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Interregional Petrochemical Symposium on the
Development of the Petrochemical Industries in
Developing Countries
Baku, USSR, ~~20~~ 21 - 31 October 1969

DRAFT

R E P O R T

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

Baku - Az.S.S.R.
U.S.S.R.
21 - 31 October 1969

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We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

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INTRODUCTION

The Interregional Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries was held in Baku, AzSSR, Union of Soviet Socialist Republics (U.S.S.R.) from 21 to 31 October 1969. The Symposium was organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Government of U.S.S.R.

The purpose of the Symposium was to review and to bring up to date the various data on economic, technological and policy aspects affecting the establishment or development of the petrochemical industries in developing countries. Particular emphasis was given to new areas of development since the first United Nations Interregional Petrochemical Conference in Teheran, Iran, in 1964. The Symposium aimed principally, at bringing together the scientists, engineers, technologists and economists responsible for the planning, organization and execution of petrochemical projects of both developing and developed countries to discuss technological and related economic problems and to exchange views on the basis of discussion papers and regional and country papers.

Discussions during the Symposium laid particular emphasis on two other major items, namely prospects for the petrochemical development during the United Nations Second Development Decade and possible areas of technical assistance in petrochemical industries by UNIDO including planning and implementation of projects, problems connected with existing plants and installation of small industrial plants.

The Symposium was attended by participants from Algeria, Argentina, Austria, Belgium, Bolivia, Brazil, Burma, Canada, Ceylon, Chile, Cuba, Czechoslovakia, Federal Republic of Germany, Gabon, Hungary, India, Indonesia, Iran, Iraq, Italy, Japan, Lebanon, Malaysia, Mexico, Morocco, the Netherlands, Nigeria, Pakistan, Philippines, Poland, Romania, Spain, Trinidad and Tobago, Turkey, U.A.R., United Kingdom, Uruguay, U.S.A., U.S.S.R., Venezuela, Yugoslavia, as well as the Economic Commission for Europe, International Atomic Energy Agency and the United Nations Economic and Social Office in Beirut.

A list of participants is given in Annexure III of the report.

The Symposium was opened by Mr. N.J. Sorokin, Chairman of the

Organizing Committee, Deputy Minister of Oil Processing and Petrochemical Industries of the U.S.S.R. Addresses were also given by Mr. F.A. Guseynov, Deputy Chairman of the Council of Ministers of the AZSSR, Mr. P.H. Abdullayev, Chairman of the Baku City Executive Committee and Mr. N.C. Verghese, Director of the Petrochemical Symposium. A message was read from Mr. I.H. Abdel-Rahman, Executive Director of UNIDO.

Academician I.G. Ismailov, President of the Academy of Sciences, AZSSR was unanimously elected Chairman of the Symposium. The Symposium elected Mr. Max Richards (Trinidad and Tobago) as the Vice-Chairman.

In order to facilitate discussions and the preparation of the report of the Symposium, Sectional Chairmen and rapporteurs were appointed for the major substantive items of the agenda. The Symposium also established a committee to prepare the report of the Symposium. Mr. A. Shah Nawaz was elected as Chairman of the Report Committee.

As part of the Symposium programme, participants took part in visits to the Baku and Sumgait petroleum refineries and petrochemical complexes, to the off-shore petroleum exploration in the Caspian Sea, the Olefins Institute and Scientific Petrochemical Research Institute, and to the Scientific Research Institute and the Astrophysic Observatory at Shemakha.

The Symposium held a total of 24 meetings, at which 93 papers were presented for discussions. The presentation of the papers was followed by discussions at each meeting or after each substantive item.

The agenda of the Symposium included the following substantive items: present and future prospects of the petrochemical industry in developing countries; basic petrochemical products and raw materials; plastics; synthetic fibres; synthetic rubbers; development of the petrochemical industry during the United Nations Second Development Decade and possible assistance to the developing countries in the petrochemical field by UNIDO.

The Symposium held its concluding session on 31 October 1969 when this draft report was discussed and approved. Concluding speeches were made by the Chairman, Academician Ismailov and Mr. Guseynov, Deputy Chairman of the Council of Ministers of AZSSR.

CHAPTER I

Present and future prospects of the petrochemical industry in developing countries

1. The overall picture

This section of the Symposium was devoted to a discussion on the recent developments in petrochemical technology considered significant since the first Petrochemical Conference in Teheran in 1964. It consisted of papers contributed by the United Nations Regional Economic Commissions followed by individual country papers describing:

(a) progress made in petrochemical development since the 1964 Teheran Conference in the region or country;

(b) present and future prospects in production, consumption and trade in petrochemicals projected up to 1980;

(c) the factors affecting petrochemical development;

(d) the kind of external assistance required including from the United Nations particularly from UNIDO.

The recent technological progress in primary petrochemicals production has been centred round achieving reduction of manufacturing costs in the two basic processes viz steam-cracking for olefins and aromatics and catalytic reforming for aromatics. Progress has been made in reducing capital cost or power consumption, or in increasing yields of desirable end product. However, in most cases, the yield of desired products does not exceed 50 per cent. Recently, the idea of a "petrochemical refinery" designed to produce mainly basic petrochemicals rather than mainly fuels as in a normal refinery has been proposed. In fact, some new plants in e.g. Puerto Rico, Priolo, Brindisi, etc. are approaching the petrochemical refinery idea.

Recent progress in the production of oxygenated products, polymers and proteins has been reviewed and some of the products are discussed in more detail in later chapters.

2. Regional assessment and development prospects

Papers were presented to the Symposium containing details of regional consumption patterns, estimated production as well as the likely pattern of the petrochemical industry within each region. These are summarized below, with summaries for individual countries being given in Section 3 of this chapter.

AFRICA

The situation of some forty odd countries grouped under four subregions (North, West, Central and East) were reviewed.

Demand

Because of the varied assumptions and approaches necessary owing to the lack of reliable information in the region as a whole, it was rather difficult to summarize the demand. However, projections have been made up to 1980 for plastics, synthetic fibres, synthetic rubbers and some other petrochemicals. Although it was not possible to state clearly the relative importance of petrochemicals by sub-regions certain observations could be made. Polyethylene, nylon, dodecyl benzene and carbon black seemed to be of major importance in North Africa, while PVC, polyester fibres and adhesives predominated in West Africa. DDT is of major importance in East Africa. Figures showing the trends are given and indicate to some extent the relative significance and potential of the petrochemical industry in the sub-regions of Africa.

It is anticipated that by 1980 demand for the main plastics will reach 438,000 tons, 140,000 tons of synthetic rubber and 103,000 tons of synthetic fibres.

Raw material

Reserves of crude oil in 1967 estimated at some 32 thousand million barrels are nearly eight times the estimated figures of 1958. The share of the world reserves increased very substantially over the same period.

Production of crude oil in 1967 was 14[illegible] million tons, some six times the 1961 figure.

Exports of gas from the region are now a significant item reaching 800,000 tons to OECD countries in 1966.

However, the distribution of oil and natural gas is uneven in the region i.e. well-endowed in the north and relatively poor in the south and the East African sub-region being least endowed. The limited number of producer countries are: Algeria, Angola, Congo(B), Gabon, Libya, Morocco, Nigeria, Tunesia and the UAR. Within the foreseeable future Cameroon, Congo (Democratic Republic) and Dahomey are expected to join the rank of producers.

At present, there is over-capacity in the established refineries in the region. No major increases are foreseen in 1970-1975. In contrast, a surge in capacity increase is expected in 1975-1980 to meet requirement for petrochemical development in the region.

Factors inhibiting petrochemical development

Although the availability of raw materials and fuel favour petrochemical development, there are many inhibiting factors affecting developments in the region. These are unsatisfactory electric power supply position at present, gaps in transport links and hence high transport costs, lack of trained manpower and limited market size. Efforts are being made to overcome these difficulties by some countries in the region and the ECA. The multinational and sub-regional approach has been adopted by the ECA for some time and some economic groupings are emerging.

Other remedies suggested were small plants based on simple economical processes and techniques, and multi-purpose small plants adaptable to varying market conditions.

Development possibilities

A trend toward diversification is evident in existing establishments in Africa especially in the final stage of processing petrochemicals. However, it does not appear possible to avoid import of certain final products for some time to come.

Proposals for a number of production combinations and alternatives are possible in each sub-region depending on several factors such as consumption centres, availability of raw materials, utilities and infrastructure and the need for fair allocation of the production units among member countries.

It was suggested that an inter-sub-regional approach could render the production of a number of petrochemicals practical.

The fixed investment implications of a number of proposed units were made with a possible investment of 400 million dollars by 1975 and an additional 500 million dollars between 1975 and 1980.

ASIA AND THE FAR EAST

The world position and the part played by the countries of the region covered by ECAFE, and the demand for petrochemical products in the latter group of countries, was discussed.

Present consumption and future demand and requirement for plastics, synthetic resins, synthetic fibre and synthetic rubber were discussed. Detergents, insecticides and carbon black were also discussed.

The sources of raw material, namely crude oil and naphtha as well as natural gas in each country of the region were discussed.

Current production figures were next discussed. Plastics, synthetic fibres and synthetic rubber production figures were given for those countries in the region producing them. Following this, the number of plants as well as their capacity in each country were given.

Next, import and export figures for the more significant countries in the region were given followed by a section detailing the announced plans for expansion in the countries.

The various factors affecting the development of petrochemicals were then discussed including the demand for end products and the processing [illegible] necessary, disposal of co-products, raw materials availability, financial resources, engineering design, know-how and training of personnel.

The rate of expansion of consumption of end products expected in the period 1970-1980 was next discussed and the new plants necessary to meet this growth were forecast together with the anticipated costs of production and investment necessary. Attention was given to the possibility of [illegible] countries being able to match world prices for various petrochemical products. Grouping of the production of primary product at central locations [illegible] consideration with some estimates of the transport costs involved.

The demand for petrochemicals in the ECAFE region is sharply [illegible] is estimated that excluding the developed countries in the region, the [illegible] for the basic plastics (polyethylene, PVC, polystyrene and polypropylene) [illegible] reach 2,110,000 tons in 1980, the demand for synthetic fibres [illegible] synthetic rubber 335,000 tons and for detergents [illegible]8,000 tons in 1980. Growth rates are high in the region and average a cumulative 15 per cent for many countries.

Substantial additional production capacity is required to be developed in the region, to meet demands. These amount to 1,675,000 tons/year fo[illegible] basic plastics; 460,000 tons/year for the synthetic fibres, 240,000 tons/year for synthetic rubber and 380,000 tons/year for synthetic detergents. In addition, substantial amounts of monomer production will be required. However, continuing reliance on imports of both finished products and monomers from the developed countries of the region, as well as other countries, will continue to be made.

Finally, tables were drawn up for each country in the region showing the estimated demand in 1980 for the principal plastics, fibres and synthetic rubbers together with detergents and basic petrochemicals, capacity required by 1980, plant size, and number of plants. The possibility of joint ventures e.g. several countries investing and/or sharing production from one plant was examined in detail and recommendations made.

EUROPE (WEST)

The growth in production, consumption and trade of the principal petrochemical basic materials in Europe over the years 1964 to 1967 inclusive, and forecasts of the demand in 1970 and 1975 were discussed. Countries were broken down under three headings: EEC, EFTA and others. The following basic materials were considered:

1. Ethylene, divided into its principal uses: polyethylene, ethylene oxide, ethyl benzene, vinyl chloride, ethyl alcohol, acetaldehyde, and others (linear alcohols and olefins, ethylene-propylene rubbers, ethyl chloride etc.)
2. Propylene, divided into its principal end uses: acrylonitrile, polypropylene, cumene, propylene oxide, oxo-alcohols, isopropyl alcohol and others (propylene trimer, tetramer and synthetic glycerine).
3. Butadiene, divided into its principal end uses: SBR, polybutadiene, nitrile rubber, ABS resins and others (butadiene trimer and tetrahydrophthalic anhydride).
4. Benzene, divided into its principal end uses: cumene, ethylbenzene, cyclohexane, dodecylbenzene, chlorobenzene, maleic anhydride and others (nitrobenzene, diphenyl etc.).
5. Para-xylene, with some discussion on the future of polyester fibres.

Present indications were that there should be an increase of 22 per cent per year over the 1967-1970 period but a reduction to 13-14 per cent per year between 1970 and 1975 may become inevitable. The slacking off period could [illegible] attributed to the onset of a quieter period after a few years of rapid expansion.

From the data available from ECE, the production of ethylene derivatives will reach 12 million tons in 1975, propylene derivatives 5.75 million tons and butadiene derivatives 1.16 million tons.

EUROPE (EAST)

The rapid growth in the plastics and synthetic resins industry was stressed. In the countries of COMECON, thermosets had, up to now, both a great significance and also a great share in the total production, while the production of thermoplastics mainly polyolefins was to develop in the near future.

Because of the shortage in crude oil in the COMECON countries, except USSR and Romania, substantial imports are necessary. The description of the position of each country in this respect followed. In the second part, the stage reached in each country of COMECON in the production of plastics and synthetic resins and particularly thermoplastics from petrochemical sources was described. As for the exports and imports of plastics and synthetic [illegible] in the countries of COMECON, it could be said that they were altogether not very significant because the countries of COMECON had a greater plastics [illegible] synthetic resins consumption than production at present.

However, the production of petrochemicals in the COMECON countries and Yugoslavia will have reached a substantial volume in 1970 amounting to 1,673,000 tons of plastics and synthetic resins, of which PVC will be [illegible] tons and polyethylene 494,000 tons.

THE MIDDLE EAST

The Middle East region was one of the richest in the world for raw material for petrochemicals, but the market for the latter was small compared with the world market.

The position in each country in the region was first discussed, [illegible] by its petroleum and natural gas resources, its existing petrochemical [illegible] tion, if any, and its plans for the future.

Summary tables were made for the whole region. This section was [illegible] to include transport possibilities, energy availability and the existence of petroleum refineries.

The consumption of petrochemicals within the region will increase between 1975 and 1980. Plastics will increase from a possible [illegible] tons in 1975 to 210,000 tons in 1980; synthetic rubber from [illegible] tons to 40,000 tons/year and synthetic fibres from 160,000 tons to 300,000 tons.

A scheme was drawn up showing the [illegible], benzene, polymers, synthetic fibres and rubbers and other [illegible] which the region could reasonably produce by 1975 and by 1980. The current and future markets were discussed, broken down into countries as a whole and for the regions in terms of different plastics, rubbers and fibres. The rubber tyre imports into the different countries were next given as a guide to potential rubber production.

Suggestions were made for action on a [illegible] basis e.g. tariff modifications to allow exchange of products and standardization of qualities by the various technical institutes. Action on a national basis was then dealt with including the setting up of a joint panel of [illegible], joint planning, reduction of natural gas flaring and improvement in chemicals [illegible] raised four fold by 1980 but an investment of US$ 200 million [illegible] be necessary to enable this increased quantity to be produced within the region.

Currently petrochemical conversion of natural resources besides fertilizers production existed in the Middle East countries, which have the biggest crude oil reserves of the world. The flaring of natural gas amounted to more than 70 per cent of the production. However, petrochemical products many of them based on Middle East crude oil, were imported from all over the world. In evaluating import figures of plastics, synthetic rubber and synthetic fibres in the last years an actual per capita consumption of 2 - 3 kg had been found. The erection of a petrochemical complex based on natural resources was suggested. Following a given model the main petrochemical [illegible] and their derivatives could be produced in the Middle East region serving the home market during the Second Development Decade, which is expected to be in the range of 8 - 10 kg petrochemicals per capita in 1980.

Thus production in the Middle East will rise to 170,000 tons/year plastics, 60,000 tons/year synthetic rubber and 65,000 tons/year synthetic fibres by 19[illegible]

3. Country papers

ALGERIA

Algeria possessed major resources of liquid and gaseous hydrocarbons. It had been decided to base the industrialization and the economic development on these resources.

Thus some dozen projects had been studied and are mostly in the course of being implemented.

These projects were major ones and would take up much of capacity for absorption of the Algerian market.

Therefore, Algeria offered the possibility of exchange of trade with both developed and developing countries.

Algeria was seriously looking into all schemes of co-operation which would be of mutual benefit and is ready to place its modest expertise at the disposal of developing countries.

Special institutes had been created to solve problems of manufacture. But Algeria appreciates the willingness of UNIDO to aid them in solving marketing problems and giving technical assistance.

GABON

There was actually no petrochemical industry but numerous studies had been made to make use of the relatively abundant raw materials (crude petroleum, natural gas and a heavy residue from the refinery). The products concerned were:

(a) crude petroleum - 4.6 m tons in 1968
5.2 m tons in 1969

reserves estimated of 130 m tons (or about 25 years at the present rate of consumption);

(b) heavy residues - 100,000 tons/year. In two or three years the capacity would certainly be doubled, perhaps increased fivefold;

(c) reserves of natural gas - 2,500 million m^3 taking into account only gas associated with oil. Further, there should be considered gas obtained by drilling fields not connected with oil. Of the output of 448 million m^3 only 25 million have been commercialized.

Projects foreseen were the use of natural gas for the production of ammo of urea and synthetic fibre for textiles.

Ammonia and urea - 600 tons per day of ammonia, 700 tons per day of urea. Investment(collection of gas and the plant); 11,000 m of CFA Francs (US$ 40 million) Process Stamicarbon(Netherlands).

Staple synthetic fibre for weaving: 5.2 to 6.5 tons/day. Investment at the order of 1,500 million CFA Francs (US$ 6 million). Market orientated to that of the Tariff Economic Union of Central Africa.

Studies to be undertaken:

(a) Use of crude kerosene fraction for the production of solvents in the small units associated with a refinery;

(b) use of refining residues for the production of synthetic detergents petroleum coke (30,000 tons/year is consumed by ALUCAM - electrolysis of alumina at Edea in the Cameroons).

The problems are limitation of market and lack of capital and Gabonese technicians.

MOROCCO

Petrochemical industries were non existent in Morocco. The consumption of petrochemical products was characterized by a high rate of increase (200 per cent between 1951 and 1966). The import of petrochemicals (not included finished products) amounted actually to 30 million dollars.

A project for producing synthetic fibres (polyamide 6 and polyesters) was under consideration.

Difficulties encountered in the rapid installation of petrochemicals industries were among others:

- the lack of sufficient number of specialized technicians;
- the absence of research for developing new petrochemical materials adapted to local conditions.

UNIDO should help Morocco in solving these two difficulties by studying the possibility of creation in Morocco of an institute for the training of specialized technicians and of a research centre for the application of plastic materials to agriculture and building construction.

NIGERIA

As there was, at the moment, no petrochemical industry in Nigeria, the paper was oriented to emphasizing local over-abundance of resources from which chemicals, fertilizers, pharmaceuticals, etc. can be derived. Statistical data on historical basis and projections were provided on : the production of crude oil and natural gas, local consumption, qualities and specifications of same, importation of PVC compounds and resins, polyethylene, calcium carbide, caustic soda and LPG, phosphoric acid, nitrogenous fertilizers. On this basis, future prospects were considered in their respective order of priorities indicating possible date where such projects might be established. Problems encountered were analysed, the assistance required of UNIDO was defined which included among others staff training, evaluation and integration of varieties of products, capital requirements, etc. The paper ended with policy and incentives which were required to encourage the rapid establishment of such a complex.

BURMA

Present position - 1969 : 1 x 200 tons/day urea producing plant based on natural gas was to come into production in 1970. A similar one with equal capacity was to follow in 1971.

Total refining capacity was now 1 million tons/year having a naphtha surplus of 40,000 tons. Increase in oil products is 7 per cent per year such another 1 million tons capacity is scheduled to come into operation in 1975. Surplus naphtha then was estimated at 100,000 tons.

Plans for development

(a) intensive search for oil and gas within the country was continuing. Total fertilizer requirement is 700,000 tons/year. More fertilizer plants became necessary to close the import gap. Expected expansion in five years i.e. 1970 to 1975 is 1 x 400 tons/day nitrogenous fertilizer plant.

(b) Naphtha which will become available, to the extent of 100,000 tons per year would be used to put up 1 x 33,000 tons ethylene producing unit, from which 20,000 tons of polyethylene and 10,000 tons PVC was planned. Chlorine and caustic soda production facilities would be incorporated.

CEYLON

There had been no concentrated thought given so far for the development of chemical industries. The attitude had been that in view of the "[illegible] of potential" it would have been uneconomical to enter this segment [illegible] industry, more particularly synthetic fibres and plastics.

Two major steps could be highlighted in the petroleum industry:

(a) The establishment of the first Government owned petroleum refinery to meet the country's entire domestic demands of petroleum products.

(b) The proposed creation of an ammonia plant for manufacture of urea from chemical naphtha from the refinery. This plant was expected to go into production by 1972 to meet the country's total requirements of nitrogenous fertilizers.

Plans are also afoot to install a 10,000 metric tons LPG plant and a 10,000 metric tons sulphur extraction plant by the end of 1970. The problem for a country like Ceylon was not to catch up with industrialized countries on the development and generation of new technology but it was more a question of effectively utilizing the best available technology for each purpose and condition. In a small country like Ceylon with no natural resources, the petroleum refinery should made to yield the maximum value for both primary and secondary products. As a first step it was [illegible] to start with finishing plants, e.g. polymerisation of imported caprolactum to give nylon, which was an industry growing rapidly.

In Ceylon, lack of capital, a confined local market, low priced competition from highly industrialized countries and a lack of technical "know-how" and personnel are among the many obstacles to contend with, in establishing a petrochemical industry.

INDIA

The earlier history of the development of the petrochemical industry in India and the present position had been elaborated. The result of the initial planning had been brought forth in details. The details of the first petrochemical complex aroung two refineries in Bombay area that had already been implemented comprising of two crackers and subsidiary products, like polyethylene, polystyrene, PVC, polyester fibre, solvents (acetone, benzene, butanol, etc), plasticizers, chemical intermediates, like phthalic anhydride, phenol, 2-ethyl hexanol, etc. and the fertilizer plant along with a methanol unit, a carbon bl black unit etc. had been furnished.

The peculiar situation of the simultaneous development of organic chemical industries from different sources in India had been stressed. A consolidated chart giving details of chemicals known commonly as petrochemicals and been presented along with separate tables giving the details of these petro-chemicals, which were also being produced from non-petroleum sources.

An idea of the future planning for the development of this industry had been given along with estimated demand patterns for 1973-1974 and 1978-79.

The position regarding the second petrochemical complex in the Gujarat area round a Government refinery had been indicated in details. A few of the units in this complex, like fertiliser, UDEX plant producing BTX, phthalic anhydride plant based on ortho-xylene, have already been on stream. Several other projects like caprolactam, polyester, DMT, ortho and para-xylene, were under erection and the rest based on ethylene production had been contracted for completion within the next five years. The planning had been made for this complex in such a way that the import bills for maintenance of the already established or under implementation units could be reduced to minimum by providing basic chemicals from this project. The complex was expected to cater for the vital intermediates for synthetic fibre units which had already been in operation in different parts of the country, in addition to expanding the capacity of plastic polymers and providing basic intermediates, pharmaceuticals and pesticides manufacturing industry.

An idea has been given regarding future planning of other complexes in different parts of India like Barauni, Haldia and Madras. These were not likely to materialize earlier than 1975.

A picture of the present and future position of the nitrogenous fertilizers based on naphtha/natural gas had been presented.

The special features of petrochemical industries and the general constraints in their development problems encountered and solutions found had been stressed and elaborated.

The capital intensive nature, the sophisticated technology, the comparatively large sized economic units, the need for a complex because of the interdependent nature of down stream units vis-à-vis main olefin plant had been brought forward.

The problem associated with the development of this industry in developing countries like India, and its likely repetition in other developing countries had been put forward. The assistance which this country can offer to [illegible] because of her acquired experience in this line had been stated and the type of assistance that UNIDO can offer to this country had been indicated.

IRAN

Vast resources of petrochemical feed stocks at very low prices were available in Iran.

It was desirable to utilise these valuable national resources in plants of economic size to meet the local demands and to market abroad, at competitive prices, the output of the units which were surplus in the internal demands.

To be able to achieve this, a policy of formation of joint ventures with foreign partners having the necessary technical and financial qualifications and access to various markets of the region or the world had been adopted.

Iran's local market potential and Iran's favourable geographical proximity in potential foreign markets east of Suez and availability of skilled personnel, infrastructure, suitable feed stocks, economic and financial stability, etc. were the main reason for adopting the policy stated above.

The availability of many advantages and benefits to potential investors has accelerated the implementation of the policy adopted. Some of these advantages and benefits were as follows:

- the Law of the Attraction and Protection of Foreign Capital;
- the Act concerning the Development of Petrochemical Industries in Iran;
- the Direct Taxation Act;
- exemption from all custom duties, taxes and other charges and payments on all imports required for the construction and operation of the complex;
- free convertibility and transfer of local currencies and foreign exchanges of the joint ventures and free establishment of bank accounts in Iran and abroad;
- assurance of the supply of the necessary raw materials to the joint ventures;
- special provisions giving the joint venture the right to conduct and manage all production, transportation and other operations of the complex;
- financing of the projects which was done with the help of Iranian Government through its agency called Plan Organization.

Iran had successfully established and completed three petrochemical complexes within a span of three years using the policy described above. The total cost of these three complexes exceeded 320 million dollars.

Iran would welcome any foreign investor with necessary qualifications to participate with National Petrochemical Company of Iran in implementing these projects shown on the chart appended to the paper.

Iran would also welcome UNIDO's assistance to identify the potential investors and would appreciate any help which could be given in this respect.

INDONESIA

Five years national development 1969-1973 with emphasis on food production.

Development of agro-oriented industries (fertilizers, pesticides) is emphasized.

Private participation encouraged/invited (Foreign Investment Law).

Present status

Type of plant	number of plants		
	existing	under construction	in the planning stage
fertilizers	1	1	2
pesticides	1*	-	2
synthetic fibres	-	-	2
LPG and carbon black	-	1	-
detergent	2**	-	-
plastics	2**	-	-

* presnetly not operating

** using imported raw materials

Prospects

raw material	favourable
labour	no particular problem, however training required
capital	supplemented by foreign investments

Present problems—

low domestic market, limited domestic capital, condition of infrastructure especially transportation of heavy equipment and limited public utilities.

UNIDO assistance expected

- to draw up a market plan for future development of petrochemical industries by carrying out national petrochemical industries survey in Indonesia (preferably as soon as possible);
- investment promotion in petrochemical industries among potential investors;
- training of experts in pre-investment studies and project evaluations.

MALAYSIA

Present position

The recovery of sulphur and its utilization in the manufacture of sulphuric acid, ammonium sulphate fertilizers and synthetic detergents was already in existence.

Similarly the manufacture of ammonia, nitric acid and nitrogenous fertilizers from raw materials of petroleum sources had also been established.

Prospects of development

The petrochemical manufactureres of certain varieties of carbon black, plastics, synthetic adhesives for Malaysia's expanding plywood industry, alkyl aryl hydrocarbons, acetylene and ethylene could not be accurately forecast at this stage. Detailed surveys were necessary on the possible growth of industries that will be consumers of the above chemicals. Perhaps a complete feasibility study needed to be undertaken in collaboration with some foreign experts before concrete steps were taken to advance the petrochemical industry.

PAKISTAN

Petrochemical industry had only made a beginning. The existing capacity was limited to one small PVC plant based on imported calcium carbide, one polyethylene plant based on indigenous molasses and two urea formaldehyde plants based on indigenous urea and imported formaldehyde.

Proven gas reserves were 16 million cubic feet in West Pakistan and 10 million cubic feet in East Pakistan. Gas had so far been used only to make nitrogenous fertilizers and as fuel for power generation. In East Pakistan, a scheme costing US$200 million for making per year PVC (50,000 tons), acrylonitrile staple (12,000 tons), acrylonitrile filament (4,000 tons), polymethyl-methacrylate (4,000 tons), caustic soda (42,000 tons), bleaching powder .

(1,000 tons), methanol (37,000 tons), ammonium sulphate (2[illegible],000 tons), urea (320,000 tons), and surplus acetylene (3,000 tons) was under consideration of the Government.

In West Pakistan, where a sizable quantity of [illegible] available from the refineries, a scheme for using naphtha to produce [illegible] tons of ethylene in the first phase was currently under the consideration of the Government. The main products envisaged were per [illegible] polyethylene ([illegible] tons), [illegible] (15,000 tons), polypropylene (5,000 tons), [illegible] ([illegible],000 tons), [illegible] benzene (5,000 tons) and vinyl chloride monomer ([illegible] tons).

The capacities were higher than indigenous demand and [illegible] export was envisaged to utilize capacity. [illegible] demand to bring down production costs [illegible] domestic demand would grow fast once domestic production was [illegible] a high demand for the end use products like wires and cables, electrical [illegible], packing materials, flexible sheets, [illegible], footwear, [illegible] textiles, synthetic fibres and synthetic [illegible].

Despite availability of raw materials at cheap prices (about [illegible] cents per 1,000 cubic feet of gas in East Pakistan, [illegible] in the development of petrochemical industry has been the [illegible] for high capacities and consequent dependence on a highly competitive export market, apart from traditional bottlenecks like lack of trained manpower.

Any assistance the UNIDO could give particularly in [illegible] export markets and possibility of long term contracts ensuring offtake would be most welcome.

PHILIPPINES

The Philippines had advanced rapidly in the manufacture and consumption of finished products from petrochemical based raw materials. It was now looking into the feasibility of setting up a petrochemical complex for the [illegible] of basic raw materials centered on a naphtha cracking plant with an ethylene capacity of 100,000 metric tons per year.

The Government was taking a [illegible] lead in the development of the industry through the Board of Investments which in turn had organized a Petrochemical Committee composed of members from the public and the private sectors.

AZERBAIJAN SOVIET SOCIALIST REPUBLIC (AzSSR)

The foundation of the petrochemical industry of Azerbaijan was laid in the 1930's. Extensive development of petrochemical science and industry happened in the 1950 -1960's. The necessity for the construction of initial crude oil distillation units having a capacity of 6 to 10 million tons per year had been shown as the only way so that all the main succeeding petrochemical processes be supplied with raw materials.

During the last two decades, extensive investigations into the pyrolysis of oil and casinghead gases, middle and heavy petroleum distillates had been conducted; a new improved pyrolysis technology as well as new integrated scheme for the utilization of all pyrolysis products had been elaborated. The results of these investigations had found wide commercial application.

The technology for the production of high-purity ethylene and propylene had been developed; on the basis of these products large-scale processes aimed at the production of polymers and other valuable petrochemical products had been elaborated, for instance, direct ethylene hydration.

Important studies had been performed in Azerbaijan aimed at further development of the synthetic rubber industry (production of butadiene and isoprene by catalytic dehydrogenation of oil processing gases, development of the technology for ethylene-propylene rubber production, elaboration of oxidative dehydrogenation processes).

Azerbaijan's scientists had carried out interesting investigations on hydrocarbon oxidation and oxidative ammonolysis (production of acrolein, maleic and phthalic anhydrides, ethylene and propylene oxides, acrylonitriles etc).

The production of chloro-organic compounds proved to be one ot the key trends in Azerbaijan's petrochemical industry.

One of the new trends in the works of Azerbaijan's scientists was to obtain polymeric materials (elaboration of a new original technology for polyethylene production using oxidation catalysts).

CZECHOSLOVAKIA

The first petrochemical production was started in 1961 after the large-scale import of crude oil from the USSR started. At the present time, crude oil and natural gas coming by pipeline provided the raw material basis for the petrochemical industry.

The production of petrochemicals in recent years was divided into three basic groups: production of olefins in two separate small capacity units with downstream petrochemical processes producing synthetic ethanol, ethylbenzene and styrene, ethyleneoxide and glycols based on ethylene and oxo-alcohols and cumene-phenol and polypropylene based on propylene. Butadiene was extracted from the C_4-fraction and used for synthetic rubber production; production of aromatics from petroleum using diethylene glycol extraction. Benzene was used for ethylbenzene and cumene production. P-xylene and ethylbenzene were prepared from mixed xylenes; synthetic gas production for ammonia and methanol with eventual co-production of acetylene using natural gas as feedstock.

To cover raw materials for production of plastics and other chemicals for the future period up to 1980, it would be necessary to erect, with international co-operation with neighbouring countries, two big ethylene units having a capacity of 200,000 to 300,000 tons per year together with increasing production on existing units. New plants would be erected for high density polyethylene, vinylchloride, vinylacetate, acetaldehyde, polypropylene and acrylonitrile based on ethylene and propylene respectively.

A new aromatics recovery plant was engineered and erected now including dealkylation of toluene. Benzene would be used for the production of caprolactam.

The production of ammonia would be expanded in the same period three times in comparison with today's production, using steam reforming of natural gas or partial oxidation of fuel oil.

An important part of existing petrochemical units already installed in Czechoslovakia was developed, engineered and executed by Czechoslovak institutes and companies. The machine industry delivered equipment for own and foreign licenced petrochemical processes as olefin production, ammonia, synthetic ethanol and PVC production, styrene and polystyrene foam production etc. Processing development had been achieved in modified types of BS rubbers and from polystyrene.

<u>POLAND</u>

The utilization of petrochemical raw material basis had started in [illegible] On the natural gas basis several plants for production of ammonia, methanol and acetylene had been built. Due to the investment already finished and in the course of bringing on stream the production would attain 7,000 tons/day in 1973.

On the crude oil basis, the refining and petrochemical processes had been developed.

Refinery capacity had risen to 7 million tons/year in 1969 and would attain a foreseen level of 13.5 million tons/year before 1975.

The first small plant for naphtha steamcracking was put into operation in 1967 and the production of polyethylene, ethylbenzene, cumene phenol and acetone was started.

The xylenes from the platforming were utilized for the manufacture of DMT for production of polyester fibres.

On the turn of 1970/1971, the production of basic olefins would reach only 100,000 tons/year of ethylene and 50-60,000 tons/year of propylene. The production of butadiene would be of 70-75,000 tons/year (mainly from Houdry's process).

In the next five year plan after 1970, a new steamcracking plant of a capacity of 200-300,000 tons/year of ethylene had to be erected. After 1975, a second cracking plant of the same capacity.

In the planned development of petrochemical products the priority would be given to polyolefine plastics, synthetic fibres, various resins and new kinds of synthetic rubber.

<u>ROMANIA</u>

In accordance with the two raw material sources, methane and petroleum products, one can distinguish in the petrochemical industry of the Romanian Socialist Republic (RSR) two main lines of development: one part of the petrochemical factories utilizing methane as raw material, while the other one was based on raw materials from petroleum refineries.

The production of ammonia, vinyl chloride, trichloro-ethylene, acetic acid, butane, vinyl acetate and its polymers were based on methane.

The refinery gas was utilized for the manufacture of isopropylbenzene, intermediate for the production of phenol-acetone and of synthetic rubber, and for pyrolysis for the production of ethylene and propylene of high purity which ... then transformed into polyethylene, ethylene oxide, glycols and phenol.

The liquid petroleum products represented today raw materials for ethylene production.

The petrochemical industry of the [illegible] relatively short time an important promoter of the industrial production in general and of the technical achievements in all domains of the national economy.

SPAIN

This paper presented the development of the petrochemical industry in Spain and included the following points: recent development - present situation of basic petrochemicals production and utilization [illegible] capacities for all petrochemical products; future prospects - total [illegible] of plants under construction and short range project; problems encountered [illegible] problems in the development of this industry in Spain; assistance - need of technical and financial assistance.

TURKEY

The first petrochemical complex of Turkey [illegible] up in October 19[illegible]. The location of this complex was Yarimca, about [illegible] the city of Istanbul, [illegible] PETKIM and belonged to PETKIM PETROKIMYA A.S. [illegible] the PETROKIMYA AS had been entrusted with the [illegible] petrochemical industry in Turkey.

Fourteen units comprising the Yarimca complex [illegible] to be realized in three phases. The first phase units [illegible] operation one by one, as completed, were [illegible] 125,000 metric tons /year naphtha; polyethylene [illegible] metric tons/year; vinyl chloride monomer unit 2[illegible] metric tons/year, polyvinyl chloride unit 26,000 metric tons/year; chlorine-alkaline unit [illegible] metric tons/year chlorine; 20,300 metric tons/year caustic; dodecyl benzene unit [illegible],000 metric tons/year.

The rapid development of the [illegible] the first-phase units except DDB. The [illegible] be as follows: naphtha steam cracker 250,000 metric tons/year of naphtha; [illegible] unit 27,000 metric tons/year; VCM unit 54,000 metric tons/year; PVC unit [illegible],000 metric tons/year; chlorine alkaline unit 37,[illegible] metric tons/year chlorine, 40,600 metric tons/year caustic.

The units which would be added into the Yarimca complex in the second phase were as follows: carbon black unit 30,000 tons/year; styrene unit [illegible],000 tons/year; polystyrene unit 35,000 tons/year; butadiene extraction unit 33,500 tons/year; SBR unit 35,000 tons/year; CBR unit 13,500 tons/year, acrylonitrile unit 10,000 or 20,000 tons/year; caprolactam unit 25,000 tons/year; polypropylene unit 15,000 tons/year and ABS unit 10,000 tons/year.

In order to meet the increasing demand of Turkish market by the years, a second complex in Turkey parallel with Yarimca complex will have to be constructed. The location of the second complex would be Izmir and it would be completed by the end of 1975. The units of Izmir complex were as follows: Final product unit - polyethylene unit (LD) 45,000 tons/year; polyethylene unit (HD) 30,000 tons/year; polypropylene unit 35,000 tons/year; PVC 65,000 tons/year; ethylene oxide 46,000 tons/year; ethylene glycol 30,000 tons/day; TEA 2,000 tons/year; DMT 40,000 tons/year and phthalic anhydride 29,000 tons/year. Intermediate units - naphtha steam cracker 650,000 tons/year (naphtha) chlorine 62,600 tons/year; VCM 94,500 tons/year; [illegible] 46,500 tons/year. Aromatic separation - P-xylene 27,000 tons/year; O-xylene 27,700 tons/year and benzene 82,800 tons/year.

YUGOSLAVIA

This brief paper described the problems of the organic chemical industry in Yugoslavia.

In relation to developed countries, Yugoslavian organic chemical industry bore all the characteristics of the initial development stage of complex technology incorporated in the economic structure of a developing country.

With a limited market, without strong centres, with know-how and key equipment dependent on outside sources, without sufficient capital available, the organic chemical industry naturally differed from the similar industries in the developed countries.

Within the organic chemical industry in Yugoslavia industrial production of the following was now being realized: plastics, such as polyethylene e.g, polystyrene, polyvinyl chloride, pheno-and amino-plasts, polyesters; synthetic fibres, such as polyacrylic and polyamide; organic chemicals- methanol, formaldehyde, ethylbenzene, styrene, vinylchloride, acetone, phenol, dodecyl benzene, phthalic anhydride, ethylene and similar.

All the initial development problems of organic chemical industry in Yugoslavia arose from the fact that the prices of the organic chemical products were considerably higher than those ... countries on the world market. ... reform (1965) when the transition ... type economy began. Import ... domestic production not only ... too.

In the report submitted, ... opinion that developing countries with ... stage of development would not ... in developed countries.

The Yugoslav experience shows ... industry was to be developed, in ... been a a free market and decentralised ... industry specific approach to this ... could not be established ... the developed markets ... developing country ... effectively influence the ... a price level that would ... products wish to normal limits. This ... system of for a substantial period (5-6 ... processing domestic prices, without however, ... industry (converters). The ... expected to appropriate selection of the ... follow the prices of the ... function to the price. Without the ... deter- mine the optimum ... into consi- deration in all economic policy ...

By 1985, Yugoslavia was expected ... of an industrially developed country.

IRAQ

Iraq did not yet have a petrochemical industry (except a fertilizer plant of 180,000 tons/year under construction), but it was on the threshold of development in this sector. Guidelines for development had been suggested in some reports prepared by some consultants and experts during the last few years. These reports were studied but no final conclusions were reached. They dealt with the possibility of establishing petrochemical industries such as plastics, fertilizers, synthetic rubber, synthetic detergents and carbon black.

The need for building petrochemical industries had become important and urgent because of the continuously growing demand for these petro products and because of the abundance of light distillates and natural gas and refinery gases which could be utilized for such purposes.

The most feasible of petrochemicals industries that could be built in Iraq were low density polyethylene and polyvinyl chloride (PVC) because this material was growing at a very rapid rate in demand and it was expected to reach quite a high figure in 1975 (about 16,000 tons/year).

However, it was proposed to contact Arab countries and establish a co-ordinated project, if possible, which would become both economical and large enough in capacity for at least the Arab common market now being seriously considered. The importance of UNIDO aids in this respect was emphasized to help bring about this industry for the Arab market.

LEBANON

The petrochemical industry was practically non-existent in Lebanon and there were no firm projects in the immediate future. Two questions were thus raised: is there any chance that such an industry could be established in the near future and what part could Lebanon play in the development of an Arab petrochemical industry.

Because of the inside limited market and considering the sources of crude oil and natural gas, the Lebanese petrochemical industry could not develop outside an Arab development plan. Facilities were: high scientific and technical potential, low cost utilities and state encouragements. Hindrances were: shortage of feedstocks in the output of actual refineries and lack of local private and public capital. [illegible], it was not expected that oil producing Arab [illegible] regional [illegible].

The main [illegible] tion could [illegible] of an Arab petrochemical [illegible] developing [illegible].

It was then [illegible] for petrochemical research be established [illegible].

SYRIAN ARAB [illegible]

Crude oil [illegible] available in S.A.R. [illegible] and local production. The latter [illegible] 1968 [illegible]. Associated gas [illegible] available [illegible] production.

Petroleum refining

[illegible] refinery was established [illegible] has been increased from [illegible] to [illegible], increase [illegible] production [illegible].

Nitrogenous fertilizers

An [illegible] large rate of [illegible] consumption [illegible] additional [illegible], probably in [illegible].

Future of petrochemical industry

[illegible] an increase in [illegible] production and in the hydrogenation [illegible] envisaged that 40,000 tons/year of [illegible] would be produced [illegible] initial stage of a petrochemical [illegible].

ARGENTINA

Since the first International [illegible] (1964) the recently installed Argentine petrochemical industry [illegible] growing at a significant rate of [illegible] per cent [illegible] projects, reaching a gross production value of [illegible] in 1968 compared to 20 million dollars in [illegible]. However, [illegible] reached the expected level in relation to the growth of the [illegible] other pertinent economic indicators considering that much of this growth was due to the substitution of imports.

The next five years appeared more promising in view of a recently issued petrochemical decree (No. 4271/69) which, amongst other things, established prices for feedstocks to be supplied by the state, at levels equal to those prevailing on the international markets. This should allow local production to compete, by 1975/76, with imported products with duties of only 20 to 40 per cent, related to ECM domestic prices.

By 1973, Argentina expects to be self-sufficient in petroleum and natural gas. Therefore this industry has a solid base to stand on.

The main restraints that the development of the petrochemical industry faces, are: costs due to economy of scale and idle capacity resulting from the relative small isolated geographically market; economic and political problems resulting from the substitution of cotton, wool, and leather, significant natural resource industries for the synthetic fibres and plastics.

BOLIVIA

In the development of its petrochemical industry Bolivia was very close to crystallizing its first petrochemical projects. Attractive raw materials especially natural gas and the attainment of an Andean regional agreement (Bolivia, Colombia, Chile and Peru) to plan more efficiently the regional industry are important factors in materializing the possibilities of Bolivia. The characteristic problems of the less developed countries and the peculiar transportation problem of Bolivia were the main problems to be overcome. An ammonium nitrate fertilizer-explosive project was directed to the internal market, while various alternatives were present for production towards the regional market.

BRAZIL

The purpose of the paper was to give an idea of the order of magnitude of the Brazilian consumption, both present and in the near future, of petroleum raw materials and of natural gas, as well as of basic petrochemical products.

As of 1965, several incentives were created in Brazil for the chemical industry (in [illegible] petrochem[illegible] [illegible] upon an agency [illegible] [illegible] group of the [illegible]

[illegible] ved by GEIQUIM [illegible] in [illegible]

[illegible] 1967 the Government [illegible] PETROQUISA, [illegible] through with the [illegible] the [illegible] itself, with [illegible] in

As a result of [illegible] Brazil [illegible] private investors [illegible]

[illegible] ments of the [illegible] plants and also [illegible] of [illegible] balance [illegible] fore- casting [illegible] chemical industry, [illegible]

CHILE

While [illegible] the order of US$ 8[illegible] [illegible] the period 19[illegible] [illegible] and [illegible] through [illegible] Petroquim [illegible] the following divisions: [illegible] and Personnel.

In 19[illegible]8, the Chil[illegible] through the initiation of [illegible] both of [illegible] fi[illegible] product.

The market for [illegible] [illegible] 1968 and 1968 and it is expected that this rate of increase will be maintained to 1973. This would mean a consumption of plastics by 1973 of 6-7 kg per capita.

Various organizations had been studying and planning the development of petrochemicals as a whole. This had led to a complex now under construction at the San Vincente refinery in the Concepcion area. This plant, belonging to E.N.A.P., would have a capacity of 60,000 tons/year of ethylene, 40,000 to 50,000 tons/year of propylene and 10,000 tons/year of butadiene. It is expected to be on stream early 1970. The ethylene [illegible] would be used as the chief raw material for the production of vinyl chloride, polyethylene and vinyl acetate. It was hoped to have the first two with capacities of 15,000 and 20,000 tons/year respectively on stream by the latter part of 1970. To provide the chlorine, a chlorine caustic soda plant was to be installed in the same area, to start operating in 1970. The caustic soda would be used for rayon, cellophane, soap, detergents, textile and cellulose. The chlorine would have additional uses in cellulose, drinking water and chlorine derivatives.

Further it was planned to produce vinyl acetate from ethylene and acetic acid in quantities of 15,000 to 20,000 tons/year, higher alcohols by the oxo process from propylene and synthesis gas (up to 20,000 tons/year of n-butanol and 2 ethyl hexanol).

E.N.A.P. also envisaged the separation of natural gas in the Magellan area with the production from it of ammonia and methanol.

An aromatics plant was not yet thought justified. Polyester chips will however be made from imported dimethyl terephthalate. An alkylate plant for the manufacturing of detergents and possibly a plant for phthalic anhydride would come later.

The question of the supply of experts and technologists was discussed. Much of the development would have to take place as a result of imported know-how.

Raw material could largely be obtained from existing refineries, coupled with planned extensions, their capacities and present output being given.

The development plans were then summed up and a table given showing the production capacities [illegible] and the dates of coming on stream.

<u>MEXICO</u>

The petrochemical industry [illegible] properly [illegible] industry in the portion reserved for the [illegible] enterprise.

The industry is widely [illegible] participating companies. [illegible] by Mexican [illegible] The Mexican Petroleum Institute [illegible] own technologies, with much [illegible] future.

<u>PUERTO RICO</u>

Puerto Rico [illegible] many development [illegible] problems with respect to [illegible] and the [illegible] some guidance [illegible].

At [illegible] organized [illegible] Puerto Rico [illegible] countries, with [illegible]. The initial [illegible] availability of [illegible] establishment of petrochemical [illegible] chemical raw materials [illegible] development of [illegible] beginning of the petrochemical industry in [illegible] installation of two oil refineries, [illegible] for the local market and for [illegible] refining and petrochemical complexes have been [illegible] Commonwealth Oil, Phillips [illegible] another has been started by [illegible].

The progress to date in [illegible] of a stepwise petrochemical development [illegible] refining/

petrochemical core facilities. At the present time, petrochemical raw materials and intermediates were being exported but the pattern had already been established for increasing downstream utilization in Puerto Rico. Developing countries now considering petrochemical installations should review the merit of this approach versus the possibilities of starting initially with an unwieldy and excessively capital intensive integrated petrochemical complex. Each step could be taken on an economic basis without foreclosing any of the subsequent downstream processing possibilities when and if such further installations were economically justifiable.

Puerto Rico's fortuitous situation of having a competitively priced source of raw materials within close reach, a strong export market on the US mainland, and an established and growing local consumer goods market, was rarely enjoyed by developing countries. It was suggested, however, that pooling of markets on a regional basis could be advantageously utilized in some cases to permit installation of petrochemical facilities of economic size. The advantages to be gained by avoiding duplication or construction of several small units were obvious. Admittedly, the consent of different countries to pooling of their markets for this purpose would probably have to be contingent on simultaneous pooling of resources and mutual agreements on reduction of protective tariffs and customs. Each country which provides some market to support a petrochemical project must have other incentives in overall participation in such a regional co-operative effort.

TRINIDAD AND TOBAGO

The economic development of Trinidad and Tobago was dominated by the growth of the petroleum production and refining sector. Facilities exist for the production of a wide range of petrochemicals including aromatics, n-paraffins, cyclohexane, trimer, tetramer and di-isobutylene. Natural gas was utilized for the production of ammonia, urea and ammonium sulphate. Trinidad and Tobago (with a population of one million) lacked an appreciable domestic market so that the production of petrochemicals was dedicated almost exclusively to the export market.

Government has introduced various [illegible] (including [illegible] tax relief) [illegible] the [illegible]

[illegible] favourable [illegible] existed [illegible]

[illegible] with [illegible] prospects [illegible] for further [illegible] questions [illegible] of these [illegible]

[illegible]

[illegible] petrochemical [illegible] in Uruguay. A brief outline of chemical [illegible] related to petrochemistry [illegible] that interfere with the development [illegible] Uruguay – the limited [illegible] inflation existing [illegible] promotion of the [illegible] technology [illegible] possibilities in the [illegible]

The immediate [illegible] of the [illegible] assistance. However, [illegible] operating [illegible] and harmonious development of [illegible] to the establishment of petrochemical [illegible] infrastructure, a certain degree of [illegible] qualified labour force.

VENEZUELA

Existing plants (Carabobo State) in the Moron complex area were:

i) fertilizers: around 130,000 m.tons/year

ii) civil explosives: 23,000 m.tons/year

iii) chlorine-soda: 10,000 and 11,000 m.tons/year

New projects

a. Moron complex (Carabobo State)

i) fertilizers: 530,000 m.tons/year

b. El Tablazo complex (Zulia State)

i) basic group: ethylene 150,000 m.tons/year
propylene 90,000 m.tons/year

ii) chlorine-soda: 35,000 m.tons/year and 40,000 m.tons/year

Joint ventures

a. existing: (Carabobo State area)

i) dodecyl benzene 15,000 m.tons/year

ii) phthalic anhydride 4,800 m.tons/year

b. in project (Zulia State)

i) polyethylene 50,000 m.tons/year

ii) PVC and VCM 25,000 and 50,000 m.tons/year

iii) ammonia and urea 590,000 and 790,000 m.tons/year

i iv) polyisoprene 50,000 m.tons/year

Ex-patriate joint ventures

a. Colombia

i) caprolactam 16,500 m.tons/year

ii) fertilizers 142,000 m.tons/year

h. Sto. Domingo

i) fertilizers mixing [illegible]0,000 m.tons/year

LATIN AMERICA

[illegible] production, [illegible] of installed and/or [illegible] capacity, [illegible] production [illegible]

In [illegible] development [illegible] with production [illegible] installed [illegible] of [illegible]

[illegible] the [illegible] of imports [illegible] addition, they [illegible] with [illegible] regional development [illegible] the [illegible] from [illegible] reaching [illegible] of the countries [illegible]

Regional development [illegible] demand for [illegible] of finished [illegible] the production of [illegible] in response to the growth of demand for [illegible] aromatic and olefin hydrocarbons, [illegible] to the demand for plastics, textiles and [illegible] first, that installed capacity [illegible] plants manufacturing [illegible] that intra-regional trade was [illegible] comparatively [illegible] small scale and [illegible] involving [illegible]

It was considered that [illegible] failed to reach [illegible] since it had not had the [illegible] effect on [illegible] and the United States), in spite of Latin American [illegible] specially enacted legislation for promoting this branch of industry.

In the light of recent events, it may be assumed that Latin America's petrochemical industry was reaching a somewhat critical stage of its development, inasmuch as it was beginning to be affected by national and regional circumstances connected with integration and competition. The industrial development policies adopted in each country in relation to the domestic, regional or world markets and the characteristics of the existing petrochemical industry would determine whether Latin America will be able to reach exceptionally high levels in the production of petrochemicals. Organizations have already been set up for the integration of markets, at least at the subregional level, and for some products market integration has been going on for many years. The integration of production is indubitably a rational method of developing certain industries - particularly petrochemicals - on a scale which would today be technologically and economically justified. From the characteristics of some plants now under construction, it may be assumed that the petrochemical industry has already reached this critical stage of development.

In spite of these problems, it is anticipated that the production capacity of basic petrochemicals, including ammonia, will reach 4.4 million tons/year in 1975, of which about 1.2 million tons/year will be ethylene and 290,000 tons year propylene.

NORTH AMERICA

Originally the North American synthetic organic chemical industry was based on coal tar and distillates for aromatics and on wood distillates and fermentation for aliphatic compounds.

Acetylene was available from calcium carbide and the advent of cracking in the oil refining industry made olefins available so that in the years before World War II there was a changeover to these materials as the starting point for aliphatic chemicals. Immediately after the war, supplies from refineries began to be supplemented by cracking natural gas and, as the industry grew up alongside the oil refining industry, the chemical and oil companies began to integrate their operations to make the most efficient use of the gas and liquid streams available.

Attempts were made to outline the growth and the changes which will take place in the North American petrochemical industry up to 1980. This is mainly the US industry since the Canadian and Mexican facilities are only a small part of the total. The survey was confined to existing products of major importance since there does not appear to be anything new in [illegible] which can become a billion-pound/year product by [illegible]

The emphasis was likely to be [illegible] and process improvements in a continuing effort to keep costs down.

At present, [illegible] America has [illegible] of world [illegible] and about 40 per cent of world petrochemical activity. [illegible] expected to [illegible] the total [illegible] new facilities. [illegible] will be [illegible] figures being found in the [illegible] and [illegible] no petro- chemical will actually decrease in output tonnage during the [illegible] review.

4. Discussion [illegible]

Developing countries fall into three broad categories. [illegible] first category consists of those countries which [illegible] large [illegible] resources, limited domestic markets and [illegible] generally [illegible] position which enables them to invest in [illegible] plants the products of which are to be exported. The problem [illegible] these countries is to identify petrochemicals for which export markets can be found and to develop a strategy to firm up such export markets in order that they are able to build viable petrochemical plants.

The second category consists of countries which have potentially large domestic markets and a reasonable raw material position. Their problem is how to realize the potential market at an early date so that [illegible] production plans can be accelerated and viable plants erected. [illegible] which do not have a large [illegible] domestic [illegible] adequate suitable raw materials fall in the third category. [illegible] possible for some of these countries to develop manufacture of selected petro- chemical products but these may have to be of high value and in the production of which they may be able to occupy an advantageous position due to [illegible] design and availability of highly trained [illegible] low [illegible].

During the last five years developing countries have progressed [illegible] in knowledge and understanding of the problems of promoting petrochem-manufacture. The quality of market studies undertaken by developing countries has improved vastly. However, assistance is often required in studying export markets for petrochemical products especially for fabricated articles for which export markets may be more promising and substantially more remunerative, to identify just what can be sold and where and how to develop a sound market strategy to penetrate and hold export markets.

Developing countries have begun to prepare sound feasibility reports using modern techniques of economic and financial analyses. More is now known about petrochemical processes and their relative economic merits so that several developing countries are now in a better position to select products and processes. However, a real need is felt for the regular publication of detailed information on processes available in other countries, names of process licensors and plants built elsewhere in the world using these processes. This will greatly assist developing countries in taking advantage of the competitive situation prevailing in developed countries in respect to purchase of technology, and thus be able to negotiate the purchase of technology on reasonable terms.

A number of process licensors from developed countries continue to impose conditions restricting the freedom of the licensee to export products manufactured on the basis of their processes. This acts as a particularly severe constraint on the rapid development of petrochemical manufacture in developing countries and the United Nations organizations could render valuable assistance to developing countries in studying how such process licensors can be persuaded to eliminate these restrictions.

Several developing countries have purchased plants which are unable to operate at design capacity since the basic design was often faulty and more often badly adapted to local raw materials, operating skills and other relevant local conditions. The importance of proper preparation of bid documents which would take into account important local conditions was emphasized. Some developing countries have reached the stage of preparing bid documents themselves and they as well as UN organizations could help other developing countries to reach this stage quickly.

Many developing countries face an acute shortage of foreign currency which severly inhibits the rapid development of the petrochemical industry even though other conditions for the development of [illegible] industries are favourable. An analysis of the foreign currency cost of [illegible] in the last five years in certain developing [illegible] 15 to [illegible] per cent of the total cost of such [illegible] engineering design and construction [illegible] developing countries have [illegible] sufficient number of [illegible] and engineers to establish engineering [illegible] able to provide increasing engineering [illegible] in the country. Such a development [illegible]. It has been the experience that with the [illegible] in developing countries it will also enable [illegible] the total project cost thereby improving the competitive [illegible]. Furthermore, the establishment of domestic engineering [illegible] organizations tend to [illegible] procurement of equipment, provide challenging and [illegible] employment opportunities to the [illegible] and [illegible] is vital in the development [illegible] should study this important area. [illegible] available from other developing countries [illegible] tions and from United Nations organizations.

Most developing countries now [illegible] manufacture face a shortage of skilled manpower [illegible] in petrochemical manufacturing operations. [illegible] developed countries is expensive and can often [illegible] of production. Adequate assistance [illegible] plants is seldom available from process licensors. [illegible] organize training programmes well in advance [illegible] assistance in this area can be obtained from the United Nations organizations [illegible] from other developing countries who have already [illegible] petrochemical [illegible] and established training programmes.

Experience in certain developing countries appears to indicate that technology for certain petrochemical processes, many of which are of immediate interest in such countries, can be developed relatively inexpensively. It has also been experienced that mere purchase of [illegible] technology is not [illegible].

Knowledge and basic scientific understanding of the technology utilized is required to adapt what is purchased to local conditions arising from such matters as operation and maintenance methods, specifications of local raw material and equipment and utilization of by-products. Continuing technological development is required to obviate obsolescence and further purchase of overseas assistance at high cost which further affects the already adverse foreign currency situation. This adaptation and technological development necessitates the establishment of domestic research and development facilities at an early stage in the commencement of petrochemical manufacture and United Nations organizations should study how they will be able to assist developing countries in such efforts.

Substantial cost reductions can be achieved in developing countries by cutting down the gestation period of petrochemical projects which is still high and much longer than in developed countries. There are several well-developed techniques which can help in this and experts for this could be made available by United Nations organizations.

Studies carried out recently by United Nations Economic Commissions indicate that there could be tangible advantages in regional co-operation in joint ventures between member countries. Much detailed work is still required in preparing detailed project reports and finding acceptable solutions to a number of complicated problems such as patterns of ownership management, offtake agreements, tariffs, and possibly trade balances.

Attention was drawn to past resolutions in United Nations discussions and meetings that developed countries should lower tariffs to encourage imports from developing countries. This would certainly assist developing countries in increasing unit sizes to achieve viable production plants. There was general concern among developing countries that constraints in economic development inhibited the erection of viable units at an early date and that, in fact, the magnitude of difference between developed countries and the developing countries continues to increase.

CHAPTER II

Basic petrochemical products and raw materials

1. Recent developments

Advances in ethylene, propylene and butadiene production

The main points of the recent development [illegible] 1964 can be summarized as follows:

- Increasing ethylene capacities and requirements

The rapidly increasing requirements [illegible] fibres and detergents are leading to the planning and [illegible] plants characterized by extremely high capacities [illegible] countries in the range of 300 to 250,000 tons/year.

There are inter-relations established between producers and consumers of the basic intermediates with [illegible] permitting the realization of high capacity units which can [illegible] shortly after the start up with a maximum economy. The inter-[illegible] maximum flexibility between the producers and consumers [illegible]

The transportation of ethylene [illegible] are becoming distances not only in pipelines [illegible] liquified state, are becoming usual in many developed countries [illegible] applied in developing countries as well.

- Ratio of ethylene, propylene and butadiene requirements

Relative demand for ethylene [illegible] and the ratio of 2 to 1. This ratio can [illegible] without difficulty under the right conditions of pyrolysis. This change has been largely due to the increasing quantities of ethylene used for vinyl chloride, acetaldehyde and vinyl acetate, previously made from acetylene.

With the increase of propylene requirements [illegible] of acrylonitrile [illegible] of existing processes like polypropylene and change of [illegible] duction to the propylene raw material basis, the requirements of [illegible] have also increased so that they are in a ratio obtainable in the pyrolysis process under severe operating conditions.

With the increased capacities of ethylene and propylene production, practically all new requirements of butadiene production can be covered by butadiene extracted from the C_4 mixture obtained from the newly erected ethylene units. The progress in C_4 fraction separation was highlighted. The advances in butadiene extraction by different solvents mainly N-methyl pyrollidine and isobutylene extraction by sulphuric acid were highlighted.

New methods were presented for the possible direct polymerization of the olefinic and diolefinic components contained in the butadiene butylene fraction eventually suitable for the application in developing countries. The chemical processing of the rest of C_4-fraction after extraction of butadiene and isobutylene is an important step to the full utilization of all by-products from the olefin plants.

Advances in acetylene and ethylene production by autothermic high temperature pyrolysis realized on the principle of autothermic oxidation.

The development in this field is concentrated on the questions of using full range crude oil as a raw material which is principally possible in the case of autothermic oxidation processes. The above mentioned processes are resulting mainly in acetylene and ethylene production as basic intermediates for downstream processes. The processes are important not only from the point of view of the possibility to use crude oil without preliminary primary refining but also they give other ranges of intermediates. This is important mainly for the production of acetylene, which can replace the carbide acetylene in existing process units and establish a cheaper acetylene raw material basis for the plants, where the replacement by the olefins is not possible or a corresponding process is not yet available.

For the production of acetylene together with an eventual production of ethylene, the process of HTP - developed by Farbwerke Hoechst and the acetylene production processes developed by BASF are at present the most important ones. The newer process using the submerged burners, seems very progressive.

The processes reached the total yields of 40 per cent of C_2-fraction from the primary crude.

The development work was originally initiated by the existing shortage in refinery intermediates especially in FRG. Today the processes are important from the point of view that they are able to process the basic petrochemical intermediates from crude oil without the primary refining and from the point of view of production of petrochemical acetylene.

With reference to these aspects [illegible]

ful for some of the developing coun[illegible] [illegible] following

Particular [illegible]

- production of [illegible]

Preheated crude [illegible] with the

and cracked [illegible] 1.5 [illegible]

older process were presented. [illegible]

3.6 tons; [illegible]

35 per cent by weight [illegible]

- production of [illegible]

In this process [illegible]

result of the [illegible] cracking of [illegible]

bourhood of the flame temperature [illegible] production

leading to rapid quenching of t[illegible]

of a considerable quantity of [illegible]

economies [illegible] crude

For the production of 1 ton of [illegible]

oil 8.7 [illegible]; oxygen 5.1 tons.

- crude oil cracking by [illegible] process [illegible]

The process is in development [illegible]

tion of [illegible] with oxygen [illegible]

steam of the hydrocarbon fraction [illegible]

trolled by the quantity of hydro[illegible]

acetylene-ethylene ratio.

- the process for manufacture of [illegible]

The current process [illegible]

gas or straight-run [illegible]

complete combustion of the [illegible]

- the hydrogen electric arc process [illegible]

This enables a much higher [illegible] The technique

materials to be obtained. Hydrogen [illegible]

of avoiding soot and the burning [illegible]

Advances in downstream ethylene, propylene and butylene processes

Special attention was paid to ethylene down stream processes. In fact the development and commercialization of some of these processes lead to the high requirements from ethylene production, to high severity cracking and a temporary surplus on propylene.

Acetaldehyde

Acetaldehyde represents the most important chemical which has changed from acetylene to ethylene feedstock after suitable processes were developed. New aspects in both acetaldehyde processes, one step process using oxygen and two step process using air as an oxidation agent were presented.

The olefins are oxidized by palladium salts (palladium chloride) in aqueous solution with reduction of the palladium chloride to metal. The palladium metal is again converted into palladium chloride by cupric chloride with reduction of the cupric chloride to cuprous chloride. The cuprous chloride is oxidized again by oxygen to the cupric chloride. In the single stage process ethylene and oxygen are passed into a vertical reactor containing catalyst solution, regeneration of the catalysts taking place continuously. In the two stage process air is used to regenerate the catalyst in a separate reactor and the oxidation of ethylene carried out with air.

The aldehyde process has already reached the 1.2 million tons total capacity.

Vinylacetate

The recent trend to ethylene as a basic raw material has led to the development of a synthetic method based on ethylene, acetic acid and oxygen.

In the Hoechst method, the palladium salt catalytic route is used by which acetaldehyde is obtained as a co-product. Ethylene and oxygen are reacted at 120-130° C at a pressure of 30-40 atm. in the presence of the catalyst dissolved in aqueous acetic acid.

In the Bayer method, ethylene and oxygen are recycled through a vaporizor in which they pick up acetic acid vapour. Fresh oxygen is added and the gaseous mixture passed at 140-250°C and 5-10 atm g; over a metallic noble metal catalyst. The total capacities of operating units or under construction are more than 250,000 tons/year.

Ethylene oxide [illegible]

In the [illegible]

given [illegible]

oxid[illegible]

[illegible]

b[illegible]

re[illegible].

Aceton[illegible]

[illegible]

acetone. [illegible]

[illegible]

at [illegible]

used for the [illegible]

Acetic acid by oxidation [illegible]

[illegible]

formation of [illegible]

butyl[illegible]

The [illegible]

is [illegible]

the presence [illegible]

and [illegible]

solution [illegible]

phase with high [illegible]

through [illegible] heat ex[illegible].

Advances in [illegible] recover[illegible]

The incr[illegible]

to increase. Thus between [illegible]

oil had increased from 50 [illegible]

nil to 61 per cent.

The overall demand for [illegible]

benzene for 19[illegible], 1965 and [illegible]

Japan are shown in the fol[illegible]

In 1,000 tons:

	1960	1965	1970
USA	1,562	2,650	3,600
EEC	608	1,158	1,910
Japan	387	850	n.a.

The major consumers of benzene are styrene, phenol and cyclohexane. A similar table for consumption figures for ortho and paraxylenes are:

	Ortho		Para	
	1965	1970	1965	1970
USA	50	200	150	500
EEC	140	350	130	400

Orthoxylene is mainly used for the production of phthalic anhydride and paraxylene for polyester fibres.

Aromatics from petroleum are produced by two main routes. The first is by catalytic reforming of suitable naphtha. This process is also being used to produce high octane gasoline. The second is as a by-product in the pyrolysis gasoline obtained in the steam cracking of naphtha.

Catalytic reforming favours xylenes and pyrolysis gasoline tends to contain more benzene. The latter also contains olefins and diolefins which must be catalytically hydrogenated before extraction of the paraffins. Fractionation is not a satisfactory method of separation due to formation of azeotropes. Solvent extraction is however widely practised. The principal solvents used are ethylene glycol, sulpholane and N-methyl pyrrolidone and to a lesser extent dimethyl sulphoxide and formyl morpholine.

Assuming a 50 per cent aromatic content in the input, a sulpholane can extract 99 per cent of the benzene, 98 per cent of the toluene and 96 per cent of the xylene. Benzene toluene and the three xylenes together can be readily separated by fractionation; ethylbenzene (b.p. 136.2°C) and orthoxylene (b.p. 144.4°C) can be separated from meta- and paraxylenes by superfractionation, but the boiling points of the latter two products (139.1°C and 138.35°C respectively) are too close.

Paraxylene can be separated by freezing out but only about half of this compound can be separated in a single pass. The residue is therefore isomerized by a catalytic process using, e.g. noble metals or a silica-alumina catalyst. Hydrogen is needed with the first catalyst to prevent deposition of carbon but it has the advantage [illegible]

process has appeared called [illegible] [illegible]

life. [illegible] hydrogen [illegible]

removed by [illegible] [illegible]

roughly [illegible] of the [illegible]

whole process [illegible]

Two entirely new processes [illegible]

announced. The [illegible]

metaxylene and [illegible]

[illegible]

of freezing out. It [illegible]

an isomerization [illegible] still needed to [illegible]

it may provide [illegible]

Unfortunately, the [illegible]

line with [illegible] [illegible]

greater [illegible]

large part of the [illegible]. The [illegible]

raw material [illegible] relatively [illegible] [illegible]

This is carried [illegible] [illegible]

to a temperature of [illegible] [illegible]

is the principal [illegible]

Two new processes for [illegible]

and transalkylation. [illegible]

Rayon) convert the toluene to [illegible] [illegible] xylenes.

involves the conversion of toluene [illegible]

New units for the production of aromatics are being brought on stream at frequent intervals in the developed countries. It is believed that production units are operating at some 90 per cent capacity in USA and from time to time there have been [illegible] scares in many countries. It is expected that the USA (including Puerto Rico) will increase its capacity by 50 per cent between 196[illegible] and 19[illegible] [illegible] to [illegible] million tons. In Western Europe, production capacity [illegible] aromatics might be estimated at 1.9 million tons in 1965 and should exceed 3 million tons by [illegible].

Production of benzene etc. by coal carbonization is still a major factor in the Federal Republic of Germany and in the COMECON countries.

Work is going on in the USA to develop a viable process by the hydrogenation of coal, preliminary results show a 60 per cent yield of an oil which can then be treated by conventional oil processes.

This process which has been developed by Hydrocarbons Research Inc. converts in hydrogenation of a pulverizer coal oil slurry in an ebullating catalyst bed (similar to a fluid bed operation).

5. Some advances in downstream aromatic processes

Some development work has been going on in the production of chemical intermediates.

A new process for the production of diphenylol propane has been described in which phenol and acetone are condensed in the presence of ion exchange resins with certain additives. High quality diphenylol propane is produced with little by-product formation, the reaction mixture is non corrosive, the process is continuous and due to better conversion of phenol less need to be recycled.

Diphenylol propane is used for the production of expoxy resin and polycarbonates.

Divinyl benzene is mainly used in the production of ion exchange resins but it can also be used to the cross link with other monomers.

This compound is normally produced by the catalytic dehydrogenation of divinyl benzene but co-products are formed which are separable only with difficulty. An improved process has been developed which involves the following steps: (a) oxidation of diethyl benzene to diacetyl benzene in the [illegible] phase using cobalt stearate as a catalyst [illegible] of acetyl benzene to bis ([illegible]) [illegible] of a suspended [illegible] nickel catalyst [illegible] benzene to [illegible]

The production of [illegible] lene or the same starting [illegible] propylene oxide has been developed [illegible] to allyl alcohol over [illegible] glycerol by [illegible] cohol itself [illegible] hydrogen peroxide [illegible]

Surface active [illegible]

Three trends in the [illegible] conversion of normal paraffin [illegible] of alcohols by [illegible] with hydrogen under pressure [illegible] process of [illegible] fatty acids [illegible]

The method of [illegible] normal paraffins with oxygen [illegible] and commercialized.

Primary alcohols [illegible] oleum, chlorosulphonic acid, [illegible] as sulphating agents. Depending [illegible] of conversion of alcohols into alkyl [illegible] cent.

Secondary alcohols and alcohols [illegible] effectively into surface active [illegible] this case, the degree of conversion [illegible], formed [illegible]

On the basis of the above-[illegible] powder [illegible] have been worked out for the manufacture [illegible] tic detergents for domestic and industrial [illegible].

2. **Factors affecting the production of basic petrochemicals and intermediates in developing countries.**

i/ the availability of raw materials e.g. naphtha from a refinery or natural gas.

ii/ the market and price for the range of petrochemicals which it is proposed to make; thus it is little use putting up a steam cracker based on naphtha if there is a good market for ethylene but not for propylene. On the other hand, if ample supplies of ethane and propane were available e.g. from natural gas or even from the distillation of crude petroleum, cracking under these market conditions might be worth examining due to the much higher proportion of ethylene produced.

iii/ If the home demand is insufficient, the possibility of exports at remunerative prices.

iv/ The willingness of the Government to give protection by tariffs or restrictions on imports in suitable cases.

v/ The availability of a suitable site e.g. either near a refinery or with habour facilities with adequate process water and power supplies and means of disposing of effluents cheaply.

vi/ The availability of either skilled labour or labour capable of being easily trained.

vii/ The possibility of obtaining the necessary capital including foreign exchange, either raised locally with or without Government support or by foreign participation e.g. in a joint venture. In the latter case, the foreign participation may assist in (ii), (iii) and (v).

viii/ The availability of technical process and know-how in the desired field at a reasonable charge.

ix/ The possibility of making an intermediate product from imported raw material should not be overlooked: e.g. diphenylolpropane from phenol and acetone as considerable savings in foreign exchange will result compared with the importation of the diphenylolpropane etc.

3. Assessing petrochemical processes

"ork has been actively progressing on better methods of evaluating petrochemical processes.

Conventional methods such as pay out [illegible] do not take into account the full life of the project, but [illegible] by methods which set out the capital employed against the [illegible] of the project. Neither of [illegible] the time value of money, i.e. money [illegible] worth less [illegible] to the interest [illegible] period. This [illegible] taken into account [illegible] the value of receipts and pay outs [illegible] project are discounted back to zero year. By trial [illegible] found which enables receipts and pay outs [illegible] project. [illegible] more advantageous it will be. [illegible] that money received in the first few [illegible] project is worth more than the same money received [illegible].

Where co-operation between [illegible] or different countries is being considered, [illegible] which the most economical way of transferring [illegible] between the different plants taking into account [illegible] of transport available, the market in various [illegible] has been demonstrated [illegible] problem [illegible].

4. Discussion

The advisability of acetylene [illegible] was suggested that the submerged flame [illegible] both [illegible] and acetylene as a base raw material [illegible] crude oil available but little or no refinery capacity. Sulphur [illegible] on the crude was 0.4% per cent.

The Plasma process for producing [illegible] but it appeared at present the process was only at pilot plant stage.

The HTP process when operated to [illegible] a ratio of acetylene to ethylene of 40 - 60. When [illegible] yield of C_2's on the base material the fuel requirements were [illegible].

These high temperature processes were not [illegible] by the [illegible] specification of the crude oil.

The use of tubular furnaces for ethylene crackers [illegible] discussed [illegible] explained that raw materials in the range of ethane to gas oil could be used.

Turning now to the production of aromatics, it was explained that the disproportionation of toluene was normally carried out in the gas phase over a fluid bed catalyst.

On the subject of fatty acid production, it was explained that these were produced from either hard paraffins with a melting point above 50°C or soft paraffins separated by the urea process from a gas oil fraction. Development was in hand for the production of higher alcohols.

CHAPTER III

Plastics

1. Recent developments

[illegible] rapid growth of plastic [illegible] predicted tremendous impact on the industrial [illegible] developing countries. Indeed [illegible] that both [illegible] as well as developing [illegible] only the average annual consumption of all plastics [illegible] (e.g. [illegible] kg) per capita, the development [illegible] polyvinyl chloride and polystyrene in developing [illegible] emerging and will be expanded [illegible] area of constraints, and the trend of [illegible] considerations, to formulate the ways [illegible] technical assistance programmes.

2. Selected technologies of [illegible]

The manufacture of [illegible] production with the anticipated [illegible] competition the competition will [illegible] have often found their production [illegible] consumption.

The situation is more [illegible] started with expensive raw materials. [illegible] the cost of manufacture of vinyl chloride [illegible] derived from petrochemicals, i.e. [illegible] readily available at a [illegible] reasonable price [illegible] of vinyl chloride by ethylene route [illegible] and with the development of [illegible] hydrogen chloride can be fully [illegible] logical progress has been far [illegible] threatened by the increasing costs of [illegible] handling of bulky solids.

There are many less direct [illegible] that increase costs. Aside from license costs, [illegible] engineering design and maintenance can be very expensive, therefore some have established their own engineering groups.

Within the polymer field, technology is changing rapidly. High density polyolefin has gone through several stages - solution polymerization; solution/suspension mixtures; suspension systems only (for blow molding and recently for injection molding). Gas phase polymerization appears to provide lower costs, and has already been commercialized for producing polypropylene. Production of low pressure polyethylene is also possible in the near future in several countries. Radiation polymerization of polyethylene is coming closer to commercial reality. Capital costs may be lower than existing conventional plants. There is some controversy concerning the comparative merits of tubular and autoclave methods for producing high pressure polyethylene. The choice of either is dependent on specific circumstances in each country.

A novel technique has been developed for the bulk polymerization of vinyl chloride. In comparison to resins by conventional methods, bulk PVC possesses higher porosity and absorption rate of plasticizers. It also requires a shorter period of gelation during processing. By all means the quality of PVC polymer is more and more stressed to make the finished products acceptable in a tightly competitive market.

Polystyrene is well established in many developing countries. Imports of polymer is often followed by production of monomer. Technology to produce general purpose grades has sometimes been self-developed. Production of more specialized impact and high heat types is more difficult. Suspension technology and new continuous mass polymerization processes represent interesting possibilities, particularly where low tonnage plants can be built at reasonable capital costs. Careful consideration must be given to estimating the delivered cost of monomer; and determining the demand of monomer for rubber applications in planning monomer facilities.

New polymers are being developed in increasing quantities. Many are too specialized for developing countries for production, but could be imported for conversion into high value export products. Polyblends of major and specialized plastics permit "marriage" of the best properties of two materials, and is expected to be an important source of polymers in the future.

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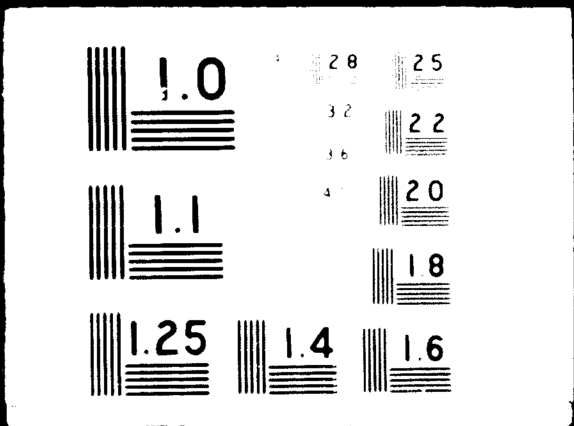


Injection moldable polyesters ... excellent properties as engineering plastics and should be ... raw materials. Water soluble polymers ... ethylene oxide) are being ... recovery. Several new ... and reduction as well as ... mers are also being ... butadiene to PVC ... polyethylene has been in production ... interest expanding its market.

Radiation processing of finished ... to developing countries in the future. ... curing of wood/plastic composites, and textile ... polyester and acrylic paints ... and for curing of reinforced ... impregnation of ... these composites ... tion of available indigenous fibres ... sisals, etc., with ... vinyl tics for construction. ... monomers to cellulose to prevent ... interest for many cotton producing coun...

The plastic processing industries ... changes. The trend is toward automation ... increase production speed, to keep ... device to In coupling with this ... monitoring the quality of product ...

In one instance installation ... saved million dollars annually ... reduction of off-quality products.

The design of injection molding ... vacuum forming equipment and alike, ... the ... portion of the polymer to be processed. ... complexities for the selection of right equipment for production, ...

as quality of finished products is decisive in market competition, there will be shortages of alternatives.

3. Typical applications of plastic products of special interest to developing countries

Application of plastics in agriculture are certainly of interest to developing countries which are in the domain of agricultural- based economy. Progress along such applications will increase agricultural production and will also provide a ready market for plastics. A few interesting applications will improve the irrigation efficiency or modify the nature of soils. By ploughing closed-cell polystyrene foam into the soil, it will make it more permeable to water. Plastic sheets are used in a variety of ways to protect the growth of crops. The difficulties in irrigating sandy soils have been overcome by placing plastic materials underneath the surface soil.

The ever-increasing use of polyethylene or polyvinyl chloride sheets in the packaging of agricultural products and fertilizers have changed the picture of hard fibre consumption. The plastic packages give better performance during storage. Cross-linked polyethylene films are used for poultry products and other wrapping purposes. Silos for storage of grains can be constructed from reinforced polyester resins.

Important contributions of plastics have been made in the field of construction materials. Urea-formaldehyde resins and to a lesser extent phenol formaldehyde resins are indispensible to the plywood and chipboard industries. Polyvinyl chloride and fibre reinforced polyesters (FRP) are the common plastics used for corrugated sheets and panel products. Wood-plastic composites have been gaining market in parquet flooring. Polyethylene, polyvinyl chloride and FRP are the economic materials for tubes and pipings and a variety of plastics is extensively used in electrical insulations.

Furnitures made from injection molded polystyrene, cast polyurethane, or FRP laminates will play an important role in future market. Polyethylene foams have just gained ground in the manufacture of toys and household appliances and will compete with polystyrene foams for insulation in cold storages.

Paints and surface coatings based on alkydes, acrylics, unsaturated polyesters, and epoxies are durable and weather resistant. Special formulations can meet the demand for severe corrosive or high temperature service. Coated [illegible] developed for [illegible].

...lystyrene film has been developed for [illegible] for their strength,

Many outlets of plastics are in the [illegible] serving for

durability and light weight. FRP reinforced [illegible]

the construction of vehicles for road, [illegible]

small boats are of major importance in [illegible]

Many polymers have been [illegible]

following the spun bonding process. [illegible]

wallpapers or for one-way linen for [illegible]

Special applications of plastics [illegible]

in water purification and other industrial [illegible]

4. Factors [illegible] the development of the [illegible] developing countries

In the planning and expansion of plastic [illegible] import countries, careful consideration on the [illegible] demand, availability of raw materials, [illegible] should become the critical phase [illegible] to produce first [illegible] consumer goods. In order to link the [illegible] of living standard, the production [illegible] areas, food packaging, construction [illegible] will be of vital importance to both [illegible] is necessary to emphasize that [illegible] justify the huge investment involved [illegible]

Extrusion, injection molding [illegible] cessing techniques for making [illegible] have been successful in designing [illegible] and capital investment, but due to the [illegible] mold making industries, and also to [illegible] the resulting finished products [illegible] production costs are usually not economic [illegible] during processing. It is pertinent to [illegible] to improve the efficiency of plastic [illegible] countries.

Many problems that could b come the bottlenecks in the development of plastics industries in developing countries vary with the social and natural environment of the country so concerned. In fact, it would be impossible to make a generally acceptable solution for individual cases. But the pooling of limited manpower and material resources within the country or within the geographical region of a few countries is one of the possible principles that can be cited.

Another point is to start with plastics that can b processed by simple and easily adaptable techniques in the country or region whichever market and technical feasibilities prevail. Gradual build-up from backward integration, i.e. from polymer processing to polymer and monomer manufacturing can be taken into consideration during the growth of the local plastics industry.

5. Suggestions for future development

The following suggestions for future development have been made: development for control of polymerization techniques to be adopted for developing countries; programmes for economic batch cycling for efficient utilization of polymerization equipment; dissemination of information for handling and transportation of monomers in bulk or in tanker; systematic studies of formulation problems in developing countries; promotion of high strength plastic films in food packaging and agriculture; modificationof polymers by grafting and cross-linking; research in the use of plastics and composite materials for prefabricated housing and furniture; cost reduction in the production of plastic foams; studies of polymer flow characteristics during the molding process and evaluation of stresses in finished articles.

6. Discussions and observations

The problem of economic plant size has been of considerable interest to most participants. It was envisaged that at different stages of growth the justification would be dependent on the consumption in local market, standard of living, capital investment for expansion and export potential. The supply of raw materials, technological progress and the infrastructure on transportation and distribution of products should also be fully considered.

The encouragement of export to earn foreign [illegible] tion in principle was worthwhile for serious consideration, apart from self-sufficiency in domestic

...onsumption and savings of foreign [illegible] world market situation
...ncluding the price and quality of competitive products [illegible] decisive
...fore launching [illegible] development or expansion [illegible] previous-
...rly significant if an integrated project [illegible]
...nd plastic processing facilities were [illegible]

Joint venture with experienced [illegible]
...ave favourable influence on marketing of [illegible]

During the growth of local plastic [illegible] products
...etrochemicals would increase the cost of [illegible] The
...n domestic markets and would also limit the [illegible]
problem was not so simple as it appeared, but [illegible]
must be comparable to the locally made [illegible]

Developing countries which have [illegible] to a
certain extent were eager to acquire not [illegible] and
process, but also preferably to obtain [illegible] in
equipment [illegible] from developed countries [illegible] of
This [illegible] would be most desirable and [illegible]
plastic industries in these countries.

Considerable discussions [illegible] of
polyethylene by tubular reactor [illegible] plants.
autoclave [illegible]
The quality of products for various end uses [illegible]
costs related to the [illegible] of products
policies that influence the preference. [illegible]
was envisaged then the problem [illegible] It was
another and the [illegible] operation,
felt that a large single stream plant might be [illegible]
maintenance and marketing could be kept well [illegible]
production plants.

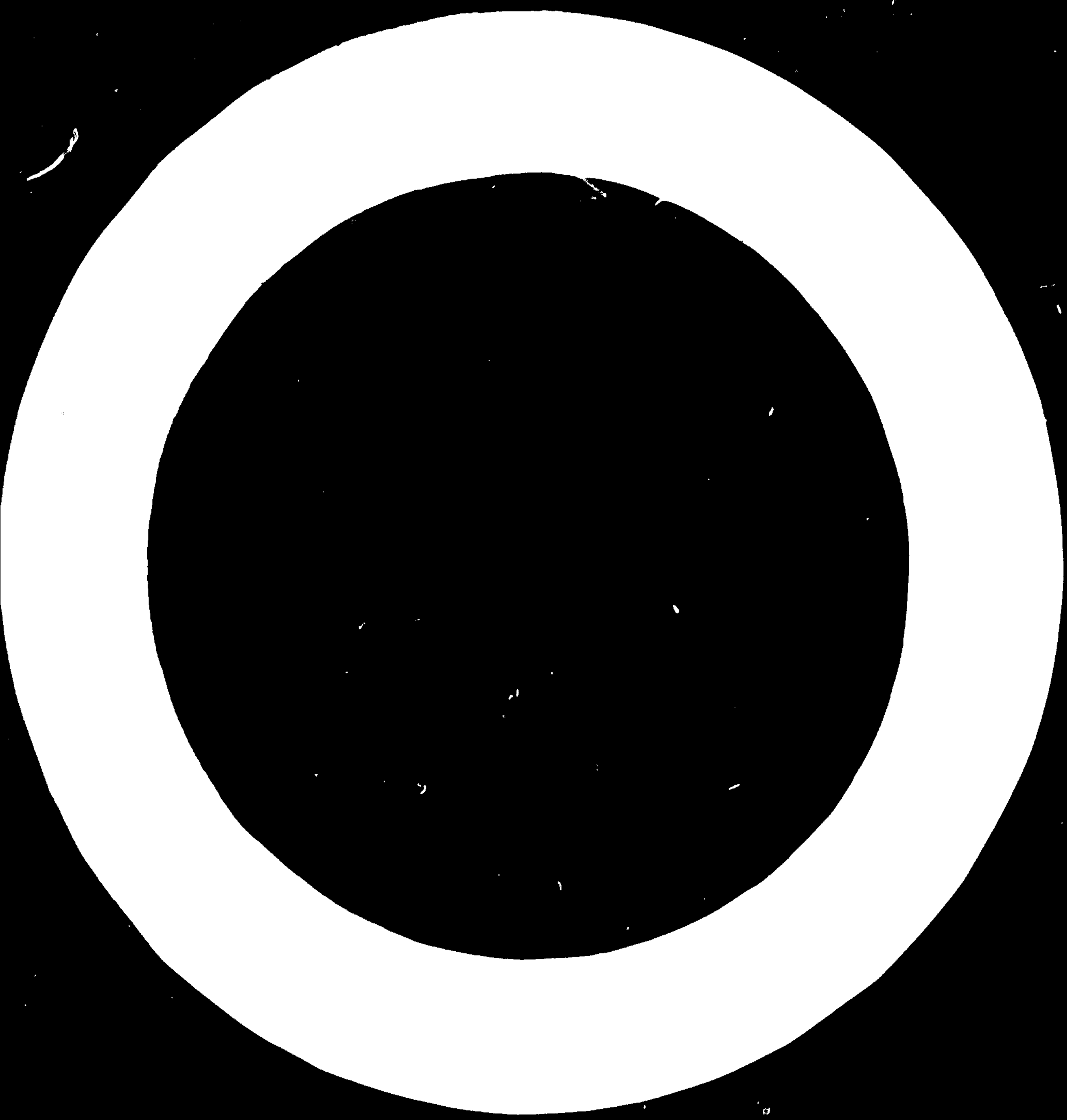
Concerning the use of plastic bags [illegible] fertilizer or agricul-
tural products, it was felt that PVC bags [illegible] poly-
ethylene bags for tropical and humid regions. [illegible]

black or stabilizing agent to polyethylene could extend its service life.

The polymerization of styrene was considered quite straightforward. Isotactic polystyrene possesses high heat distortion temperature, but difficult processing problems.

The use of ion exchange resins in water purification and desalination would of value to public health, in particular for water containing fluorine and other harmful elements.

Radiation-induced polymerization of trioxane appeared a convenient way to polyformaldehyde. Similarly the vulcanization of natural rubber latex and oxidation of hydrocarbons to fatty acids have reached the stage of semi-commercial production. The advice on the selection of radiation sources for the proper uses was needed for such treatment.



CHAPTER IV

Synthetic fibres

1. Recent developments

The world production of synthetic fibres has increased sharply since 1964. At that time, the share of true synthetics was 9.5 per cent in the total fibre market, but by 1967 it has arisen to 16 per cent and at present is closer to 20 per cent by weight. In actual covering power, the utilization of synthetics is even higher because of their lighter weight.

Between 1964 and 1967, the growth rate has been about 20 per cent per year, similar to previous growth rates, and actual production was 2,860,000 tons in 1967. Since then, the growth rate has been over 30 per cent. However, 80 per cent of the total world production in 1967 has been in West Europe, USA and Japan.

In developing countries, the growth rates of demands in fourteen countries for which data is available for 1963 and 1967, show wide variations, from as little as 2.2 per cent to as high as 65 per cent per year. In many cases, however, the lower rates have been due to causes other than market demand, and actual demand growth in developing countries has been high. In some developing countries the demand has reached levels of 3 kg per capita which is in line with European consumption although, in general, consumption is substantially lower.

While a number of the developing countries are now producing fibres, imports still account for 60 per cent of the consumption in developing countries.

In the production of fibres in the world, while polyamides still occupy the first position, their share has dropped from 53 per cent in 1964 to 43 per cent in 1968, although production has grown in absolute terms. Polyester fibres on the other hand have grown from 20 per cent to 29 per cent while acrylics and other synthetic fibres have remained stationary at 18 - 19 per cent and 9 per cent respectively. It is probable that the share of polyester will rise further in future.

The structure of utilization in developing countries is, however, difficult to estimate and often based upon local factors, such as the historical development of the market , and import restrictions.

The size of synthetic fibre plants [illegible] monomer plants, is not big when compared [illegible] of the petrochemical industry. Thus in the United [illegible] 13,500 tons/year, in Japan 8,300 tons/[illegible] and in Eastern Europe 4,000 tons/year in [illegible] sizes of plants were smaller and [illegible] in size of the average plant has only [illegible] in developed countries.

The size of monomer plants on the [illegible] ger with the result that only a few [illegible] dia and Mexico have plants under construction [illegible] being planned in other developing countries.

2. Production of monomers of special [illegible]

The main monomers of interest to [illegible] nylon-6), acrylonitrile (for acrylic fibres) [illegible] (for polyester fibres). The world production [illegible] DMT is all concentrated in the developed [illegible] tons/year caprolactam.

In the production of caprolactam, [illegible] cyclohexane and phenol, although a process [illegible] toluene.

While currently cyclohexane is [illegible] the changing position of the availability of hydrogen [illegible] of again using phenol.

The processes used in 1964, with a few exceptions, produced [illegible] tons of ammonium sulphate per ton of caprolactam as a by-product. [illegible] ficulties in selling ammonium sulphate a number of [illegible] which sharply reduce ammonium sulphate [illegible] or to replace it with nitrophosphates, and in some cases, [illegible] tion of by-product fertilizers altogether.

One of the processes which has been developed substantially [illegible] is the photonitrosation of cyclohexane ([illegible] process) developed [illegible] tails of which were given to the Symposium. This process, [illegible] the last few years after solving many technical problems such as the problem [illegible] side reactions, the life and type of the lamps and the development of anti-corrosion materials. The advantage of the process is that it produces cyclohexanone oxime from cyclohexane in a single step. It cuts down ammonium sulphate production in half when compared to conventional processes.

In the production of acrylonitrile, the use of propylene as a raw material has almost totally replaced acetylene, and a large majority of plants are now based on this raw material.

Since 1964, a process using acetaldehyde has been developed in the Federal Republic of Germany, but this has not been used widely at present, and propylene is likely to be the preferred raw material for many years.

The use of the propylene route involves the production of acetonitrile and hydrocyanic acid as by-products and substantial efforts have been made to minimize the production of these by-products.

In the production of monomers for polyesters, (such as dimethyl terephthalate and terephthalic acid) the main processes up to 1964 were the Witten, Mid Century and Henkel processes for producing DMT and all continue to be used, with a preference continuing for the Witten process.

The development of high-purity terephthalic acid has resulted in the introduction of newer processes, based upon this material.

Among monomers for other fibres, may be mentioned the raw materials for vinylon fibres, which are obtained from vinyl acetate and methanol. The former is still produced substantially from acetylene although ethylene is now being widely and increasingly used. Among other monomers are propylene and vinyl chloride and these are produced in the same manner as for plastics except for more rigid specifications.

3. Production of fibres of special interest to developing countries

The main interest continues to be in nylon, polyester and acrylic fibres, although there have been developments in the production of PVC, polypropylene and vinylon fibres. There is also a growing interest in more specialized fibres such as fibres which more closely resemble silk.

The production of nylon-6 and nylon-66 continues to follow well-established production techniques. While there hase been some development of other nylons in the developed countries, these are not currently of interest to developing countries.

The development in the USSR of [illegible] for the direct spinning of nylon-6 was reported to the Symposium. This process pro- duces high quality [illegible] zation to by-pass more [illegible] per day is in operation at the [illegible] costs for the production of [illegible] nal processes.

No special developments were [illegible]. Not polyester fibres, but the [illegible] natural only is polyester staple of [illegible] polyester fila- fibres, but there has been [illegible] ment including industrial uses such as [illegible]

Polyester fibres continue to be [illegible] by the [illegible] thods or by the direct esterification method [illegible] is being used.

In earlier processes, the [illegible] spinning was usual but [illegible] polymeri- of the polymer without chips [illegible] zation methods.

In the production of acrylic fibres [illegible] solvents in use are DMF, DMA, [illegible] tions, such as zinc chloride, [illegible] continue to be widely used but the newer solvents are [illegible] largely

Polyvinyl alcohol (vinylon) fibre [illegible] being largely used in Japan, is of some interest to other countries and some aspects of these fibres were discussed in the Symposium.

While this fibre has many advantages [illegible] better moisture absorbency and excellent durability, on the other hand [illegible] disadvantages such as lower softening point under wet [illegible] (about 65 per

In Japan, this fibre is mainly used [illegible] cent). It is also widely used for [illegible]

Some part of the market for these fibres [illegible] by the entry of other synthetic fibres, but polyvinyl [illegible] through into new areas such as industrial purposes, [illegible] soluble fibres, [illegible] like fibres. However, their main use is in industrial fibres.

With the development of the PVC plastic industry in developing countries the production of PVC fibre, which is a low cost fibre, is of interest. However, conventional PVC fibres have drawbacks which have restricted their field of application. Among these drawbacks are poor heat resistance and shrinkage.

A new development in Italy, details of which were given to the Symposium, is the manufacture of a new PVC fibre with substantially improved dimensional stability under heat made by the introduction of a low temperature polymerization technique utilizing catalysts such as organic hydroperoxides, sulphurous anhydride and an alkali or alkaline earth alcoholate.

Since 1964, there has been a substantial development in the production of polypropylene fibres although not as much as at one time predicted. Of these the most important use is for floor coverings and this was discussed at the Symposium.

Combining the factors of the wide availability of polypropylene resin, the simple conversion process from resin to fibre and low cost pigment dyeing, with the technical and economical aspects of the needle punch process, the polypropylene needle punch carpet now meets the requirements for low cost floor-coverings.

In 1967, some 70 million square meters of floor coverings were made with polypropylene corresponding to more than 13 per cent of the total carpet production in the USA and Europe, which might indicate some possibilities of future application in the developing countries.

In recent years, there has been substantial interest in the development of silk-like fibres. These fibres have been developed mainly in the USA and in Japan. Details were made available to the Symposium of the development of such fibres in Japan.

Recently, the relationships between the structure and the texture of silk fibres have been clarified. This knowledge, coupled with recent advances in fibre production and processing techniques , has allowed the production of more silk-like fibres by physical and chemical modifications of fibres already in use, and by new polymers. In Japan, several silk-like fibres have been developed.

Silk-like nylon and polyester are obtained by the modification of the cross section into trilobal or hexagonal shapes.

Vinylon filament by a dry [illegible] process [illegible] silk-like and also acrylic filament is produced [illegible]

Benzoate fibre [illegible] polyethylene oxybenzoate.

Acrylonitrile-protein copoly[illegible] natural protein and acrylonitrile [illegible] significant differences from other [illegible]

Of [illegible] interest [illegible] is the problem of inter-firm competition [illegible] nylon and polyester were discussed. [illegible] all synthetic fibres.

In clothing, nylon is suitable for [illegible] owing to its soft [illegible]re. Polyester, because of its excellent [illegible] the field where the natural fibres [illegible] from polyester textured yarn [illegible]

In industrial uses, nylon [illegible] to be preferred with [illegible] properties [illegible] price.

While [illegible] cannot be [illegible] petrochemical industry, [illegible] formation is of interest to the industry.

With the appearance [illegible] e.g. polyolefins, polyesters, [illegible] of web formation have been invented, of which the [illegible] possible application to developing countries [illegible] advantages of [illegible] web-spin process are encouraging [illegible], even considering the actual market of [illegible]

4. Suggestions for the [illegible] fibre industry in [illegible] ping countries

The development of a synthetic fibre industry [illegible] developing country has certain basic problems which are [illegible] to those involved in other petrochemical industries.

The first problem arises from the fact that a synthetic fibre [illegible] often dependent upon the growth of the textile industry and its ability to absorb new fibres requiring new textile operations. It is essential therefore, not only to survey existing textile operations, but also to provide the investments required for modifying these plants. Often these are not large, for instance the conversion of a 5,000 spindle unit to use polyester-cotton blends requires less than US$100,000, but the necessary foreign exchange and other facilities must be provided. Blends of natural and synthetic fibres are of special interest to developing countries.

The next step is the manufacture of the fibres themselves. In the first instance, developing countries should concentrate on the conventional synthetic fibres in nylon and polyester and in colder climates acrylic fibres. The development of more exotic fibres must await conditions of market development.

These synthetic fibre plants can be set up on imported chips, or where foreign exchange problems exist, on imported monomers and can be of relatively small size. However, the production of a good grade of fibre by the use of established processes is important. In the ultimate analysis, the textile industry judges fibres from their quality and poor quality synthetics would retard development of the industry.

In integrating the fibre industry back to petrochemicals, the final step is the production of monomers. The size of monomer plants is rather large, and the production of monomers is only possible where a substantial development of the industry has taken place. Thus DMT plants are seldom economical below 25,000 tons/year and usually not below 50,000 tons/year, and this would mean a very large development of the fibre industry before monomer production was possible.

One method of overcoming this difficulty is the development of monomer facilities by groups of countries, such as those being planned between Iran and Pakistan or between other ECAFE region countries.

5. Discussions and observations

The Symposium discussed the problem of whether developing countries should commence fibre production based upon imported monomers, or by producing both the monomer and the fibre. Based on the experience of some of the developing countries, such as India, it was felt that, as there were substantial foreign exchange savings and as the markets needed development, the import of monomers in the first instance would be of advantage. [illegible] cost of [illegible] / pro-

[illegible] size of [illegible] plants [illegible]

[illegible] nylon [illegible]

[illegible] compared to a [illegible] / [illegible]

[illegible]

[illegible]

[illegible] 5,000 tons/[illegible] polymer production.

[illegible]

[illegible] fibres [illegible]

[illegible] nylon plants. It [illegible]

[illegible]

Inter-fibre competition [illegible] will be of [illegible] will continue to be important [illegible] the future [illegible] ing importance in the [illegible] of [illegible] the market.

With regard to tyre cord [illegible] was felt that in [illegible], [illegible] duty [illegible].

Substantial discussion took [illegible] (origin) fibres. The question of [illegible] long staple cotton was raised. However, [illegible] with medium [illegible] yond 60 counts, and experiments in India [illegible] staple cottons, does not spin beyond 50 [illegible] replacement would continue to be in the [illegible] from nylon and polyester would [illegible] cords etc.

Whether new fibres are likely to be [illegible] current the existing [illegible] synthetic fibre [illegible] new fibres fibres meet most of the [illegible] would have difficulties in breaking into [illegible] h for silk-like fibres and [illegible] production [illegible] as benzoate fibres are high-priced at present, [illegible] likely to come down when production increases.

With regard to competition of synthetic fibres with rayon, it was felt that nylon and polyester are making substantial inroads upon rayon filament demands, particularly in the industrial field. However, polynosic rayon staple is holding its own in the cotton blend market.

Keen discussion took place on other papers presented to the Symposium, in particular the paper on the PNC process for caprolactam, because of the fact that details of this process were revealed for the first time in public at the Symposium.

CHAPTER V

Synthetic rubbers

1. Recent developments

Major developments have occurred in [illegible] the rubber industry i.e. in both natural and synthetic rubber [illegible] the processing and use of these materials.

The ratio of synthetic [illegible] rubber used in the U.S.A. and the U.S.S.R. approximately [illegible] of all rubber used is synthetic.

The growth rate for total world rubber consumption [illegible] approximately [illegible] and 4.6 per cent per year with synthetic rubber [illegible] growth of natural rubber at 2.4 per cent. In developing [illegible] rate in rubber consumption is considerably greater [illegible] developing countries between two and three times [illegible] availability the [illegible] largely unsaturated [illegible] of raw materials, processing equipment [illegible]

In recent years many of the [illegible] improve efficiency and reduce costs in [illegible] increased rubbers and there have been many examples of [illegible] leading to increased productivity. This has caused a need for [illegible] with a high level of consistency. This is demonstrated by the quality (in consistency and processability) of modern [illegible] by the [illegible] the natural rubber producers (SMR grades, etc.). Continuous [illegible] introduced by one company and tyre companies [illegible] automation in tyre building. In the [illegible] injection moulding and continuous vulcanization are being widely adopted.

In tyre manufacture, the level of rubber [illegible] tyre has decreased through the increased use of both [illegible]-extended [illegible] and cis-polybutadiene. This combination of rubbers permits higher loadings of carbon black and oil in tread compounds particularly [illegible] furnace blacks. In truck tyres, the most significant development is the use of the dual tread. The portion of the tread in contact with the road [illegible] abrasion and chunking resistant, with the undertread being highly resil[illegible] to minimize peak build-up. This development, which replaces a single tread of highly resilient rubbers, permits the use of a substantially higher level of synthetic rubber including SBR in truck tyre treads. (The average composition of the total tread using the dual tread is natural rubber 20 per cent, cis-polybutadiene 45 per cent, SBR 35 per cent compared to natural rubber 75 per cent, cis-polybutadiene 25 per cent).

Specialized new polymers have been developed including rubbers with greater resistance to extreme service conditions (high temperatures, special lubricants, etc.). These include polyacrylates, silicone and fluorinated polymers. A new family of rubbery polymers which have been called thermoplastic rubbers, has been introduced. These products can be processed like thermoplastics and yet set on cooling to a rubber. So far their use has been limited to applications where temperatures do not rise above 60-65°C, but further improvements in this concept are possible.

Another major trend during recent years has been the blending of rubbers (and plastics) to achieve special properties e.g. the use of cis-polybutadiene with styrene to give high impact polystyrene, the blending of nitrile rubbers with PVC to achieve impact resistance and to act as non-migratory plasticizers.

There have been many developments in the field of synthetic latices and many new types and applications have arisen. This stems from the fact that the application of latices involves liquid handling equipment instead of the heavy high shear equipment of rubber and plastic processing. Latex technology is therefore one of the major ways by which the rubber industry is simplifying its operations. New latices particularly carboxylated types of SBR and nitrite rubber and new methods (pressure agglomeration) for the manufacture of high solids latices have been introduced during recent years.

2. <u>Selected technologies (polymer production) of special interest to developing countries</u>

Many factors are important in the selection of technologies for the production of synthetic rubber in developing countries. These factors include the versatility of the processes for producing a range of rubbers in order that imports of specialty rubbers are minimized, the availability of local raw materials including catalysts and other chemicals, the ability to use locally manufactured components and spare parts, the reliability of the process, the vulnerability of the process [illegible] and of course the specific nature and size of [illegible].

The technologies which [illegible] cis-polyisoprene [illegible] polybutadiene [illegible] butadiene [illegible]

Other [illegible] rubber and polychloroprene [illegible] only be considered as subsequent [illegible]

Cis-polyisoprene has been [illegible] highly resilient rubber for large [illegible] is a desire to become independent [illegible] up to now, offers a technical [illegible] been [illegible] it is not [illegible] without its disadvantages [illegible] and consequently it makes the [illegible]

The most important aspect of [illegible] of the world [illegible] known, [illegible] butadiene. Further development [illegible] until new processes are developed [illegible] scale, isoprene will be an expensive [illegible] polyisoprene an expensive polymer relative to SBR and pol[illegible].

Owing to the new techniques which have been [illegible] for producing natural rubber and which result in [illegible] applicability in Malaysia, Indonesia, [illegible] other developing countries, the desirability of using techn[illegible] to produce a replacement for a product which can be produced by agricultural means must be questioned.

The situation with cis-polybutadiene differs from that of polyisoprene in that the raw material will be available [illegible] polybutadiene consumption has grown very [illegible] the last five [illegible] because it improves the abrasion resistance of both passenger and truck (and bus) tyres in blends with SBR and natural rubber respectively. It [illegible] also resulted in the virtual elimination of the groove cracking problem encountered in North American passenger tyres.

A major problem with polybutadiene has been, and still is, the tendency of tyres (large tyres for buses, trucks, etc.) to chip and chunk. This has resulted in very low use of polybutadiene in service requiring a proportion of "off-the-road" driving or of driving on poor roads. The greatest benefit from the use of cis-polybutadiene has been achieved in truck and bus fleets employed continuously in highway driving, and in North American passenger tyres. Similar service in developing countries will benefit from the use of cis-polybutadiene as a partial replacement for natural rubber and SBR. Because the wet traction (skid resistance) of tyres decreases with increasing cis-polybutadiene content, it is unlikely that greater proportion of cis-polybutadiene will be used than is currently used in North America. In Europe, where the climate involves roads frequently wet and with high traffic densities, the penetration of polybutadiene has been even less than in North America owing to the emphasis on road safety.

Cis-polybutadiene and other polybutadienes are being used in increasing amounts as a component of carcass compounds in both truck and bus tyres. The application takes advantage of the dynamic properties and the aging behaviour of these compounds relative to natural rubber compounds. SBR is also frequently used in carcass compounds to reduce the tendency of natural rubber compounds to soften on extended use at high temperatures.

Up to now, very little polybutadiene has been used outside the tyre segment of the rubber industry. Its only other major use is as an impact modifier for certain grades of high-impact polystyrene.

Several processes are available for the manufacture of cis-polybutadiene, covering a range of cis-content and with some differences in properties. High cis-polybutadiene based on the cobalt process has been found to provide the best processing properties and, in particular, to give least "bagging" when its compounds are milled. This is particularly important in areas where the installed equipment was designed around natural rubber, i.e. with high friction ratio mills. The titanium catalyzed polybutadiene is superior to the lithuim catalyzed polymer but is inferior to cobalt in processing behaviour.

Recently, a growing trend to the use of [illegible] has taken place, as through this route [illegible] levels of oil and black to reduce compound [illegible] properties, owing to the relationship [illegible] which [illegible] found with the cobalt system [illegible] oil extended BR in the [illegible] system [illegible] possible to vary properties [illegible] through changes in reaction conditions, and the [illegible] behaviour like the titanium [illegible] the cobalt system becomes extremely useful [illegible] range of processes.

To determine the desirability of building [illegible] plant, it is [illegible] conditions and the [illegible] system in a developing country. As [illegible] plant will be required but in general [illegible] for the first plant in [illegible].

Although an olefin process might [illegible] route to additional rubber for developing countries [illegible] that this process has still to be introduced and proved [illegible] scale, and also that the rubbers available from this process have not been accepted and used by any of the major rubber companies [illegible] attractive process.

As the growth in a developing country [illegible] in all segments of the industry, including [illegible], footwear, belting, hose, automotive products, etc., [illegible] emulsion SBR/BR type must also be [illegible].

The solution type of SBR/BR [illegible] to produce random type SBR for the tyre industry, [illegible] SBR for [illegible] and polybutadiene for tyres. Experience with these [illegible] that they have good dynamic properties and their [illegible] comparable to conventional SBR. Processing has [illegible] and while the process can be modified to [illegible] these modified products show low green strength [illegible] makes the building of tyres more difficult, particularly [illegible] quality and uniformity are required. The block type SBR's produced for application in moulded products such as footwear, show good moulding behaviour but because they have low green strength, considerable difficulties are encountered in mill mixing and production rates are adversely affected.

In summary, the solution SBR's provide interesting and useful properties, but it must be recognized that they are not interchangeable with conventional SBR without the use of special compounding and processing technology.

Polybutadiene produced in this combined solution SBR/BR system is similar to the lithuim type of polybutadiene and has relatively low cis-content. North American experience with this type of product shows that it can be widely used wherever the high cis-types are used, but because of the lower cis-content, its dynamic properties are slightly poorer, and its mixing and extrusion behaviour in blends with both natural rubber or with SBR is also slightly reduced and results in slower throughput through slower mixing and through tread extrusions running hotter and, on occasion, causing scorch.

From the manufacturing process viewpoint, the combined solution SBR/BR process permits a very attractive flexibility. However, the changes from polybutadiene to SBR do require a short period of shut-down between types (up to a few days, depending on the equipment installed). The process is also capable of using dilute streams of butadiene, provided appropriate recycle facilities do not result in concentration of impurities in the diluents. It is also important to recognize that this process uses organometallic catalysts, consequently, although dilute butadiene has been used, the butadiene must be free from polar impurities including moisture. Ideally, as with all the organometallic systems, including the Zeigler-Natta catâlysts used to produce the high cis-polybutadienes the best control of the process is achieved with extremely high purity raw materials and which are consistently pure. The process is therefore sensitive to upsets in, say, the cracking operations providing the monomers.

The alternate combination process – the conventional emulsion process for producing SBR, and also emulsion polybutadiene, is also extremely versatile. From a product viewpoint, the system is capable of producing a wide range of unextended and oil extended polymers which are well known in industry and for which the process and application technology is well defined. More recently, further research [illegible] SBR, with [illegible] superior balance of processing dynamic and [illegible] properties, coupled with an unusually high degree of product uniformity. [illegible] have resulted in reduced mixing [illegible] which have permitted an increase in the [illegible] without additional equipment. The [illegible] uniformity has also contributed to increasing productivity [illegible] through the reduction of reject rates.

Because of these changes in SBR [illegible] recent developments in truck tyre design (where [illegible]. An abrasion resistant [illegible] over a highly resilient under tread based on NR [illegible] increase in SBR usage is occurring in North America [illegible] or developing countries provided [illegible] dual tread is installed.

The emulsion system also permits [illegible]. This polymer has [illegible] produced along with solution SBR. [illegible] some improvement in the [illegible] natural rubber and SBR. This improvement in abrasion [illegible], however, is not as great as with the high cis-polybutadiene [illegible].

From the process viewpoint, the [illegible] of all synthetic rubber processes [illegible], and also permits the greatest variation [illegible] polymerization medium is an aqueous emulsion, solvent [illegible] together with solvent losses) [illegible] continuous [illegible] ensuring minimum upsets to polymerization [illegible]. In many plants, the continuous grade change is also very [illegible] view-point as the "twilight" material produced [illegible] can be segregated, but still used as "off grade" [illegible] for less critical applications). Emulsion polybutadiene [illegible] in combination with SBR because during its [illegible] "stripping" [illegible] used to separate unreacted styrene, is not [illegible]. As [illegible] must be cleaned periodically, polybutadiene can be [illegible] during these periods without curtailing the polymerization reactors and finishing systems. The capacity of the plant is thereby increased. Further advantages of this process of significance in developing countries are that as the need develops for production of specialty products such as nitrile rubbers for oil resistant applications, or a need for latices for tyre cord and in textile and paper coatings, the technology to produce such polymers can be acquired and used with minimum additional investment.

The potential to produce latices which is provided by the emulsion system also permits advantage to be taken of the recently developed technology to produce high solids latex by pressure agglomeration as described by I.S.R. at this Symposium. This technology permits entry into applications in moulded and spread foam in addition to the use of conventional latices in carpet and fabric backings, adhesives, tire cord dips, etc.

It is obvious that there is no single preferred choice for the most suitable rubbers to be made in a specific country, and a choice must be based on the local requirements of the market as it can be forecast, taking into consideration the country's plans for its overall economic development.

3. Selected techniques of [illegible] of special interest to developing [illegible]

Developments in the field of [illegible] of rubber continue to provide [illegible] existing technology and through [illegible].

The advantages of latex technology [illegible] equipment for fabricating rubber has already [illegible] continuing.

In the field of rubber mixing, [illegible] have resulted in substantial reduction in [illegible] improvements in dispersion. This provides higher [illegible]. The Banbury mixer is by its nature a batch process, but a very high degree of automation is now used in modern mixing rooms with automatic weighing and filling equipment and automatic take-off [illegible].

One North American Company has [illegible] (the [illegible]) in their latest [illegible] plants [illegible] for this new process which can be adapted to [illegible].

Extruders have been developed further, and cold feed extruders are now widely used. The development of the [illegible] for truck tyres is a further example of extruder developments.

Injection moulding of rubbers is now being used extensively, but in general its use is confined to products which permit long production runs. In certain applications it does offer benefits by reducing the costs for moulds as fewer moulds are required. Many different injection moulding processes are now commercially available.

Continuous vulcanization of extruded sections is also being more widely used, and it is worth noting that the technology was developed by the British Rubber and Plastics Research Association, i.e. by an industry financed joint research institute.

A number of improvements have been made in tyre retreading such as the Arbitread process. Tyre retreading is particularly important, as the most complex part of a tyre is the carcass, and its re-use, through retreading, can be a highly economical route to increasing the effective production capacity of a developing country's tyre industry.

4. Possible areas of application of synthetic rubbers of special interest to developing countries

The main areas of application for synthetic rubbers are well known, e.g. tyres, conveyor and transmission belting, hose, rolls including printing rolls, footwear, chemical plant lining. However, [illegible] new applications have been developed and some of these are extremely important in countries wishing to leap-frog into more modern technology. An excellent example of this is in carpet manufacture, where it is possible to enter tufted carpet manufacture using carboxylated SBR latex to lock the tufts, without the manufacturer having to evolve through woven carpet technology.

The major application areas of interest are: (a) construction - rubber window seals, flashings, water proofing membranes for foundation and roofing, adhesives; all of these applications are important for improving the efficiency of construction and for minimizing building maintenance; (b) furnishings - upholstery (cushioning, curled hair or foam), mattresses, car seats, carpet backing (tufted carpets), carpet underlay (foam), furniture (high impact polystyrene replacing wood).

The attractiveness of these applications depends on local conditions e.g. a country without timber may find high impact polystyrene, which uses rubber to gain impact strength, very important. Countries with indigenous coarse fibres (coconut, animal hair) will probably prefer to use latex impregnated curled hair for cushioning whereas those without may prefer to use latex foam for cushioning. (c) Agriculture - rubber membranes for grain silos, for irrigation ponds and ditches, dams - latex for soil stabilization (wind erosion); (d) Plastics modification - polystyrene (regular and high impact), for furniture, packaging, PVC modification with nitrile rubbers, ABS manufacture and modification (nitrile rubbers).

5. Factors affecting [illegible] synthetic [illegible]

The establishment of [illegible] synthetic rubber [illegible] countries [illegible] complex [illegible]

[illegible] to the [illegible] producers in the developed countries [illegible] within such developing countries [illegible] rubber, [illegible] countries [illegible]

[illegible] protection [illegible] of the industry [illegible] economic development of the [illegible].

The advantages of scale, experience [illegible] export markets [illegible] by the [illegible] [illegible] [illegible] [illegible]

[illegible] ternal market [illegible] of the market [illegible] closely [illegible] the country [illegible]. The [illegible] agricultural and mining products [illegible] tion in addition to [illegible]. Because consumption of [illegible] large [illegible] must [illegible] rubber needs. It is not sufficient to [illegible] rubber consumption [illegible] determining [illegible] Many examples [illegible] freely available from a domestic producer [illegible] of a domestic [illegible] domestic production of [illegible] unforeseen increase in consumption.

Factors related to the [illegible] cussed in part two of the [illegible].

In addition to the markets, it [illegible] to consider the [illegible] for successful production. These include: the availability of modern technology to minimize delays in construction, start-up and market acceptance (and availability of future improved technology); the availability of a strong equipment-producing industry coupled with local engineering staff to minimize foreign currency expenditures; the availability of raw materials; the availability of experienced manpower (or readily trained manpower) for management supervision, operation and maintenance of the industry; the availability of resources for training staff.

As assistance is likely to be required in ensuring the availability of some or all of the above resources, it is also important to consider factors affecting licensing, technology (and patents), government policies regarding joint ventures, local participation, repatriation of profits, protection of foreign investors in cases of compulsory take-over and the nature of protection to be provided to the industry.

[illegible]. Discussions and observations

There was considerable discussion on isoprene monomer and cis-polyisoprene manufacture in the USSR. Isoprene monomer was produced both by dehydrogenation of isopentane and from isobutylene and formaldehyde. The economic size of the plant based on isobutylene was regarded as 50-100,000 tons. The USSR has developed the technology to produce truck tyres based 100 per cent on synthetic rubber and the level of synthetic rubber used in all tyres had increased to 72.5 per cent by 1968. In contrast to producing synthetic cis-polyisoprene, it was suggested that advances in techniques for growing natural rubber will make it possible to produce a lower cost rubber than the synthetic equivalent for many years.

On the subject of speciality rubber production, it was stated that because the volume of consumption was so small it was not practical to produce highly specialized rubbers such as the fluorinated rubbers in developing countries. It might however be desirable to produce latices and save on the relatively high transportation costs of these forms of rubber.

The importance of a developing country [illegible] and not just rights to use a patent was emphasized. [illegible] when a basic patent expired, [illegible] still valid. Consequently, the opportunity must [illegible] technology (and patents) available [illegible] himself under further cost and quality [illegible].

The need to base synthetic [illegible] emphasized.

It was suggested that because the [illegible] finished rubber product is low, it may be more beneficial [illegible] developing country to devote its resources initially [illegible] rather than to build up a petrochemical [illegible] [illegible] which make it [illegible] facturing industry based on imported [illegible] desirable in some cases to build [illegible] production costs relative to large existing [illegible].

CHAPTER VI

Development of the petrochemical industry during the Second Development Decade.

Attempts at projecting the world demand for petrochemicals have been made by the United Nations regional economic commissions and by Karl H. Rönitz of Farbwerke Hoechst A.G. (for UNIDO). The results of these projections have been compared and are presented in the following tables.

Data derived from the Rönitz report for the different regions of the world could be used as a basis for giving a rough order of magnitude for the world demand for petrochemicals in 1975 and 1980. But the two sets of data given by Rönitz and by the regional economic commissions are, in most cases, neither comparable nor uniformly classified. For this reason it seems that it would be extremely important for UNIDO to evaluate in depth the consistency and comparibility of the data given in the two sources.

The attached tables include estimates of projected consumption of petrochemicals for 1975 and 1980, divided into regions and into different groups of petrochemicals. More specifically, the Rönitz report dealt with the developing countries of the world, divided into the developing countries of Africa, America, Asia and the Middle East.

According to the Rönitz study the total world consumption of major thermoplastics will amount to 35 million tons in 1975 and to 60 million tons in 1980 (see table 1). Of this total, the consumption of major thermoplastics by the developing countries amounts to 2.67 million tons in 1975 and 5.91 million tons in 1980. No data for the total world consumption estimates of synthetic rubber has been prepared by Rönitz. However, estimates of consumption of synthetic rubber by the developing countries are available. These amount to 430,000 tons in 1975 and 672, 672,000 tons in 1980. The estimated consumption of synthetic fibres by all the developing countries amount to 996,000 tons in 1975 and to 1.93 million tons in 1980. The total world consumption of synthetic fibres are also not available in this report.

The estimated investment requirements by the developing countries are given in table 2 as given in the above survey. According to these figures, the total capital required by [illegible] in the two periods, 1970-75 and 1975-80, are as follows:

	1970-75	1975-80
	(in [illegible] dollars)	
Major thermoplastics	[illegible]	[illegible]
Synthetic rubber	[illegible]	[illegible]
Synthetic fibres	1,[illegible]	[illegible]

Tables 3 to 7 give projections [illegible] Economic Commissions and UNSOB.

Using both sources at [illegible] Africa are comparable. The figures for 1975 and 1980 as given by the [illegible] Commission for Africa and by Rürtz are summarized below.

	[illegible]		[illegible]	
(in thousand tons)	1972	[illegible]	[illegible]	1980
Major thermoplastics	[illegible]	[illegible]	[illegible].8	[illegible]8.3
Synthetic rubber	58.3	[illegible]	[illegible]	n.a.
Synthetic fibres	[illegible]	[illegible]	[illegible]	[illegible].0

It will be noticed that [illegible] are not too far different. However, [illegible] countries indicates substantial differences [illegible] investments required during the development decade [illegible].

While the above figures give [illegible] should be further scrutinized and [illegible] by UNIDO [illegible].

CHAPTER VII

United Nations Industrial Development Organization - Technical Assistance possibilities for the development of the petrochemical industry

During the course of the Symposium discussions were held with the participants from developing countries for indications of possible UNIDO assistance in the petrochemical development in their countries.

The "Note to the participants [illegible] the Symposium" (ID/WG.34/78, 10 October 1969 PET.Symp.INF/6) distributed during the Symposium outlined the main topics for these discussions under the following three sections: planning and implementation of petrochemical facilities; assistance to solving problems connected with the operation of petrochemical plants; assistance towards the installation of small petrochemical plants for which UNIDO/UNDP could underwrite the foreign currency component. In the course of these discussions which took place, the problems confronting the development of a petrochemical industry in the country represented by each participant from a developing country were reviewed and, by the end, the conclusions and recommendations as to the ways and means in which UNIDO could assist solving these problems were elaborated.

The discussions were carried out with the understanding that on return to their home countries the participants would be instrumental in trying to generate the official Government request for UNIDO assistance which was to be channeled through the Resident Representative of UNDP.

It was also understood that the indicated requests were not binding for UNIDO, the scope of the discussions having amongst others been to assist UNIDO in the effort of planning, co-ordinating and determining priorities for technical assistance to member countries, and for getting indications as to the needs of the developing countries.

Summing up, the requests for UNIDO's technical assistance show a fair spread over the various sectors and phases in which UNIDO can assist the developing countries in their petrochemical developments.

In the following paragraphs the main sectors concerned are indicated together with the number of requests as well as the source of financing of the assistance in view of their timing, scope and urgency. The abbreviations used are for Special Fund projects (SF), for Special Industrial Services (SIS) and for assistance under Regular Programme and [illegible] Technical Assistance (TA).

It should be noted here that for the [illegible] the training component is understood as [illegible]

Group 1 : covering the sector from preliminary [illegible] to bankable projects, backed by market [illegible] SF 4; SIS 11.

Group 2 : market research, marketing [illegible] promotion and marketing. SF 2; SIS 6.

Group 3 : process and product selection. SIS [illegible].

Group 4 : preparation of tender specifications and [illegible] of tenders. SIS 2.

Group 5 : small petrochemical plants [illegible] foreign currency component. SF [illegible].

Group 6 : materials inspection for [illegible]. SIS [illegible].

Group 7 : increasing operating efficiency [illegible] SIS [illegible]; TA 2.

Group 8 : effluent disposal problems for operating petrochemical plants. SIS [illegible]

Group 9 : promotion of financing, identification of [illegible] joint ventures. SIS 2.

Group 10: legal aspects of establishing joint ventures [illegible] investment promotion. SIS 1.

Group 11: process engineering design in the petrochemical [illegible]. TA 1.

In conclusion, the discussions [illegible] developing countries have led to the [illegible] (SF) projects [illegible]; Special Industrial Services (SIS) projects 2[illegible], Technical Assistance (TA) projects under regular programme 3. Total [illegible].

CHAPTER VIII

Conclusions and recommendations

Development of the petrochemical industry in developing countries

1. The Symposium recommended that in developing their petrochemical industry, developing countries should undertake detailed market studies for end-products including the impact of the production of such end-products on more conventional materials. Where the necessary services were not available within a country, the Symposium recommended that the services should be obtained from other developing countries, who have already progressed in the establishment of their petrochemical industry and faced similar problems.

2. The Symposium suggested that the development of the petrochemical industry within a developing country would be greatly helped by obtaining information on the experience of other developing countries and on available processes. The Symposium therefore suggested, that:

a. country papers at future conferences should give more emphasis in discussing problems faced in the establishment of petrochemical industries and the measures undertaken to solve them. It was also considered helpful if UNIDO or regional commissions such as ECAFE, ECLA, etc. would prepare reports on experiences in the development of petrochemical industries in selected developing countries rather than only statistical data;

b. UNCTAD/UNIDO should collect data on the imports and exports of petrochemicals in developing countries;

c. a mechanism should be worked out for publishing on a regular basis detailed information on processes available for licensing.

3. The Symposium recommended that efforts should also be made by developing countries to offer facilities for pre-investment studies, feasibility and detailed project reports, engineering design and construction, plant commissioning and operation, and in research and development to other developing countries.

4. The Symposium emphasized the importance of adequate training in all branches of the petrochemical industry. It recommended that developing countries who have established petrochemical plants should provide facilities

for training of personnel from other developing countries. The use of facilities at specialized institutions [illegible], such as for instance [illegible] is also of importance.

5. Discussions during the Symposium [illegible] countries planning large investments [illegible] industry should develop their own design, fabrication [illegible] facilities step by step. The Symposium [illegible] that in order to build up the technical "know-how" [illegible] and in order to reduce overall costs of projects, countries [illegible] petrochemical projects should build up a nucleus [illegible].

6. The Symposium emphasized the [illegible] maintenance in the petrochemical industry [illegible] the programme of UNIDO in the field of repairs and maintenance in developing countries. It is recommended that UNIDO [illegible] maintenance of petrochemical plants [illegible] training maintenance and instrument [illegible] abroad and possibly provide a mobile team [illegible] to developing countries for assisting [illegible] problems.

7. The main petrochemical industry [illegible] basic petrochemicals, monomers for [illegible] and the synthetic rubber industry is so constituted that [illegible] are important and relatively large [illegible]. Many of the developing countries do not have [illegible] production and the Symposium recommends [illegible] consider joint ventures with other countries for [illegible] industries. In this connexion a study of problems [illegible] transport of petrochemicals is important and the Symposium suggested that UNIDO undertake such a study.

8. In order to meet the criteria of [illegible], many countries are considering developing industries mainly based upon exports. Several participants at the Symposium suggested that exports of petrochemicals at marginal costs would be possible only if there was a substantial home market to meet the base production costs. Only in exceptional cases were

specialized raw materials are present in oil producing countries could large scale plants meant exclusively for export be considered.

9. In view of the resolutions of the United Nations General Assembly to the effect that computer technology should be introduced into developing countries where appropriate, and in view of the fact that the Advisory Committee on Science and Technology is in favour of such development, and bearing in mind the discussions of the Symposium, it is recommended that developing countries should encourage the use of computer technology in research and in design of petrochemical plants, using assistance from UNIDO if necessary.

10. Several developing countries possess substantial reserves of natural and associated gas containing substantial proportions of ethane, propane and higher hydrocarbons. The Symposium recommended that as these fractions are of special economic advantage in the production of ethylene permitting entry into the field of petrochemicals without having to invest in a number of down-stream processes, countries with such resources should pay special attention to their utilization.

11. The Symposium noted the development of processes for the production of olefins from relatively inexpensive and readily available raw materials such as crude oil and fuel oil and recommended an examination of such processes by countries where conventional raw materials are not easily available and specially where manufacture of products such as PVC are desired.

12. The Symposium suggested that, in view of delays in bringing large olefin plants up to capacity, the economics of smaller ethylene plants in relation to larger plants should be re-examined specially in the context of optimum integration of such plants with refineries.

Resources for the plastics industry

13. The Symposium noted that present trends are for the use of ethylene for the manufacture of vinyl chloride, rather than acetylene except under exceptional circumstances, and integration of facilities with ammonia and methanol production. The Symposium also noted the satisfactory commercialization of a number of oxychlorination processes using ethylene which eliminate the problem of disposal of hydrochloric acid.

14. The Symposium noted the satisfactory commercialization of processes for the manufacture of vinyl acetate from ethylene which should be of special interest for developing countries in view of the wide range of application for this product.

15. The Symposium noted with interest the active developments in research on the production of polyethylene by the use of radiation techniques.

Plastics industry

16. The Symposium noted that the relatively newer plastics have so far succeeded in capturing only specialized markets of relatively low volume. Polyethylene, PVC, styrene plastics and polypropylene continue to dominate the thermoplastics market with rates of growth in developing countries often exceeding those of developed countries. The Symposium suggested that developing countries should concentrate in the first instance on the manufacture of these [illegible].

17. The Symposium noted developments in the field of plastics which permitted substantial improvements in their properties at relatively low cost by the use of reinforcement materials. These are of special interest to developing countries, as it enables them to restrict plans for the development of the plastics industry to a relatively small number of basic plastics and yet diversify the range of end use plastics.

18. The Symposium recommended that developing countries pay special attention to setting up adequate facilities for the plastics processing industry such as shops for the manufacture of moulds and dies and their maintenance.

19. The Symposium recommended that in planning the establishment of the plastics industry, developing countries should pay special attention to the use of plastics in the substitution of [illegible] traditional materials and also take into account particular [illegible] of such traditional materials in their own country which are often different from materials in other countries. This replacement has a special role to play in the substitution of imports of not only plastics but also such products as steel and non-ferrous metals and could lead to substantial savings in foreign exchange.

Synthetic fibres

20. The Symposium recommended that, before embarking on large-scale synthetic fibre production, developing countries should carefully survey existing textile production facilities in relation to their ability to absorb synthetic fibres. Investments where required for modifying such plants, or for building new facilities, should be made available to the textile industry.

21. The Symposium suggested that developing countries newly entering the synthetic fibre field could make a start by establishing relatively small size synthetic fibre plants based on imported polymers. Such countries should, however, concentrate in the first instance on the manufacture of the high volume fibres such as nylon, polyester and in colder climates, acrylic fibres.

Synthetic rubber

22. Several developing countries are located in regions where natural rubber is produced, but where synthetic rubber demands are increasing. The Symposium recommended that a study should be undertaken by UNIDO to project the economics of natural rubber relatively to synthetic rubber, on a country to country basis.

23. Current technologies in the synthetic rubber field are for relatively large-scale plants. The Symposium felt that there were technological possibilities in connexion with the development of small economical plants, and suggested that engineering companies should be approached for such development.

24. The Symposium emphasized that the build-up of rubber demands in a developing country is only possible by co-operation between the rubber companies and the rubber producers and recommended that institutional facilities should be provided in developing countries for this purpose.

25. The Symposium recommended that the exchange of information by countries such as Argentina, Brazil, India and Mexico with other developing countries would be of help in planning synthetic rubber industries in the latter. It recommended that UNIDO call an expert group meeting to consider possibilities in this connexion.

<u>United Nations Second Development Decade</u>

26. The Symposium noted with interest the work being undertaken by the United Nations in establishing data for the projections of production, consumption and investment in petrochemicals. It recommended that UNIDO convene a meeting of experts to consider [illegible] from this Symposium and other sources.

<u>UNIDO technical assistance</u>

27. The Symposium noted the interest shown by developing countries in the projects for technical assistance and welcomed the action by UNIDO in initiating such projects. It recommended that member countries and UNIDO expedite completion of formalities and the implementation of the projects identified during the Symposium without undue delays.

28. The Symposium [illegible] technical assistance and help in a number of fields. Among the more important recommended for consideration by UNIDO were:

(a) Preparation of market studies, [illegible] pre-investment studies for specific projects and [illegible] availability of consultancy services.

(b) Guidance in the selection of optimum processes, [illegible] engineering design and location of plants.

(c) Guidance in formulating plans for the step-wise build-up of the petrochemical industry in countries where capital investment and financial factors necessitate this approach.

(d) Examination by UNIDO of guidelines for the establishment of minimum economic capacity plants under the specific conditions of various countries.

(e) Assistance by UNIDO after start-up such as continuing technology for process, marketing and product application.

(f) Assist in establishment abroad of exhibitions of finished products from developing countries.

(g) Give help in establishing and maintaining quality controls in products such as synthetic fibres and finished plastic products and in establishing standards for these products.

(h) Advise countries in the establishment of research and development centres for various branches of the petrochemical industry.

(i) Study the problems of plants in developing countries which are in difficulties due to obsolescence or other problems.

(j) Help in the solving of problems of disposal or further processing of by-products and surplus intermediates.

(k) Advise on the problems of the handling of petrochemicals safety regulations and waste disposal.

<u>Co-operation with International Atomic Energy Agency (IAEA)</u>

29. The Symposium noted with interest the development of radiation techniques for various petrochemical processes. The Symposium recommended continuing co-operation with IAEA in developing such processes, which are of special interest to developing countries.

Table 1 Expected consumption of petrochemicals in the developing countries in 1975 and 1980 (in thousand tons)

	Africa a/		America a/		Asia b/	
	1975	1980	1975	1980	1975	1980
Major thermoplastics d/	223.8	483.3	1,172.5	2,400.9	1,246.2	2,571.5
Synthetic rubber	-	-	336.0	528.0	48.0	72.0
Synthetic fibres	65.0	120.0	290.0	440.0	560.0	650.0

	Europe c/		Total developing countries	
	1975	1980	1975	1980
Major thermoplastics d/	223.5	453.0	2,866.0	5,914.0
Synthetic rubber	48.0	72.0	432.0	672.0
Synthetic fibres	81.0	121.0	996.0	1,331.0

	Rest of the World		Total World	
	1975	1980	1975	1980
Major thermoplastics d/	32,134	54,086	35,000	60,000
Synthetic rubber	n.a.	n.a.	n.a.	n.a.
Synthetic fibres	n.a.	n.a.	n.a.	n.a.

Source : Karl H. Rönitz, "Perspectives for the Petrochemical Industry in the Developing Countries up to 1980", 30 September 1969 (study commissioned by UNIDO)

a/ excluding U.S.A. and Canada

b/ including Middle East, South and South-East Asia and Far East

c/ only Yugoslavia and Turkey

d/ polyethylene, PVC, polystyrene and polypropylene

Table 2 **Investment requirements for additional capacities of petrochemicals 1970-1975 and 1975-1980** (in million US dollars)

Major thermoplastics	Africa 1970-75	Africa 1975-80	America 1970-75	America 1975-80	Asia 1970-75	Asia 1975-80
Low density polyethylene	-	-	64.0	128.0	80.0	208.0
High density polyethylene	-	-	60.0	90.0	50.0	130.0
PVC	9.0	44.5	49.5	113.0	63.5	136.0
Polystyrene	-	12.0	22.5	24.5	29.0	45.5
Polypropylene	-	-	50.0	100.0	30.0	130.0
	9.0	56.5	246.0	455.5	252.5	549.5

Major thermoplastics	Europe 1970-75	Europe 1975-80	Total developing countries 1970-75	Total developing countries 1975-80
Low density polyethylene	32.0	16.0	[illegible]	352.0
High density polyethylene	10.0	20.0	[illegible]	[illegible]
PVC	22.0	[illegible]	[illegible]	[illegible]
Polystyrene	4.0	10.0	[illegible]	[illegible]
Polypropylene	-	30.0	[illegible]	260.0
	65.0	94.5	[illegible]	1,156.0

Synthetic rubber	Africa 1970-75	Africa 1975-80	America 1970-75	America 1975-80	Asia 1970-75	Asia 1975-80
Polybutadiene and Styrene-butadiene	-	-	32.0	64.0	-	8.0

Synthetic rubber	Europe 1970-75	Europe 1975-80	Total developing countries 1970-75	Total developing countries 1975-80
Polybutadiene and Styrene-butadiene	16.0	8.0	48.0	80.0

cont's

Table 2 (cont'd)

Synthetic fibres	Africa 1970-75	Africa 1975-80	America 1970-75	America 1975-80	Asia 1970-75	Asia 1975-80
Acrylic	18.0	18.0	12.0	18.0	42.0	42.0
Polyamide	39.2	52.5	154.0	52.5	[illegible]	376.0
Polyester	32.0	72.0	36.8	107.4	94.5	391.8
	89.2	142.5	202.8	177.9	628.2	809.8

Synthetic fibres	Europe 1970-75	Europe 1975-80	Total developing countries 1970-75	Total developing countries 1975-80
Acrylic	--	12.0	72.0	90.0
Polyamide	28.0	21.0	712.9	502.3
Polyester	48.5	40.0	411.8	611.2
	76.5	73.0	1,196.7	1,203.5

Source : Karl M. Rönitz, "Perspectives for the Petrochemical Industry in the Developing Countries up to 1980" 30 September 1969 (study commissioned by UNIDO)

Table 3 Expected consumption of petrochemicals in the developing countries in 1975 and 1980 (in thousand tons)

	ECAFE region a/		Middle East b/		Africa		Total	
	1975	1980	1975	1980	1975	1980	1975	1980
Major thermoplastics	n.a.	2,110.1	105.0	125.0	233.7	437.9	n.a.	2,673.0
Synthetic fibres	n.a.	656.1	20.0	50.0	58.3	103.0	n.a.	809.1
Synthetic rubber	n.a.	355.2	30.0	40.0	87.4	140.7	n.a.	515.9

Source : ECAFE, ECA and UNESOB - Studies prepared for UNIDO (Baku Symposium)

a/ excluding Japan

b/ Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia and Syria

Table 4 **Growth of installed capacity of basic petrochemicals in Latin America (in thousand tons)**

	[illegible] installed capacity in 1967/68	growth of installed capacity in [illegible]
Ammonia	489.5	2,24[illegible]
Butadiene	80.0	[illegible]
Benzene	229.0	[illegible]
Ethylene	134.3	1,219.2
Methanol	55.5	54.6
Naphthalene	10.8	7.2
Carbon black	117.1	11.2
Propylene	236.0	289.8
Carbon sulphide	19.5	--
Toluene	100.0 a/	111.0 b/
Xylene	59.0 a/	90.0 b/
Total	1,530.7	4,424.[illegible]

Source : ECLA

a/ figures for Mexico only; for all other countries included as BTX under benzene

b/ figures for Brazil, Colombia and Mexico only; for all other countries included as BTX under benzene

Table 2 Consumption of petrochemicals in West Europe in 1970 and 1975 a/ (in thousand tons)

Ethylene derivatives	1970	1975
Polyethylene	3,17[illegible]	6,500
Ethylene oxide	975	1,750
Ethylbenzene	507	900
Vinyl chloride	735	1,570
Synthetic ethanol	250	350
Acetaldehyde	263	450
Others b/	210	4[illegible]0
	6,1[illegible]	[illegible]
Propylene derivatives		
Acrylonitrile	750	1,720
Polypropylene	350	970
Cumene	300	500
Propylene oxide	275	615
Oxo-alcohols	650	1,115
Isopropyl alcohol	[illegible]	600
Others c/	365	420
	3,235	5,750
Butadiene derivatives		
SBR	420	650
Polybutadiene	210	320
Nitrile rubber	38	60
ABS resins	32	70
Others c/	45	60
	745	1,160

Source : ECE

a/ EEC, EFTA and other countries in Western Europe

b/ mainly tetramer, trimer and synthetic glycerine

c/ chloroprene, adiponitrile, trimer, etc.

Table 6 Production of petrochemicals in [illegible] countries and Yugoslavia (in thousand [illegible])

	[illegible]	[illegible]	[illegible]
Plastics and synthetic resins	1,67[illegible]	n.a.	n.a.
PVC	636.0	n.a.	n.a.
Polyethylene	49[illegible].0	n.a.	n.a.
Polystyrene	1[illegible].[illegible]	[illegible].0	n.a.
Propylene	39[illegible].0	[illegible].0	1,[illegible].0
Ethylene	1,[illegible].0	n.a.	n.a.

Aminoplastics (19[illegible]) = 3[illegible].1
Acetylene (1966) = 975.0

Source : J. Müller, Brno, "Development of [illegible] from Chemicals in the Countries of the [illegible] and in Yugoslavia" ID/WG.34/6 of 23 [illegible]

Table 7 Investment requirements for the development of petrochemicals in 1975 and 1980 (in million US dollars)

	Africa		ECAFE a/		UNESOB region b/	
	1975	1980	1975	1980	1975	1980
Petrochemicals	435.0	876.0	-	-	-	300.0
Plastics	-	-	-	470.0	-	-
Synthetic fibres	-	-	-	919.0	-	-
Synthetic rubber	-	-	-	116.5	-	-

Source ; ECA and ECAFE

a/ excluding Japan

b/ Iraq, Jordan, Kuwait, Lebanon. Saudi Arabia and Syria

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