CLAUDE MERCIER

petrochemical industry

and the possibilities of its establishment in the developing countries

PUBLICATIONS DE L'INSTITUT FRANÇAIS DU PÉTROLE
Collection "Science et Technique du Pétrole" n° 7 bis

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1966

ÉDITIONS TECHNIP • 7 RUE NÉLATON • PARIS 15e

technip

Distributed in the United States and Canada by:

GORDON AND BREACH, SCIENCE PUBLISHERS, INC.

150 Fifth Avenue, New York, N.Y. 10011

2nd printing 1968

COLLECTION **SCIENCE ET TECHNIQUE DU PÉTROLE**

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7bis Petrochemical industry and the possibilities of its establishment in the developing countries. C. MERCIER *with the assistance of* B. BARTOLI and M. BARRAQUÉ.

REMINDER

This volume is made up of a series of papers drawn up at the request of the United Nations Organization by the Institut Français du Pétrole and presented at the Conference on the Development of Petrochemical Industries in Developing Countries held in Teheran in November 1964.

We should like to express our thanks to the United Nations Organization which has kindly given us permission to publish these papers.

C. M.

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SECTION I

GENERAL INFORMATION CONCERNING THE PETROCHEMICAL INDUSTRY

THE EXPANSION OF THE PETROCHEMICAL INDUSTRY AND THE REASONS FOR ITS RAPID DEVELOPMENT

Between the two World Wars the petrochemical industry grew slowly to meet the needs of the automobile industry by supplying it with such products as new paint, antifreeze and additives. Then, towards the end of this period, synthetic rubber and plastics made their appearance. Lastly, the second World War acted as a powerful stimulus on the development of chemical synthesis products put out by this new industry to meet a demand which surpassed the possibilities of such conventional sources as the coal industry and farm production, whether it was a question of quantities needed or the quality required.

The petrochemical industry is distinguished by its dynamism and rapidity of development. Its dynamism lies in the demand it has to face, and its rapid development concerns techniques as well as far-reaching and rapid changes in its industrial structures and installations.

New Materials

The utilization of oil and gas as sources for the production of chemical products was made possible by the development of molecular structure transformation techniques which led to a production increase of certain products and enabled new types of artificial materials to be manufactured meanwhile the conventional chemical industry was not able to satisfy the needs of the market by showing itself incapable of producing new materials.

The utilization of these materials was developing along with these techniques. Detergents, synthetic fibers and plastics, all of which are manufactured from chemical synthesis materials, created new markets which expanded very rapidly. The same was true of other products such as fertilizers and synthetic rubber which now have a very large turnover.

Large-Scale Availability and Certainty of Supply

The existence of enormous resources of crude oil or natural gas and the highly competitive and stable prices at which petroleum cuts can be offered as raw materials, along with the certainty and regularity of the supply, are additional causes for the increased demand for petroleum products.

The abundance of the available supply has had a considerable effect on the demand. The existence, in larger and larger quantities, of light distillates, natural gas and refinery gas, mainly due to the development of refining, has meant that new outlets have had to be found which, in turn, has stimulated the search for new uses.

Other sources of raw materials, such as molasses for ethyl alcohol and coal tar for benzene, required either a certain amount of time or else the manufacturing of coke, and in both cases prices tended to be unreliable.

Expansion of Existing Markets and Creation of New Finished Product

The general rise in the standard of living and, consequently, the increase in consumption per inhabitant as well as the creation of new outlets have had the following result:

1) Intensification in the search for new applications for the products. This can be seen in the invasion of synthetic materials on markets which were formerly dominated by traditional products.

- Synthetic fibers have made their way into the textile industry to the detriment of cotton and wool.
- In the rubber industry the most recent synthetic products have qualities which are equal and sometimes superior to those of natural rubber. These synthetic products are more stable from the point of view of price, and their output is not dependent on political events.
- In the field of packing, polyethylene has widely replaced glass and cellophane. Plastics have also made their way into the field of construction where their resistance to corrosion and weathering, their lightness and their flexibility are precious assets.

2) The possibility of putting finished products on the market at attractive prices by reducing production costs through the discovery of new processes or methods, by technological advances in existing processes, and by technical improvements in instrument and equipment design.

3) The orientation of research towards the diversification of processes so that chemical products can be produced from several raw materials.

Under the impetus of lively commercial competition, the petrochemical industry is a difficult field, but the dynamism of its expansion justifies the attempt to develop it in countries which have:

1) Large reserves of raw materials such as oil and natural gas;

2) Existing consumer markets which are sufficiently developed or which are destined to expand considerably to support the creation of such an industry;

3) Favorable export conditions despite the competition imposed by the international market.

CHAPTER I

DESCRIPTION AND SPECIFIC CHARACTERISTICS OF THE PETROCHEMICAL INDUSTRY

I. 1. DESCRIPTION OF THE INDUSTRY AT THE PRESENT MOMENT

I. 1. 1. Raw Materials

The reasons behind the utilization of larger and larger quantities of oil and natural gas as raw materials in the chemical industry are as follows:

1) Oil and natural gas can produce purer products than those from carbochemistry.

2) Petroleum refining can, by means of normal or special processing, produce substances which are difficult to derive from other sources (xylenes).

3) Oil and natural gas can increase supplies of certain products which would not otherwise be available in sufficient quantities (glycerin).

4) Oil and natural gas can usually provide the required products at lower prices than can other sources (plastics).

Raw materials come from sources which are varied and adapted to local conditions. They are made up eitheir of primary hydrocarbons obtained by simple separations from natural gas or oil, or of products which have already been transformed such as residual gas or petroleum cuts left over from refining.

In the United States use is made primarily of natural gas as well as ethane and the liquefied gas extracted from it. Gas from catalytic cracking, which is rich in olefins, is also an interesting source. Aromatics are extracted from reformed gasoline.

Europe, which has only recently been able to exploit its own natural gas resources and which, as a result of the structure of the petroleum market, is less heavily equipped with catalytic cracking plants, has centered its petrochemical industry around excess light gasoline which is difficult to valorize on the European market where large quantities of medium distillates are consumed.

Primary hydrocarbons continue to be a favorable source for industries, even though the current disfavor towards acetylene eliminates an important outlet for natural gas. Some industries which consume large quantities of gas, as is the case for ammonia production, have been installed themselves near production fields, far from any market. For example, ammonia plants have been built:

- In the Caribbean, on Trinidad, where Federation Chemicals Ltd, an affiliate of W. R. Grace & Co., has just begun production at its 235,000 T/year plant, thus increasing the total output to 500,000 T/year if existing installations are also included.
- In the West Indies, on Aruba, where Antilles Chemical & Co., an affiliate of Standard Oil of New Jersey, has built a 360 T/day ammonia plant to supply its urea and nitrate installations and export markets in Latin America.

In addition, naphtha is widely used in countries which do not have primary hydrocarbons at their disposal. A European petrochemical industry based on naphtha is being established. The same is true in India where excess naphtha produced by refineries is

used as a raw material in the production of ammonia and fertilizer and in the production of olefins by steam cracking. This trend is accelerated by the fact that naphtha processes are undergoing numerous improvements.

I. 1. 2. Location

The largest centers can usually be found in regions where crude oil refining and natural gas availability are the most highly developed. This is the case in the states of Texas and Louisiana, in the United States. This is also the case for the leading petrochemical installations in Europe:

- The S. N. P. A. and the Pardies Complex near the natural gas deposit at Lacq, France.
- The ENI and the Ravenna Complex in Italy.
- Naphtachimie and the Shell Petrochemical Units near the Berre Lake refineries in France.
- The Esso Standard and C. F. R. petrochemical process units near the Basse-Seine refineries in France.
- The Shell petrochemical units in Rotterdam, the Netherlands.

This dense concentration of similar types of activity can be seen immediately upon the creation of a new complex. It enables the initial efforts to be better valorized while making the most of the multiplication effect it entails by reducing investment burdens necessitated by associated services and the production of utilities and by decreasing production costs by providing for more widespread utilization of by-products.

I. 1. 3. Producers and the Relative Position of Petroleum and Chemical Products Companies Interested in the Petrochemical Industry

As a general rule, the former supply the latter with raw materials, and the latter manufacture finished products.

However, there are many exceptions to this rule, and the integration of petroleum and chemical activities is carried to greater or lesser degrees, depending on the case. The same company can also be engaged in several activities.

1) Some oil companies supply the chemical industry with raw materials and intermediate products. Among these are: Standard Oil of New Jersey, S. O. of California, Shell, and Gulf in the United States; Shell, Compagnie Française de Raffinage, Esso-Standard and S. N. P. A. in France; British Petroleum Co., Shell Chemical and Esso Petroleum Co. in Great Britain; and the ENI in Italy.

2) Some chemical companies depend on the oil industry for large quantities of raw materials and intermediates. They devote most of their efforts to manufacturing complex products and are specialized in organic chemistry products. Among these are: Du Pont, Monsanto, Rohm & Haas and Wyandotte in the United States; Péchiney, Saint-Gobain, Rhône-Poulenc, Progil and Ugine & Kuhlmann in France; Monsanto Chemicals Ltd. in Great Britain; Bayer and Hœchst & BASF in Germany; and Sicedison in Italy.

3) Other oil companies extend their activities beyond basic products to include intermediate products and their derivatives and even end-products: Shell in Great Britain, the United States and France; Antar in France; and the ENI in Italy.

4) There are also some companies which do not make large-scale demands for raw materials and which usually make use of natural gas, liquefied petroleum gas, refinery gas and naphtha: Imperial Chemicals Industries in Great Britain; Naphtachimie in France; and Montecatini & Edison in Italy.

5) Some chemical companies team up with oil companies to carry out joint activities. There are many arrangements of this sort in Europe, for example: British Petroleum Co.

(50%) and National Distillers (50%) in Great Britain; and Naphtachimie (BP and Péchiney) and Shell-Saint-Gobain in France.

6) Chemical companies also have a tendency to buy up plastic manufacturing plants and the like. In this manner they guarantee themselves an outlet for some of their products at the same time as they acquire technological and practical experience in the field in question. This is the case with Imperial Chemical Industries which is the largest producer of polyethylene films in Great Britain.

7) Lastly, some companies, in France in particular, pool their resources in order to create affiliates. In this category are Péchiney-Saint-Gobain, Ugine-Progil and Rhône-Poulenc-Usines de Melle. These associations sometimes go so far as to include a foreign partner: Progil-Bayer-Ugine, and Kuhlmann-Du Pont de Nemours. The main advantages of such associations lie in the following points:

- Possibility of building a large-capacity unit which is competitive on the international market but which avoids harmful competition with small producers on the domestic market.
- Reduction of investments for each of the companies, thus enabling them to become involved in new fields of activity at the same time.
- Certainty of supplies and, reciprocally, of outlets.

It is difficult to evaluate the respective share of production as a whole that is taken up by the different types of structures. But it is quite evident that there is a greater and greater tendency towards integration. However, this does not often assume the form of vertical integration whithin the same legal entity, but rather of an association which enables basic product suppliers to consolidate their outlets and to participate in the profits all along the line right up to the finished products, and it also provides consumer distribution networks with an insurance against fluctuations in the supply of raw materials (certainty and cost) by pooling their production.

The extremely severe competition which exists between the different finished products on the market and the rapid growth of production have led research to be oriented so as to assure the production of chemical products from several basic products or to reduce the intermediate stages to a minimum. This requires, on the part of the numerous interests involved, a pooling of knowledge and a concentration of experience such as has reached an extremely advanced stage in England. An example of this is where refineries, chemical industrial installations and finished product transformation industries are associated and linked together in a comprehensive complex within which they mutually aid each other.

I. 2. SPECIFIC CHARACTERISTICS OF THE PETROCHEMICAL INDUSTRY

I. 2. 1. Principal Features

I. 2. 1. A. Investment Volume

The investments put into petrochemistry are very extensive. This is illustrated by the figures for the four leading European producing countries.

The size of the sums committed comes partly from the fact that investments are very high per unit. The investment per new job created of approximately $ 20,000 to $ 100,000 is among the highest in the world.

Furthermore, the position occupied by petrochemical production within the chemical industry is becoming larger and larger. In the United States the part represented by petrochemical products was negligible in 1930. It will have reached 40 % of the overall chemical output in 1965. In England, production went from 6% in 1959 to 65% of the organic chemistry industry in 1962. Comparable trends are being experienced in Italy, France,

INVESTMENTS MADE BY EUROPEAN COUNTRIES
FOR PETROCHEMICAL PRODUCTION

(in millions of U.S. $)

	1959	1960-1962	TOTAL
France	52	248	300
West Germany . .	80	142	222
Italy	54	238	292
England	82	206	288
	268	834	1,102

Germany and Japan. Petrochemical products now account for 57 % of the dollar value of all the chemical products in the United States.

The increase in investments does not proceed without upsets and sometimes results in overcapacity crises which affect all branches of petrochemistry. Butadiene and ethylene in the United States and benzene markets in Europe have all gone through or are going through such crises. These crises reveal themselves by a sharp drop in prices and by an attempt at dumping. Some upheavals can even lead to the buying up of entire plants by more stable colleagues (buying up of Texas Butadiene by Sinclair and of various Montecatini plants by Shell).

Increase in Capital Cost Along With Manufacturing of More Highly Elaborated Products

Basic products and intermediates require larger and larger investments as they progress from the stage of transformation to the state of finished products and then to consumer goods.

1. The example of the production of ammonia and fertilizers:

For a plant, built in Europe, using natural gas and consisting of:

- the production of synthesis gas from natural gas and supplying 300 T/day of ammonia synthesis gas;
- an output of 300 T/day of ammonia;
- a 300 T/day ammonium nitrate (27.5 % nitrogen) unit;
- a 200 T/day urea unit;
- a 212 T/day sulfuric acid unit and a 280 T/day ammonium sulfate unit;

and operating according to the flow sheet below (Fig. 1). The breakdown of investments is shown in Table I.

It can be seen that the production of fertilizers (finished products) requires investments which are four times as large as those needed for the production of synthesis gas (basic products) and 1.6 times greater than for the production of ammonia and sulfuric acid (intermediate products).

2. The example of the production of aromatics, synthetic fibers and plasticizers:

For a plant built in Europe, using a gasoline cut from a refinery, and consisting of: