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A SYNTHETIC RUBBER PLANT? OR NOT? 1/

Some basic facts to be considered by a developing country when contemplating the establishment of a synthetic rubber plant

by

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I. INTRODUCTION

Throughout this paper, when [illegible] is made to the use of synthetic rubber the author assumes that such use [illegible] the large [illegible] outlets be combined with natural rubber [illegible] – for technical and cost reasons and because some developing [illegible] are themselves [illegible] natural rubber producers.

The study of the overlapping interests of natural and synthetic rubber producers is a highly complex one. As [illegible] can be foreseen, however, synthetic rubber producing countries, whether developed or developing, will continue to use very substantial quantities of natural rubber except, perhaps, in times of national emergency when supplies of the natural product may be cut-off.

II. REASONS FOR ESTABLISHING A SYNTHETIC RUBBER PLANT

A typical sequence of events leading to the establishment of the first synthetic rubber plant in a developing country could be represented by one or more of the following:

A) "Demand-pull" growth. That is, a well-established consumer demand for rubber based products (particularly vehicle tyres) leads to the building-up of a locally based rubber converting industry requiring imports of raw rubber for conversion.

It goes without saying that the development outlined above implies a degree of industrialisation which includes a wide variety of industries and their infra-structure. For example heavy and light engineering, transport, perhaps mining and to a lesser extent such consumer products as footwear. A major factor in the sequence outlined above is the implied high level of self reliance in the form of engineering and technical know-how across a broad front of activity.

B) "Policy-push". This can happen when for example a manufacturer who is established in another country, maybe internationally, decides to expand into a developing country perhaps to supply one or more possibly tied outlets (particularly a tyre plant) supplemented perhaps by a certain amount of exports. In this case the developer would probably supply his own know-how and technical personnel.

[illegible] [illegible] which [illegible] by [illegible] polym[illegible]

A [illegible] a country [illegible] for [illegible] reasons [illegible] [illegible]. In [illegible] enough to [illegible] natural rubber.

[illegible]ES OF SYNTHETIC RUBBER

The following [illegible] the approximate [illegible] percentages of the various grades of [illegible] world [illegible] produced throughout

Natural rubber (NR)	27%
[illegible] rubber ([illegible])	[illegible]
Butadiene rubber ([illegible])	[illegible]
Isoprene rubber (IR).	[illegible]
Other rubbers (Butyl, EP, Chloroprene, [illegible] etc) [illegible]	[illegible]
	100%

Undoubtedly SBR remains the most significant synthetic rubber used today. This is due to its price and performance characteristics [illegible] used and its universal consumption by manufacturers of [illegible] certain end-tyres for technical reasons. IR has certain drawbacks relating to the passenger vehicle availability of isoprene precursor feedstocks and polymerisation technology, amongst others. BR, a more recently developed product, has some of the characteristics of NR.

On a par with IR in terms of potential [illegible] are the ethylene/propylene (EP) polymers. These too have [illegible] performance characteristics (heat resistance and atmospheric [illegible]) which could lead to reasonably large tonnage consumption for tyre manufacture. However, owing to the time-consuming test and blend development programmes to which all new elastomers are subjected, especially by tyre companies, it is unlikely that a decisive assessment of the true potential of EP rubbers will be made in the near future. In addition the status of current polymerisation chemistry and curing techniques are [illegible] insufficiently developed to allow the product to be used other than in processing plants with highly specialised staff and equipment.

Polychloroprene [illegible] and [illegible] the USA. The former is [illegible] to produce [illegible]. The [illegible] of the latter is mainly confined to [illegible] and attempts to extend this by, for example, incorporation into tyre tread blends have not proved successful.

Isoprene rubber (IR)

Two different types of know-how are required for making this rubber - that involved in making the monomer as well as that required for its polymerisation.

i) The SVA process uses acetylene and acetone. The disadvantage of this process most frequently cited is the (usually) high cost of acetylene.

ii) The IFP process, uses isobutylene and formaldehyde as raw materials. This is used widely in Eastern Europe and Japan, but is unlikely to be suitable for developing countries.

iii) The Goodyear/Scientific Design process, uses propylene as the starting material. This is one of the most successful processes for producing IR and could be of interest to developing countries. A modification, developed in Japan is based on the dehydrogenation of a product formed from a reaction between ethylene and propylene by disproportionation.

iv) The Shell process, uses the dehydrogenation of iso-amylenes extracted from refinery streams. Although in the literature on synthetic rubber production it is stated that the Shell process is competitive and perhaps cheaper than the other commercially established processes there remain substantial doubts about the availability of satisfactory quantities of suitable refinery streams. As a large oil product producer, Shell is perhaps not as limited by this restriction as other possible users may be This argument of course may not apply in the case of a developing country with a substantial refining capacity. Isoprene can also be obtained by extraction from the C5 stream from a naphtha cracker but again, very large quantities are required (very roughly 30,000 tonnes of isoprene co-produced with 1 million tonnes of ethylene).

Polymerisation technology is based on highly sophisticated catalysis techniques. Some (e.g. Goodyear) produce high cis stereo-regular IR and some (e.g. Shell) produce low cis polymer.

[illegible] in [illegible] companies [illegible] Phillips, [illegible] and [illegible].

[illegible] to take place – mainly in Japan and USSR [illegible] in W. Europe but [illegible] type [illegible] for a developing country to [illegible] the establishment of a synthetic rubber industry.

Butadiene rubbers (BR)

Although [illegible] developed and [illegible] processes these materials emerged as commercially viable only in the early 1960s. Two [illegible] types are available, both [illegible] content (98%) and [illegible] low [illegible] having a high cis-[illegible] based on "solution" techniques ([illegible] below). Polymerisation for blends designed to produce specific qualities [illegible] can be used in and greater scope in blending (see [illegible]). [illegible] improved resilience

Styrene-butadiene rubber (SBR)

The technology of SBR production and compounding is well known and has been the subject of repeated scientific papers over a period of years. Many plants have been built, some in developing countries. Most are 'emulsion' types (see below) and chemical engineering contractors are able to make 'turnkey' quotations.

Over the last few years a new family of SBR types has emerged. These are the SBRs produced by 'solution' techniques. These allow the intrinsic properties of the polymer (particularly the molecular weight) to be modified within limits required. The older established SBRs are usually based on well-known emulsion polymerisation techniques. These give random co-polymers of styrene and butadiene with wide molecular weight distribution. Solution polymerisation techniques on the other hand, although allowing the production of random co-polymers, also permit the production of products having specified molecular weight distribution patterns differing substantially from the older emulsion types. Through polymerisation control it is possible to produce SBRs having a wide range of chemical and physical characteristics. For example high vinyl products and low vinyl products.

As a result many rubber specialists predict that the future growth in SBR production capacity will be based mainly on solution SBR technology perhaps on plants capable of producing both BR and SBR. Production techniques [illegible] any developing country [illegible] plant should [illegible] of emulsion and solution [illegible] made on the same plant [illegible].

Thus for most developing countries the elastomers most likely to be of interest are BR and SBR - particularly the latter. Many grades of SBR are produced for many end uses. Some contain a petroleum oil which is incorporated during manufacture.

IV. BASIC CONSIDERATIONS

A) Available manpower

The production of synthetic rubber is not manpower-intensive. Emberson, in a paper on the economics of establishing a synthetic rubber plant in a developing country (UNIDO conference, Baku 1969) stated that a 50,000 t.p.a. plant requires 5[illegible] men, 1[illegible] of them unskilled. Thus some authorities would criticise the establishment of a synthetic rubber industry in a developing country as not satisfying what they consider should be the main aim of the governments of such countries namely to provide employment for large numbers of people, particularly those unskilled and semi-skilled. Certainly the availability of adequate numbers of skilled and trained personnel is an important factor when considering the establishment of a synthetic rubber plant.

Of course imported skilled operatives maybe used but this is likely to be very expensive and cannot be considered on social grounds for more than a limited period.

The problem of skilled labour is a particularly important one throughout the rubber industry perhaps more so in the rubber processing sector than in the manufacturing sector. Formulations which yield the most acceptable products are derived from combinations involving the art of mixing by personal judgement based on experience as well as on technical and scientific grounds. The rubber industry demonstrates to an unusual degree the co-operation on the one hand of conservative personal experience (combined art and "cookery") and on the other hand highly sophisticated scientific techniques. Even in the highly developed tyre industry certain functions, if performed in [illegible]

[illegible] to [illegible] the mill [illegible] supervisor [illegible]

[illegible] of a [illegible] training programme to [illegible] qualified personnel. If possible arrangements should be made to attach [illegible] to [illegible] developed countries.

[illegible]

The government of any developing country contemplating the establishment of a synthetic rubber plant should [illegible] specialists to obtain and collate as much [illegible] as is possible. These specialists should not only study the technical literature and published statistics very thoroughly but should also make extensive personal contact [illegible] wide a possible selection of established producers and consumers. Often such personal contacts will show up inaccuracies in published [illegible] which may be vital for decision making. Above all an accurate survey should be made of likely rubber usage over the next say 10 years in the country concerned. Possibilities for exports should not be overlooked but considering the world supply situation for the foreseeable future very little weight should be attached to exports when coming to a decision.

Published statistics on the production costs, outputs, qualities etc. of natural rubber are exceedingly well documented, but there is not quite such detailed information available about synthetic rubbers. It is most important that very thorough studies of estimated plant production capacities and likely availabilities and prices of feedstock materials be made at the same time since the cost of synthetic rubber is very dependent upon the costs of the raw materials - some would estimate as high as 65-70%.

C) Vehicle Tyre Consumption

In terms of total rubber usage worldwide, vehicle tyre outlets account for about 50-70% of the rubber consumed. The proportions consumed for this end-use in developing countries are likely to approach the higher rather than the lower figure. Thus it is most important that thorough surveys be done of the future patterns of rubber consumption for new tyres and f[illegible].

Care must [illegible] to [illegible] different types [illegible].

The following table gives approximate [illegible] figures for rubber consumption by type and end-use in a [illegible] W. European country (in 1000 tonnes):-

Product	NR	SBR	Other	Total
Car Tyres	[illegible]	[illegible]	[illegible]	90
Commercial Vehicle Tyres	[illegible]	[illegible]	[illegible]	74
Tractor etc Tyres	6	10	1	17
Cycle	0.[illegible]	1	0	[illegible].5
Other	4	[illegible]	20	[illegible]
Retreads	6	[illegible]	0	[illegible]
Total Tyres etc.	91.5	92	[illegible]	218.5
Cables	2	4	3	9
Hose	3	[illegible]	6	12
Belting	5	[illegible]	[illegible]	9
Footwear	6	6	1	13
Cellular products	6	0	10	16
Miscellaneous & Unknown	64	2[illegible]	60	145
Total Non-tyres	86	37	82	205

D) **Patent and licensing situation**

Usually provision of know-how will include access to patented techniques of which there are very many. A fee of 2-3% of proceeds is sometimes asked. The whole field of polymerisation techniques is surrounded by patent restrictions and the advice of experts must be sought particularly in the field of solution polymerisation where sophisticated techniques requiring complex catalyst technology are necessary.

E) **Process and Production Costs**

The literature abunds with costing studies for synthetic rubber - particularly SBR. These mostly relate to hypothetical cases in developed countries although Vachez in a paper presented at the

UNIDO conference in [illegible] quoted [illegible] figures. It is impossible to [illegible] (or [illegible] developing countries) with so many variables - [illegible] of plant, [illegible] cost of feedstocks and utilities.

It seems unlikely, however, that wherever situated a plant of capacity less than [illegible] tonnes p.a. would be a sound proposition - and this would have to reach full loading within a few years. It is possible, however, that a smaller 'ro[illegible]' type rubber plant based on imported feedstocks may be viable but, as mentioned earlier complex techniques are required.

F) Monomer Feedstocks

i) General

Most of the monomer feedstocks are derived from petroleum refining sources and hence the cost of their production is linked closely with the cost of the conversion of crude oil into a variety of products. The latter range between heavy fuel oil and the sophisticated lighter fractions used for the production of, for example, motor gasoline and petroleum chemicals. Various sources of crude oil yield differing proportions of the many fractions and as demand and capacities vary so does the value of each product.

Perhaps more important than the cost of production is the alternative use value of many of the basic chemicals since many can be used for different purposes.

For example, at present in the USA there is a shortage of motor gasoline. This shortage is caused partly by alterations in crude oil quality and supply patterns and partly by environmental considerations. This has lead to a shortage of aromatics which now tend to be retained as constituents of motor gasoline rather than being produced as chemicals or feedstocks.

One of the aromatics is benzene and the current shortage has grown dramatically almost overnight. In mid 1972, for example, benzene could have been purchased at about US $ 80 per tonne but now the price is nearer US $ 135 per tonne. This has important consequences for the SBR producer because the cost of styrene monomer is related directly to the price of benzene. Because styrene will polymerize slowly even when additives are used, it is not possible to organise large buffer stocks. Thus changes in benzene supply and cost are reflected almost immediately in the supply and cost of styrene monomer. For example, in mid 1972 styrene could be purchased in Western Europe for about US $ 150 per tonne. In April 1973, spotlot quotations had increased to about $ [illegible] per tonne and prices are expected to reach $ 700 per tonne by end 1973. Even consumers having long term supply arrangements are being confronted with substantial price increases of up to 30% or more on previously agreed prices. The effect on SBR manufacturing costs may be imagined.

The moral for developing countries is clear. If raw material monomers are to be imported then supplies must be safeguarded as far as possible. Even then some allowance will have to be made for increasing prices. The growing world energy demand which, certainly in the medium term will continue to rely on fossil fuels is bound to influence monomer prices. As prices for motor gasolines and other fuels increase these outlets become attractive alternatives for refinery streams which would otherwise be used for processing into petrochemical feedstocks.

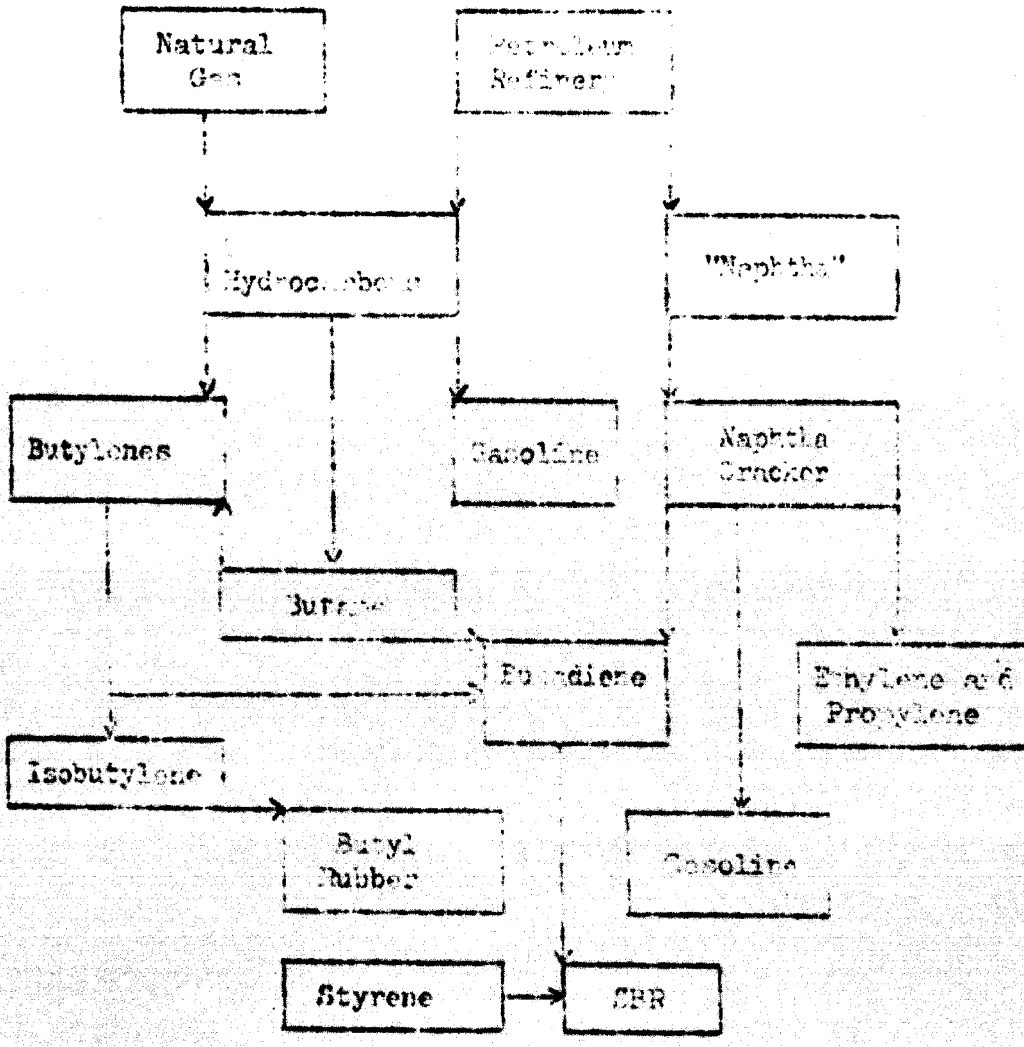
Even if the synthetic rubber plant of a developing country is linked directly to an oil and/or petrochemical complex, world economics will probably dictate that the supply prices of feedstocks to the synthetic rubber plant will increase as the management of the oil refinery section sees the need for increasing the returns on its various hydrocarbon streams.

ii) Butadiene

The major sources of butadiene are as follows:

Butane dehydrogenation	about 35%
Butylene dehydrogenation	about 45%
Recovery from olefin plants	about 20%

these sources can be illustrated by the following highly simplified diagram:-



The dehydrogenation of butylenes or butane by catalytic processes as depicted on the lefthand side of the above diagram is in common use in the United States. Production of butadiene from naphtha crackers is used much more extensively in Europe. The C4 streams emerging from a naphtha cracker operating at high severity can contain as much as 30% butadiene.

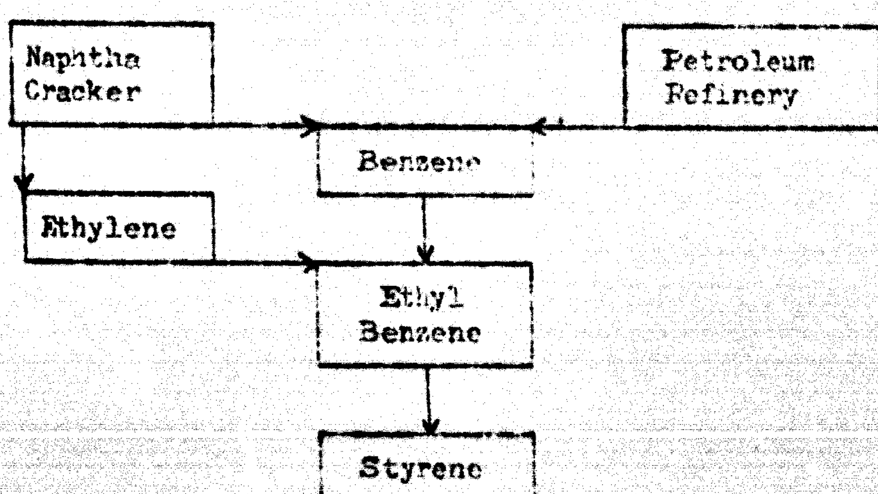
The above diagram clearly illustrates the inter-dependence of the various end-products which in turn become feedstocks for further downstream operations including the manufacture of synthetic rubber. Note the linking of ethylene, propylene and butadiene ex naphtha crackers. The catalytic dehydrogenation processes also produce a wide variety of products and inevitably the introduction of new capacity will have repercussions on related co-products. Catalytic dehydrogenation facilities are an integral part of refinery operations and a list of producers of butadiene will [illegible] the major oil companies.

Naphtha cracking, although relying on [illegible] to oil company refinery technology has become an area in which chemical companies are participating far more deeply, and this evolution may represent [illegible] of interest [illegible] developing countries. In a typical naphtha-cracker complex operating at normal severities producing say 30% ethylene there would be co-produced 3-4% butadiene. Thus to produce about 20,000 tons per annum of butadiene (i.e. sufficient to produce about 30,000 tons per annum of clear polymer) would require a naphtha feed of about 700,000 tons per year. This represents very roughly a 200,000 tons per year ethylene cracker.

At present spot quantities of butadiene are obtainable at about US ¢ 6-7 per lb. but this could easily approach ¢10 per lb. if relative demand patterns in the USA and Western Europe were to change significantly.

iii) <u>Styrene</u>

For the production of this monomer two raw materials are required, benzene and ethylene. The benzene can be obtained from refinery operations or (with the addition of ethylene) from a naphtha cracker. The two can be combined in the following scheme:-



However such a production scheme would not normally be set up to provide monomer for SBR production. The largest outlet for styrene is for the production of polystyrene. Consequently any developing country considering the production of styrene feedstock for SBR would need to evaluate polystyrene as well. As a guideline to the order of [illegible] tons per year ethylene cracker would probably support a styrene unit of about 50,000 tons per year depending upon the levels of aromatics produced from the pyrolysis [illegible].

V. NECESSITY FOR TARIFF PROTECTION

Always assuming that foreign exchange is available it is almost certain that for the foreseeable future a developing country could import supplies of synthetic rubber grades at lower prices than these could be manufactured locally. Thus some sort of import control or tariff protection would have to be instituted by the authorities of the country concerned. This form of protection for industry in developing countries is allowed for in the GATT rules. However care should be taken that too great a burden is not placed upon rubber users who of course have to pass their costs on to the community at large.

In addition, countries who are signatories to the GATT and who impose import restrictions and taxes to protect a local plant would need to consider the possibility that balancing concessions on other products may be required (may be at a later date) to fulfill GATT obligations.

VI. CONCLUSIONS

The effects of a synthetic rubber plant on the related sectors of the economy of a developing country and, to a lesser extent possibly in so far as such a plant would reduce NR consumption, on the economy of other developing countries who produce natural rubber may be considerable. The foreign exchange requirements for the construction of the plant could be relatively large and prices to the consumer are likely to be higher (but his supplies may be more secure). On the other hand the take-up of under or non-employed labour is likely to be small. The securing of sufficient, steady supplies of feedstocks at the right prices will be difficult.

The government of the country should certainly be closely involved in all discussions and studies from the earliest stage.

III. RECOMMENDATIONS

Bearing in mind what has been said in the previous pages, if a developing country wishes to investigate a case for the establishment of a synthetic rubber plant the following steps are recommended.

1) A thorough grade by grade survey of the current and future rubber consumption of the country should be organised.

2) If this indicates that the national consumption of synthetic rubber is likely to rise to about 30,000 tons p.a. within say 5-10 years then a study should be made of the possibility of establishing an emulsion-type SBR plant based on imported feedstocks. Alternatively a smaller plant could be considered for making solution-type SBR and perhaps BR. It is essential, however, that this study includes a thorough assessment of the likely international supply/demand situation over the foreseeable future with regard to both feedstocks and rubber and the implications of this situation on the economics of a local plant.

3) At any stage it would be possible to integrate the rubber plant with a naphtha-cracker. For countries (usually those with petroleum resources) with an established naptha cracker (or considering one) the studies can be based on local feedstocks. There would have to be a policy decision on whether to value these at cost or alternative use value and if the latter, whether to consider only local values or world values.

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