Process Development for the Production of 10 TPD of Sulfur Trioxide from Sulfur Dioxide

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A. Background

Sulfur trioxide is an industrially important chemical used in the manufacture of Sulfuric acid. Gaseous Sulfur Trioxide is odorless and extremely corrosive. Liquid Sulfur trioxide is transparent and the solid form of Sulfur trioxide is crystalline in nature [1].

B. Description of Flow Sheet

This flow sheet was adapted from Shreve (1956) [2].

The feed containing Sulfur dioxide and Oxygen was first pre-heated to the reaction temperature i.e., 560°C. The pre-heated mixture was then fed to an equilibrium reactor where oxidation of gaseous Sulfur dioxide takes place to produce Sulfur trioxide. The exit stream which contains gaseous Sulfur trioxide, unreacted Sulfur dioxide and Oxygen was cooled to 75°C and then fed to a distillation column. In the distillation column gaseous Sulfur trioxide was obtained as bottom product and the rest as distillate. Then the bottom product was cooled to room temperature and sent to a storage vessel.

C. Results

The process flow sheet was simulated for a typical capacity of 10 TPD of Sulfur trioxide at a temperature of 560°C and at 1.01325 bar pressure. A shortcut distillation column was simulated to calculate the actual number of stages, minimum reflux ratio for the given light key and heavy key compositions and optimal feed stage location. Sulfur dioxide was taken as the light key component and Sulfur trioxide as the heavy key component. The light key composition was fixed at 0.01 in the bottom stream and the heavy key composition was fixed at 0.1 in the distillate stream and the reflux ratio was assumed to be 5 for the shortcut column. The shortcut column was simulated and a minimum reflux ratio of 4.54 and actual number of stages equal to 12 were obtained as results. The results obtained from the shortcut distillation

column were used to specify the input parameters required for the simulation of a complex column using CAPE-OPEN Unit Operations. The complex column was operated at a constant pressure of 1.01325 bar. Reflux ratio of 5 was assumed for the column and the mole fraction of Sulphur trioxide in the bottom stream was specified as 0.99. Additionally, the complex column was simulated with a partial condenser and a partial reboiler. Thus the desired product flow rate of 419.77 kg/h was obtained which corresponds to approximately 10 TPD of Sulfur Trioxide.

Results				
Object	S-1	S-7	S-8	
Temperature	25	25	25	C
Pressure	1.01325	1.01325	1.01325	bar
Mass Flow	500	80.22677	419.77271	kg/h
Molar Flow	9.3488671	1.4836683	5.2535152	kmol/h
Molar Fraction (Mixture) / Sulfur dioxide	0.67	0.66580829	0.01	
Molar Fraction (Mixture) / Oxygen	0.33	0.3191027	6.1139409E-17	
Molar Fraction (Mixture) / Sulfur trioxide	0	0.015089006	0.99	

D. Conclusion and Recommendation

This simulation carried out shows that DWSIM serves the purpose of an open source simulator for simulating process and development of process flow sheets. This work can also be extended to simulate production of Sulfuric acid by absorption of Sulfur trioxide in water. In the future, recycle of unreacted Sulfur dioxide and Oxygen can also be done in order to increase the productivity of the process.

Unit System: (Custom 5 in DWSIM)

Temperature - °C

Pressure - bar

Molar Flow Rate – kmol/h

Mass Flow Rate – kg/h

Volumetric Flow Rate – m3/h

Density – kg/m3

References

1. https://en.wikipedia.org/wiki/Sulfur_trioxide

2. Shreve R. N., The Chemical Process Industries, 2nd Edition, Mc Graw Hill, 1956, p 384