Progress in Production and Specifications of Crumb Rubber

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Natural Rubber is extracted from the bark of the trunk of *Hevea Brasiliensis* trees by a process of controlled wounding, called tapping. The milky white tree sap called latex is processed either into dry forms of rubber or as concentrated latex depending on the facilities available in the rubber estate. In conventional methods latex is processed into sheet or crepe rubber. The field coagulum rubber is processed as Estate Brown Crepe (EBC) remilled crepe and or flat crepe. The sheet or crepe rubber produced by processing the crop from rubber plantations is graded by the visual comparison methods. The details of this system of classification is evolved by the Rubber Manufacturers Association, New York and it is given in the "Green Book". The latest edition of the Green Book was published under the direction of Part II of the fourth international rubber quality and packing conference held in Brussels, Belgium in June 1968 and is endorsed by 19 countries having direct dealing in natural rubber.

In the visual classification system there are 35 grades within eight types of natural rubber, all of which are produced from the latex of '*Hevea Brasiliensis*'.

The classification system is based on visual examination of rubber and it is not helpful in judging the inherent technological properties of rubber. This also gives room for malpractices. From 1945, after the IInd World War many manufacturers in developed countries started using factory made synthetic rubbers. Several Scientists in different parts of the World evolved procedure for production of different types of rubber like polymeric materials. By 1965 many factories in U. S. A, Germany, U. K. and Japan switched over completely to product mixes which contained either only synthetic rubbers or only very little of natural rubber. Thus the natural rubber producers in South-East-Asian countries faced a serious problem in the marketing of their produce in the face of competition from different types of synthetic rubbers. The advantages claimed by manufacturers for different types of synthetic rubbers are the following.

1) Uniformity in properties, as the synthetic rubbers are prepared in factories under pre-determined conditions.
2) Technical specification of product
3) The flexibility of being processed in tailor cut forms as per requirement of the consumers.

So the natural rubber producing countries made earnest efforts to improve the appearance, presentation and grading of the rubber produced by them and the developments seen today in production of technically specified rubber (TSR) and crumb rubber are the result of this.

Natural rubber processed as crumb rubber is marketed in appearance, grading and packing similar to those of synthetic rubbers. This modern form of processing natural rubber is adopted by the rubber plantation industry to improve its competitive position against the synthetic rubber industry.

The important unit operations in the processing of natural rubber as crumb rubber are listed under.

1) Coagulation
2) Dewatering, blending and dirt removal
3) Size reduction
4) Drying
5) Baling, packing and grading.

Coagulation

Rubber is extracted from the rubber trees as a milky white dispersion called latex. From this colloid, rubber is precipitated by addition of an electrolyte. In plantations this is brought about by addition of acid and this process is called coagulation. In the production of crumb rubber from field coagulum, acid coagulation step is not needed as this from of rubber is collected from the field already in coagulated forms.

Coagulation is done in large tanks after bulking and blending the latex from different sources in a central tank. This procedure is useful in ensuring uniformity to the latex. Coagulation is brought about by addition of formic acid or other suitable coagulants. For production of viscosity stabilised rubber (Constant Viscosity) addition of chemical is done prior to coagulation. Bleaching agents, if any, added in processing are also incorporated in latex prior to coagulation. If oil extended rubber is to be produced oil emulsion is added to latex before acid coagulation.

Size reduction, de-watering and dirt removal

In this stage rubber coagulum is crumbled mechanically to small pellets of 0.1 to 2 mm size. Such disintegration of coagulum is helpful in removal of trapped dirt and foreign matter. Crumbs are received in a pool of water and blended properly to reduce variability in the processed material. Crumbling is brought about by the combined action of a series of machinery like macerators, crepers, hammer mills etc. Shredders, extruders etc. are also used in some factories for this. In the hevea crumb process crumbling is brought about by mechano-chemical action. Here the chemical crumbling agent used is castor oil. But in most factories chemical crumbling agents are not used now. Crumbling of coagulum is useful in ensuring proper blending of the raw rubber from various sources and also for removal of foreign matter.

Drying

Rubber crumbs in the wet stage will have water content in the range of 16 to 22 percent. This is dried in a current of hot air. The final moisture content in dry crumbs should be below 0.5 per cent. The drying temperature employed is in the range of 80 to 110°C. The duration for drying is four hours.

Baling, Packing and grading

The dry crumbs are pressed in hydraulic passes in the shape of solid blocks of definite dimensions. These blocks are wrapped in polythene sheets which are compatible with rubber. Samples of rubber are taken from the corners of the blocks for assessing the conformity of the material to set standards. Grading of the rubber so processed is based on the analytical results.

ISI Standards for raw natural rubber

Specifications for raw natural rubber is given in the IS document No. 4588. The parameters prescribed for raw rubber as per this document are given in Table 1. It may be seen from the document that the properties specified for raw natural rubber are dirt content, ash, volatile matter, nitrogen centent, plasticity and *plasticity retention index*. Each property prescribed gives useful information to the consumer. Dirt content and ash will give information on foreign matter present in rubber. Since the maximum content of these impurities are specified in each grade, adulteration of rubber at any stage can be checked effectively. Volatile matter specification is helpful in ensuring complete drying of rubber. If a high value is observed in this property the indication is that the rubber is not dried properly. Nitrogen content value is specified to avoid chances of contamination/admixture of rubber with low grade rubber like skim rubber. Specification for initial plasticity and plasticity retention index are technologically very significant properties. The former gives information on the viscosity/molecular weight of rubber while the latter gives the tendency of rubber to degradation by heat. It is not necessary to state here that the conventional visual classification system gives no useful information to the consumer other than the visual appearance of it. So all progressive and modern factories in major consuming countries are now giving preference in the use of technically specified natural rubber in place of visually graded sheet or crepe rubbers.

Specially processed natural rubber

Natural rubber can be processed for specific applications and in forms which consume less energy during processing. The following chart may be seen in this context for assessing the processing advantages of modern forms of processed rubber.

Conventional sheet/crepe	Solid block rubber (TSR)	Constant Viscosity rubber	OENR–L
↓	↓	↓	↓
Unload to factory	Unload to factory	Unload to factory	Unload to factory
↓	↓	↓	↓
Clean Bale surface			
↓			
Bale cutting			
↓			
Premastication	Premastication		
↓	↓		
Mixing chemicals	Mixing chemicals	Mixing chemicals	Mixing chemicals
↓	↓	↓	↓
Compound	Compound	Compound	Compound

It may be seen from the chart that the new forms of processed rubber can provide considerable benifits to the consumers. These rubbers can also contribute to substantial saving in energy at the mixing and compounding stages. Use of latex stage compounds and carbon black master batches can provide still better results in energy saving. Use of these master batches and latex compounds can minimise air pollution and factory floor contamination. Following histogram may also be seen to study the extent of energy saving possible by using specially processed NR (Fig. 1).

Constant Viscosity natural rubber (CV Rubber)

Natural rubber undergoes hardening during storage by intermolecular cross link reactions because of the presence of active groups *in the poly isoprenic chain* structure. In C V rubber, these active aldehydic groups are rendered inactive by reactions with hydroxylamine hydrochloride. *The resultant rubber maintains its* viscosity at constant level, just as in the case of most mineral purpose synthetic rubbers. The manufacturers who procure CV *rubber gets consistency in pro–* perties for their rubbercompounds. In Malaysia around 12 per cent of the total SMR production is in the form of CV rubber. These *rubbers are used in production of* high quality engineering goods like mountings, bearings, suspension units etc. They are also good in making extruded or *injection moulded goods.*

Carbon black rubber master batches from latex

In this process carbon black is *admixed with rubber latex in the* plantations. The resultant product are useful in saving energy and for keeping the factory floor clean. Air pollution can *also be minimised in the areas* where factories are located by using this material.

Polymer blends

In most rubber products it is advantageous to use a blend of two or more polymers. Previously only elastomers were used in such blends. But now thermo plastic polymers having compatibility with natural rubber are also used. *Blends of natural rubber* and emulsion poly buta diene were prepared in latex stage and evaluated by the Rubber Research Institute in 1979. The results show that there is scope for popularising this type of rubber.

General purpose natural rubber (GP SMR)

This is a viscosity stabilised general purpose grade of natural rubber. Consumers of this grade of rubber can do away with pre-mastication. In GP rubber three types of raw materials are used, viz. factory processed latex, sheet material and field coagulum. These are processed separately and blended in predetermined ratio after viscosity stabilisation. Dry coagulum materials are given viscosity stabilisation by using a proper dispersion of mercaptans and hydroxylamine neutral salts in water. Coagulum treated in this mixture gives viscosity stabilisation only when it is dried at a temperature of around 100°C. In Malaysia around 4 per cent of the SMR produced is GP Rubber. It is reported that GP rubbers are specially suited in production of tyres, belts and hoses.

SP Rubber

This is *partially* vulcanised natural rubber. Its main application is in the production of goods which have strict diamentional specifications. This rubber *finds application in the pro-* duction of extruded and calendered products. Dye swell will be reduced appreciably by use of this item in extrusion com*pounds. Several grades of* SP rubber are available commercially based on the extent of vulcanised rubber present in the mix.

Low protein rubber

This is a new grade of natural rubber with low nitrogen and ash contents. It is produced by treating natural rubber latex with anenzyme which breaks down the naturally occuring proteins *into water soluable products* that are washed away during manufacture. DPNR will not absorb water. So variation in properties of scorch or cure by *water absorption can be avoided.* Also water absorption by rubber products adversely affects electrical properties. Low protein natural rubber gives higher *resistance and lower creep for* the vulcanisates.

Production of TSR in major NR Producing countries

There has been substantial growth in production of TSR *in major rubber producing coun-* tries like Malaysia and Indonesia. The growth in production of TSR in Malaysia may be *seen* from the following graph.

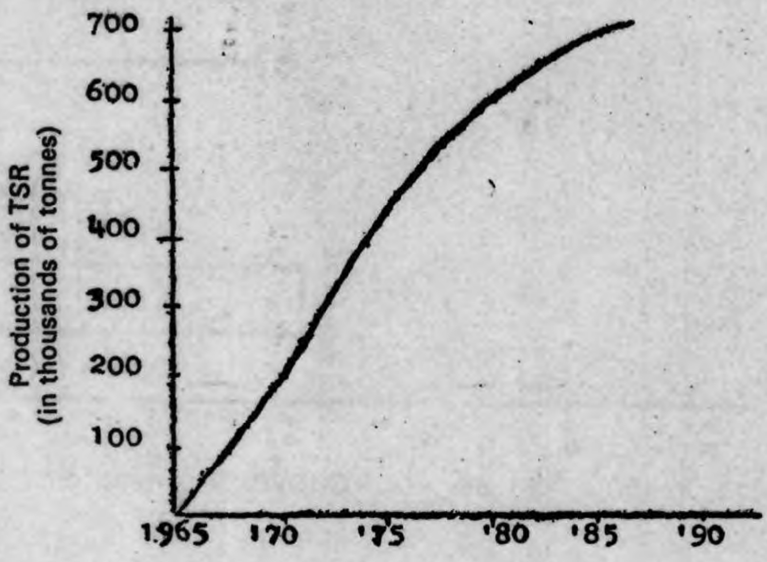
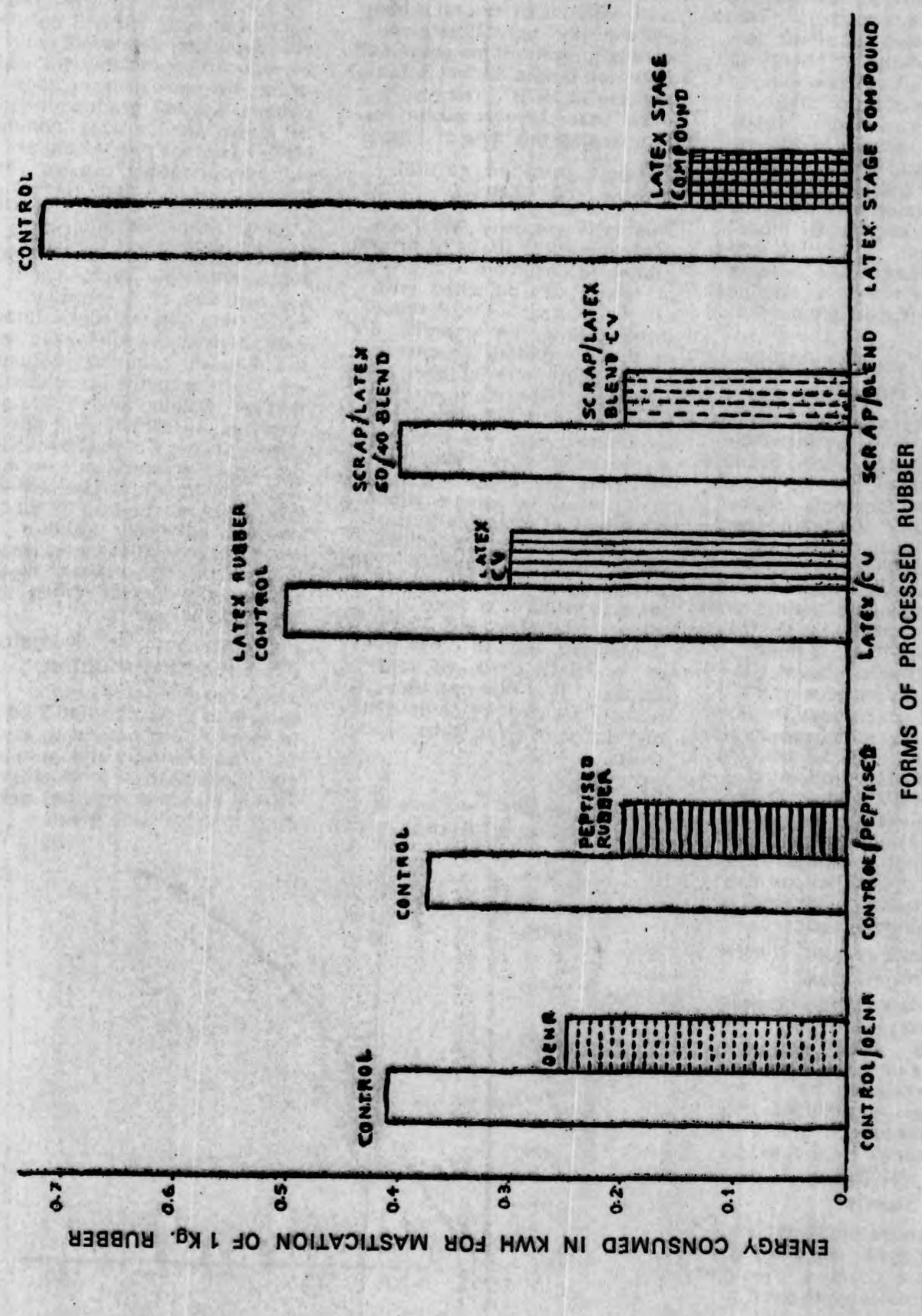


Fig. 1 ENERGY SAVING OF THE PROCESSED RUBBERS



IS : 4588-1977 (Indian Standard)

SPECIFICATION FOR RUBBER, RAW NATURAL (Second Revision)

Table 1 Chemical Requirements for Natural Rubber (Clauses 3 & 4.2)

Sl. No.	Characteristic	Requirement for					Method of Test Ref : to
		ISNR 5 (Special)	ISNR 5	ISNR 10	ISNR 20	ISNR 50	
i)	Dirt Content, per cent by mass, Max	0.05	0.05	0.10	0.20	0.50	NR: 1 of IS:3660 (Part 1)–1966*
ii)	Volatile matter, per cent by mass, Max	1.0	1.0	1.0	1.0	1.0	NR:2 of IS:3660 (Part 1)–1966*
iii)	Ash, per cent by mass, Max	0.6	0.6	0.75	1.0	1.5	NR:3 of IS:3660 (Part 1)–1966*
iv)	Nitrogen, per cent by mass, Max	0.7	0.7	0.7	0.7	0.7	NR:11 of IS:3660 (Part III)–1968**
v)	Initial plasticity, Min	30	30	30	30	30	NR: 12 of IS:3660 (Part III)–1971***
vi)	Plasticity retention Index (PRI), Min	80	60	50	40	30	MR:13 f IS:3660 (Part III)–1971***

* Methods of test for natural rubber, Part I

** Methods of test for natural rubber, Part II

*** Methods of test for natural rubber, Part III

Table IV
SMR specifications, grade types and grade codings mandatory from January 1, 1979

(Property (a))	SMR CV	SMR LVb	SMR L	SMR WF	SMR 5	SMR GP	SMR 10	SMR 20	SMR 50
	Latex grade				Sheet material grade	Blended grade	Field grade		
	Viscosity-Stabilized					Viscosity stabilized			
Dirt retained on 45 um aperture (max., % wt)	0.03	0.03	0.03	0.03	0.05	0.10	0.10	0.20	0.50
Ash content (max, % wt)	0.50	0.50	0.50	0.50	0.60	0.75	0.75	1.00	1.50
Nitrogen content (Max,% wt)	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Volatile matter (max.,% wt)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Wallace plasticity number, Po (min).	—	—	30	30	30	—	30	30	30
Plasticity Retention index (PRI) (min)	60	60	60	60	60	50	50	40	30
Colour index (Loyibond scale) (max.)	—	—	6.0	—	—	—	—	—	—
Mooney Viscosity ML 1+4,100°C	-(c)	-(d)	—	—	—	-(e)	—	—	—
Cure	R(f)	R(f)	R(f)	R(f)	—	R(f)	—	—	—
Bale marking colour (g)	—Black—			Light green		Blue	Brown	Red	Yellow
Bale identification strip colour	Orange	Magenta	Transparent colourless				Opaque white		
Standard bale wrapping	Transparent and colourless								

a) Based on ISO test methods

b) Contains 4 of light non-staining mineral oil. Additional producer control parameter: Acetone extract, 6-8%(wt)

c) Three Mooney viscosity classes (sub-grades), viz CV50, CV60 CV70, the classification (producer) limits being 45-55, 55-65, 65-76 Mooney units respectively.

d) One Mooney viscosity class, viz LV50, the classification (producer) Limits being 45-55 Mooney units.

e) One Moodney viscosity class, the classification (producer) limits being 58-72 Mooney units.

f) Cure information is provided in the form of a rheograph (R)

g) The colour of the printing on the bale identification strip.

Table V Requirements

Characteristic	CV	L	5	10	20	50	Test method
	Green	Green	Green	Brown	Red	Yellow	
Dirt content, %(m/m) retained on 45 um sieve max.	0.05	0.05	0.05	0.10	0.20	0.50	ISO 249
Initial plasticity, min.	—	30	30	30	30	30	ISO 2007
Plasticity retention index (PRI), min.	60	60	60	50	40	30	ISO 2930
Nitrogen content, % (m/m) max.	0.66	0.66	0.66	0.66	0.66	0.66	ISO 1656
Velatile matter content, % (m/m) max.	0.8	0.8	0.8	0.8	0.8	0.8	ISO 248 (oven method at (100± 5° C)
Ash, %(m/m) Max.	0.6	0.6	0.6	0.75	1.0	1.5	ISO 247
Colour index, max.	—	6	—	—	—	—	ISO 4660
Mooney viscosity, ML (1+4) 100°C	*	—	—	—	—	—	ISO 289

Header note: "Limits for grade of rubber" spans columns CV to 50; "Colour Grade" spans the colour row.

* Producer viscosity limits on production only, 60± 5

It may be seen from the graph that in Malaysia production of TSR was started in 1965 and after this there is steady growth in its production. Today almost 40 percent of the natural rubber produced in Malaysia is marketed under SMR Scheme.

The following table gives the percentage of different grades of SMR being produced in Malaysia for the past four years.

in the first year of production. There is a visible trend of growth in TSR production in India now. It is expected that the annual production of TSR will reach 10,000 tonnes by the end of 1987. Some countries like Nigeria and Ivory Coast have managed to convert almost all of their rubber production in specified forms. But the total production of NR in these countries are very small.

Table II
Changes in percentage of SMR Grades

Year	SMR production percentage						
	5L	CV	5	10	20	50	GP
1975	12.0	11.2	8.4	15.7	48.8	1.8	—
1980	8.9	13.2	5.8	16.6	53.4	0.8	0.5
1985	8.8	10.6	3.7	21.4	51.3	0.3	3.3

It may thus be seen that the production of higher grades of specified rubber are remaining at comparatively lower levels. This is because the consuming industries prefer to use lower grades of SMR which are available at lower price. Same trend is seen in other producing countries also. Table below gives the production of TSR in major rubber producing countries.

Suggested production programmes for TSR in India

Natural rubber production in India has reached 210,000 tonnes per year. Almost 20 percent of this is available as field coagulum rubber. This type of rubber is now sold mostly as estate brown crepes and or remilled crepes. Part of it is converted to TSR also. It is desirable to convert all of the field

Table III
Production of TSR (in thousands of tonnes)

Year	Country					
	Singapore	Malaysia	Indonesia	Thailand	Srilanka	India
1980	76.3	564.8	658.3	90.1	8.5	2.2
1981	64.5	613.9	563.5	75.8	14.6	2.1
1982	47.6	579.4	579.8	79.9	10.8	2.1
1983	50.6	708.8	709.6	73.8	5.4	2.4
1984	49.6	767.1	783.9	76.5	8.1	4.6
1985	38.8	754.4	774.3	95.0	14.0	6.7

All the rubber producing countries in the world are thus encouraging production of technically specified rubber and the consuming industries give preference in use of this type of rubber in their applications.

The progress recorded in Indian TSR factories is not satisfactory in the earlier years. India started production of TSR in 1974. But even in 1983 total production of TSR in Indian factories remained at the same level as

coagulum as TSR. For this it will be necessary to provide assistance in conversion of some of the existing crepe mills to TSR factories.

Ten to fifteen percent of the rubber produced is converted to concentrated latex. The balance 65 per cent is processed as Ribbed Smoked Sheet. Many small farmers who do this processing are not bestowing proper attention to ensure production of good quality rubber sheets. Besides many units have no facilities for smoke drying sheet rubber. So around 20 percent of the Ribbed Sheet produced are marketed as off sheets. It is possible to use such off sheets in producing GP Rubber by blending with field coagulum and latex rubber after proper treatment for viscosity control.

In all producing countries around ten percent of the rubber produced is processed as high quality rubber like CV rubber. This type of material can be used in engineering applications and in products which need rigorous service properties. Two or three factories have to concentrate in the production of such high quality latex grade crumb rubber.

There is also need for production of speciality rubbers like OENR, SP. rubber and graft rubbers. It is felt that an intensive campaign will help in establishment and viable operation of three or four factories for producing these special grades of NR.

Complaints on use of TSR

There are some complaints from consumers on quality of TSR produced in different factories. These complaints are based on degree of dryness of the material or on presence of foreign matter, or on the level of degradation of rubber. Some complaints received on the TSR produced in India are also on these lines. The producing units should bestow personal attention to avoid such complaints. Every consignment should be tested and marketed only with ISI mark. Consignments failing to prescribed specifications should be reprocessed.

Developments in TSR

Modifications in specifications of natural rubber are reported mostly from Malaysia. The SMR grades were first specified in 1965. Main changes were incorporated in it in 1979.

Revised specifications for different SMR grades is given in Table IV. □