TAME Production using Reactive Distillation and Pressure Swing Column

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Background & Description:

Introduction

tert-Amyl Methyl Ether abbreviated as TAME, is a type of ether which is a member of oxygenated fuel additive family. Its main purpose in chemical industries is to oxygenate gasoline, enhance octane, and to replace the banned tetraethyl lead. TAME could significantly help reduce exhaust emissions of some volatile organic compounds and it also could help in reducing gasoline losses from evaporation. TAME is usually produced by reacting methanol with 2-methyl-1-butene and 2-methyl-2-butene in plug flow reactors. The reactions are reversible hence one of the reactant is usually added in excess, to increase the productivity of TAME.

2M1B + MeOH ⇌ TAME (Esterification)
2M2B + MeOH ⇌ TAME (Esterification)
2M1B ⇌ 2M2B (Isomerization)

Flowsheet description

In this flowsheet, the stated reactions are converted using a fixed conversion reactor to increase TAME in the output. This output is then fed to a reactive distillation column along with excess methanol. In the bottoms, the TAME produced is collected. While in the distillate, the other components (majorly methanol) are then fed to an azeotropic distillation column where more than 99% of mole fraction of methanol is recovered from the bottom which is then sent back for recycling to the feed stage. Distillate of the column is fed to another azeotropic distillation column for further separation of C5 components. The distillate of this column is then recycled back to the preceding azeotropic distillation column for further separation of methanol. Meanwhile the bottoms, collect the C5 components. For input values of all the columns, relevant material streams and other unit operations I have referred the paper of Al-Arfaj et. al, more precisely Table 3, Table 4 and Table 5.

Results:

In the simulation, Methanol recovered was more than 99.99%(mole) of the fed value. TAME recovered from the Reactive Distillation column was around 41 %(mole). Also the azeotrope formed by methanol with the other components was also able to be recovered by Azeotropic Distillation columns.

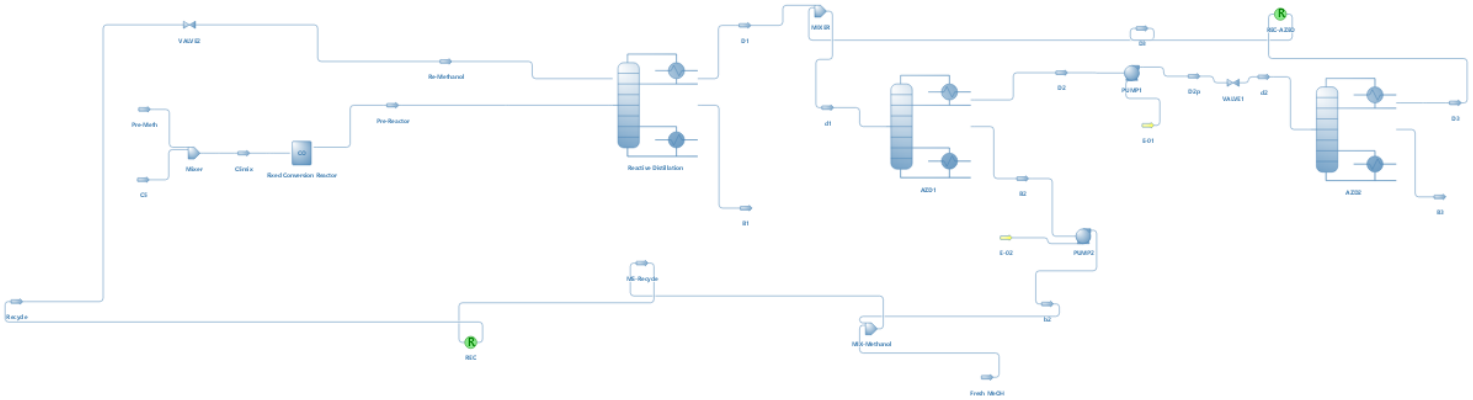
Recommendations:

Although this is the conventional method of producing TAME, new methods using integrated RDWC + PS Columns have been proposed [1]. With the newer methods we can produce TAME in a cost effective and more efficient manner.

References:

1. **Figure 1, Yang et. al**
2. **Table 3,4,5 Al-Arfaj et. al**

Flowsheet:



Results:

Material Stream Property Table								
Object	Re-Methanol	Pre-Meth	Fresh MeOH	C5	B3	B2	B1	
Molar Flow	503.41	313	230.41	956.704	806	273	300	kmol/h
Molar Fraction (Mixture) / Methanol	0.999989	1	1	0	0.18468	0.999949	0.583432	
Molar Fraction (Mixture) / 2-methyl-1-butene	6.24889E-07	0	0	0.0894739	0.0419898	3.20234E-06	7.39592E-10	
Molar Fraction (Mixture) / 2-methyl-2-butene	1.11006E-06	0	0	0.172258	0.0838447	5.71757E-06	2.85585E-07	
Molar Fraction (Mixture) / Methyl tert-pentyl ether	3.52568E-06	0	0	0.000108707	0.000411979	1.07269E-05	0.416567	