

# Trends in NR processing

When NR seemed on the verge of being ousted from the market by SR, Malaysia came up with the idea of TSR. Not long ago India too joined the TSR club. In this article the authors describe some of the latest trends in NR processing.

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**M**ODERNISATION in rubber industry is the need of the day. NR processed into conventional marketable forms like sheet and crepe rubber and graded visually was the only rubber available to the manufacturing industry during the pre-World War period. Need based R&D works in different parts of the world, especially in Europe and USA, paved the way for the development of synthetic rubbers. Working in close proximity with the rubber manufacturing industry, the synthetic rubber producing units came up with polymers which met the requirements of the former. The effect was tremendous and synthetic rubber made inroads into the realm of NR applications.

Intensified research activities in different NR producing countries paid dividends and in 1964, Malaysia came forward with Technically Specified Natural Rubber (TSR) and NR was made available to the consuming sector in a form cognate with that of synthetic rubbers. TSR presented in block form, soon received consumer acceptance. A brief description of the processing techniques followed in the production of TSR and the advantages of using TSR for rubber goods manufacture is given below.

### Modernisation of NR processing

Malaysia launched the Standard Malaysian Rubber (SMR) into the world market with the main objective of enhancing consumer preference for NR. The major advantages claimed for block rubber

were the following:

- Presented in well defined grades with levels of contaminants specified for each grade.
- Packaging in modern form akin to that of synthetic rubbers.
- Number of grades kept to minimum.
- Implementation of a rigid sampling/testing programme and inspections to be the basis for grading TSR.

The production was done in bulk quantities ensuring proper homogenisation of the raw material during the different stages of processing.

The unit operations involved in the modern processing of NR are (a) Reception and storage (b) Pre-

cleaning (for field coagulum grades) (c) Blending (d) Initial size reduction (e) Final size reduction (f) Drying (g) Sampling, grading and packing

The processing industry which used the existing machinery for TSR production during the initial period, soon switched over to new specific items of machinery for accommodating bulk processing and for improving homogeneity of the processed rubber. The machinery commonly used for TSR production are the following:

- (1) For initial size reduction
  - (a) Creper-Macerator (b) Pre-breaker
- (2) For pre-cleaning
  - (a) Creper-Macerator (b) Granulator (c) Hammer Mill

TABLE 1 Production of TSR (in '000 MT)

Year	Malaysia	Indonesia	Thailand	Sri Lanka	India
1981	613.9	563.5	75.8	14.6	2.1
1982	579.4	579.8	79.9	10.8	2.1
1983	708.8	709.6	73.8	5.4	2.4
1984	767.1	783.9	76.5	8.1	4.6
1985	754.4	774.3	95.0	14.0	6.7
1986	810.9	761.8	105.6	12.3	7.8

- (3) For final size reduction
  - (a) Creper/Hammer mill
  - (b) Extruder
- (4) Dryer
- (5) Bailing press

The long-felt need for marketing NR with technical specifications was given a warm welcome by the consuming sectors. Table 1 shows the production of TSR in the major NR producing countries of the world.

Close adherence of the TSR to the specifications laid down in the relevant standards was made possible by the efficient functioning of control laboratories. Once the TSR processing industry had overcome its teething problems, the consuming industry began demanding TSR with more stringent specifications and also for speciality rubbers.

**Viscosity controlled forms of TSR**

The development of TSR met the main objective of improving the processing technology of NR for making it more attractive and acceptable to the rubber products manufacturing sector. Subsequently, special grades of TSR which conferred certain distinct techno-economic advantages in specific fields of application were introduced. These special grades were processed by different techniques such as blending of latex and field coagulum grades of rubbers, chemical modification of NR, incorporation of rubber compounding ingredients at the latex stage etc. Constant Viscosity (CV) rubber, General Purpose (GP) rubber, Superior Processing (SP) rubber and Oil Extended natural rubber (OEN) are the typical examples.

**Constant Viscosity Rubber**

During product manufacture, rubber consumes substantial quantities of energy. In the present situation of rampant power shortage energy conservation becomes all the more relevant. Table 2 gives the information on energy consumption at different stages of rubber products manufacture.

*Table 2 Energy requirement in processing rubber*

Process	Energy for a compound of specific gravity = 1.0 in GJ/M <sup>3</sup>
One pass Banbury mix	3-4
Mill mix from bale	15-35
Warm-up operation	2
Hot feed extrusion	1-2
Cold feed extrusion	2-3
Mixing (Banbury)	2.8
Plasticising	0.5
Injection	0.3
Curing	0.2

Rubber products manufacturing industry use both natural and synthetic rubbers. The product energy which is the energy required to make a product is high in the case of synthetic rubbers. NR, which is a tree crop, utilises renewable solar energy for its production in the trees, and has low product energy since non-renewable fuel is required only at the stage of its conversion into marketable forms. Although the product energy is high in the case of synthetic rubbers, the energy required for conversion of most of them into products is low when compared to that required by most forms of NR. Polymers are produced by one sector of the industry and consumed generally by another sector for rubber goods manufacture. Rubber products manufacturing industry will have preference for a polymer which utilises less energy in their plants, other parameters being comparable. Considering the above views, R&D works were carried out in NR producing countries and Malaysia came up with the CV rubber.

It is a fact that NR undergoes hardening during storage. This results in increase in viscosity of NR and Mooney Viscosity (ML (1+4) 100°C) in the range of 100-120 is

not uncommon as against the Mooney Viscosity of synthetic rubbers in the range of 50-60. Treatment of NR with chemicals like Hydroxylamine or Semicarbazide is found to be effective in preventing the undesirable increase in viscosity of rubber. Though the viscosity of NR can be stabilised at different levels, consumers prefer CV rubber of Mooney Viscosity 60±5. Some of the tyre factories in India use sheet and crepe rubber only after masticating them to a low viscosity. For quality control, the viscosity of the masticated rubber was being tested at the Rubber Research Institute of India (RRII). Values obtained over a period of one year showed that the Mooney Viscosity (ML (1+4) 100°C) of masticated rubber was in the range of 60-70.

A study was conducted at RRII to ascertain the stabilised Mooney Viscosities of NR derived from the popular clones (different varieties of rubber trees) available in the country. The results are given in table 3.

*TABLE 3 Stabilised Mooney Viscosity, (3) ML (1+4) 100°C of natural rubber from popular clones*

Clone	ML (1+4)100°C
RRII-105	58
RRIM--600	56
GT--1	57
GL-1	70
RRIM--605	50
Tjir--1	80

The results indicate that by the judicious blending and viscosity stabilisation of different clonal lattices, NR having the viscosity of pre-masticated rubber can be easily processed. This technique enables the consuming industry to save the enormous energy being expended for pre-mastication.

In India, bulk trials were undertaken on the processing of CV 60 rubber using Hydroxylamine Sulp-

hate as the viscosity stabiliser. The chemical was procured from Gujarat State Fertilisers Co. Ltd., Baroda. When latex from selected clones was coagulated in presence of Hydroxylamine Sulphate at a dosage of 0.15% by weight on the dry rubber content of latex and the coagulum processed into block rubber, the resulting rubber was having Mooney Viscosity stabilised at 60±5 units. Latex from eight collection centres under the Palai Rubber Marketing Co-operative Society were examined for their suitability in producing CV rubber. All the centres yielded rubber of CV 60±5 range. The raw rubber specifications of CV rubber and typical vulcanisate properties in a tread mix are given below.

**Raw Rubber Specifications**

Dirt % (maximum) wt.	0.03
Ash % (maximum) wt.	0.50
Nitrogen % (maximum) wt.	0.60
Volatile matter % (maxi.)wt.	0.80
PRI % (minimum)	60.00
Mooney Viscosity (ML 1+4 @ 100 °C)	60±5*
P, Accelerated storage hardening (maximum)	8**

Note: \* Mooney Viscosity is also stabilised at other viscosity ranges.

\*\* For production control purpose only.

**Typical Vulcanisate Properties:**

**Tread Mix recipe**

**Compound formulation Parts by wt.**

ISNR CV	100.00
Zinc oxide	5.00
Stearic acid	2.00
HAF black	45.00
Santoflex IP (antioxidant)	1.50
Aromatic oil	5.00
Santocure CBS (Cyclohexyl benzthiazyl Sulphenamide)	0.50
Sulphur	2.50

**Processing parameters**

Compound Mooney Viscosity (ML 1+4, 100°C)	57
Mooney Scorch Time (min. to unit rise above minimum @ 120°C)	25

**Monsanto Rheometer at 140°C**

Optimum cure, t90 (mins)	25
Cure rate t90-t2 (mins)	19
Scorch time t2 (mins)	6

**Physical vulcanisate properties**

<b>Cure Conditions: 25 min. at 140°C</b>	
Tensile strength (kgs/cm 2)	
Unaged	240
Aged (14 days at 70°C)	235
Elongation at break (%)	
Unaged	440
Aged (14 days at 70°C)	415
Modulus at 300% (kgs/cm 2)	
Unaged	165
Aged(14 days at 70°C)	172
Hardness (Shore A)	
Unaged	59
Aged (14 days at 70°C)	62
DIN abrasion loss (mm 3)	
Load 10N	64
Dunlop Resilience (%)	55
Tear Strength (Kg/cm)	130
Compression set (%)	38
Dematia cut growth life	
Initiation: K cycle	58
Failure : K Cycle	258
Goodrich heat build up	
Dynamic compression set %	6.0
Temperature (°C) at 25 min.	28

**General Purpose (GP) Rubber**

More than 55% of NR produced in the world are consumed by the tyre industry for the production of automobile tyres. Analysis of the pattern of consumption of NR by the tyre sector showed that the industry mainly consumed lower grades of RSS and EBC. When TSR was made available to the consuming industry, the tyre sector preferred the lower grades like SMR 10 and 20. The above consumption pattern indicated that the tyre sector needed a large volume supply potential raw material with reasonable technological performance and relatively lower price.

The requirement of the tyre sector was met by introducing 'Tyre Rubber' which was produced from latex rubber (30%), sheet rubber (30%), field coagulum (30%) and rubber process oil (10%) by modern processing techniques. This viscosity

stabilised rubber had reasonably good technological properties. The relatively high oil content may be one of the reasons why this rubber has not received the expected acceptance from the consuming sector.

Malaysia came forward with a new general purpose NR, tailor made to meet the precise requirements of the tyre industry. This rubber was produced from a blend of latex and field coagulum rubbers. In general, the process involves the following operations.

1. Field coagulum is pre-cleaned and creped into blankets.
2. Bulked latex is coagulated and creped into blankets.
3. The wet blankets are blended and crumbled
4. Crumbs are soaked in a solution of Hydroxylamine for imparting viscosity stabilisation.
5. The crumbs are dried, pressed, tested and packed.

At the Pilot Crumb Rubber Factory of the Indian Rubber Board, a slightly modified technique also was standardised for the production of GP rubber. Off sheet was masticated in presence of Renacit VII (About 0.02 -- 0.03 phr) and brought to a Mooney Viscosity of about 60. Commercially available dry scrap was soaked in water for about 24 hours and creped into blankets. Masticated rubber was also processed into blankets. The blankets were thoroughly blended in crepers in the ratio of off sheet to scrap as 40:60 (on dry basis) and then crumbed using a creper hammer mill. The crumbs were given 5-10 minutes soaking in a tank containing 0.3% hydroxylamine sulphate solution, dried and pressed into blocks of 25 kg. Table 4 gives the raw rubber specifications and technological properties in a standard tread formulation of the GP rubber.

TABLE 4 Typical raw rubber specification of GP rubber Properties

Dirt content % (maximum)wt	0.10
Nitrogen % (maximum) wt.	0.60
Ash % (maximum) wt.	0.75
PRI % (minimum - Plasticity	

Retention Index	50	<b>Processing parameters</b>	Compression set (%), 22 hrs at 70°C	32	
Volatile matter % (maximum) wt.	0.80	Compound Mooney viscosity (ML 1+4, 100°C)	56	Demattia cut growth life: Initiation K. Cycles	60
Mooney Viscosity (ML 1+4 @ 100°C)	65 ± 7*	Mooney Scorch Time (min. to 5 unit rise above minimum @ 120°C)	21	Failure K. Cycles	245
P, Accelerated storage hardening (maximum)	8**	Monsanto Rheometer at 140°C Optimum cure, t90 (mins)	23	Goodrich Heat Built up: Dynamic compression set %	5
<i>Note: * Mooney viscosity is also stabilised at other viscosity ranges.</i>		Cure rate, t90-t2 (mins)	17.5	Temperature rise (°C) at 25 mins	28
<i>** For production control purpose only</i>		Scorch time, t2 (mins)	5.75	The Rubber Board has already taken measures for ensuring bulk production of the above speciality rubbers viz. GP and CV Rubber through the rubber processing co-operative societies.	
<b>Typical Vulcanisate Properties:</b>		<b>Physical Vulcanisate Properties</b>		<b>Reference:</b>	
<b>Trade Recipe</b>		Cure Conditions: 23 min. at 140°C Tensile strength (Kgs/cm <sup>2</sup> )		1. IRSG, Rubber Statistical Bulletin; Vol. 41 No.11, August 1987.	
<i>Compound Formulation Parts by wt.</i>		Unaged	259	2. Byan J.D. <i>etal</i> , "Energy requirements for elastomer mixing and processing"; <i>Elastomerics</i> , March 81.	
NR GP	100	Aged (14 days at 70°C)	237	3. E. V. Thomas & D. Joseph Francis, "Development of Energy saving forms of raw natural rubber." Paper presented at the seminar organised by the Plastics & Rubber Institute, Kerala Sub Branch at Cochin on 31st August 1986. □	
Zinc oxide	5	Elongation at break (%)			
Stearic acid	2	Unaged	453		
HAF black	45	Aged (14 days at 70°C)	427		
Santoflex IP (Antioxidant)	1.50	Modulus at 300% (Kgs/cm <sup>2</sup> )			
Aromatic oil	5.0	Unaged	168		
Santocure CBS (Cyclohexyl benzthiazyl Sulphenamide)	0.50	Aged (14 days at 70°C)	168		
Sulphur	2.50	Hardness (Shore A)			
		Unaged	60		
		Aged (14 days at 70°C)	65		
		DIN Abrasion loss (mm <sup>3</sup> )			
		Load ION	68		
		Dunlop Resilience (%)	54		
		Tear strength (Kg/cm)	107		

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