

Oil Refining Business in China

Guo Sizhi, Senior Researcher, Energy Strategy Department

Kaku, ShiShi (Guo,Sizhi), PhD.
Senior Researcher
Energy Strategy Department

Introduction

The oil refining industry in China faces the challenges of coping with expanding crude oil imports, increasing processing volume for Middle East high-sulfur crude (sulfur content of 1% or more) and improving the quality of oil products with the increase in domestic demand for petroleum products. The following report goes over oil refining situations and trends in China as well as Chinese oil companies' moves to deal with the situations.

1. The present state of oil refining

The crude processing capacity in China was 304 million tons/year as of the end of 2003, and the volume of crude processed that year was approximately 243 million tons. Of China's total, the processing capacity for Sinopec Corp. and PetroChina was 142.3 and 111.05 million tons/year, respectively, with volume processed 116.26 and 91.2 million tons/year, respectively. Their refining capacities increased 7.5% and 0.2%, respectively from the previous year and the volume of processed crude also increased 10.7% and 9%, respectively, compared with the previous year. Likewise, their capacity utilization rates increased 3% to 81.7% for Sinopec and 8.8% to 82.1%.

The two major oil companies processed 29.162 million tons of high-sulfur crude imported from the Middle East in 2003, or 14.1% of the two companies' combined total volume of processed crude (207.46 million tons). In 2003, the amount of high-sulfur crude processed by Sinopec Corp. accounted for 23.77 million tons, up 18% from a year earlier, out of its total crude processing volume of 116.26 million tons.

PetroChina produced 80.35 million tons of flagship petroleum products, such as gasoline, diesel fuel, kerosene, lube oil, base oil, fuel oil and LPG in 2003, up 2.9%

from 2002. Of the total, the production of gasoline, diesel fuel, and kerosene rose, respectively, by 9% to 19.38 million tons, 11.7% to 34.41 million tons, and 0.7% to 2.96 million tons. Sinopec Corp.'s production of petroleum products during the same year jumped 10.9% from the previous year to 106.74 million tons, largely surpassing PetroChina. Its production of gasoline, diesel fuel, and kerosene amounted, respectively, to 19.38 million tons, up 10.8%, 41.67 million tons, up 10.4% and 2.96 million tons, up 5%.

2. Breakdown of oil refineries by type in China

These two major oil companies in China have three main types of oil refineries.

1) Major oil refineries of the low-sulfur crude processing type

Oil refineries affiliated with PetroChina, such as Dushanzi Petrochemical refinery, Lanzhou Petrochemical, Dalian Petrochemical, Jinzhou Petrochemical, Fushun Petrochemical and Daqing Petrochemical process crude with low sulfur content produced from oil fields mainly in such inland regions as northeastern and northwestern China. Most of the refineries owned by PetroChina are those of the type to process low-sulfur crude. Also, oil refineries affiliated with Sinopec Corp., such as Yanshan Petrochemical and Tianjin Petrochemical are of the same type to process low-sulfur content crude. Sulfur content of the gasoline produced at refineries of this type is usually 200 ppm or lower.

2) Major oil refineries for processing medium-sulfur crude

Most of the refineries of this type belong to Sinopec Corp. These refineries are capable of producing gasoline equivalent to Euro II class (sulfur content: 500 ppm) and diesel (sulfur content: 500 ppm). This type can also be divided into two subtypes.

A. Domestic crude processing type

Luoyang Petrochemical in Henan Province, Changling Petrochemical Refinery in Hunan Province and others are processing crude from domestic oil fields other than Daqing.

B. Imported crude processing type

Jiujiang Petrochemical, Wuhan Petrochemical, Jingmen Petrochemical Oil Refinery and Shanghai Gaoqiao Oil Refinery, located along the Yangtze River, import and process crude with relatively low sulfur content (medium- to low-sulfur) in view of their locations in coastal areas and access to Yangtze River transportation.

3) Major oil refineries of the high-sulfur crude processing type

Strong points of oil refineries of this type are their high refining capabilities and their being equipped with hydrogenation refining facilities (desulfurization facilities) and hydrocracking facilities. All but PetroChina's Dalian West Pacific Petrochemical Co. refinery belong to Sinopec Corp. They include Zhenhai Petrochemical Oil Refinery in Zhejiang Province, Qilu Petrochemical Oil Refinery in Shandong Province, Jinling Petrochemical Oil Refinery in Jiangsu Province, Yangzi Petrochemical Oil Refinery in Jiangsu Province, Maoming Petrochemical in Guangdong Province and Guangzhou Petrochemical in Guangdong Province. Oil refineries of this type can process high-sulfur crude from the Middle East and produce gasoline with the quality standard equivalent to Euro III Standard (sulfur content: 150 ppm) and diesel with the standard equal to Euro II Standard (sulfur content: 500 ppm). Processing of high-sulfur Middle East crude oil is expected to increase further with the further expansion of this type of facilities.

3. Approaches to oil refining business by China's two major oil companies

1) Expansion of Facilities and Handling Imported Crude

PetroChina and Sinopec Corp. have been expanding facilities to cope with the fast rising crude import and increasing demand for petroleum and petrochemical products, and they are achieving a transformation to large-scale modern oil refineries, integrated with their petrochemical divisions. Through promoting this facilities expansion process, these oil companies aim at achieving economies of scale by handling imported crude, particularly high sulfur content crude from the Middle East, optimization of oil products and improving quality of their products, raising product yields, and lowering costs for refining and production. As specific steps to achieve the goals, they are implementing such measures as shutting down small refineries that are economically inferior in terms of meeting environmental requirements, enhancing topper capacity at major refineries,

to meet ethylene demand by creating refinery-petrochemical complexes, and introducing additional facilities to produce lower-sulfur fuel oils.

With the widening gap in the domestic oil supply and demand in China, the country's dependency on overseas imported crude has been increasing. China's crude imports in 2003 totaled 91.13 million tons, a 71% jump from the previous year, and in 2004, crude imports again rose sharply by 34% to 122.72 million tons from 2003. To cope with the fast rising crude imports, plans to expand refining capacity are also underway. Under the 10th five-year economic plan, the Chinese government already laid out plans to beef up the country's oil refining capacity to 270 million tons a year during 2005. It also plans to increase the refining capacity for rising imported high-sulfur crude to 75 million tons by 2005.

Against this backdrop, PetroChina and Sinopec Corp. have been aggressively tackling with increasing their refining capacities. In 2005, plans are to expand the two companies' refining capacities to about 118 million tons and 160 million-170 million tons, respectively. Sinopec Corp. is expanding the refining capacities at its Zhenhai and Maoming refineries in eastern China to 20 million tons each, and also trying to increase processing capacities for high-sulfur crude at Shanghai Gaoqiao, Jinling, Yangzi and Fujian petrochemicals to meet the need to process more imported high-sulfur crude.

Thanks to those efforts, Sinopec Corp.'s refining and production costs have been decreasing. In 2003, its refining cost declined from 136 yuan/ton in 2002 to 132 yuan/ton. As a result of the above mentioned expansion of facilities, Sinopec Corp. is expected to maintain its high-sulfur crude refining capacity at 60 million tons and over as of 2005.

Expansion of refining capacity by PetroChina is relatively small, compared with Sinopec Corp. It plans to increase its refining capacity to some 118 million tons. Most of the company's refineries, except its Dalian Petrochemical, are located in inland areas close to oil fields and have processed domestically produced low-sulfur crude. At Dalian Petrochemical, the only exception, it plans to increase the refining capacity from the current 7.1 million tons to 20 million tons by 2005. In addition to processing Dalian crude, the refinery aims to more high-sulfur crude oil, and an additional capacity of at least 5 million tons out of the all increased capacity will be used to process high-sulfur

crude. Also, the refining capacity at Dalian West Pacific Petro-chemical (a joint venture refining company with French TOTAL) is planned to be expanded to 10 million tons from the current 8 million tons; and that of Lanzhou Petrochemical in western China is to be increased also to 10 million tons from the current 7 million tons. At present, PetroChina is aggressively building up its major refineries' capacities, while closing down gradually smaller refineries (their combined refining capacities: 16 million tons), with low production efficiency and inferior economies of scale.

These two major oil companies are trying to expand and improve their facilities for hydrocracking and hydrogenation refining. Currently, the two companies' facilities have a very high ratio of fluid catalytic cracking (FCC) capacity compared the atmospheric distillation capacity. On the other hand, they have low ratios of catalytic reforming, hydrocracking and hydrogenation refining capacities.

In the case of PetroChina, the ratio of its FCC capacity compared to atmospheric distillation capacity is high at 46%, while that of catalytic reforming capacity is only 7.7%. At Sinopec Corp., too, the FCC capacity ratio to the atmospheric distillation capacity is 41%, while the catalytic reforming capacity is 8.2%.

The reason for this unbalance is that major types of domestically produced crude, such as Dalian crude, are low-sulfur-content, heavy crude oil. In other words, the crude contains much heavy distillate, a material for FCC, and much less naphtha, a material for catalytic reforming. Refineries in China were originally designed and built to process domestically produced crude with such characteristics.

For the two major oil companies, it is essential and urgent that they increase the ratios of hydrocracking and hydrogenation refining facilities to produce high quality middle distillate and deal with the increasing processing of Middle East crude. The ratio of hydrocracking capacity to the atmospheric distillation at Chinese oil companies is 2.7% on the average, much lower than the international average of 5.6%. Also, the ratios of hydrogenation refining capacity for PetroChina and Sinopec Corp. are 23% and 32%, respectively, much lower than the world average of 49.2%. Both companies are now trying to expand refining capacities, according to the types of refineries based on the differences of sulfur contents of the crude they process. And they are also working to increase hydrocracking and hydrogenation refining facilities. Furthermore, they are aiming to raise the ratios of catalytic reforming and alkylation facilities, which are

manufacturing facilities for high-quality, high-octane gasoline components.

Refineries affiliated with PetroChina are, as previously noted, mostly refineries designed for processing low-sulfur crude. Actions can be seen there in actively increasing refining capacities and expanding facilities. For example, the Dalian Petrochemical refinery, which has been processing Dalian crude and low-sulfur Indonesian and Malaysian crude similar in quality to Dalian crude, has begun also processing Russian crude (Siberia Light's sulfur content: 0.6 to 0.7%) with higher sulfur content than Dalian crude (sulfur content: 0.1%). Plans are for it to also process imported crude from the Middle East in the near future. To meet the need for this change, Dalian Petrochemical signed a contract with Shell in April 2003 to introduce refining technology. The latest Shell process and technologies are employed in seven refining plants, including those for catalytic cracking, catalytic reforming, hydrocracking and hydrogenation refining, attached to the 10 million ton topper scheduled to be completed in 2005.

Also, Sinopec Corp. Yangzi Petrochemical refinery, which has been processing both domestically produced and imported low- to medium-sulfur crude from the start, is rapidly expanding processing of high-sulfur crude to cope with increases in imports of high-sulfur crude from Saudi Arabia and other Middle East producers. This refinery spent some \$200 to introduce UOP's Unibon method technology for the 1.0 million-ton/year hydrocracking facilities and 1.2 million-tons/year diesel hydrogenation refining unit and completed those new facilities.

2) Improving the quality of oil products and meeting environmental requirements

The oil companies in China have been stepping up their efforts to introduce latest facilities to improve the quality of their petroleum products and to meet environmental requirements in addition to expanding their production facilities aggressively to cope with the rapid increases of oil demand and rises of crude imports.

A. The present state of and future plans for quality standards for gasoline and diesel fuel in China

a. Gasoline

Following the strengthening of environmental regulations in China, sale of leaded

gasoline was banned from the second half of 1999 in the three largest city areas of Beijing, Shanghai and Guangzhou and in other coast cities. From January 2000, the Chinese government prohibited the oil companies from producing leaded gasoline. In July the same year, sale of leaded gasoline was banned throughout the country. Also, in the same month, the government introduced new gasoline quality standards (GB17930-1999) to the areas around the three largest cities. Those standards were also applied to the rest of the country beginning in 2003. According to the quality standards, unleaded gasoline is divided into three grades by Research Octane Numbers: RON90, RON93 and RON95.

The sulfur content was also cut to 0.1 wt % or lower from the previous 0.15 wt %, and the benzene content is limited to 2.5 vol %, and olefin and aromatics contents 35 vol % each. The sulfur content regulation was further tightened to 0.08 wt % beginning on January 1, 2003.

b. Diesel fuel

The government introduced new quality standards (GB252-2000) for diesel fuel throughout the country. According to the new standards' specifications, the sulfur content was set at 0.2 wt % or less from the previous 0.5 wt % to 1 wt %, with the cetane number at 40 to 45 or higher. The standards are set to become stricter on July 1, 2005, with the sulfur content limited to 0.05wt percent or lower and the cetane number required at 49 or higher.

c. Plans to introduce quality standards

China plans to introduce quality standards equivalent to the EUII Standard for gasoline and diesel fuel on the nationwide basis in 2004 to 2005, and the EUIII Standard to the three largest city areas of Beijing, Shanghai and Guangzhou, as well as other major cities during 2005. The gasoline and diesel standards equal to the EUIII are planned to be extended to the rest of the country in 2008, when the three largest city areas and other major cities will have EUIV standards.

B. Approaches by PetroChina and Sinopec Corp.

The two major oil companies in China have made efforts to improve the structure of refining capabilities and expand facilities to cope with the tightening of the quality standards, as mentioned above. At the same time, their refineries are characterized as

having a high ratio of gasoline obtained by FCC process making up their overall gasoline components and high sulfur and olefin content in diesel fuel. Some of the major steps are as follows.

The first such step is to improve and expand capacities of processing facilities, such as catalytic reforming and hydrocracking, with the aim of expanding their production capacity for quality gasoline and diesel gas oil. The second such step is to expand the hydrogenation refining capacities, and the third one is to introduce MGD— technology related to the FCC process—to improve the FCC facilities and catalyst technologies.

During the period from 1999 to 2003, Sinopec Corp. expanded reforming facilities' capacity by 2.25 million tons/year, hydrocracking capacity by 4.8 million tons/year and hydrogenation refining and processing capacity by 21 million tons. It also modified and improved 21 units of FCC facilities.

Sinopec Corp.'s Maoming Petrochemical refinery will expand its annual processing capacity from the current 13.5 million tons to 18.8 million tons. At the same time, it will introduce facilities for hydrogenation refining of 2 million tons of diesel fuel annually, as well as 1.5 million-ton hydrocracking and 30,000-ton desulfurization facilities. That will allow the refinery to handle more high-sulfur Middle East crude and better process high-sulfur crude, thereby meeting the Euro III standards and producing "cleaner" gasoline and diesel gas oil.

PetroChina has also aggressively promoted introduction and expansion of facilities. For example, its affiliate, Jinxi Petrochemical, introduced UOP's ultralow-pressure process and other technologies to produce gasoline conforming to the 2003 new standards (olefin content: 35% or lower) and completed a 600,000-ton/year continuous catalyst regenerator (CCR) with an investment of 420 million yuan.

In 2003, PetroChina also spent 450 million yuan to build a hydrocracking facility with capacity to produce 600,000 tons a year at its Dushanzi Petrochemical, with completion expected by the end of 2004. With the completion of the new facilities, Dushanzi refinery will become capable of processing high-sulfur, high-metal crude, and thereby become possible to produce clean gasoline, diesel fuel, high quality jet fuel, lube and base oil. It is expected to be able to handle processing of high-sulfur Kazakhstan crude. Also, PetroChina's Dalian Petrochemical has been constructing gas

desulfurizing facilities with an annual processing capacity of 100,000 tons and 30 million-ton/year sulfur recovering facilities to cope with new quality standards for fuel oils. Those facilities are scheduled to be completed by the end of 2005.

Conclusion

China's oil consumption in 2004 increased 14.2% over the previous year to approximately 314 million tons. Subsequently, crude imports totaled 122.72 million tons, a sharp 35% increase over those for 2003. In 2005, the country's oil consumption will rise to 320 million tons, with crude imports of more than 140 million tons. Thus, crude imports, particularly imports of crude with high sulfur content, have been further increasing to cope with the fast rise in domestic energy demand. To meet the expected need to process more high-sulfur crude and to satisfy new quality standards for oil products to be introduced in the future, the two Chinese oil giants PetroChina and Sinopec Corp., are expected to take on expansion of refining capacities and building up of secondary facilities through aggressive introduction of advanced technologies.

For inquiries: report@tky.iej.or.jp

References

National Development and Reform Commission Economic Bureau/ Sinopec
“Annual Report on the Study of the Chinese Petroleum and Petrochemical Industry and Economy”, volumes for individual years
CNPC “2003 Petroleum and Natural Gas Yearbook”, Beijing, 2004
Sinopec “2004 Petrochemical Yearbook”, Beijing, 2004
China OGP
Dow Jones China Energy Report
PEC materials, others