Benzene–Cyclohexane Separation System Via Extractive Distillation

MehulKumar Sutariya
Sardar Vallabhbhai National Institute of Technology, Surat
Email: mehulsutariya09@gmail.com

Unit System: Pressure-atm; Molar Flow-kmol/hr; Other-SI

Background

Hydrocarbons like Benzene and Cyclohexzane are important raw materials in the petrochemical industry. They often require high-purity Cyclohexane and benzene, Which is widely used in polymer industry, in the synthesis of pharmaceutical intermediates and in many others. Cyclohexane is mainly produced by the hydrogenation of benzene; Due to the high tendency of aromatic hydrocarbons to form an azeotropes with nonaromatics, this reaction often gives us an azeotropes of Benzene and Cyclohexzane. Which must be separated out to obtain highly pure Cyclohexane and Benzene.

The mixer of Cyclohexane and Benzene can not be seperated out by the simple distillation column because of the less difference between their boiling point(near 0.6 K) and same boiling point behaviour of azeotrope.

Extractive Distillation of Close Boiling Compounds

Extractive distillation is the method of separating close boiling compounds from each other by carrying out the distillation in a multiple columns in the presence of an added liquid or liquid mixture.[1] This Liquid or Liquid mixture is known as extractive agent or entrainer. The presence of the entrainer alter the volatility of compounds and thus the degree of separation is increase with the same numbers of plate. This entrainer must have high boiling point than the compounds which are going to separated.

Here, we can also use the pressure swing distillation or heterogeneous azeotropic distillation, but pressure swing distillation is not feasible when the azeotropic composition is insensitive to pressure changes.The extractive distillation can be more energy-efficient than the heterogeneous azeotropic distillation.

Description of Flow-Sheet

The flow sheet contain total two distillation columns named “Extractive distillation column” and “Entrainer recovery column”.Here we use the Sulfolane as entrainer and mixer of Benzene and Cyclohexane as feed.The presence of sulfolane alters the relative volatility between benzene and cyclohexane to make cyclohexane move toward the top part and benzene move to the bottom part of the column.[2] The “Extractive distillation” take entrainer and feed and give the pure Cyclohexane as top product and the bottom product which has the Benzene and Sulfolane are enter to the “Entrainer recovery” column; which separate out Benzene and the Sulfolane, this recovered sulfolane are recycled to the

"Extractive distillation". Feed rate with the composition of compounds and the other necessary data for the column are shown in the table in Result section with the Top and Bottom products.

Result

Table 1: Columns Data

Name	**Extractive distillation**	**Entrainer recovery**
Pressure (atm)	1	0.08
Total Stage	29	10
Feed (kmol/hr) (%mol/mol) (%mol/mol) (%mol/mol)	100 Benzene(50%) Cyclohexane(50%)	160 Benzene(31.2%) Cyclohexane(0.1%) Sulfolane(68.7%)
Feed Stage	20 from top	5 from top
2nd Feed(kmol/hr) (%mol/mol)	110 Sulfolane(100%)	-
2nd Feed Stage	4 from top	-
Top(kmol/hr) (%mol/mol) (%mol/mol)	50 Benzene(0.1%) Cyclohexane(99.9%)	50 Benzene(99.95%) Cyclohexane(0.05%)
Bottom(mol/hr) (%mol/mol) (%mol/mol) (%mol/mol)	160 Benzene(31.2%) Cyclohexane(0.1%) Sulfolane(68.7%)	110 Sulfolane(100%)

References

[1] Lloyd Berg; "Separation Of Benzene From Close Boiling Hydrocarbons By Extractive Distillation",United States Patent - 5458741; 1995

[2] Jiwei Qin, Qing Ye, Xiaojuan Xiong and Ning Li; "Control of Benzene–Cyclohexane Separation System via Extractive Distillation Using Sulfolane as Entrainer", Ind. Eng. Chem. Res; 2013

compiled in LaTeX