Steady State Simulation of Separation Column for Propylene-Propane Mixture

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INTRODUCTION

Propylene is one of the most significant intermediate petrochemical products. The blend of propylene, propane, C-5 fraction, hexane, water, hydrogen, N_2 and some other constituents from a petrochemical plant are the raw material. Due to necessity of a high purity feed stream propylene has to be separated from propane and the other impurities in the separation column. The simulation of the propane-propylene separation column was carried out using DWSIM simulation engine, to determine the effect of the main operating parameters on the product composition. The similarities in physical and chemical properties between the molecules lead to separation of propylene from mixture being problematic. Due to the high product purity and the low relative volatility, the number of stages required generally for this separation is very high. The process requires high capital cost and energy consumption. To maximize profit, as energy prices rise, energy efficiency, together with optimizing product quality and maximizing high–value product yields have become more important. Thus, modification of propane/propylene separation process can highly affect the economics of the whole production system.

FLOWSHEET

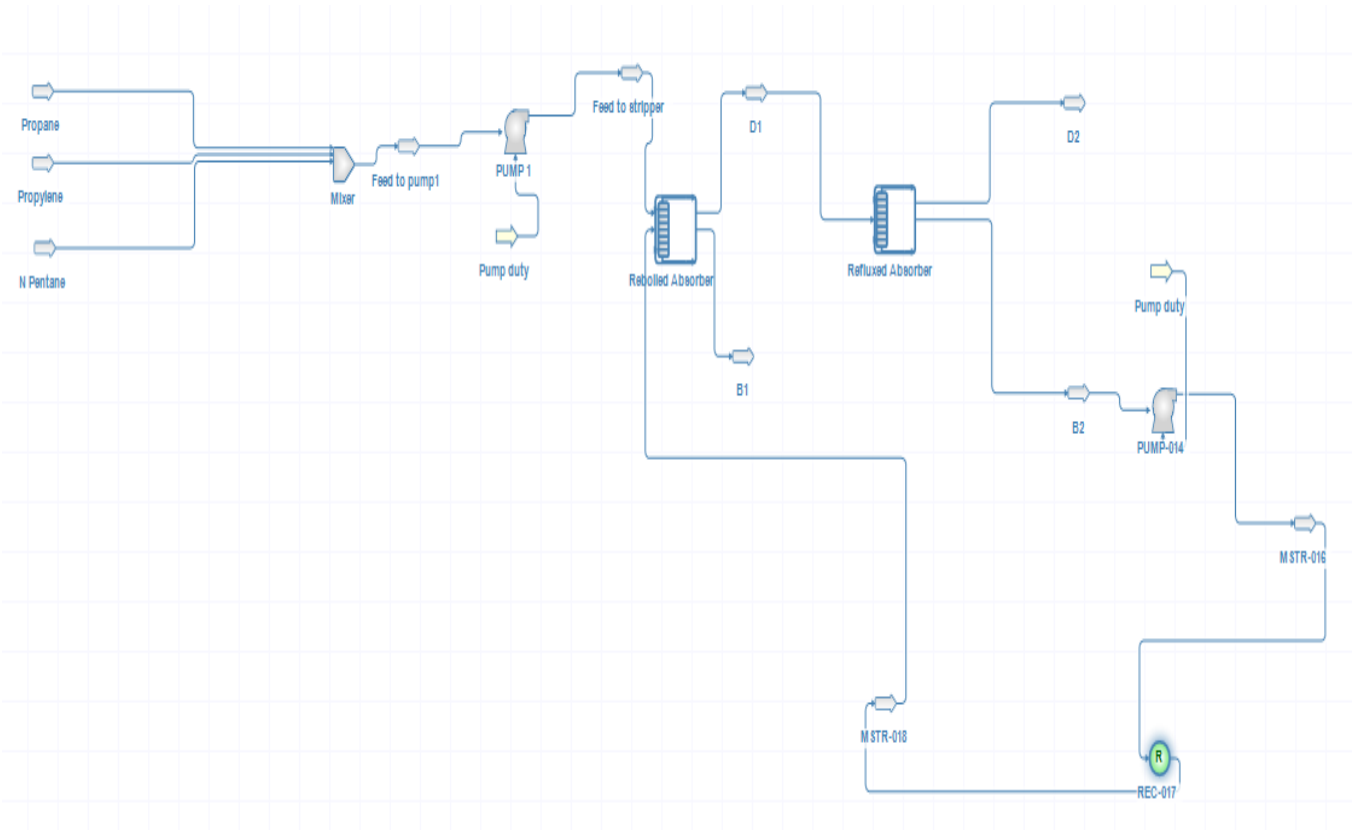

Figure 1. Simulation in Dwsim software

PROCESS DESCRIPTION

The Soave—Redlich—Kwong which is an equation of state thermodynamic property model is selected for the simulation.

The ternary feed mixture of Propane, Propylene and n-Pentane mixture is fed into the mixer at a molar flow rate of 45.2385, 79.012 and 1.2599 mol/s respectively, temperature of 310.92 K, and pressure of 1999 kPa. The pump is employed to increase the pressure to 2137kPa. The feed then enters at 70^{th} stage of stripping column (Reboiled absorber) which has a total of 100 stages and maintained at top pressure of 1931 kPa and bottom pressure of 2068 kPa with a pressure drop of 0.2 psia. Due to the high product purity and the low relative volatility, the number of stages required for separation is very high.

The distillate has a mole fraction of 0.5295 Propylene and 0.4704 Propane which is further sent to the Refluxed Absorber of 120 stages. 0.9900 mole fraction of Propylene is distilled out. Also the bottom stream with a mole fraction of 0.5039 Propylene and 0.4960 Propane is recycled back to the Reboiled Absorber. Thus Propylene is separated from the feed mixture and 99% product purity is obtained.

RESULTS

Table 1. Master Property Table for the feed mixture.

Table 1					
Object	Propylene	Propane	N Pentane	Feed to stripper	
Temperature	310.927777777778	310.927777777778	310.927777777778	311.085228973729	K
Pressure	1999475.999393	1999475.999393	1999475.999393	2137000	Pa
Molar Flow	79.0120889645126	45.2385196271855	1.25997825690929	125.510585588629	mol/s
Mixture Density	482.576505058557	474.796001877277	546.535456237209	481.441427272339	kg/m3
Molar Fraction (Mixture) / Propylene	1	0	0.333333	0.632871569551654	
Molar Fraction (Mixture) / Propane	0	1	0.333333	0.363782160248581	
Molar Fraction (Mixture) / N-pentane	0	0	0.333333	0.0033462701997654 7	

Table 2. Master Property Table for the pump.

Table 2		
Object	PUMP 1	
Pressure Increase (Head)	137524.000607	Pa
Efficiency	100	
Delta-T	0.162860733390289	K.
Power Required	1.53945017127486	kW

Table 3. Master Property Table for the streams in and out of the Reboiled Absorber.

Table 3				
Object	Feed to stripper	D1	B1	
Temperature	311.085228973729	323.635734857725	336.135990140144	K
Pressure	2137000	1930532	2271822.521	Pa
Molar Flow	125.510585588629	1403.64555934	42.845855285588	mol/s
Mixture Density	481.441427272339	42.7838947868101	425.309871495038	kg/m3
Molar Fraction (Mixture) / Propylene	0.632871569551654	0.52958693586523	0.04	
Molar Fraction (Mixture) / Propane	0.363782160248581	0.47041306413477	0.95019759716182	
Molar Fraction (Mixture) / N-pentane	0.00334627019976547	1.6140626067554E-21	0.0098024028381831	

Table 4. Master Property Table for the streams for the top and bottom streams of the Refluxed Absorber.

Table 4			
Object	D2	B2	
Temperature	318.747373131745	323.902427095101	K
Pressure	1896058	1942943.1444	Pa
Molar Flow	74.069241356896	1329.5763179831	mol/s
Mixture Density	463.354208237588	451.332490635698	kg/m3
Molar Fraction (Mixture) / Propylene	0.99000000000002	0.50393811401091	
Molar Fraction (Mixture) / Propane	0.01	0.49606188598909	
Molar Fraction (Mixture) / N-pentane	6.5438565027954E-20	4.4797164853558E-21	

Table 5. Master Property Table for the Recycle stream.

Table 5		
Object	MSTR-018	
Temperature	324.231046171099	K
Pressure	2137000	Pa
Molar Flow	1329.5763179831	mol/s
Mixture Density	452.44801159245	kg/m3
Molar Fraction (Mixture) / Propylene	0.50393811401091	
Molar Fraction (Mixture) / Propane	0.49606188598909	
Molar Fraction (Mixture) / N-pentane	4.4797164853558E-21	

REFERENCE

1. Amiya K. Jana “Process Simulation and Control Using Aspen”, 2nd edition, Prentice-Hall, New Delhi. (ISBN: 978-81-203-4568-3)