Design of a Commercial Scale PET Facility

Jada Cooper, Allison McGinnis, Jack Pearsall, and Kavan Williamson
Mentors: Catherine Hill, Aleecia Marshall, Rheagan Sizemore, and Cameron Williams

1. Goals

- Design a greenfield production plant capable of producing 450,000 MT/year of polyethylene terephthalate (PET)
- Choose between starting with dimethyl terephthalate (DMT) or terephthalic acid (TPA)
- Provide a recommendation on whether plant construction should proceed based on economic analysis

2. Reactant Selection

Categories	DMT	TPA
Chemical Prices	⊗ More Expensive	✓ Less Expensive
Catalyst Price	⊗ Requires 2 catalyst	✓ Requires 1 catalyst
Additional Equipment Price	⊗ Methanol Recovery System	✓ N/A
Byproduct	⊗ Methanol	✓ Water
Environmental	⊗ More Impact	✓ Less Impact

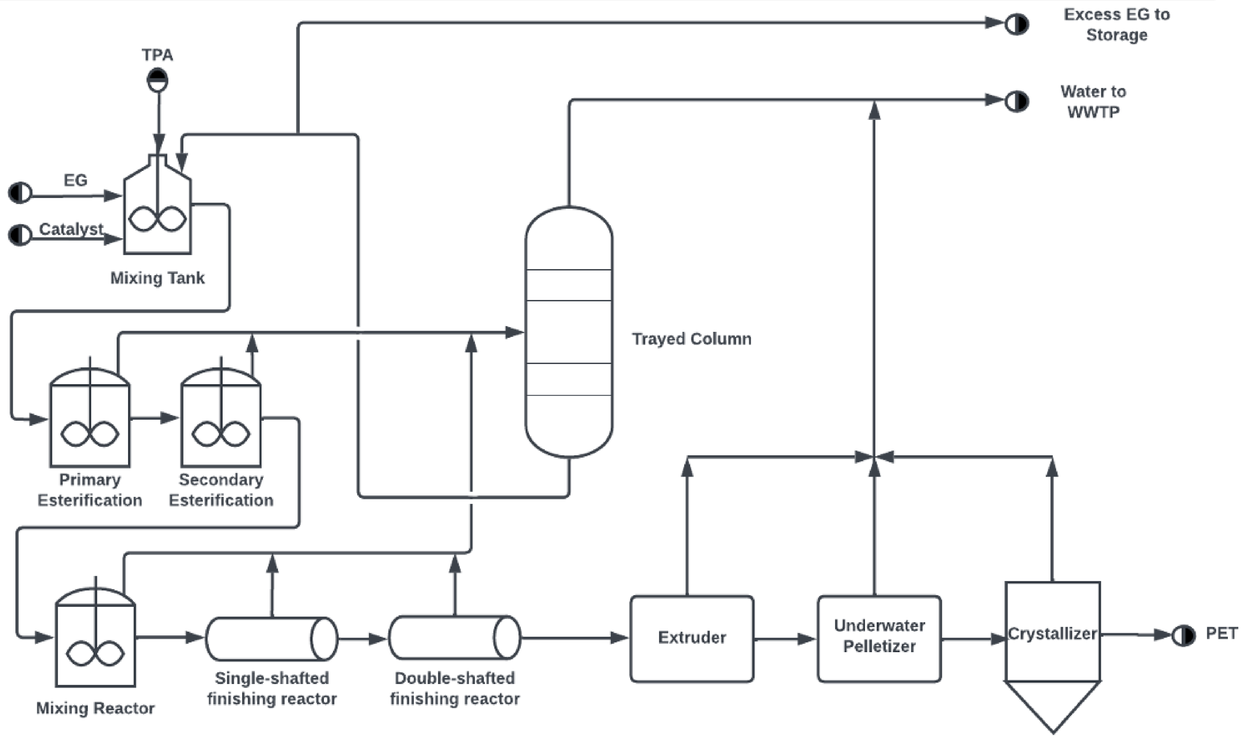
3. Safety and Environmental

Antimony Trioxide and EG are hazardous chemicals that can cause long term health effects

TPA and EG can cause irritation to the skin, eyes, and respiratory tract

PET is 100% recyclable and has a lower carbon footprint than other plastics

4. Process Flow Diagram



Esterification

- Primary Reactor:
  - T: 250 °C
  - P: 4.4 atm
- Secondary Reactor:
  - T: 270 °C
  - P: 1 atm

Polycondensation

- Temperature : 275 °C
- Pressure : 8 mmHg
- Antimony Trioxide Catalyst
- 20 – 40 Degree polymerization

Crystallization

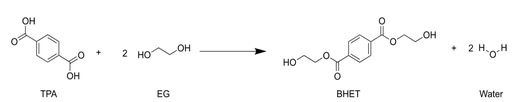
- PET temperature cools from 290 °C to 150 °C
- PET produced in small pellets
- 5-minute residence time

Distillation

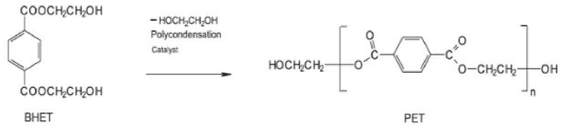
- 99 wt% water purity in distillate
- 5 Trays – Feed Tray: 3
- Pressure: 760 mmHg
- Reflux Ratio: 1.2

5. Reaction Chemistry

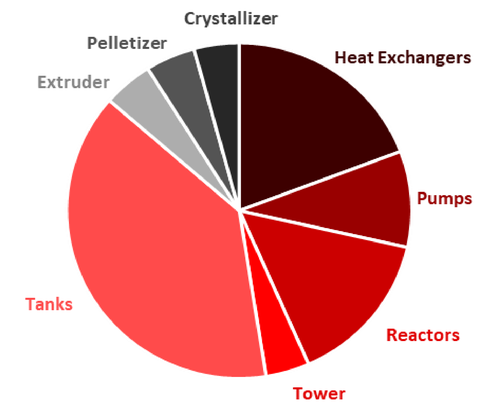
Esterification Reaction



Polycondensation Reaction



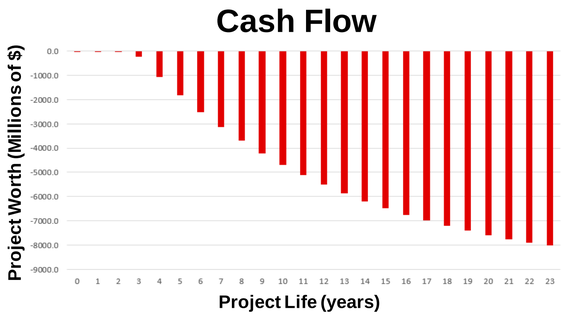
6. Economics



Total Capital Investment
$280M

Cost of Manufacturing
$3.3B/year

Revenue from Sales
$1.1B/year



Net Present Value
-$8.1B

Rate of Return
-9800%

7. Recommendations

1) Researching less expensive chemicals for the feed, instead of EG
2) Limit the amount of EG used in the facility
3) Terminate the project based on cash flow and economics

8. Acknowledgements

- Thank you to our Eastman Mentors: Catherine Hill, Aleecia Marshall, Rheagan Sizemore, and Cameron Williams
- Thank you to the NCSU CBE Department, Dr. M. Cooper, and Dr. L. Bullard

Sources

https://www.ccohs.ca/oshanswers/chemicals/howto/health_hazard.html
https://www.cleanpng.com/png-recycling-symbol-paper-recycling-codes-rot-3955740/
https://en.wikipedia.org/wiki/Irritation