In this section we are publishing articles by staff members of the All-Union Scientific-Research Institute of Petrochemical Processes (VNIINeftekhim) describing the main trends in activity of the Institute, timed to coincide with the 50th anniversary of the founding of the Institute.

CONTRIBUTION OF VNIINeftekhim TO THE DEVELOPMENT OF PROCESSES FOR MANUFACTURING MOTOR FUEL COMPONENTS AND AROMATIC HYDROCARBONS

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The development of theoretical principles and technology for the production of motor fuel components and aromatic hydrocarbons is one of the principal themes in the work of the Institute. From the time the Institute was organized in 1929, work was begun in the area of thermal cracking, then catalytic cracking and various hydrogenation processes for petroleum products. These studies have furnished the basis for development of the theoretical principles governing these processes.

In 1935, two staff members of the Institute, B. L. Moldavskii and G. D. Kamusher, discovered the reaction of paraffinic hydrocarbon dehydrocyclization, the basis for later developments that culminated in the catalytic reforming process. These inventors were awarded the State Prize of the USSR. But the most extensive developments in the production of high-octane gasoline components of aromatic hydrocarbons came in the 1950s, when USSR modifications of the catalytic reforming of naphtha cuts were developed, and catalysts for this process were synthesized.

Catalytic reforming is one of the most important processes in petroleum refining, occupying the leading place in the production of high-octane gasoline. Thanks to this process, it has become possible to set up the production of high-quality automotive gasolines in grades A-72, A-76 and AI-93. This process is also of the utmost importance in the production of aromatic hydrocarbons (benzene, toluene, and xylenes). Currently, more than 50% of the total benzene production in the country is obtained in catalytic reforming units, as well as more than 90% of the total production of toluene and xylenes. The first catalytic reforming unit, with a charging capacity of 300,000 metric tons per year, was put into service in 1962. Today, more than 80 units, with capacities from 300,000 to 1,000,000 tons/yr, are operating in the USSR. The first reforming units used a fluorine-promoted platinized alumina catalyst (AP-56), giving a naphtha with an octane number of 76-78 (motor method) from a feedstock containing up to 0.05% (mass) sulfur.

The year 1967 saw commercialization of an Institute-developed version of catalytic reforming for the production of naphtha with an octane number of 95 (research method). In order to make this process possible a new and more selective and stable chlorine-promoted platinized aluminum catalyst was developed; this catalyst is designated AP-64. The use of a chlorinated catalyst required the development of a new process technology in order to maintain the required content of chlorine in the catalyst. The operation of the first units in this version of the process showed that, as measured by the technoeconomic indices, the USSR catalytic reforming process, designed for the production of naphtha with an octane number of 95, is at least as good as the best foreign processes.

The special place of catalytic reforming among other petroleum refining processes demands that it be constantly improved, particularly with respect to increases in selectivity and in the length of runs between regenerations. These problems are being resolved primarily by the development of new, more stable catalysts, in particular the bimetallic and polymetallic series KR. As shown by experience in reformer operation, with the catalyst the process pressure can be reduced to 1.5-2 MPa without any shortening of the lengths of the runs between regenerations. The yield of 95-ON naphtha on these catalysts is 5-7% higher than on the AP-64 catalyst. In the units that are operated for the production of aromatic hydrocarbons, the yields of these hydrocarbons were increased by 15-20% when the changeover was made to the new catalysts.

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Currently, more than 20% of the catalytic reforming units in the country are operating on series KR catalysts, and the conversion of the other operating units to these catalysts is being carried out successfully. The advances that have been made in the field of catalytic reforming have enabled our country to supply catalytic reforming units to other countries. Today, on the basis of VNINeftekhim developments, catalytic reforming units are operating successfully in Bulgaria, Hungary, Korea, India, Turkey, and Ethiopia; a unit is being built in Yugoslavia; and new units are being designed for Turkey, Cuba, and other countries.

However, catalytic reforming alone does not give a complete solution to the problems in obtaining high-octane automotive fuels. Catalytic reforming is the process that yields the main component for commercial automotive gasolines. For one of the other components, VNINeftekhim has developed processes for the production of high-octane isoparaffinic hydrocarbons and by selective hydrocracking.

Studies on catalytic isomerization were started at the Institute in the 1950s; by the early 1960s, it was possible to develop a USSR process for the high-temperature isomerization of n-pentane and naphtha head cuts. This process had another important aspect in that, along with the production of high-octane isoparaffinic naphtha components, it became possible to furnish the synthetic rubber industry with isopentane, the starting material for isoprene production.

The high-temperature isomerization process that was developed by the Institute has been commercialized successfully in a number of refineries and synthetic rubber plants. The technoeconomic indices of this process are at least as good as those of the comparable foreign processes, so that the USSR process can compete successfully in the world market. A number of licenses for this process have been sold, and several commercial units for the isomerization of n-pentane and naphtha head cuts, in accordance with these licenses, have either been built or are in the construction stage.

The Institute has recently developed and tested on a semicommercial scale a process for the low-temperature isomerization of paraffinic hydrocarbons. This process is carried out on NIP-74 catalyst at temperatures of 130-150°C, i.e., under conditions that are thermodynamically more favorable for the isomerization of alkanes than the conditions existing in high-temperature isomerization. By the low-temperature isomerization of naphtha head cuts (C₅-C₆), it is possible to obtain in a single pass a naphtha with an octane number of 83-84 (research method) in comparison with the 77-78 octane numbers obtained in the high-temperature process; the low-temperature process also has an advantage in its considerably lower energy costs. Low-temperature isomerization units are being included in the expansion schemes for a number of refineries; in the immediate future, it is planned to convert certain high-temperature isomerization units to the newer version of the process. Currently in the development stage at VNINeftekhim is a process for the liquid-phase isomerization of alkanes at 30-50°C on super-acid catalysts. This will be a substantial step forward in the production of high-octane gasolines.

Another extremely interesting and promising development of the Institute is the production of isoparaffinic components of automotive gasolines by selective hydrocracking. This process has been checked and the conditions worked out in a commercial unit with a charging capacity of 100,000 metric tons per year; with this process, the octane number of raffinate naphthas can be increased from 45-60 to 70-77. However, this process is not limited to the upgrading of raffinates; it can also be used to raise the octane number of reformer naphthas and to give higher yields. An extremely interesting fact is that, with the flow plan that has been worked out at the Institute, high-octane automotive gasolines can be produced without using any costly alkylate. The selective hydrocracking process has been included in the flow plans for automotive gasoline production in a number of refineries.

VNINeftekhim is the leading organization in the field of monocyclic aromatic hydrocarbon production, primarily benzene and xylenes. Along with the production of aromatic hydrocarbons by catalytic reforming, which is widely practiced on a commercial scale, new methods for benzene and xylene production are being developed. In the last 10-15 years, one of the most important methods for benzene production (worldwide) has become the hydrodealkylation of alkylaromatic hydrocarbons. Today, up to 30% of the total benzene production is obtained by dealkylation. The feedstock for the hydrodealkylation process is either toluene or hydrostabilized cuts from pyrolysis naphthas. Hydrodealkylation, however, has certain serious shortcomings that lower the economic indices of the processes; here we refer particularly to the considerable consumption of hydrogen.

A new process has been developed at VNINeftekhim for toluene dealkylation by means of steam conversion, without any consumption of hydrogen. This process also had advantages in the milder conditions (pressure 0.5-1.5 MPa, temperature 430-520°C). However, as shown by calculations, the raw material cost in the