CL-402: Chemical Process Technology

July-November session, 2018

7th semester, Department of Chemical Engineering Indian Institute of Technology Guwahati, Guwahati

Tutorial 4

Use Aspen Plus V8.8 to solve all the problems. Problem-1: Rigorous Distillation Calculations: RadFrac

A feed consisting of 40 mol% propane and 60 mol% isobutane is to be separated by distillation. Feed flowrate is 1 kmol/s and the feed temperature is 322 K. Condenser is operating at 16.8 atm pressure while stage pressure drop is 0.0068 atm. Use CHAO–SEAD thermodynamic model. Assume that the specification of the heavy impurity in the distillate (isobutane) is 2 mol% and that the specification of the light impurity in the bottoms (propane) is 1 mol%.

- **a.** Design a distillation to accomplish the separation i.e. find number of stages, feed stage, diameter and height of the column.
- **b.** Investigate the effect of feed stage on reboiler heat duty.
- **c.** Perform the steady-state economic optimization of the distillation column based on total annual cost (TAC) using the following data:

Parameter	Value
Condensers	
Heat Transfer Coefficient	0.852 kW/K.m^2
Differential Temperature	13.9 K
Capital Cost	7296 (area in m^2) ^{0.65}
Reboiler	
Heat Transfer Coefficient	0.568 kW/K.m^2
Differential Temperature	34.8 K
Capital Cost	7296 (area in m^2) ^{0.65}
Column Vessel Capital Cost	17640 [diameter (D) in meters) ^{1.066}
•	$[\text{length } (L) \text{ in meters})^{0.802}$
Energy Cost	\$4.7/10 ⁶ kJ

$$TAC = \frac{capital \ cost}{payback \ period} + energy \ cost$$

Payback Period

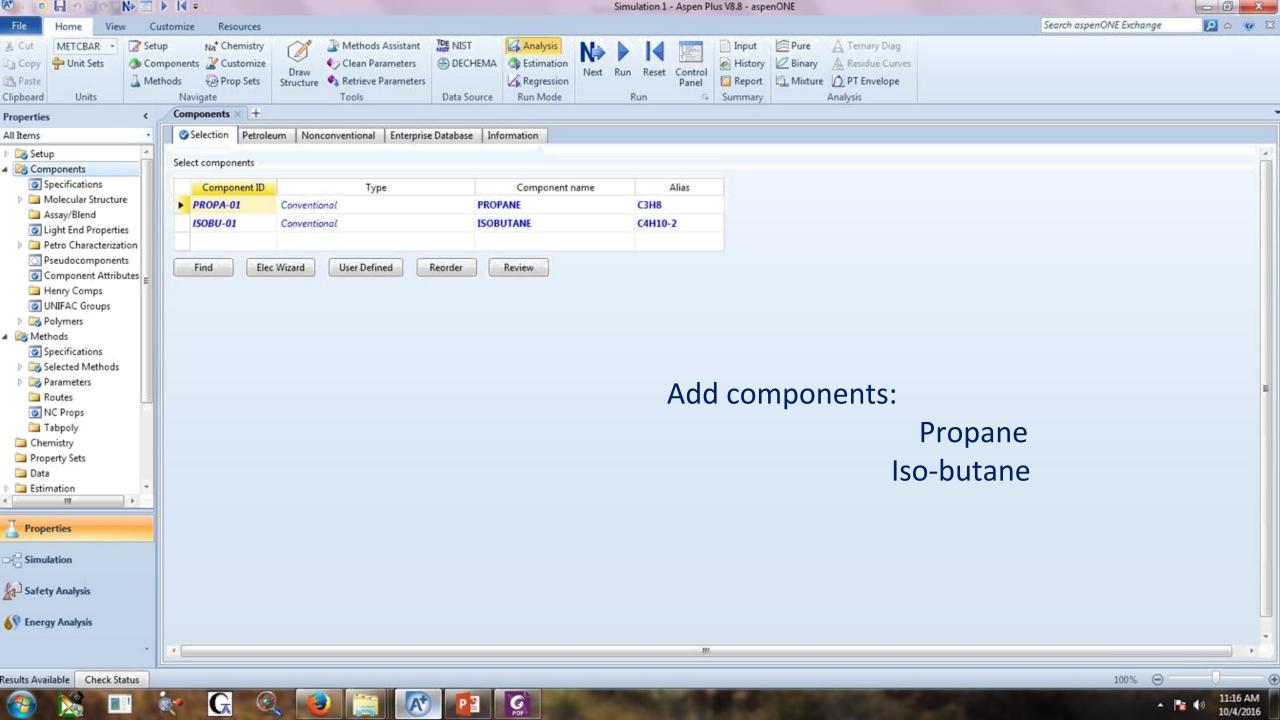
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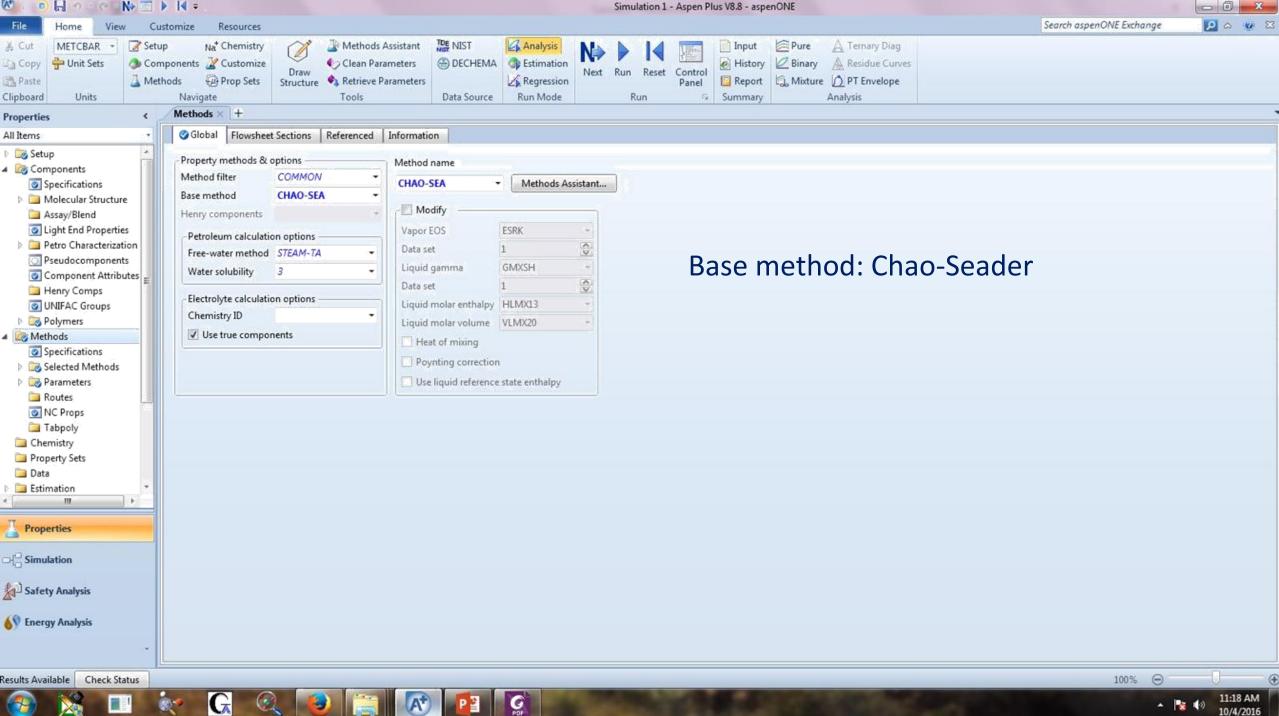
In Tutorial-3, we have used DSTWU and RadFrac models to design a separation process.

As we have seen, various configurations are possible which can meet the desired specifications. So the question is which one of the many possible configurations should be used. To answer that question, one has to bring other factors. If costs were the only consideration, then there would be a trade-off between capital costs and operating (heat and cooling) costs.

In this Tutorial, we will Perform the steady-state economic optimization of the distillation column based on total annual cost (TAC).

Problem 1





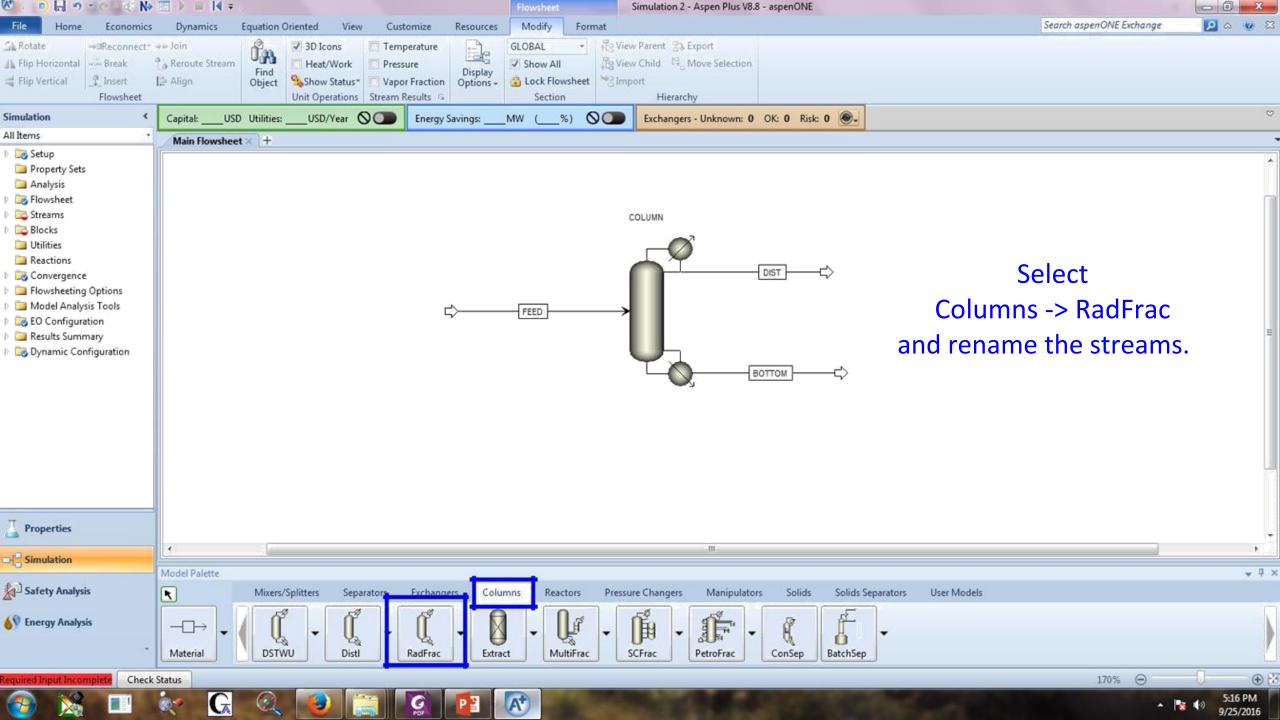
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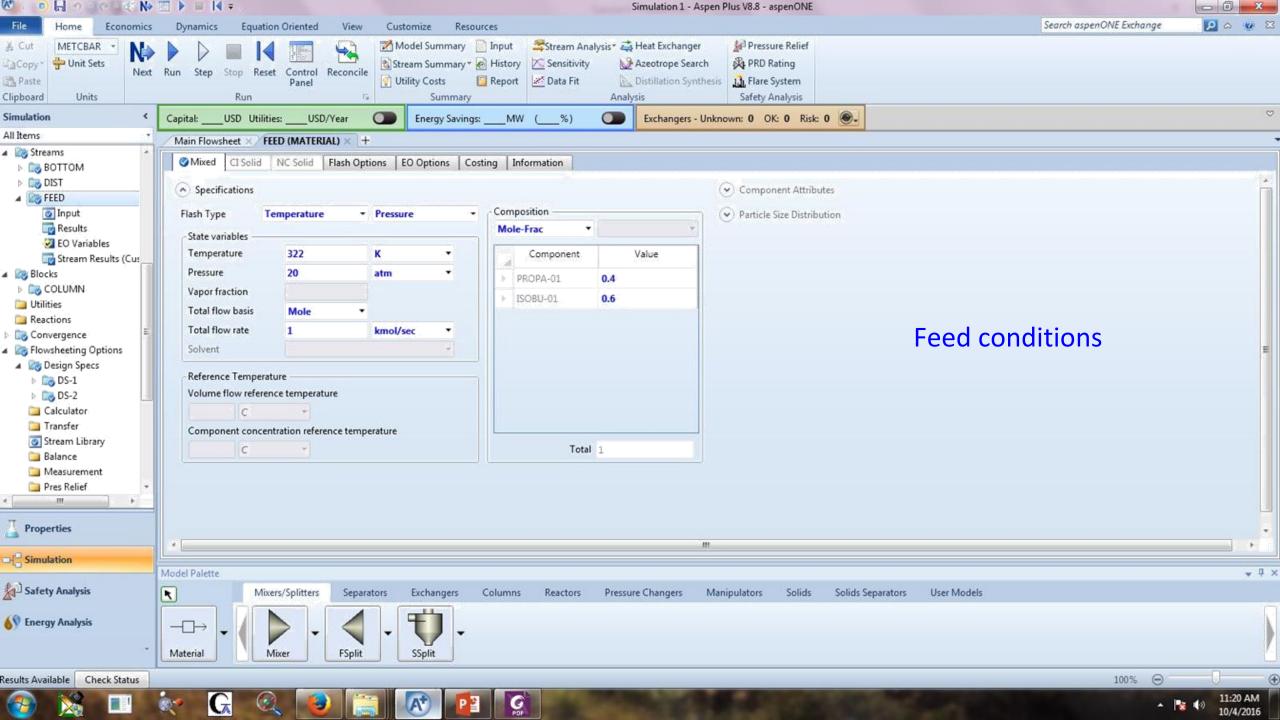
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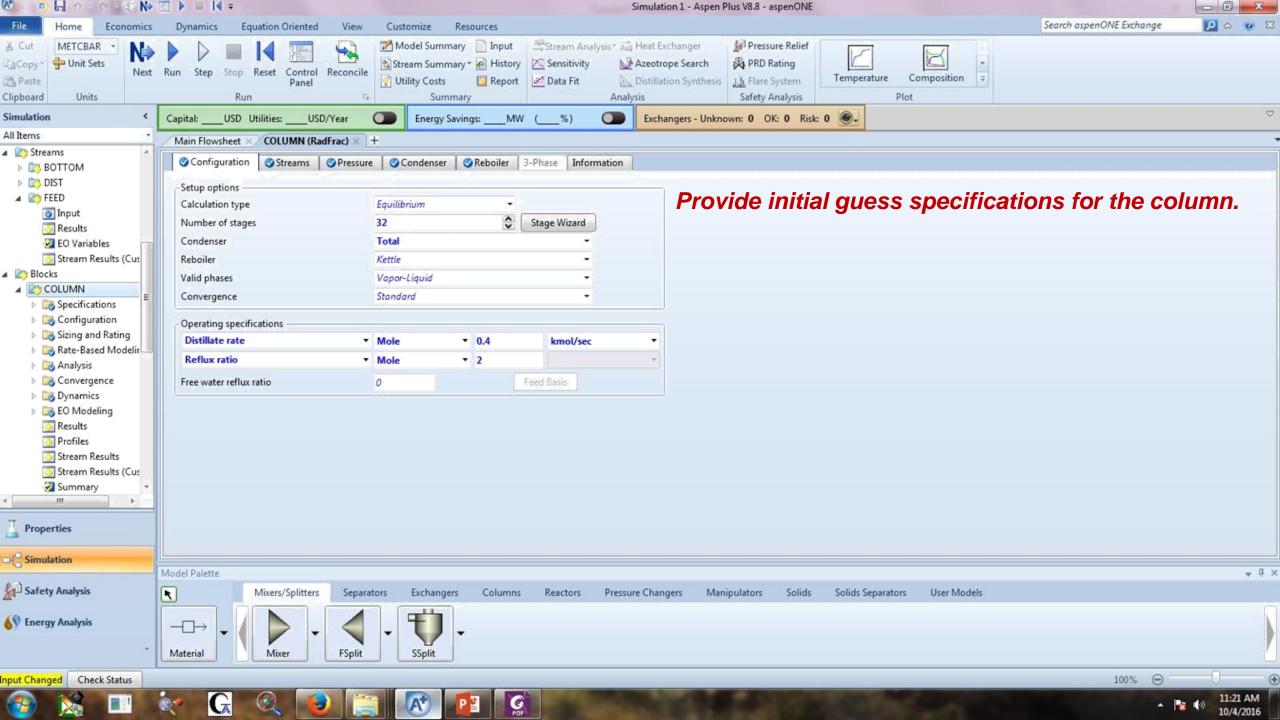
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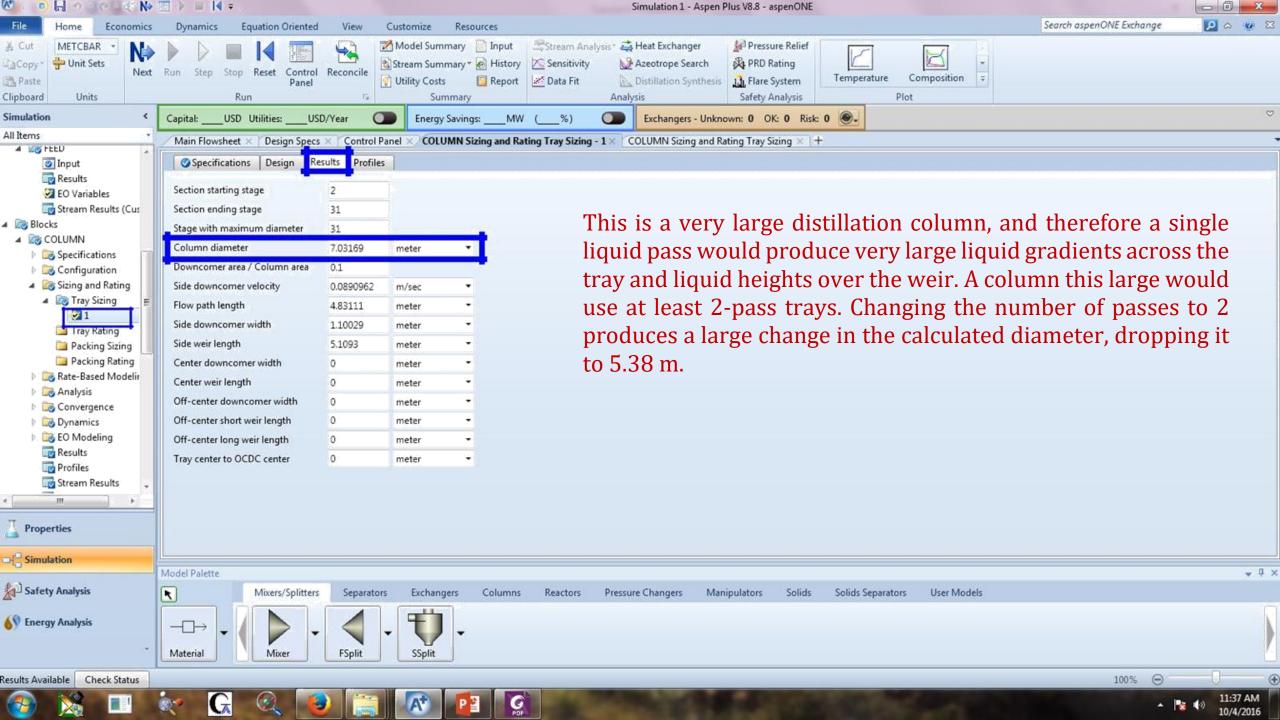
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C Streams	PROPA-01		0.4	0.863887	0.0907418	90 mol% iso-butane in bottom.	1_3
Convergence	> ISOBU-01		0.6	0.136113	0.909258		
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·[PROPA-01		0.335893	0.828036	0.0703845		
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Determination of Column diameter

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Analysis	Tray spacing	0.6096 meter			
Convergence	Minimum column diameter	0.3048 meter			
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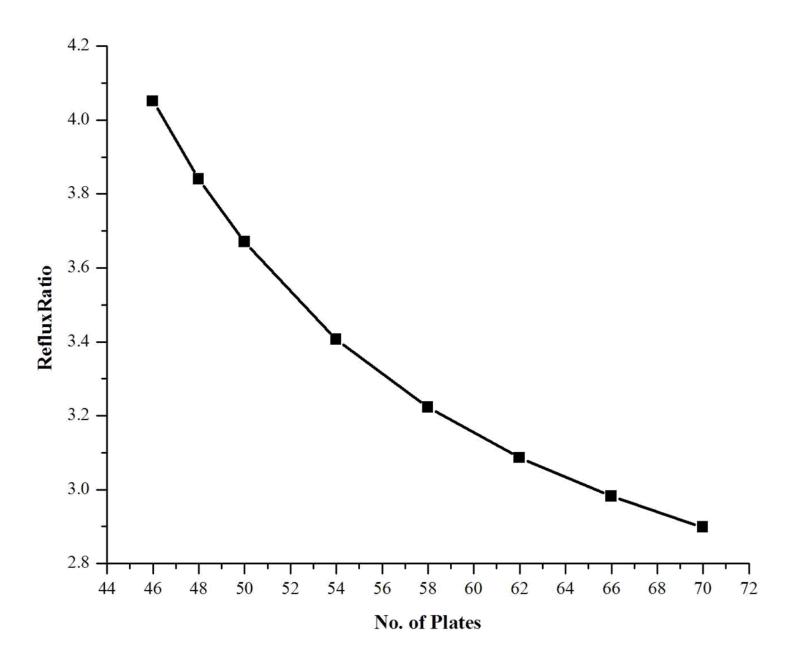
Effect of feed stage on Reboiler heat duty

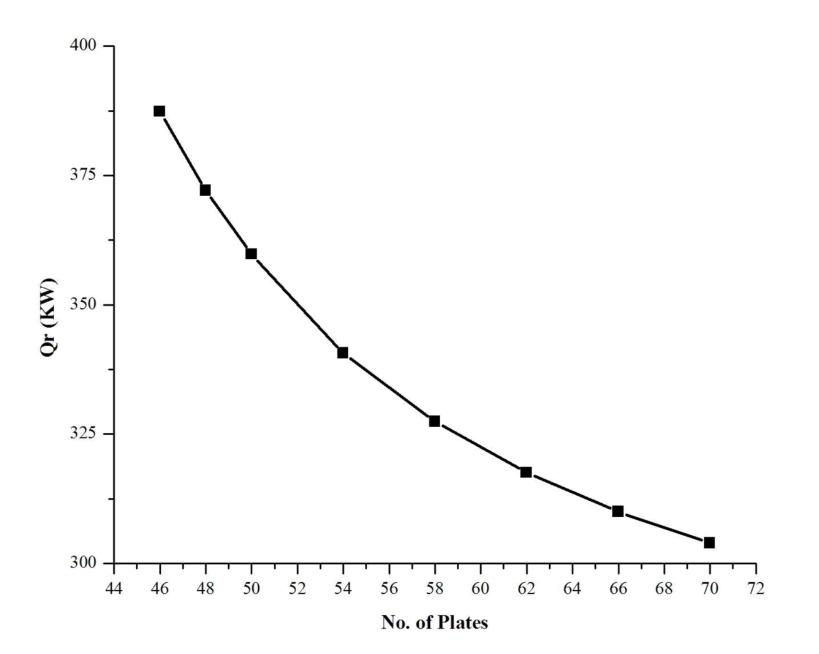
Feed Stage Number	Reboiler Heat Input (MW)	Condenser Heat Removal (MW)	Reflux Ratio
12	28.04	-23.58	3.64
13	27.54	-23.07	3.54
14	27.02	-22.56	3.44
15	26.98	-22.51	3.43
16	27.26	-22.80	3.49

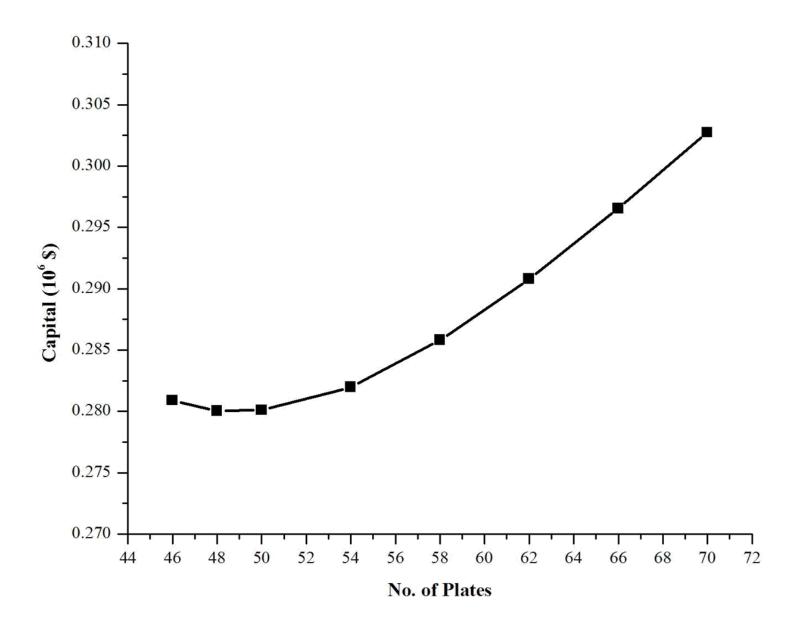
Feed at stage 15 gives minimum Reboiler heat duty. [Feed stage/total no. of stages = 0.46875]

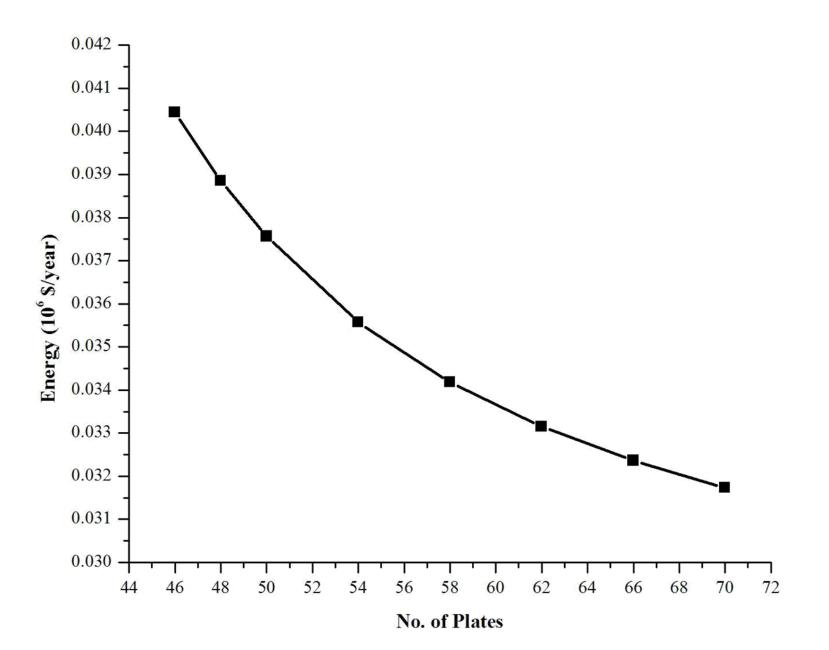
Now, change the number of stages in the column and use TAC calculation sheet to calculate the TAC. (Maintain feed stage/total no. of stage ratio at 0.46875 while changing the total no. of stages)

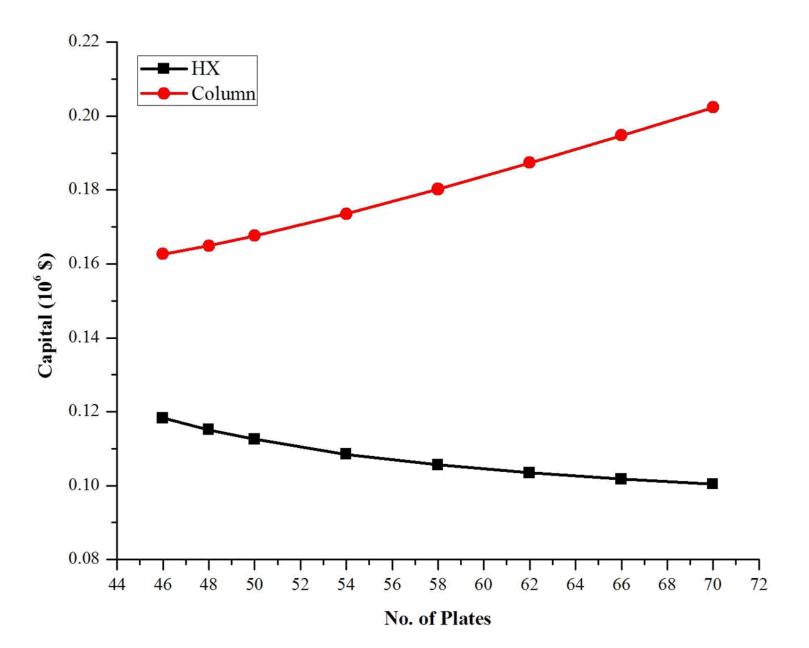
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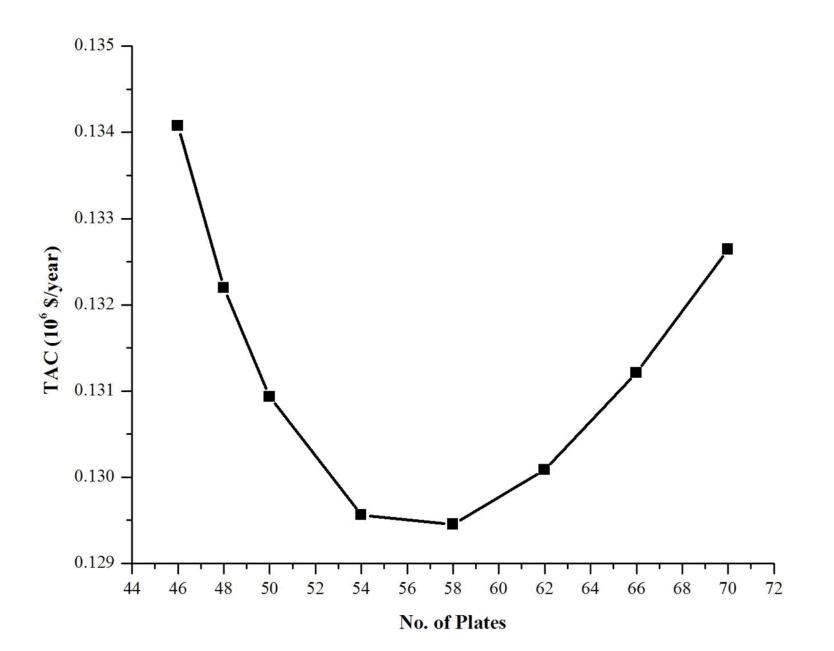












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