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Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries

Baku, USSR, 21 - 31 October 1969

PET.SYMP.A/17

# MAIN TRENDS IN THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY OF THE USSR[1]

by

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**SUMMARY**

# MAIN TRENDS IN THE DEVELOPMENT OF THE PETROCHEMICAL INDUSTRY OF THE USSR[1/]

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The chemical and petroleum industry in the USSR is one of the sectors which shows the quickest development in the national economy.

The USSR produces practically all chemical and petroleum products on an industrial scale (low molecular weight olefins, aromatics, hydrocarbons, phenols, alcohols, ketones and acids).

The chemical and petroleum industry has generally developed in those regions where crude oil is produced like in the Azerbaijan Soviet Socialist Republic (AzSSR), in the Karachian Soviet Socialist Republic, in Bashkiria and Tataria. Their participation in the production of chemical and petroleum products in 1968 has been 60 per cent.

The success of the chemical and petroleum industry in the USSR is mainly due to:

1. the presence of raw materials and their concentration in certain centres;
2. the cost of crude oil and natural gas which is lower than of other raw materials;
3. the possibility to combine petroleum refining with chemical production.

In the paper the principal particularities for the development of the raw materials and the production of the most important chemicals are discussed (olefins, aromatics and diolefins).

Furthermore, the problem of the expansion of the production facilities in the chemical and petroleum industry are considered in the paper as well as the specific problems relating to the creation of petroleum and chemical complexes.

The intensive development of the chemical and petrochemical industry of the Soviet Union begins after the Great October Socialist Revolution. For the last years the manufacturing of chemical products from petroleum and gas feed-stock became the most important branch of our industry. Many significant industrial processes of large-scale manufacturing petrochemical products, such as lower olefins, aromatic hydrocarbons, diolefines, phenols, alcohols, ketons, acids, and polymeric products, have been carried out and installed in the Soviet Union.

Dozens of specialized petrochemical plants and hundreds of separate units at petrochemical and chemical plants producing hundred thousand tons of petrochemical products came into operation.

At present the total cost of manufacturing of petrochemical products exceeds 1 milliard roubles.

The annual increase in industrial production of petrochemical manufacture reaches 12 - 15%.

The rise of a share of petrochemical products in a total volume of chemical manufacture is also an evidence of advantages in the development of petrochemical processing.

In the period of 1958-1969 the output of the petrochemical industry doubled every five years. According to the plan on 1971-1975 the output of the petrochemical industry will be increased in 2.3 times.

More than ten large-scale petrochemical processes will be built during this period, many of them will be the largest in Europe.

The development of petrochemical industry of the Soviet Union is characterized by a rapid growth of this branch in economical regions of union and autonomous republics with advanced source of raw materials. Considerable achivements in the development of petrochemical industry are mentioned in Azerbaijan Soviet Socialist Republic, Turkmenia, Kazakhstan, Uzbekistan,

Latvia, Estonia and Ukrainian Soviet Socialist Republic. The share of regional republics in the total output of petrochemical products exceeds 60%.

Such rapid development of petrochemical industry is defined by the objective course of technological progress which can be characterized as the most rapid growth of the industry of synthetic and polymeric materials.

The progress of the petrochemical industry of the Soviet Union is due to a number of factors, such as:

1. The availability of a powerful and quick-growing source of raw materials, the concentration of considerable resources of feed-stock in single point.

2. Higher [illegible] of oil and gas compared with other types of chemical feed-stock of vegetable, animal, and mineral origin.

3. The possibility of a wide combination of oil and gas refining, with primary processing which results in complex using oil feed-stock to obtain fuel and chemical products.

4. Favourable technical and economical coefficients of petrochemical plants compared with other methods of synthetic material production, this factor being a consequence of the factors mentioned above.

The petrochemical industry is a totality of dozens technological processes manufacturing hundreds monomers and semiproducts. Nevertheless the overwhelming majority of the processes is based on lower olefines $C_2$-$C_4$, diolefines, aromatic and paraffinic hydrocarbons. The level of developing the petrochemical industry is reflected in technical and economical level of production of these products. At the same time the coefficients of producing the basic products are limited to a great extent by a state of source of raw materials. Let us consider this problem in details.

The basic processes of liquid and gas feed-stock are concentrated at the plants of oil and gas refining. At present

60% of feed-stock for petrochemical industry are produced by oil-refining and 40% - by casing-head gas and gascondensate refining. Individual hydrocarbons $C_2$ - $C_5$ are produced at plants of casings of casing-head gas and gascondensate refining by a cold method of oil fractionation. All kinds of hydrocarbon feed-stock mentioned above can be used in different ways. For instance, gasoline fractions can be used for production of olefines, aromatics and high-octane motor-car fuel.

Liquefied gases can be used in production of diolefines by dehydrogenation and ethylene and propylene by pyrolysis. Besides, they can be used for non-chemical purposes, such as: manufactured gas supply, gas cutting of metals etc. Ethane used for the productions of ethylene by pyrolysis is an exception to the rule.

Working out well-grounded economical recomendations on the structure of consumption of hydrocarbon feed-stock is of a great necessity because of a number of different available ways of its use.

## Olefinic Hydrocarbons

It is known that ethylene and propylene produced at the units of pyrolysis and gas fractionation ones are the base of petrochemical production. These monomers can be produced from different types of hydrocarbon feed-stocks, heavy ends including by modern technological methods.

Up to now in the USSR the majority of lower olefines has been produced from $C_2$ - $C_4$ hydrocarbons of different origin. But in 1967 30% of ethylene were already produced by pyrolysis of gasoline fractions. In 1970 this figure will reach 40%. According to the plan the structure of feed.stock for pyrolysis in the USSR by 1975 will be as follows:

| | |
|---|---|
| Gasolines and heavy charge . . . . . | 52% |
| Liquefied gases . . . . . | 30% |
| Ethane and ethane fraction . . . . . | 18% |

The tendency to the rise of gasoline and heavy charge share in the feed-stock used for pyrolysis is due to the following factors.

1. Technical and economical coefficients of olefin productions by gasoline pyrolysis considerably exceed (by 30-40%) those of olefin production from liquefied gases, that is caused by a greater cost of propane and butane in comparison with gasoline - in 2.4-3 times. It is to be noted that even at high prices of liquefied gases the effect of their use for manufactured gas supply would by very high. We can consider this trend of their use of the foremost importance because of a great want in liquefied gases for every-day life. Besides the production of divinyl and isoprene must be provided with a feed-stock, and the hydrocarbons $C_4 - C_5$ cannot be substituted.

Besides, the decrease to some extent of a share of liquefied gases in the pyrolysis feed-stock in the USSR can be explained by a not general distribution of this feed-stock.

Ten-fifteen years ago the pyrolysis units built in the USSR were not of great capacity. They were supplied with refinery gases or liquefied gas fractions from gasoline plants without certain difficulty. But when the capacity of ethylene units reached 300-400 thousand tons even the large plants of oil and gas refining were not able to supply pyrolitic units with feed-stock.

The use of heavy charge and crude oil for olefine production will present a certain problem. Pyrogenic refining to produce olefines seems to be very effective. Working out of new processes of manufacturing of olefines from crude oil and heavy oil products is being carried out intensively in the Soviet Union. The realization of these processes in industry will result in improving technical and economical coefficients of manufacturing of olefines nd in enlarging the number of regions where such plants will be distributed.

## Aromatic Hydrocarbons

The past years are characterized by a sharp growth of the production of aromatics in the USSR.

The share of aromatics manufacturing from the petroleum feed-stock can be characterized by the following figures

| | 1970 (planned) |
|---|---|
| Benzene . . . . . | 96.6 |
| Toluene . . . . . | 76.5 |
| Xylenes . . . . . | 93.6 |

In 1975 more than 75 per cent of aromatics will be produced from the petroleum feed-stock.

The basic method of aromatics production from petroleum feed-stock is reforming of gasoline fraction. The research works carried out in the USSR reveal new opportunities of modernizing this process by obtaining modified catalysts and improving technological conditions. It will result in obtaining greater yields of aromatics - 15-20 per cent higher than at present.

At present in the USSR reforming units are operated on a fraction 62-105°C to produce benzene and toluene in the main and on a fraction 105-140°C to produce xylenes. New units which are under construction are estimated to operate on a fraction 62-140°C using a modified catalyst and improving technological conditions. It will result in increasing the unit capacity by 2-3 times, increasing the yield of aromatics and sharply decreasing their cost price. The peculiarity of reforming is that the yield of toluene is two times greater than that of benzene. At the same time the total consumption of toluene is considerably lower than that of benzene. This state of things will remain unchangeable in the nearest future.

In order to satisfy constantly rising requirement in benzene the capasities of toluene demethylation are supposed to be intensively increased. Catalytic conversion of toluene with water

Dielefinic Hydrocarbons

It was in the USSR in thirties that the industry of synthetic rubber basing on S.V. Lebedev's method of conversing ethanol in divinyl was created. In the fifties this process was orientated on the use of synthetic ethanol produced from oil feed-stock. Then a new method of producing divinyl- dehydrogenation of butane was developed. It was due to a specific feature of our refining industry - the absence of a large-scale cracking processes. The last circumstance did not permit orientating on a wide use of cracking butane-butene fraction when producing divinyl.

The dehydrogenation of butane will rem in the main process in producing divinyl in the USSR in the nearest future. But the increase of importance of pyrolytic $C_4$-fraction is expected, and this fact is worth noting. It is due to introduction of new methods of its separation and increase of pyrolysis of gasoline fractions.

Large-scale production of divinyl and isobutylene basing on refining pyrolytic butylene-divinyl fraction came into operation in the USSR. During 1971-1975 a construction of a some more several units is expected.

The development of the industry of synthetic rubber in the USSR is characterizedly a great share of polyisoprene rubber. Such trend became possible because of successful working out and industrial realization in large scale of economically effective process of producing isoprene through dimethyldioxane, the latter being produced from isobutylene and formaldehyde. It is to be noted that isobutylene is produced by dehydrogenation of isobutane. The use of a cheap feed-stock in combination with progressive technology leads to producing isoprene with cost prise comparable with that of divinyl. The latest researches lead to using isobutylene contacting in pyrolytic $C_4$ - fraction as a feed-stock.

At present another method of isoprene synthesis - two-stage dehydrogenation of isopentane - is developped in

industry. According to estimations, both methods of producing isoprene have equal technical and economical coefficients. But two methods available, basing on different feed-stock, satisfy the want of industry in this product to a greater extent.

The tendency to increase of isoprene production leads to a necessity of expanding the source of feed-stock. For this purpose different researches on working out the processes isomerisation of $C_5$-$C_4$ hydrocarbons were carried out in the USSR. Besides a problem of producing individual isobutane and isopentane of a definite quality by a sink-head gas refining is being solved.

## Processing of Paraffines

Unlike different advanced countries the Soviet Union has considerable capacities of chemical refining of oil paraffines. The industry of synthetic fatty acids produced by oxidizing solid paraffines which was founded in the fifties played a significant role in releasing of food fats from soap-boiling. Then this branch was reorientated because of the development of producing surfactants. The processing of synthetic fatty acids in alcohols, plasticizers, lubricants and other valuable products was carried out in the USSR.

Straight-branched alcohols $C_7$-$C_9$ and $C_{10}$-$C_{18}$, produced by hydrogenation of corresponding fractions of synthetic fatty acids are of the greatest importance, the former being an excellent feed-stock for producing of plasticizers, the latter being used for producing of detergents of high quality.

It is supposed that the greater part of synthetic fatty acids should be used for producing of higher alcohols by 1975. In connection with this fact the original method of direct hydrogenation of $C_{10}$-$C_{18}$ synthetic fatty acid fraction in corresponding alcohols carried out in the USSR is to be noted. The realization of this process planned by 1970-1971 will be

an important step in increasing the effective use of synthetic fatty acids. Compared with present methods current expenditure will be thereby decreased and capital expenditure will be decreased by 40 per cent.

More than 60 per cent of all petrochemical products and monomers used for producing polymeric materials, solvents, surfactants and other synthetic products which substitute traditional materials are produced on the base of olefinic and aromatic hydrocarbons. Occasionally processing of raw olefinic or aromatic hydrocarbons is carried out in several stages, every monomer produced in any stage is of its own value.

There is a definite rule in the economics of chemical industry: expenditures are usually proportional to the number of stages. It is to be noted that in modern petrochemical industry there is a tendency to working out the direct syntheses or with the shortened number of stages.

Proceedings from this tendency in the Soviet petrochemical industry are being realized and carried out those processes which meet this requirement (the direct oxidation of propylene in propylene oxide, oxosynthesis, the direct oxidation of butane etc.)

The most considerable tendency in the development of petrochemical industry is the enlargement of technological units, the increase of single capacity of aggregates. The results achieved in this direction would have been unreal five-ten years ago.

The attempt to enlarge aggregates is caused to two factors. 1. the decrease of capital and operating costs, 2. time problem.

It is obvious that to achive necessary rate of growth by constructing a great number of small units is impossible. It is to be noted that the duration of constructing the large unit is comparable with that of a small one.

The rise of unit capacities was predetermined by the course of scientific and technical progress, by the achievments

in metallurgy, transport, organizing of the design work etc. The achievements of Soviet scientists in heat and mass-transfer, chemical technology, catalysis, means of control and automation are to be mentioned here. A great host of highly-skilled engineers, specialists in operating and constructing the plants is ready to carry out the construction of huge units. All these factors provide the rise of unit capacities. The choice of optimal capacity must be of economic nature for different countries. First of all it can be referred to problems of providing resources of feed-stock, market for production and skilled specialists available.

In the Soviet Union the extent of cooperation by feed-stock of an oil refining and petrochemical plants is determined when designing an oil refining complex. The main requirement is the necessary of building both oil refining and petrochemical plant. This results in developing at the same time oil refining with producing fuel and petrochemical products.

Another trend which provides a rapid growth of petrochemical production is the construction of specialized petrochemical processes with an autonomous source of feed-stock. Such an autonomy can be reached by introducing the unit for preparing feed-stock in a petrochemical complex, such as a unit for separating light fractions to produce necessary amounts of pyrolytic feed-stock and to pass heavy fractions to oil refining plants for energy use. Such variant is also possible for the USSR the construction of units for stabilizing oil in the Western Syberia to produce 30-40 million tons of wide fractions annually and using a part of it as a feed-stock for super-power pyrolytic units. This variant is very attractive from the economical standpoint. But it requires solving a number of complex technical problems (transportation of unstable oil to the units for oil stabilization, construction of super-power aggregates for oil stabilization, aggregates for pyrolysis and gas separation etc.)

The problems of processing gas condensates enriched by aromatics is to be considered separately. For example, a specialized petrochemical unit where condensates of the Northern Caucasus containing up to 5% of benzene and significant amounts of naphtenates will be processed is being under construction. The extraction of aromatics from gas condensates will be carried out in the first stage of this process. Then the condensate is passed to a reforming and separation unit. The total item of aromatics will increase to 20%. The construction of large units for the dehydration of toluene, its isomerization and separation of xylenes at the same complex is planned. Thus, it will be a specialized plant for processing of aromatics.

The designs of plants specialized for producing certain olefine derivatives, e.g. - 250 thousand tons of ethylene by pyrolysis of ethane and 200 thousand tons of polyethylene or ethylene oxide- ethylene glycol derivatives, or ethylene-acetaldehyde-alcohols - are being under consideration from the same standpoint. In any case it is considered that the whole number of units for producing olefine derivatives must be minimal at large modern oil refining plant with a powerful unit for producing olefines available.

In the USSR to satisfy this requirement the units for producing ethylene with capacity of 300-450 thousand tons, reforming - 1 million tons of feed-stock, polyethylene - 300 thousand tons with reactors for 30-60 thousand tons, ethylbenzene - 125-250 thousand tons, acetaldehyde - 90 thousand tons, oxo-synthesis - 120 thousand tons of alcohols, ethylene oxide - 120 thousand tons annually etc. are being designed.

The most important characteristic of technical progress in petrochemistry is working out of new processes. Two trends - working out of new producing of new monomers and semiproducts are to be considered. These trends are reflected in the researches of Soviet scientists. The synthesis of isoprene,

conversion of toluene with water vapour, dehydrocyclization of n-hexane, oxidative dehydrogenation, synthesis of divinylbenzene, glycerol, diphenylolpropane etc. - all these processes are illustrations of the first trend.

The second trend is represented by new syntheses of 3-methylhexanol from dimer of propylene by oxoprocess, ethylbutyrate from propylene and ethanol, unsaturated -branched acids, several polyatomic alcohols, vinylcyclohexane etc.

Considerable expenditure are required for working out of new processes. First of all a thorough economical estimation of a new synthesis, its perspectiveness is carried out.

In modern practice of petrochemical applied researches there is also a tendency to modernizing processes which are under operation. It is known that in advanced countries one half of all the expenditures on scientific researches is spent on this trend. It can be explained by the fact that even a low decrease of expenditures in a large-scale process gives a great economy. In the Soviet Union, as well as in other countries, considerable efforts are directed to modernize operating plants. Much has been said about successful attempts in catalytic reforming and isoprene synthesis. New more effective schemes of oxosynthesis are carried out side by side with a scheme of thermal decomposition of cobalt carbonyles. The researches of one of the first petrochemical processes - synthesis of phenole and acetone through isopropylbenzene- hydroxide - could be very successful. Basing on modern concepts about the oxidation a new selective of producing isopropylbenzene hydroxide is suggested. The researches on pyrolysys and gas separation on producing synthetic fatty acids, hydrogenation processes etc. are versatile.

The greatest economical effect can be obtained by a right combination of efforts for working out new petrochemical processes and modernizing operating plants.

12. 1. 72