Separation of Isopentane-Methanol Azeotropic mixture using Pressure Swing Distillation

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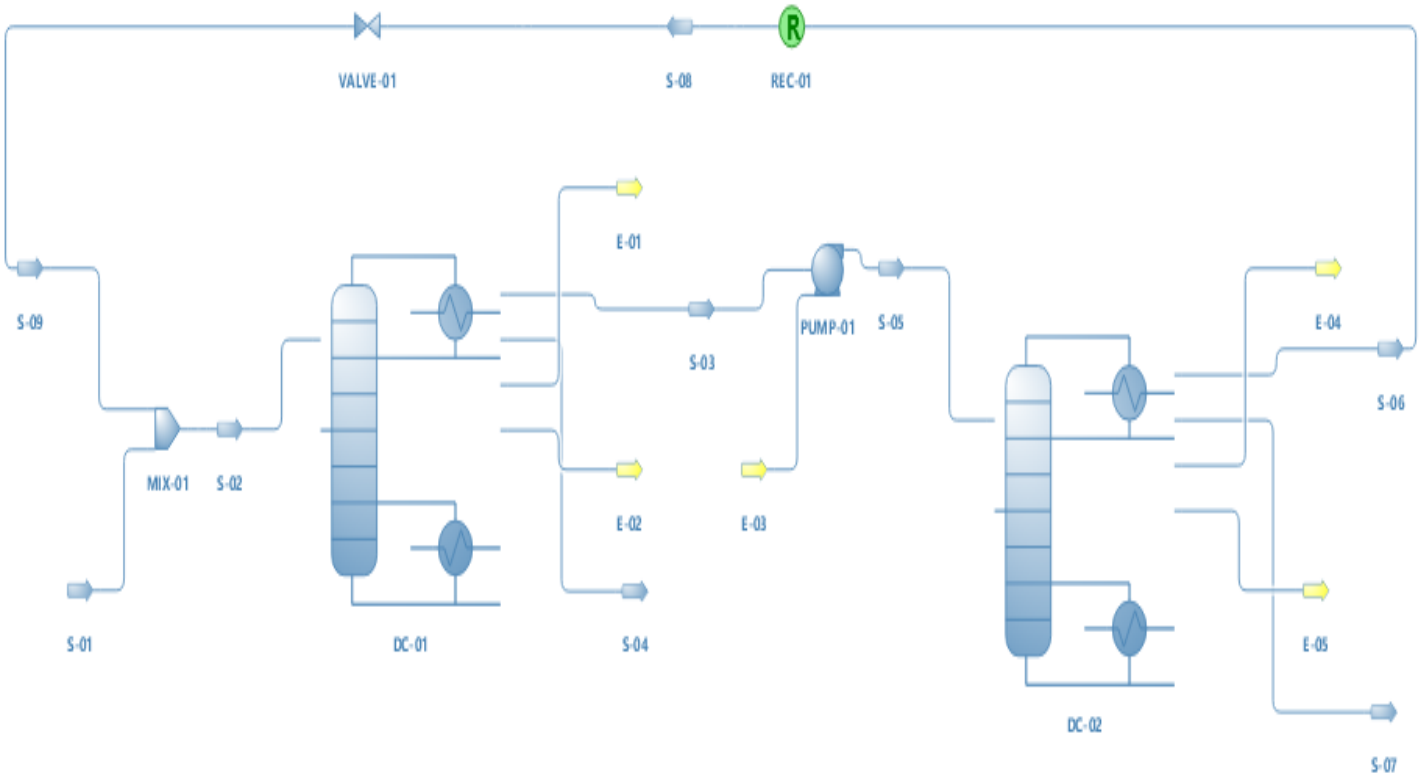
Background:

Some of the typical industrial technologies to produce tert-amyl methyl ether (TAME), an ordinary gasoline oxygenated additive, require an advanced purification process for methanol recovery from the reactor effluent. This process is essential due to the presence of the iC5-methanol minimum boiling point azeotrope in the mixture. Pressure-swing distillation (PSD) is a widely used unit operation, an efficient method for separating pressure-sensitive azeotropic mixtures in chemical processes vital on an industrial scale. However, the major hurdle with distillation units is the energy-intensive nature for chemical separation facilities, reaching in some cases 95% of the total energy cost. But, PSD doesn't need an entertainer for separation, which can add additional costs for solvent. Thus, PSD becomes an economical alternative for separating azeotropic mixtures for larger time-scale and large chemical separations compared to competing technologies. The PSD concept is based on the fact that the azeotropic mixture only needs to exhibit sensitivity to pressure variation, which means that a simple increase or decrease in pressure can change the relative volatilities of the components with close to boiling points. In our case, the azeotropic mixture of methanol and iC5 is less sensitive towards pressure changes. The property package being used for the setup is UNIFAC, which was found to give the least deviation from actual property values.

Description of the flowsheet:

The flowsheet contains two Distillation Columns, DC-01 and DC-02. These two columns are used for separating Isopentane and Methanol Azeotropic Mixture. DC-01 is the low-pressure column or Methanol recovery column, the number of trays is ten, and the feed tray is 3. The Pressure of DC-01 is 2 bars. A Pump-01 is installed for increasing the pressure to 10 bars for feed flow to the High-pressure column. Since there is a pressure shift from 2 bars to 10 bars, there is a shift in azeotropic composition. The larger the shift is, the lower the recycling flow rate and the energy consumption in the two reboilers. DC-02 is the high-pressure column or Isopentane recovery column, the number of trays is ten, and the feed tray is 3. A recycling block is inserted for recycling operations—the valve functions as a pressure-reducing valve as it reduces the pressure to 2 bars.
The purity of Methanol in DC-01 is 99.9%, and that of Isopentane in DC-02 is 99.99%. The products are obtained in Bottoms (S-04 and S-07) of both the Columns.

Flowsheet:



Results:

Master Property Table										
Object	**S-09**	**S-08**	**S-07**	**S-06**	**S-05**	**S-04**	**S-03**	**S-02**	**S-01**	
Temperature	355.661	375.038	388.883	375.038	317.738	355.284	317.449	348.373	341	**K**
Pressure	2	10	10	10	10	2	2	2	2	**bar**
Mass Flow	68595	68401	58341.9	68401	126743	10158.1	126743	136901	68305.9	**kg/h**
Molar Flow	1170.94	1167.63	808.679	1167.63	1976.31	316.628	1976.31	2292.94	1122	**kmol/h**
Volumetric Flow	17312.1	118.695	115.619	118.695	204.11	13.8888	204.407	33206.1	15904.8	**m3/h**
Molar Fraction (Mixture) / Isopentane	0.661713	0.661706	0.9999	0.661706	0.80009	0.001	0.80009	0.689745	0.719	
Molar Fraction (Mixture) / Methanol	0.338287	0.338294	0.0001	0.338294	0.19991	0.999	0.19991	0.310255	0.281	

Reference: https://doi.org/10.1007/s41660-020-00115-w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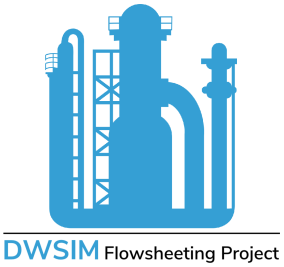
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