

Energy efficiency of the cold train of an ethylene cracker

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Definition of the problem

Steam cracking of hydrocarbons is one of the most important processes of the petrochemical industry. In this process hydrocarbons are cracked into commercially more important products such as light olefins and aromatics. Feedstocks ranging from light alkanes such as ethane and propane up to complex mixtures such as naphthas are converted at temperatures ranging from 900-1200 K in tubular reactors suspended in large gas-fired furnaces. Next the obtained product mixture is quenched to terminate the chemical reactions. At this point, the hydrocarbon gases need to be liquefied for purification, and this is done by compressing the gases to high pressures and cooling them to very low temperatures (as low as -150 °C). Once the gases are liquefied, they are moved to the fractionation system and are separated by distillation columns as ethylene, propylene, a crude C4-fraction, pyrolysis gasoline and fuel gas. The enormous difference between the temperatures in the hot section (900 °C in the reactor) and the cold section (-150 °C in the demethanizer) are the main reason why the steam cracking process is the most energy-consuming process in the chemical industry. The separation train alone consumes gargantuan amounts of energy. The Kyoto protocol and the reducing profit margins have focused research attention to energy efficient design of the cold section. Therefore several alternative designs for the cold section of an ethylene cracker are simulated and compared with each other in order to decide which alternative is the most energy efficient.

Contribution

Ethylene cracking technology providers have continuously worked to improve the energy efficiency of their cracker designs. As a result, current designs are highly heat integrated. The three different schemes for the cold section are:

- De-methanizer first design
- De-ethanizer first design
- De-propanizer first design

The general feeling from talking to technology vendors is that these three schemes have roughly the same energy efficiency. However, for a naphtha steam cracker with an annual ethylene production capacity of 10⁶ ton ethylene simulation results show that significant differences exist between these different designs. These results allow to select the most energy efficient cold section and address the role of back-end and front-end hydrogenation in the separation train from an energetic point of view.

Significance

For the first time the different cold section designs used in highly integrated steam cracking facilities are compared with each other based on their energy efficiency. These results allow petrochemical companies to compare this important fixed operation cost to the capital cost of the different designs for a new steam cracker.

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