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Reduction of CO_2 Emission in Ethylene Oxide Process by Ethylene Recovery from Purge Gas

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Abstract: Ethylene oxide is important petrochemical used for the production of Ethylene Glycol. Manufacturing of Ethylene Oxide emits carbon dioxide due to its side reaction. Carbon di oxide emission is major concern globally. Out of total emission, 36% emission is attributable to manufacturing industries including chemical industry. Energy conservation practices will reduce CO2 emission caused by energy use. For reduction from non-energy use, selection of alternative technology, improvement in catalyst selectivity, waste heat recovery plays very important role. In the present paper an attempt has been made to recovery of ethylene from purge gas is studied which otherwise will convert into carbon dioxide. Membrane separation is used to recover ethylene gas from purge gas. Recovered ethylene can be used again in the process for the production of ethylene oxide. This recovery will be helpful to reduce carbon footprint of Ethylene Oxide process.

Keywords: Ethylene oxide, Carbon dioxide, membrane separation, ethylene, purge gas

I. INTRODUCTION

Ethylene is important building block used for the many petrochemical and polymer products. Ethylene oxide is one of the processes where ethylene is used as a raw material. Ethylene Oxide is then converted into Ethylene Glycol. Ethylene glycol is used for the production of polyesters, coolant in automobiles and as a antifreeze agent. In most of the places both plants are together and called as EO-EG process. Due to decreasing selectivity of catalyst over the time carbon dioxide is emitted in this process in large quantity. Carbon dioxide emission is a major concern globally. In past two centuries, more than 2.3 trillion tons of CO_2 is released into atmosphere [1]. Rapid change in climate has forced industries to shift their focus on the reduction of GHG emission. Paris agreement is an important step in this direction. Chemical industry is a significant contributor in CO_2 emission due to energy and non-energy uses of fossil fuels. It is called as "combustion related emission" and "process related emission" [3]. A loss due to catalyst selectivity is one of the major concerns in chemical industry. Various studies have been carried out to reduce CO_2 emission in chemical manufacturing processes [2, 4, and 5]. Ethylene oxide manufacture is one of the processes where CO_2 emission is due to lower selectivity of catalyst. Environmental impact of CO_2 can be reduced by two ways – 1) Utilisation of CO_2 for the production of various chemicals 2) Reduction of CO2 emission at source.

In the present paper an attempt has been made to study Ethylene Oxide-Ethylene Glycol and CO2 emission from it. Increase in emission over the reduction in the catalyst is also studied. Selective membrane is used to separate ethylene form the purge gas. Saved ethylene is again used for the production of ethylene oxide. This reuse will increase the overall production rate and will reduce carbon dioxide emission from the process.

II. ETHYLENE OXIDE-ETHYLENE GLYCOL PROCESS

Ethylene is oxidised in the presence of Silver catalyst in the tubular reactor. Following reactions are taking place in the reactor.[6]

$C_2H_4 + ½\ O_2 \rightarrow C_2H_4O$ (1)

$C_2H_4 + 3\ O_2 \rightarrow CO_2 + H_2O$ (2)

$C_2H_4O + 5/2\ O_2 \rightarrow 2CO_2 + 2H_2O$ (3)

$C_2H_4O + H_2O \rightarrow HOC_2H_4OH$ (4)

Along with main reaction (no.1) two side reactions (no.2 & 3) are also taking place. Conversion per pass is kept low in the rector to reduce production of CO_2. The catalyst must maximise primary and minimise side reactions. In this process, high activity catalyst with 81% initial selectivity and three-year life is used. Product gases from rector are send to Ethylene Oxide absorber unit for separation of Ethylene Oxide and then to CO_2 absorber unit for separation of CO_2 as shown in Figure 1.

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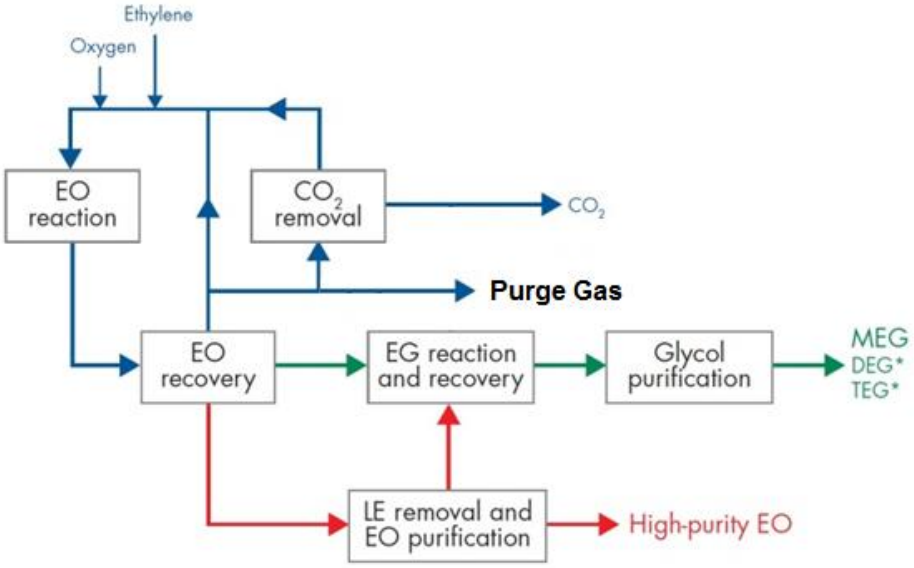

Fig.1 Process flow diagram for production of Ethylene Oxide - Ethylene Glycol [7]

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During initial period, catalyst activity is higher and CO_2 production is 478.69 kg/ton of EO. Catalyst is replaced at 77.9 % selectivity. CO_2 production is 564 kg/ton of EO at the time of replacement (Figure 2).

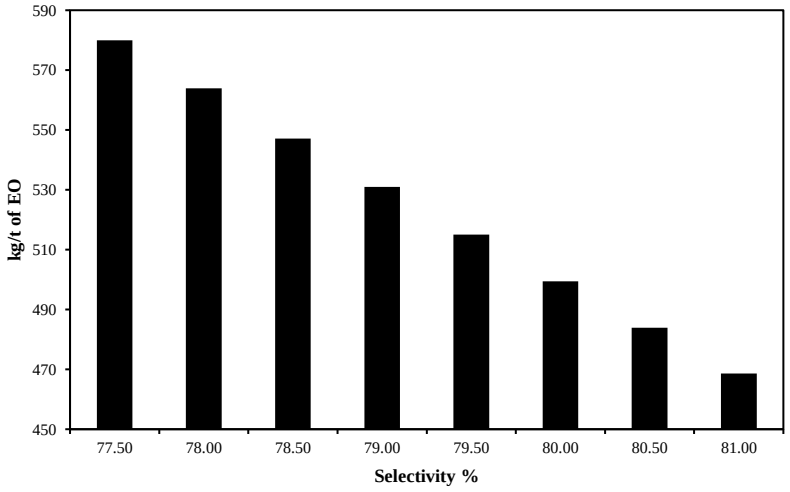

Fig. 2 CO2 production at different catalyst selectivity values

III. ETHYLENE RECOVERY FROM PURGE GAS

Purging of recycled gas is necessary in Ethylene Oxide - Ethylene Glycol process to maintain the concentration of ethane and argon in the process (Table-1). Purge gas is used as fuel in the boiler. Commercial value of ethylene is lost

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and only heating value remains due to purging. If ethylene is recovered from purge gas, it can be recycled back to reactor. This will reduce input quantity of reactants. Double benefit is obtained by coveting ethylene to ethylene oxide and reducing emission of carbon dioxide. A semipermeable membrane made up of silicone rubber can be used to recover ethylene as shown in Figure 3[8]. It will selectively separate ethylene from mixture of gases. Almost 75% ethylene is recovered from purge which will be otherwise burned in boiler as a fuel. 28 kg of CO2 /tone of Ethylene Oxide can be saved due to recovery of ethylene.

Table 1 Percentage composition of purge gas

Component	Higher Selectivity	Lower Selectivity
Ethylene	29.85	29.95
Oxygen	8.57	8.10
Nitrogen	0.68	0.69
Argon	24.31	24.47
Methane	33.02	33.42
Ethane	3.58	3.38
Total	100	100.00

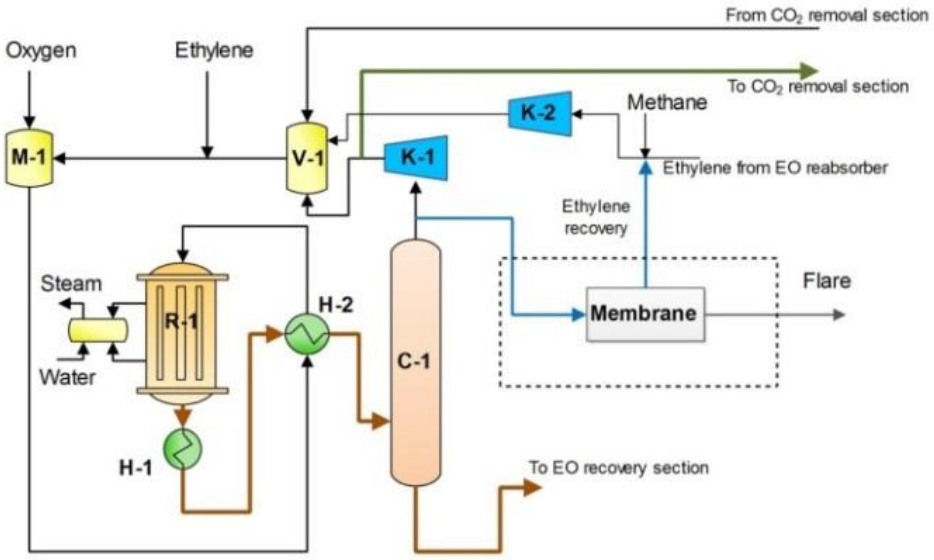

Fig. 3 Recovery of ethylene from purge gas [9]

IV. CONCLUSION

Environment friendly process is todays need in chemical industry. Along with production of various important chemicals carbon di oxide emission is also taking place. Modification in the process is one of the ways to reduce emission. In this study we have analysed one method which can selectively separate ethylene from purge gas and recycled in the process. Approximately 1.06 M$/yr can be saved for the plant having an annual capacity of 150 kt of EO (considering ethylene price is1200 $/MT). Ethylene recovery unit is installed in various plants worldwide. It will also reduce 4200 tons of CO_2 emission with same capacity of ethylene oxide production. Other types of membrane can be used to recover methane and ethane also present in the purge gas.

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