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THE PRESENT STATE OF THE CHEMICAL INDUSTRIES IN DEVELOPING COUNTRIES 1/

BACKGROUND PAPER

prepared by

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I. STATE OF THE CHEMICAL INDUSTRY IN THE WORLD WITH SPECIAL REFERENCE TO DEVELOPING COUNTRIES

The role of the chemical industry in world industry

Of all industrial branches, the chemical industry has had the highest rate of growth in the last decades. This important trend is characteristic for almost all developed or developing countries in the world.

Thus in the period 1960-1973, the average annual growth rate of industrial output in the world was 6.7 per cent, whereas world chemical output was 9.8 per cent. During the same period in the developed market economy countries and the socialist countries of Eastern Europe, the average annual rate of growth of the industrial output was 5.9 and 8.5 per cent respectively while that of the chemical industry was 8.7 and 11.7 per cent, respectively. In the developing countries the difference between the rates of growth was small: 7.3 per cent for total industrial output and 8.1 per cent for chemical industry output.(1)

The faster growth of the chemical industry as compared with other industries has increased this industry's share in total industrial output. Thus the share of the world chemical industry's output in the total industrial output of the world increased from 9.6 per cent to 12.4 per cent in the 1960-1970 period; during the same period the share of the chemical industry in the total industrial output of the developed countries increased from 10.7 per cent to 14.2 per cent. The chemical industry of the developing countries has shown a similar increase, its share in total industrial output increasing from 11.2 per cent to 12 per cent in the last decade.

On the other hand, the share of industry in developing countries in world chemical output is small, which is a consequence of the generally low industrial development of this group of countries. Thus in the 1960-1970 period, the share of the developing countries' industrial output in the world industrial output varied between 6.1 and 6.3 per cent, while the share of the output of the chemical industry of these countries in the total output of the chemical industry of the world ranged between 6.3 per cent and 5.6 per cent

during the same period. Comparing these statistics one can say that the chemical industry of the developing countries has shown a slower rate of growth than in the developed areas of the world in the last decade.

A complete listing of all the factors which determined the general upsurge of the chemical industry is virtually impossible. Nevertheless, one can say that this upsurge was especially due to the:

- Capacity of some chemical products (fertilizers, synthetic fibres and yarns, plastic materials etc.) to meet the ever-increasing requirements of mankind, especially since some of the natural resources have proved to be scarce;

- Continuous increase of per capita income, which has meant a constantly increasing demand for consumer goods, to meet which requires more products to be supplied by the chemical industry;

- Permanent expansion of industrial output and increased complexity of the products, which has resulted in both increased demand for chemical products and in the development of new, specialized chemical products;

- Advance of scientific, technological and applied research, which has led to the improvement of some units capable of producing increasing quantities of chemical products at more and more advantageous costs;

- Increasing use of crude oil and natural gases as the main basis of raw materials for the organic chemical industry.

The developing countries can be grouped into four main categories according to the development level of the chemical industry and the prospects for its growth:

- Crude oil producing and exporting countries

- Countries such as Argentina, Brazil, Chile and Mexico (especially Brazil and Mexico) that already have a substantial chemical industry and allot an important share of their investments to this industrial branch as compared with other developing countries

- Developing countries with available raw materials for expanding their chemical industry (such as Egypt, Morocco and Tunisia)

- Countries with a large population, which offer sizable markets (such as India, Indonesia, Pakistan)

The countries belonging to the Organization of Oil Producing and Exporting Countries (OPEC) - Abu Dhabi, Algeria, Indonesia, Iran, Iraq, Kuwait,

Libyan Arab Republic, Nigeria, Qatar, Saudi Arabia and Venezuela - account for about 60 per cent of the crude oil production in the world and more than 90 per cent of crude oil exports. At the same time, important crude oil processing capacities exist in these countries.

This important petroleum resource has given birth to a chemical industry and even of a petrochemical industry in some of these countries in the last decade and to national petroleum and petrochemical companies.

In the coming years, these countries will endeavour to build up capacities for the production of both basic petrochemicals and of products requiring a relatively low degree of processing. Thus, most of the existing projects or those planned for the next few years are for the production of nitrogen fertilizers, methanol and plastic materials, especially polyethylene and polyvinyl chloride.

Under the new conditions created by the energy crisis, a new appraisal of the possibilities of these countries for developing their petrochemical industry is to be expected. This reappraisal is necessary because of the increase of the capital that will become available in these countries. As a result, some of the above mentioned countries will become exporters of basic petrochemical products or of products with a relatively low degree of processing as for instance ammonia. Export-oriented large industries will also be set up. The reduction of environmental pollution in developed countries by refining crude oil at the source will be considered.

In some Latin American countries the development of the chemical industry is being considered seriously. Interest in this industry became evident in the first years of the last decade and has become marked in the last few years. The crude oil reserves of these countries will cover the domestic consumption requirements and thus provide a basis of raw materials for the chemical industry. The announced projects for the coming years allow us to conclude that the import of chemical products of these countries will decrease in the future.

Some of the other countries in Africa, Asia and Latin America do not possess crude oil but have important deposits of phosphates, sodium chloride and various salts necessary for the development of a chemical industry.

International trade in chemicals

The rapid growth of the world chemical industry has led international trade in chemical products to grow at a more rapid rate than international trade as a whole. Thus, the average annual growth rate for chemical exports in the last decade was almost 11 per cent, whereas the average annual growth rate of total world exports was about 8.5 per cent.

Likewise it is worth mentioning that the growth of international trade in chemical products was faster that that of world chemical production, the average annual rate of increase being 10.8 per cent for world exports of chemical products and 9.3 per cent for world chemical production.

The steadily growing trade in chemical products has increased the share of this category of products in total world trade. The share of chemical exports in world trade increased from 5.1 per cent in 1955 to 6.6 per cent in 1965 and to 7 per cent in 1970. In the last decade a large part of international trade was carried out among the advanced industrial countries, but at present there exists a stronger trend in the world to liberise and diversify this trade.

The chemical industry as one of the key sectors for economic growth in the developing countries

The developing countries have a strong desire to exploit their natural resources and to obtain the maximum benefit by processing them. At present, almost all developing countries export large quantities of minerals and other raw materials for the chemical industry in an unprocessed form, as for instance, crude oil, phosphate rock, bauxite and copper.

The growth of a modern chemical industry in the developing countries ensuring the processing of some of these raw materials up to intermediate chemical products or even end products designated for the domestic market or for export should increase employment, raise the living standard and accelerate economic growth in general. In many countries the chemical industry has become the key sector on which both industrialization and economic growth as a whole depend. Fertilizers, pesticides and some products such as plastomers and elastomers have become the most important support for agri-

culture, a sector playing a predominant role in the economy of many developing countries.(2)

Agriculture is one of the main customers of the chemical industry. It is expected that chemical fertilizers and pesticides will help reduce the chronic food shortage in the developing countries.

The chemical industry is closely linked to other industrial branches through the products it supplies. Thus in numerous developing countries the chemical industry represents the nucleus of a diversified industry.

Raw materials for the chemical industry: distribution, resources and consumption

For setting up and developing the basic inorganic and organic chemical industry, the availability of the four major raw materials is decisive (3). They are: sulphur, phosphates, sodium chloride, potassium salts, coal, crude oil and natural gas.

It should be especially emphasized however that the developing countries have an extremely important type of resource material in agricultural resources or agricultural derivatives. Among these resources one can mention oleaginous seeds and fruits, fatty substances of an animal or vegetable nature, wood and straw (cellulose or its derivatives), vegetable dyes and extracts, natural rubber, resin, turpentine and medicinal plants etc.

With the exception of these natural raw materials that can be used by the food sector and whose chemical processing cannot be justified in view of the food problem in developing countries - the extraction of ethyl alcohol from cereals to produce ethylene, for example - it is advisable to make use of and process chemically all these raw materials domestically instead of exporting them to the developed countries. In such a case production may be more profitable in a developing country than in the developed country which imported the raw material, owing to the abundance of the raw material available and to the manpower, which often turns out to be much cheaper.

In special cases, countries that have important coal resources or proper vegetable raw materials but do not possess crude oil or natural gas resources can choose the alternative of developing a chemical industry based on such

products as: acetylene from carbide, ethyl alcohol and furfural from agricultural products, aromatic hydrocarbons by coal distillation and acetic acid and acetone from wood distillation.

In view of the raw material crisis and the abundance of coal resources as compared with crude oil resources, it is assumed that coal chemistry will make great strides. The specialists have unanimously agreed upon the future ways of processing the coal: carbide, gasification and liquefaction. It can be ascertained that in view of the lack of hydrocarbons, there will be further development of ethylene-based technology using oil, as well as acetylene-based technologies using coal and natural gas. The new coal gasification processes will permit the production of methane and synthetic crude oil at competitive prices as compared with natural gas and petroleum products. The acetylene will be obtained by using the plasma directly from bituma coals, being replaced whenever necessary by carbide. The selection of one of these ways is ultimately dictated by techno-economic and financial factors.

It must be emphasized that for developing countries possessing coal resources, coal processing closely related to the basic carbonization industry (coal coking) must be thoroughly studied.

A few observations on production and consumption in industrialized and developing countries may be made.

The developing countries are small consumers of raw materials, in contrast with the industrialized countries, which are large consumers. Thus, in 1972, the developing countries accounted for the following share in world consumption: sulphur, 11.5 per cent; phosphates 17.5 per cent; potassium 10.8 per cent; natural rubber 3.3 per cent; and crude oil, 16 per cent. The developing countries hold the greater share of known reserves of raw materials; in 1972, their share in the world was: sulphur, 69.4 per cent; phosphates, 52.8 per cent and crude oil 74 per cent.

The industrialized countries consume their raw materials at a much faster rate than the developing countries. This is confirmed by the share of these countries in world output: sulphur 88.7 per cent; phosphates 39.3 per cent; potassium 93.2 per cent; salt 93 per cent and crude oil 83 per cent.

The conclusion to be drawn is that the developing countries have raw materials favourable for the development of a chemical industry. They wish to manage them rationally to prevent wastage, and to promote industrialization.

II. PROSPECTS FOR PRODUCTION AND CONSUMPTION OF CHEMICALS.

In the coming 10-15 years, the rate of growth of the chemical industry is expected to surpass the average rate of growth of industry as a whole, which indicates the part it plays in total industrial output. (4)

This idea is determined by the more and more important part which the numerous branches of the chemical industry have in the world economy.

The necessity for developing the production and consumption of chemical fertilizers, plastic materials, synthetic fibres, synthetic rubber or drugs makes the increasing importance of the chemical industry to the economy of any country clear.

The main raw materials for the chemical industry are crude oil and natural gas. In 1970, at the world level, the requirements of the chemical industry represented 5 per cent of the total consumption of hydrocarbons, and in the developed countries, 7-10 per cent. This latter percentage will increase to a great extent in the following decades, reaching about 20 per cent by 1990-2000. In 1985, the derivates of crude oil and natural gases will form the raw material for more than 95 per cent of organic chemical products. (9)

World consumption of organic chemical products of a mineral oil source increased in the decade 1960-1970 by 15 per cent a year. Up to 1985, the average rate of growth is foreseen as 11 per cent.

Forecasts for the main categories of chemical products are described below.

Chemical fertilizers

In the decade 1960-1970, the average annual growth rate for consumption in the developed countries was 7.5 per cent and in the developing countries 14 per cent. In 1972/73, the developing countries produced 6.3 million tons and consumed 10.9 million tons of fertilizer nutrients, resulting an apparent deficit of 4.6 million tons. Based on the data gathered during 1969/70, world fertilizer production is foreseen at 168.2 million tons and consumption at 133.5 million tons in 1980-1981. Effective planning and large amounts of capital will be necessary for the developing countries to be able to increase their production of fertilizers from 6.3 million tons in 1972/73 to 18 million tons in 1980/81. (7) (8) (9) (10)

Polymers

In the year 2000, the consumption of polymers will amount to 530 million tons, corresponding to an increase by a factor of 15 over present consumption. Per capita consumption will increase from 11 kg in 1970 to 81 kg around 2000.

The largest part of polymers will be used as plastics, where per capita consumption will represent about 70 kg, while for synthetic fibres it will be only 9 kg and for synthetic rubber, 4 kg.

Production of plastic materials in most of the countries will grow at a high rate, ranging between 10 and 7 per cent.

In the developing countries where plastic materials have not yet been used by all sectors, the average annual rate of growth will be very high, around 12 - 16 per cent. The rate of growth for synthetic rubber is mainly connected with the automotive industry, for the developed countries one expects a growth rate of 3-4 per cent, and for the developing countries a growth rate of 7 per cent. (11) (12)

The production of synthetic fibres, which have a great value, requires greater investments. Production will not have an important growth in the developing countries. The rate of growth of production is foreseen of about 14 per cent around 2000. In the developed countries the rate of growth will probably be less - about 6 per cent. (11)

In 1970, the share of the production of the chemical industry of the developing countries in world chemical production represented 3.6 per cent, and for 1980 it is expected to be 7-8 per cent. In 1980, the countries of Latin America will account for about 60 per cent of chemical production of the developing countries, the countries of Asia 35 per cent and those of Africa 45 per cent. (14) (15) (16)

III. MAIN CONDITIONS FOR ESTABLISHING A CHEMICAL INDUSTRY IN THE DEVELOPING COUNTRIES (PRIORITIES, INTERRELATIONSHIPS)

In view of the lack of financial resources, inadequate markets, low growth rate for exports and low productivity in developing countries, it is easy to understand why the establishment of a chemical industry, for which modern technology and large financial resources are necessary, is extremely difficult in these countries.(17)(18)

The structure of industrial development and the choice of key industries differs from country to country. In countries where production of consumer goods has an important role in the economy, the key industries will be light industries and certain sectors of the chemical industry.

In countries having the necessary raw materials and whose Governments plan industrial development and encourage the growth of heavy industry, the development of the basic chemical industry is essential.

Industrialization, as a principal means of promoting growth, has a greater and greater justification in the developing countries. On the other hand, the economic growth of numerous developing countries is limited by the unsatisfactory increase of the agricultural products per inhabitant owing to fast demographic growth. The forecasts of population growth during the coming decades show that it will be sizable in these countries.

Since fertilizers and pesticides are essential for increasing agricultural output, their importance is obvious. The chemical industry plays a major part in the production of both. In the developing countries, the choice of one project or another generally depends on the availability of certain technologies, which should be most appropriate and advantageous. There may be many reasons for establishing a chemical plant, but the final decision to proceed will be based on such considerations as the social and economic benefits to be derived, the creation of a nucleus for other more advantageous related industries or the use of available raw materials.

Each developing country has its own characteristics with regard to raw materials, population and degree of development. These factors are so diverse that it is impossible to come to a general conclusion and make recommendations

For example, countries with abundant resources of crude oil and natural gases have every reason to produce primary petrochemical products instead of exporting the raw materials.

The existence of certain deposits of raw materials should be centres of development for the chemical industry; so should large harbours, especially if they are provided with refineries. One should take advantage of these factors, multiply the centres of development, and enlarge the capacity of production. In regions rich in raw materials, the creation or extension of a basic chemical industry (nitrogen, fertilizers and petrochemical products) is required. In developing this industry, it is desirable to start with the production of consumer goods which provide the possibility of creating a market before going on to other products.

At a certain moment, mutual connexions and an interdependence is established between the branches of the chemical industry; and the industry as a whole is connected to other industries at the country or the regional level. This means that plans to create and develop a chemical industry at the national or regional level should be integrated in the general plans for economic development. The various industrial sectors cannot and must not be planned independently; they must appear as co-ordinated elements of a whole.

The development of the chemical industry in any region depends on the living standard of the population, on the nature of the resources of raw materials and energy, on the state of agriculture and of commerce, and none of these factors should be neglected. Thus the chemical industry must have its place in economic long- and medium-term planning. Two approaches to planning the development of the chemical industry are possible.

The first approach would be to establish an industry producing both for consumers and for the other economic sectors and to import the necessary raw materials for the intermediate products. This approach permits imports of end products to be replaced by intermediates. If economic conditions are favourable, as in certain Asian countries, the industry can also be oriented to exports. If this approach is chosen, it is necessary to take into account that imports are not entirely eliminated: the import of end products is replaced by the import of technologies and equipment necessary for the manufacture of these products.

The second approach is to develop a basic chemical industry. This is determined by the existing economic infrastructure and raw materials, but the prime cost of the manufactured products will be decisive.

It is obvious that the two approaches are not mutually exclusive. In some cases they could be combined, the manufacture of some products being the logical complement of the others.

IV. TRENDS IN TECHNOLOGIES AND ALTERNATIVES

The chemical industry is characterized by a great number of products and by a variety of technological processes. To cope with the increasing demands of the market, taking into account the growth in consumption of existing products and the development of new ones, it will be necessary to make use of improved manufacturing methods.

A fundamental feature of the new trends in technology is the stress laid on quality, environmental protection and on products having a high degree of technical input. (4, 19)

The availability of new products and the price level can lead to the improvement of new processes, to the development of new ones and to the disappearance of others.

The continuous increase of demand and especially the necessity for decreasing production costs have led to the setting up of large production capacities. This trend will continue and will have an impact in the world. The advantages of large capacities are limited by economic losses to the enterprise arising from underutilization and from the risks occurring during start-up (accidents, repairs, etc.). Thus, after a period in which the size of the units has continuously increased comes a period when the maximum profit of the units will be obtained by limiting the capacity also in favour of safe operations and continuity of the technological processes. The problems raised by the great volume of by-products lead to the building up of several integrated units on the same site, which allow the products obtained to be put to better use. Putting the by-products to the best use is a fundamental problem that can be solved only in integrated complexes, which should permit the establishment of large units and reduce to a minimum transport charges. Nuclear power stations are foreseen as the energy sources.

As regards the working conditions, the trend is to use processes in which the pressures and temperatures are less severe than those used in the present conventional processes. An example is the new process for the ammonia and methanol synthesis, in which the pressure has decreased from 400 atm to 80 atm and the temperature from 450-480°C to 250°C. As concerns the equipment, the trend is to use big compressors, which allow savings to be made in the

consumption of utilities. To operate effectively with increased output, the units will be equipped with an increasing number of computers.

Steam pyrolysis will remain the key process of petrochemistry. Process improvements will lead to a rigid control of the operation through use of catalysts, batches adjustment and recycles, a controlled distribution of the ethylene, propylene, diolefins and aromatics.

Heterogeneous catalytic processes must be steadily improved owing to the increase of catalyst stability and activity. Reforming units, producers of aromatics having fully used continuous regeneration techniques and reaching a climax this decade, will be replaced by processes using more stable catalysts, avoiding the regeneration; the same applies to catalytic cracking. Through these developments one can hope for a better utilization of the petrochemical raw material, leading to an improvement of the basic operational yields, which at present do not exceed on average of 67 per cent in olefin and aromatic production. On the other hand, research on the activity and the selectivity of the organo-metallic compounds and of the enzymes must lead to the development of some homogeneous catalysis processes, even for basic chemical processes.

As for the improvement of other processes, the separation in liquid phase and the considerable progress achieved by the automation of production units should be mentioned.

In the case of ethylene, the trend towards improving the preparation of the raw material (impurities removal) and the orientation towards high severity cracking has been noted. A large dissemination is foreseen for fluid-bed pyrolysis, which has the great advantage of being adjustable within wide ranges of operation depending on the composition of the raw materials and on the end products to be obtained. Consequently a broad range of raw materials, including heavy products, will be able to be used.

In the field of chlorinated products, diaphram cells are tending to replace mercury cells for production of caustic soda and chlorine, limiting in this way the pollution problem of mercury wastes.

From the large number of processes that appear promising, one can mention production of vinyl chloride from ethane, chlorine and hydrochloric acid mixture or from ethane acetylene and hydrochloric acid; production of ethylene

trichloride, perchloroethylene and trichloroethane; production of superior alcohols by oxo-synthesis, acetic acid either from ethylene passing through acetaldehyde (direct oxidation) or from carbon oxide and methanol; manufacture of acetone by propylene oxidation; production of isoprene from formaldehyde and isobutylene in the presence of hydrochloric acid.

Two points should be considered in connexion with trends in technology. The chemical industry, a consumer of certain agricultural raw materials, is a supplier of products necessary for the intensive development of agriculture (fertilizers, pesticides, bio-stimulants, plastic materials for irrigation and maintaining humidity of the soil, greenhouses etc.). Unlike other branches of heavy industry, the chemical industry was and continues to be an important outlet for some agricultural products. This is of interest for developing countries that have or may have agro-vegetable by-products that can be rendered profitable by chemically processing with a high economic efficiency. The technologies used in such cases are much simpler than those based on petrochemicals.

With respect to the pollution problem, new chemical plants should be provided with facilities to reduce to a minimum their effect on the environment. This will raise the investment costs by up to 5 per cent in some cases, but, in return, a total capitalization of the by-products mostly regarded as wastes can be assured. As an example one can cite sulphur recovery from crude oil, which assured that world requirements for sulphur would be met at a time in which the demand was higher than the supply.

Both chemical plants and products of the future will be less pollutant, and the investments made in this area are economically justified, since some valuable wastes can be recovered, for instance, the wastes from chlorinated products, sulphuric acid, crude oil refining, various ashes.

V. MAJOR TECHNO-ECONOMIC FACTORS IN THE GROWTH OF THE CHEMICAL INDUSTRY IN THE DEVELOPING COUNTRIES (TECHNOLOGY, SKILLED LABOUR, RESEARCH, OPERATIONS, MAINTENANCE AND PURCHASING)

The conditions and factors permitting the establishment and growth of a chemical industry in the developing countries are numerous, complex and interdependent.

One condition is the existence of a sufficiently large market either in the country or abroad, capable of absorbing the production of a unit having as low production costs as possible. (17)

On the other hand, the planned projects must be integrated in the general economic plan of the respective country or of the region to avoid competing other projects belonging to other sectors. Chemical products must be sold at competitive prices, taking into account the price level of some similar or substitute products with very similar qualities. Adequate and various means of transport are necessary. Finally, for the construction and the exploitation of these industrial units, considerable financial resources, sufficient raw materials at reasonable prices and proper quality, water and power supplies and a large range of skilled workers to operate and maintain the units are essential.

Experience has shown that in the developing countries expenses for the infrastructures for large chemical units are higher than in the developed countries; therefore the setting up of industrial areas which would include large chemical units producing various products is to be recommended, since here the infrastructure expenses could be shared among more products.

The existence of a market has proved to be a prerequisite for establishing a chemical industry. A market that cannot entirely absorb the products leads to underutilization of the respective unit and finally to a high price of products lacking any competitions. It can be stated that the minimum production capacity below which an enterprise ceases to be profitable is that in which the amount of the expenses proportional to the capacity also plus the fixed expenses becomes equal with the market price without obtaining any profit.

With regard to the absorptive capacity of the market or of the countries in a certain region, it is advisable to undertake in advance a marketing survey. In Romania, for example, every industrial project is preceded by a detailed marketing survey.

The Institute for the Study of the International Economic Situation at Bucharest has produced studies on the size and characteristics of the market and on investment relating to particular products.

The domestic market in the developing countries sometimes appears to be too small to permit the creation of a profitable industry. If it is assumed that the implementation of a project requires the existence of some advantageous natural conditions, for instance: raw materials, energy, means of transport, then it is advisable to achieve regional co-operation and engage in exporting. For the developing countries, co-operation may be a solution offering advantages for each country if the political and psychological difficulties in achieving it can be overcome. It is extremely difficult to find financing for the development of heavy industry in most developing countries. As far as exporting is concerned, this raises important problems from the point of view of competition and of winning the respective market.

Assuming that the marketing survey is favourable, before any units are set up the necessary financial resources should be assured. The basic chemical industry is known to be a branch of heavy industry and the investment cost of a chemical unit is higher than that for a unit in other industrial branches. Numerous studies have shown that local conditions affect the investment costs of a chemical unit in various developing countries.

The developing countries with few exceptions, for instance, the crude oil producing and exporting countries, lack resources for investment. To implement their projects they have only two possibilities - to enter into direct partnerships with foreign parties or to obtain medium- or long-term loans from developed countries or international bodies. Without going into details, it is necessary to emphasize that the interest charged on loans is high for the developing countries and it raises the estimated price of the end product by 10 to 15 per cent. In conclusion, one must calculate exactly

all price increments that may arise in the case of an investment in a developing country.

Developing countries, such as India, which have large markets but have no possibility of paying for imports of the raw materials necessary for the development of a chemical industry that would meet the domestic requirements, are a special case. Here the only solution to be considered is co-operation in production with countries having the necessary raw materials, with payment in terms of finished products.

Few raw materials are necessary for the chemical industry, but they must be available in sufficient quantities to supply satisfactorily the designed projects for a period at least equal to that required for paying off the investment. The price of extraction of raw materials should permit their delivered price to be competitive on the world market. However, unprofitable reserves may become profitable overnight owing to price increases or to some improvements in the extraction and processing technologies.

Before a project in the chemical industry is set up, it must be ascertained that a source of energy, whether from fossil fuels or electricity, is located nearby.

Electric power is necessary for the chemical industry and for energy. As compared with other industrial branches, the chemical industry accounts for about 20 per cent of total consumption. Within the basic chemical industry there are big consumers of electric power (calcium carbide, abrasives, calcium cyanamide, chlorinated products, boride, nitrogen, phosphorus) and the developing countries have available raw materials. To conclude: the establishment of a chemical industry requires a supply of energy at a reasonable price.

In the developing countries, one can always consider setting up a power station, if the fuel is made available at a reasonable price. When the electric power is not supplied from a network at a well-established price, on the basis of a feasibility study, a power station can be installed, and its construction should start the same time the chemical complex starts.

Along with the natural factors mentioned above, water must also be mentioned. Its importance is often neglected. Water as a chemical agent

for heating - steam - or for cooling, as solvent, washing, dispersion or transfer agent, is necessary for the chemical industry and for most of the other industries. Taking into account the particular natural conditions of some developing countries, it is necessary to draw up a rigorous balance of the quantities and qualities of the various types of water.

Absolutely essential for the creation and development of a chemical industry is the personnel necessary for management, operation and maintenance. The chemical industry uses more and more improved techniques, which require skilled personnel with even higher qualifications. In the developed countries about 70 per cent of the total number of employees in the chemical industry are skilled.

Recruiting engineers and management personnel is generally not very difficult because few are required and they can be trained in other countries in the beginning. More of a problem is to find technicians, maintenance and repair personnel. Many such workers are needed and they must be trained in special schools. Romania's experience has shown that it is possible to establish training centres near large chemical units where the training of the necessary personnel can start as soon as operations begin. In this respect Romania's experience should be valuable to the developing countries.

The importance of maintenance must be stressed. A chemical complex comprises apparatus and equipment: reactors, tanks, autoclaves, columns, pressure containers etc. linked by pipes, compressors and pumps and by electric and electronic materials - engines, transformers, instruments, remote control. Such materials frequently corrode, which means that maintenance and repair are more difficult than in other industries and require a great number of maintenance personnel. Therefore, some specialised enterprises capable of performing maintenance and repair jobs beyond the everyday maintenance that is normally performed by the maintenance services of the plant should be set up in the area in which the chemical complexes are to be constructed.

In the industrialised countries there is a tendency to reduce to a minimum maintenance and repair workshops and teams and to use the services of specialised enterprises located in an industrial area. Experience has proved that this method permits a substantial reduction in the maintenance jobs

within the complex. Chemical complexes located in an industrialized area, however, require a very large maintenance services department, capable of meeting any emergency.

Another problem among the less important is to recruit design and research personnel. If in the first stage the building up of the units and the technologies are obtained with great financial assistance from the developed countries, in the next stage, namely 5 - 7 years from the start-up of the units, the problems are to replace some apparatus, increase capacity, set up new units, improve and modernize the technological processes, and exchange some catalysts.

To solve these problems and to avoid new imports, it is essential to establish indigenous design and research centres. The training of specialists and the equipping of the institutes require time and large financial resources.

Economic and geographical conditions and other factors dictate the creation and development of research centres for the adaption and development of techniques suitable to local conditions and for assuring a certain independence for the young chemical industries. It should be mentioned that the amounts allotted for research represent 5 per cent of the sales figures in the developed countries.

The importance of maintenance and repair workshops which can perform preventive maintenance as well as undertake repairs promptly and efficiently when a breakdown occurs should be stressed.

VI. CO-OPERATION BETWEEN DEVELOPING COUNTRIES AND DEVELOPED COUNTRIES AND AMONG DEVELOPING COUNTRIES IN ESTABLISHING A CHEMICAL INDUSTRY

The economic and social transformations that have taken place in the world in the last decades have brought about significant changes in the economic relations among states. As far as the chemical industry is concerned, international economic and technological co-operation has become essential; international economic relations have shifted from the simple form of exchanging goods and values to complex exchanges in research and production. (20)

To mark more precisely the directions in which the advantages of co-operation between the developed and the developing countries and among the developing ones in setting up and developing national chemical industries can be obtained, the following fields should be mentioned: production, science and engineering, international trade, payments and credit system.

Economic co-operation irrespective of form and content should contribute to the mutual development of the co-operating countries. Specifically, reasons for co-operation in the chemical industry could be:

A. In production

1. To establish large units that could not be established by any company or country through its own efforts, the units becoming thus an important factor of economic growth;

2. To exchange knowledge of the potentialities of the co-operating countries, with a view to discovering new fields of co-operation in both the chemical industry and related branches;

3. To improve the structures of the national economy in each co-operating states;

4. To create conditions for making the best use of natural resources;

5. To meet the requirements for raw materials of countries in which the reserves are inadequate;

6. To ensure the training of specialized personnel, to extend the exchange of experience and of knowledge, to increase the skills of the labour force;

7. To contribute to the improvement of management in enterprises by promoting the latest methods and techniques and by adapting them to the national conditions in each country.

B. In science and engineering

1. To avoid duplication of research activity and to permit funds to be saved (in this way international co-operation in the chemical industry can bring substantial benefits, since investments in research are very large and they can be recovered only over a long period);

2. To reduce the rate of depreciation of the fixed capital, which under present technological conditions has one of the highest rates in the chemical industry;

3. To diminish and eliminate in the future the technological gap between countries;

4. To open the possibility of establishing indigenous research and development centres.

C. In international trade

1. To promote the growth of mutually advantageous international trade;

2. To enable developing countries to increase their trade in processed chemical products;

3. To increase the competition in products and to develop new outlets.

D. In the economic and social sphere

1. To create an adequate frame for solving the payments problem especially by exchanging equipment and technology for end products;

2. To introduce flexibility in the international system of credits, enabling trading generations;

In the developing countries co-operation is increasingly taking the form of joint ventures. It sometimes runs directly the parties through the multiple implications of the risk capital. For the chemical industry - if the considerations are kept in mind - this form of co-operation and commitment of the parties through the economic instrument of "risk capital" - requires the existence of capital or commercial co-operation and concurrently generates a system of other co-operation actions related to other branches of industry.

The experience of Romania, a developing country, shows how a chemical industry can be developed through initiatives and efficiency which can participate steadily in international economic affairs. (5)

Co-operation investigation of its form and content must be based on the observance of sovereignty, national independency and it must ensure full equality of rights, non-interference in domestic affairs and mutual advantages.

VII. SUMMARY AND CONCLUSIONS

In the decades to come the rate of growth of the chemical industry is expected to surpass the average rate of growth of industry as a whole, its role becoming more conspicuous in total industrial production. This trend is the result of the ever-increasing role of the various sub-branches of the chemical industry in the world economy.

Many developing countries have the basic raw materials necessary for the long-term development of the chemical industry (crude oil, natural gas, sulphur, phosphates, salt, potassium and natural rubber).

The developing countries should be more and more concerned with exploiting their natural resources and with acquiring the maximum profit by processing them. At present, almost all developing countries export large quantities of minerals and other raw materials (generally over 80 per cent of the exports of the developing countries consists of raw materials).

The development of a modern chemical industry ensuring the processing of some of these raw materials up to intermediates or even end products for the domestic market or for export would result in an increase in employment, a higher standard of living and accelerated economic growth. The chemical industry has become the key sector in a country, and both industrialization and economic growth depend on it. Fertilizers, pesticides, plastomers and elastomers have become a most important support for agriculture, a sector which plays a prevalent role in the economy of many developing countries. Fertilizers and pesticides can contribute to overcoming the chronic scarcity of food in the developing countries, especially as the forecasts on the population dynamics show a considerable increase in the following decades.

Each developing country has its own characteristics in terms of raw materials, population or degree of development. These factors are so diverse that it is impossible to generalize and make recommendations.

Two ways are foreseen with regard to the development programme of the chemical industry in a developing country:

- Establishment in the first place of an industry producing both for consumers and for the other economic sectors;

- Establishment of the basic chemical industry.

The latter is determined among others by an adequate infrastructure and it is characteristic of those countries in which the Government plan the industrial development and encourage the expansion of the heavy industry. Irrespective of the way selected, it is advisable to start with the production of consumer goods capable of creating a market before embarking on the manufacture of the basic products.

The lack of a sound economic infrastructure influences the adoption of the "downstream" industrialization process. The creation of a chemical industry for consumer goods permits the setting up of a market step by step for "upstream" products which can later on be replaced by regional production.

The conditions and factors permitting the establishment and growth of a chemical industry in the developing countries are numerous, complex and interdependent: the availability of financial resources, the existence of a market and of raw materials, the supply of energy, water, means of transport and trained personnel. Consequently, very careful studies have to be carried out and elaborated even for the smallest units.

Experience has shown that the expenses for infrastructure for large chemical units in the developing countries are higher than in the developed ones; therefore, the creation of industrial areas in which chemical units could be installed is recommended. Thus the costs of the infrastructure could be shared on a broader basis.

Owing to a wide dispersion of the population, many countries do not have a domestic market large enough to absorb the production of big units. In such cases the co-operation of several countries in the region is essential.

The complexity of the economic processes and the necessity for removing economic disadvantages have stimulated an increased desire of nations for economic and technological co-operation, especially in the chemical industry.

Fields of co-operation mainly covers production, science and engineering, international trade, payments and credit systems. Economic co-operation, irrespective of form and content, must contribute to the optimal development

of the co-operating countries. Within the chemical industry, co-operation can take various forms, but their effects must be understood.

Irrespective of the form and content, co-operation among states must be based on the observance of sovereignty and national independence, and it must ensure full equality of rights, non-interference in the internal affairs and mutual advantages.

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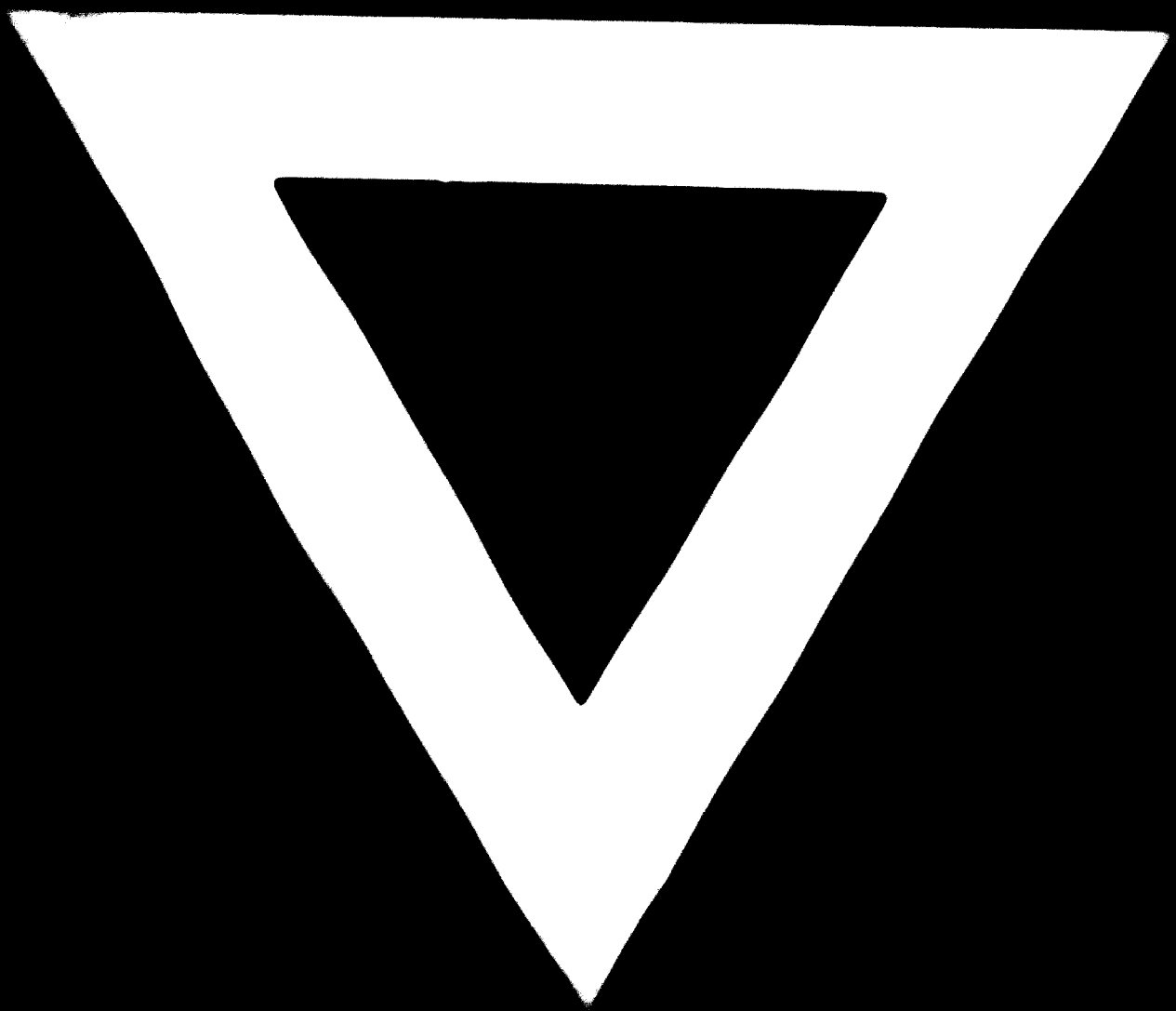

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