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# CATALYTIC CRACKING DEVELOPMENT AND ITS ROLE IN MODERN RUSSIAN REFINERY

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*Problems of Russian refineries in face of new requirements for motor fuels considered in the article. It is made review of modern state and development plans of catalytic cracking in Russia. It is considered actual foreign and domestic technologies.*

*Keywords: catalytic cracking process, FCC, ultimate gasoline, cracking catalyst, octane number*

Because of enacting technical regulations "Requirements to gasoline, diesel oil and some fuels and lubricants" there will be dramatic changes in Russian gasoline market in 2011 (Table 1):

- growth of ultimate gasoline (Class 3 and higher) demand;
- decreasing of low-octane gasoline demand.

Most of Russian refineries are not ready to produce high-quality fuels because of underdevelopment of secondary processes and lack of time and money for adoption of new technologies. There is necessity of deep modernization of oil-refining industry on the basis of catalytic cracking, hydrocracking or combination of these processes as a best way for production of full range of high-quality fuels.

Catalytic cracking plays a key role in the refining industry as a light products yield increasing process. But the part of this process in Russian refineries is low comparing to developed countries (Figure 1).

Only 13 of Russian refineries have catalytic cracking units, i.e. every second big refinery (Table 2). There are 21 catalytic cracking units in Russia with total capacity 19.8 million t/year, 11 of these units are old-fashioned G-43-102 with bead catalyst [2].

 

Table 1

Motor gasoline specifications [1]

| Parameters | Requirements for classes | | | |
|---|---|---|---|---|
| | 2 | 3 | 4 | 5 |
| Sulfur content, mg/kg, no more than | 500 | 150 | 50 | 10 |
| Benzene content, vol. %, no more than | 5,0 | 1,0 | 1,0 | 1,0 |
| Lead content | absence | absence | absence | absence |
| Oxygen content, mass %, no more than | - | 2,7 | 2,7 | 2,7 |
| Hydrocarbons content, vol. %, no more than: | | | | |
| aromatic | - | 42 | 35 | 35 |
| olefinic | - | 18 | 18 | 18 |
| Octane number, no less than: | | | | |
| research method | 92 | 95 | 95 | 95 |
| motor method | 83 | 85 | 85 | 85 |
| Vapor pressure, kPa | | | | |
| summer gasoline | - | 45-80 | 45-80 | 45-80 |
| winter gasoline | - | 50-100 | 50-100 | 50-100 |
| Oxygenates content, vol. %, no more than | | | | |
| methanol | - | absence | absence | absence |
| ethanol | - | 10 | 10 | 10 |
| isopropanol | - | 10 | 10 | 10 |
| tret-butanol | - | 7 | 7 | 7 |
| isobutanol | - | 10 | 10 | 10 |
| ethers with 5 or more carbon atoms in molecule | - | 15 | 15 | 15 |
| other oxygenates (with end boiling point no more than 210 °C) | - | 10 | 10 | 10 |

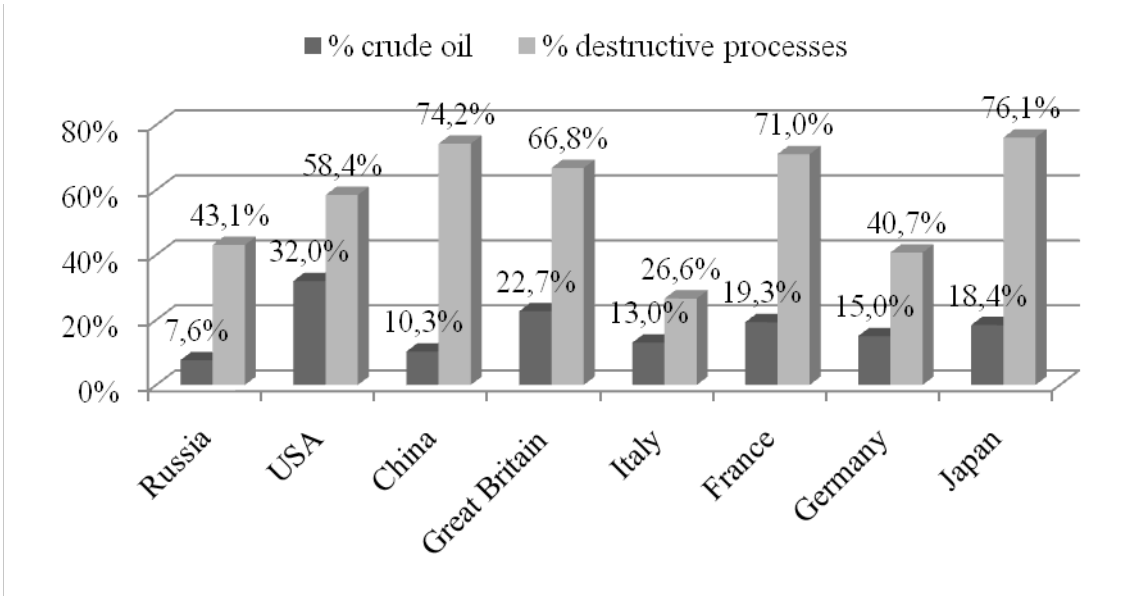


Figure 1. Part of catalytic cracking in the leading countries [2]

Table 2

Catalytic cracking units in Russia [2]

| Refinery | Type of unit (start-up year) | Designed (actual) capacity, thousand t/year |
|---|---|---|
| Syzran refinery | G-43-102 (1960), G-43-102 (1963) | 288 (322); 435 (322) |
| Kuybyshev refinery | G-43-102 (1952) 3 units | 250 (892,4) |
| Novokuybyshev refinery | G-43-102 (1955) 2 units | 250 (355); 250 (355) |
| Angarsk petrochemical plant | CC GK-3 (1969), 1A/1M (1967) modernization in 2003 | 760 (846); 750 (917) |
| Moscow refinery | G-43-107 (1983) | 2000 (2000) |
| Salavat petrochemical plant | G-43-102 (1955) 2 units | 250 (320); 250 (320) |
| Omsk refinery | G-43-103 (1971), G-43-107 (1994) | 1200 (1546); 2000 (2000) |
| Ufa petrochemical plant | 1-A (1963) | 750 (1800) |
| Ufa refinery | G-43-107M/1 IFP Technip (1995) | 2000 (2177) |
| Yaroslavl petrochemical plant | 1A/1M (1967, revamping 2000) | 750 (1250) |
| Perm petrochemical plant | G-43-102 (1959, revamping 1996) G-43-102 (1959) | 700 (568); 250 (382) |
| Ryazan refinery | 1A/1M (1967, revamping VNIPIneft JSC and ABB Lummus Global 2001) | 2500 |
| Nizhnekamsk refinery | VNIPIneft JSC and VNIINP JSC (2006) | 880 (925) |

Many Russian refineries planned modernization or building new FCC units within next years (Table 3). Investment plans estimation indicates that about 27 % of gasoline produced in Russia will meet Euro-4 specifications in 2012 [3]. But making allowance for world economic crisis this value would be less.

The main licensors of catalytic cracking are foreign companies (Table 4) but experience of JSC “TAIF-NK” in Nizhnekamsk shows that there are modern competitive catalytic cracking technologies in Russia. There was built FCC unit with hydrotreatment of gasoline with VGO processing capacity 880 thousands t/year developed by VNIPIneft

JSC and VNIINP JSC jointly with GrozNII. It performed high efficiency and potential to increase capacity which will reach 1 million t/year after modernization in 2009 [6].

Table 3

Planned catalytic cracking development in Russia [2, 3]

| Refinery | Development (licensor, capacity, start-up year) |
|---|---|
| Syzran refinery | Revamping G-43-102 (till 2010) |
| Kuybyshev refinery | Building FCC (UOP, 1150 thousand t/year) |
| Novokuybyshev refinery | Revamping G-43-102 |
| Angarsk petrochemical plant | Revamping CC GK-3 and 1A/1M |
| Salavat petrochemical plant | Building FCC (Shell, 1200 thousand t/year, 2012) |
| Volgograd refinery | Building FCC (1400 thousand t/year, 2009) |
| Perm petrochemical plant | Building FCC (1500 thousand t/year, 2009) |
| Nizhny Novgorod petrochemical plant | Building FCC (2000 thousand t/year, 2009) |
| Kirishi petrochemical plant | Building FCC (1600 thousand t/year) |
| Kirishi-2 | Building FCC (3000 thousand t/year) |
| Saratov refinery | Building FCC (1200 thousand t/year) |
| Nizhnekamsk refinery | Revamping (1000 thousand t/year, 2009) |
| Nizhnekamsk refinery-2 | Building FCC (1000 thousand t/year) |
| Orsk petrochemical plant | Building FCC (1300 thousand t/year) |

Table 4

Main licensors of catalytic cracking [5]

| Licensor | Process, features |
|---|---|
| UOP LLC (in collaboration with BARCO) | MSCC (Millisecond Catalytic Cracking, >6 units) |
| | FCC |
| | RFCC (Residue FCC) |
| | PETROFCC (Petrochemistry FCC) |
| ABB Lummus Global Inc. | FCC (>13 units) |
| Kellog Brown & Root, Inc. | FCC (>120 units) |
| Shell Global Solution International B.V. | FCC (>30 new units and >25 revamped units) |
| Stone & Webster Inc., Shaw Group | FCC (>26 new units and >100 revamped units) |
| | DCC (Deep Catalytic Cracking, >6 units) |
| | Residue FCC |

More than 95 % of world market of cracking catalysts is controlled by 3 producers: Grace Davison, BASF (Engelhard) and Albemarle (AkzoNobel). Bead and microspheric cracking catalysts consumption in Russia is 12 to 18 thousand tons per year. Only 35 % of bead catalysts and 15 % of microspheric catalysts are produced in Russia [4]. Modern Russian catalysts have good efficiency and quite competitive but its usage impeded by practically total absence of catalysts factories in Russia (only 2, in Salavat and Omsk).

JSC "Salavatnefteorgsintez" produces C-600 bead cracking catalyst developed by CATACHEM Company Ltd which enables to obtain light products yield 75-76 wt. % including 30-37 wt. % of gasoline with MON 80. At the moment JSC "Salavatnefteorgsintez" also uses C-600U catalyst which makes it possible to produce 29 wt. % of gasoline with MON more than 81 remaining light products yield at the level 75 wt. %.

JSC "Gazpromneft – Omsk refinery" uses FCC catalyst Luks-1 developed jointly with IHPP SB RAS. This catalyst ensures gasoline yield 58 wt. % with MON 81.5 and RON 92.5. Resent developments of IHPP SB RAS make it possible to produce FCC gasoline with yield more than 60 wt. % and MON more than 82 [7,8].

IHPP SB RAS also developed deep catalytic cracking catalysts with light olefins yield up to 42 wt. %, metal-resistant cracking catalysts for heavy feedstock, CO oxidation promoter without noble metals [8].

In spite of big lifetime of catalytic cracking process it still has development potential. There are different directions of improvement:

1. development of new catalysts with improved products yield and quality (higher gasoline octane number, lower sulfur content etc.);
2. revamping of reactor section in order to improve products yield and quality: fast separation systems, reactors with very short contact time (SCT, MSCC etc.), high-performance feed input devices;
3. improvement of regeneration process (different regenerator designs for even regeneration with minimal catalyst deactivation, catalysts with CO afterburning promoters, special additives for regeneration);
4. optimization of energy balance of the unit;
5. using of special catalytic cracking processes to produce light olefins (DCC) or to process heavy feedstock (R2R, HOC, RCC etc.);

6. development conditions and promoters for regeneration in order to decrease emissions with regeneration gases.

Modernization of Russian refineries based on catalytic cracking with maximum application of domestic technologies will make it possible to increase high-quality fuels production in shortest time with relatively low capital expenditures.

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