Production of 1400 TPD of Ethylbenzene by Liquid Phase Alkylation of Benzene

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A. Introduction

Ethylbenzene is a colorless and flammable liquid. Ethylbenzene is used primarily in the production of styrene and synthetic polymers. It is also used as a component of automotive and aviation fuels. It is a precursor for many chemicals such as acetophenone, cellulose acetate, diethyl-benzene, ethyl anthraquinone, ethylbenzene sulfonic acids, propylene oxide, and alpha-methyl benzyl alcohol. Production of ethylbenzene can be accomplished by different routes such as, from mixed xylenes by isomer separation and catalytic isomerization, 1,3-butadiene in a two-step process, the zeolite-based process using vapor/liquid/mixed phase alkylation, etc. North America and China are the major producing countries all over the world. In India, Petrochemical industries such as Reliance petrochemicals, IOCL (Panipat), Haldia are the leading producer of ethylbenzene. This process flowsheet is developed as part of the Chemical Engineering final semester project work.

B. Process Flow Sheet Description

The process flowsheet involves the reaction of ethylene and benzene in a conversion reactor. The reaction is highly exothermic with the formation of Ethylbenzene. The reactor was maintained at 210 ºC and at a pressure of 20 bar in order to keep the benzene in the liquid phase. SRK model was chosen for the process. Fractional conversion of the base component, ethylene was assumed as 0.9 for the simulation. Three distillation columns were used to separate the desired component with maximum purity as well as quantity. Sensitivity analysis of a flash column was done to find the operating window followed by converting it to a shortcut column. The reactor outlet was sent to the shortcut column-1 (B-04). Light key and heavy key mole fractions in the bottom and distillate were given as input. Further, two shortcut columns were used in order to increase the purity of ethylbenzene. The heat exchangers that is coolers/heaters were used appropriately wherever necessary. A recycle block was added to the flowsheet in order to recover the lost EB from process streams.

C. Results and Discussion

The process flowsheet was simulated for a plant capacity of 1400 TPD of EB of 98% purity. Fractional conversion of ethylene was assumed to be 0.9. Sensitivity analysis for the flash column was done in order to find the operating temperature and pressure of the shortcut column. Ethylene was the light key compound and Ethylbenzene was the heavy key compound. The light and heavy key mole fraction was taken from the flash results. Such as, light key mole fraction in bottom was 0.07539 and heavy key mole fraction in the distillate was 0.1148 for the shortcut column -1(B-04). Light key mole fraction in bottom was 0.00611 and heavy key mole fraction in the distillate was 0.4758 for the shortcut column -2 (B-06). Light key mole fraction in bottom was 0.00015 and heavy key mole fraction in the distillate was 0.7613 for the shortcut column -3 (B-08). It was observed that 5131 kg/h of ethylbenzene and 2023 kg/h of ethylbenzene was lost in stream S-08 and S-11 of shortcut column 2, and 3 (B-06 and B-08) respectively. In order to recover the ethylbenzene, a recycle block and a mixer equipment was added to the process flowsheet. The stream S-13 was from the mixer (B-09) after the recycle which was sent to the reactor along with the feed ethylene and benzene. This found to have an increase in the product purity.

D. Future Work

In the present work the simulation of shortcut columns showed error for certain critical parameters such as minimum reflux ratio and number of stages. Further analysis is required to know the reasons for these errors and convert shortcut columns into rigorous distillation columns. Integration of energy streams shall also be carried out as a prospective candidate for energy conservation and better energy usage.