CHE251 (2024-25-I): Term Project Presentation

ETHYLENE OXIDE PRODUCTION

Group number 2

ABSTRACT

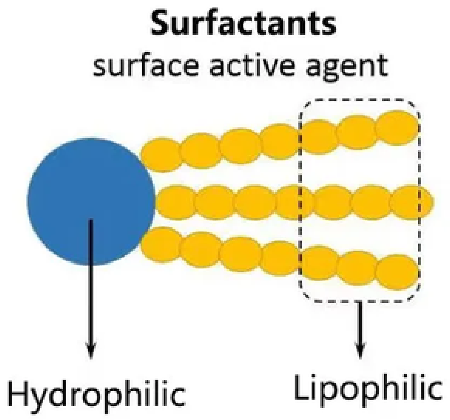
Ethylene oxide is usually made by directly oxidizing ethylene (E) with oxygen over a silver catalyst. This happens in a tubular reactor at around 450 to 545 K and high pressure (1–3 MPa), all while keeping the cooling temperature steady. The oxygen needs to be highly pure (over 99%), so it's typically produced in air separation plants.

Mixing ethylene oxide, ethylene, and oxygen can be really dangerous, thus usually something like nitrogen or methane is added to the mix to keep things safe. This also means the conversion in the reactor isn't that high. Plus, since the reactions are highly exothermic, good cooling is a must.

USES OF PRODUCT

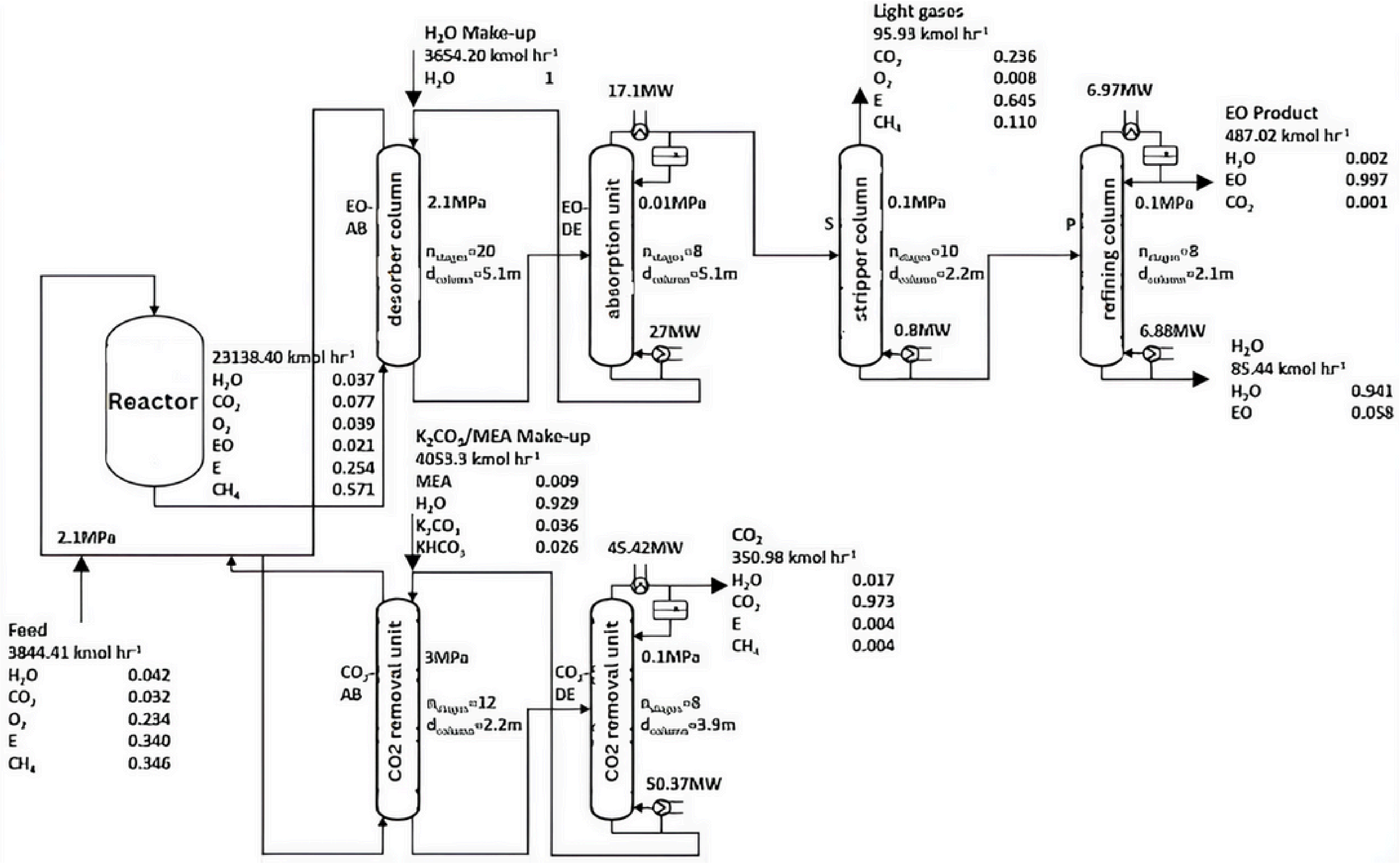
Ethylene oxide (EO) is a highly versatile chemical compound with a wide range of industrial and commercial applications. Some of its primary uses include:

- **Medical Device Sterilization**: Ethylene oxide is widely used to sterilize medical instruments and devices that cannot withstand high temperatures or moisture, such as plastics, electronics, and certain surgical tools. EO sterilization is effective against bacteria, viruses, and fungi.
- **Antifreeze and Coolants**: Ethylene oxide is a key precursor in the production of ethylene glycol, which is used in antifreeze, coolants, and as a solvent in various industrial applications.
- Ethylene oxide can be polymerized to form a polymer known as polyethylene oxide (PEO), which is used in applications such as drug delivery systems, adhesives, and coatings.
- **Polyester Production**: Ethylene glycol is a building block for producing polyethylene terephthalate (PET), which is used in the manufacture of plastic bottles, textiles, and packaging materials.



INTRODUCTION

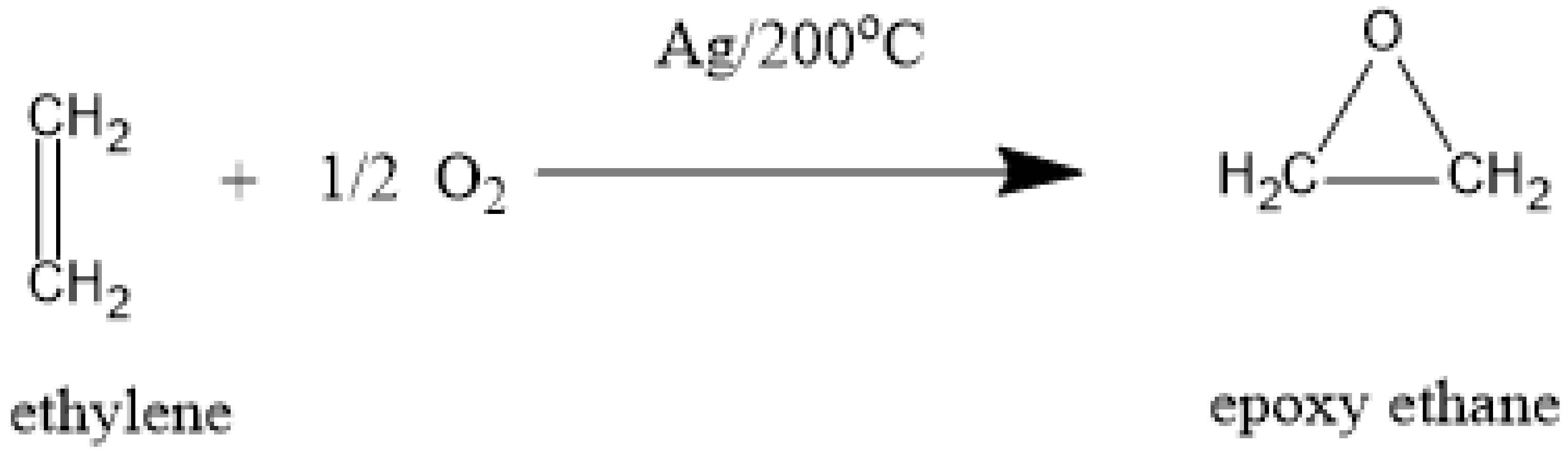
This project sought to conduct a comprehensive material balance of the flowsheet associated with the production process of Ethylene Oxide. Another aim was to think of methods to optimize the process. The flowsheet for the same is provided alongside.



METHODOLOGY

In the ethylene oxide production process, ethylene reacts with oxygen in a tubular reactor under controlled conditions to promote ethylene oxide formation while minimizing by-products like CO2. The reaction occurs at high pressure (2.1 MPa) and moderate temperatures, using a silver-based catalyst. Efficient cooling with boiling water keeps the highly exothermic reaction safe. The reactor feed includes ethylene, oxygen, water, and inert gases like methane. After the reaction, the output—comprising ethylene oxide, unreacted ethylene and oxygen, water, and by-products—is sent for separation and purification.

The desorber column first separates gas streams, recycling unreacted gases (CO2, O2, and CH4) while capturing ethylene oxide. In the absorption unit, ethylene oxide is absorbed, and remaining gases are vented or processed further. Next, a stripper and refining column purify the ethylene oxide by separating it from water and by-products. The final product is collected, while water and trace gases are either recycled or disposed of. Energy efficiency and resource recycling are vital for improving yield and reducing environmental impact.



IMPLEMENTATION

- **Flowsheet Analysis**

The flowsheet was examined to identify key data for performing the material balance across the system. Molar flow rates and compositions were recorded where available, and the function of each unit was assessed.

- **ASPEN Simulation**

The flowsheet was divided into four distinct units, and material balances were performed for each unit separately. Of these, two units* (the Reactor and Flash Distillation) were simulated using ASPEN Plus.

*The remaining two were not simulated due to limitations in the syllabus of the course

- **Material and Energy Balance**

Molar flow rates for all input and output streams of each unit were recorded. Missing data was calculated manually. An energy balance was conducted around the reactor* using ASPEN.

*Enough information wasnt provided to conduct further energy balances.

KEY ISSUES AND FIXES

- **Lack of complete information:** The Flowsheet lacked complete information about the Temperature of the different streams.
- **Accumulation of Potassium compounds and MEA :** In the CO2 removal unit, there was an absence of a purge stream which would lead to an accumulation of Potassium make up and MEA in the system. This also made it unfeasible to conduct material balances across the other units as a recycle stream was an input to the reactor.

To tackle these challenges, we had a discussion with the Course Instructor. We also mailed the original authors of the paper we used as reference.
The authors confirmed that there existed a purge stream which was not explicitly mentioned in the flowsheet. We were asked to vary the purge stream values to match the other specifications about the flowsheet.
On suggestion of the Instructor, we made envelopes around the different blocks in an aim to perform material balances.
Due to incomplete data of the purge a proper energy balance could not be performed.

Message preview

Regarding the research publication titled "Analysis of Capacity Potentials in Continuously Operated Chemical Processes" and request for ASPEN files.

From aswarup23
To julia.riese@uni-paderborn.de
Date 2024-10-25 22:46
Priority Highest

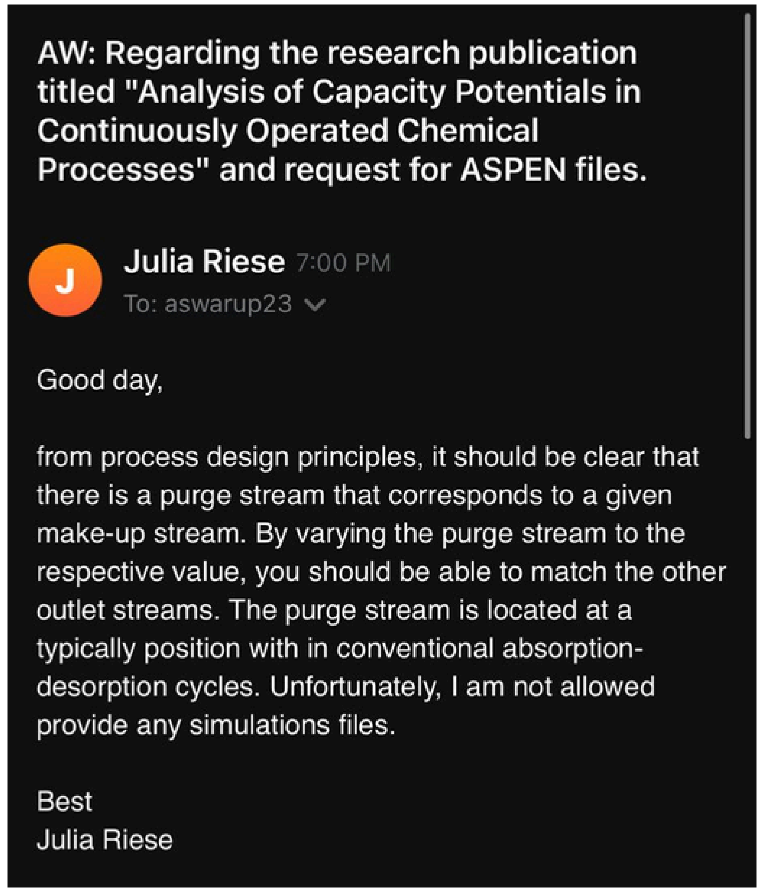
Summary Headers HTML

Respected Professor Riese,

I hope this email finds you well. My name is Akshat Swarup, and I, along with my group, am currently working on a course project at IIT Kanpur, India where we are analyzing the process flowsheet from your paper. While reviewing the system, we noticed that potassium (K_2CO_3) enters via the CO_2 removal unit's make-up stream, but it is unclear where potassium exits the system or how it circulates.

Could you kindly clarify if this is an oversight, or if potassium remains in a cycle within the system? This clarification would help us better understand the process for our project.

Mail to authors



AW: Regarding the research publication titled "Analysis of Capacity Potentials in Continuously Operated Chemical Processes" and request for ASPEN files.

J Julia Riese 7:00 PM
To: aswarup23

Good day,

from process design principles, it should be clear that there is a purge stream that corresponds to a given make-up stream. By varying the purge stream to the respective value, you should be able to match the other outlet streams. The purge stream is located at a typically position with in conventional absorption-desorption cycles. Unfortunately, I am not allowed provide any simulations files.

Best
Julia Riese

Reply

RESULT

The Single Pass Conversion of the Reactor is 8.5%. Yield of Ethylene Oxide is 23.46%. Overall Conversion is 42.15%. The energy output of the reactor is 4750.5 kW.

Ways to optimize the process are as follows:

- **Optimize Temperature and Pressure**: EO production typically operates at 200-300°C and 10-30 bar. Fine-tuning these conditions to the most efficient levels can increase yields and reduce by-product formation
- **Ethylene Recycling**: Recycling unreacted ethylene from the reactor outlet back into the feed stream minimizes raw material waste. Implementing high-efficiency separation techniques, like selective membranes, ensures the maximum recovery of unreacted ethylene.
- **Oxygen Recovery**: Improved oxygen recovery from reactor effluent, using pressure swing adsorption or other separation techniques, can reduce oxygen consumption and lower costs.
- **Closed-Loop Systems**: Implementing a closed-loop system for waste gases and by-products can reduce emissions and improve feedstock efficiency. Capturing and reusing heat from exothermic reactions further improves overall energy efficiency

CONCLUSION

The given Flowsheet was reproduced successfully to the best extent.
The single pass conversion, yield and overall conversion were found.
Energy balance was performed across the reactor.
Methods to optimise the process were thought of.
Optimizing ethylene oxide production requires a combination of advanced catalysts, process intensification, energy recovery, and improved monitoring. By focusing on these areas, industrial producers can reduce costs, improve yields, and create a more sustainable production process.

THANK YOU!

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