Production of Ethylbenzene

Alchymia Engineering

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Abstract

Our task was to create a preliminary design of an ethylbenzene (EB) plant at the SA petrochemical facility to maximize efficiency while considering various external factors. To do this, we gathered information related to the process to determine the best approach. We utilized a process flow diagram to construct the process and determined the appropriate temperatures, pressures, and phase change operations for each step of the process. Then, we simulated the design using Aspen Plus followed by calculating the profitability parameters of the design including return on investment (ROI), payback period (PBP), annual cash flows (CF), net present value (NPV), and investor's rate of return (IRR). Public health, safety, welfare, global, cultural, social, environmental, and economic factors were considered when designing the plant.

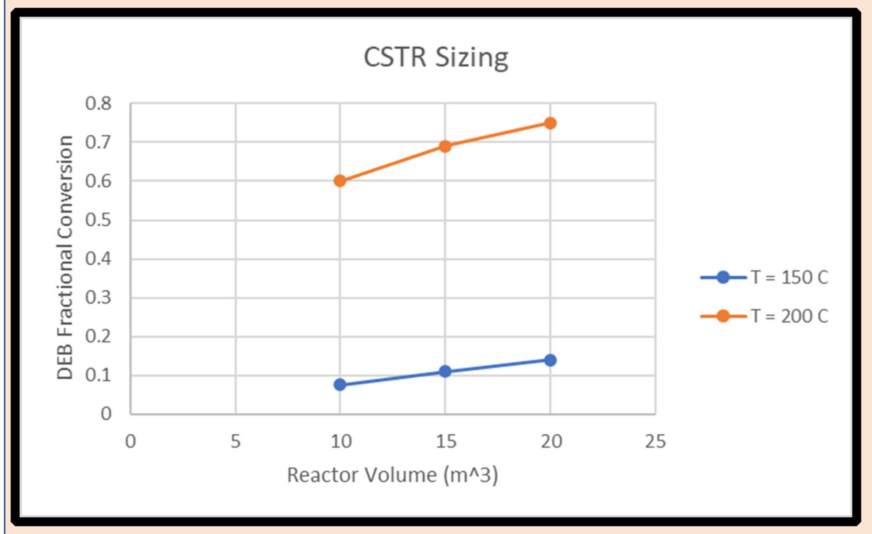
Motivation

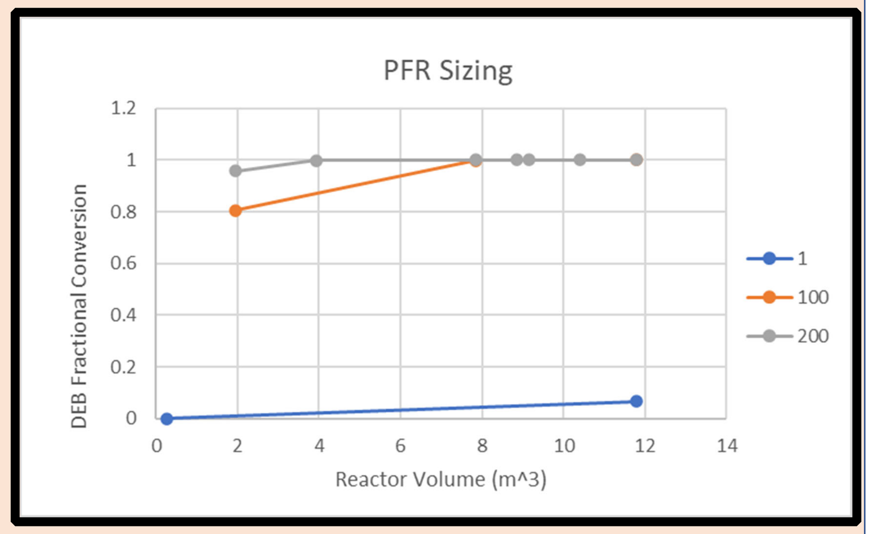
Ethylbenzene is mainly used in the production of styrene. Styrene is most commonly used in thermoplastics including food packaging, car parts, electronics, and much more. Due to the high demand for styrene, it would be beneficial to optimize the production of ethylbenzene to be more efficient.

Simulation Summary

	Unoptimized	Optimized
Ethylbenzene *flow (kmol/yr)* *purity (%)*	*628,254.07* *99.67*	*759,440.66* *99.94*
Toluene *flow (kmol/yr)* *purity (%)*	*30,489.22* *19.12*	*84,186.78* *99.54*

The table above displays flow rates and purities of the final product streams in the simulation before and after optimization. Ethylbenzene is the main product, and toluene is a side product obtained from an impurity in the benzene feed used. The graphs below were produced during the optimization of the chemical plant design.



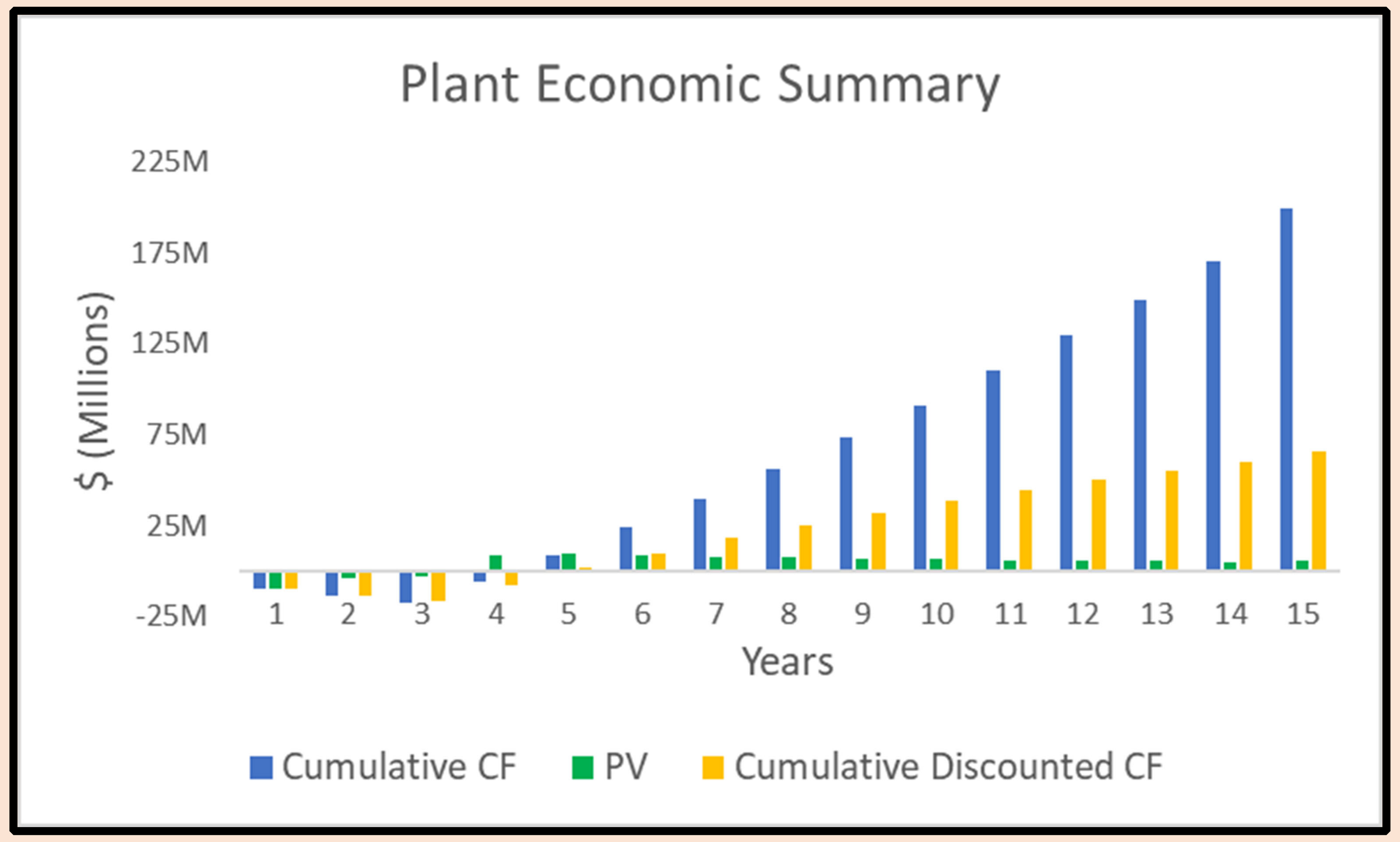


Economics

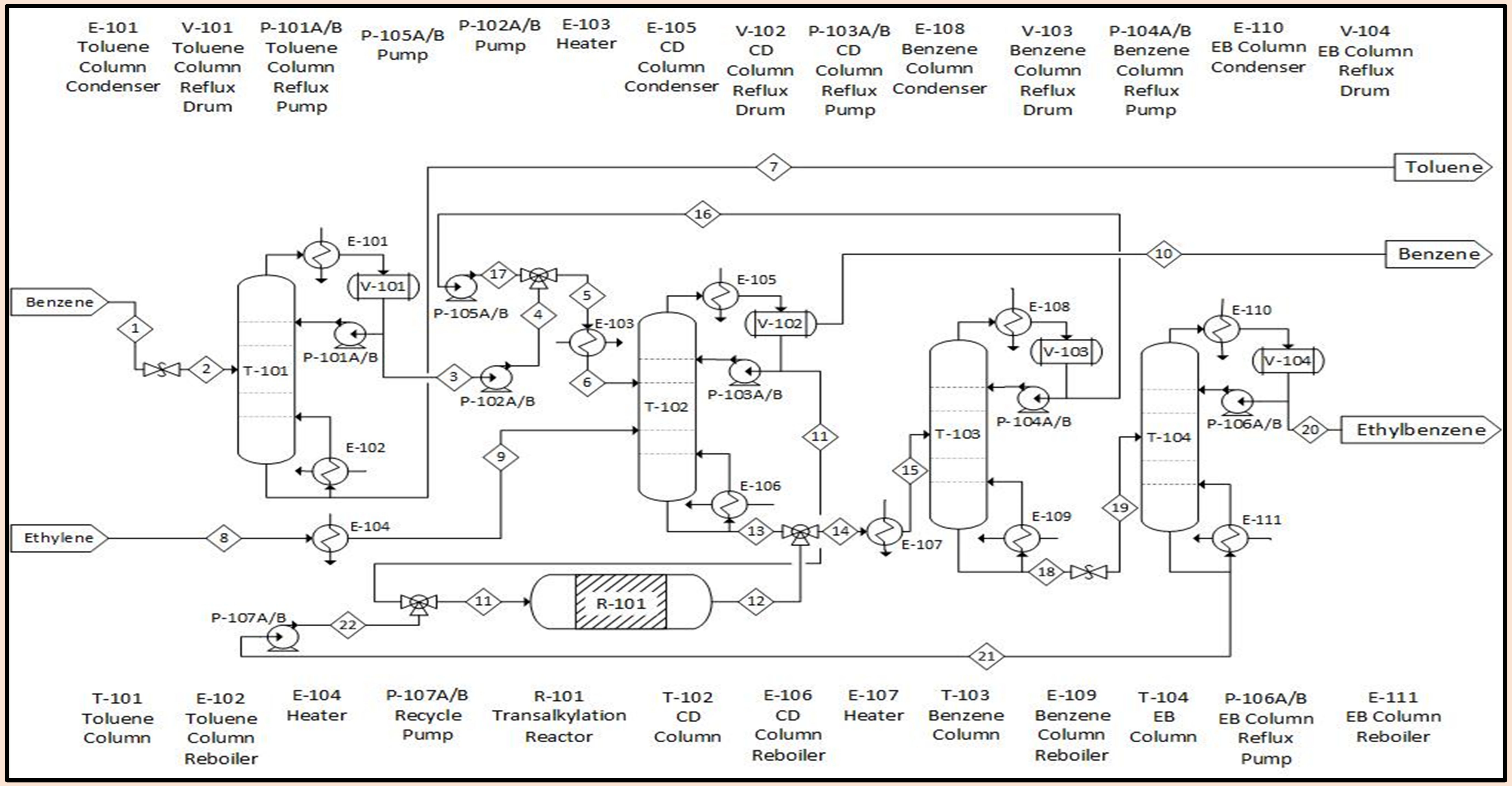
Initial Cost estimates of the components were found in ASPEN Plus. Percentages for C_{TBM}: site (6%), services (5%), and allocation (5%) to compute the total depreciable capital, C_{TDC}. Percentages of the C_{TDC} allocated for C_{TPI} were: land (2%), royalties (2%), and startup for a new process (30%). The sum of C_{WC} and C_{TPI} resulted in the C_{TCI}. Costs were subtracted from total benefits and savings to find the plant net income over a 12-year life. Costs: feedstocks, catalyst, utilities, labor, equipment, maintenance, overhead, property tax, general expenses, and depreciation. Benefits: toluene sales, ethylbenzene savings, and end-of-project salvage values. The net cash flow and cumulative cash flows were calculated using these values in conjunction with the percentages. A profitability analysis that included ROI, PBP, NPV, and IRR was calculated for the optimized plant with a sum of the annual discounted cash flow.

NPV(12.0%)		$66,200,870
DCFROR		46.75%
ROI		143%
PBP	$	0.64
MARR		12%

At Startup		
Sales Revenue		$123,972,405.56
Annual Expenses	$	(106,536,320.89)
Taxable Income		$17,436,084.67
Income Taxes		($3,661,577.78)
Net Income		$13,774,506.89
Depreciation		$615,389.66
Net Cash Flow		$12,430,206.89
At Salvage		
Sales Revenue		$158,695,160.26
Annual Expenses	$	(130,446,578.55)
Net Income		$22,316,379.55



Process Flow Diagram (PFD)



Conclusion/Summary

With our current design, we were able to achieve a purity of 99.94% and 99.54% for EB and Toluene, respectively, and be able to sell both products for profit. The beginning of the project led to significant costs, but after start-up, we were able to start making a positive net CF. While the PV was negative for the first 3 years and slightly decreases after a positive start-up value, we obtained a $66M NPV and ROI of 143% using the 3rd year of operation. Our plant design is determined to be successful considering the purity of the products, efficiency, and a positive economic summary.

Acknowledgements

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