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Future Prospects for Natural Rubber: Production, Processing, End Uses*

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Only one statement can be made with complete assurance concerning the future development of the natural rubber (NR) industry: the future is clouded with greater uncertainty than at any time in the past. The NR industry is certainly not unique in this respect; *all* industries are finding it exceptionally difficult to plot their future course, given the complex economic problems that have resulted from the various shocks that the world economy has experienced since 1973. Despite this, it is essential to try to identify and analyse the principal factors which seem likely to influence future developments with the production, processing and end uses of NR, recognizing the virtual impossibility of quantifying the outcomes.

1. Market share

For many materials and products, market share provides some measure of competitive status, a high share being regarded as desirable, a low one as dangerous. This is not the case with NR; its market share (i.e. the amount of NR used worldwide expressed as a percentage of total elastomer demand) is virtually entirely governed by supply rather than demand. In any year a certain quantity is produced and all of this is consumed (disregarding changes in stocks). Thus, NR's market share is not a measure of its technical strengths and weaknesses relative to synthetic rubbers, and the fact that this share has fallen from 100 per cent prior to 1939 to about 30 per cent today results simply from NR production having grown much too slowly, for various reasons, to match the growth of world elastomer demand. Indeed, there is evidence to suggest that, if the rate of increase in production could be accelerated, NR's market share could rise to around 40 per cent on the basis of its technical and economic characteristics [1].

In fact, NR's market share has stabilized somewhat in recent years *(Figure 1)*. This is not the result of a relative increase in NR production but is due to a sharp cut-back in the rate of growth of world elastomer demand since 1973. From 1955 to 1973 this rate was 6,7 per cent/year; from 1973 to 1980 it averaged 2,7 per cent/year, and this much lower rate largely offset the similarly sluggish growth in NR production.

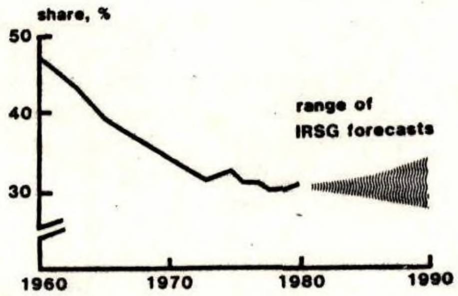

Figure 1. Natural rubber's share of the world market, 1960 – 1980, showing the range of International Rubber Study Group forecasts for 1990

For the future, up to 1990, as Figure 1 shows, the most recent and authoritative forecasts by experts reporting to the *International Rubber Study Group* are widely scattered, exemplifying the basic uncertainty noted earlier. The middle view is that NR's market share will remain fairly static, but even if the growth in NR production follows the pattern predicted by the gloomier forecasters there should still be an adequate supply to satisfy the minimum demand for NR, and talk of a 'growing shortage' of NR does not seem warranted. This, though, could come about if there were to be a major resurgence in world economic activity: the expected increase in NR production during the 1980s probably would not cope with this.

2. Future production requirements

Whatever view one takes as to the future course of the world economy there is no doubt that there is need to plan for a substantial increase in NR supply over the coming decades.

By the end of this century the world will require not less than 7 – 8 million tonnes/year of NR, double the present supply. It is true that part of this could be replaced by synthetic polyisoprene, but – again from a world rather than a national viewpoint – it does not seem desirable to

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plan to replace one polymer with another requiring ten times as much energy to make it (ca 15 GJ/t for NR; ca. 150 GJ/t.for synthetic rubbers) [2]. It is also true that part of this could be replaced with polyisoprene from *Guayule;* there are ambitious plans for large-scale cultivation of *Guayule* in the southern USA and Mexico, but it is not easy at this time to anticipate the extent to which these will be fulfilled. Substantial production from *Guayule* over the next 10 – 15 years seems unlikely.

It is reasonable to suppose that most of this 7 – 8 million tonnes/year will come from *Hevea,* and from those countries which are currently NR producers. Indeed, there is now renewed confidence among these countries concerning the long-term value of NR to their economies. This is evidenced by the substantial investment of time and money in a recent major expedition to the Brazilian rain forests to search for new types of *Hevea* for another generation of breeding programmes. This confidence is reinforced by inception of the *International Natural Rubber Agreement* which provides a guarantee to smallholders – who produce the bulk of the world's NR – that they will be protected against unreasonably low prices.

This required doubling of NR production over the next 20 years will require attention to several important problems. The problems arise principally because the major NR producing countries (notably Malaysia) are experiencing very rapid transformation from agrarian to industrial economies, with consequent shifts in socio-economic structures. In particular, there is now appearing a severe *shortage of labour in the villages as people (especially the* younger generation) move into the towns where new industries are being developed.

There is thus need to reverse the traditional view that the labour intensiveness of NR production is valuable to a developing country; this is no longer true in many areas. At present, labour for tapping and collection of latex constitutes about one-half the total production cost, and this will need to be substantially reduced. The NR production process will need to follow the developmental pattern of other agricultural activities, with introduction of mechanized processes. Recent work along these lines suggests that this is feasible. For example, replacement of orthodox tapping methods with 'puncture' tapping combined with use of yield stimulants is claimed capable of reducing tapping labour requirements to one-third [3], and there are also possibilities concerning reduction in the labour needed to collect material from the trees after tapping. There will be need to integrate and develop such ideas. There will also be the need to minimize the amount of land required; land has alternative uses (other crops including food, factories, housing) with which NR production increasingly will have to compete. Energy, as noted, is not a problem; the quantum involved is small and arises from fertilisers, processing and transport.

To sum up the production outlook: NR production should be adequate to meet demand throughout the 1980s on the assumption that the current depressed growth in world elastomer demand does not undergo significant change upwards. For the longer term, given that the production processes are evolved along the lines indicated, NR production can meet the expected demand for the rest of this Century.

3. Consumption patterns

Discussion of consumption in terms of individual end uses will be deferred for the time being, but there is one point that must be made at this stage since it is relevant to the sequel.

A significant new trend in NR consumption is emerging: a substantial increase in the proportion of NR consumed within developing countries, including those that are NR producers *(Figure 2).* Among this latter group, Malaysia is now consuming about 70000 tonnes/year and for neighbouring countries in South East Asia consumption is running at 30000 – 40000 tonnes/year. These are large figures, approaching the consumption of NR in medium-sized industrialized countries, and indeed the per caput consumption of NR in several producing countries has become substantial *(Table 1).*

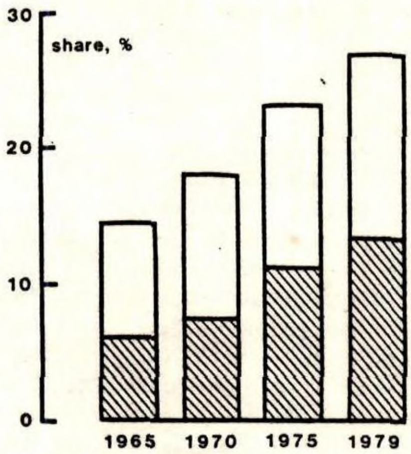

Figure 2. Share of natural rubber consumption taken by the developing countries. The shaded areas represent consumption by the natural rubber producing countries.

Table 1. **NR consumption**

	kg/head
Malaysia	3,1
Philippines	1,4
Sri Lanka	0,7
Brazil	0,6
Thailand	0,6
China	0,4
Indonesia	0,3
India	0,3
Developed countries	*0,4 – 3,4*

Once again, it is necessary to reverse former attitudes. For the past 80 or so years it has been seen as the role of certain countries, mostly in Asia, to produce raw NR for export to other countries, mostly in North America and Europe, for processing into products. This pattern is about to change, so much so that the centre of gravity of NR consumption will steadily shift from ‚North' to ‚South', and one may expect to see an increasing flow of rubber products from the NR producing countries.

4. Processing: energy and labour inputs

Processing, especially primary processing (mastication, mixing), is also about to undergo a number of significant changes. NR has to adapt to these changes otherwise it will lose ground. In the past, NR has proved a very versatile material; it proved able to adapt to the new requirements of rubber injection moulding 15 – 20 years ago, for example, and one need not doubt that it will cope with future processing needs.

These changes influence choice of the form and nature of the raw material, and the driving force behind them is the imperative need on the part of product manufacturers to conserve labour and energy. Concerning these two inputs it is necessary to make some observations to provide the correct perspective. Energy saving is of course important, and it can in effect be tackled in two stages. First, energy can be saved by thorough attention to 'housekeeping' throughout the factory, and it is interesting to note that both Czechoslovak and British research institutes have recently found that about 10 per cent of processing energy can be saved in this way [4, 5]. This aspect is largely unaffected by the elastomer used. Secondly, one can examine the possibility of using raw materials which are intrinsically less demanding of process energy, though it is important that the chosen raw materials do not require more energy for production that they save during processing. In fact, if total energy saving were the sole criterion affecting choice of raw material, NR would always be used, wherever technically suitable, but this is an oversimplification. In any event, when converted into costs, energy is outranked by labour. Analysis of some European statistics indicates that the process energy cost per tonne of rubber processed is about £ 150, against £ 500 – 700 for labour, and the energy costs are typically less than 10 per cent of the total value added during processing [6].

5. Thermoplastic NR

Conventional rubber processing suffers a distinct energy disadvantage compared with plastics processing: 50 GJ/t against 15 GJ/t. This is probably not the main reason for the fast growth in use of thermoplastic elastomers; there are other features such as lower labour requirements, the ability to rework scrap, etc., i.e. all the features which favour plastics over rubber. In the USA, virtually the entire increase in elastomer consumption between now and 1985 is expected to be accounted for by thermoplastic elastomers, with a no-growth position for conventional rubbers [7].

To this challenge NR has already reacted: there exist thermoplastic NR (TPNR) materials which are based on blends of NR with a polyolefin, typically polypropylene, the blends being readily prepared by normal internal mixing [8]. Production can take place anywhere in the world, though there are cost advantages for production in an NR producing country *(Table 2)* [9]. Although these materials are not yet in full commercial production, sufficient experience has been gained to be confident that production poses no technical problems. Envisaged applications include automotive components *(Figure 3)* and a variety of industrial and domestic products.

Table 2. **Production costs of TPNR blends**

	£/t UK	£/t NR producing country
NR	300	270
PP	*250*	*250*
other mtls	30	30
capital	80	25
labour	40	5
power	20	15
maintenance	5	5
	725	600

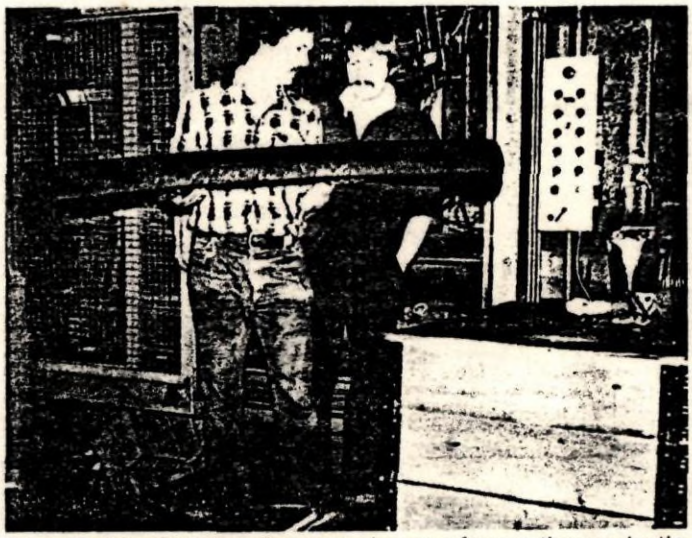

Figure 3. Injection moulding a car bumper from a thermoplastic natural rubber/polypropylene blend

For the more distant future there is the possibility of another form of TPNR similar in structure and properties to block copolymers of the SBS type. Laboratory work has established the feasibility of preparing graft copolymers of NR with a number of polymers including polystyrene, though much chemical engineering development will be needed to achieve viable production [10]. The chemical route is set out in *Figure 4.*

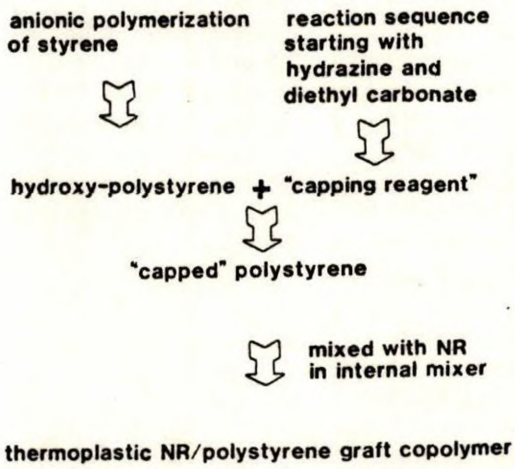

Figure 4. Reaction sequence for the preparation of a thermoplastic graft copolymer from natural rubber and styrene

6. Powdered NR

In theory, powdered elastomers offer energy savings, plus simplified and therefore cheaper processing. In practice, despite many claims by many people over the past decade, powdered elastomers have not yet taken off; world usage is less than 2 per cent of total elastomer usage, and an earlier 'Delphi' study by the *Du Pont Company,* that by 1980 50 per cent of elastomers would be used in powdered or granulated forms, now looks optimistic in the extreme.

There is no doubt, though, that use of powdered elastomers can save energy, though the savings are smaller than some have claimed, around 10 per cent of primary processing energy at best. For conventional internal mixers, powdered elastomers also have the advantage of eliminating the peak power consumption which is disproportionately expensive *(Figure 5)*. Their real potential for energy and labour saving (the latter being more significant) is seen only when used in the new generation of powder blenders/extrudermixers, where there is another perhaps more significant advantage: the ability to adapt to automated microprocessor-controlled mixing which will provide a degree of control of mix consistency unobtainable by normal batch methods [11]. This indeed could become one of the most important developments in rubber processing before very long.

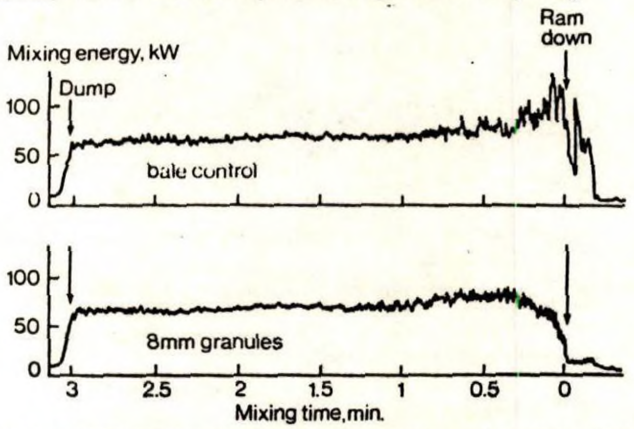

Figure 5. Comparison of mixing power consumption for powdered and bale natural rubber. The initial peak with bale rubber disappears when powdered rubber is used.

Again, NR is in a position to meet this new situation. Powdered/granulated NR can be made available, either as a material exported from producing countries or made locally from bale NR. In fact one form of fine-particle powdered NR, made direct from latex, is already commercially available from Malaysia [12], and there is a new process from latex involving elimination of the need to use a partitioning agent by hardening the particles via surface chlorination [13]. Production of coarser granulated material, by mechanical granulation, is undertaken in some consuming countries, and the technology has recently been described [14]. In Britain, current capacity for granulation is about 4000 tonnes/year.

Given the background of general uncertainty concerning the future it is not possible to be categorical as to when and where these and other new developments affecting the processing of NR will take place, but there are some clues. Concerning powdered NR, the main take-off is, as noted, dependent on investment in the new powdered rubber processing machinery, and this is more likely to happen in the case of completely new factories designed specifically and solely to use powdered elastomers. Given that the build-up of rubber products manufacturing is so great in the developing countries, and especially in the NR producing countries, the likelihood is that such countries may become the first major users of powdered NR. Indeed, there are interesting technical and economic possibilities in the idea of feeding a powder extruder-mixer direct with granules produced during the 'block rubber' processes operated in most of these countries.

There are no such obvious guidelines in the case of TPNR. This material is likely to be made not only in consuming but also in producing countries, according to the way the market develops.

The above discussion has concentrated on primary processing (mastication, mixing) because this is where current developments are seen to be especially significant. Concerning compounding and vulcanization the need is always recognized to improve the performance of NR, eg in respect of high temperature performance during processing and in service. 'Efficient vulcanization systems' are now well established [15], and further improvement is now possible using the new 'urethane vulcanization' method which is starting to attract interest and some usage, mainly in Britain [16].

7. End uses

A significant trend has emerged in recent years: the percentage of NR going into tyres and tyre products has increased substantially, from under 60 per cent twenty years ago to over 70 per cent today *(Figure 6)*. This results from the combination of the following factors:

- Production of car and truck tyres has grown much faster than NR production over this period (car tyres 12; truck tyres 16; NR 3,5, all in per cent/year).
- The proportion of NR in car tyres has been greatly increased by conversion to radial-ply tyres, and the extra NR consumption thus generated is only partly offset by the longer tyre life.
- Truck tyres which as noted have shown faster growth than car tyres contain a much greater weight of NR per tyre.

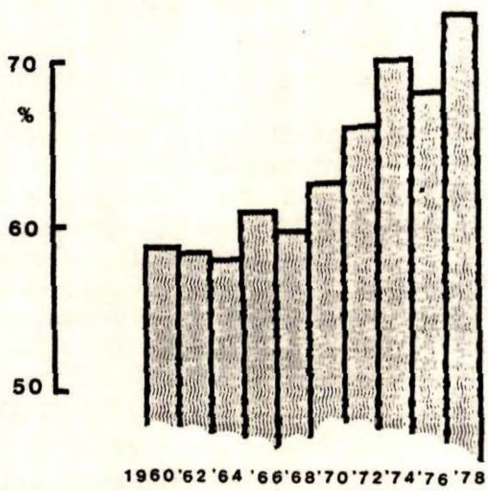

Figure 6. Share of natural rubber consumption taken by tyres and tyre products for eight major consuming countries

By definition, therefore, the proportion of NR consumed in 'non-tyre' uses has been getting appreciably smaller. In fact, after making allowance for NR consumption in developing countries as previously discussed and for latex consumption, one can estimate that only about 15 per cent (say 500000 tonnes/year) of NR is used by the industrialized world for non-tyre dry rubber applications.

This statistical inference reinforces an impression gained over many years, that in those less demanding applications where the special technical merits of NR (eg high strength) are not really needed, NR has been largely replaced by general-purpose synthetics and by plastics. This is an inevitable consequence of the slow NR production growth relative to grown in elastomer demand (as shown by the market share graph, Figure 1) combined with the tyre situation just discussed.

There is only one further point that needs to be made concerning the future status of NR in tyres. This status is unlikely to change over the next decade; NR is well-placed to cope with current technical developments and indeed has proved specially suitable for certain special needs such as improved winter tyres [17]. Over this time scale there is no serious likelihood that the usage of NR (and SBR as well) will be jeopardized by developments such as injection-moulded or cast cordless tyres made from polyurethanes; such tyres, if they come into serious use, will be suitable only for low speed vehicles.

In non-tyre applications NR has in effect become a special-purpose elastomer. That is to say, the fact that it accounts for only a small tonnage, as just discussed, does not mean that NR is in a state of decline. The reverse is true: NR's unique qualities have enabled it to establish new and demanding applications, of high value, consonant with the tonnages available. In this connexion, the move to high-quality technically-specified NR types since the launch of Standard Malaysian Rubber in 1965 is very relevant; so also is the development of special-performance modifications of NR eg epoxidized NR [18].

Typical of such end uses is the use of NR in laminated steel/NR bearings in civil engineering, either to permit slow thermal movements in bridge decks [19] or to isolate buildings from external vibrations [20]. In this applicational area the latest idea is to use such bearings to protect buildings against earthquake shock; preliminary indications are hopeful and development is under way [21].

It is not possible to predict exactly what kinds of new applications along these lines will come forward in the future. They will arise in response to 'consumer-pull': recognition by an industry, or an individual, of a problem or an unfulfilled need, which may be assisted with the use of NR. The NR industry actively seeks to encourage this innovatory flow, by maintaining a continuous dialogue with end users in many different kinds of industry worldwide, and by making sure that appropriate research and testing are carried out, with effective promulgation of the outcome.

8. Final comments

Throughout this paper a picture has deliberately been built up of an industry facing the need for major changes. Production technologies have to change in response to changing socio-economic needs in the producing countries. The geographical distribution of consumption has changed, very dramatically, and this will influence future technological options. The form in which the raw material is offered may also change to meet the new requirements of consumers concerning the need for higher labour productivity and energy conservation. And end usage patterns look very different from those of twenty or thirty years ago.

The NR industry is well used to coping with change; it has done so for many decades. There is no doubt that the intrinsic qualities of the material itself, allied with the resourcefulness of its producers and the wide-ranging nature of its supporting research and development activities, will ensure that the industry will react sensibly and correctly to whatever the future may have in store.

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