Pressure Swing Distillation of Benzene and Ethanol

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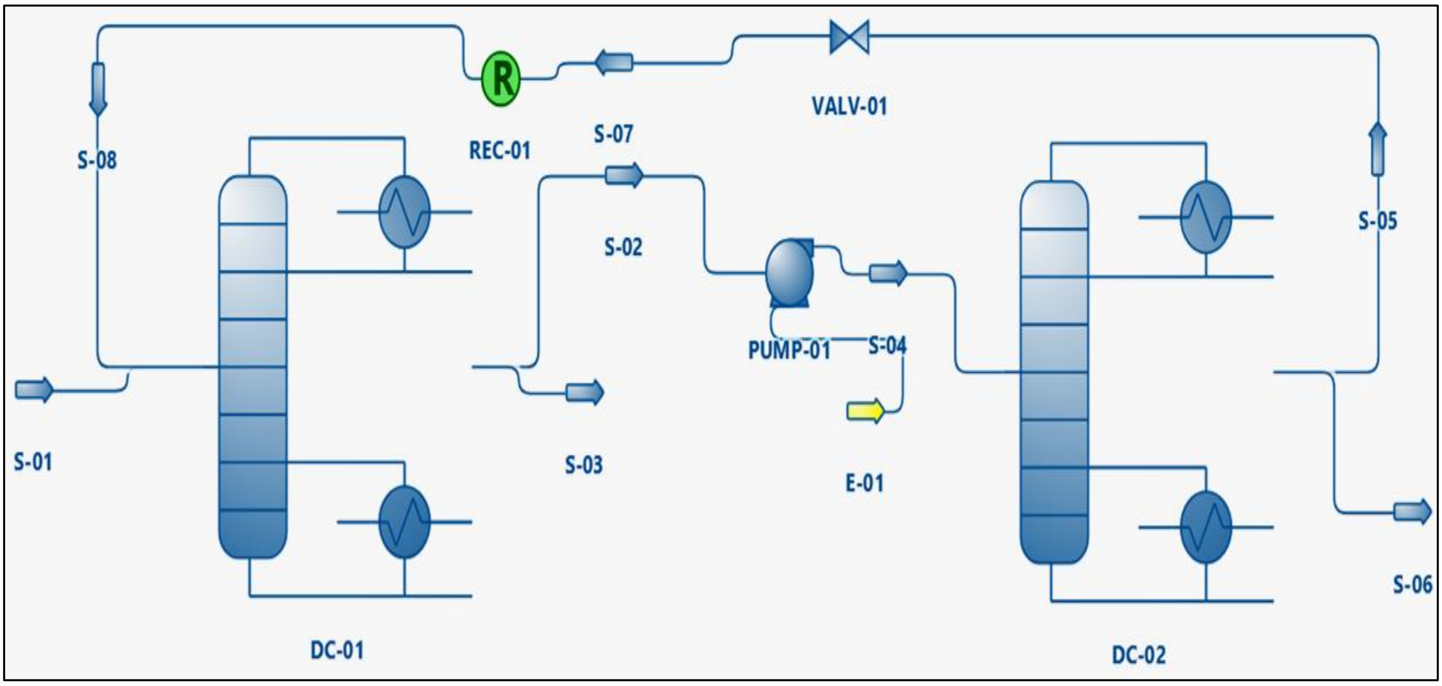
Background: Benzene and ethanol are industrially important solvents that have numerous applications in our daily life. They are used for making resins, plastics, fibers dyes, drugs and lubricants. Separation of any components of mixtures (i.e. Benzene and ethanol) is essential and distillation is one such direct separation technique, which uses heat to separate the components in the mixtures. But, when the mixture shows high deviation from Raoult's law and if it has close boiling point compounds then the system exhibits relative volatility close to one, this result in the formation of a special class of mixtures called azeotropes. Conventional methods of distillation cannot be used for the separation of azeotropes.

Benzene - Ethanol azeotropic mixture at a composition of 55% benzene - 45% ethanol, at a pressure of 101.32 kPa and a temperature of 341.2 K forms a homogenous, minimum boiling azeotrope. Since benzene ethanol azeotrope shows a pressure-sensitive behaviour. Any change in pressure can have a significant effect on the vapour-liquid equilibrium compositions; hence pressure swing distillation can be a suitable and attractive technique for the separation of benzene ethanol mixture.



Optimized Flow sheet of Pressure Swing Distillation for Benzene – Ethanol System

Description: Pressure swing distillation was performed with two columns operating at a pressure of 1 atm and 15 atm. The azeotropic feed was fed to the first column operated at 1 atm pressure and at 68.2 °C temperature having 35 theoretical trays and the feed of 55% benzene, 44% ethanol was provided at the 16th stage and the recycle feed is given at the 6th stage with 69.9 °C temperature and 1 atm pressure. The distillate stream composition was found to have a 55% mole fraction of benzene, 44% mole fraction of ethanol and the bottom stream composition had a 99% mole fraction of benzene. The first column distillate stream was pressurized using a pump and the same pressurized distillate stream was provided as a feed at the 16th stage to the second column which was operated at a pressure of 15 atm. The high-pressure distillate stream from the second column was found to have a 29% mole fraction of benzene, 70% mole fraction of ethanol and further the stream pressure at 15 atm was reduced using a pressure control valve and the pressure was brought to 1 atm. The same stream was used as a recycle stream to the first column. The bottom stream product from the second column had a 99% mole fraction of benzene.

Master Property Table									
Object	S-08	S-07	S-06	S-05	S-04	S-03	S-02	S-01	
Temperature	69.9438	69.9438	202.648	164.087	68.3943	78.6149	67.7535	68.2	C
Pressure	1.01325	1.01325	15.1988	15.198	15	1.01325	1.01325	1.01325	bar
Mass Flow	6601.67	6601.67	5265.91	6601.67	11867.6	2514.77	11867.6	7834.15	kg/h
Molar Flow	118.632	118.632	67.4703	118.632	186.102	54.5686	186.102	123	kmol/h
Molar Fraction (Mixture) / Benzene	0.298965	0.298965	0.998	0.298965	0.552396	0.0005	0.552396	0.55	
Molar Fraction (Mixture) / Ethanol	0.701035	0.701035	0.002	0.701035	0.447604	0.9995	0.447604	0.45	

Master Property Table for Pressure Swing Distillation Flow sheet of Benzene Ethanol System

Reference: Park, Hoey Kyung, KIM, DONG SUN, & CHO, JUNGHO. (2015). Computational simulation of pressure conversion distillation process for separation of Ethanol-Benzene azeotrope. *Korean Chemical Engineering Research* , *53* (4), 450–456. https://doi.org/10.9713/KCER.2015.53.4.450