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NEW PRESENTATION PROCESSES—AN ESSENTIAL FEATURE OF MODERNISATION OF THE NATURAL RUBBER INDUSTRY

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INTRODUCTION

The need for modernisation in the NR industry stems fundamentally from the competitive pressures that are applied by the synthetic rubber industry on the one hand, and scientific progress in consumption technology on the other. While these pressures have been with the industry for some time, a new dimension in this competition was introduced with the discovery and development of methods of producing the chemical substitute of natural rubber, *i.e.* cis-1, 4-polyisoprene, in the test tube. An effective answer to these competitive pressures can only be found in modernisation of the agricultural sector to attain cost efficiency and cost competitiveness and modernisation of the technological sector to achieve processing efficiency and product competitiveness.

In the first instance the NR industry accepted the need to attain cost efficiency, and a concerted effort was mounted to modernise the agricultural sector of the industry. The most successful endeavour in this regard has been the progressive upgrading of genetic material available for replanting. From materials capable of yielding 500 — 600 lb/acre/year, improvements effected by breeding in many producing countries have made available planting materials capable of sustained yields averaging more than 2,000 lb/acre/year. Along with this development, sophistications were also introduced in propagation and planting methods, fertiliser applications, disease control and exploitation methods. Two other outstanding developments are in the pipe line. I refer here to (1) the three-part tree combining the best characteristics in stock, scion and crown; (2) the control of factors governing latex flow on tapping. The former should ensure healthy *Hevea* trees possessing satisfactory high yield characteristics by immediate manipulative techniques using available genetic material. The latter development is potentially not only capable of upgrading planting materials already on the ground, but also for the first time providing flexibility and elasticity in labour productivity and production. In a series of trials some extending for more than 18 months, the new concepts on stimulation and exploitation methods were tested with the following broad indications :—

(1) Yields of many of the older clones particularly on panel C can be doubled, *e.g.* yield levels of PB 86 and Tjir 1 increased to well over 2,000 lb/acre/annum ;

(2) Tapping systems of reduced intensity can at least maintain yield levels of conventional tapping systems ;

(3) Some of the more modern clones, inspite of their already high levels of yield, respond to stimulation with corresponding increases, *e.g.* RRIM 600 yield increased to over 5,000 lb/acre/annum on panel C ;

(4) Seedlings have also responded in similar fashion to the new treatments ;

(5) No detrimental effects on the tree have become evident so far, although sustained experimentation for a much longer period would be required before the general applicability of these preliminary findings can be established.

Some of these biological innovations are yet to be implemented in practice. However within the Malaysian context, modernisation in the agricultural sector has already begun to pay handsome dividends. The effectiveness of the replanting programme, good agricultural practice and discriminating exploitation in the conventional sense, are together increasing substantially the national yield per acre per annum. In 1955 with 3·8 million acres under rubber, Malaysia produced 637,000 tons, while in 1969, 1·19 million tons were produced from 4·2 million acres. In the next five years it is anticipated that West Malaysia alone will contribute at least a further 500,000 tons of rubber to total annual production.

Taking the agricultural improvements as a whole—past, present and imminent, the simple consequences of all these will be (1) cost efficiency and cost competitiveness of natural rubber can be assured, and (2) appreciably increasing supplies of natural rubber will become available in the coming years. This situation is certainly true of the Malaysian NR industry and it should also progressively obtain in all other producing countries. Against this background, the need and importance of the second aspect of modernisation has to be assessed and viewed. Not only has the NR industry to withstand existing pressures to retain present markets, it has in fact to enhance preferential market acceptability for NR, to ensure the uptake of increasing supplies that will become available in the coming years.

Before reviewing the progress made in the area of new processing methods, it would be appropriate to define requirements and desirable objectives. Two factors govern market acceptability. These are : (1) NR presentation must be in tune with changes in handling and processing methods dictated by developments in transport systems and consumer operations, and (2) NR must remain technologically competitive in consumer product fabrication and product performance, especially in those areas of severe service conditions where NR is still the preferred polymer. Analysing the position of natural rubber with respect to these two features against the situation with regard to synthetics should enable the definition of worthwhile objectives.

REQUIREMENTS, OBJECTIVES AND LIMITATIONS

Presentation and consumer processing

Fig. 1 depicts the movements of NR and SR through a consumer process prior to compounding and vulcanization. Synthetic rubbers are available in neat small compact bales or in pelletised form. They arrive in the consumer factory properly wrapped, ensuring maintenance of the clean conditions of the rubber during the movement from producer to consumer. Synthetic rubbers have consistent viscosities and breakdown characteristics. They do not have to undergo extensive storage under cold conditions. Synthetic rubbers are technically graded.

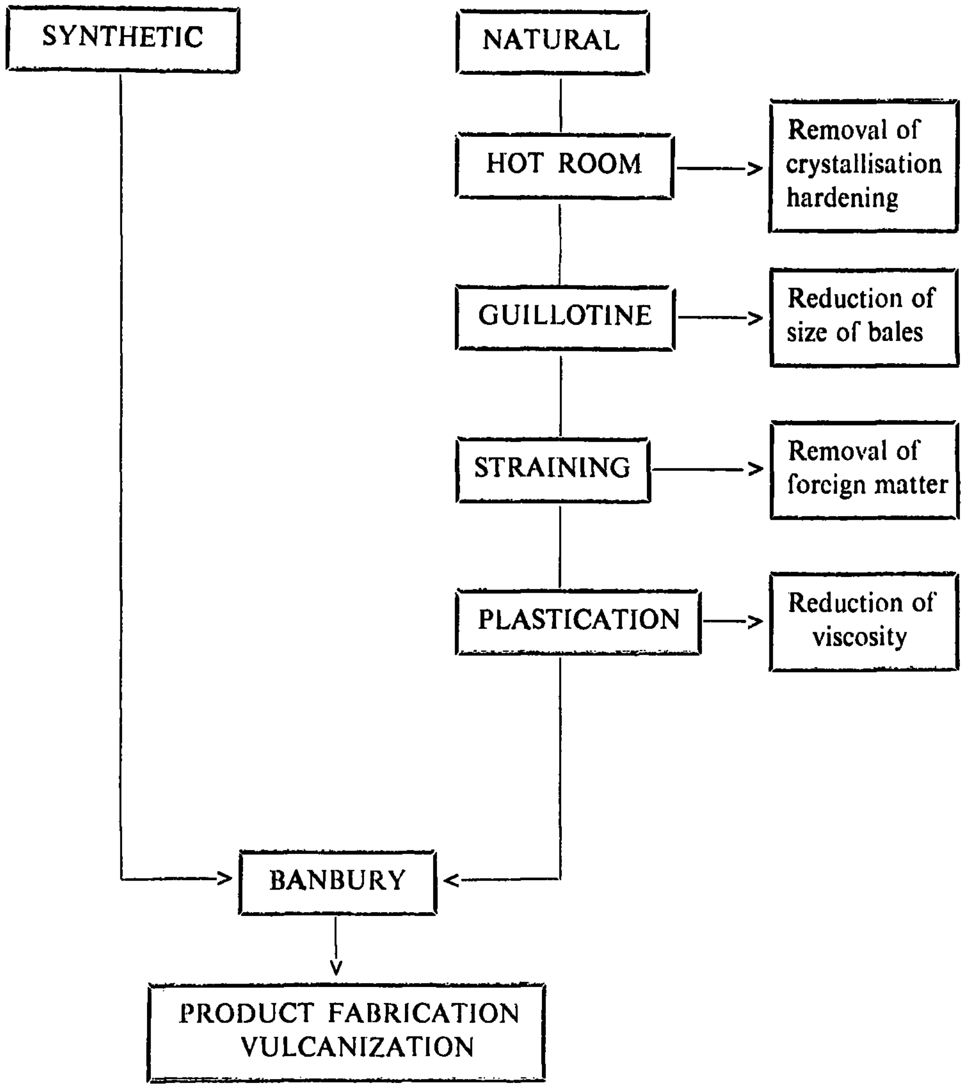

Fig. 1.

Against this, NR is supplied in 5 cu. ft/bare back bales, coated with talc. It is graded by a complex subjective visual assessment system. NR is variable in dirt contents, Mooney viscosities, breakdown characteristics and cure behaviour. NR necessarily undergoes storage under cold conditions at times and crystallisation hardening occurs. These differences are responsible for the extra steps in the NR flow chart (Fig. 1). They constitute deficiencies which must be overcome. The changes required to overcome these are :—

(1) Clean compact bales polyethylene-wrapped ;

(2) Consistent viscosity, breakdown and cure characteristics ;

(3) Ability to withstand low temperature storage without undue crystallisation hardening.

Product fabrication and performance

Table 1 compares properties of synthetic cis-1, 4-polyisoprene and natural rubber. In product performance NR still retains superiority. However, the lower viscosities, coupled with the greater consistency of the synthetic product tends to erode this superior position of the natural polymer.

TABLE 1

GENERAL COMPARISON OF PROPERTIES

NR VS CIS-POLYISOPRENE

Characteristic	Conventional natural rubber	Cis- 1, 4-polyisoprene (high cis contents)
Viscosity	High and variable	Low and consistent
Cure	Variable	Slow but consistent
Raw rubber oxidisability	Excellent but variable	Inferior
Product fabrication	Satisfactory	Superior
Green strength	Excellent	Inferior
Strength properties	Excellent	Inferior
Resilience	Excellent	Excellent
Compression set	Satisfactory	Slightly superior

Intrinsically natural rubber as obtained from the tree is excellent. It is in the handling and processing operations subsequent to its emergence from the tree, that drawbacks are introduced into natural rubber as presented to the consumer. An appreciation of the properties important to the consumer permits adjustment of processing operations to ensure better maintenance of the standards. The basic properties of importance in this context are :—

(*a*) Viscosity — must be low and consistent ;

(*b*) Oxidisability — must have excellent resistance ;

(*c*) Cure characteristics — must be consistent and fast without tendency to scorch ;

(*d*) Diluents and contaminants — must be minimal.

Limitations of conventional methods

The conventional methods of processing latex and field coagulum into dry rubber for shipment have evolved around the visual grading system. The grading system, which is complicated and subjective, imposes serious limitations to processing adjustments. These are :—

(1) Rubber must be in a form enabling visual assessment ;

(2) Must be free from bubbles and blisters, requiring dilution of latex prior to processing and long cumbersome drying operations ;

(3) Technical standards are not available to ensure consistency in basic technological characteristics ;

(4) Marketing and trading operations have been designed around this system of visual grading, and changes in processing and grading can only be sustained by some reorientation in the attitudes and practices of the market operators.

THE ORIGINAL SMR SCHEME

It was in the light of all these factors that Malaysia initiated two major developments in 1965. The first of these was the introduction of the SMR scheme for presentation and grading. The scheme provided uniform standards for technically grading rubber and imposed certain requirements with regard to size of bales and packaging. Right from the outset, it was accepted that the scheme only provided the initial basis for the change over from visual assessment to a technical form of assessment. Experience and consumer reactions will progressively dictate the modifications and refinements that must be absorbed. The basic scheme as launched (Table 2) received considerable publicity and is well known.

TABLE 2

SMR GRADING

Constituent	SMR 5L	SMR 5	SMR 20	SMR 50
Dirt, % wt	0·05	0·05	0·20	0·50
Ash, % wt	0·5	0·5	1·0	1·5
Copper, ppm	8	8	8	8
Manganese, ppm	10	10	10	20
Nitrogen, % wt	0·7	0·7	0·7	0·7
Volatile matter, % wt	1·0	1·0	1·0	1·0
*Colour	Good ADS standard	—	—	—
* PRI—screening level	65	65	50	40

*Producer screening levels for grading with no consumer guarantee

NEW PROCESSING METHODS

The second development initiated in 1965 was the change over of processing methods. With technical grading and presentation standards available, the restrictions imposed by visual grading no longer applied. The requirement, simply stated, is to develop suitable methods to convert latex and field coagulum into a form amenable to efficient drying, compacting, testing, and shipment. Producers from many countries have participated in the overall development of new processing methods.

Processing operations have come to be described by house names, trade names, machinery employed *etc.* and this has added much to the confusion that exists and has in some respects detracted the consumer from appreciating the fact that all these processes have uniform common objectives and technological standards. It is not my intention in this presentation to add to this confusion. However, it would be appropriate to describe the latest techniques in operation at each stage of processing and in respect of latex and coagulum material.

Bulking

Bulking tanks up to 900 gal capacity have been used in RSS production for many years. Improved homogeneity is required for technically specified rubbers and bulking tanks up to 6,000 gal or one day's throughput are now in use. The need for efficient bulking and mixing cannot be over-emphasized especially in the production of rubbers with controlled and specified properties. This applies even more when the starting material for processing is field coagulum.

Coagulation

This is effected by one of several methods. The coagulant may be the conventional formic acid at a pH ranging from 4·8 to 5·2. Alternative acids that can be used include acetic acid or phosphoric acid. Coagulation may also be achieved through bacterial action either naturally or modified by the addition of substrates. The former is known as "autocoagulation" and the latter "assisted biological coagulation". The particular process of coagulation used influences to some appreciable extent properties such as viscosity, oxidation resistance and cure rate. This is exemplified in Table 3. In practice, acid coagulation at pH 5 — 5·2 and field DRC produces a rubber with properties similar to RSS and has been adopted as the most popular method in Malaysia.

TABLE 3

EFFECT OF COAGULATION CONDITIONS ON PROPERTIES

Method	Raw Mooney viscosity	PRI	TC strain %
Formic acid coagulation at field DRC	65	100	70
Coagulation at 15% DRC	59	98	101
Natural coagulation + 24 hours maturation in air	83	67	54
Natural coagulation + 24 hours soaking in water	78	46	57
Assisted biological coagulation	74	94	57

Apart from the method of coagulation, the equipment used for coagulation can vary. The conventional partitioned tanks (or larger models) are applicable in the majority of processes. Special coagulum tubs (Michelin type) or tiled concrete tanks have a lower capital cost but require additional cutting equipment or macerating rolls. They are being installed in large factories.

Size reduction

To reduce the coagulated latex into granules many types of machines have been tried. They include :—

(i) Crumblers: These are basically crepers and the crumbs are formed due to the presence of a crumbling agent (*e.g.* castor oil) in the latex coagulum or on the crepe feed. Normally the coagulum is passed four times through the crumbling rolls to obtain a fine crumb.

(ii) Creper-hammermills: Hammermills have not proved satisfactory alone for processing latex coagulum but give good results when the feed material is pre-creped. Although the use of a single creper-hammermill is possible there are some advantages in multiple passes. When a crumbling agent is also used, the resulting crumb has the advantage of easy handling without massing. This combination is becoming increasingly popular in Malaysia.

(iii) Pelletisers: These are based on the same principle as mincing machines. A few are still being used on latex coagulum with or without prior creping.

(iv) Granulators: These consist of a number of rotating blades (usually three) passing stationary blades. The granulated rubber passes out through the bottom of the machines through a screen. These are satisfactory for carefully aged latex coagulum obtained by biological coagulation. Uneven and slow drying is often experienced with acid-coagulated feed. Pre-milling or pre-creping helps to overcome this drying problem.

(v) Creper-shredder: Shredding mills are similar to creping mills but with much higher roll speed ratio (*e.g.* 30 : 1). In some instances the slow speed roll is replaced by a stationary plate, which almost changes the machine to a type of granulator. Shredders are not used at present for latex coagulum processing.

The processes by themselves do very little to influence the properties of rubber. The specific method used is determined by the type and nature of coagulum to be processed and to some extent by the equipment already available during the changeover. Two factors have however emerged in the course of experience. The first is the versatility of a creping operation as a pre-treatment step and the second the influence of the small addition of castor oil on the handling of wet crumbs. Consumer experience with crumb containing this small amount of castor oil, indicates that crystallisation is slower in the final rubber when stored at low temperatures, thereby reducing the period of " hot housing " necessary prior to use.

Drying

Drying operations for all the new process methods are basically similar. The RRI/GEC dryer produced in 1965 on the basis of work by the RRIM, reduced the drying costs to one quarter of the cost of other systems then in use. This system using a higher humidity in the first stage, has been adopted by most dryers now used. The majority of dryers operate deep bed systems with air flow through the bed at temperatures up to 110°C and at a speed of 70 — 150 ft/min. Continuous belt-drying has appeared on the scene. This technique requires further improvement before it can be generally applicable. Drying time is dictated by the nature and size of the comminuted material rather than the specific drying system used. Two rubber properties which can be influenced by the drying process are viscosity and oxidation resistance. Excessive heating of dry particles can cause oxidation. Drying time will also influence the extent of natural hardening or crosslinking through the aldehydic groups in rubber.

The Malaysian industry uses most of these processes. The present rate of output for new process rubbers represents approximately 20% of total dry rubber shipped. Table 4 shows the increase in various SMR grades during the five-year period.

TABLE 4

NEW PROCESS SMR SHIPMENTS 1965 — 1970
(in long tons)

Year	5L	CV	LV	5	20	50	Total
1965	249	—	—	234	223	6	712
1966	2,921	419	66	2,807	2,342	20	8,575
1967	8,242	2,060	160	6,292	6,731	92	23,577
1968	17,534	8,242	1,725	11,797	23,005	19,401	81,704
1969	19,250	15,015	4,003	22,437	58,383	19,629	138,717
Jan — June 1970	10,527	10,489	2,196	12,754	48,427	11,718	96,471

Field coagulum

In addition to size reduction and water removal, field coagulum must be efficiently cleaned and blended. Thus, the final processing can often be similar to that detailed for latex coagulum, but the pre-treatment will be dictated by the state and nature of the raw material. Large lumps require initial cutting or milling on heavily grooved rolls ; almost dry rubber must first be reduced in size, perhaps by a high powered macerator ; clean cup lump may only require a simple granulation to lower the dirt sufficiently.

In the past too much emphasis has been placed by some producers and equipment manufactures on reducing the cost of cleaning and blending. Shearing the rubber in a creper produces a rubber that dries evenly ; a hammermill removes dirt more efficiently ; but a combination of these two steps have proved efficient both in laboratory trials and factory operation. This is illustrated in Fig. 2. An almost dry mixture of tree lace and cup lump containing bark and other natural contaminants was passed several times through a creper-hammermill. Samples were taken during processing, dried under standard conditions and tested for dirt and volatile matter. Fig. 2 shows that three passes would be sufficient to reduce the dirt to the SMR 50 level, but excessive VM and white spots would be encountered. Increasing the number of passes to eight gives more even and rapid drying and lowers the dirt to the SMR 20 level. Differing source materials would necessitate extensive bulking for uniformity. Storing prior to processing, washing and machining have direct influence on the ultimate properties. Attention to proper bulking and mixing in comminuted form, after creping, would ensure consistency as indicated in Fig. 3. Fig. 3 shows dirt distribution with and without proper attention to mixing in the comminuted state.

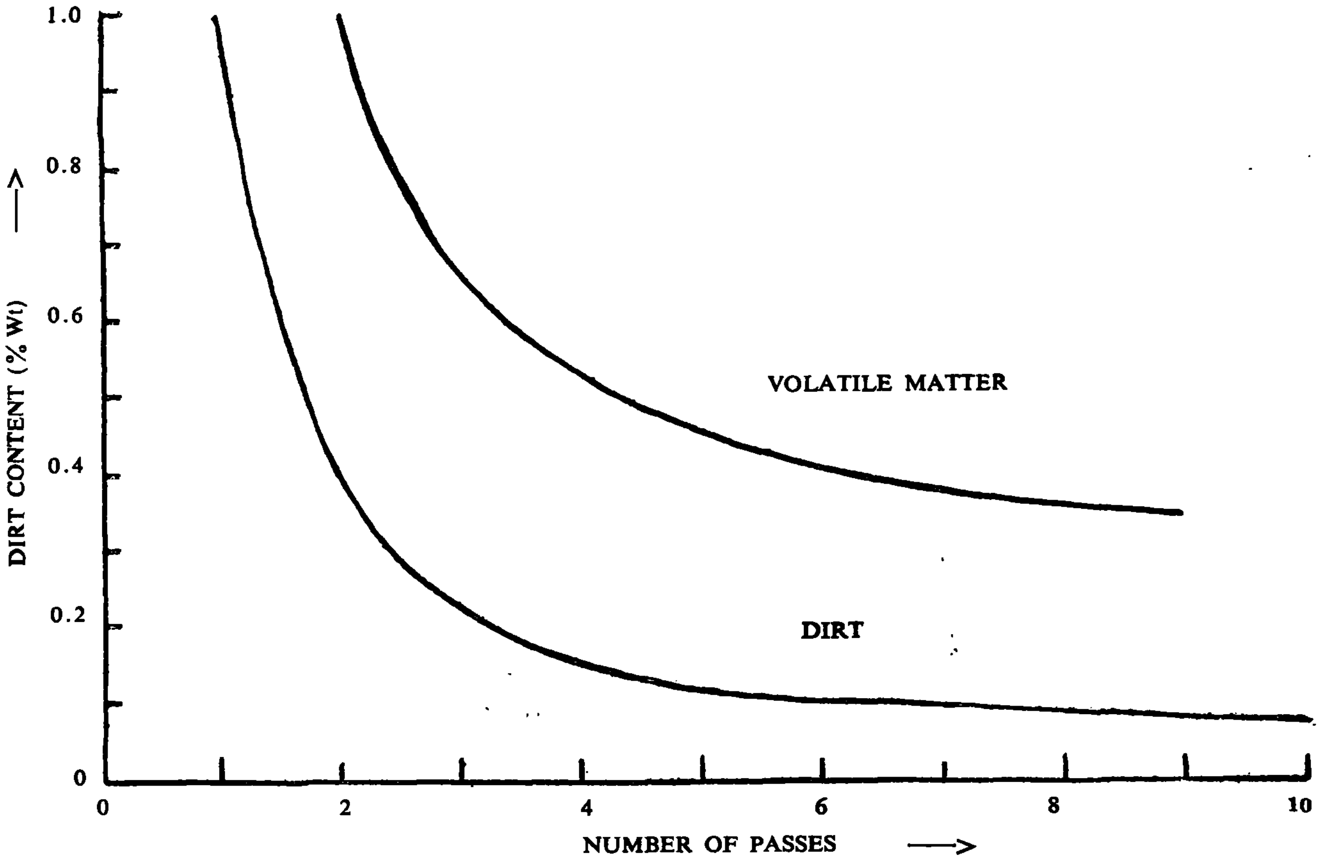

Fig. 2. Effect of repeated creper-hammermilling on dirt and volatile matter.

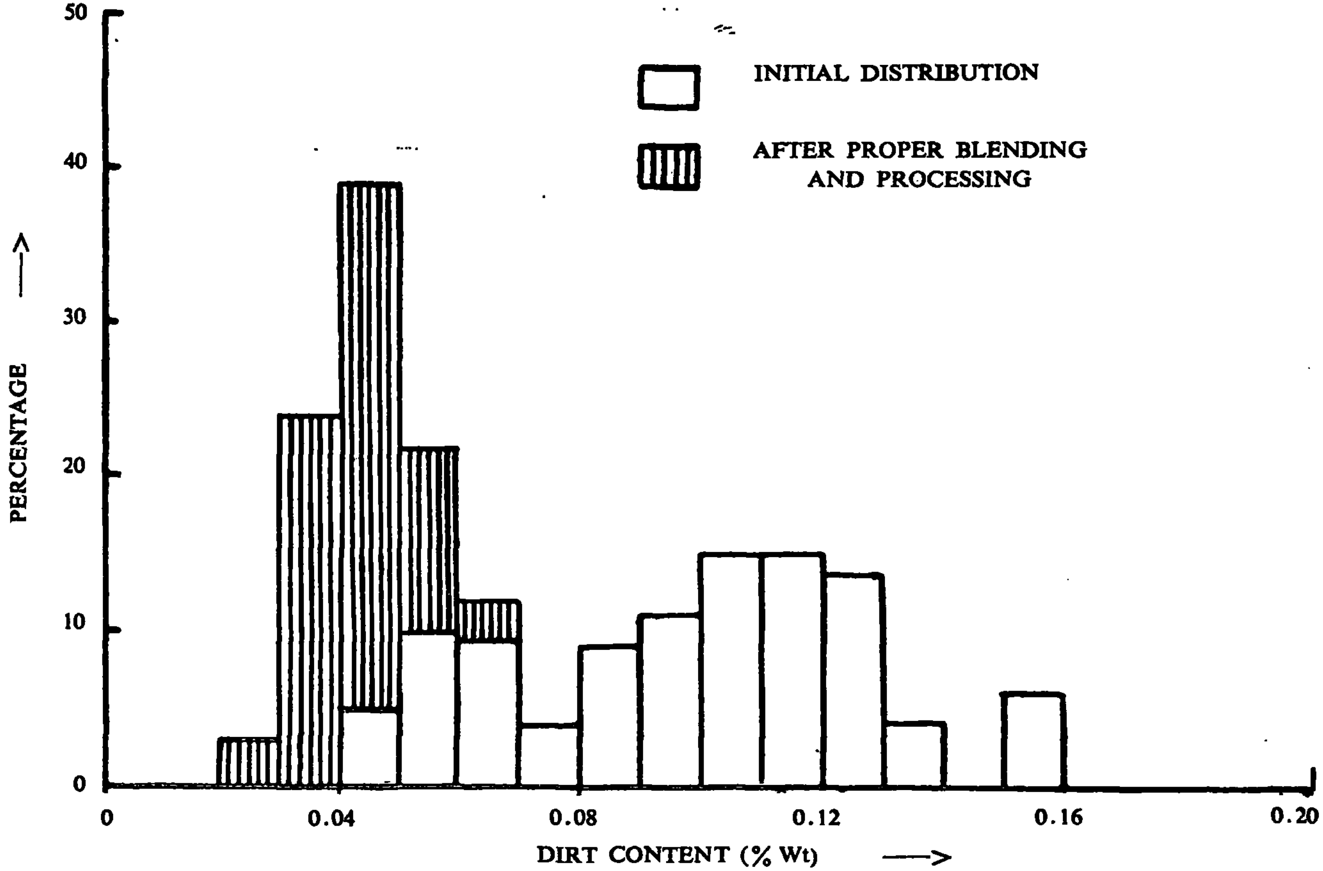

Fig. 3. Effect of proper blending on the frequency of dirt distribution at one remilling factory.

STATISTICS ON NEW PROCESSING FACILITIES

There are at present 82 factories equipped with new processing facilities in West Malaysia alone ; three factories are in operation in East Malaysia. Many more are under construction or on the drawing board. With over 50 % of Malaysian production emanating from smallholders, four central factories have already been established to deal directly with smallholder rubber. It is anticipated that many more of these central factories will come into being in the coming years.

ADHERENCE TO SPECIFIED STANDARDS

It is of the utmost importance to establish the genuineness of the guarantee behind a technical grading scheme. This requires an independent authority with adequate facilities for testing, inspection and legal powers to control shipment under the grading scheme. Production standards will certainly have to be higher than the guaranteed levels. The Standard Malaysian Rubber Scheme has the following features :—

(1) The Malayan Export Registration Board with legal control over licences and shipment ;

(2) The Rubber Research Institute of Malaya with full control over technical supervision of SMR standards and testing.

Technical control and testing are carried out by the RRIM through (*a*) an inspectorate for spot checks, (*b*) central testing laboratories, (*c*) approved commercial laboratories, and (*d*) a standards laboratory.

To enable producers to meet the standards and solve day-to-day processing problems, the Institute has implemented (1) training schemes for factory managers on processing and for supervisors of testing laboratories, (2) an advisory service locating processing instructors strategically throughout West Malaysia. These features are important and must be enlarged with increased production to ensure the maintenance of standards. Five years of experience has established the need and effectiveness of these control measures.

FUTURE CONSIDERATIONS

The successful launching of a technical specification scheme and the establishment of new processing facilities cannot by themselves effect modernisation as defined earlier. These steps have only removed the inhibiting factors and opened the door. They permit a more meaningful approach to the chemical and physical aspects of processing so as to impart the right balance of technological characteristics in a uniform and consistent manner. The specifications on dirt, volatile matter, ash, nitrogen, copper and manganese, around which the SMR scheme was initially fabricated, have with the change over of processing methods, become simple, easy targets to attain. Attention is now required to the more important refinements such as (*a*) control of technological characteristics at desired levels, (*b*) uniformity and consistency, (*c*) volume production of types and grades attuned to consumption demand, and (*d*) production of tailor-made natural rubbers to meet specific and special requirements. The possibilities of achieving these objectives are discussed below.

Control of technological characteristics

The technological characteristics of importance to consumers are hardness (Mooney viscosity or Wallace plasticity), oxidisability and cure. All these are appreciably influenced by the physico-chemical changes involved during processing.

An understanding of the likely reactions and the factors influencing these reactions would enable standardisation and control of processes to be achieved. Extensive information is already available but much of this is scattered in literature and has not been developed in the context of the changes in processing operations, which are now taking place.

Mooney viscosity depends on the average molecular weight of the polymer and the extent of plasticisation imparted by the non-rubbers present in the rubber. The Mooney viscosity can vary considerably between rubbers from different clones as shown in Table 5. Further variations may be caused by the presence of microgel in the latex. This effect is pronounced when trees are first brought into tapping or when rested trees are tapped.

Most estates and smallholdings have a mixture of clones. The planting materials are chosen purely on the basis of yield and other secondary biological characteristics. To achieve consistency in viscosity levels, bulking and blending operations are necessary to offset the clonal variations in respect of this property.

Two types of reactions may then impart variability, *i.e.* an oxidative reaction and a non-oxidative reaction. Considering the oxidative reaction first, it must be recognised that all operations concerned with collection and processing of latex and field coagula are carried out in the presence of air. This could lead to reaction of rubber with oxygen, resulting in hydro-peroxidation. Such hydro-peroxidation provides active centres in the rubber through which crosslinking or degradation or both may take place, depending on the conditions obtaining. The various possibilities under different conditions and treatments are shown in Table 6.

TABLE 5

MOONEY VISCOSITY/WALLACE PLASTICITY OF CLONAL RUBBERS

Clone	Mooney viscosity	Wallace plasticity	Clone	Mooney viscosity	Wallace plasticity
RRIM 501	38	23	GT 1	73	46
RRIM 513	84	53	LCB 1320	75	55
RRIM 607	86	54	PB 5/51	94	62
RRIM 612	66	44	PB 86	82	51
RRIM 600	70	51	PB 5/63	93	60
RRIM 605	64	43	PB 28/59	92	60
RRIM 623	74	53	Ch 30	80	55
RRIM 701	57	36	AVROS 1349	100	67
			AVROS 1734	71	50
RRIC 5	56	32	PR 253	54	33
RRIC 7	90	59	PR 261	87	56
RRIC 36	99	66	PR 255	86	58
RRIC 41	79	51	PR 107	68	40
RRIC 45	58	41	PR 251	71	45

TABLE 6

INFLUENCE OF HYDRO-PEROXIDATION OF LATEX

Crosslinking conditions	Degradation conditions
1. Storage as latex in closed systems	1. Excessive hydro-peroxidation
2. Presence of active reducing substances	2. De-activation of reducing substances
3. Presence of certain types of amino acids	3. Immediate processing and drying at high temperatures
4. Addition of tetra-ethylene pentamine or other active polyamines	4. Presence of metal ions
	5. Excessive washing—leaching out anti-oxidants

Hydro-peroxidation of latex is favoured by ammoniation of latex in the field. Formalin treatment leads to inactivation of reduction activators. In normal standard conditions of latex collection and treatment in the factory, however, significant hydro-peroxidation of latex rubber does not occur to provide any problems in this respect. The possibility of such reactions taking place either in latex or field coagulum cannot, on the other hand be ignored, when instituting changes in handling operations attuned to new processing methods. Tables 7 and 8 show the role of hydro-peroxidation in normal and aerated latices respectively on Mooney viscosities and oxidisability. The influence of added tetra-ethylene pentamine is similar to the well known peroxamine system of crosslinking natural rubber.

TABLE 7

EFFECT OF TEP (TETRA-ETHYLENE PENTAMINE) ON

VISCOSITY/PLASTICITY OF LATEX CREPES

Treatment	Mooney viscosity	Williams plasticity* D10	
		Normal	After ageing at 100°C for 48 hr
Control	78	4·4	1·3
0·5% TEP on DRC	87	4·6	2·8

* Williams D10 measurements are no longer in operation. Ageing tests now use Wallace plasticities.

TABLE 8

EFFECT OF TEP TREATMENT AND STORAGE ON VISCOSITY/PLASTICITY OF 172 HOURS AERATED LATEX FILMS

Treatment	Mooney viscosity	Gel %	Williams plasticity D10	
			Normal	After ageing at 100°C for 48 hr
Control	70	18	3·2	liquid
0·5% TEP	75	40	3·2	3·9
One week's storage of aerated latex in a closed system	101	—	4·4	2·7
Four weeks' storage of latex as above	108	—	4·6	4·1

The non-oxidative reaction is initiated by abnormal groups (aldehydic and aldehyde condensing) in rubber. The essential reaction is one of crosslinking on storage. While part of the reaction takes place on processing and drying, the crosslinking process continues on dry rubber storage. The addition of mono-functional carbonyl reagents to latex inhibits the crosslinking reaction, while bi-functional reagents effect the crosslinking almost immediately. These reactions are now well known and the use of hydroxylamine hydrochloride to produce constant viscosity (CV) rubbers is well established. Malaysian production of CV rubbers annually amounts to 25,000 tons at present. While it is desirable to have all rubbers with viscosities that do not change on storage, additional chemical cost of treatment and consumer price considerations necessitate a gradual change over. In the interim period, consumers have established in respect of new process rubbers, advantages in obtaining rubbers that leave producing factories at uniform, low viscosity levels. This is particularly true of rubbers from field coagulum.

The non-oxidative factors that contribute to changes in initial viscosity therefore also assume importance. All these changes are governed largely by pH conditions of coagulation and/or storage. Table 9 shows the influence of pH on the initial Wallace plasticity of latex films. The Table also gives Wallace plasticities after storage hardening. The pH of latex was altered by the addition of formic acid or KOH to attain the desired levels, prior to filming.

TABLE 9

EFFECT OF pH OF LATEX ON PLASTICITY/PRI BEFORE AND AFTER STORAGE HARDENING

pH	Control Wallace plasticity	PRI	*Storage hardened Wallace plasticity	PRI
4·8	42	105	92	70
5·0	42	110	91	71
5·5	54	96	98	72
6·0	53	94	98	67
6·5	53	91	96	70
10·0	63	83	98	67
10·5	72	56	99	55
11·5	74	43	95	52
12·0	75	34	92	50

*Storage hardening carried out by heating Wallace pellets at 140°F over P_2O_5 in vacuum for 48 hr.

Alkaline conditions favour the aldehyde condensing reactions. A further factor that may be involved is the hydrolysis of proteins providing suitable amino acids capable of effecting crosslinking. The uniformity of the hardened values under all pH conditions confirm the concept that non-oxidative hardening is a continuing process through processing, drying and subsequent storage. Retention of initial viscosity levels are on this basis favoured by storing field coagulum under acid conditions. Storage in water or under alkaline conditions introduces changes in viscosities both oxidative and non-oxidative. In the case of latex, coagulation with acid at pH levels below 5 favours lower viscosities, while higher level or auto-coagulation favours increase in viscosity levels. Table 10 shows in summary form some of the conditions favouring higher or lower viscosities.

TABLE 10

Higher initial viscosities	Lower initial viscosities
pH 5 >	pH < 5
Bi-functional carbonyl reagents	Mono-functional carbonyl reagents
Dry storage	Wet storage
Ammonia preservation	Formalin preservation

Oxidisability (PRI)

The plasticity retention index is a measure of oxidisability of the rubber. This property indicates not only the storage quality of the rubber, it also provides information on the breakdown characteristics of the rubber in a consumer factory. Latex rubbers, as obtained from the tree, display excellent resistance to oxidation. This situation may deteriorate either by leaching out of antioxidants, or by the presence of pro-oxidants. Imbalances in antioxidant, pro-oxidant contents may result from pH of coagulation, syneresis of serum, adulteration with metal ions, or even perhaps by changes in non-rubbers during excessive periods of wet storage. Hydro-peroxidation of latex rubber or field coagulum will, of course, have a determining role in the context of such imbalances in the rubber. The PRI values given in Table 9 for the films, both in the hardened and unhardened states, demonstrate the following features :—

(*a*) Under normal conditions NR is excellent in oxidation resistance ;

(*b*) Considerable changes can occur due to processing conditions ; and

(*c*) Hardened films in all cases show an apparent drop in PRI, although aged Wallace plasticities in some cases at least are higher than the unhardened control values.

The last feature is important to appreciate in the context of a guaranteed PRI level. In normal storage, however, such extensive hardening does not occur, but changes in PRI due to normal storage hardening may represent a drop in PRI of ten units. Some of the conditions in processing favouring low or high resistance to oxidation are given in Table 11.

TABLE 11

High PRI	Low PRI
Coagulation pH> 5	Coagulation pH < 5
Phosphoric acid	Storage of coagulum
Oxalic acid	Storage or agitation of ammoniated latex in air
Storage of dewatered coagulum	Metal ions (Cu, Mg, Ca, *etc.*)
Certain amino acids (glycine, alanine)	Excessive washing
Reduction activators	

Cure

Certain non-rubbers accelerate vulcanization, and the variable incorporation of these non-rubbers influence cure characteristics of the final rubber. It is also well known that pH of coagulation, type of coagulant used, dilution of latex prior to coagulation, maturation of coagulum and washing of wet comminuted particles have appreciable influence on this property. The influence of these and some other factors have already been discussed earlier (Table 3).

In the context of these observations an intelligent approach in the direction of processing chemistry should easily achieve the desired degree of control in the relevant technological features.

Uniformity and consistency

The mere control of the important technological characteristics at the desired levels does not always constitute uniformity and consistency from the purchasers' view point. The adage "justice must not only be done, but must be seen to be done" also applies here. An excellent polymer with the desired level of properties, when presented in a form showing (*a*) the 'plum pudding' effect or (*b*) 'psychedellic' colours or non-homogeneity in appearance does very little to enhance market acceptability. Admittedly with technical grading in the scene, colour does not represent quality, but non-uniformity in colour within and between bales is denigratory to the product and is bound to cause suspicion and negative attitudes. No technical specification can legislate rules to achieve the standards required in this respect. Producers must adopt a 'missionary approach' towards arriving at a satisfactory level. This must include extensive bulking and adequate mixing and processing, particularly with regard to field coagulum. Each step of transition of rubber between the tree and the final pallets must be controlled and treatments introduced where necessary to ensure that standards are maintained. Certain producers in Malaysia working to tighter house specifications in direct contact with consumers, have achieved uniformity and consistency in initial Wallace plasticity, PRI, the SMR standards and uniformity in appearance even in respect of field coagulum. This attitude or approach must pervade the producing scene.

Volume production of types and grades attuned to consumption demand

The change over of processing methods under the technical grading scheme requires a review of grades in respect of consumer end-uses. In the conventional grading and processing system, consumers have largely concentrated on particular grades for specific areas of use on the basis of a balanced consideration of quality — price interaction. This has largely meant that the top quality latex rubber, *i.e.* RSS 1 is only marginally used in the transportation sector. The lower grades of RSS and the brown crepes are preferentially consumed. With well over 65% of total NR consumed by the transportation sector, the source materials for the new process grades assume importance. Under the SMR scheme, the tyre manufacturers have concentrated on SMR 20 and SMR 50. Both these grades are produced largely from cup lumps, tree lace or other forms of field coagulum. Admittedly in certain remilling factories, off-grade wet sheets, clippings *etc.* are also proportionately mixed in. The increasing number of new process central facilities is bound to change this pattern. Other factors also may impinge on this picture. These are :—

(*a*) Polybag collection when this becomes practicable ;

(*b*) High-yielding clones and new exploitation systems tending to produce greater quantities of cup lump material ;

(*c*) Processing efficiency tending to convert all latex rubbers into the highest grade under the technical grading scheme.

The vagaries of a commodity market, coupled with fluctuating differentials in the price of conventional grades, introduce uncertainties on the proper course of development. This is particularly true when market reaction on new process rubber is based on production representing approximately only 15 — 16% of the total. In the ultimate analysis, it is important to ensure that rubbers originating from latex as against field coagulum, defined in the conventional sense, must enter a substantial part of the tyre market. This raises the need for a general purpose grade which in volume, price and quality fits in with the realistic requirements of the transportation sector. This may be achieved by the following developments :—

(1) CV characteristics in top grades allowing for savings in processing operations ;

(2) Blending of latex rubbers with field coagulum along with plasticisation to provide economic and technological balance.

The need to analyse and review this situation is important and urgent as the producing industry is now geared to a massive change over into new processing methods.

Modifying natural rubber to meet specific requirements

In the past, a limited effort has been expended in modifying NR for special applications. Cyclised rubbers, rubber powder, peptised rubbers, MG rubbers, SP rubbers, PA 80 and partially purified rubbers have all been produced from time to time and some are still in production. However, none of these rubbers have really reached volume production. There is perhaps little scope for substantial modifications of NR. This does not mean that a certain degree of modification is not rewarding. Cure, Mooney viscosity and breakdown characteristics are amenable to adjustment individually or together and may meet certain specific needs of consumers. CV and LV rubbers and cure activated rubbers have already become part and parcel of the scene. Oil-extended rubbers, carbon black masterbatches, compounded rubbers in particulate form, and even blends with appropriate synthetic rubbers can be considered for the future. Once an active technical dialogue between producer and consumer becomes an established fact, a completely new vista is open. New processing facilities and the technical grading scheme provides the flexibility required to absorb without difficulty any modifications in processing chemistry required. In this context, perhaps, producers must pay some attention to flexibility when choosing among the different types of new process machinery.

CHANGES IN THE SMR SCHEME

With the new developments and requirements in mind and on the basis of an analysis of consumer attitudes and established producer ability, the SMR scheme is being modified as from the 1st October, 1970. These changes are described in detail in *SMR Bulletins* 5, 6, 7 and 8. In essence the changes are :—

(1) The top grades SMR 5L and SMR 5 are confined to rubbers derived from the controlled and deliberate coagulation of latex ;

(2) A new grade SMR 10 is introduced ;

(3) A minimum PRI value becomes a guaranteed specification for each grade. With the introduction of PRI, Cu and Mn cease to be part of the specifications ;

(4) Nitrogen levels are reduced to 0·65% and certain adjustments to ash levels have been introduced to be consistent with discussion at ISO meetings ;

(5) It becomes mandatory for range and average Po (initial Wallace plasticities) values of every consignment to be reported for all grades ;

(6) Where cure is indicated, a uniform method of depicting cure is introduced as a permissive feature ;

(7) CV and LV rubbers with specific ranges of viscosities are introduced as part of the SMR scheme ;

(8) Colour standards for SMR 5L and a colour coding system for presentation of all SMR grades are introduced.

The permissive and mandatory reporting features in the scheme should in the course of time become guaranteed specifications. The interim step will provide ample opportunity for consumers to assess their relevance, importance and suitability, while enabling producers to become familiar with the controlling factors of these characteristics.

Arising from these changes designed to control processing chemistry, impart consistency and modernise presentation of the product, the natural polymer is emerging with a new strength *vis-a-vis* synthetic rubber in the eyes of the consumer. This is easily understood, when the earlier flow chart (Fig. 1) and comparison table (Table 1) are reconstructed using technologically controlled new process SMR in place of conventional NR. Fig. 4 and Table 12 display these new features.

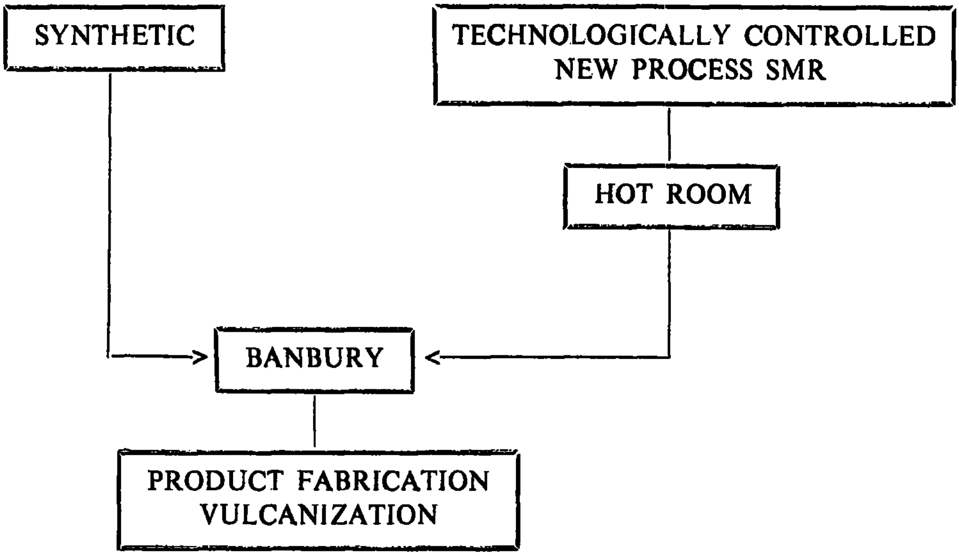

Fig. 4.

There is already the likelihood of reducing the period of hot housing required for certain types of new process SMR. Further improvements can be expected to arise from current research on this problem.

TABLE 12

GENERAL COMPARISON OF PROPERTIES

NEW SMR VS CIS-POLYISOPRENE

Characteristics	New process SMR	Cis-1, 4-polyisoprene (high cis contents)
Viscosity	Satisfactory and consistent	Low and consistent
Cure	Medium and consistent	Slow and consistent
Raw rubber oxidisability	Excellent	Inferior
Product fabrication*	Satisfactory	Slightly superior
Green strength	Excellent	Inferior
Strength properties	Excellent	Inferior
Resilience	Excellent	Excellent
Compression set *	Satisfactory	Slightly superior

The two areas (*) remaining, in which the synthetic is slightly superior have only marginal technological significance. The influences of certain non-rubbers on compression set and creep properties of NR are now better understood. It should not therefore be difficult to enhance even these properties by processing adjustments.

CONCLUSIONS

Modernisation of the technological sector (processing and presentation aspects) of the NR industry is imperative to ensure continuing increased uptake of natural rubber by the consuming industry. Experience in Malaysia with the SMR scheme and new processing methods have clearly established that such an approach will be practical and rewarding. The next logical and necessary phase is adjustment and control of the physico-chemical reactions taking place during processing, to achieve the end objective of imparting enhanced quality, uniformity and consistency to technically graded NR in " modern dress".

At present the volume of new process rubbers available to the market represents only a fraction of total world production of NR. The impact of these revolutionary changes will gather momentum and force as increasing proportions of NR presented to the world market reflect these changes. This undoubtedly requires all producing countries to imbibe the need and urgency for adopting new methods of processing and technical grading. It is particularly necessary to have a consistent approach internationally, in presentation and technical standards among NR producers. Obviously in the transition from the " old " to the " new", the first targets must remain as national operations and national standards. The " new look " and the " new image " then must permeate in the international scene. Multiplicity of types, grades, lack of standards, absence of uniformity and poor presentation, all have tended to erode the strength of natural rubber, which still remains elastomer No. 1. The way is now clear for concerted action to improve this situation. This challenge must be accepted by all rubber producing countries, because it is primarily the natural polymer itself that is under pressure.

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QUESTIONS AND ANSWERS

Question : Could you tell us whether the method of concentration of field latex by electrodecantation imported by two Dunlop estates about 20 years ago is used at present in Malaysia? What were the reasons for this process not becoming popular ? (Mr. L. P. Mendis).

Answer : It is not used now in Malaysia because centifuging is more economical.

Question : If a batch is rejected what happens to it ? How is it re-treated to make it exportable and acceptable to consumers ? (Mr. E. A. Straarup).

Answer : It can be remilled into conventional grades and sold as such.

Question : I believe that a fairly large quantity of rubber is now manufactured in Malaysia using the granulator/pelletiser method. You said in your speech that creping is necessary for blending the rubber. Is there any evidence of the rubber processed with the above process being rejected by the consumer for suffering in price ? (Anon).

Answer : If it is not uniform, the testing of the rubber would necessitate taking more samples. In any case the rubber has to be uniform — if it is not uniform it will be down-graded.

Question : (*a*) Manganese content of ' tree lace ' is high. Can this be brought down to acceptable levels by the addition of any chemical ?

(*b*) Is there any harm in bulking the fractioned rubber which has a high nitrogen content with the cup lump and if so in what proportion ?

(*c*) Can the fraction rubber from latex — to which has been added 8 oz of sodium bisulphite be bulked with cup coagulum ?

(*d*) Why use a mechano-chemical process when the mechanical process is satisfactory? (Anon).

Answer: (*a*) Yes, by phosphoric or oxalic acid treatment.

(*b*) It is advisable not to mix, as the technical properties differ considerably and to obtain a uniform rubber a lot of mixing will have to be done.

(*c*) See above.

(*d*) This process (mechano-chemical) is recommended in preference to the mechanical process where creping mills are already available.

Question: Does the use of castor oil in processing cause any difficulty when it comes to further processing? (Anon).

Answer: If the recommended dosages are used, there is no problem.

Question: (*a*) Do you consider that a NPR plant of capacity 105 tons/month is economical to operate?

(*b*) Would you recommend that a crepe producing factory diversifies to NPR considering the attractive market for crepe at the moment? (Mr. Malcolm Peiris).

Answer: (*a*) No.

(*b*) No — conversion would be the wrong step to take. I am sure the Rubber Research Institute of Ceylon is not advocating a change over for crepe producing estates. You produce the world's best crepe and have a reputation for doing so. It is important for you to hold on to your crepe markets.

Question: (*a*) What is the price differential generally between the technically specified rubber (SMR) and the RSS (sheet)?

(*b*) What is the difference in C.O.P.? (Mr. W. W. J. Mendis).

Answer: (*a*) 5 CV and 5 L get a premium of 4 cts; the other grades are sold at a discount.

(*b*) For large crops there is a big saving and that is why we specify a minimum size for a NPR factory.

Question: (*a*) Dr. Sekhar's talk clearly illustrates as to how far behind we are in scientific development in new process rubbers for present and future needs.

(*b*) What steps are we anticipating for the future of this industry in this country? (Mr. C. N. M. Rodrigo).

Answer: The paper to be read by Messrs. Veerabangsa and Nadarajah at this conference sets out our programme on new process rubber (NPR) development in Ceylon very clearly, and we have a definite plan for the future, which we have recommended to the Government. (Dr. O. S. Peries)

Question: In the event of Ceylon marketing its blanket crepe in dimensions similar to that of new processed rubbers and also to technical specifications, would we not be competing successfully with the new processed rubbers? (Mr. Boralugoda).

Answer: There is a new grade of NPR called SMR EQ which is meant to substitute for blanket crepe grades so that in future blanket crepe will have to compete with this grade of NPR.

Question: How can you control or prevent the increase in viscosity of a loaded natural rubber compound (unvulcanized) within a few days of storage? (Mr. Rasaratnam).

Answer: Yes, by using CV rubber. Processing of the synthetic polymer is facilitated by the ready incorporation of filler without prior mastication of the rubber, an advantage also shown by the CV forms of natural rubber.

Question: (*a*) Is synthetic polyisoprene inferior to NR with regard to strength properties in the vulcanized or unvulcanized state?

(*b*) Which rubber has better green tack? (Anon).

Answer : (*a*) NR is superior in green strength.

(*b*) Natural rubber compounds show some advantage in green tack and a more marked superiority in green strength.

Question : Hasn't China obtained samples from Malaysia ? (Anon).

Answer : Yes, I am sure she has. Any country can obtain samples of a product manufactured in another country without much difficulty. (Dr. O. S. Peries).

Question : Will it be possible to obtain a copy of the paper read by Dr. Sekhar ? (Anon).

Answer : Yes, all papers read at this conference will be published in the RRIC Journal at an early date. (Dr. O. S. Peries)

Question : (*a*) Is the use of fixed hammers or swinging hammers preferable in hammermills ?

(*b*) Do the lower grade rubbers such as scrap if over-cleaned or over-washed, lose their essential qualities ?

(*c*) Is the liability of mould formation when packed in poly bags greater than in other types of packing ? (Mr. G. T. L. de Soysa).

Answer : (*a*) Both are used successfully.

(*b*) If soaked for too long a period, the antioxidants present in NR tend to get leached out.

(*c*) To a certain extent this is true. However, the solution is not to switch over to another type of packing but to treat the rubber with a fungicide, if the problem becomes acute.

Question : Will the papers presented at this conference be cyclostyled and distributed ? It will be very useful if it is arranged. (Mr.M. Hapugoda).

Answer : Sorry, the papers will not be distributed as cyclostyled copies, but they will be published in the Institute's Quarterly Journal shortly. (Dr. O. S. Peries).

Question : (*a*) Dr. Sekhar, wouldn't you think that NR is gradually getting to be a special purpose rubber rather than a general purpose one ?

(*b*) In this respect is it vital that properties such as resistance to oils, weather *etc.* of NR be improved, for example in the synthetic field in respect of cis-polyisoprene (the equivalent of NR) is the introduction of a grade of nitrile that resists oil and still leaves the original properties of polyisoprene ? (Mr. Charles Gunaratne).

Answer : (*a*) No, NR is a general purpose rubber but research is being done to improve the properties of NR.

(*b*) Yes, naturally it would be useful to improve the properties of NR in various respects. That is why such heavy investments are made on research in this field. (Dr. O. S. Peries).

Question : (*a*) Why cannot pale crepe too be sold on technical classifications rather than on visual appearances ?

(*b*) In this age of new developments of rubber why is there no change in the ancient Green Book requirements ?

(*c*) What is the price range in SMR 5L to 50 and what is the average price against highest price of 5L ? (Anon).

Answer : (*a*) Pale crepe can be sold on SMR EQ grade.

(*b*) Organisations interested in the trading and marketing of rubber meet regularly and revise the Green Book. The latest Green Book incorporates the technically specified rubbers as well.

(*c*) SMR 5L sells at a premium of about 4 cts, SMR 5, 10, 20, and 50 sell at discounts of 2, 4, 5 and 6 cts, respectively.

Question : Will Dr. Sekhar be able to answer the following :—

(a) Is the market for SMR grades in any way connected or dependent on the RSS market ?

(b) If so (1) why, (2) why don't the SMR grades command an independent market between RSS and crepe ?

(c) Dr. Sekhar said during his speech this morning that the consumers are able to by-pass three stages of their normal production methods by using SMR grades instead of RSS. This must be resulting in a substantial saving in costs. But do the producers of SMR receive a fair proportion of this saving. We also know that certain SMR grades fetch a premium over RSS. Isn't this mainly due to lower handling and shipping charges than to consumer preference ? (Mr. D. C. Wickremasinghe).

Answer : (a) Yes.

(b) Because production is still not large enough.

(c) Natural rubber is normally used for tyre manufacture, where they usually use lower grades of sheet or scrap crepe, because of their savings in processing they could purchase NPR and pass on their savings to the producers.

Question : With the use of Ethrel

(a) Can one maintain high yields by reducing the frequency of tapping ?

(b) How frequently has the application to be made ?

(c) What is the duration of effectiveness of each application ? (M. Forster).

Answer : (a) Yes, possible.

(b) Once in six weeks.

(c) About six weeks. (Dr. O. S. Peries).

Question : What joint action do you see necessary on the part of producers for marketing natural rubber ? (Anon).

Answer : The Governments of all natural rubber producing countries should get together, discuss this problem and take joint action, so as to ensure a fair price for NR. This has already been done, the first meeting of the Association of Natural Rubber Producing Countries was held in 1968. The second meeting is scheduled for October 1970.

Question : Was the stimulant used following peak yields or at peak yielding of the tree ? (Anon).

Answer : On panel C, which means after peak yields. (Dr. O. S. Peries).

Question : Can stimulants be used at commencement of tapping, without falling yield trends after a period ? (Anon).

Answer : No.

Question : (a) What tapping systems were used and the intensity of tapping with application of stimulants ?

(b) Can higher intensities than 100% be used with stimulants ? (Anon).

Answer : (a) Stimulants are used at 100% tapping intensity.

(b) Intensities higher than 100% are generally not used with stimulants.

Question : (a) Is scraping of bark prior to application of stimulant necessary ?

(b) How many applications were made per year ? (Anon).

Answer : (a) A light scraping of the bark is necessary before application of the stimulant.

(b) Six applications are made during the year. (Dr. O. S. Peries).

Question : What is the width of bark treated per application ? (Anon).

Answer : 1½ in. per application, which is tapped out in about two months.

Question : What clones were stimulated and is there different reactions to stimulants from clone to clone ? (Anon).

Answer : A number of clones respond well to stimulation, particularly PB 86. Yes, the reaction varies from clone to clone.

Question : Ceylon manufactures a large amount of crepe ; how will this fit into the general envisaged trend of producers getting together and producing crumb rubbers ? (Anon).

Answer : Ceylon is not recommending the change over from crepe into NPR production, but it would be advisable if smallholders and small estates, producing sheet rubber, can be grouped together to manufacture NPR. (Dr. O. S. Peries).

Question : What are your views on the *bale size of block rubber* ? Is there a controversy on this point ? Which will be the preferred bale size for the future ? (Anon).

Answer : The two most acceptable bale sizes measure 22½" × 15" and 28" × 14". The former fits the ISO pallet which has been recognised by most standards institutes. The latter is the most common synthetic bale size and some consumers prefer this size.

Question : Can crown budding on a large scale make the tree more susceptible to wind damage ? (Mr. D. Coorey).

Answer : Theoretically it could, because there could be a point of weakness at the crown union and the type of branching that results may also be prone to wind damage. However, crown budding is done at a very young stage with green buds now in Malaysia, and there has been no indication of excessive proneness to wind damage.

Question : Would you care to comment on the possible mechanism of latex flow stimulation by " Ethrel " ?

If this arises by some distortion or " opening up " of the latex vessels, is it possible that bark characters may adversely be affected in the long term ? (Anon).

Answer : We are working on the problem of the mechanism of action of Ethrel along with the N.R.P.R.A. in the U.K. We do not yet have a great deal of information on this — we know that Ethrel releases ethylene in plant tissues, and ethylene is the precursor of a number of plant growth substances and is responsible for various changes in plants such as the ripening of fruit and the abscission of leaves. However, we do not have any direct lead as to its mode of action in the rubber tree.

We have used Ethrel stimulation for more than 18 months now, and have not observed any ill-effects as you refer to, so possibly it does not act in the way you suggest.

Comment: We must not let Dr. Sekhar get away with the idea that it is only in the rubber industry that Geneticists and Plant Breeders have helped to produce astounding yields. Let us inform him that counterparts in our own tea industry have improved yields from 300 lb/acre to 4000 lb/acre. (Anon).

No answer — this is merely a statement.

Question: Have you used stimulants on panels A and B ? (Anon).

Answer : Yes, we have used stimulants on panels A and B and also on very young trees, but we are carrying out these trials on an experimental basis. We recommend the use of Ethrel only on panel C and later.

Question : Should Ceylon start with Ethrel ? (Mr. M. Singh).

Answer : Yes, I am sure you should start experiments with Ethrel.

Question : An article in the " Investors' Guardian " about three to four weeks ago stated that the yield stimulant " Ethrel " while increasing the yields to the extents mentioned by Dr. Sekhar, reduces the life of a rubber tree by approximately five to eight years.

Is this correct and can you please comment ? (Mr. G. Dias - Wanigasekera).

Answer : The results obtained so far by the Rubber Research Institute of Malaya do not indicate that the life of the tree would be endangered by the use of Ethrel. I do not know from where the " Investors' Guardian " got its information.

Question : Which machine gives a consistent particle size, the hammermill or rotary cutter ?

Answer : Preliminary creping of rubber is necessary before feeding into a hammermill and this gives a consistent particle size suitable for efficient drying. Blocks of coagula fed into a rotary cutter also gives consistent particle size but the actual size is dependent on the size of the screen used. With the smallest screen used the size of the particle could be about ½ in. or more. In this case, unless the coagulum is comparatively porous, drying is delayed.

Question : Could you please let us know :

(*a*) the extent of area served by new process rubber factories established in Malaysia for smallholders.

(*b*) the capacity rated in the factories ;

(*c*) comparative costs of production ? (Anon).

Answer : (*a*) approximately 100,000 acres ;

(*b*) there are presently four factories rated between 10 — 40 tons throughput per day ;

(*c*) the cost of production is about 7½ Malaysian cents and is not expected to vary very much with the larger size factories.

Question : (1) With excessive initial creping operations (prior to hammermilling or granulation) will the dirt and particularly the bark get embedded in the rubber ? This may be difficult to remove with subsequent hammermilling. I refer to lower grade processing.

(2) Is it correct that comminuted rubber, as produced with the granulater/pelletiser method in Malaysia, is increasing at a very much more rapid rate than rubber manufactured by other particular process ? Can you give recent figures ? (Anon).

Answer : (1) The shear forces operating in the cleaning of rubber in the creper/macerator and the hammermill are the same except that it is very much higher in the case of the hammermill. Any dirt left after the preliminary creping is over, is removed by the hammermill.

(2) The first method commercially exploited in Malaysia has been the granulator/pelletiser method but subsequent developments have given rise to modifications of this method and also the adoption of other methods. It cannot, however, be said that rubber produced by the granulator/pelletiser method is increasing but it may be said that the conversion of low grade rubber into new process rubber by all methods available for comminution is on the increase. Reference to Malaysian statistics on rubber production should give up-to-date figures.