Intensified hydrogenation process via catalytic chemistry and engineering.

Yutao Ding, Chong Peng*

State Key Laboratory of Fine Chemicals, School of Chemical Engineering, Dalian University of Technology, NO. 2 Linggong Road, Dalian 116024, China

**Corresponding author: pengchong@dlut.edu.cn*

Highlights

- Intensified hydrogenation process via catalytic engineering.
- Hydrogenation technology with low energy consumption and low project investment.
- LCO hydrocracking to produce high octane number gasoline.
- Hydrocracking catalyst grading to improve product quality.

1. Introduction

Hydrogenation technology is an essential cornerstone in the production of clean oils and the improvement of product quality, which is the core of refining and chemical integration. Despite its extensive development over decades, considerable strides have been made in hydrogenation technology, but there are still several problems such as high investment and operating costs, alongside elevated energy consumption, etc., which are unable to meet the requirements of petrochemical companies for sustainable development. Herein, this review endeavors to systematically discuss the principle of intensified hydrogenation process via catalytic chemistry and engineering, which involved catalytic materials and the process design, etc. Moreover, the perspectives and pivotal research directions within hydrotreating and hydrocracking for the intensified hydrogenation process will be outlined.

2. Results and discussion

2.1 SHEER hydrocracking technology.

Nowadays, there are many technologies that are meaningful to reduce energy consumption, such as the method of operating a hydrocracking reactor that reduces energy consumption and avoids over-temperature situations, thus enhancing operational safety from SINOPEC; Jet-type internal circulation flow reactor that lowers energy use and enhances the effective use of reactor space from Zhejiang University; Hydroprocessing method that operates at higher temperature and pressure while reducing energy sand hydrogen consumption by Astanovskij et al. To reduce energy consumption, SINOPEC developed a highly efficient hydrocracking technology named as Sheer. This technology fulfills the integration of high temperature and high-pressure counter-current heat transfer, state-of-the-art reactor internals, micro-swirl separation and non-directcontact fouling prevention. The new start-up scheme for a set of partial autothermal hydrogenation technology was developed. This scheme lowers project investment and operation costs. The calculation results of Sheer hydrocracking process are based on a hydrocracking unit. It shows that high efficiency Sheer hydrocracking technology can reduce unit energy consumption by 44.85% and save 4.56% project investment. This scheme has good economic and social benefits, as well as good application prospects. The schematic diagram of the Sheer process is displayed in Fig. 1.

2.2 LCO hydrocracking technology.

Light cycled oil (LCO) hydro-conversion technology for producing clean gasoline with high octane number features the catalyst, which leads to oriented conversion of polycyclic aromatic hydrocarbons (PAHs). This catalyst was invented and prepared by micro-regulating the structure-effect relationship of the bi-functional catalyst. Besides, multi-dimensional manipulation method with pressure, temperature and other factor regulation ability was invented. The developed LCO hydro-conversion process which features the ability of restricting excessive hydrogenation or saturation, can produce National V gasoline component with yield beyond 50% and high cetane number between 91 to 94.

2.3 Hydrocracking catalyst grading technology.

Different from the current technology using a single type of hydrocracking catalyst, the invention technique uses the novel method for partitioning to strengthen the selective conversion of hydrocarbon molecules. By using different functional hydrocracking catalysts in a graded configuration, the “ideal” hydrocracking reaction process is efficiently strengthened to achieve high quality and high yield production of chemical feedstock. The invention hydrocracking technology with extended reaction temperature interval, significantly reduces the amount of cold hydrogen, and reduces the energy consumption of unit (over 21%). It meets the needs of the society and the industry, and is a model of green and low-carbon development in the petroleum refining industry. Ten industrial units using the new technique has been constructed for three years, saving 460,000 tons of standard coal and reducing 122 million tons of carbon dioxide.

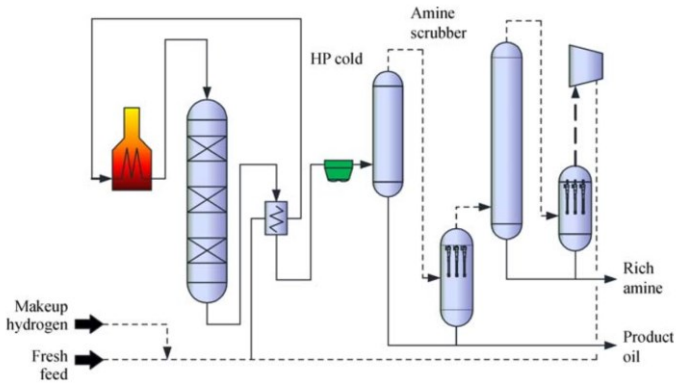

Figure 1. Process flow diagram of 2.0Mt/a SHEER hydroprocessing unit.

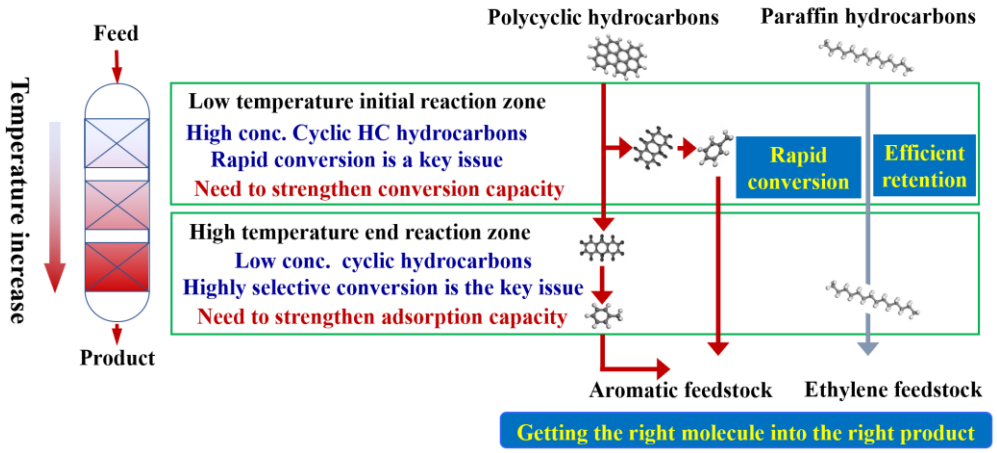

Figure 2. Method for partitioning to strengthen the selective reaction of molecules.

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Keywords

process intensification; reaction engineering; catalyst activation; hydrogenation.