MODELING AND SIMULATION OF DISTILLATION COLUMN

Ronak Prajapati[1], Parth Patel[2], Vishal Parmar[3], Nirali Tharwala[4]

[1,2,3] student, Chemical Engineering, Department of Chemical Engineering,
Shroff S R Rotary Institute of Chemical Technology. Ankleswar-Valia Road At & Post-Vataria
[4] Assistant Professor, Department of Chemical Engineering,
Shroff S R Rotary Institute of Chemical Technology. Ankleswar-Valia Road At & Post-Vataria

ABSTRACT

Distillation a widely used method for purifying liquids and separating mixtures of liquids into their individual components. It is employed to separate benzene from toluene, methanol or ethanol from water, acetone from acetic acid, and many multicomponent mixtures. This project will comprises the methanol-water mixture distillation. All the parameters that can be varies and affect the distillation process like reflux ratio feed and composition will be studied. Calculation of feed tray and number of stages for the same will be done using McCabe-Thiele Method.

The objective of the project is to study all the parameters that can affect the distillation process. on the modelling and simulation for the process using hysy or using Microsoft Excel.

Keyword: - *Distillation, modelling, simulation, Hysys, Methanol water system, excel.*

---

1. Introduction

Distillation is a unit operation that is used in almost every industries for the separation process. Distillation is a widely used method for separating mixtures based on differences in the conditions required to change the phase of components of the mixture. To separate a mixture of liquids, the liquid can be heated to force components, which have different boiling points, into the gas phase. The gas is then condensed back into liquid form and collected. Repeating the process on the collected liquid to improve the purity of the product is called double distillation. Although the term is most commonly applied to liquids, the reverse process can be used to separate gases by liquefying components using changes in temperature and/or pressure. Distillation may result in essentially complete separation (nearly pure components), or it may be a partial separation that increases the concentration of selected components of the mixture. In either case the process exploits differences in the volatility of the mixture's components. In industrial chemistry, distillation is a unit operation of practically universal importance

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest.
A simulation of a system is the operation of a model of the system. The model can be reconfigured and experimented with; usually, this is impossible, too expensive or impractical to do in the system it represents.
Modeling and simulation is important in research. Representing the real systems either via physical reproductions at smaller scale, or via mathematical models that allow representing the dynamics of the system via simulation, allows exploring system behavior in an articulated way which is often either not possible, or too risky in the real world.

1.1 Model Equations

Q line calculation $q = \frac{\lambda + Cp\Delta t}{\lambda}$

Relative Volatility $\alpha = \frac{\left(\frac{y_{LK}}{x_{LK}}\right)}{\left(\frac{y_{HK}}{x_{HK}}\right)} = \frac{K_{LK}}{K_{HK}}$

A total material balance for tray n
$V_{n+1} + L_{n-1} = V_n + L_n$

Material balance around top section use the composition of vapour leaving tray
$Y_{n+1} V_{n+1} + X_{n-1} L_{n-1} = Y_n V_n + X_n L_n$

Generalize equation

$$Y_{n+1} = \frac{Rx_n}{L + D} = \frac{1}{R + 1} X_D$$

Reboiler Duty Calculation

$$\overline{L} * \Delta H_{vap} + (\overline{L}) C_{p,bottom} \Delta T$$

2. Material and Methods

Flowrate	10000 kg/hr = 423.37 Kmol/hr
$\Delta \boldsymbol{H}$ of water	40.65
$\Delta \boldsymbol{H}$ of methanol	38.278
$\boldsymbol{C_p}$, of water	4.18
Column Operating Pressure	Atmospheric Pressure 1 atm
Column condense	Total condenser
Feed Composition	Methanol 40 % Water 60 %
Room Temperature	30 °C
Feed Condition q	1.12
Relative Volatility α	3.10

(Table 2.1 Material and required values)

	F		D		W			
	kmol/hr	%	kmol/hr	%	kmol/hr	%		R
Methanol	169.348	0.4	166.815	0.99	2.5487	0.01		
water	254.022	0.6	1.685	0.01	252.3213	0.99		
total	423.37		168.5		254.87			Cp of water
								Room temperature
		Reboiler duty	L'*H+L'Cp(tb-tr)					bubble point
			466012.4693	KJ/hr				
			129.4479081	KW				

(Table 2.2 – Reboiler Duty Calculation)

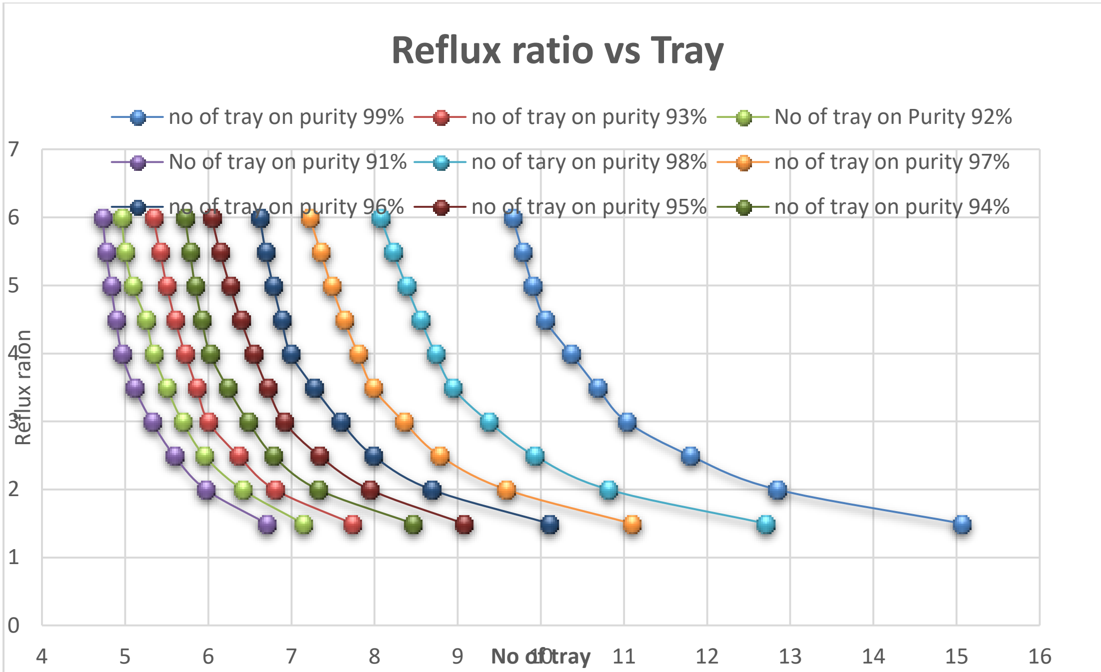
3. Result

Xd	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
R	No. of trays								
1.5	15.06	12.7	11.09	10.1	9.07	8.46	7.73	7.14	6.7
2	12.84	10.81	9.58	8.68	7.94	7.32	6.8	6.41	5.97
2.5	11.79	9.92	8.78	7.98	7.33	6.78	6.36	5.95	5.59
3	11.03	9.37	8.35	7.59	6.91	6.48	6	5.69	5.32
3.5	10.68	8.94	7.98	7.27	6.71	6.23	5.86	5.5	5.11
4	10.36	8.73	7.8	6.99	6.54	6.02	5.72	5.34	4.96
4.5	10.05	8.55	7.63	6.88	6.39	5.92	5.6	5.25	4.89
5	9.9	8.38	7.48	6.78	6.26	5.84	5.5	5.09	4.83
5.5	9.78	8.22	7.35	6.69	6.14	5.78	5.42	5	4.77
6	9.66	8.07	7.22	6.62	6.04	5.72	5.34	4.96	4.73

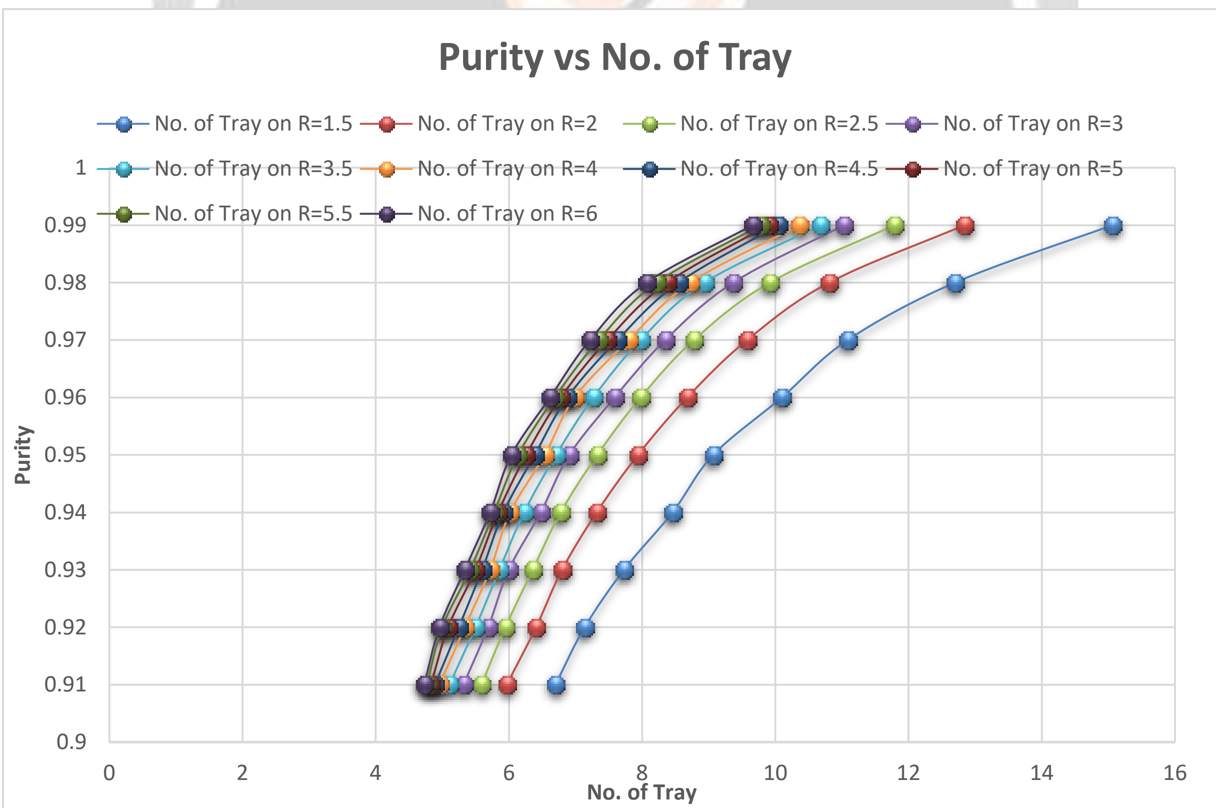
(Table 3.1 – Reflux ratio vs Number of Trays)

Xd	.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91
R	Reboiler duty								
1.5	61.39	61.4	60.76	60.12	59.48	58.83	58.23	57.62	57.02
2	68.953	69.02	68.28	67.54	66.79	66.03	65.32	64.61	63.9
2.5	76.517	76.65	75.8	74.95	74.09	73.23	72.42	71.59	70.78
3	84.081	84.28	83.32	82.36	81.4	80.42	79.51	78.58	77.66
3.5	91.64	91.9	90.84	89.77	88.7	87.62	86.61	85.57	84.53
4	99.208	99.53	98.36	97.19	96.011	94.81	93.7	92.56	91.81
4.5	106.77	107.15	105.88	104.6	103.31	102.01	100.79	99.54	98.29
5	114.33	114.78	113.4	112.01	110.62	109.21	107.89	106.53	105.17
5.5	121.89	122.4	120.92	119.43	117.92	116.4	114.98	113.52	112.05
6	129.462	130.03	128.44	126.84	125.23	123.6	122.07	120.51	118.93

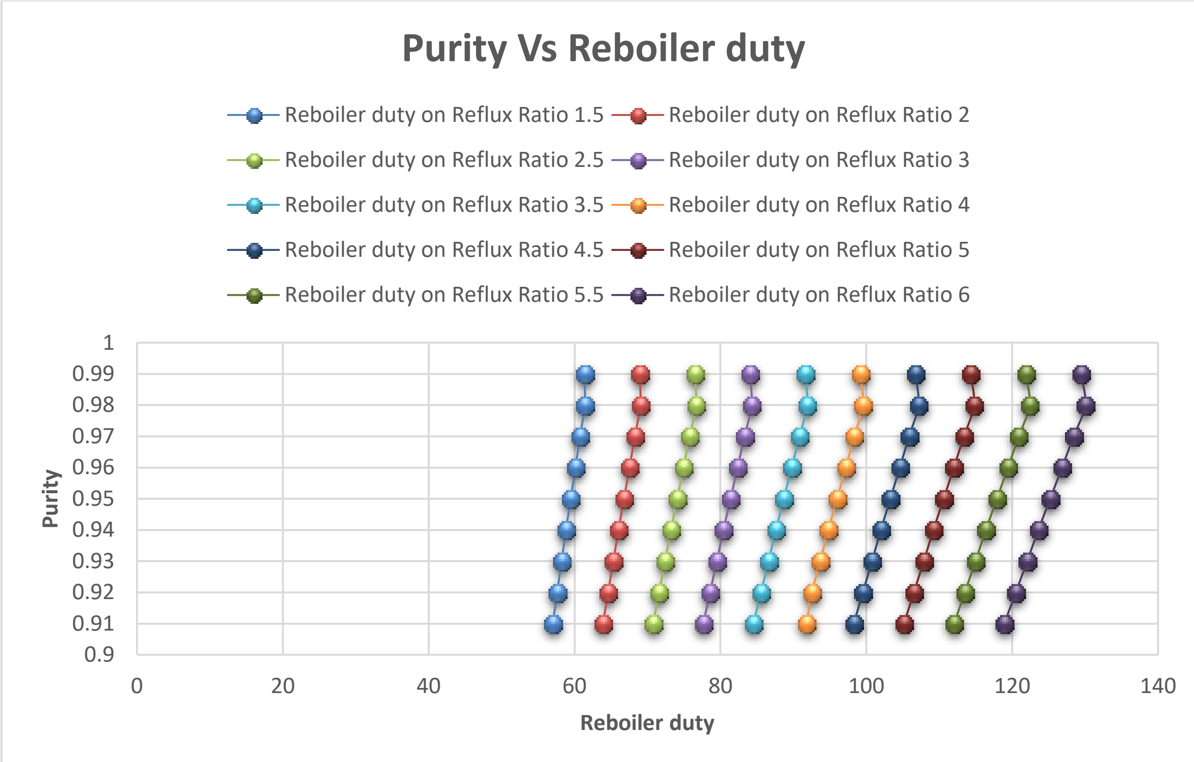
(Table 3.2 – Reflux ratio vs Reboiler Duty)



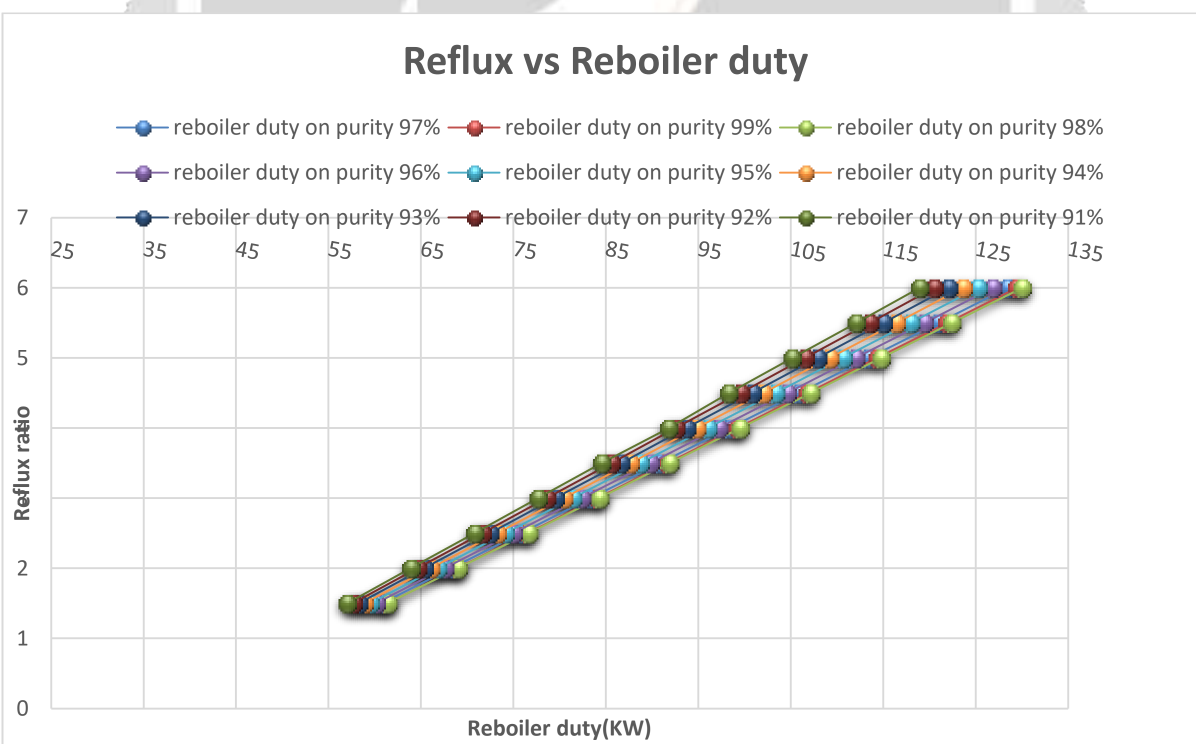
(Graph 3.1 Reflux ratio vs Reboiler Duty)



(Graph 3.2 Reflux ratio vs Reboiler Duty)



(Graph 3.3 Reflux ratio vs Reboiler Duty)



(Graph 3.4 Reflux ratio vs Reboiler Duty)

4. CONCLUSIONS

We determine the relation between reflux ratio, number of trays and reboiler duty and had concluded that to get high purity reflux ratio should be high which result in high reboiler duty. To minimize the reboiler duty and we had to go for optimum reflux ratio to get desire purity.

.

5. ACKNOWLEDGEMENT

It is great pleasure and privilege to have an opportunity to take this work entitled **"**MODELING AND SIMULATION OF DISTILLATION COLUMN**"**. We would like to express our deepness of gratitude to our project work guide Mrs. NIRALI THARWALA (Asst. Prof. C.E Dept.**)**, for his inspiring guidance and invaluable suggestions that he had given throughout the project work. We would like to express our deep sense of gratitude to all faculty members of the department of chemical engineering. At this junction, it is appropriate to express our gratitude to the people who have been with us throughout & have helped us to successfully accomplish this work. Last but not least, we are grateful to our family & friends to provide us support & guidance mentally as well as financially to finish & submit our work successfully. Errors and deficiencies are likely to be there; therefore we apologize for the same in advance.

6. REFERENCES

1. McCabe, Warren L.; Smith, Julian C.; Harriot, Peter (2005), "Unit Operations of Chemical Engineering"
2. S. B Thakore, B Bhatt, "Introduction to Process Engineering and Design" Robert Treybal, "Mass Transfer Operations"
3. Srivastava, R.K. and Joseph, B., Simulation of packed bed separation processes using orthogonal collocation, *Comp. Chem. Eng.*, 8(1). 43–50, 1984.
4. Mujtaba, I.M. and Macchietto, S., Efficient optimization of batch distillation with chemical reaction using polynomial curve fitting technique, *Ind. Eng. Chem. Proc. Design Devel.*, 36, 2287–2295, 1997.
5. Robert Treybal, "Mass Transfer Operations"
6. Wajge, R.M. and Reklaitis, G.V., An optimal campaign structure for multicomponent batch distillation with reversible reaction, *Ind. Eng. Chem. Res.*, 37,1910–1916, 1998.
7. Farhat, S., Czernicki, M., Pibouleau, L., and Domenech, S., Optimization of multiple-fraction batch distillation by nonlinear programming, *AIChE J.*, 36, 1349–1360, 1990.
8. Chiotti, O.J. and Iribarren, O.A., Simplified models for binary batch distillation, *Comp. Chem. Eng.*, 15(1), 1–5, 1991.
9. Lotter, S.P. and Diwekar, U.M., Shortcut models and feasibility considerations for emerging batch distillation columns, *Ind. Eng. Chem. Res.*, 36, 760–770, 1997
10. Srivastava, R.K. and Joseph, B., Simulation of packed bed separation processes using orthogonal collocation, *Comp. Chem. Eng.*, 8(1). 43–50, 1984.
11. Mujtaba, I.M. and Macchietto, S., Efficient optimization of batch distillation with chemical reaction using polynomial curve fitting technique, *Ind. Eng. Chem. Proc. Design Devel.*, 36, 2287–2295, 1997.
12. Diwekar, U.M., Malik, R., and Madhavan, K., Optimal reflux rate policy determination for multicomponent batch distillation columns, *Comp. Chem. Eng.*, 11, 629–637, 1987.