# ASSIGNMENT-5 PROCESS ENGINEERING

T = (a+b+10*c) = 0 + 2 + 10*0 = 2
X = 2 mod 9 = 2
Y = 2 mod 19 = 2

## 1. Achieving given specifications

Design specifications that can't be directly achieved: maintaining less than 37 lbmol/hr waste gas, 99% conversion, 99.2% purity cumene in output. To achieve these specifications we vary parameters that haven't been directly given in the problem. Those are as follows:

| Specification | Parameter varied | Value of parameter for which specs achieved |
|---|---|---|
| 37 lbmol/hr waste gas | Vapor fraction in distillate | 0.02 |
| 99% conversion | Length of the reactor | 3.54731947 m (DS-1) |
| 99.2% purity cumene | Propylene inlet flow rate | 50.5205273 kmol/hr (DS-2) |

| | Units | T | L-DISTIL | PP-FEED | REACT-IN | REACTOUT | TOPS | V-DISTIL | WASTE-F | WASTE-GA | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mass Solid Fraction | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Molar Enthalpy | cal/mol | 5434.89 | -21242.8 | 5961.5 | 12840.2 | -3132.91 | -645.577 | -12333.5 | -815.772 | -1527.7 | |
| Mass Enthalpy | cal/gm | 52.0907 | -436.62 | 141.669 | 220.68 | -30.0273 | -15.2496 | -714.348 | -14.2409 | -71.3777 | |
| Molar Entropy | cal/mol-K | 108.608 | -59.8089 | -30.5532 | -30.1534 | -102.037 | -57.9173 | -18.4927 | -43.1924 | -8.26739 | |
| Mass Entropy | cal/gm-K | 1.04096 | -1.2293 | -0.726064 | -0.518238 | -0.977974 | -1.3681 | -1.07108 | -0.75401 | -0.386271 | |
| Molar Density | mol/cc | 233125 | 0.0190453 | 3.35121e-05 | 3.35532e-05 | 0.000156711 | 0.0144821 | 5.93477e-05 | 0.000181486 | 4.61513e-05 | |
| Mass Density | gm/cc | 243232 | 0.92661 | 0.00141021 | 0.00195228 | 0.0163505 | 0.613088 | 0.00102467 | 0.0103961 | 0.000987781 | |
| Enthalpy Flow | cal/sec | 76903.1 | -203532 | 83660.7 | 325797 | -44330.3 | -1826.97 | -2411.64 | -20557.1 | -6536.37 | |
| Average MW | | 104.335 | 48.6529 | 42.0806 | 58.1845 | 104.335 | 42.3341 | 17.2655 | 57.2836 | 21.4031 | |
| **+ Mole Flows** | lbmol/hr | 12.302 | 76.0426 | 111.379 | 201.379 | 112.302 | 22.4605 | 1.55189 | 200 | 33.9574 | |
| **+ Mole Fractions** | | | | | | | | | | | |

Figure-1: Waste gas flow < 37 lbmol/hr

| | Units | BZ-FEED | COLD-OUT | CUMENE | F |
|---|---|---|---|---|---|
| Average MW | | 78.1136 | 48.6529 | 119.836 | |
| **+ Mole Flows** | kmol/hr | **40.8233** | **34.4924** | **40.7516** | |
| **− Mole Fractions** | | | | | |
| BENZE-01 | | 1 | 0.39087 | 0.00852322 | |
| CUMENE | | 0 | 0 | 0.991477 | |
| METHA-01 | | 2.04001e-07 | 0.470807 | 4.60956e-11 | |
| METHA-02 | | 9.30346e-13 | 0.0567036 | 1.06058e-26 | |
| ACETY-01 | | 1.90075e-10 | 0.0815999 | 6.64405e-20 | |
| NITRO-01 | | 2.1198e-21 | 8.18724e-06 | 0 | |
| OXYGE-01 | | 2.24188e-20 | 1.1965e-05 | 0 | |
| PROPY-01 | | 0 | 0 | 7.48682e-09 | |

Figure-2: Achieving 99.2% purity

All these were achieved using Flowsheeting options -> Design Specs in ASPEN. It is also found that 206.247 °F is the temperature for 30 degrees of superheating.

## 2. Cumene product flowrate vs Preheater Temperature
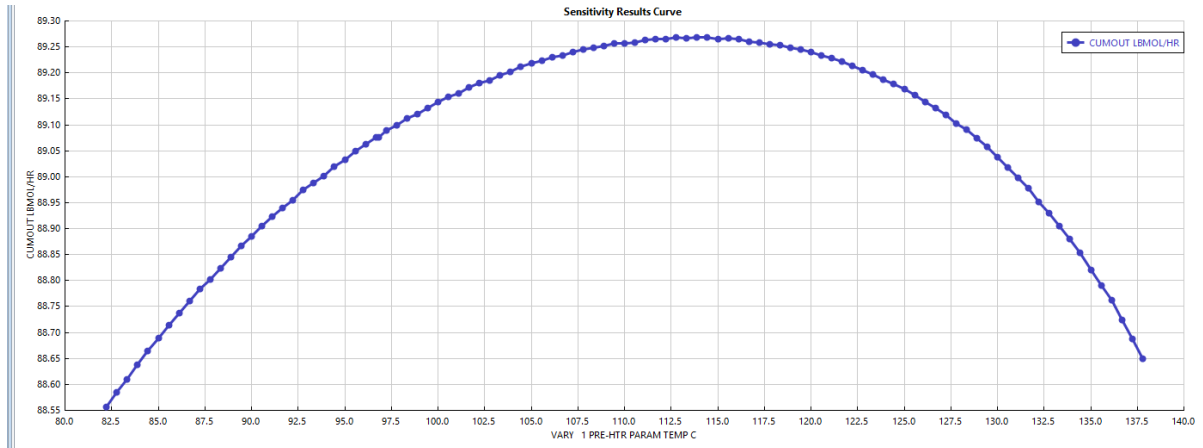


Figure-3: Cumene product flowrate with the preheater temperature
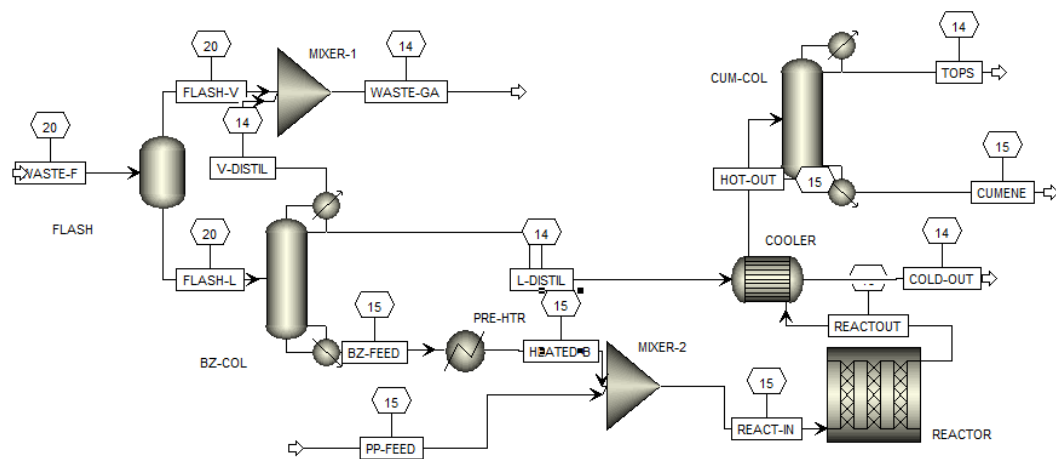
## 3. PFD for process and stream table.



Figure-4: PFD

We see a significant pressure drop at the two distillation columns: BZ-COL and CUM-COL, so pumps are present in those two units (say, 1 pump for each).

Due to space constraints, I am sharing the stream table in this drive link.