Crude Oil to *p*-Xylene

Zhejiang Refinery-PX Complex (Phase 1)

PEP Report 303A

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Abstract

Refinery based crude oil-to-chemicals (COTC) technology involves configuring a refinery to produce maximum chemicals instead of traditional transportation fuels. COTC complexes elevate petrochemical production to an unprecedented refinery scale. Due to the huge scale as well as the amount of target chemicals each COTC complex produces, COTC technology is expected to be disruptive, in terms of abrupt supply increase and price fluctuation, to the global petrochemical industry when each project starts. COTC is happening now with three refinery-PX projects, Hengli (Dalian, China), Zhejiang Phase 1(Zhejiang China), and Hengyi (Brunei) starting in 2019.

Hengli announced on May 17, 2019 that its COTC refinery-PX complex had achieved full line trial production. The complex is expected to produce 4.34 million tons of PX (paraxylene) per year, in addition to 3.9 million tons of other chemicals. The total chemical conversion per barrel of oil is estimated to be 42%. Hengli's configuraton is mainly based on hydrocracking of diesel, gas oil, and vacuum residue with technologies licensed from Axens. PEP Report 303, published in December 2018, analyzed Hengli Petrochemical's refinery-PX complex, provided PEP's independent analysis of the process configuration and production economics.

Zhejiang Petroleum and Chemical (ZPC) Co.'s COTC refinery-PX project has two phases. Phase 1 is close to completion with several units in the intial trial operation. During the recent visit by IHS Markit on May 23, 2019 to Rongsheng, the majority share holder of ZPC, said that full operation is expected in the third quarter of 2019. When completed, Phase 1 is expected to produce 4.0 million tons of PX, 1.5 million tons of benzene, 1.4 million tons of ethylene, and other downstream petrochemicals. The total chemical conversion per barrel of oil is about 45%.

ZPC's configuration is mainly based on diesel hydrocracking with technology licensed from Chevron and gasoil hydrocracking with technology licensed from UOP. For vacuum residue upgradation, ZPC uses Delayed Coking (open art) and Residue Desulfurization followed by Residue Fluid Catalytic Cracking (RFCC) licensed from UOP. The Phase 2 project construction has also started, and when completed it will have a similar scale to Phase 1. However, the Phase 2 refinery configuration will be further enhanced by UOP to produce more mixed feeds to support two word-scale steam crackers as compared to one cracker for Phase 1. The total chemical conversion has been announced to increase to 50%, up from 45% in Phase 1. The number of downstream petrochemical units is also expected to differ from Phase 1.

The objective of this report (PEP 303A) is to analyze ZPC's Phase 1 refinery-PX complex. Although Zhejiang Phase 1 project, as announced, includes a steam cracker and fifteen downstream

petrochemical units, PEP 303A analysis will draw a boundary before steam cracker to focus on PX production economics to be compared to that of Hengli's complex.

Section 1 introduces various crude oil-to-chemicals (COTC) approaches including directly feeding a light crude to steam cracker and configuring a refinery to produce maximum chemicals. In this section, we have discussed the merits and impacts of each approach, and why COTC is different from the conventional state-of-art refinery-petrochemical integration. We have elaborated the potential impact and implications of COTC on global petrochemical production.

Section 2 summarizes the overall PX production economics of Zhejiang Phase 1 refinery-PX complex. The economics are evaluated under a wide range of oil price scenarios and compared with Hengli's project.

Section 3 provides a status update of all announced COTC projects with emphasis on ZPC's project progress and Phase 1 as well as Phase 2 main process units and technology choices. We also discuss the market impact of PX focused COTC projects that are expected to start operation this year on future supply along with demand in China and around the globe.

Section 4 provides technology overview and process description of all ZPC-1 refinery process units.

Section 5 presents ZPC-1 refinery production economics of each individual unit, and for the major process blocks in the complex.

Section 6 presents the overall complex process economics and an investment return (ROI) sensitivity analysis.

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