

PRODUCTION OF ETHYL CHLORIDE USING RECYCLE STREAM

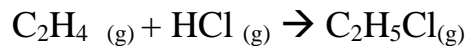
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INTRODUCTION:

Chloroethane, better known as ethyl chloride, is used in the production of tetraethyl lead, a gasoline additive. It is a colourless, flammable gas or refrigerated liquid, mainly employed as a chemical intermediate in solvents, aerosols, and anaesthesia. It is used as a blowing agent in foamed plastics, in the production of ethyl cellulose and acts as an ethylating agent in the manufacture of dyes, chemicals and pharmaceuticals. Earlier it was formed as a by product in vinyl chloride synthesis but presently it is exclusively manufactured for a number of applications [1].

The gas phase reaction of ethylene with hydrogen chloride to form chloroethane is an addition reaction. It proceeds with almost no by-products or side reactions and it has a high selectivity for the mono-chlorinated product (chloroethane). The chemical reaction is represented by the following equation:



PROCESS DESCRIPTION:

Ethyl chloride is produced by the gas phase reaction of HCl with ethylene over a copper chloride catalyst and this is a highly exothermic reaction. The production of ethyl chloride is assumed to be a steady state process. A feed stream composed of 50 mole-percent HCl, 48 mole-percent ethylene and 2 mole-percent nitrogen at 100 kmol/hour, 25°C and 1 atm pressure enters the reactor (conversion reactor).[2]

A conversion of 96 percent was achieved and hence the unreacted reactants are to be separated from the product which is a gas . The separation of ethyl chloride from the unreacted reactants was achieved by compression to 20 bar followed by cooling to 20°C which would result in two phase formation with ethyl chloride being in liquid phase. The more volatile reactants after cooling can be easily separated from the liquid ethyl chloride. This separation was achieved using a gas-liquid separator. The unconverted reactants, namely, ethylene, HCl and nitrogen were recycled back to the mixer. To prevent the accumulation of inerts in the system, a proportion of the recycle stream was withdrawn as a purge stream.

NRTL property package was chosen to carry out the simulation.

System of units chosen – C5

Temperature - °C

Pressure – bar

Mass flow – kg/h

Mole flow – kmol/h

RESULTS:

The simulation results of the main streams were shown in Table I. The reactor outlet is a gas phase stream composed of ethyl chloride and other unreacted reactants. To separate ethyl chloride from unreacted reactants, the stream was compressed and cooled to facilitate the formation of liquid ethyl chloride.

TABLE 1 : Result table showing individual component flow rates in various streams

FLOW RATE OF MATERIAL STREAMS (KG/H)				
COMPOUNDS	FEED	REACTOR OUTLET	G-L TOP	G-L BOTTOM
ETHYL CHLORIDE	0	3052.08	3021.41	30.66
ETHYLENE	1346.592	50.77	0.090	50.68
HYDROGEN CHLORIDE	1823.05	120.17	91.32	28.84
NITROGEN	56.028	109.68	0.196	109.49

Sensitivity analysis was performed to examine the effect of compressor pressure and cooler temperature on the formation of liquid phase ethyl chloride (required product). The pressure was varied from 5 to 35 bar and its effect on the amount of ethyl chloride produced was observed in Fig. 3. No significant changes were perceived with compression beyond 20 bar in the liquid ethyl chloride formation. This is because above 20 bar pressure, the temperature of the product stream becomes very high and it is difficult to cool it further. The effect of temperature of the cooled stream of liquid ethyl chloride formed was shown in Fig. 1. It was seen that as the cooler outlet temperature increased the flow rate of liquid ethyl chloride being produced also decreased. The outlet temperature of the cooler was thus fixed at 20°C since no significant change was observed in the amount of liquid ethyl chloride produced on further cooling below 20°C. From the graph plotted in Fig.2, it can be noted that with increase in compressor pressure from 5 to 25 bar, the outlet temperature of the compressor stream also increased from 120°C to 200°C which becomes difficult to cool for further recycling(Fig.3). Hence, the compressor pressure was chosen as 20 bar for further studies.

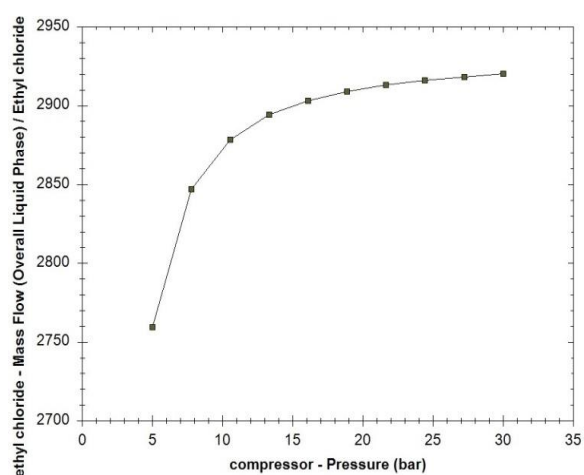


Figure 1

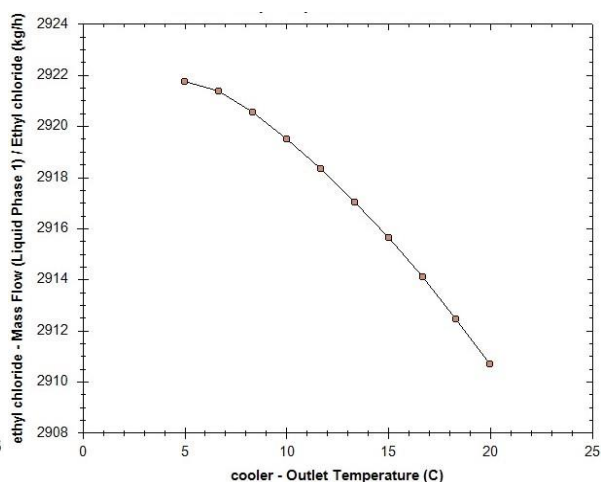


Figure 2

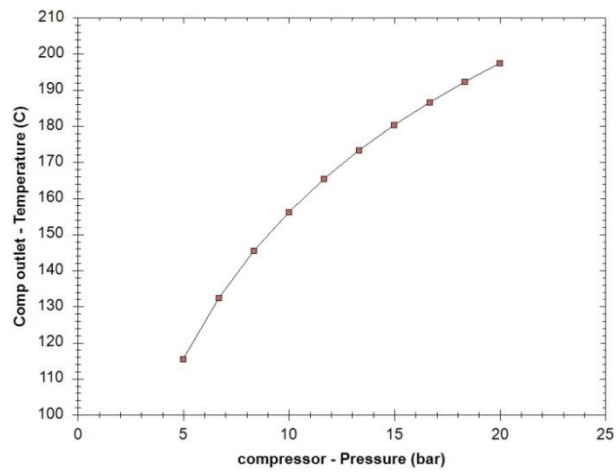


Figure 3

REFERENCES:

- [1] M. Conte, T. Davies, A. Carley, A. Herzing, C. Kiely, and G. Hutchings, Selective formation of chloroethane by the hydrochlorination of ethene using zinc catalysts, *J. Catal.*, vol. 252, 2007.
- [2] Nayef Ghasem, "Computational methods in Chemical Engineering," 1st Ed, Taylor and Francis Group, 2017