Separation of Xylene Isomers using Stacked Columns

Mohik Modi
Sardar Vallabhbhai National Institute of Technology, Surat
(modim34@gmail.com)

Introduction

Thermal instability of a compound is an important factor to decide the temperature and pressure conditions of the column for separation. When a compound is unstable at certain temperature and tends to degrade before its boiling point, pressure reduction is necessary for the phase separation. But pressures below 0.04 atm in reflux drum are not favorable and less economical. So for the compounds with less thermal stability there should be some other arrangement that should be made. Stacked Columns arrangement is one of those arrangements.

Development of Flowsheet in DWSIM

All the specifications of the unit operations and thermodynamics are elaborated in the literature. So I have used all the specifications as they are. Here, I have used Chao-Seader model as the thermodynamic property package (same is used in literature).

For more details about the unit operation specifications and the stream properties, please refer to the flowsheet and literature.

Purpose of Study

There are few systems whose separation becomes difficult due to thermal instability i.e. there is always pressure and temperature constraints at top and bottom of the column. In this flowsheet we have taken a similar example. Here we are feeding an equimolar mixture of ortho and meta-xylene. This flowsheet helps us know what can we do in order to maintain a certain temperature at top and bottom of the column. Here we use 3 columns in series because of limited temperature bandwidth available to us i.e. here we have to operate only between 350 – 320^{o}C. This helps us more efficient use of energy but also on the other hand significantly increases the capital cost.

Description of Flowsheet

A fresh feed of equimolar mixture of o-xylene and m-xylene is fed at 100 kmol/h to middle column (reboiled absorber/stripper). At the same time, a stream from the upper column and another stream from the lower column are fed to this column which gives top and bottom product as 69 mol% and 36.8 mol% purity of m-xylene respectively. Vapor product from the top is condensed and pumped to the bottom section of the upper column. Upper column separates this stream into 97.6 mol% pure m-xylene as the top product. The bottom product liquid is again sent to the top section of the middle column. The bottom product from the middle column is sent to the top section of the lower column (reboiled absorber/stripper) which gives 95 mol% o-xylene and rest m-xylene. The top product vapor from the lower column is condensed and pumped to the bottom section of the middle column. Note that in each column top pressure is maintained at 0.041 atm and bottom pressure is at 0.11 atm. Here, low pressure is definitely required because of the thermally instable nature and close boiling points of xylene isomers.

Result

Object	Feed	D1	B1	D3	B2	Pure m-Xylene	Pure o-Xylene	Unit
Flow Rate	100	722.18	697.05	634.814	667.785	54.39	56.378	**kmol/h**
m-Xylene	0.5	0.6902	0.368	0.3962	0.667	0.9756	0.05	**mol/mol**
o-Xylene	0.5	0.3098	0.632	0.6038	0.333	0.0244	0.95	**mol/mol**

References

[1] William L. Luyben, Design and Control of Stacked Column Distillation System, (2014).

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