Lummus UOP Ethylbenzene Production Process

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Abstract

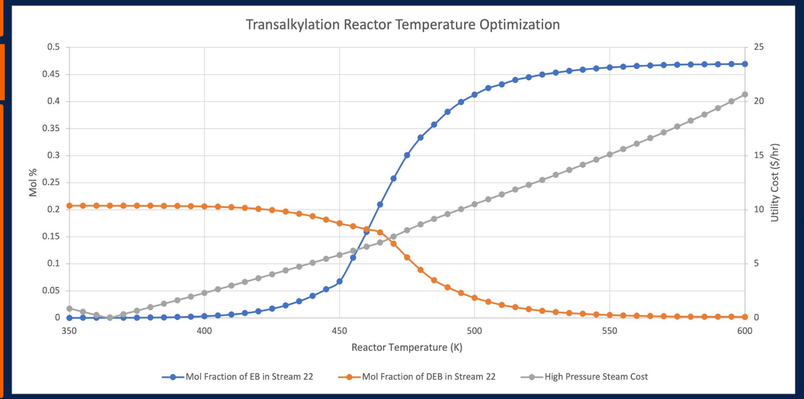
A chemical manufacturing plant was designed to produce 80,000 tonnes per operating year of 99.8 mol% ethylbenzene via the alkylation of benzene with ethylene. It was designed, optimized, and analyzed for economic, environmental, and societal viability. The innovative Lummus UOP process was selected for its increased production efficiency compared to similar industrially standardized processes.

Motivation

Ethylbenzene is used to manufacture styrene for use in subsequent plastic, latex, and rubber manufacturing operations. As such, we were contracted to design an ethylbenzene production process for a styrene & petrochemical manufacturer to combat increasing feedstock costs. On-site feedstock production facilitates more precise economic control of the overall operation.

Simulation Optimization

A rigorous optimization was conducted on all processing equipment to achieve the desired product purity while minimizing operating costs. Special care was taken to ensure process safety was not compromised at the expense of maximizing profit margins. Below, the transalkylation reactor temperature was varied to optimize the conversion of diethylbenzene to ethylbenzene.



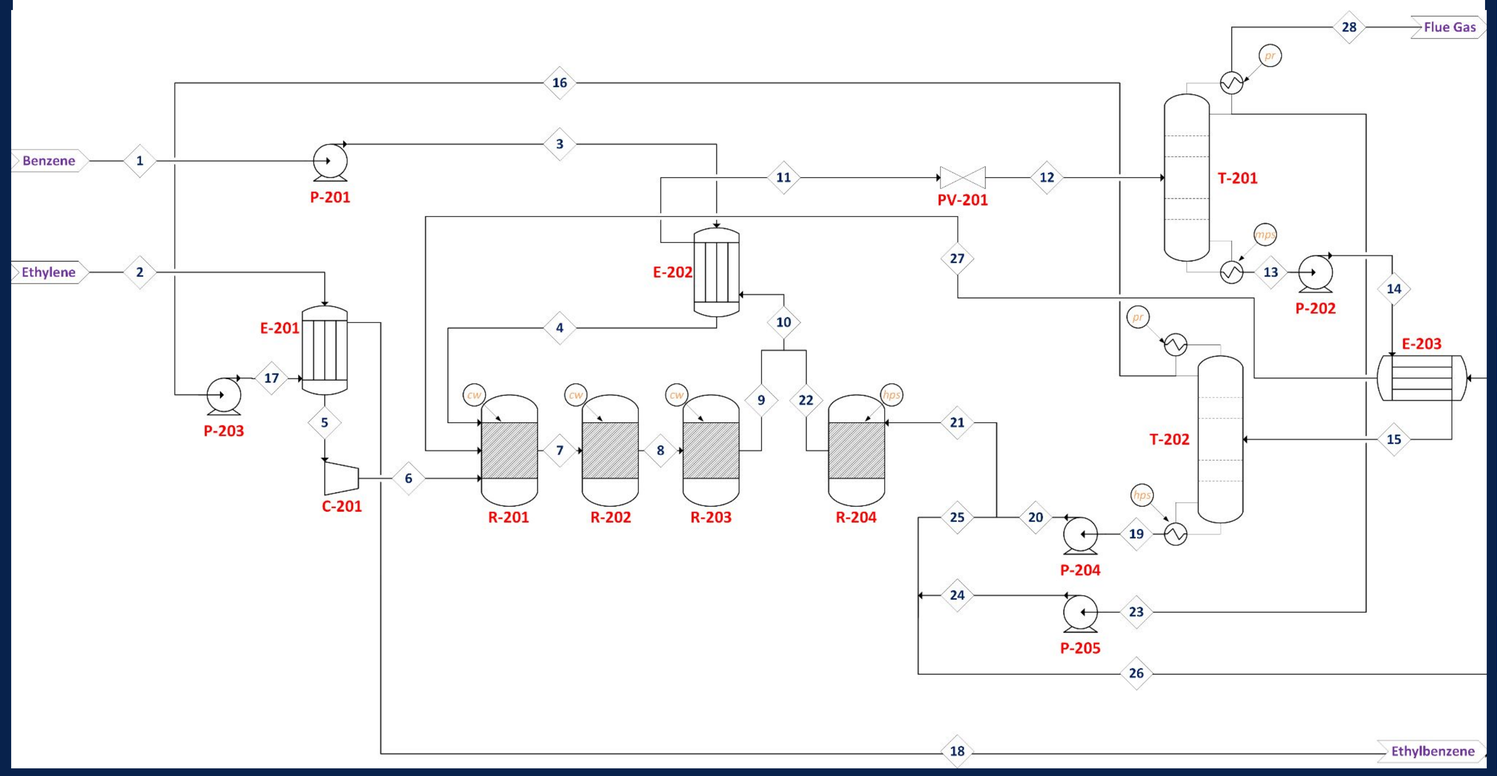
Simulation Summary

	Unoptimized	Optimized
Ethylbenzene		
Mass Flow (tonne/yr)	94,309.70	82,294.10
Purity (mol%)	43.27	99.82
Flue Gas		
Mass Flow (tonne/yr)	22,490.12	7,225.47
Feedstock Fraction (mol%)	89.3	53.9
Waste Fraction (mol%)	10.7	46.1
Operating Costs		
Install Cost	$18,253,700	$16,366,400
Utility Cost ($/yr)	12,981,230	6,730,920
Revenue ($/yr)	-38,210,000	16,883,000

The unoptimized process was wasteful and unprofitable as a large quantity of feedstock exited in the flue stream. After optimization, the flue gas mass flow was minimized, the target purity was achieved, and the overall process exceeded the minimum acceptable profit target.

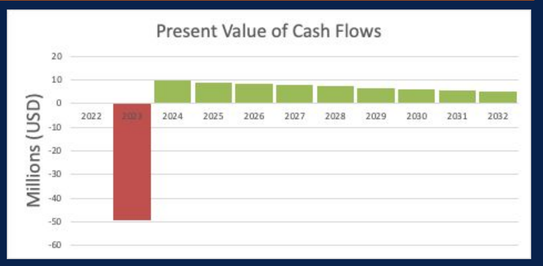
Process Flow Diagram

P-201 Inlet Benzene Pump
E-201 Heat Exchanger
E-202 Heat Exchanger
C-201 Compressor
R-201 Alkylation Reactor 1
R-202 Alkylation Reactor 2
R-203 Alkylation Reactor 3
PV-201 Pneumatic Valve
T-201 Benzene Distillation Column
P-202 Pump
E-203 Heat Exchanger
T-202 EB Distillation Column
P-203 Pump
P-204 Pump
R-204 Transalkylation Reactor
P-205 Pump



Economic Evaluation

Summing the total permanent investment and working capital costs yields $119,700,470 as the total capital investment for the construction of this facility. At an annual operating cost of $110,873,000 per year with a revenue of $16,883,000 per year, the payoff period is 7.09 years. The internal rate of return (IRR) was calculated to be 28.5147%, which far exceeds the desired IRR of 12%.



Conclusions

The Lummus UOP process provides superior process control for ethylbenzene manufacturing. The proposed chemical plant is able to achieve the target purity and annual mass flow rate, minimize losses and utility usage, and far exceed the desired economic targets. The petrochemical manufacturer who contracted this project should commission the proposed facility to produce ethylbenzene on-site.

Acknowledgements

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