KBR Catalytic Olefins Technology – K-COT™

Feed-flexible technology to maximize propylene yield

K-COT™

A PARADIGM SHIFT FOR OLEFINS PRODUCTION

KBR Catalytic Olefins Technology (K-COTTM) uses commercially proven engineering services and products for converting low-value olefinic, paraffinic or mixed streams into high-value propylene and ethylene. The engineering services and products offered under K-COT build on KBR's experience in developing catalytic olefins technology for various feed types, and combines the know-how into one offering. K-COT™ can be implemented with a stand-alone olefin production unit or be readily integrated into a refinery or petrochemical complex to enhance profitability, operational flexibility and to meet market-driven product demand.

UPGRADE LOW-VALUE STREAMS

K-COT can be used to produce propylene from a variety of C4-C10 feeds. The technology effectively upgrades a variety of processes and feeds, including olefin-rich streams such as:

- Mixed C4s from refineries and conventional steam crackers
- Amylenes, TAME raffinate and mixed C5s from conventional steam crackers
- Cracked naphtha from FCCs, steam crackers, cokers and visbreakers
- Oxygenates, such as methanol and ethanol
- Other low value olefinic streams

The K-COT engineering services and products can also be employed as an alternative to steam cracking of naphtha.

PROPYLENE ALTERNATIVE

Most propylene worldwide is produced as a by-product from either steam crackers or FCC units. However, with the number of new ethane-based crackers coming online in the next few years and with few new FCC units being built, it is anticipated that the traditional sources of approximately 84% of the world's propylene will fall short of demand.

KBR Catalytic Olefins Technology (K-COT) uses commercially proven engineering services and products for converting low-value paraffinic streams, such as straight-run naphtha, into high-value propylene, ethylene and aromatics.

K-COT REACTOR DESIGN

While the reactor design associated with K-COT is based on KBR's proprietary Orthoflow™ FCC technology, it features unique and innovative design aspects to address the fact that the petrochemical feeds to these units are much lighter than those in a traditional refinery FCC. These patented, commercially demonstrated design features include:

Heat Balance – The processes used under K-COT are endothermic, so fuel must be continuously imported into the reaction system to maintain heat balance. KBR's patented catalyst well design with continuous fuel firing is commercially proven.

Catalyst/Hydrocarbon Separation – Although the cyclones are quite efficient, invariably some catalyst fines will carry over with the reactor effluent cracked gas. KBR's patented catalyst fines removal system is commercially proven.

FEATURES

The reactor (converter) comprises four sections:

- **Riser/reactor,** where the cracking reactions take place in the presence of catalyst
- **Disengager,** where catalyst is separated from product gas through the use of cyclones
- **Stripper,** where cracked gas contained in catalyst pores is removed via stripping with steam or nitrogen and routed with the other product gas
- **Regenerator,** where coke formed on the catalyst during the cracking process is removed by combustion with air, supplying heat of reaction or the cracking process

TYPICAL K-COT APPLICATIONS

- **Steam Cracker Integration**
  - Recycle converter for low-value steam cracking by-product
  - Furnace expansion replacement alternative
  - Grassroots combined olefins process
- **Refinery Integration**
  - Excess naphtha
  - High-value gasoline blending components
  - FCC units
- **Small scale standalone application**

  P/E ratio ≈ 1 –> size of economy for both PE and PP
- **Coal-based F-T or MTO integration**

  No additional processing for Olefinic/oxygenates feed

RECOVERY SECTION DESIGN

K-COT engineering services and products produce both polymer-grade ethylene and propylene. Much of the product-recovery flow scheme is similar to typical olefins-plant recovery sections; however, there are some unique features. For example, nitrogen oxides, oxygen, and other trace impurities from the FCC-type reactor must be removed. These and other issues are addressed in the process flow scheme, which features all the advantages of KBR's Depropanizer-First flow scheme including:

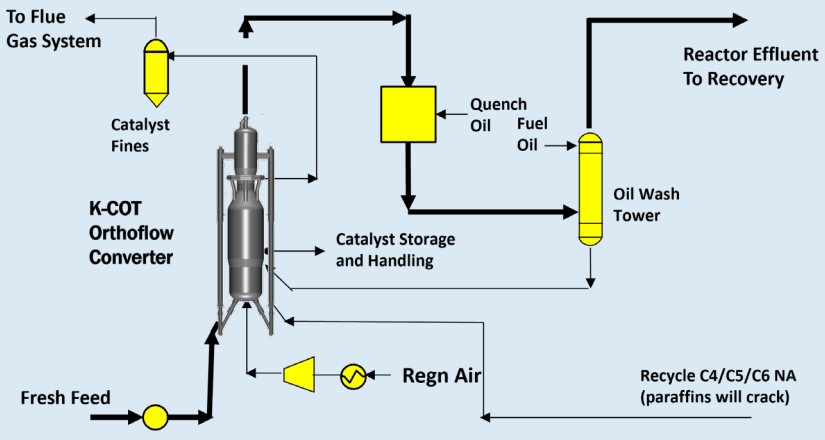
- Lower capital investment
- Exceptional reliability and operability
- Efficient energy utilization
- High on-stream factor
- Wide feed and turndown flexibility
- Smooth start-ups
- Lower maintenance costs
- Lower ethylene production cost
- Safe, environmentally compliant designs

COMMERCIALIZATION

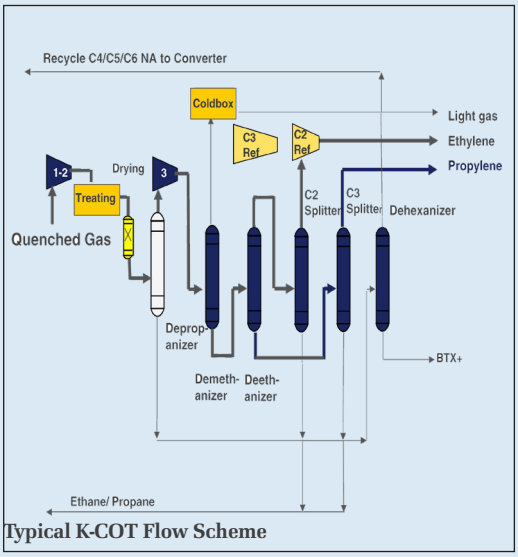
The first commercial catalytic olefins unit running on olefinic feed was started up at Sasol in South Africa in 2006. This unit converts a highly olefinic feed to produce approximately 250 KTA of propylene. The recovery section is designed to process additional olefin-rich streams and has ultimate capacity of 525 KTA of propylene and 200 KTA of ethylene.

The commercial demonstration catalytic olefins unit is located at the SK facility in Ulsan, South Korea. This unit achieved design feed rate as scheduled in late October 2010 and demonstrated good performance across a range of naphtha feed types and process conditions during its period of operation.

KBR has licensed several other units around the world.



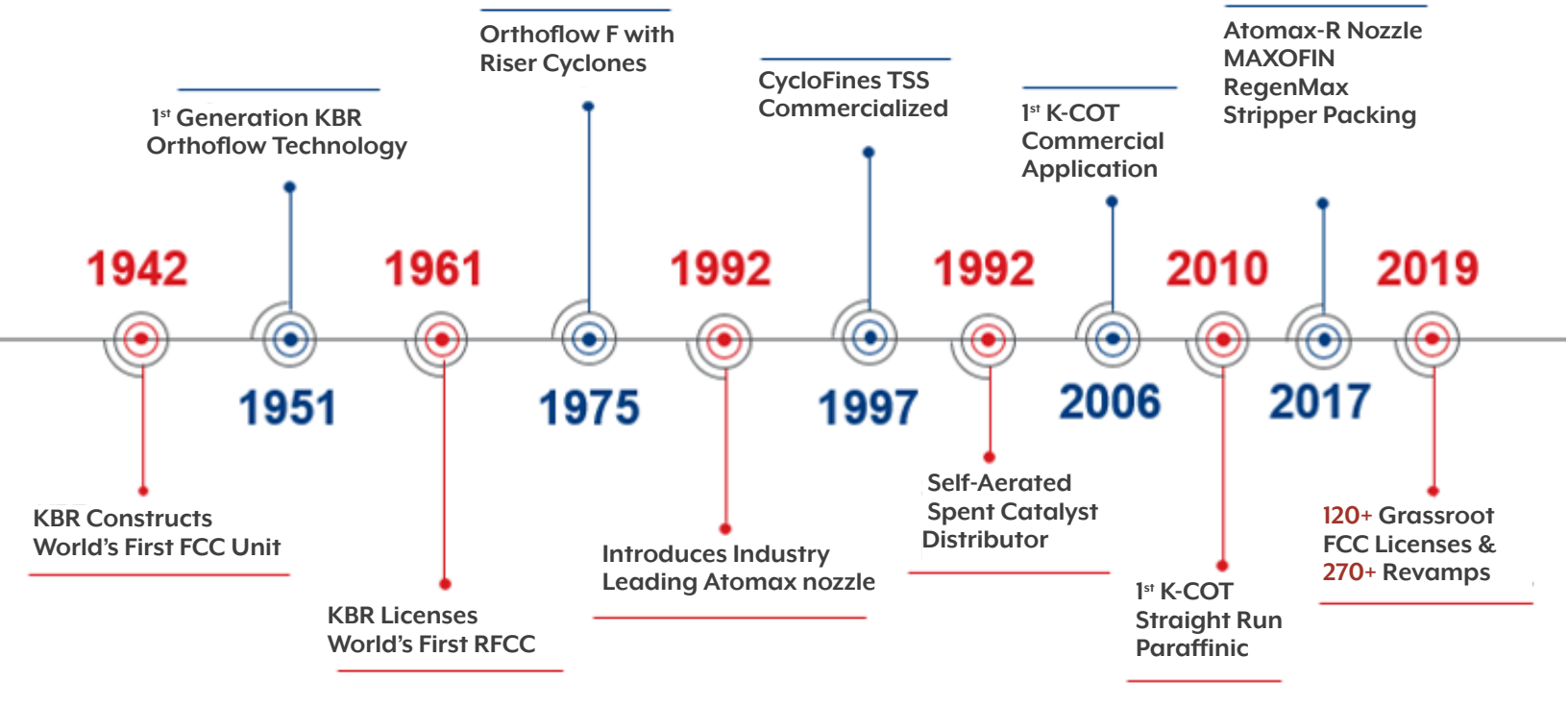
Process flow diagram with K-COT



Typical K-COT Flow Scheme

- This novel technology utilizes proprietary catalysts operating in fluid bed reactors
- KBR's know-how and extended experience in fluid bed reactor design and engineering ensures optimal operation
- K-COT engineering services incorporate KBR's years of experience in designing innovative, efficient and cost effective ethylene units
- K-COT increases propylene yields, reduces energy consumption and improves liquid cracker cost of production when compared to steam cracking

FCC REACTOR DESIGN TIMELINE



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