

## Styrene Production From Ethylbenzene

### Styrene:

It is the product of the dehydrogenation of ethylbenzene. It is the monomer used in the production of polymers like polystyrene, ABS etc. and has commercial importance. Polystyrene is used for packaging and for making disposable insulated cups for hot beverages.

### Process Description:

Main Reaction: Ethylbenzene  $\rightarrow$  Styrene + Hydrogen

Side Reactions:

- Ethylbenzene  $\rightarrow$  Benzene + Ethylene
- Ethylbenzene + Hydrogen  $\rightarrow$  Toluene + Methane

Reaction Conditions: 500-600 degree Celsius, 125 to 170 kPa

The process flow diagram for the process is shown in Figure 1.

The fresh ethylbenzene (Stream 1) along with the recycled ethylbenzene (Stream 24) is heated and mixed with hot steam (Stream 6). A temperature of around 570 deg is achieved which drives the endothermic main reaction to the right. The reaction occurs in two packed bed conversion reactors in series (R-401, R-402) with interheating, where the steam from feed is used (Stream 25). The reactor effluents are cooled and fed to a three-phase separator to separate vapours (hydrogen, ethylene and methane), organic liquids and water as separate streams. (Streams 14, 15, 16 respectively). The hydrogen is sent for purification and water as wastewater. The organic liquids are distilled twice, once to remove benzene and toluene (T-401) and again (T-402) to remove unreacted ethylbenzene which is recycled to the feed mixture (Stream 19).

The following points need to be noted while creating this flowsheet in DWSIM:

- a) A single pass conversion of 45% in the first reactor and 21% in the second reactor was considered for the main reaction while it was less than 1% for the side reactions.
- b) The reactor operation was considered isothermal.
- c) One recycle loop was used for the ethylbenzene obtained from the second distillation column.
- d) The data given in Turton, et al. was used as the basis for developing the flowsheet and to confirm the results obtained.
- e) Instead of a V-401 Three Phase separator, 2 successive compound separators were used to separate the organic liquid, vapour and water streams.

### Process Flowsheet:

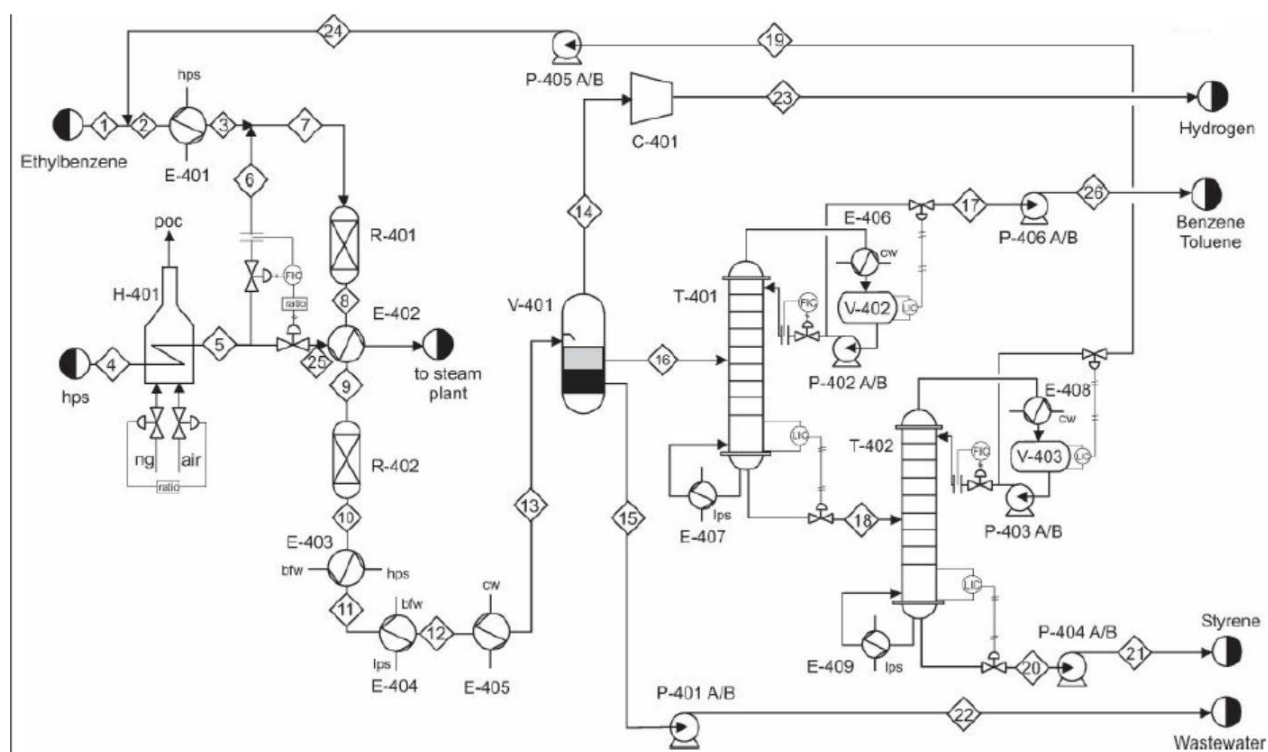


Figure 1: Production of Styrene from Ethylbenzene

### Results from Flowsheet:

Parameter	Units	Input		Output				
		Steam	Fresh Ethylbenzene	Hydrogen	Benzene-Toluene	Wastewater	Styrene	Steam Out
Temperature	Deg C	253.7	136	142.185	70.143	65.39	124.19	131.85
Pressure	kPa	4237	200	140	200	200	200	4187
Mass Flow	Kg/h	72353.64	13052.21	253.257	288.380	54045.21	12515.58	18308.64
Molar Flow	Kmol/h	4016.3	123.42	119.104	3.322	3000.017	120.146	1016.3

### Reference:

Analysis, Synthesis and Design of Chemical Processes. (Fourth Edition), Turton, Baile, Whiting, Shaeiwitz and Bhattacharya – Appendix B (Information for the Preliminary Design of Fifteen Chemical Processes)