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SUMMARY

THE TRANSFER OF TECHNOLOGY FOR PETROCHEMICALS IN DEVELOPING COUNTRIES 1/

by

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Vienna, Austria

Contracts in regard to the delivery of KNOW-HOW and ENGINEERING are necessary for specifying the basic conditions for the transfer of petrochemical technology to developing countries. Process KNOW-HOW is often covered with patent rights. An ENGINEERING-contract can be, depending on the amount of work, feasible in the developing country, split off in BASIC ENGINEERING and several dependent ENGINEERING services, e.g. final drawings, details, etc.; it contains further CIVIL ENGINEERING. Legal aspects have to be considered not only in regard to licensing of the process in question, but also as for as the legislation of the developing country effects for agn investments.

Economically, prior to the transfer of technology, market research studies in regard to local consumption, export and import facilities for the products of the different petrochemical generations as raw materials,

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intermediates and finished products within the region of the developing country must take place. As the necessary capital for financing petrochemical investments can only seldom be provided from their own national income e.g. by selling natural resources, monetary funds originating from foreign aid are available. The total foreign aid for developing countries has amounted to 11 thousand million dollars in 1967; as the UNCTAD conference in New Delhi 1968 has determined the contribution of the developing countries to 1% of the GNP it is expected to amount in 1975 to 20 thousand million dollars. Export prices for petrochemicals produced in developing countries have to be adequate to world market conditions. Most of the developing countries enable freedom of import duties for investment of machinery in a project and temporary or partial relief from income tax.

For compiling the different suitable technological specifications which have to be contained in an EQUIPPING contract, studies covering the technological basis of the country have to be performed. The availability and production of the raw materials crude oil and natural gas or their processing in refineries is a primary condition for the production of petrochemicals of the first generation. Of the already existing 174 petrochemical plants in developing countries the experiences on similar installations and their specifications must be considered when evaluating the transfer of technology for new projects. Electric energy, steam and water have to be provided at reasonable prices. Electric power, if not available locally, is relatively easy to get by the installation of gas turbines. Steam can be generated by own boilers. The costs of qualified labour (engineering hour rate Dar pr 7 dollars) are decided for the calculation of the engineering costs from the contractor's angle. The contractor's responsibility for labour ends after supervision of the erection and the starting up of the plant. Labour, its availability, quality and its costs in a developing country contributes to a great extent to the functioning and to the operating costs of a petrochemical plant. The technological specifications of an EQUIPPING contract can be considered as minimum conditions for the installation of a petrochemical plant in a developing country which is unwilling to achieve the guarantees given according to

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THE ROLE OF TECHNOLOGY FOR PETROCHEMICALS TO PETROLEUM COUNTRIES[1/]

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This paper will give a review of the main technical aspects which are important for the transfer of technology in order to realize petrochemical projects in develo ing countries.

As a matter of fact, the transfer of process know-how and engineering in each individual case has to be effectuated by observation of the economic situation as well as utilizing the means of the technical background existing in the developing country.

Legal aspects have to be considered, not only in regard to licensing of the process in question, but also as for the legislation in the developing country effects foreign investments.

Economically, for building up the plant the transfer of technology involves costs for licensing of process know-how and engineering. For evaluating the transfer a accurate analysis of several factors as the future home market, foreign exchange, financial and investment facilities, pricing policies, taxes and duties etc., is necessary.

Technologically, the overall dimension of the future plant in determining the engineering efforts for the construction, dimension and lay-out of the different parts of the equipment consisting mainly of reaction vessels, storage containers, tubing, control equipment, power plant, etc.- For the optimal construction and production of the petrochemical plant investigations are necessary in regard to the raw material, energy and water supply, availability of labor, transportation facilities and the whole level of industrial development existing in a country.

The transfer of technology involves process know-how and engineering. The price of process know-how and engineering is of great importance by considering the economic situation of the developing country.

The owners of technology should evaluate to hold the profit margin low in order to help industrial development.

The most important point by committing the know-how seems to be the evaluation of the potential development of the future market of the petrochemical production in question, characterized by the future consumption in this region.

PROCESS KNOW-HOW

Process know-how is the basis for building up a plant. Economically its value depends on the position it gives to the owner in regard to manufacturing a product and the market position thus built in region. For legal protection it is often covered with patent rights.

In practice the amount of 1 to 3 per cent of the value of the whole project is payable for delivering the know-how.

PROCESS ENGINEERING

Besides the know-how for a petrochemical process for the practical transfer of technology the so-called "Engineering" is necessary.

It consists in delivering a complete documentation for building up the whole plant and services which only can be given by a firm with experience in the construction of petrochemical plants, according to an existing process know-how.

Basic engineering covers services which are absolutely necessary for building up the plant; it includes only fundamental work; it implies the cooperation with other engineering contractors for several services as f. i. final drawing of details, etc.

Full engineering is according to its volume more expensive and covers practically all services which are necessary for building up a plant, including all drawings for construction, data sheets and equipment specifications for all details of the plant (reactors, warehouses, control equipment, power plants, piping, sanitaries, electrical wiring, etc.). Material balances are delivered summarizing the flow rates of raw and ancillary material through each process step and equipment based on the plant capacity. - The "Piping and instrument diagram" is the basis for the design of plant equipment and buildings and for the procurement of equipment, machinery and instrumentation. Further operating instructions, materials and functioning test certificates, lubrication schedules and spare parts lists are provided.

The engineering includes the supervision of the erection and the start up of the plant. - The plant is turned over to the customer after a test run fulfilling the guarantees.

A modern method for demonstrating the engineering value consists of the preparation of a lay-out model of the finished plant. Such models provide a good survey of the optimal flow of material, utility lay-out, arrangement of conveying systems, economical use of the available area, including future expansions, proper location of safety facilities, etc. Design models are scale models which show the buildings, equipment and machinery as well as piping above two inches. The isometrics include all characteristic data. This information is put on punchcards and serves as a basis for the requisition of piping materials. Complicated process design and engineering problems such as the calculation of reaction rate, heat stresses, optimum safety allowances, etc. are handled by electronic computers which are also used for preparation of the critical path diagram and for drafting design.

Engineering contracts can be carried out in cooperation by several contractors. This happens often according to the knowledge and experience of different engineering firms and local conditions.

The measuring devices for engineering costs are the labor costs. Generally in Europe the engineering hour is calculated with 7 U.S. Dollars. As a general rule, the engineering costs account for between 10 and 15% of the delivery costs of the whole plant.

Civil engineering has to be included in the engineering contract. It can often be carried out practically, sometimes to a great extent by contractors available in the developing country.

The transfer of technology involves further studies, evaluating the economic and technological basis for planning petrochemical investments or petrochemical processing plants.

1.0) ECONOMIC ASPECTS

The gross national product of the developing country in relation to the number of inhabitants can serve as first approach for an economic study. Thus in Asia, Africa and Latin America can vary between more than 1000 U.S.Dollars per capita and less than 100 U.S. Dollars in developing countries.

A relatively high value indicates a background, not only of the monetary funds, but also the availability of tools, which can be used practically to prepare a technical project.

Economically different criteria of a developing country exist which may influence the policy for optimum planning of a petrochemical project. -- The following factors will be discussed:

1.1) Home Market

1.2) Foreign Commerce

1.3) Monetary Funds

1.4) Capital for Developing Projects (Foreign Aid)

1.5) Pricing Policies

1.6) Taxes and Duties.

1.1) HOME MARKET

Considering the petrochemical derivatives, different markets exist for products of the first, second, third, etc. generation till the final stage. Marketing possibilities of all these products, especially in as far as plastics, synthetic fibres or synthetic rubbers are concerned, have to be evaluated.

1.1.1) Derivatives of the First Generation

Products of the first generation are represented by ethylene, propylene, butene, benzene, etc. They are market raw materials for sale or production facilities for further intermediates or final products. Only the production of big quantities is profitable. Delivery is effectuated generally in gaseous form. Primary products are generally produced in refineries. Delivery

of ethylene and propylene to the second step of production is effectuated in pipelines. Ethylene pipelines of more than 100 km length have been built following conservative estimates.

According to the standard of living and the relatively small number of inhabitants in most of the developing countries, there is seldom a market for products of the first generation. However, petrochemical centers will develop in several regions as f. i. Argentina, Brazil in Latin America, Iran in Asia, etc.

1.1.2) Derivatives of the Second Generation

By evaluating the market in developing countries, mainly products of the second generation or the third of petrochemicals are needed, not justifying production of the first generation derivatives.

An example of this is the polymerization plant for 10.000 tons polyvinylacetate which was erected in Africa some years ago by FARBWERKE HOECHST. Similar models of this plant have been erected at several places of the world, following the market conditions. The raw material for these plants is liquid vinylacetate monomer and is provided by shipping in vessels to the factory.

1.1.3) Petrochemical end products

A homogeneous market of final products, independent from their petrochemical generation as for plastics raw materials, synthetic rubbers and synthetic fibres, can relatively easily be found in developing countries.

Considering the fact, that in a developing area a market for rubber tire reinforcement exists, a polyester fiber plant should be planned and erected. -- Compared to the already existing plants for rubber tire reinforcement made out of rayon or polyamide fibres, the new plant has the best position. There is no question that polyester cords represent the latest technical development in rubber tire reinforcement. - Entering the market at the right moment gives a chance for a better position in regard to the competitors producing rayon cord or polyamide fibre reinforcements.

The already established home market should be the basis for further extension of sales and mutual exchange of petrochemicals in different generations to other countries or even regions. - If the chemical plastics the building industry is [illegible] for example, it could be big quantities of raw materials for the production of building panels, elements, tubes, etc.

Generally, the correct interaction with the consumption of petrochemicals for which the following conditions are significant:

Technical and economic development

Rising of living standard

Growth of the population

A criterion for the influence of the technical development to the consumption of plastics raw material on the home market is the number of existing plastics processing machinery for compression and injection moulding, extrusion, calendering, casting, etc.

For evaluating the trend of the home market development it would be worthwhile to follow up in all developing countries the percentage of yearly growth of the consumption for each product of the different petrochemical generations.

1.2) FOREIGN COMMERCE

Besides the home market the foreign commerce, especially exporting facilities for petrochemical raw materials is of importance for the future transfer of technology for the investment of petrochemical plants.

Existing trade statistics give a good view for evaluating the status and development of foreign commerce of a developing country. The structure of the commerce indicates the lines which could be followed in regard to the transfer of technology. A typical example in this regard is Libya as an oil exporting country which could profitably build up a petrochemical industry.

By oil refinin[illegible] and starting of petrochemical production better prices for the existing natural products could be achieved, which would raise the income of the population and could bring a better standard of living.

Oil represents more than 90% of the Libyan exports which amounted in 1963 to 284.471 Libyan Pounds (1 Dollar = 0,35 Libyan Pound). Imports in 1963 reached 114.418 Libyan Pounds. - Up to 20% they consisted of chemicals, machinery and transport equipment which belong to the oil and petrochemical industry.

Favourable for the existing foreign commerce is the sea location of Libya. It is only a question of planning the transfer of technology according to a suitable time schedule for realizing in the future a profitable petrochemical complex in this country.

1.3) MONETARY FUNDS

As indicated before, the costs for the transfer of technology amount to a certain percentage of the investment costs of the whole plant. The providing of capital for it depends on the monetary funds which are available for the whole investment.

As it is generally difficult to provide capital in developing countries, foreign investments or joint ventures are often the case of petrochemical enterprises. In many developing countries by law the foreign participation on a plant is restricted to a certain percentage of the whole investment.

Monetary funds are rare in developing countries. However, many countries are rich on natural resources which enable the building up of monetary values. The exploitation of minerals or petrochemical raw materials characterizes in general the first industrial activity of a developing country.

Due to incomes by selling big quantities of raw materials on the world market several developing countries are independent of foreign help in regard to financial helps e.g. i. Kuwait. However, annual sales of 100 million tons of crude oil are not sufficient to build up a stable economy for the future. For this technical experts with specific industrial experiences are needed.

1.4) FOREIGN CAPITAL AND MULTINATIONAL ENTERPRISES

Capital can be received by the transfer from industrially developed countries, i.e. the OECD countries.

[illegible] the amount of the transfer to developing countries has been determined [illegible] OECD by the Pearson Commission to 1 % of the GNP of the participating countries. In 1967 the total flow of resources amounted to 11 billion Dollars, which the OECD countries contributed 98.4 %. International organizations [illegible] countries 1.6 %. - Another characteristic feature of the flow of resources in the OECD countries in 1967, including not only the multilateral and public but also private capital resources, but [illegible] through the ODP to the developing countries.

Switzerland's participation is characterized by the fact that the only private resources have been capital investments, whereas Switzerland's private investor gets from the government [illegible] investment.

Development aid covers 20 per cent of only multinational enterprises have been created in the meantime. However the world bank (1967) has expected that the development aid of the OECD countries will amount to [illegible] 20 billion Dollars. The resources available to the multinational enterprises can be regarded not only from the standpoint of common financial strategy, but also from the standpoint of international pool of technical, financial and managerial resources.

Besides public aid, private financial resources [illegible] of the investments. For promoting the efforts by the application of private financial aid the API (Association Internationale pour la Protection des Investissements et Privés en Territoires Etrangers) was founded in 1960 with headquarters in Geneva. The API is convinced that the increase international flow of private foreign investments can be promoted by the conclusion of multilateral conventions, - based on strict reciprocity and generally accepted principles of conduct towards foreign property.

In this regard, the following principles, which have been accepted by the OECD Council, by which OECD member governments affirm their adherence to the following principles in their capital ex

The right to fair, equitable and non-discriminatory treatment.

The observance of undertakings given by a State.

The compensation of damages caused by acts of strife to property, in accordance with the treatment with regard to expropriation, compensation, repatriation of capital and profits and freedom of transfer.

For establishing equitable rules governing international investment, the World Bank staff prepared guidelines, using as a basis the OECD report on that subject. The first draft of guidelines for treatment of international investment includes a key provision, that foreign investment be an integral part of the national development strategy. The guidelines, when finalized by an intergovernmental group, would be formulated as recommendations, which governments might be invited to apply to private foreign investors, through an exchange of letters. The World Bank staff proposals are now under study by its executive directors.

It might be advantageous for private investors to orient their activities with the investments of international organizations such as

The World Bank

The International Finance Corporation

The Regional Development Bank (Inter-American, African, Asiatic)

These principles have been recognized by an increasing number of capital importing countries as attested by the fact that they are to be found in more than 90 bilateral investment promotion and protection agreements concluded since 1959 by various countries. The UNIDO International Symposium on Industrial Development in December 1967 recommended the entering of governments into those agreements which promote and guarantee foreign investments.

The World [illegible] settlement [illegible] investment [illegible] int [illegible], [illegible] (I [illegible]) [illegible] , [illegible] , [illegible] but [illegible].

[illegible] settlement of investment [illegible]. [illegible] through [illegible].

1.c) PRICING POLICIES

The pricing policies [illegible] shall [illegible] with protection [illegible] the [illegible] of the export price of [illegible] the world market level [illegible] prohibitive for the future [illegible].

[illegible], the pricing policy is of great importance.

The selling price should [illegible] such production and market possibilities [illegible] in the developing country, but [illegible] international [illegible].

A further [illegible] the price [illegible] plastic material not [illegible] the price level [illegible] the part of the world could be prohibitive for further development.

Adequate specific price policies have to [illegible] intermediates as well as [illegible] products.

1.d) TAXES AND DUTIES

Most of the developing countries [illegible] in order to enable [illegible] from import [illegible] project, further important [illegible].

Tax [illegible] exploitation, [illegible], [illegible], etc.

The [illegible] of [illegible] affecting the transfer of technology. [illegible] specialized [illegible] enterprise. In developing countries [illegible] for the [illegible].

Several developing countries have been [illegible] profitability of their profits.

2.6) [illegible]

[illegible] primary [illegible] an existing unit for petrochemical [illegible] from the point of view of transfer of technology it is necessary to analyze [illegible] necessary.

By evaluating the technical know-how or technology in a more detailed form it will [illegible] the [illegible] components of the [illegible] for a petrochemical plant [illegible].

Detailed [illegible] product [illegible].

[illegible] plant [illegible], [illegible] availability [illegible], water, [illegible], electricity, etc.

Preparation of necessary [illegible] for approval [illegible].

Design of plant layout [illegible], ground plan, sketches sketch, the arrangements [illegible] plant and the [illegible]. After [illegible] adjustment of the [illegible] type of planned machinery [illegible], [illegible] will be established.

Interests [illegible] and maintenance of steel [illegible] for [illegible].

Specifications [illegible] materials, [illegible], heat exchangers, [illegible], pipes.

Flow sheets with technical description of all parts of the plant, including pump specifications, calculation of pipe-dimensions, evaluation of the utilities, etc. inventories.

Technical description of all parts of the plant as foundations, roads, railways, columns, heat exchangers, pressure vessels, machinery, building, control equipment, electrical installations.

Purchasing of the necessary equipment by evaluation of the offers. Supervision of the building, progress and planning of assembly and installation equipment according to the progress.

Guarantees according to the offers in regard to raw material consumption, electric energy of the plant and the utilities.

In the following the volume of services for the 'urea plant' in a practical case will be given. For comparison the engineering for the side plant including installations for storage, transportation and packing, utility plants, workshops and the basic engineering are subdivided in regard to material and man hours costs for building and installation as follows.

Flow sheets, utilities	13.6%
Shop systems, water, electric plant, wiring, installations, pumping houses for products	13.2%
Tanks for storage, including piping and accessories	3.5%
Tanks for LPG and similar	8.7%
Pipes for products, air, fuel oil, gas, vapor, inert gas, connections, including measurement devices for material balances	8.5%
	47.5%

	47.5%
Underground pipelines for cooling water, extinguishing water, drinking water, canalisation	7.5%
Electroinstallation including substations, lighting, telephone system, clock installations, cables, wiring	8.0%
Pump house for cooling water including water preparation and cooling	6.5%
Pressurized air station	9.7%
Fire extinguishing installation	7.6%
Plant for inertgases, storage and preparation for chemicals	13.2%
	100.0%

By evaluation of the above mentioned details, which are necessary for providing engineering services, the following technological criteria shall be considered in a developing country in regard to quality and quantity:

2.1) Raw materials

2.1.1) Crude oil

2.1.2) Natural gas

2.2) Refineries and gas liquefaction plants

2.3) Petrochemical plants

2.4) Energy and water supply

2.5) Labor availability

2.6) Technological development and automation

2.7) Computers

2.1) RAW MATERIALS

2.1.1) Crude Oil

The world crude oil production amounts to 1,8 billion tons and is expected to grow to 2 billion in 1975. In the year 2000 the crude oil production shall amount to 5 billion tons.

The main reserves of crude oil are in the Middle East and it is expected that oil reserves all over the world will be available with the growing consumption for several hundred years.

In regard to the developing countries the world oil production is favourable. At the time being, 29% of the oil production is effectuated in the Middle East, 15% in the Caribbean area and Latin America, 8% in Africa and 3% in the Far East.

Approx. 3% of the actual crude oil production is used for the production of petrochemicals. For the year 2000 it is expected that an amount of 15 to 20% will be used for petrochemicals.

Besides the availability of petrochemical raw materials at the well head of production, modern transportation facilities make it possible to bring it to any place in the world. By sea transportation with modern tankerships with capacities up to 250 000 tons, crude oil can be made available to seaports. Pipelines for the mainland for transportation in large quantities. There exist approx. 30 000 km of crude oil pipelines all over the world.

2.1.2) Natural Gas

The natural gas composition determines the possible application for petrochemical purposes. It consists mainly of methane, higher hydrocarbons (4-40% ethane etc.) of the paraffin series and impurities as sulfur hydroxide or other sulfur bearing compounds besides dust.

The actual production of natural gas amounts to approx. 600 thousand million m^3 per year, of which approx. 7% are used for the production of petrochemicals. - The life time of existing reserves is assumed to an average of more than 100 years. However, the natural reserves shall be available for approx. 1000 years. - The detection of new sources, especially

on an ground, will bring new resources to our knowledge.

For transportation of natural gas, pipelines and tankships are available. Methane processing plants with capacity of 1,400 tons liquid methane can provide natural gas from Algeria to Great Britain.

An example of a gas pipeline system which exists in developing countries, is the network of more than 2,000 km that exists in all Iran and Turkey; further 4,000 km are under construction. Pipelines of the order of many thousands of kilometers.

Besides methane other liquid gases including ethylene are available which are important for the petrochemical industry.

Petrochemistry is that chemistry which converts the products from natural and other liquid gases into chemicals such as methanol, methanol, ethylene and its derivatives hydrocyanic acid, acrylates, etc.

The price of natural gas varies according to the distance of the well head. The price for 1 m³ at the well head amounts to 0.5 cts. at the Persian Gulf. The pipeline transportation increases the price.

Assisted natural gas reserves in developing countries may be the start of future petrochemical complexes. The most important are the natural gas reserves in the Arabian countries as Libya, Venezuela etc., where big quantities are still being flared.

2.1 [illegible]

There existed in 1967 in the whole world 60 refineries (without Eastern countries) with 1,100 million tons capacity throughput.

The refineries have petrochemical facilities and are hence the nucleus of a petrochemical complex. Naphtha production is still performed in numerous refineries with small capacities.

Whereas naphtha is available elsewhere, it means competition for raw material, which is provided from natural gas.

The highest petrochemical industry is devoted to petrochemistry in the area where refineries serve the small base petrochemistry.

2.3) Petrochemical Plants

For the transfer of technology for the project the already existing petrochemical plants are of great importance.

According to the report of the First International Conference on the Development of Petrochemical Industries in Developing Countries (1968), the following number of different petrochemical plants or projects were in existence in 1963:

Kind of Plants or Project	Number	%
Ammonia and nitrogen fertilizers	41	32.4
Plastics	36	28.6
Synthetic rubber	7	5.5
Synthetic fibres	3	2.4
Others	42	33.3
Unspecified	3	2.4
	126	100.0

The location of the above mentioned plants or projects in developing countries was as follows:

Developing Countries	1963		1968
	Plants	Projects	Plants
Latin America	46	25	117
Asia and Far East	12	30	42
Africa	1	4	5
	61	70	174

The data for 1968 are compiled from material contained in the publication "Petrochemical Plants".

2.4) ENERGY AND WATER SUPPLY

The amount of different kinds of energy needed for a petrochemical project is clearly defined in the engineering specifications.

In planning a plant it has to be adapted according to the local conditions, to the different available kinds of energy.

2.4.1) Electricity

According to the specifications for the production of 100 kg vinylacetate, 31 kwh electricity are necessary.

In a developing country electricity may be available; the costs vary according to local conditions and are dependent on the quantity of consumption per year. For example in Venezuela 1 kwh costs 0.8 cts. at a minimum consumption rate of 100,000 kwh per year.

By building gas turbines it is relatively easy to get the necessary electric power, independent of local or other considerations which may influence the plant size.

2.4.2) Steam

For the above mentioned production of 100 kg vinylacetate 560 kg vapor are needed.

Steam can be generated by own boilers. In some countries steam is available at the price of $ 1,34/metric ton (Venezuela).

2.4.3) Water

Water is necessary for the running of the production in many chemical plants. For instance for the production of 100 kg vinylacetate 56 m^3 cooling water are needed. Water costs are varying in developing countries depending on the supply situation. Generally, at 0.03 cts. per gallon water may be available. In Venezuela the costs are 0.02 cts. per gallon.

2.5) LABOR AVAILABILITY

The transfer of technology is highly affected by the amount and quality of labor which is available in developing countries.

The construction of a plant in a developing country is dependent on the labor and skill of workers and foremen. After starting the production and demonstration of the functions of a plant by the personnel of the engineering firm, the local engineers must be able to run the plant independent from outside help.

To effectuate the transfer of technology for a medium size project it is calculated that the leading engineer, the mounting engineer and one foreman will stay approx. 6 months in the developing country. During this time the personnel of the investor can be instructed on the main problems of operation. After the start of a plant by a leading engineer it is assumed that in general the personnel of the investor has learned enough to run the plant without help from the engineering firm.

Within the team of engineers for the new plant a civil engineer for construction of the buildings is necessary. Existing facilities in this regard in the developing country can help the progress of the project and the economics of the costs by utilizing indigenous personnel.

Labor costs are the basis for calculating the engineer costs on the level of industrially developed countries. 7 Dollars is the average rate for calculating engineering costs in Europe.

The fact that unskilled labor may be very cheap in developing countries (f. i. Pakistan 30 Dollars/month, Libya 40 Dollars/month, Saudi Arabia 80 Dollars/month) does not help very much for the amelioration of the situation, because skilled labor is very rare in such countries and must often be imported.

2.6) TECHNICAL DEVELOPMENT AND APPLICATION

Development is going on in the fields of technology, new processes and best methods of chemical, mechanical, electrical and civil engineering shall be applied by the transfer of technology to developing countries to compensate the difficulties and bottlenecks which are encountered in regard to industrial organizational and labor problems.

The control equipment of a chemical plant sums up all results of the progress of technology going on at this time. A high degree of automation, based on a simple design, will give the best chances for good function and high productivity of a new petrochemical plant in developing countries.

2.7) COMPUTERS

The highest degree of automation is characterized by the application of computers in addition to measuring and analytical devices used for the control of a petrochemical plant.

From approx. 40,000 digital computers in practical use today, approx. 1000 are applied in the chemical industry.- They are performing all kinds of calculations and control necessary for the different tasks existing for the running of a chemical plant, such as optimization, mixing of liquids, distillation control etc. - On-line digital computer process control is only applied to approx. 100 plants in industrially developed areas.

However, the utilization of computers in chemical plants is progressing and their application shall be considered in the transfer of technology in developing countries.

3.0) CONCLUSIONS

The setting up of an engineering contract for the transfer of technology for petrochemicals to developing countries involves besides economic considerations in regard to financing the project materials, the solution of many technological questions in regard to raw material supply, labor and utilities. - Engineering contracts for developing countries are enabling the transfer of latest technology, different as to the level of existing technologies in industrial areas the transfer to developing countries enables the

applications of suitable modern methods based on the current enormous advances of science and technology.

11.7.74