HEAT EXCHANGER RATING MODE USING DWSIM:

A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

BY

VIRAJ DESAI, PROCESS ENGINEER

EMAIL: VIRAJ DESAI

LEVEL: ADVANCED

VERSION: 0.00

JULY 2024

PREFACE

The manual “Heat Exchanger Rating Mode Using DWSIM” present a set of “Heat Exchanger Rating Mode Using DWSIM” exercise using a free and open-source chemical process simulator “DWSIM” and can be utilized to establish process simulation laboratory as part of undergraduate chemical engineering degree or in allied degree curriculum. The problem statements are of intermediate level.

Prerequisite

- Must know about DWSIM UI/UX.
- Flow sheeting in DWSIM
- Selection of Thermodynamic Packages.
- Manipulating variables
- Reading a TEMA Sheet
- Basic Modules

Thanks

Viraj Desai

P.E. O&G

Disclaimer

All the exercises are strictly restricted to learning only and not meant to be used in real world applications.

PROCESS SIMULATION USING DWSIM: A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

PREAMBLE

DWSIM is an open-source CAPE-OPEN compliant chemical process simulator. It features a Graphical User Interface (GUI), advanced thermodynamics calculations, reactions support and petroleum characterization / hypothetical component generation tools. DWSIM can simulate steady-state, vapor–liquid, vapor–liquid-liquid, solid–liquid and aqueous electrolyte equilibrium processes and has built-in thermodynamic models and unit operations (https://en.wikipedia.org/wiki/DWSIM). It is available for Windows, Linux and Mac OS.

The objective of the course is to create awareness of the open-source process simulator "DWSIM" among prospective graduates and practicing process engineers. The course will cover Intermediate aspects of create flow sheet in DWSIM and simulation of simple Pressure changing module like pipe segment, Compressor, etc.

Target Audience

- Junior Interns in Process Firms
- III / Final year B. Tech. Chemical Engineering students
- M. Tech. Chemical Engineering students
- Practicing Process Engineers

Table of Contents

List of Figures

1 HEAT EXCHANGER RATING MODE

Objective

Make a process model of Heat Exchanger based on the TEMA Sheet and specs provided:

Data

- TEMA Sheet Specs

Assumption

- Carbon steel thermal conductivity = 45 W/[m.K]

DWSIM Blocks Used

- Material Stream
- Heat Exchanger

Procedure

1. Start a new DWSIM Simulation (DWSIM VER 8.6.5 - CLASSIC UI). Click on “New steady state Simulation” as a template for new simulation.
2. The simulation configuration window will be opened. It shows a specification page. Add components required to solve the problem statement. In the present case, add benzene & toluene. Ensure the component is added from the same property database. For instance, in this case, both components are added from “ChemSep” database.
3. Specify the thermodynamic package as Peng Robinson (PR).
4. Customize the system of units for the simulation and click “Next”.
5. The flow sheeting section of simulation window will be opened. First, let’s provide four Material Streams **Toluene In, Benzene In, Toluene Out & Benzene Out** for the unit process to be performed.

8	PERFORMANCE OF ONE UNIT					
9	Fluid allocation		Shell Side		Tube Side	
10	Fluid name		Toluene		Benzene	
11	Fluid quantity, Total	kg/s	0.5556		0.5556	
12	Vapor (In/Out)	kg/s	0	0	0	0
13	Liquid	kg/s	0.5556	0.5556	0.5556	0.5556
14	Noncondensable	kg/s	0	0	0	0
15						
16	Temperature (In/Out)	°C	25	45.75	70	50
17	Bubble / Dew point	°C	/	/	93.64 / 93.64	92.34 / 92.34
18	Density Vapor/Liquid	kg/m³	/ 864.79	/ 845.49	/ 825.55	/ 846.72
19	Viscosity	mPa-s	/ 0.5543	/ 0.444	/ 0.3557	/ 0.4437
20	Molecular wt, Vap					
21	Molecular wt, NC					
22	Specific heat	kJ/(kg-K)	/ 1.572	/ 1.662	/ 1.724	/ 1.631
23	Thermal conductivity	W/(m-K)	/ 0.1308	/ 0.1248	/ 0.1276	/ 0.1342
24	Latent heat	kJ/kg				
25	Pressure (abs)	bar	2.5	2.48807	1.5	1.44606
26	Velocity (Mean/Max)	m/s	0.05 / 0.05		0.48 / 0.49	
27	Pressure drop, allow./calc.	bar	0.2	0.01193	0.2	0.05394

Figure 1 Process Conditions from TEMA Sheet

6. On clicking the “Toluene” stream & “Benzene” stream, general information about the stream will be displayed on the left side of screen. Specify the feed compositions, temperature, and pressure for the inlet streams. Once credentials are specified for the streams, the color of stream turns blue.

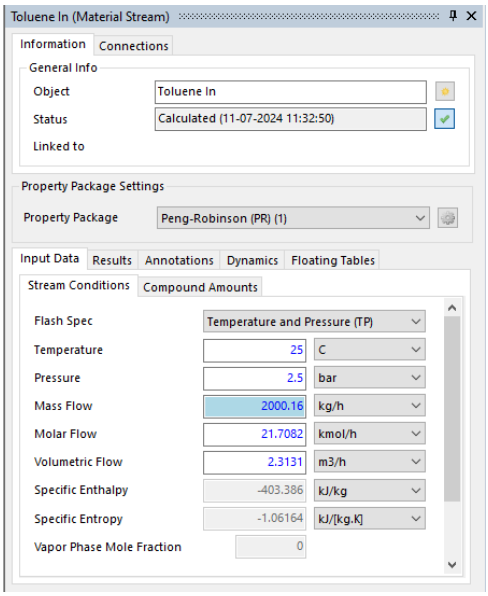

Figure 2 Toluene Specs

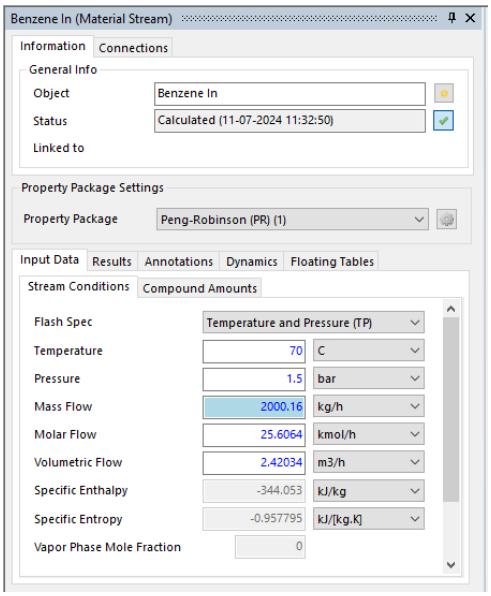

Figure 3 Benzene Specs

7. Below the Unit Operation tab on left, locate the Heat Exchanger. Drag and drop into the flow sheet.

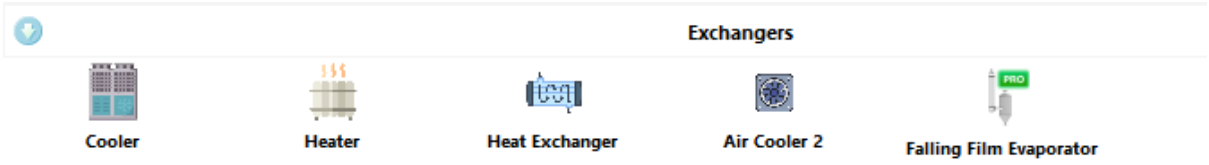

Figure 4 Heat Exchanger

8. Under Calculation type search for Shell and Tube Exchanger Rating. And open the Shell and Tube Heat Exchanger Properties.
9. Enter the specs as mentioned in the TEMA Sheet.

31	CONSTRUCTION OF ONE SHELL														Sketch	
32				Shell Side				Tube Side								
33	Design/Vacuum/test pressure		bar	3.44738 /	/			3.44738 /	/							
34	Design temperature / MDMT		°C	110	/			110	/							
35	Number passes per shell			1				4								
36	Corrosion allowance		mm	3.18				3.18								
37	Connections	In	mm	1	25.4	/	-	1	19.05	/	-					
38	Size/Rating	Out		1	25.4	/	-	1	19.05	/	-					
39	Nominal	Intermediate				/	-			/	-					
40	Tube #: 34	OD: 19.05	Tks. Average 2.11	mm	Length: 1828.8	mm	Pitch: 23.81	mm	Tube pattern:30							
41	Tube type: Plain	Insert:None			Fin#:		#/m	Material:Carbon Steel								
42	Shell Carbon Steel	ID 205	OD 219.08	mm	Shell cover	-										
43	Channel or bonnet	Carbon Steel			Channel cover	-										
44	Tubesheet-stationary	Carbon Steel	-		Tubesheet-floating	-										
45	Floating head cover	-			Impingement protection	None										
46	Baffle-cross Carbon Steel	Type	Single segmental		Cut(%d)	43.02	Hori:Spacing: c/c	171.45	mm							
47	Baffle-long -	Seal Type			Inlet	276.23	mm									

Figure 5 Shell and Tube HEX Specs

10. Once necessary specs are filled. Enter Carbon steel thermal conductivity. The Shell and Tube Exchanger Properties shall be as below:

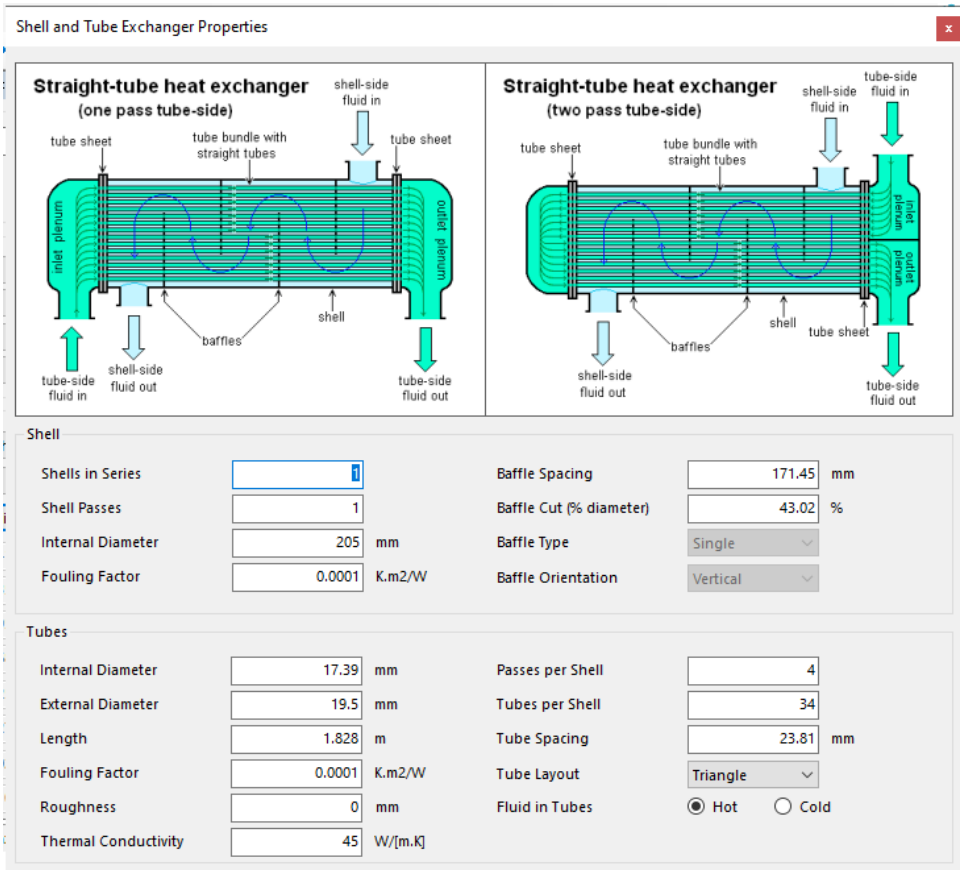

Figure 6 Shell and Tube Exchanger Properties

11. Once done connect the remaining streams in the appropriate port.

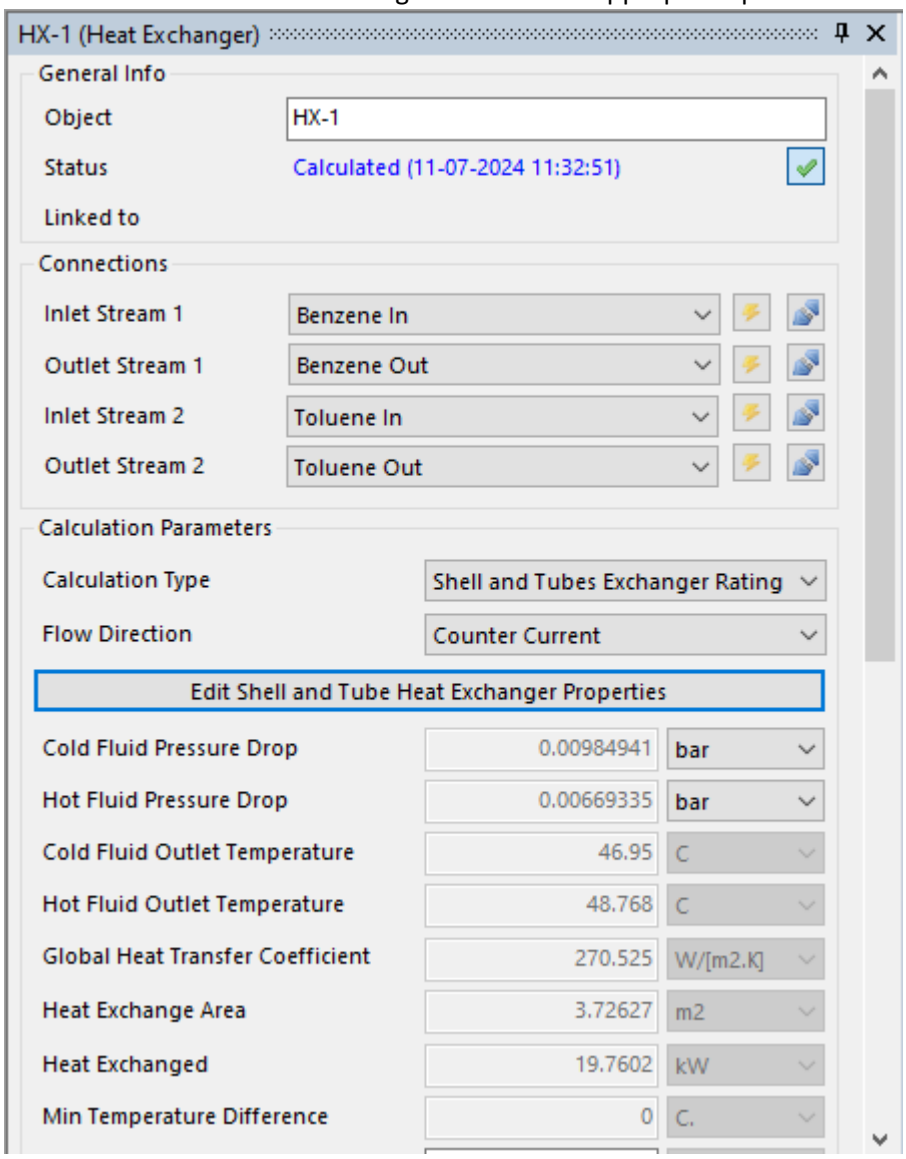

Figure 7 Heat Exchanger Properties

12. Run the simulation by pressing “Solve flow sheet” button on the top corner of the screen

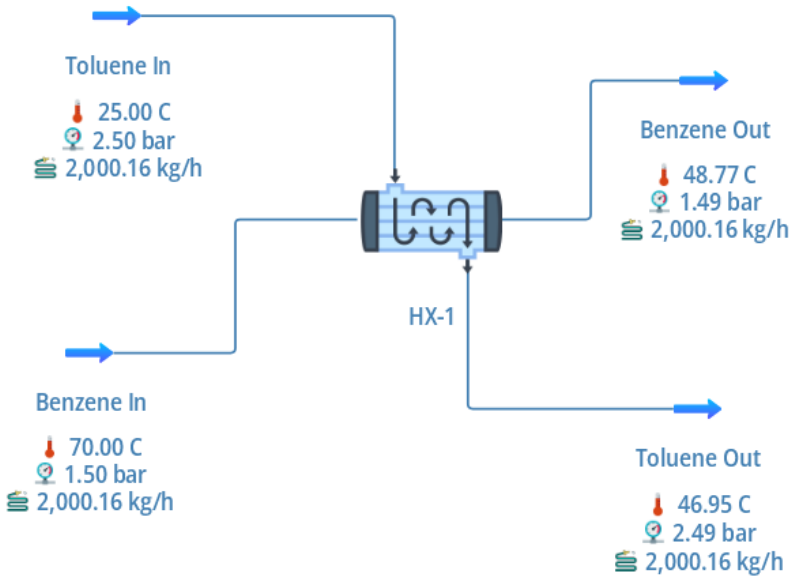

Figure 8 Solved Flow Sheet

13. Once done cross check with the outlet temperature of the streams in the TEMA Sheet which were marked as **green color.**

9	Fluid allocation		Shell Side		Tube Side	
10	Fluid name		Toluene		Benzene	
11	Fluid quantity, Total	kg/s	0.5556		0.5556	
12	Vapor (In/Out)	kg/s	0	0	0	0
13	Liquid	kg/s	0.5556	0.5556	0.5556	0.5556
14	Noncondensable	kg/s	0	0	0	0
15						
16	Temperature (In/Out)	°C	25	45.75	70	50
17	Bubble / Dew point	°C	/	/	93.64 / 93.64	92.34 / 92.34
18	Density Vapor/Liquid	kg/m³	/ 864.79	/ 845.49	/ 825.55	/ 846.72
19	Viscosity	mPa-s	/ 0.5543	/ 0.444	/ 0.3557	/ 0.4437
20	Molecular wt, Vap					
21	Molecular wt, NC					
22	Specific heat	kJ/(kg-K)	/ 1.572	/ 1.662	/ 1.724	/ 1.631
23	Thermal conductivity	W/(m-K)	/ 0.1308	/ 0.1248	/ 0.1276	/ 0.1342
24	Latent heat	kJ/kg				
25	Pressure (abs)	bar	2.5	2.48807	1.5	1.44606

Figure 9 Cross checking of the properties of the fluid

2 RESULTS OF DWSIM

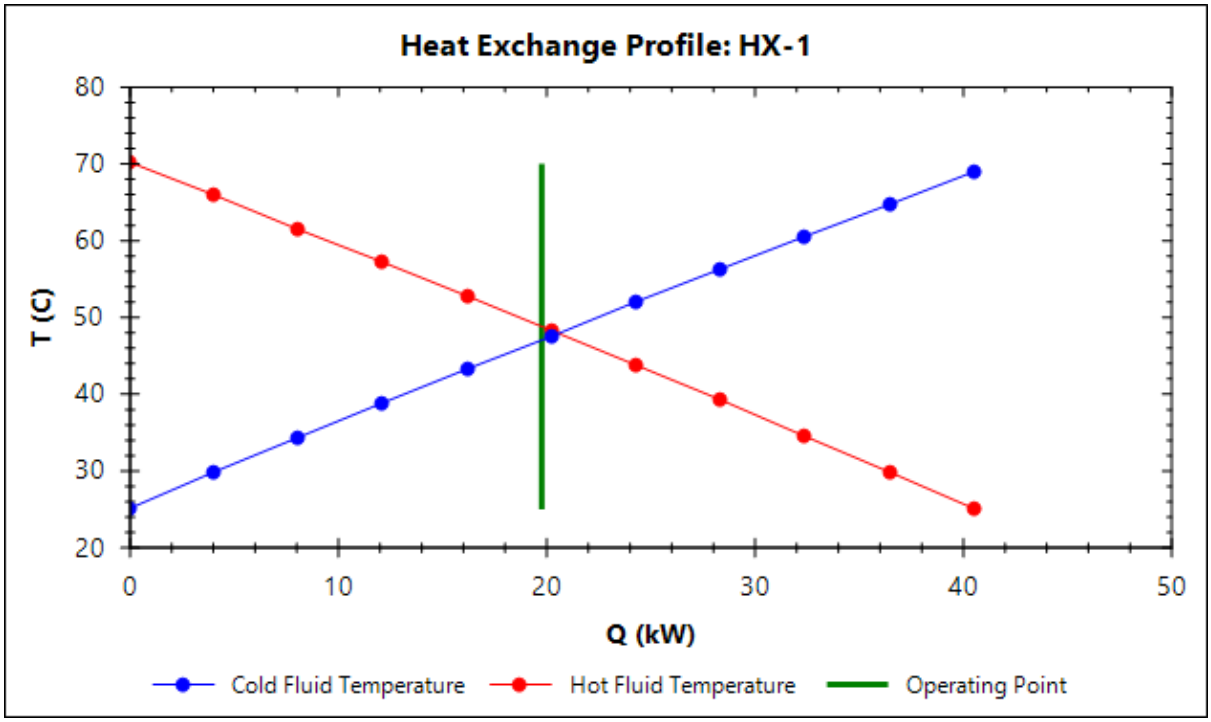

Figure 10 Heat Exchanger Temperature Profile

2.1 HEAT EXCHANGER PROPERTIES

Maximum Heat Exchange	40.5348	kW
Thermal Efficiency	48.7487	%
Log Mean Temperature Difference (LMTD)	23.4129	C.
LMTD Correction Factor (Shell and Tube)	0.83725	
Shell-side Reynolds Number	3111.96	
Tube-side Reynolds Number	12098.9	
Shell-side Resistance	1.946531E-003	K.m2/W
Tube-side Resistance	1.513040E-003	K.m2/W
Pipe Wall Resistance	2.481248E-005	K.m2/W
Fouling Resistance	2.121334E-004	K.m2/W

3 REFERENCES

TEMA Sheet

Aspen Model Link