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

aspentech

Objective

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

Additionally you would learn how to

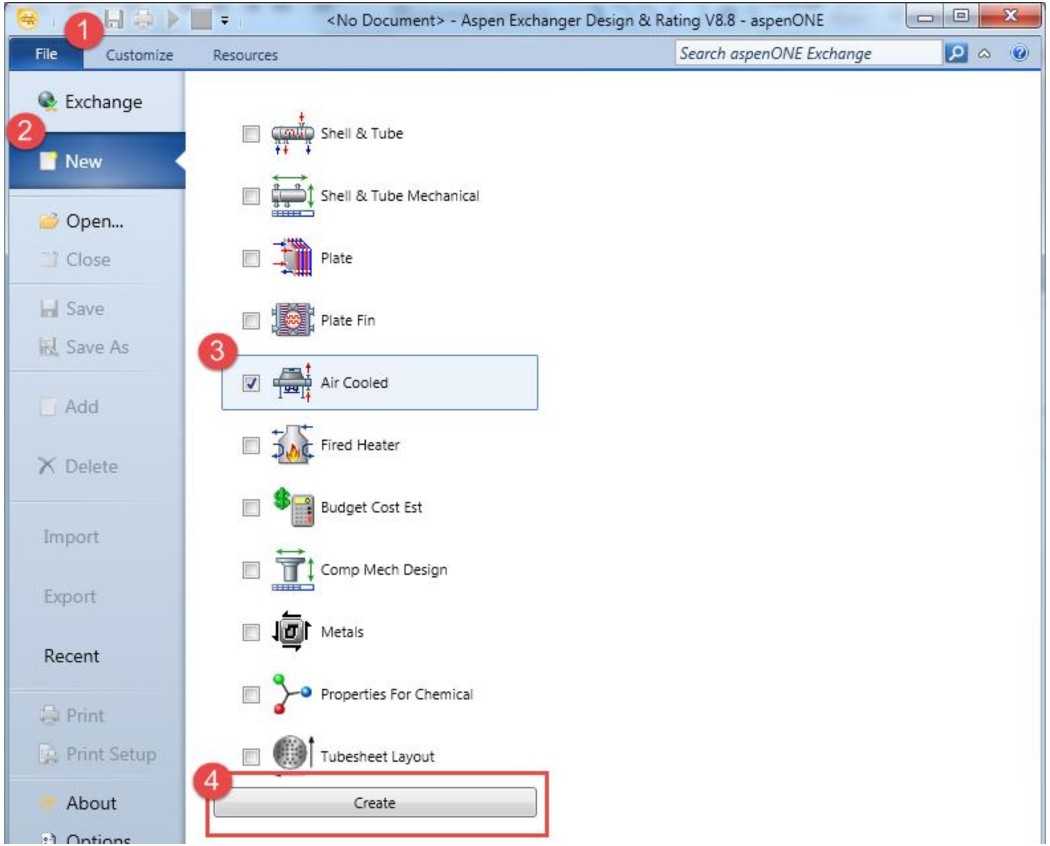
- Import necessary data from an Aspen HYSYS model
- Find the optimal air flow for the air cooler
- Export the final air cooler model to Aspen HYSYS

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.

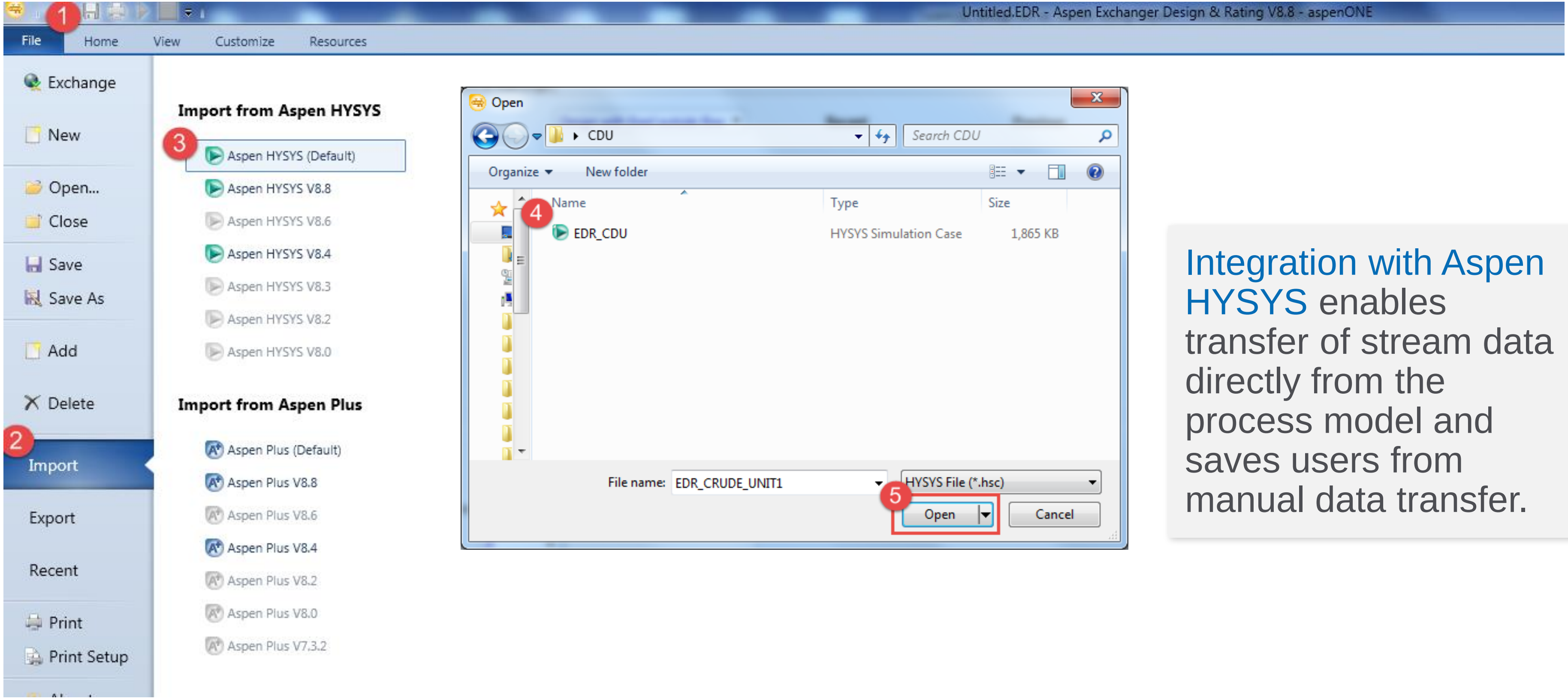
Open Aspen EDR



Open a new case in

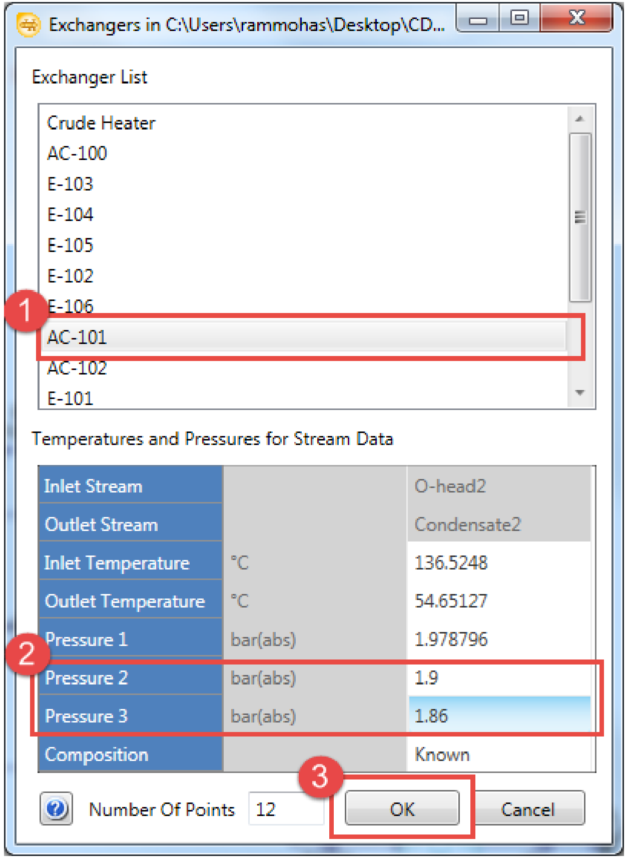
Aspen Air Cooled Exchanger

Import data from HYSYS file



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

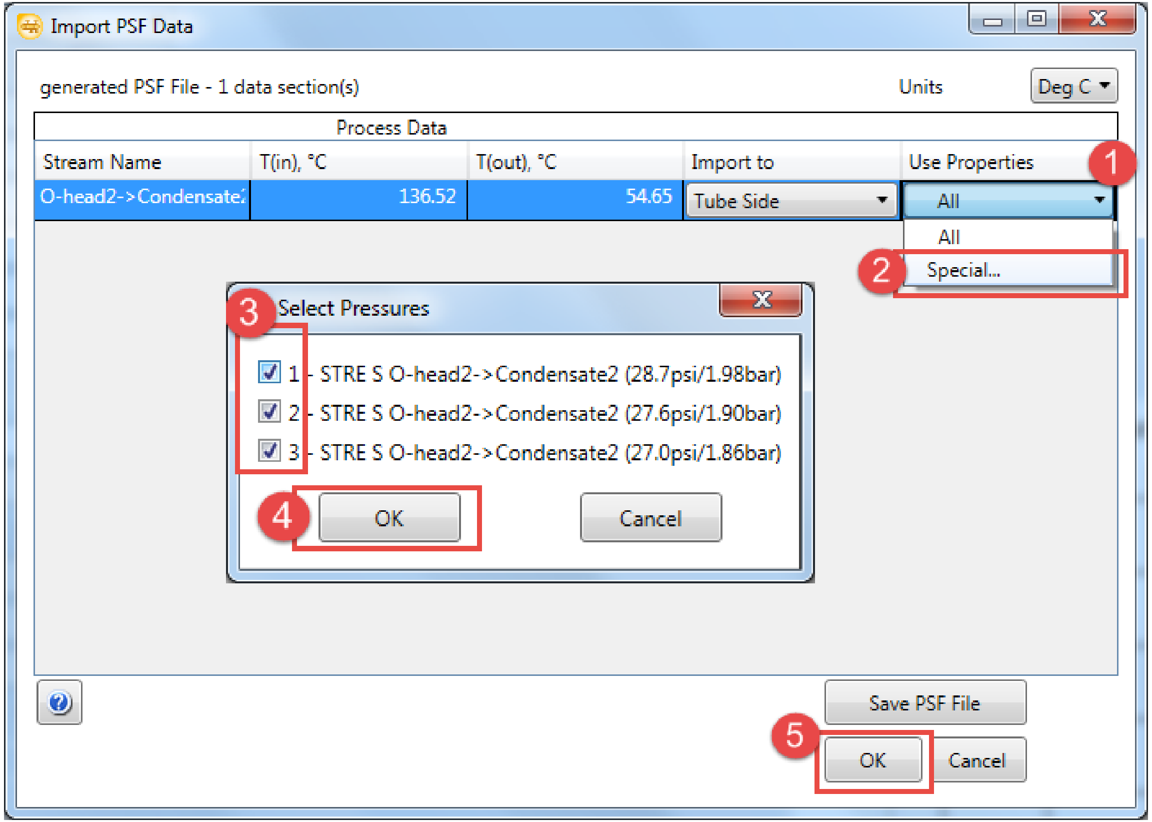


From the list of heat transfer units (exchangers, heaters, coolers) presented, select the air cooled overhead condenser titled AC-101.

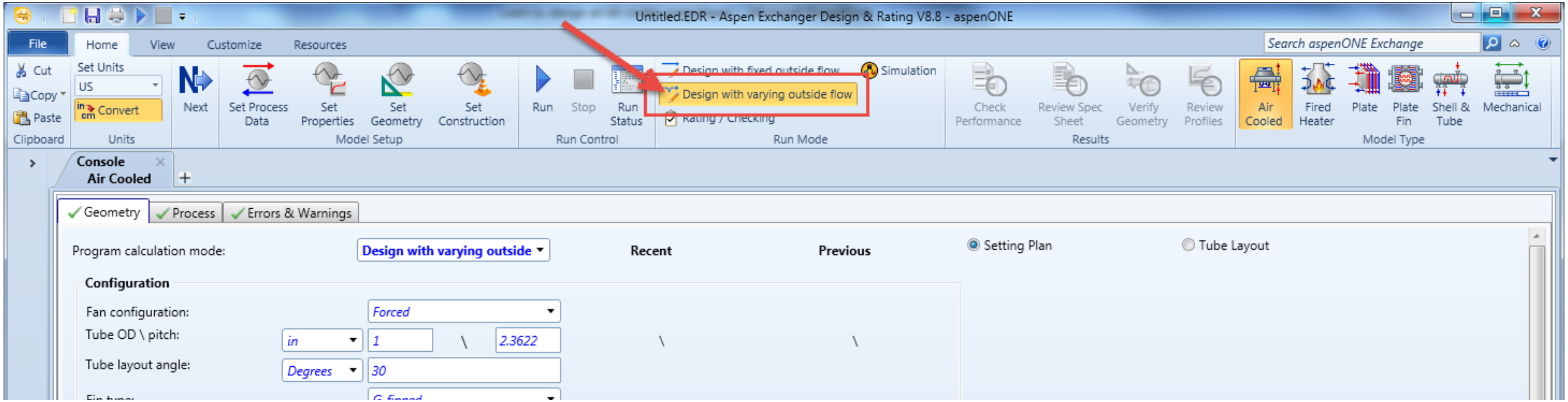
Also change the intermediate and lower pressure levels for property and VLE calculations to

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

Import data from HYSYS file

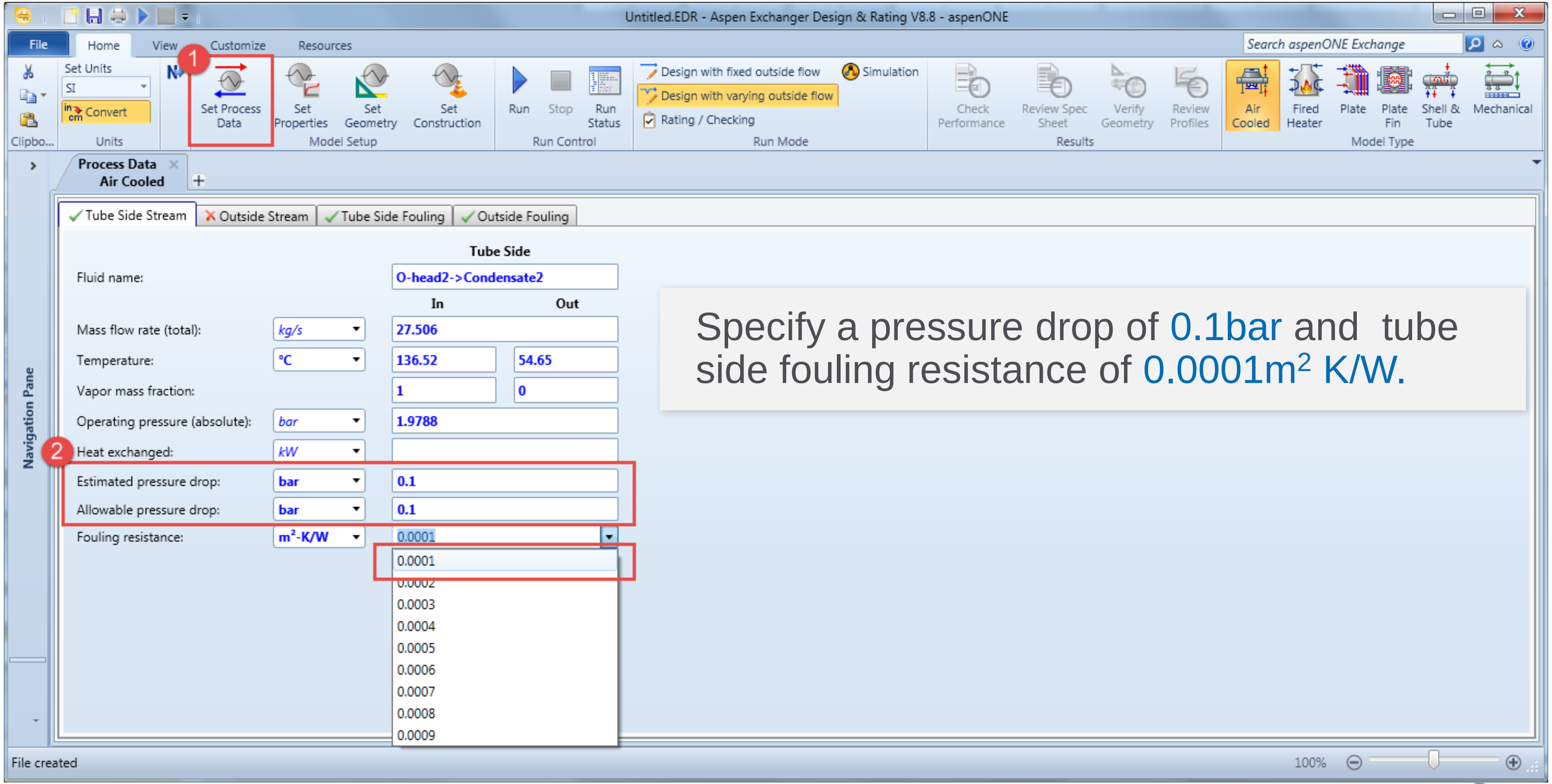


Select ‘Run Mode’



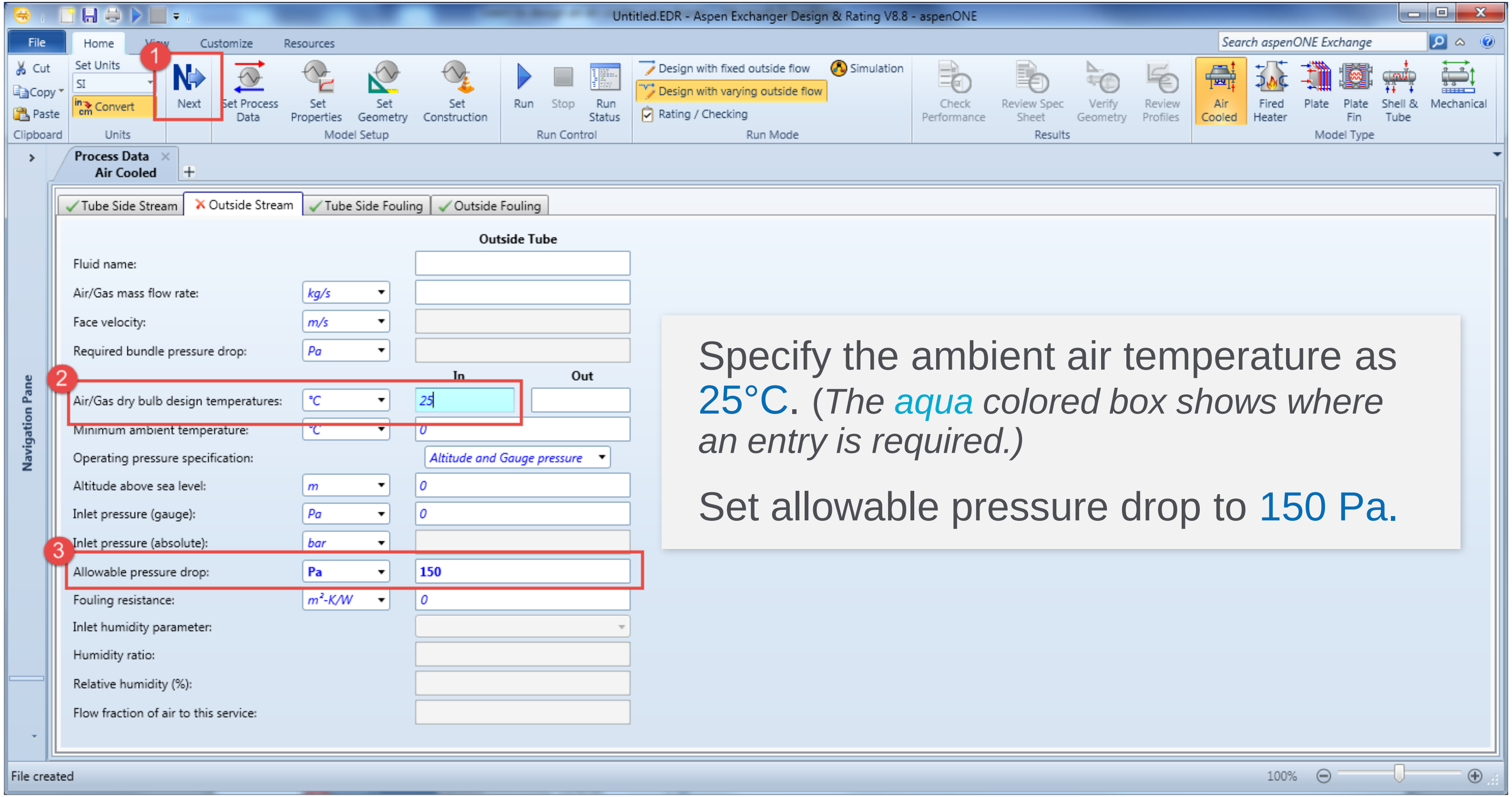
To get the program calculate the amount of air flow, in addition to the air cooler geometry, select ‘Design with varying outside flow’ for the run mode.

Set Process Data



Specify a pressure drop of 0.1bar and tube side fouling resistance of 0.0001m^2 K/W.

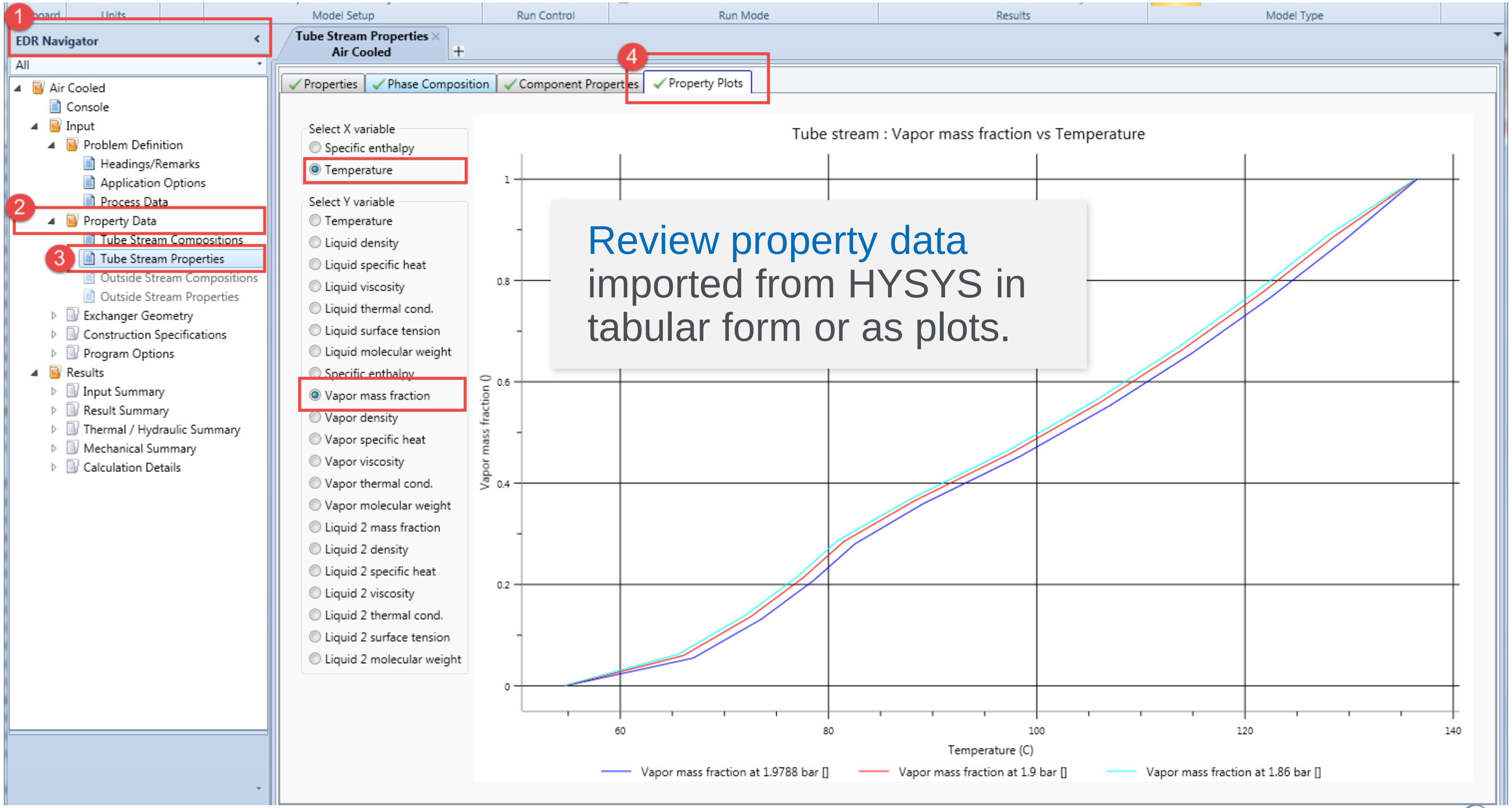
Set Process Data



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

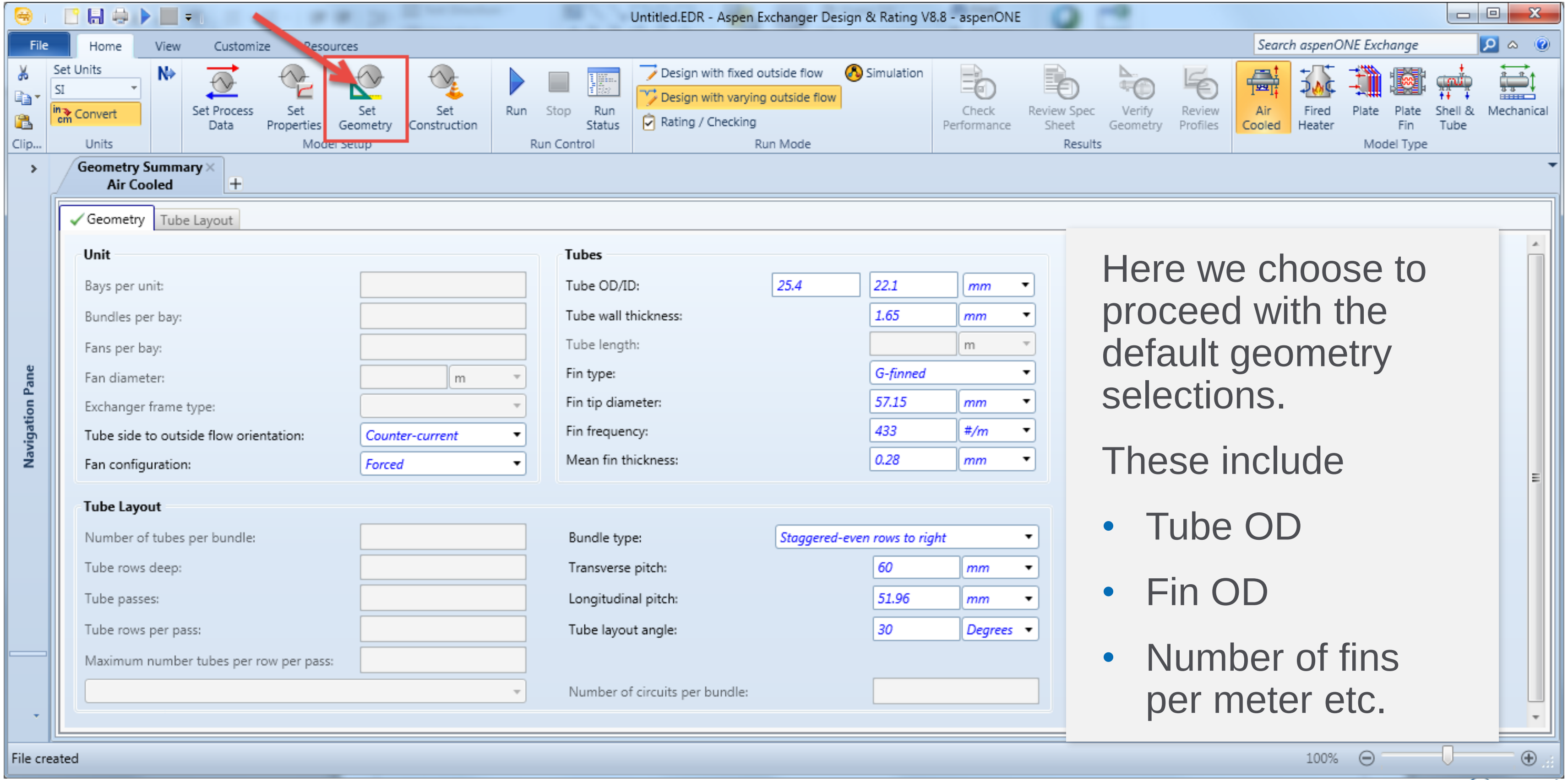
Set allowable pressure drop to 150 Pa.

View Property Data



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

Set The Air Cooler Geometry

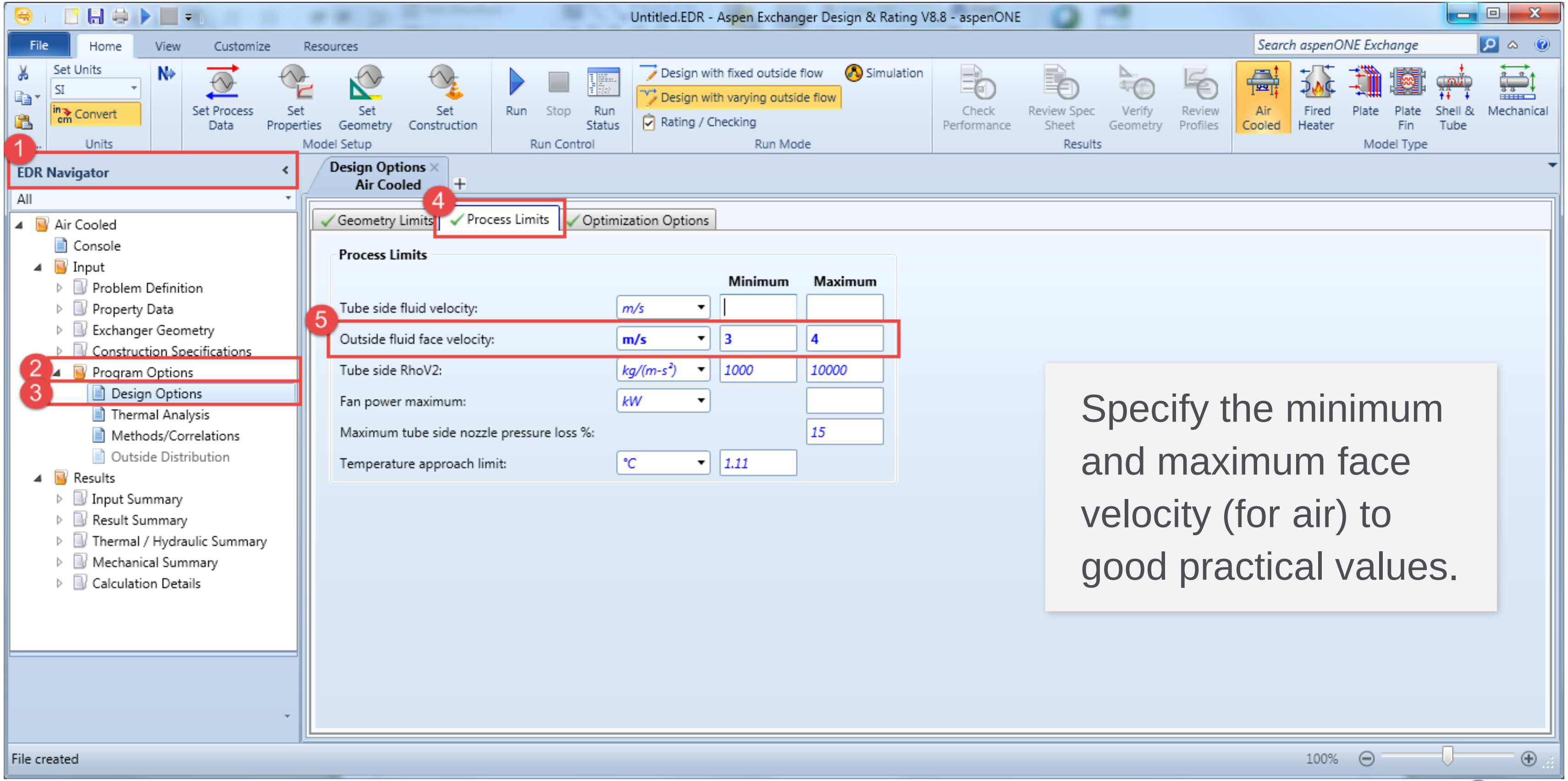


Here we choose to proceed with the default geometry selections.

These include

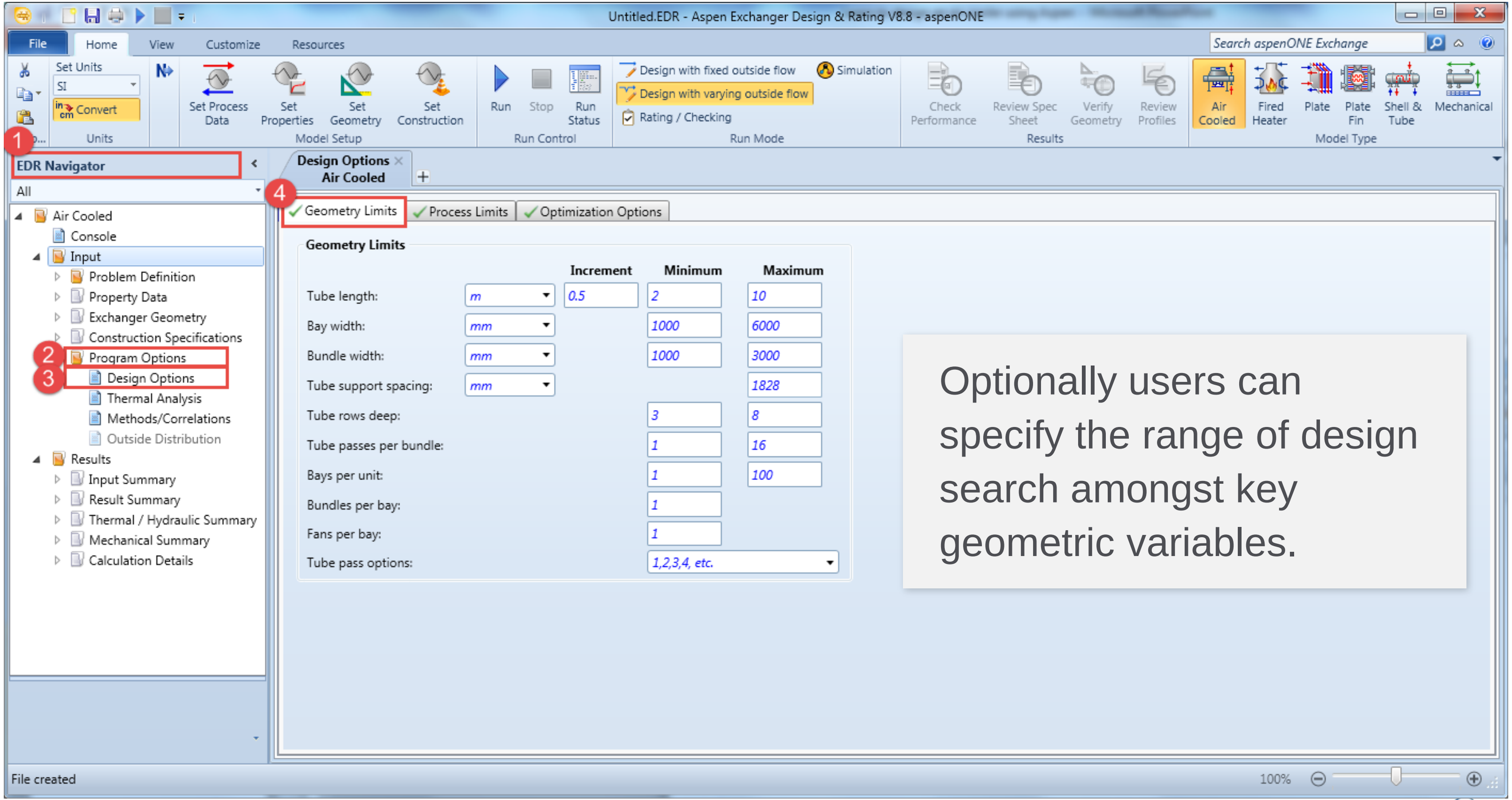
- Tube OD
- Fin OD
- Number of fins per meter etc.

Specify Process Limits



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

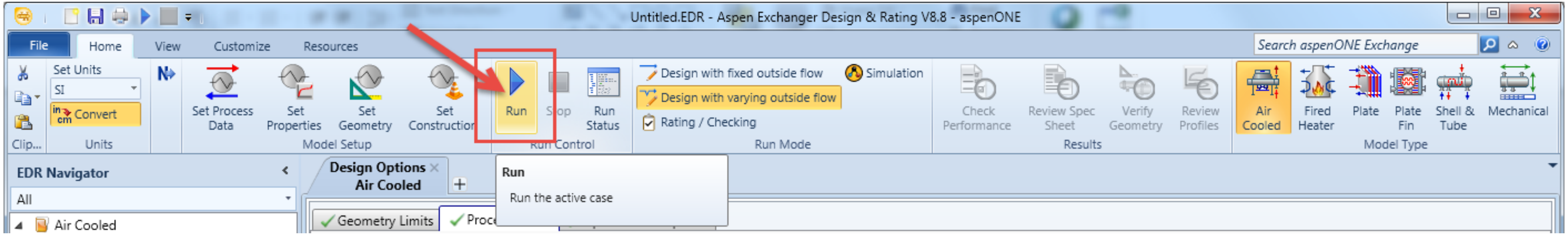
Specify 'range of search'



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

aspentech

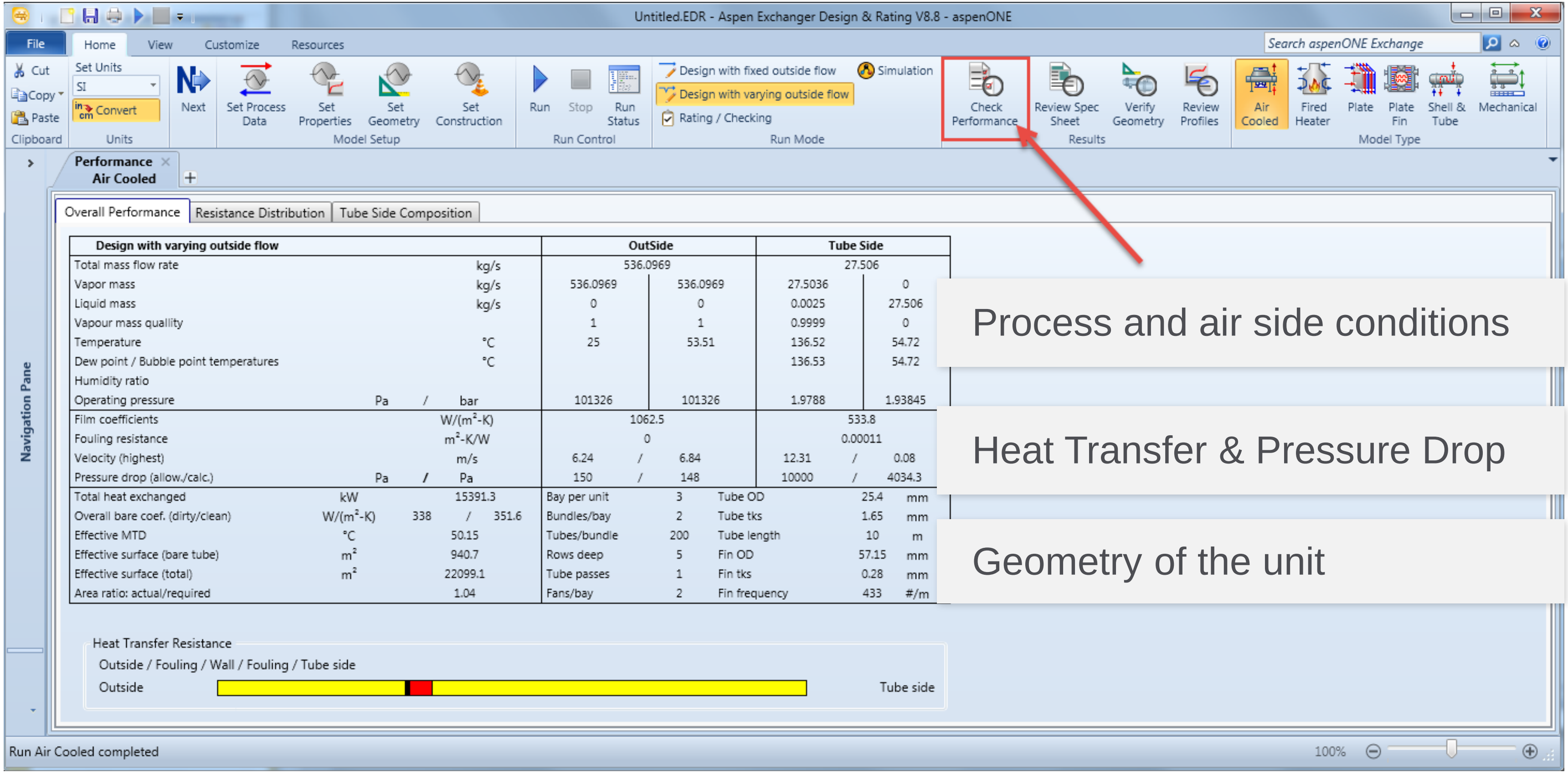
Run Sizing Optimization



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



Design with varying outside flow		OutSide		Tube Side	
Total mass flow rate	kg/s	536.0969		27.506	
Vapor mass	kg/s	536.0969	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	$W/(m^2\text{-}K)$	1062.5		533.8	
Fouling resistance	$m^2\text{-}K/W$	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

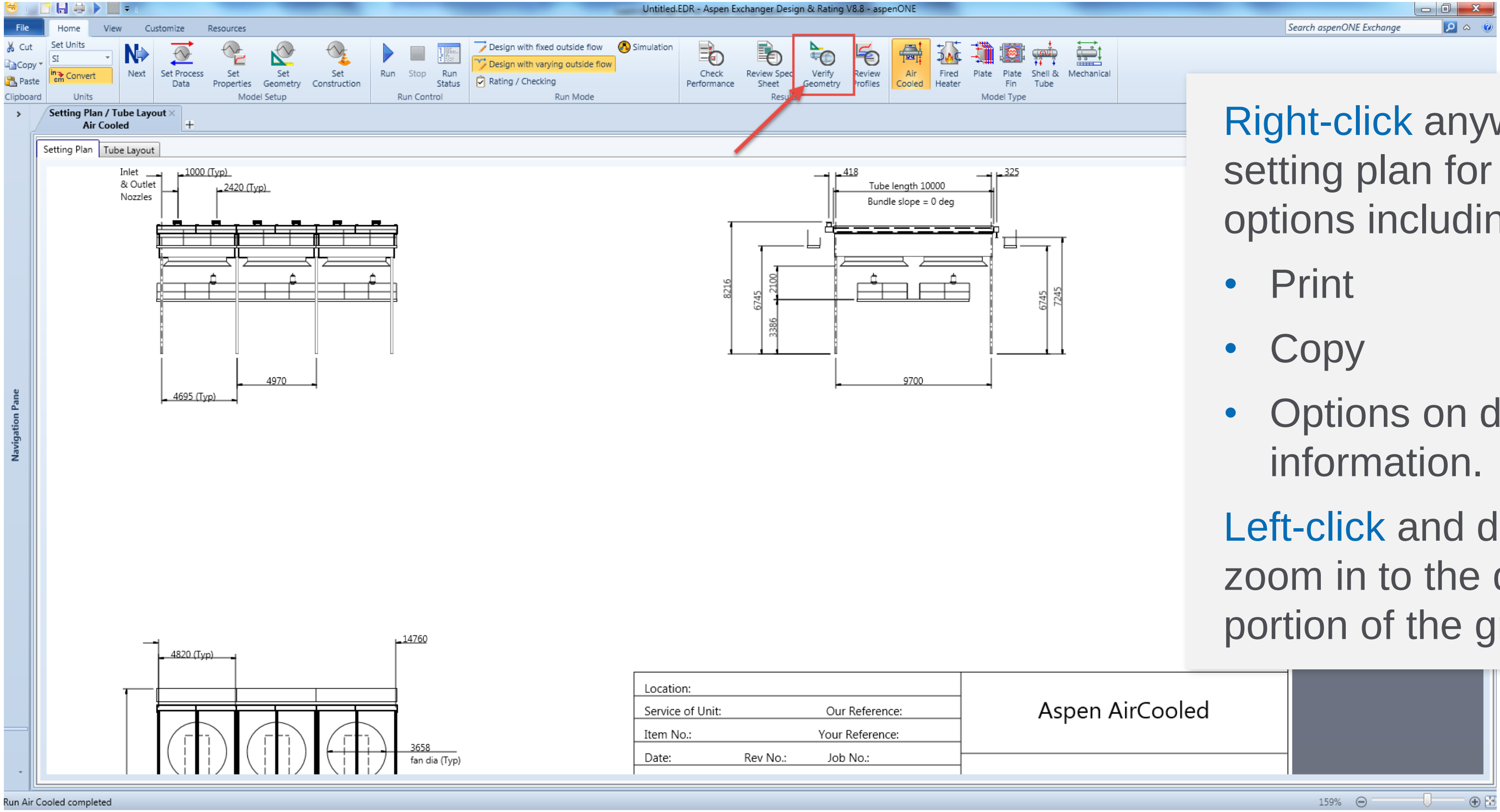
Total heat exchanged	kW	15391.3	Bay per unit	3	Tube OD	25.4	mm
Overall bare coef. (dirty/clean)	$W/(m^2\text{-}K)$	338 / 351.6	Bundles/bay	2	Tube tks	1.65	mm
Effective MTD	°C	50.15	Tubes/bundle	200	Tube length	10	m
Effective surface (bare tube)	m^2	940.7	Rows deep	5	Fin OD	57.15	mm
Effective surface (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

Process and air side conditions

Heat Transfer & Pressure Drop

Geometry of the unit

Verify Air Cooler Geometry



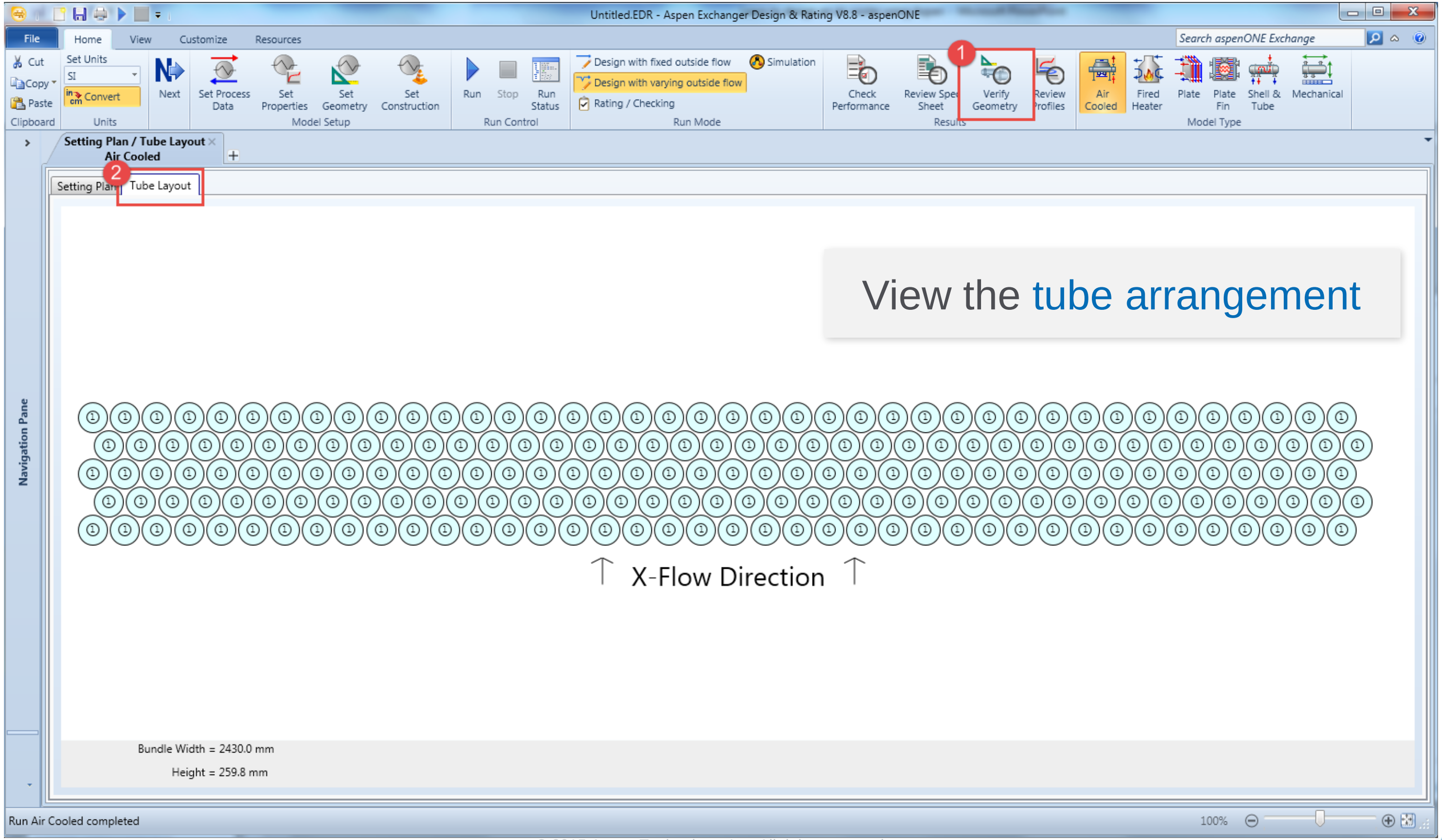
Right-click anywhere in the setting plan for a menu of options including

- Print
- Copy
- Options on display of information.

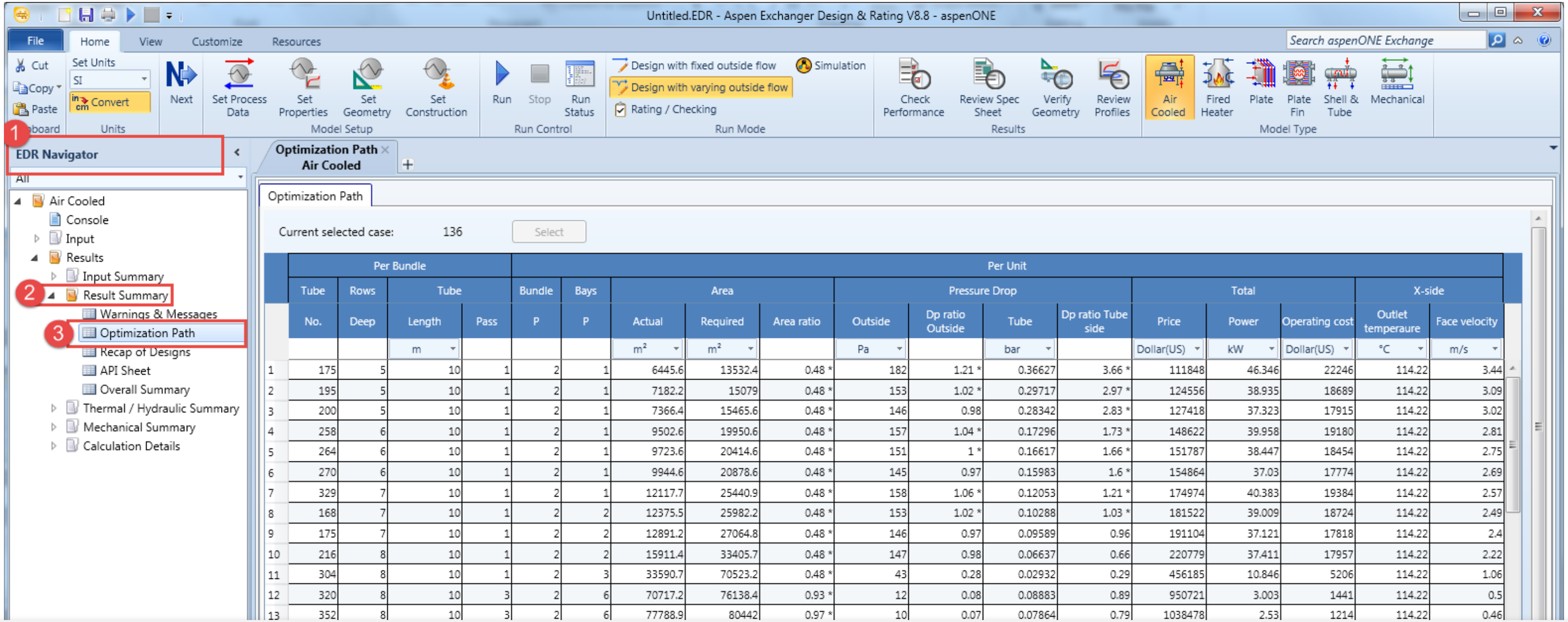
Left-click and drag will zoom in to the dragged portion of the graphic.

aspentech

Verify Air Cooler Geometry



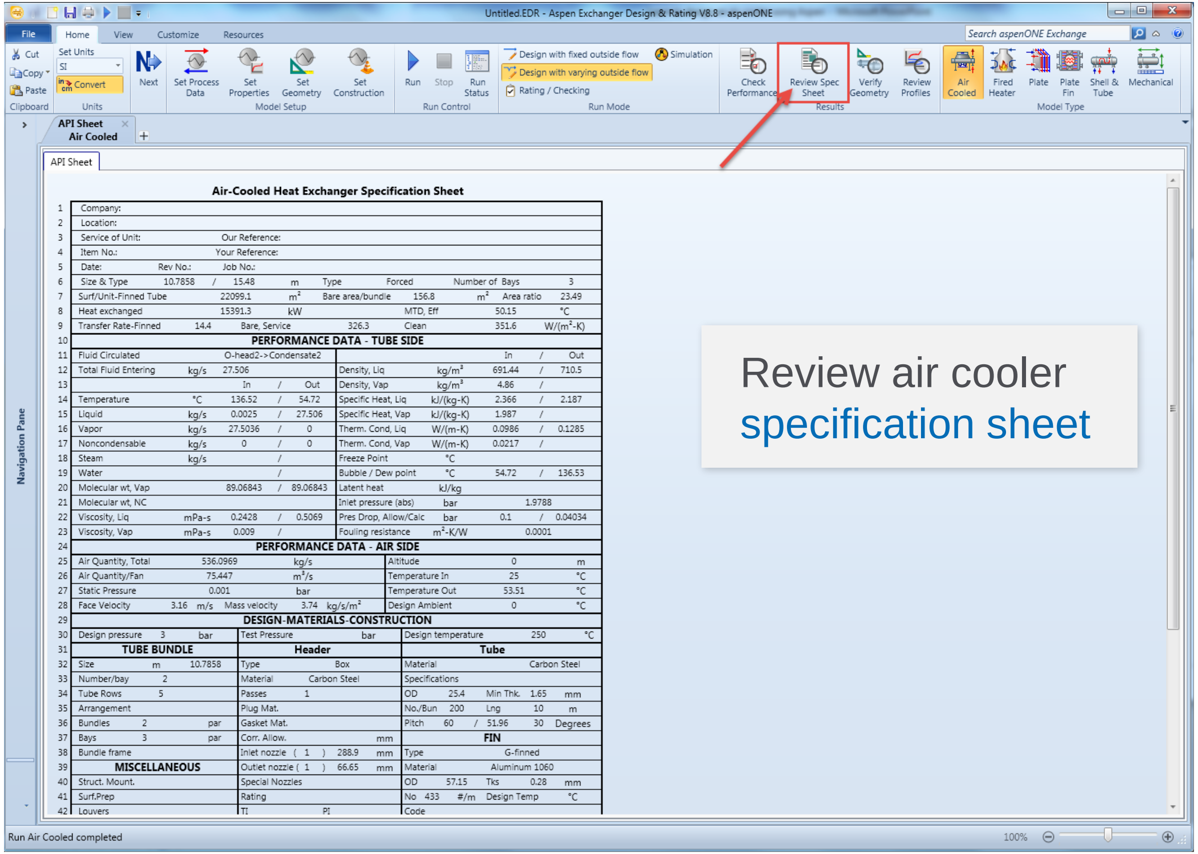
Review other designs considered during sizing run



	Per Bundle				Per Unit													
	Tube	Rows	Tube		Bundle	Bays	Area			Pressure Drop				Total			X-side	
	No.	Deep	Length	Pass	P	P	Actual	Required	Area ratio	Outside	Dp ratio Outside	Tube	Dp ratio Tube side	Price	Power	Operating cost	Outlet temperaure	Face velocity
			m				m²	m²		Pa		bar		Dollar(US)	kW	Dollar(US)	°C	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

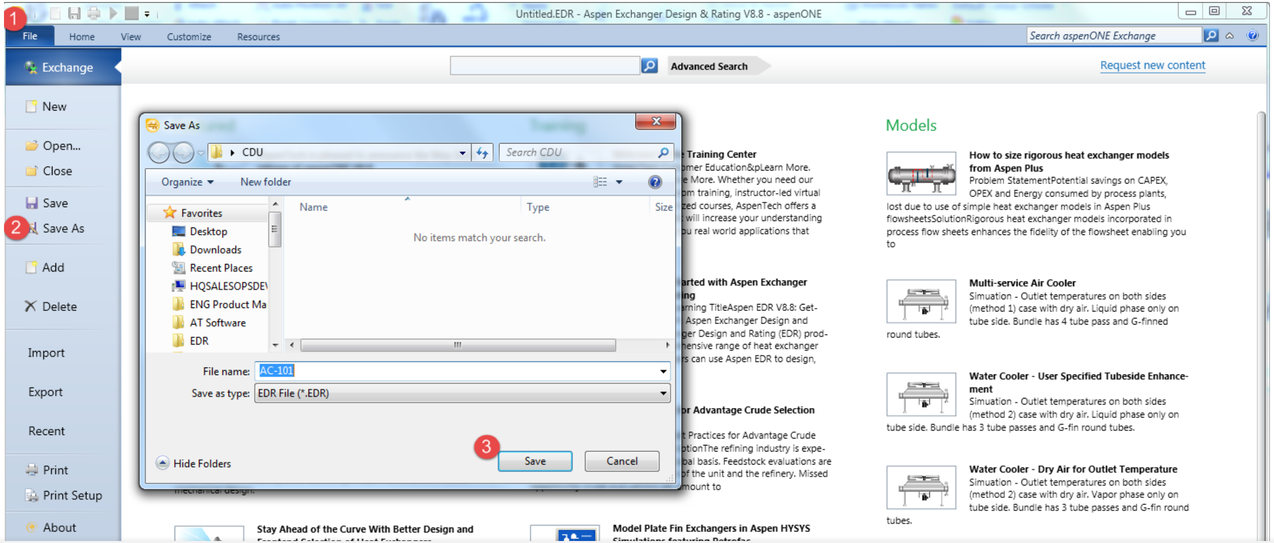


Air-Cooled Heat Exchanger Specification Sheet

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-head2->Condensate2	In / Out	
12	Total Fluid Entering kg/s 27.506	Density, Liq kg/m^3 691.44 / 710.5	
13	In / Out	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) 0.0986 / 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 75.447 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 250 °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. mm	**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 Tks 0.28 mm
41	Surf.Prep	Rating	No 433 #/m Design Temp °C
42	Louvers	TI PI	Code

Review air cooler specification sheet

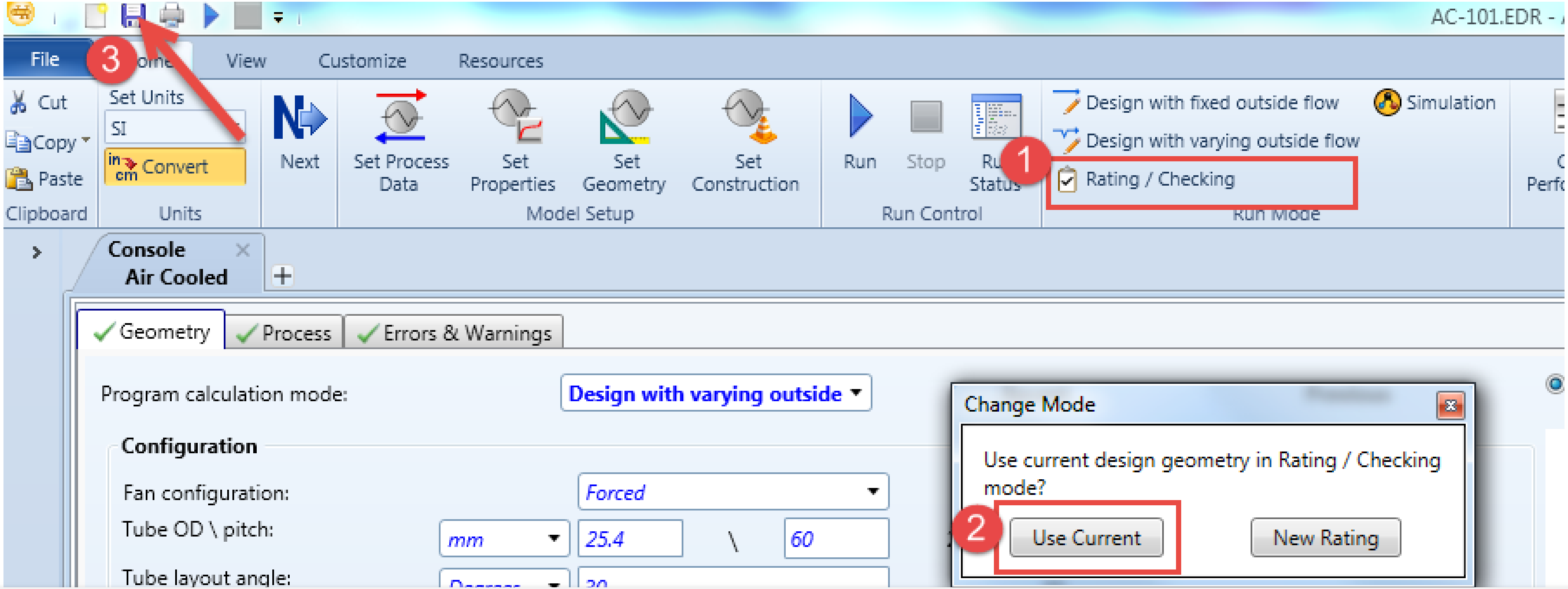
Save the EDR file



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.

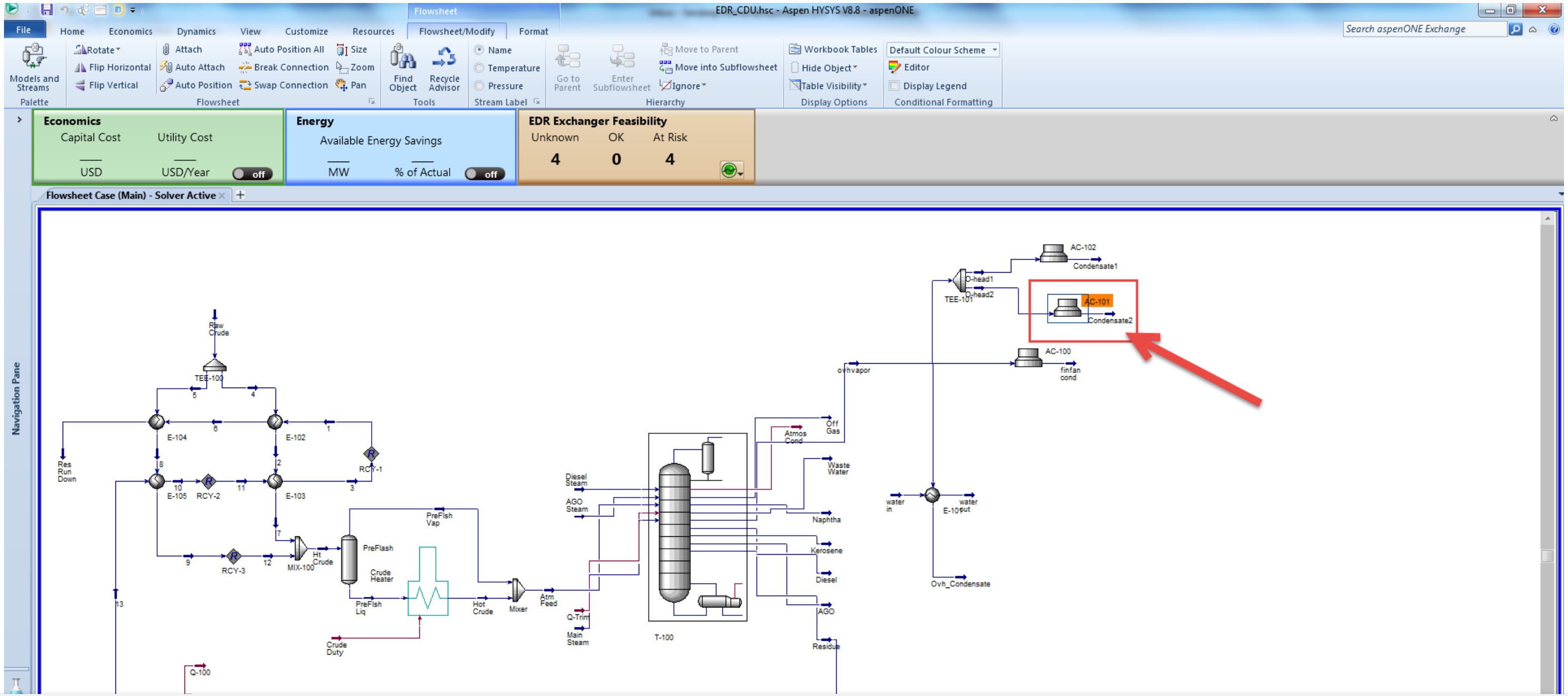
Import air cooler model to HYSYS process flowsheet



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

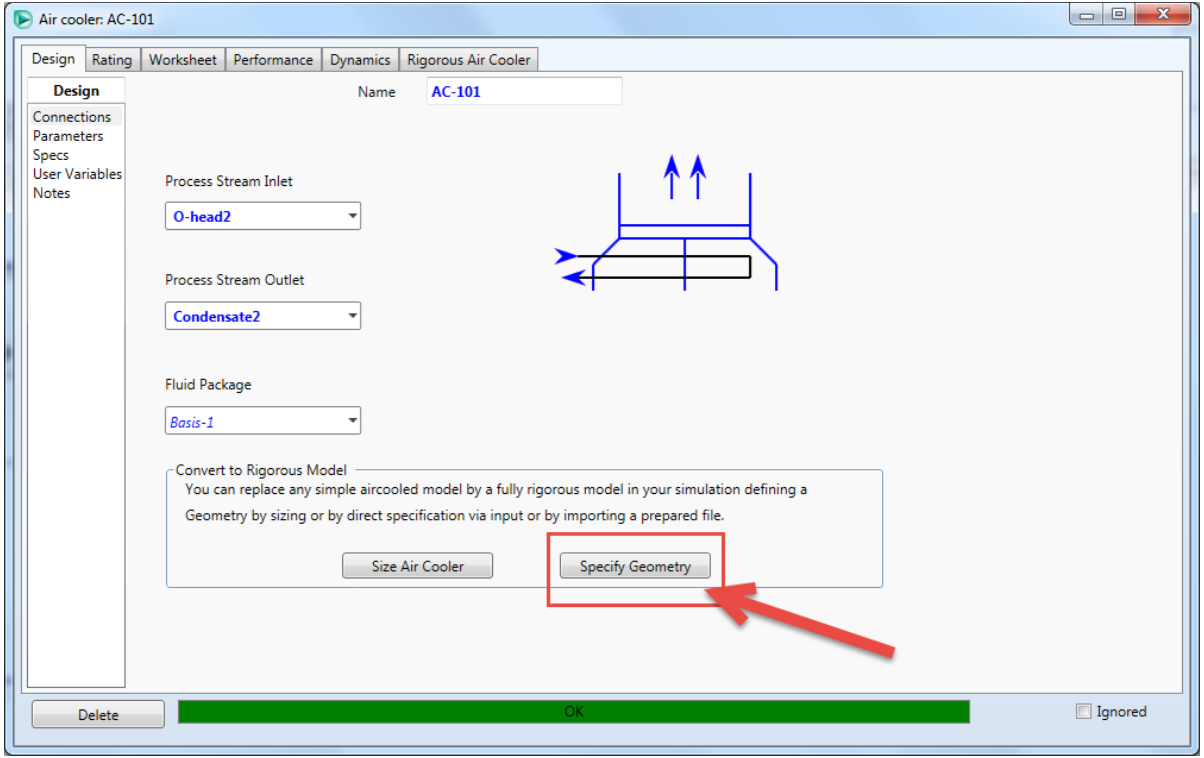
aspentech

Import air cooler model to HYSYS process flowsheet

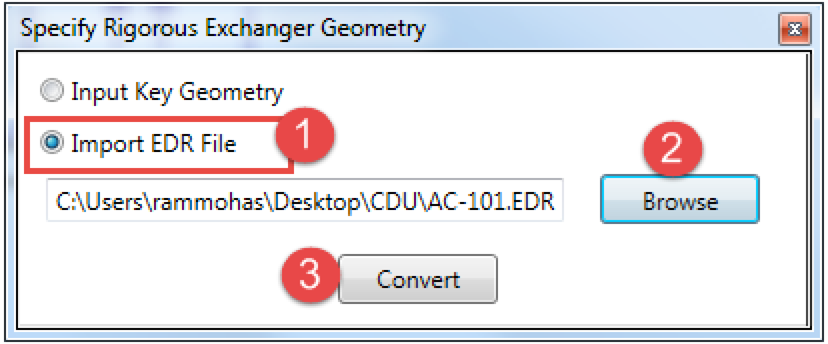


Open the Aspen HYSYS model of the crude distillation unit titled ‘EDR_CDU .hsc’ and click open the condenser unit ‘AC-101’.

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.