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Column Design by Visual Basic and Comparative Study with MATLAB

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Abstract

Columns have great importance in chemical engineering. They are mainly used for unit operations like distillation, absorption and stripping. There are many commercial software packages are available to control such column operations. But they are very costly and sometime they are difficult to operate for field operator due to lack of knowledge of such high professional suits. To meet this requirement we tried to design cylindrical column and kept graphical user interface very simple and easy to understand. This software is designed to calculate real number of trays and outlet concentration of column and all results are compared with MATLAB. This design can be further extended to calculate height of column. And results can be compared with python.

Keywords: Graphical user interface (GUI), Visual basic, MATLAB, .NET, Countercurrent operation.

1. Introduction

Chemical engineering is very vast and diversified area. It deals with material science, fluid flow, process engineering, transport phenomena, optimization and other interdisciplinary subjects like thermodynamics and environmental engineering. Figure.1 will give basic idea of chemical plant where mainly advanced mass transfer and chemical reaction engineering calculations are required. In advanced mass transfer, reaction engineering, we always encountered with rigorous numerical and analytical data and equations. Solving this equation manually is impractical and time consuming. There are many software tools are available to solve this problem like UNISIM, MATLAB, HYSIS.

But this software tools are too expensive and sometime really have no use when we are working industrially, because this software packages are made in such way that it takes much time to learn them and for field operators it is hard to work with such tools. Taking this problem in consideration we tried to develop small software that can be used by anyone. And it is assumed that user having less knowledge of computation. In this article we will develop a software tool which will be used for calculation of outlet concentrations of column and number of stages when mode of operation is cross current or countercurrent.

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Figure.1 shows typical block diagram of chemical plant involving few process equipments like reactor, separator etc.

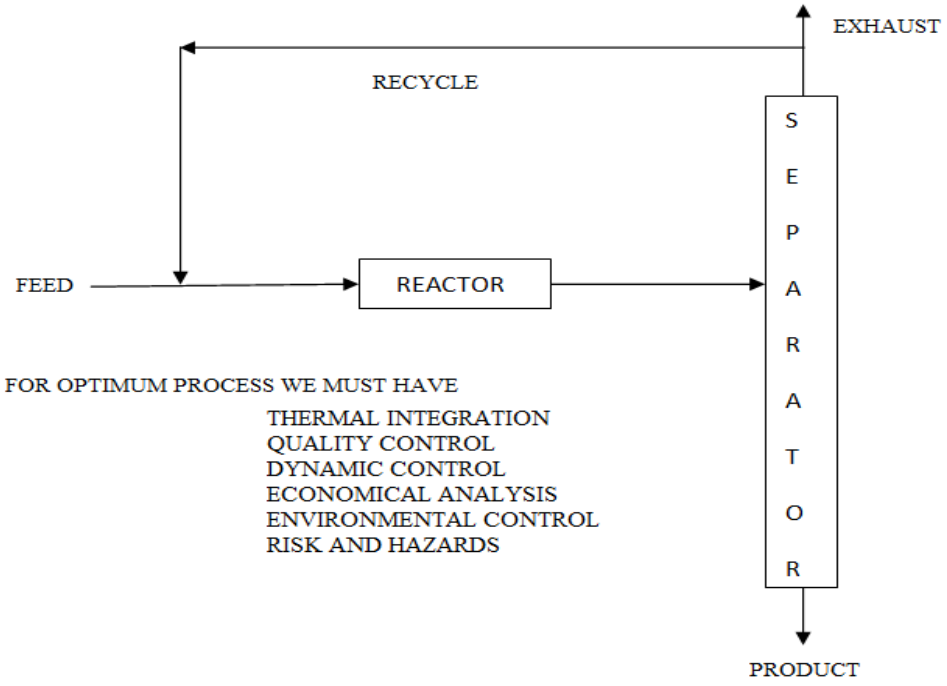

Figure.1: Block diagram of chemical plant

2. Softwares Used in Design

Version used to design this software is visual studio community 2017 (15.4.2) and all the results obtained are compared with MATLAB 9.0 and SCILAB 6.0.0. For generation of polynomial equation for equilibrium line we can use Microsoft excel and values can be verified in excel. All the software packages are of latest version and values are verified nearly 10 times for each module.

3. Computation Methods

3.1. To obtain number of stages in countercurrent column

Generally to calculate number of stages we have to use kremser equation [1]

For absorber-

$$Np = \frac{\log\left[\frac{Y_{Np+1} - m * x_0}{Y_1 - m * x_0}\left(1 - \frac{1}{A}\right) + \frac{1}{A}\right]}{logA}$$

For stripper-

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$$Np = \frac{log\left[\frac{x_0 - \frac{Y_{Np+1}}{m}}{x_{Np-\frac{Y_{Np+1}}{m}}}\left(1-\frac{1}{S}\right)+\frac{1}{S}\right]}{logS}$$

Where, A=L/mG and S=1/A

But this equations are valid for constant Y*/X i.e. when equilibrium line is not straight line and equilibrium data is in polynomial form then we have to use McCabe-Thiele graphical approach to calculate number of stages. In visual basic, we can develop a model by using simple while loop as given below

```
Count= -1
While (Cai > Cao)                    //  loop range

Coo= ((A/O)*Cai) + (Coi-(A/O)*Cao)    //  Operating Line Equation obtained from material
                                      balance to obtain horizontal line for every step   in graph
Initial=Cai
Cai=f(Coo)                            //  Equilibrium Line Equation to obtain vertical line
                                      on graph
Count=count+1                         //  to obtain number of stages

End
X= (initial-Cao)/(initial-Cai)
Y=count+X                             //  for getting precise value of number of stages in
                                      fraction
```

Many times for required purity we wanted to know optimum number of stages will be enough and for this application above code can used.

3.2. To calculate outlet concentration

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Industrially most common task is to measure purity of outlet product as well as the wastes generated by process to check whether process is running as per requirement or not. Feedback system is used mostly for processes thus we always have to keep track on outlet concentrations of every unit operation. As there is no single mathematical equation which can evaluate outlet concentration of both streams so we have go with iterative methods like bisection method. As this method can fulfill our requirement, we must have to choose upper limit and lower limit for this purpose. By using inlet concentration of gas we can predict lower limit of possible solutions. All we have to do is just put inlet concentration of gas in equilibrium equation, we will have lower limit for bisection method and inlet liquid concentration will be upper limit for operation.

For every loop we will have new outlet concentration, and by using this concentration corresponding operating line can be generated. Now using code to obtain number of stages we will have stages that are required to new outlet concentration. We can compare the value with number of stages that column actually have. In figure.2 absorber and stripper operation are represented graphically where x- axis is solute concentration in liquid and y- axis is solute concentration in gas. Same computation can be used for stripping operation. Only we have to change X axis to y axis, thus gas stream will be on x axis and liquid stream is on y axis. Remaining modeling will be same as absorption column.

In graph 2.A, Y1 is concentration of solute in gas outlet, Y2 is concentration of solute in gas inlet and X1 is concentration solute in liquid inlet, X2 is concentration of liquid outlet in graph 2.B, Y1 is concentration of solute in stripant inlet, Y2 is concentration of solute in stripant outlet and X1 is concentration of solute in liquid outlet, X2 is concentration of solute in liquid inlet.

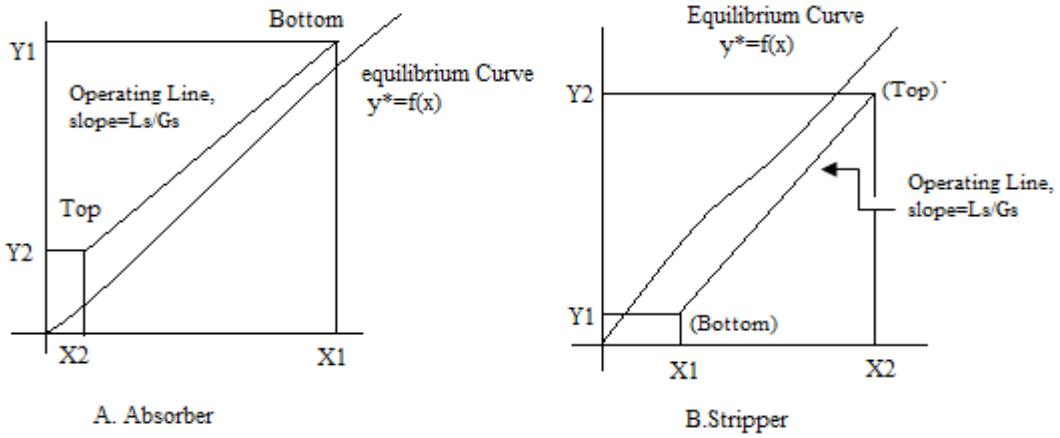

Figure.2: Graphical representation of absorption and stripping operation

If number of stages obtained are more than requirement then we have to shift operating line toward upper limit hence for that we have to change our lower limit, now value of outlet concentration obtained by previous iteration or loop will be our lower limit and value of upper limit will have to change when we have

less number of stages than requirement. Generally iteration of 50-100 will be enough to get good results. We can also check error by putting difference between upper limit and lower limit to ensure about results.

3.3. Outlet concentration of crosscurrent column

Cross current column design can be done by visual basic, as for cross current tower we have new inlet gas stream for every column. And outlet of first column is inlet for second column and operation is repeated again so it is simple to make MATLAB script and check it in visual basic. We just have to use if else loop every time.

4. Comparative Study with MATLAB

As MATLAB is primary tool for computation and despite of having tough competition with python and other advanced languages MATLAB still primary choice for numeric computation but main disadvantage of MATLAB is that it sometime really hard to operate as only experienced personnel can able to generate values for complex models. On other hand visual basic have good graphical user interface and if any process is designed once in visual basic then it is easy to understand to others also. We checked same values obtained for number of stages and outlet concentration in MATLAB we had a negligible deviation. Figure.3 shows graphical user interface of visual basic.

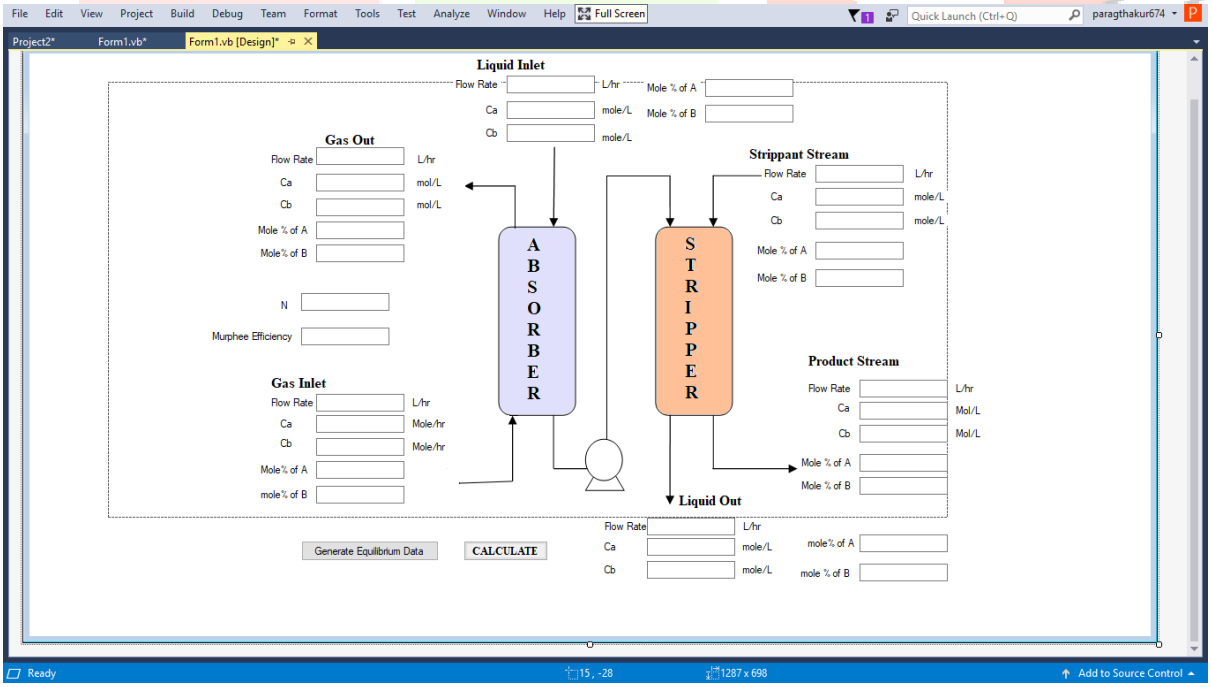

Figure.3: Graphical user interface of visual basic

5. Conclusion

While working with both software packages we interpreted that both have their advantages and disadvantages as GUI is strength of visual basic and numeric computation is strength of MATLAB. Thus, visual basic + MATLAB is best combination and using MATLAB codes in visual basic gives us really great advantages as shown in above to calculate number of stages and to calculate outlet concentration of absorber and stripper.

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