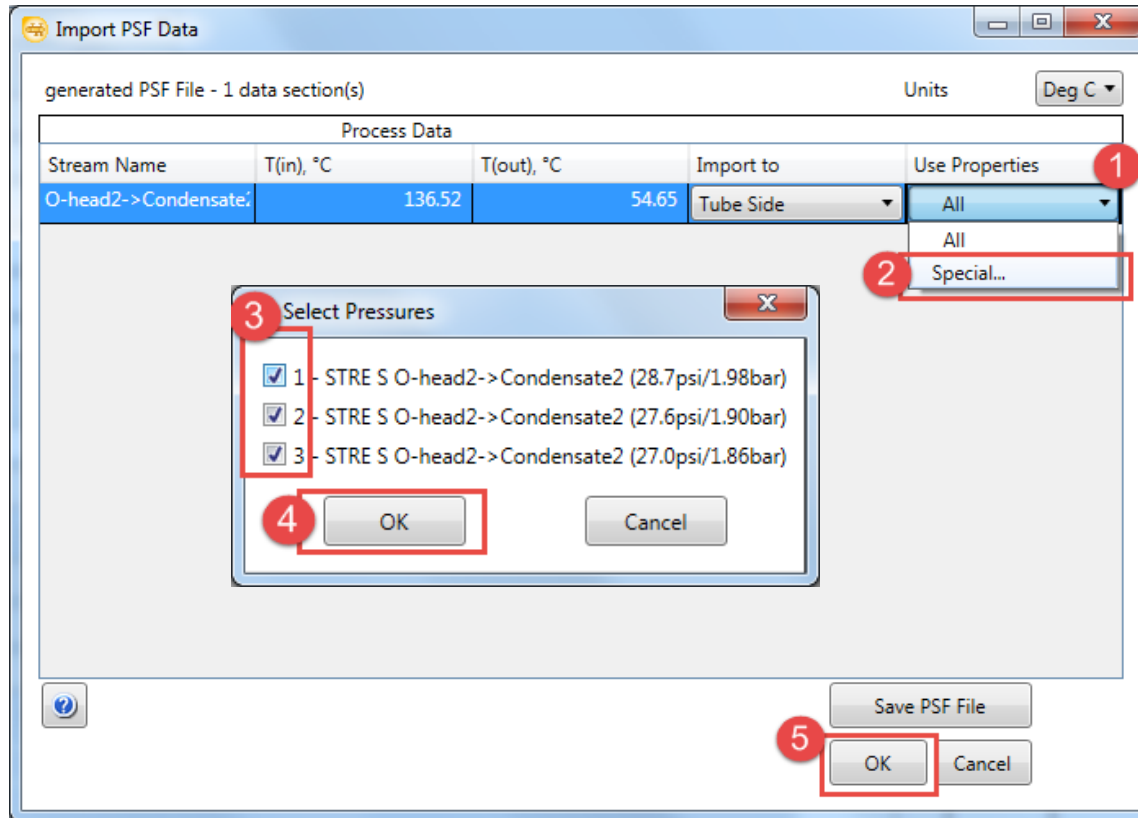


From the list of heat transfer units (exchangers, heaters, coolers) presented, **select the air cooled overhead condenser titled AC-101.**

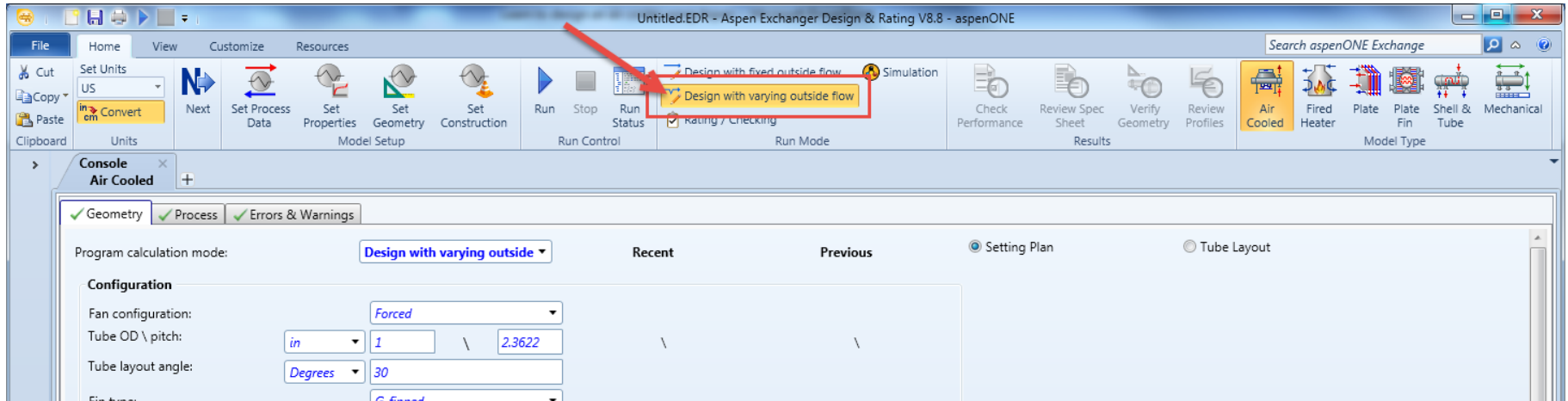
Also **change the intermediate and lower pressure levels** for property and VLE calculations to

- 1.9 bar (Pressure 2)
- 1.86 bar (Pressure 3)

Import data from HYSYS file



Select 'Run Mode'



To get the program calculate the amount of air flow, in addition to the air cooler geometry, select '**Design with varying outside flow**' for the run mode.

Set Process Data

1

2

Specify a pressure drop of 0.1bar and tube side fouling resistance of 0.0001m² K/W.

Tube Side		
	In	Out
Fluid name:	O-head2->Condensate2	
Mass flow rate (total):	kg/s	27.506
Temperature:	°C	136.52 54.65
Vapor mass fraction:		1 0
Operating pressure (absolute):	bar	1.9788
Heat exchanged:	kW	
Estimated pressure drop:	bar	0.1
Allowable pressure drop:	bar	0.1
Fouling resistance:	m ² -K/W	0.0001

Set Process Data

1

2

3

Specify the ambient air temperature as **25°C**. (The aqua colored box shows where an entry is required.)

Set allowable pressure drop to **150 Pa**.

Navigation Pane

Process Data
Air Cooled

✓ Tube Side Stream ✗ Outside Stream ✓ Tube Side Fouling ✓ Outside Fouling

Outside Tube

Fluid name:

Air/Gas mass flow rate: kg/s

Face velocity: m/s

Required bundle pressure drop: Pa

Air/Gas dry bulb design temperatures: °C In Out

Minimum ambient temperature: °C

Operating pressure specification:

Altitude above sea level: m

Inlet pressure (gauge): Pa

Inlet pressure (absolute): bar

Allowable pressure drop: Pa

Fouling resistance: m²-K/W

Inlet humidity parameter:

Humidity ratio:

Relative humidity (%):

Flow fraction of air to this service:

File created 100%

View Property Data

The screenshot displays the Aspen HYSYS interface. On the left, the EDR Navigator shows a tree view with 'Air Cooled' selected, and 'Tube Stream Properties' highlighted with a red box and a '3' callout. The main window shows the 'Tube Stream Properties' dialog for 'Air Cooled', with the 'Property Plots' tab selected (callout '4'). The 'Select Y variable' list has 'Vapor mass fraction' selected (callout '3'). To the right, a plot titled 'Tube stream : Vapor mass fraction vs Temperature' shows three curves for different pressures: 1.9788 bar (blue), 1.9 bar (red), and 1.86 bar (cyan). A text box in the center of the plot reads: 'Review property data imported from HYSYS in tabular form or as plots.'

EDR Navigator

- All
- Air Cooled
 - Console
 - Input
 - Problem Definition
 - Headings/Remarks
 - Application Options
 - Process Data
 - Property Data
 - Tube Stream Compositions
 - Tube Stream Properties
 - Outside Stream Compositions
 - Outside Stream Properties
 - Exchanger Geometry
 - Construction Specifications
 - Program Options
 - Results
 - Input Summary
 - Result Summary
 - Thermal / Hydraulic Summary
 - Mechanical Summary
 - Calculation Details

Tube Stream Properties
Air Cooled

Properties Phase Composition Component Properties Property Plots

Select X variable

- Specific enthalpy
- Temperature

Select Y variable

- Temperature
- Liquid density
- Liquid specific heat
- Liquid viscosity
- Liquid thermal cond.
- Liquid surface tension
- Liquid molecular weight
- Specific enthalpy
- Vapor mass fraction
- Vapor density
- Vapor specific heat
- Vapor viscosity
- Vapor thermal cond.
- Vapor molecular weight
- Liquid 2 mass fraction
- Liquid 2 density
- Liquid 2 specific heat
- Liquid 2 viscosity
- Liquid 2 thermal cond.
- Liquid 2 surface tension
- Liquid 2 molecular weight

Tube stream : Vapor mass fraction vs Temperature

Vapor mass fraction (0)

Temperature (C)

Vapor mass fraction at 1.9788 bar [] Vapor mass fraction at 1.9 bar [] Vapor mass fraction at 1.86 bar []

Review property data imported from HYSYS in tabular form or as plots.

Set The Air Cooler Geometry

The screenshot shows the Aspen Exchanger Design & Rating V8.8 software interface. The ribbon at the top includes 'File', 'Home', 'View', 'Customize', and 'Resources'. The 'Resources' ribbon has a 'Set Geometry' button highlighted with a red box and a red arrow. Below the ribbon, the 'Geometry Summary' dialog box is open for an 'Air Cooled' model. The dialog box has three tabs: 'Geometry', 'Tube Layout', and 'Unit'. The 'Geometry' tab is active, showing the following settings:

Category	Parameter	Value	Unit
Unit	Bays per unit:		
	Bundles per bay:		
	Fans per bay:		
	Fan diameter:		m
	Exchanger frame type:		
	Tube side to outside flow orientation:	Counter-current	
	Fan configuration:	Forced	
Tubes	Tube OD/ID:	25.4	mm
	Tube wall thickness:	1.65	mm
	Tube length:		m
	Fin type:	G-finned	
	Fin tip diameter:	57.15	mm
	Fin frequency:	433	#/m
Mean fin thickness:	0.28	mm	
Tube Layout	Number of tubes per bundle:		
	Tube rows deep:		
	Tube passes:		
	Tube rows per pass:		
	Maximum number tubes per row per pass:		
	Bundle type:	Staggered-even rows to right	
	Transverse pitch:	60	mm
Longitudinal pitch:	51.96	mm	
Tube layout angle:	30	Degrees	
Number of circuits per bundle:			

Here we choose to proceed with the default geometry selections.

These include

- Tube OD
- Fin OD
- Number of fins per meter etc.

Specify Process Limits

The screenshot shows the Aspen Exchanger Design & Rating V8.8 software interface. The main window displays the 'Design Options' dialog for an 'Air Cooled' exchanger. The 'Process Limits' tab is selected, and the 'Outside fluid face velocity' parameter is highlighted with a red box. The 'Minimum' value is set to 3 m/s and the 'Maximum' value is set to 4 m/s. Other parameters include 'Tube side fluid velocity' (m/s), 'Tube side RhoV2' (kg/(m-s²)), 'Fan power maximum' (kW), 'Maximum tube side nozzle pressure loss %' (15), and 'Temperature approach limit' (°C, 1.11).

EDR Navigator

Design Options
Air Cooled

Geometry Limits Process Limits Optimization Options

Process Limits

	Minimum	Maximum
Tube side fluid velocity:		
Outside fluid face velocity:	3	4
Tube side RhoV2:	1000	10000
Fan power maximum:		
Maximum tube side nozzle pressure loss %:		15
Temperature approach limit:	1.11	

Specify the minimum and maximum face velocity (for air) to good practical values.

Specify 'range of search'

1

2

3

4

EDR Navigator

Design Options
Air Cooled

Geometry Limits

Process Limits

Optimization Options

Geometry Limits

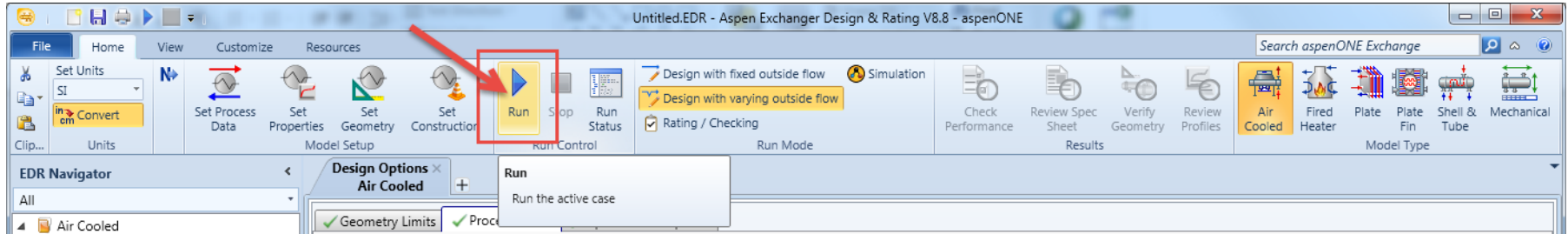
	Increment	Minimum	Maximum
Tube length:	<input type="text" value="0.5"/>	<input type="text" value="2"/>	<input type="text" value="10"/>
Bay width:	<input type="text" value="mm"/>	<input type="text" value="1000"/>	<input type="text" value="6000"/>
Bundle width:	<input type="text" value="mm"/>	<input type="text" value="1000"/>	<input type="text" value="3000"/>
Tube support spacing:	<input type="text" value="mm"/>	<input type="text" value="1828"/>	<input type="text" value="1828"/>
Tube rows deep:	<input type="text" value="3"/>	<input type="text" value="8"/>	<input type="text" value="8"/>
Tube passes per bundle:	<input type="text" value="1"/>	<input type="text" value="16"/>	<input type="text" value="100"/>
Bays per unit:	<input type="text" value="1"/>	<input type="text" value="100"/>	<input type="text" value="100"/>
Bundles per bay:	<input type="text" value="1"/>	<input type="text" value="100"/>	<input type="text" value="100"/>
Fans per bay:	<input type="text" value="1"/>	<input type="text" value="100"/>	<input type="text" value="100"/>
Tube pass options:	<input type="text" value="1,2,3,4, etc."/>	<input type="text" value="1,2,3,4, etc."/>	<input type="text" value="1,2,3,4, etc."/>

Optionally users can specify the range of design search amongst key geometric variables.

File created

100%

Run Sizing Optimization



Run the design optimization to find the best air flow rate and geometric configuration.

When the optimization is running, **it first explores a range of flow rates** evaluating the capital cost and operating cost at each possible flow. This allows the program to define the optimum air flow rate to perform the final design search.

Check Overall Performance

Untitled.EDR - Aspen Exchanger Design & Rating V8.8 - aspenONE

File Home View Customize Resources

Clipboard Units Model Setup Run Control Run Mode Simulation

Design with fixed outside flow
Design with varying outside flow
Rating / Checking

Check Performance Review Spec Sheet Verify Geometry Review Profiles

Air Cooled Fired Heater Plate Fin Shell & Tube Mechanical

Performance Air Cooled

Overall Performance Resistance Distribution Tube Side Composition

Design with varying outside flow				Outside		Tube Side	
Total mass flow rate	kg/s			536.0969		27.506	
Vapor mass	kg/s			536.0969		27.5036	0
Liquid mass	kg/s			0	0	0.0025	27.506
Vapour mass quality				1	1	0.9999	0
Temperature	°C			25	53.51	136.52	54.72
Dew point / Bubble point temperatures	°C					136.53	54.72
Humidity ratio							
Operating pressure	Pa / bar			101326	101326	1.9788	1.93845
Film coefficients	W/(m ² -K)			1062.5		533.8	
Fouling resistance	m ² -K/W			0		0.00011	
Velocity (highest)	m/s			6.24	6.84	12.31	0.08
Pressure drop (allow./calc.)	Pa / Pa			150	148	10000	4034.3
Total heat exchanged	kW		15391.3	Bay per unit	3	Tube OD	25.4 mm
Overall bare coef. (dirty/clean)	W/(m ² -K)	338	351.6	Bundles/bay	2	Tube tks	1.65 mm
Effective MTD	°C		50.15	Tubes/bundle	200	Tube length	10 m
Effective surface (bare tube)	m ²		940.7	Rows deep	5	Fin OD	57.15 mm
Effective surface (total)	m ²		22099.1	Tube passes	1	Fin tks	0.28 mm
Area ratio: actual/required			1.04	Fans/bay	2	Fin frequency	433 #/m

Heat Transfer Resistance

Outside / Fouling / Wall / Fouling / Tube side

Outside Tube side

Run Air Cooled completed

100%

Process and air side conditions

Heat Transfer & Pressure Drop

Geometry of the unit

Verify Air Cooler Geometry

Setting Plan / Tube Layout
Air Cooled

Setting Plan Tube Layout

Inlet & Outlet Nozzles

1000 (Typ)
2420 (Typ)
4695 (Typ)
4970

418
325
Tube length 10000
Bundle slope = 0 deg

8216
6745
2100
3386
9700
7945

4820 (Typ)
14760
3658 fan dia (Typ)

Location:		Aspen AirCooled
Service of Unit:	Our Reference:	
Item No.:	Your Reference:	
Date:	Rev No.: Job No.:	

Right-click anywhere in the setting plan for a menu of options including

- Print
- Copy
- Options on display of information.

Left-click and drag will zoom in to the dragged portion of the graphic.

Verify Air Cooler Geometry

The screenshot displays the Aspen Exchanger Design & Rating V8.8 software interface. The title bar reads "Untitled.EDR - Aspen Exchanger Design & Rating V8.8 - aspenONE". The ribbon menu includes "File", "Home", "View", "Customize", and "Resources". The "Home" tab is active, showing options like "Set Units", "Clipboard", "Convert", "Next", "Set Process Data", "Set Properties", "Set Geometry", "Set Construction", "Run", "Stop", "Run Status", "Design with fixed outside flow", "Design with varying outside flow", "Rating / Checking", "Simulation", "Check Performance", "Review Spec Sheet", "Verify Geometry", "Review Profiles", "Air Cooled", "Fired Heater", "Plate Fin", "Plate Tube", and "Shell & Tube". A red box highlights the "Verify Geometry" icon, with a red circle containing the number "1" next to it. Below the ribbon, the "Setting Plan / Tube Layout" tab is selected, with a red box around the "Tube Layout" sub-tab and a red circle containing the number "2" next to it. The main workspace shows a diagram of a tube bundle with 10 rows of tubes. The bundle width is 2430.0 mm and the height is 259.8 mm. Two upward-pointing arrows are labeled "X-Flow Direction". A text box in the upper right of the workspace says "View the tube arrangement". The status bar at the bottom left indicates "Run Air Cooled completed" and the bottom right shows a zoom level of 100%.

Review other designs considered during sizing run

Optimization Path

Current selected case: 136

	Per Bundle				Per Unit				Pressure Drop				Total			X-side		
	Tube No.	Rows	Tube Length	Pass	Bundle P	Bays P	Area Actual	Area Required	Area ratio	Outside Pa	Dp ratio Outside	Tube bar	Dp ratio Tube side	Price Dollar(US)	Power kW	Operating cost Dollar(US)	Outlet temperature °C	Face velocity m/s
1	175	5	10	1	2	1	6445.6	13532.4	0.48 *	182	1.21 *	0.36627	3.66 *	111848	46.346	22246	114.22	3.44
2	195	5	10	1	2	1	7182.2	15079	0.48 *	153	1.02 *	0.29717	2.97 *	124556	38.935	18689	114.22	3.09
3	200	5	10	1	2	1	7366.4	15465.6	0.48 *	146	0.98	0.28342	2.83 *	127418	37.323	17915	114.22	3.02
4	258	6	10	1	2	1	9502.6	19950.6	0.48 *	157	1.04 *	0.17296	1.73 *	148622	39.958	19180	114.22	2.81
5	264	6	10	1	2	1	9723.6	20414.6	0.48 *	151	1 *	0.16617	1.66 *	151787	38.447	18454	114.22	2.75
6	270	6	10	1	2	1	9944.6	20878.6	0.48 *	145	0.97	0.15983	1.6 *	154864	37.03	17774	114.22	2.69
7	329	7	10	1	2	1	12117.7	25440.9	0.48 *	158	1.06 *	0.12053	1.21 *	174974	40.383	19384	114.22	2.57
8	168	7	10	1	2	2	12375.5	25982.2	0.48 *	153	1.02 *	0.10288	1.03 *	181522	39.009	18724	114.22	2.49
9	175	7	10	1	2	2	12891.2	27064.8	0.48 *	146	0.97	0.09589	0.96	191104	37.121	17818	114.22	2.4
10	216	8	10	1	2	2	15911.4	33405.7	0.48 *	147	0.98	0.06637	0.66	220779	37.411	17957	114.22	2.22
11	304	8	10	1	2	3	33590.7	70523.2	0.48 *	43	0.28	0.02932	0.29	456185	10.846	5206	114.22	1.06
12	320	8	10	3	2	6	70717.2	76138.4	0.93 *	12	0.08	0.08883	0.89	950721	3.003	1441	114.22	0.5
13	352	8	10	3	2	6	77788.9	80442	0.97 *	10	0.07	0.07864	0.79	1038478	2.53	1214	114.22	0.46

Area ratio flagged with asterisks suggests designs constrained by heat transfer capability (Such as the tendency for the air outlet temperature to approach the required process stream outlet temperature)

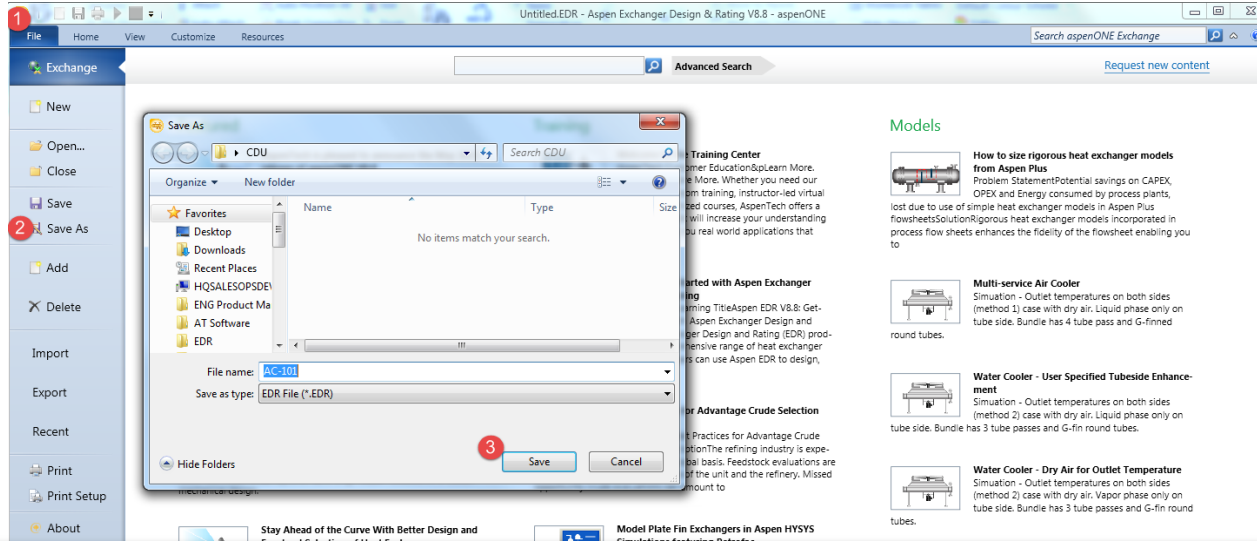
Review Spec Sheet

The screenshot shows the AspenONE software interface. The 'Review Spec Sheet' button in the top toolbar is highlighted with a red arrow. The main window displays an 'Air-Cooled Heat Exchanger Specification Sheet' with the following data:

Air-Cooled Heat Exchanger Specification Sheet											
1	Company:										
2	Location:										
3	Service of Unit:	Our Reference:									
4	Item No.:	Your Reference:									
5	Date:	Rev No.:	Job No.:								
6	Size & Type	10.7858	/	15.48	m	Type	Forced	Number of Bays	3		
7	Surf/Unit-Finned Tube	22099.1	m ²	Bare area/bundle	156.8	m ²	Area ratio	23.49			
8	Heat exchanged	15391.3	kW	MTD, Eff	50.15	°C					
9	Transfer Rate-Finned	14.4	Bare, Service	326.3	Clean	351.6	W/(m ² -K)				
10	PERFORMANCE DATA - TUBE SIDE										
11	Fluid Circulated	O-headz->Condensate2			In	/				Out	
12	Total Fluid Entering	kg/s	27.506	Density, Liq	kg/m ³	691.44	/	710.5			
13				Density, Vap	kg/m ³	4.86	/				
14	Temperature	°C	136.52	/	54.72	Specific Heat, Liq	kJ/(kg-K)	2.366	/	2.187	
15	Liquid	kg/s	0.0025	/	27.506	Specific Heat, Vap	kJ/(kg-K)	1.987	/		
16	Vapor	kg/s	27.5036	/	0	Therm. Cond. Liq	W/(m-K)	0.09986	/	0.1285	
17	Noncondensable	kg/s	0	/	0	Therm. Cond. Vap	W/(m-K)	0.0217	/		
18	Steam	kg/s	/	Freeze Point		°C					
19	Water	/	/	Bubble / Dew point		°C	54.72	/	136.53		
20	Molecular wt, Vap	89.06843	/	89.06843	Latent heat	kJ/kg					
21	Molecular wt, NC			Inlet pressure (abs)		bar	1.9788				
22	Viscosity, Liq	mPa-s	0.2428	/	0.5069	Pres Drop, Allow/Calc	bar	0.1	/	0.04034	
23	Viscosity, Vap	mPa-s	0.009	/		Fouling resistance	m ² -K/W	0.0001			
24	PERFORMANCE DATA - AIR SIDE										
25	Air Quantity, Total	536.0969	kg/s	Altitude	0					m	
26	Air Quantity/Fan	72.447	m ³ /s	Temperature In	25					°C	
27	Static Pressure	0.001	bar	Temperature Out	53.51					°C	
28	Face Velocity	3.16	m/s	Mass velocity	3.74	kg/s/m ²	Design Ambient	0			°C
29	DESIGN-MATERIALS-CONSTRUCTION										
30	Design pressure	3	bar	Test Pressure	bar	Design temperature	290				°C
31	TUBE BUNDLE			Header			Tube				
32	Size	m	10.7858	Type	Box	Material	Carbon Steel				
33	Number/bay	2	Material		Carbon Steel	Specifications					
34	Tube Rows	5	Passes	1	OD 25.4 Min Thk 1.65 mm						
35	Arrangement	Plug Mat.		No./Bun	200	Lng	10	m			
36	Bundles	2	par	Gasket Mat.	Pitch 60 / 51.96		30	Degrees			
37	Bays	3	par	Corr. Allow.			FIN				
38	Bundle frame	Inlet nozzle (1) 288.9 mm		Type	G-finned						
39	MISCELLANEOUS			Outlet nozzle (1) 66.65 mm	Material	Aluminum 1060					
40	Struct. Mount.	Special nozzles		OD	57.15	Thx	0.28	mm			
41	Surf Prep	Rating		No	433	#/m	Design Temp	°C			
42	Louvers	TI	PI	Code							

Review air cooler specification sheet

Save the EDR file



At this point the process engineer has a preliminary design of the overhead condenser. This is useful for initial cost estimation and to simulate how a real condenser would perform within the process.

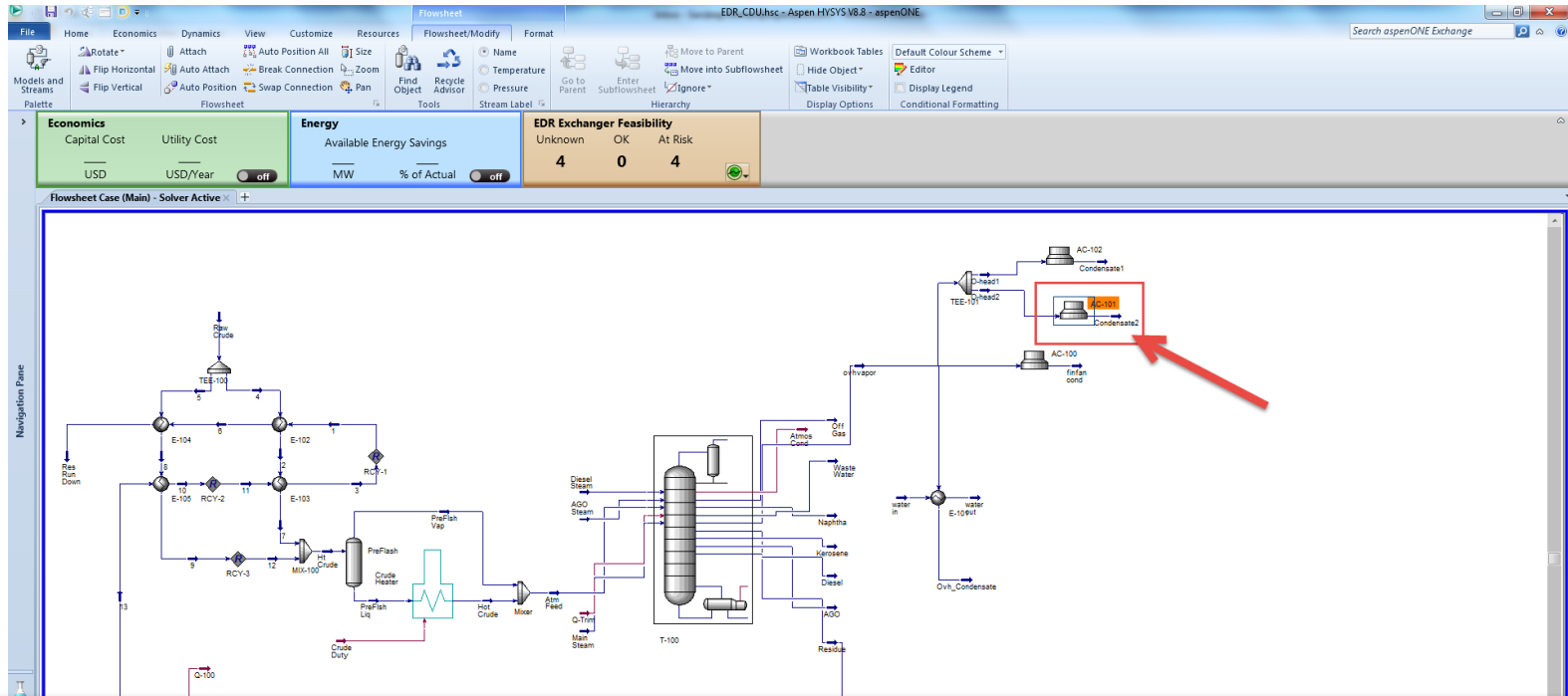
Often the final design will be done by a specialist manufacturer of air-cooled heat exchangers.

Import air cooler model to HYSYS process flowsheet

The screenshot displays the HYSYS software interface. The top menu bar includes File, Home, View, Customize, and Resources. The ribbon contains several tabs: Units, Model Setup, Run Control, and Run Mode. In the Run Mode tab, the 'Rating / Checking' option is selected and highlighted with a red box and a red circle containing the number 1. Below the ribbon, the 'Console' window shows the 'Air Cooled' model. The 'Program calculation mode' is set to 'Design with varying outside'. A 'Change Mode' dialog box is open, asking 'Use current design geometry in Rating / Checking mode?'. The 'Use Current' button is highlighted with a red box and a red circle containing the number 2. A red arrow points to the 'Convert' button in the Units section of the ribbon, with a red circle containing the number 3.

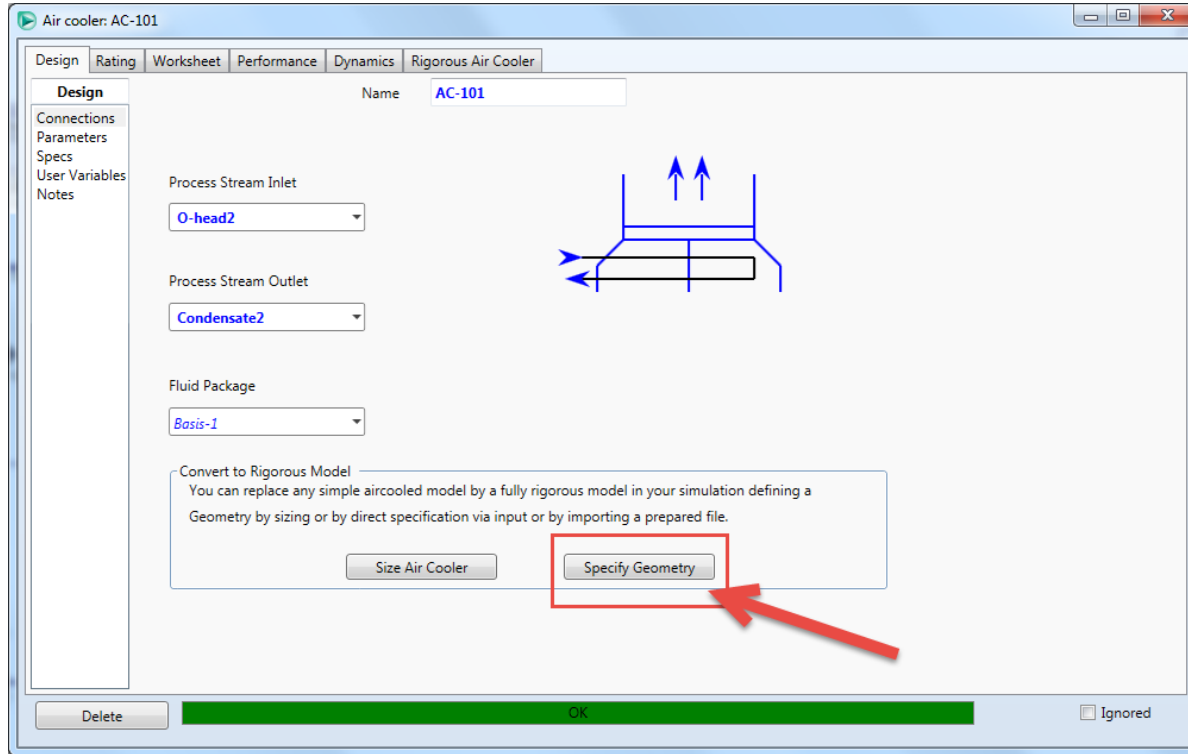
To simulate how this air cooler might perform in the HYSYS process flow sheet, prepare a **rating/checking** case.

Import air cooler model to HYSYS process flowsheet

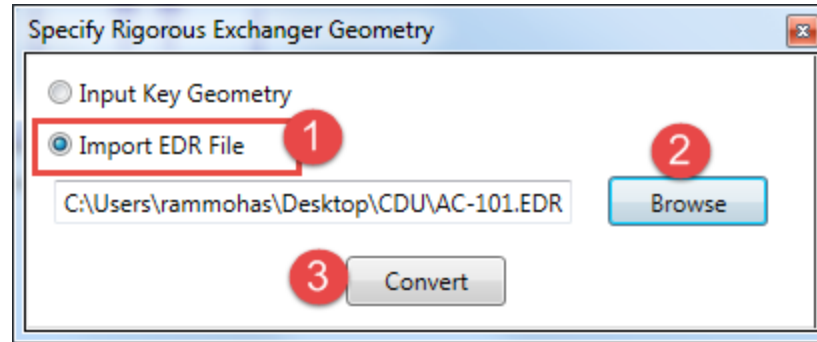


Open the Aspen HYSYS model of the crude distillation unit titled 'EDR_CDU .hsc' and click open the condenser unit 'AC-101'.

Import air cooler model to HYSYS process flowsheet



Import air cooler model to HYSYS process flowsheet



The process engineer has now incorporated the rigorous heat exchanger model to his process flowsheet and has thus enhanced the fidelity of his crude distillation process model.

Additional Resources

- AspenTech support website (<http://support.aspentech.com>)
- AspenTech courseware available in classroom and on-line versions
- AspenTech business consultants.