STYRENE PRODUCTION

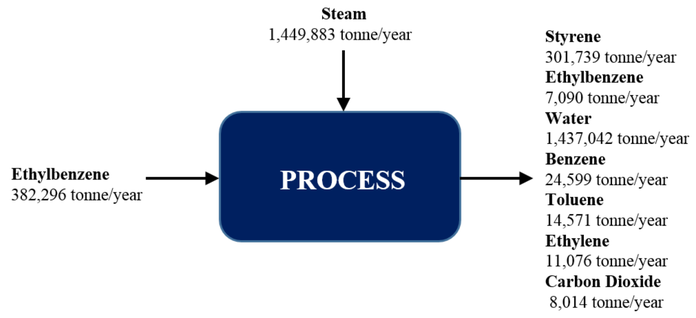
Gökmen Yağız Topcu, Melodi Özgüç, Mehmet Serhat Aydın,
Nihal Olcay Doğan, Özlem Ecem Kaynar, Zeynep Cansu Senyelli

ABSTRACT

Today, Turkey is not the one of the countries that produces styrene and the need for this monomer is met only through imports. In this project, the design and establishment of a new styrene plant, located in Izmir, Aliaga with the capacity of 300,000 tons/year is aimed. The overall reaction is an endothermic reaction in which the total conversion is 0.76 and styrene is obtained with 99.7% purity as designated by ASTM. Process options and selection, production capacity, feasible process conditions, feedstock, admissible emissions of wastes to ground/water/air etc., equipment design, process control, economy are all be considered and determined during the design of this new styrene plant.

BASIS OF DESIGN

➢ Overall Mass Balance



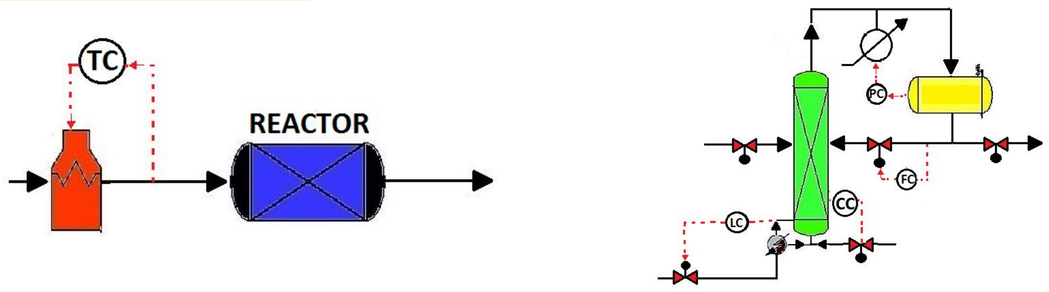
➢ Overall Energy Balance

ENERGY BALANCE (kJ/h)	Input	Output
Feed Streams	$-2.2 * 10^9$	-
Product Streams	-	$-2.6 * 10^9$
Total Heating	$1 * 10^9$	-
Total Cooling	$1.4 * 10^9$	-
Power Added	89059	-
Total	$-2.6 * 10^9$	$-2.6 * 10^9$

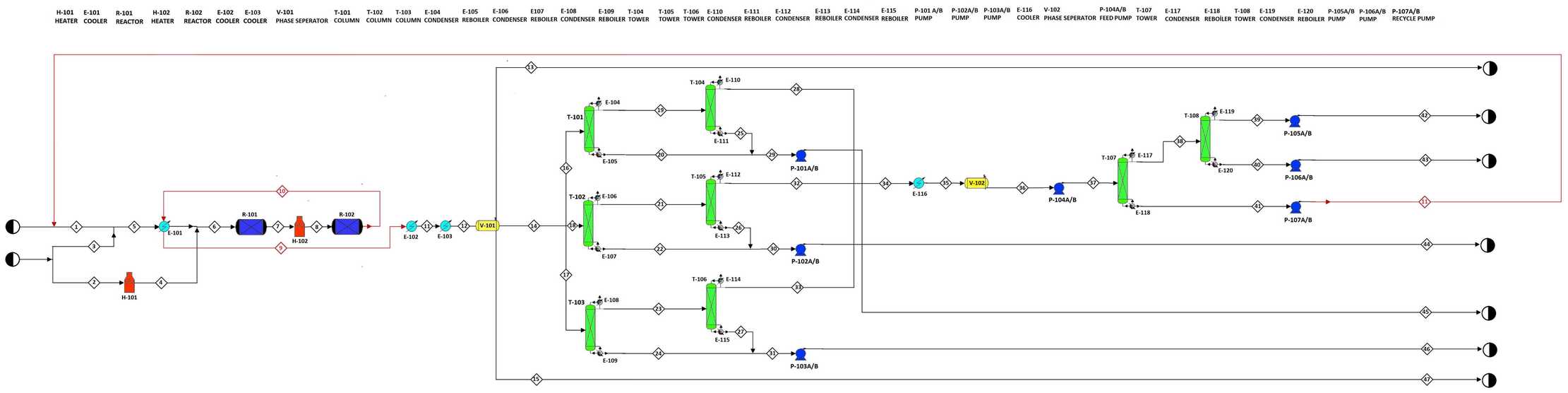
PROCESS OPTIONS AND SELECTION

PROCESS	Conversion	Cost	Energy recovery	Safety issues	Commercial scale
1. Dehydrogenation of Ethylbenzene					
1.1 Adiabatic Dehydrogenation	+	+	+	+	+
1.2 Oxidative Dehydrogenation	+	+	+	-	+
3. Benzene and Ethane	+	+	+	+	-
4. Toluene and Methanol	-	+	+	+	-
5. Butadiene	+	-	+	-	-

PROCESS CONTROL

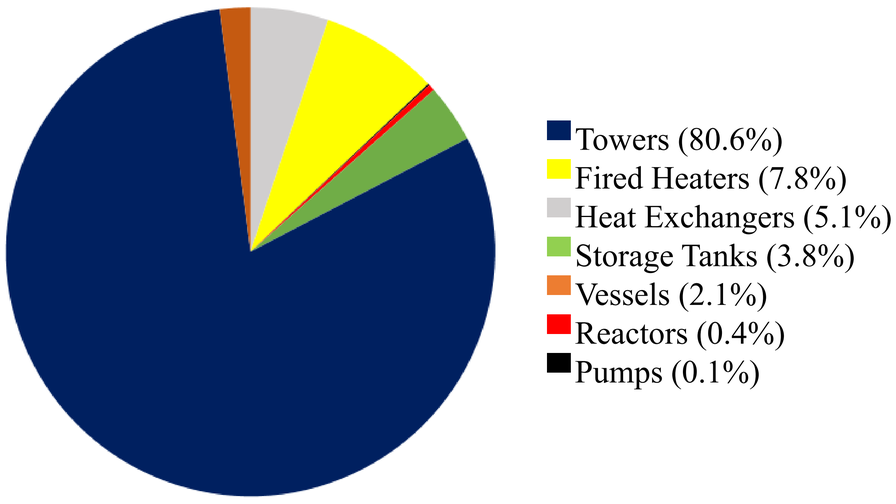


PROCESS FLOW DIAGRAM



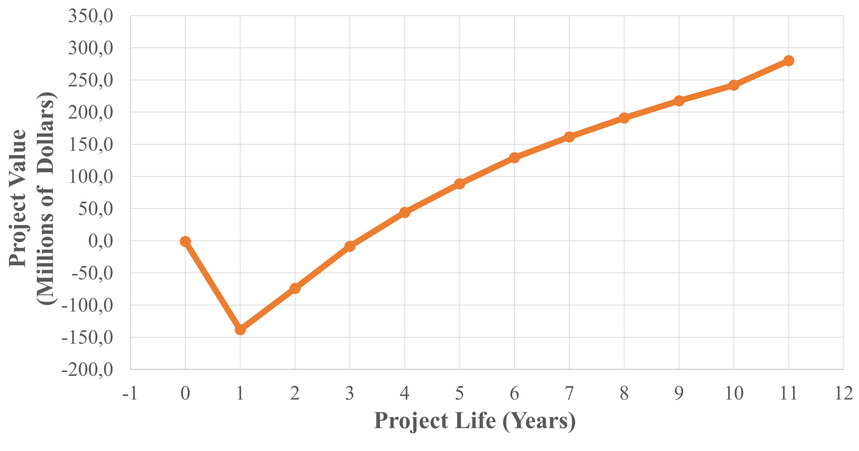
ECONOMIC ANALYSIS

Fixed Capital Investment = 177,100,000 $



FACTOR	COST ($)
Fixed Capital Investment (FCI_L)	177,100,000
Cost of Land	1,250,000
Working Capital	44,620,000
Operating Labor (C_{OL})	211,600
Utilities (C_{UT})	73,600,000
Raw Materials (C_{RW})	268,900,693

DISCOUNTED CASH FLOW DIAGRAM



Discounted payback period (DPBP)	2.37 years
Net present value (NPV)	279,000,000 $
Present value ratio (PVR)	6.08

WASTES, ENVIRONMENT AND SAFETY

➢ Environmental Considerations

MATERIAL	TYPE OF USAGE	ENVIRONMENTAL EFFECT	FLAMMABLE
Ethylbenzene	Raw Material	Non-corrosive highly toxic	Highly flammable
Low Pressure Steam	Raw Material	Non-toxic corrosive	Non-flammable
Styrene	Product	Toxic	Flammable
Water	Waste	Water pollution	Non-flammable
Benzene	By-product	Highly toxic explosive	Flammable
Toluene	By-product	Highly toxic	Flammable
Ethylene	Waste	Non-toxic	Flammable
Carbon Dioxide	Waste	Highly toxic	Non-flammable

➢ Fire & Explosion Index (F&EI)

Fire & Explosion Index	192
Radius of Exposure (m)	49.1
Area of Exposure (m^2)	7.570
Damage Factor	0.88
Loss Control Credit Factor	0.4

➢ Hazard and Operability Analysis

Process Unit: R-101, R-102 PFR				
Intention: To convert ethylbenzene to vinylbenzene				
Guide Word	Deviation	Cause	Consequence	Action
More of	Higher temperature	Excess steam flow	Low efficiency Explosion	Decrease steam flow
	More flow	Excess flow of inlet stream	Overflow in tank	Open the emergency valve of reactor

Process Unit: E-101,E-102, Heat exchanger				
Intention: For cooling				
Guide Word	Deviation	Cause of Deviation	Consequence	Possible Action
No	No flow	Blockage in line	No heat transfer	Interlock with process shutdown
More of	More flow	Malfunction in previous equipment	Unstable operation in next equipment	Interlock with high temperature alarm
Less of	Less flow	Malfunction in previous equipment	Unstable operation in next equipment	Interlock with low temperature alarm

IMPROVEMENTS

Problems;
- ➢ Problems about the sizing of distillation columns
- ➢ Should be a single storage tank or more than one?
- ➢ Is it profitable to separate toluene and benzene by adding a new tower?
- ➢ How can we reduce the required heat?

Resolved Issues;
- ✓ Solved by attaching towers in parallel
- ✓ Several storage tanks
- ✓ Toluene and benzene are separated in the last distillation column
- ✓ Heat integration
- ✓ Combustion of hydrocarbons as a fuel
- ✓ Using of water as cooling

CONCLUSION

As a consequence, at the end of the 12 years of the project the cumulative cash flow diagram is obtained positive. Cost of fixed capital investment is covered in 2.37 years and the net present value (NPV) is obtained as 279 millions of dollars. Hence, the project is considered as an feasible investment.