Triple Column Pressure Swing Distillation (TCPSD) of Ternary Azeotropic Mixture of Iso-propanol, MEK (Methyl Ethyl Ketone) and Ethanol

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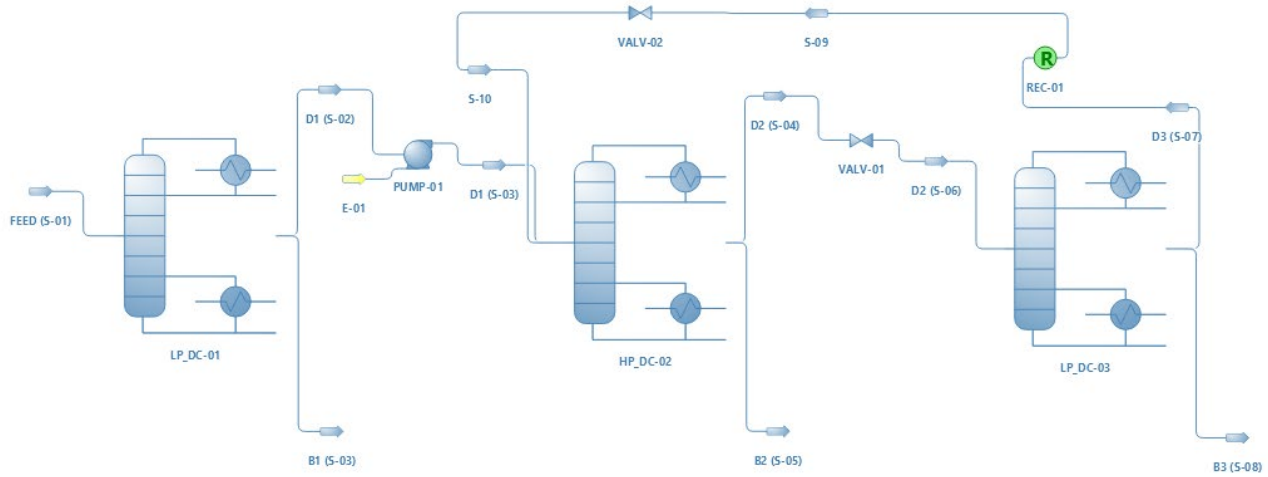
Background & Description (Flowsheet):
Methyl Ethyl Ketone (MEK), Iso-propanol (IPA), and Ethanol (Et-OH) are important chemicals and widely used as intermediates solvent in many chemical processes. MEK, Iso-propanol and Ethanol are generated in the Fischer – Tropsch Synthesis. There is a necessity for the effective separation & recovery of those industrial-grade solvents to conserve the resources and protect the environment. The boiling points of three pure components are very close and the maximum temperature difference is 3.74 K. Under atmospheric and high pressures, the MEK/ IPA/ (Et-OH) mixture forms two binary pressure-sensitive azeotropes of MEK-IPA and MEK-(Et-OH) and its residue curve maps (RCMs) present one distillation boundary. However, conventional distillation cannot achieve the separation of three components effectively due to the close boiling points, the existence of different azeotropes and distillation boundaries.

Pressure-swing distillation (PSD) is the process used to separate the pressure-sensitive mixture with close boiling point or forming azeotrope. It is based on the principle of shifting the physio-chemical compositions by changing the operating pressures which alters the relative volatility of mixture thereby, breaking the azeotrope.
Thermodynamic Model used – NRTL
Custom Unit (C5) – Temp (K) and Pressure (atm)

In the following flowsheet, a triple-column operating with different pressures has been employed. The FEED stream (S-01) with 10% IPA, 70% MEK and 20% Et-OH enters the first low-pressure column (LP_DC-01) at 19th stage operating at pressure of 0.1 atm. The first bottom product stream B1 (S-03) comprising 99.3% IPA is obtained whereas, the distillate D1 (S-02) stream obtained is pumped to high pressure of 5.8 atm enters the second high-pressure column (HP_DC-02) at 22nd stage as FEED operating at pressure of 5.8 atm. A recycle stream (S-10) also enters the (HP_DC-02) at 17th stage. The second bottom product stream B2 (S-05) comprising 99.9% MEK is obtained whereas, the distillate D2 (S-04) stream obtained is sent to a valve (VALV-01) to decrease the pressure to 0.4 atm and then enters the third low-pressure column (LP_DC-03) at 13th stage as FEED operating at pressure of 0.4 atm. The third bottom product stream B3 (S-08) comprising 99.3% Et-OH is obtained whereas, the distillate D3 (S-07) stream obtained is recycled back to (HP_DC-02) at 17th stage as mentioned earlier.

Note: - All percentage compositions mentioned above are on basis of mole fractions.



Results:

Master Property Table					
Object	**FEED (S-01)**	**B3 (S-08)**	**B2 (S-05)**	**B1 (S-03)**	
Temperature	313.15	329.873	420.162	306.982	**K**
Pressure	0.1	0.4	5.8	0.1	**atm**
Mass Flow	1000	140.641	766.856	91.9669	**kg/h**
Molar Flow	15.2214	3.04084	10.639	1.53286	**kmol/h**
Volumetric Flow	3911.1	0.185866	1.16988	0.118861	**m3/h**

References: - M. Li, Y. Ma, X. Zhang, T. Zhao, Z. Zhu, Y. Wang, Triple Column Pressure-Swing Distillation for Ternary Mixture of Methyl Ethyl Ketone /Isopropanol /Ethanol, Chemical Engineering Transactions. 61 (2017) 649-654. doi:10.3303/CET1761106.