Recycling of End of Life Tyres - New Developments

John Boyd Dunlop, a Scottish veterinarian was inventor of the first practical pneumatic tire in 1888, he invented it for his son's tricycle.

It took another seven years for someone to take the leap. André Michelin and his brother Edouard, who had previously patented a removable bike tire, were the first to use pneumatic tires on an automobile. Unfortunately, these did not prove durable. It wasn›t until Philip Strauss invented the combination tire and air-filled inner tube in 1911, that pneumatic tires could be used on automobile with success. As the use of tyres in trucks and other vehicles increased a new problem arose. There was hardly any use of the waste tyres.

- A few tyres were used as boat fenders, as fuel, and making distillate oil by pyrolysis.
- Re-treading of used tyres became popular.

In spite of above uses, stock piles of ELT (end of life tyres) starting mounting up.

Some of Statics on ELTs are as follows:

Advent of MRP

In 2004 after ten years of research carried out by the **Integrated Waste management Board of California** & a paper was published, in which Continental tyres, Michelin and Ford motor co were involved.

It was found that if the rubber in waste tyre is micronized to 80 mesh or finer and mixed with rubber does not deteriorate properties of the high tensile compounds. It was recommended to use 10 PHR in case of 80 mesh.

Some studies show that 120 mesh can be used up to 20 phr without loss of properties. Following is the data for the use of 120 mesh from 5 to 30 phr. The table shows the results.

Test Results – Tinna 3R – 125 (120 Mesh)

Sr. No.	Test Description	Test Method	0 PHR	10PHR	20 PHR	30 PHR
	Curing Temperature(degree celsius)		160	160	160	160
	Curing Time(min)			7	7	7
Sr. No.	Test Description	Test Method	0 PHR	10PHR	20 PHR	30 PHR
1	Hardness Shore A	IS 3400	58	64	65	65
2	Tensile Strength(kg/cm square)	IS 3400	212.37	222.24	212.48	198.99
3	Elongation at break (%)	IS 3400	518.47	529.54	519.57	523.79
4	Modulus at 300% (kg/cm square)		102.22	101.54	99.48	92.03
5	specific gravity	IS 3400	1.13	1.13	1.14	1.14
6	Abrasion Resistance	IS 3400	122	115	125	137
7	Angular Tear strength	IS 3400	97.05	87.4	83.33	83.04

KEY FINDINGS / OBSERVATION:
1. At 20 PHR Tensile, Elongation and Abrasion is similar to compound without Tinna 3R 175, resulting in substantial cost saving (Please refer next slide)
2. At 10 PHR, properties improved dramatically for tensile, Elongation and Abrasion.
3. Hardness increases. However the same can be controlled by reducing Carbon, which further helps in cost saving

Bird's eye view of a waste tyre yard in Oman

Some of Statics on ELTs are as follows:

There are over

1 BILLION

End-of-life tyres generated annually.

It is estimated that

4 BILLION

Unwanted end-of-life tyres exist in landfills and stockpiles.

Some

290 MILLION

Tyres are discarded in the United States each year.

Michelin and Lehigh Technologies

Michelin North America after using MRP for ten years bought Lehigh Technologies of USA, the largest manufacturer of MRP (Micronized Rubber Powder) who has sold 50,000 tons of MRP in the year 2018 as claimed by Lehigh.

Lehigh published their experience as follows.

"We sell to seven of the top 10 tire customers in 18 countries and 45 tire plants around the world," said Team Lehigh. "There are more than 500 million tires that have been made with our product".

Strong Upside

Even with the inroads Lehigh along with Michelin have made with MRP, there is potential for much more business, both in tire and non-tire applications. Thus far, the firm has focused on getting the material used in the tire tread, but other external components such as the sidewall are candidates for additional MRP usage.

Glenn Denstaedt, Lehigh technical director for tire and rubber.

As tire companies get more used to the product and learn how to process it, there will be opportunities to increase the amounts of MRP used in the compound itself, Denstaedt said, noting that current applications range from 2 percent of batch weight up to 10-12 percent.

Article by Bruce Meyer | Rubber and Plastic News

In 2016 the End-of-life tire (ELT) arising in Europe reached 3.9 million metric tons, which represented an increase of approximately 66,000 metric tons, Meanwhile, reuse of tires by re-treading dropped by 5 percent.

European Tyre and Rubber manufacturer's Association

After sorting, around 3.29 million metric tons of ELTs remained for further treatment. ELT granulation continued to be 'strong' with a growth rate of 9.3 percent when compared to 2015, the association points out. ELTs sent to energy recovery increased 'slightly' by 2 percent. Civil engineering uses of whole or shredded ELTs shrank by 3 percent, while reuse of tires as blasting mats and dock fenders was down 15 percent. As of 2018, 23 countries were operating under an extended producer responsibility (EPR) scheme for tires, representing around 65 percent of EU waste tyres.

NEW DEVELOPMENTS

Micronized Rubber Powder

Tinna Rubber & Infrastructure Ltd was the first company of India which realised the advantage of Micronized Rubber Powder in high quality compounds. The only technology known was Cryo-grinding which involved use of Nitrogen.

In India the cost of using Nitrogen was prohibitive at approximately Rs. 20 /- PKG of Rubber Crumb.

Tinna developed the **ambient grinding system**, where use of Nitrogen was not required. Today Tinna Rubber offers MRP of 80, 120 and 140 mesh.

Some tyre companies have their typical specification requirement, Tinna Rubber is able to meet their requirement and therefore is selling today 3500 tons per annum. This capacity can be increased at a short notice, since tyre cutting and crushing capacity is already in place to crush 72,000 Ton per annum.

Compounded Micronized Rubber Powder

CMRP is a unique idea of supplying MRP of 80 mesh and finer MRP in pre-dispersed compounded form.

Since MRP grades are very fine powder and have a tendency to fly causing fly loss and also makes work place dirty, we pre-disperse MRP in NR or SBR as required by customer.

Comparision chart of Radial Tyre Tread Compound

S. No.	Standard Recipe	Rate	Price
		Wt.	@
1	NR	100	130
2	zinc oxide	5	210
3	Stearic Acid	2	70
4	TDQ	1.5	400
5	4020	2	400
6	Carbon 220	55	120
7	0/ 10phr 80/ 10phr CMRP 80/ 12.5 CMRP 80	0	35
8	Oil 710	8	45
8	TBBS	1.5	400
9	Sulphur	1.5	25
10	PVI	0.1	400
	Total	177	

Standard Radial Truck Tyre Compound

PROPERTIES	Standard	10 phr 80 mesh Crumb	10 phr CMRP -80	12.5 phr CMRP-80
Hardness	62	64	62	63
Tensile Strength	181.84	170.28	174.41	168.51
Elongation at Break	458.25	444.9	444.43	466.26
Modulus at 100%	20.97	21.83	22.1	20.11
Modulus at 200%	54.2	56.94	57.27	50.95
Modulus at 300%	101.65	103.52	104.49	94.5
Specific Gravity	1.13	1.14	1.13	1.13
Abrasion Resistance Vol. Loss	128	154	151	151

Refrence: Attuned Lab Report No. 6228/2019-20 Dated 13/09/2019

CMRP made by using 20 parts of Polymer and 80 parts of 80 mesh crumb. Findings on standard radial tyre tread compound is as below:

Advantages

- CMRP is in sheet form. There are no fly losses.
- Containers can carry higher load as compared to crumb, saves cost.
- There is no leakage in transit due to a bag getting torn.
- No need of EVA pouches thus save cost.
- Pre-dispersed master batch gives better properties to compound
- Storage/stacking is easier.

SPECIFICATIONS:

S No	Parameter	Standard Specification
1	Volatile Matter (%)	Max 1%
2	Ash Content (%)	8.05%
3	Carbon Black Content. (%)	16.4%
4	Acetone Extract. (%)	12 %
5	RHC (By Difference) (%)	63%

Coated Rubber Crumb

The idea of joining crumb rubber particles together is very old. Many patents were taken but nothing succeeded. Tinna Rubber has successfully launched CRC under the name of TENSOFLEX. The advantage here is that it has a tensile strength of 10 MPa. And it imparts high abrasion resistance.

MATERIAL DESCRIPTION	COATED RUBBER CRUMB (C.R.C)
Material source	Recycled rubber crumb
Tensile strength	9- 10 MPA
Elongation at break	270%
Shore A Hardness	65 Shore A
Specific gravity	1.13 KG/LITER
Ash Content	Max 8 %
Physical Appearance	TACKY POWDER
Color	BLACK
Smell	MILD

Rubber Tackifier

Although Reclaim Rubber is known to Industry for last 70 to 80 years yet new uses are being found. One of these is to use Reclaim (modified) as a very low cost material, giving high tack to a rubber compound, particularly where Fabric Penetration is required.

MODIFICATION:

The reclaim rubber when made under certain processing conditions can produce a material of very low Mooney of 15 to 20 and thus it is like a dough. Just as when we make adhesive from NR, it is masticated several times to make it very soft and tacky. It is Oxidation of NR. Similarly Reclaim rubber can be softened by Oxidation, and this level of softness can be maintained by use of special chemicals. Therefore unlike Reclaim rubber where Mooney increases on storage, the Mooney of Tacky Reclaim is maintained between 20 and 30. Secondly to give it silky smoothness this Reclaim is made from finer mesh of Crumb.

USES:

It is currently used in tire Compounds for making Compounds which impregnate fabric. Because of its softness the Compound penetrates the fabric easily and after curing, it also vulcanizes with the rest of the Compound and the final product regains its elasticity. Another advantage is that lesser Oil is required for Compounding.

CALENDERING:

This Grade can also be used in calendared Products, since it is Grain less.

NR TUBES:

Automobile and Cycle tubes can be made from this Grade due to consistent Mooney and grain less structure.

SPECIFICATIONS:

S No	Parameter	Standard Specification
1	Volatile Matter (%)	Max 1%
2	Ash Content (%)	Max 10%
3	Carbon Black Content. (%)	25-29%
4	Acetone Extract. (%)	15-20 %
5	RHC (By Difference) (%)	48-52
6	Sp. Gravity	1.13-1.15
7	MooneyViscosity {ML(I+4)@100^{o}C}	15-30
10	Hardness (Shore A)	60-65
11	Appearance	Black Blocks
12	Tackiness	Highly Tacky Compound

CONCLUSION

A lot is happening in finding various uses of ELT tyres. Today TBR and PCR are designed to last long. The life of these tyres is 50 years. It can be used in building construction as part of aggregate, Sound insulation pads, Heat insulation sheets, Road speed barriers, floor tiles, and adhesives etc.