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

Background

Ethanol produced from renewable energy sources(like fermentation of sugars derived from crops containing starch, such as corn, wheat, sugar cane, sorghum plants, etc.) is one of the most promising biofuels for the future. Fermentation broth contain water and ethanol, which can not be completely separated by the simple distillation because their tendency to create a Azeotrope. For that so many solution are there like pre-evaporation, Entrainer-assisted distillation columns etc. But there is also one option is available to remove a water from the final concentrated Azeotropic solution by appropriate reaction in distillation column.

Description of Flow-Sheet

In this flowsheet we use two chemsep column at different pressure; In first column the broth with flow rate of 1700 kmol/hr (5 mol% ethanol,95 mol% water) are concentrated to the 85 mol% ethanol and 15 mol% water and the excess water are removed from the bottom. This concentrated stream are feed to the next column where one extra feed stream of the Ethylene Oxide with the same flow rate of water in concentrated stream are provided.
This ethylene oxide are react with the water present in the concentrated stream and produce ethylene glycol.

Ethylene Oxide + Water $\rightarrow$ Ethylene Glycol

Rate of this homogeneous reaction[1] are given by

$r(kmolm^{-3}s^{-1}) = 3.15 \times 10^{12}\ exp[-9547/T]$

to use this equation in chemsep; We have to convert it into the available equation format, Here we choose equation number 119,
$y = exp(a/t + b + ct + dt^2 + eln(t))$
(a, b, c, d, e *are constant and the* t *is temperature*) now we convert our rate equation in this form and we got $a = -9754$, $b = 28.8838$ and $c, d, e = 0$.

	pre-concentrator	reactive
Number of Stages	44	17
Feed stages	30 (broth)	12 (concentrated) 15 (ethylene oxide)
Pressure (atm)	1	4.5

Result

From reactive column we got near about 99.9 mol% ethanol from the top and nearly 96 mol% pure ethylene glycol from the bottom.

Recommendations

Reaction rate and the flow rate of ethylene oxide are going to effect the performance of the column. Small change in flow rate of ethylene oxide are able to create large deviation in the purity of product and working of column.

References

[1] Devrim B. Kaymak;"Design and Control of a Separation Process for Bioethanol Purification by Reactive Distillation",Computer Aided Chemical Engineering, Volume 40, 2017, Pages 1075-1080

compiled in LaTeX