New Developments in Recycling of ELT (end of life tires)

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The true wealth is created by value addition and not by trade and commerce. The value addition can only be done by doing something beyond tradition. The Reclaim industry has not changed in last 100 years. The tyre manufacturers which consume 75 % of rubber hardly use it, due to very poor physical properties.

The story of the End of Life tyres - the environmental hazard.

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 automobiles with success.

As the use of 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.

During Second World War the Japanese controlled the Rubber producing countries in the east and no Natural Rubber was available to western countries, President Roosevelt ordered setting up of forty synthetic rubber plants overnight in USA and England. The Reclaim rubber plants also expanded all over Europe and USA. Even tyre companies put up their own Reclaim plants. In India both Dunlop and Firestone had in-house Reclaim rubber plants.

As USA and Europe produced sufficient quantities of Synthetic rubber, the Reclaim rubber industry died its own death, primarily due to poor physical properties and high pollution.

Chinese industrial revolution started but it neither had synthetic rubber nor NR. Qingdao University created a special cell to do research to improve quality of reclaim rubber. Today China produces 60, 00,000 Tons, more than 90 % of total world production. India produces 2, 50,000 Tons per anum and Netherland and Africa also manufacture about 50,000 Tons per anum.

In the meanwhile huge stockpiles of ELT tyres are being created all over the world particularly in the developed countries, causing monumental environmental issues. Fires erupted in stockpiles cannot be doused till entire stock is gutted causing poisonous air pollution miles around.

The recycling of these tyres without causing pollution became a major challenge.

In 2004, after ten years of research involving Michelin, Continental North America and Ford motor co, a report was published by Waste management Board California, saying that the best solution to recycle ELT tires, was to make Micro-fine rubber crumb of 80 & above mesh, by ambient grinding, without causing any pollution. The micro-fine rubber powder (MRP) when added to new tire did not compromise on properties. The recommended percentage was 5% on weight of the tyre. (Equal to 10 phr)

MICHELIN

October 18th, 2017, Michelin announced, quote" it had acquired Lehigh Technologies a speciality materials co, that uses patented cryogenic turbo mill technology to transform rubber from end-of- the-life tires and industrial goods into materials for new tires and industrial goods into materials for new tires and other products, reducing the amount of raw material initially needed." "The firm produces highly engineered, versatile raw materials called micronized rubber powder (MRP)." "Its customers include some of the largest tire companies in the world".

It was further reported that more than 500 million tyres were produced with complete success.

AMBIENT (MECHANICAL) GRINDING

The Cryo grinding had limitation of use. Because of its less fractured surface due to freezing of waste tyre, to below glass transition temperature, the microfine particles had less crevasses. Therefore strong physical bond with the rest of compound could not be achieved beyond 10 phr of MRP addition.

Tinna Rubber and Infrastructure Ltd New Delhi India developed mechanical grinding process operating at ambient temperature. It successfully developed very high structure and very high surface area as compared to Cryo-grind material. The ambient grind material has twice the surface area of that of Cryo grind material therefore 140 mesh crumb can be used up to 30 phr without loss of properties.

It proved to be a very successful NEW INNOVATION and a profitable end use of waste tyres was found. There was no loss of properties even up to the addition of 20 PHR on successful dispersion of the same in a new compound.

A study was done to compare Cryo-grind and ambient grinding. The results are tabled below.

Comparison Report for Cryogenic and Ambient Grinding Crumb

S. No.	Compound	PHR
1	NR	70.00
2	PBR	30.00
3	ZnO	5.00
4	Stearic Acid	2.20
5	TDQ	1.50
6	TMT	0.10
7	Crumb Rubber	0.00
8	Carbon HAF	57.00
9	Oil 710	8.00
10	Sulphur	2.20
11	CBS	1.00
12	Rosin	2.00
13	Total	179.00

Test Description	Unit	0-PHR	Ambient 10-PHR	Cryo 10-PHR
Curing Time	Min	12	12	12
Hardness	Shore A	66	62	65
Tensile Strength	**(kg/cm^2)**	**194.84**	**188.68**	**165.92**
Elongation at Break	%	428.75	457.36	332.56
Modulus at 100%	**(kg/cm^2)**	**20.87**	**26.36**	**34.47**
Modulus at 200%	**(kg/cm^2)**	**71.28**	**64.84**	**92.34**
Modulus at 300%	**(kg/cm^2)**	**129.61**	**114.29**	**151.17**
Specific Gravity	-----	1.14	1.14	1.14
Curing Temperature	(^{0}C)	150	150	150
Curing Time	Min	14	14	14
Abrasion Resistance Vol. Loss	**mm^3**	**69**	**74**	**77**
Temperature	(^{0}C)	150	150	150
Arc	Degree	3	3	3
Chart Speed	Min	30	30	30
Torque Range	lbs	250	250	250
Scorch Time ts_2	Min	4.22	3.65	
Cure Time T_{c90}	Min	7.37	6.68	
ML	Lbs	14.89	13.33	
MH	Lbs	122.04	110.6	
Compound Cost	**Per KG**	**127.03**	**122.06**	

Cryo crumb shows high modulus, and higher hardness, Ambient crumb has higher TS, Better abrasion.

IRMRA EVALUATION

80 mesh crumb was evaluated at IRMRA laboratory using a standers tread compound as below.

NR-75 Phr, PBR-25 Phr, ZnO-3 Phr, St. acid-2 Phr, TDQ-1 Phr, MC wax-1 Phr, Crumb 80 mesh-0, 5, 10 Phr, Carbon330-55 Phr, Oil 710-8 Phr, Sulfur-2.25 Phr, CBS-1 Phr,

Note Carbon had to be reduced by 5 phr to maintain hardness when using 10m phr of 80 mesh crumb.

Test results are given below.

IRMRA
Helping Rubber World in Building Better Future

IRMRA REPORT

S No.	Test Parameters	Unit	80 Mesh		
	Before Ageing		0 phr	5 Phr	10 Phr
1	a. Tensile Strength	Kg/cm2	261	245	260
	b. Elongation @ Break	%	580	610	590
	c. Modulus @ 300%	kg/cm2	103	98	96
2	After Ageing @ 700C for 72hrs				
	a. Tensile Strength	Kg/cm2	258	242	248
	b. Elongation @ Break	%	510	510	515
	c. Modulus @ 300%	kg/cm2	131	128	126
3	Hardness	Shore A	60	63	64
4	Compression Set @ 700C for 24 hrs 25% compression	%	5.6	9	13
5	Ozone Resistance Test @ 50 pphm for 72 hrs	Visual	No Crack	Crack Observed	
6	Specific Gravity	g/cc	1.10	1.11	1.11
7	Abrasion Resistance Index	ARI	107	109	108
8	Mooney Viscosity ML (1+4) @ 1000C	MU	39	54	53
9	Dynamic Mechanical Analysis (DMA) 5Hz @ RT	Tan Delta Storage	0.068	0.061	0.072
		Storage Modulus	2.58x106	2.58x106	2.58x106
10	Thermo gravimetric Analysis (TGA)				
	Low Boiling Material	TGA	7.68	7.17	6.88
	Polymer Content		61.33	61.88	61.76
	Carbon Black Content		29	28.08	28.55
	Ash Content		2	2.8	2.7

- While adding 10 PHR crumb, carbon N 330 was reduced by 5 PHR.

REVOLUTIONARY INNOVATION

Manufacture of Microfine Rubber Powder (MRP), has all the advantages

- IT CAN BE ADDED AS A RAW MATERIAL IN NEW TYRE COMPOUNDS WITHOUT LOSS OF PROPERTIES.
- IT IS PART OF CIRCULAR ECONOMY
- IT USES WASTE TYRES WHICH OTHERWISE ARE AN ENVIRONMENT HAZZARD.
- IT REDUCES THE USE OF PETROLIUM BASED MATERIALS LIKE CARBON, OILS AND SYNTHETIC RUBBER.
- HELPS IN REDUCING GLOBAL WARMING BY REDUCING CO2 EMMISSIONS
- IT IS LOW COST AND NOT SUBJECTED TO VAGERIES OF MARKET FLUCTUATION DUE TO PETROLIUM PRICES.
- IT DOES NOT CAUSE ANY POLLUTION.

Tinna Rubber and infrastructure Ltd a New Delhi base company IS THE LARGEST PRODUCER of MRP by ambient process which gives fractured particles with highest surface area.

ROADS

Tyre crumb is now widely used in rubberising bitumen used in the road surfacing. By adding 10 to 20 parts of tyre crumb in Bitumen, for the road surfacing enhances the life of roads to 10 years.

- **Roads do not break during rains, since rubber makes it waterproof**
- **The bitumen being rubberised does not belt in extreme atmospheric conditions.**
- **Nor does it develop cracks in extreme cold at minus temperatures.**
- **Very cost effective the cost of tyre crumb is 60% of that of the Bitumen.**

ALL OVER THE WORLD ROADS ARE BEING MADE BY USING RUBBER CRUMB ADDED 10 TO 10 PARTS IN THE BITUMEN.

Other possibilities

- **Work is going on developing high T.S. reclaim with stable Mooney.**
- **Activated crumb rubber , in which case the tyre crumb is surface treated with certain chemicals so that it gets combined to the new compound, and no reclaimation is required.**
- **Pyrolysis is the oldest method of using waste tyres, where rubber is dry distilled and high caloric value fuel oil is produced. It is widely in use all over the world. However sale is dependent upon the vagaries of petroleum prices. Being a simple technology it can be very competitive.**

UNLOCKING WORLD CLASS BONDING AGENTS FOR HIGH PERFORMANCE RUBBER & PU TO SUBSTRATE BONDING

SPECIAL FOCUS ON ONE COAT BONDING TECHNOLOGIES

The Cilbond™ range of Rubber and Polyurethane to Substrate Bonding Agents allow engineers to combine the different properties of rubber, urethane, plastic, metal, and fabric to develop industrial components with benefits that outweigh the sum of their parts.

This combination of benefits include flexibility, strength, abrasion resistance, chemical resistance, cost, and weight - all features critical to the Automotive, Aerospace, Petrochem, and Transportation industries that H.B. Fuller serves.

Developed at our in-house research and development laboratory, the Cilbond™ range of products is at the forefront of technology with respect to performance, versatility, and the environment.

The Cilbond™ bonding agents are relied upon in the toughest environments across industries as diverse from Aerospace & Automotive to Marine & Defence.

CILBOND™ NEW GENERATION ONE-COAT TECHNOLOGIES:

Convention states that polymer to substrate bonding agents should always consist of a primer and a topcoat.

Whilst H.B. Fuller manufacture a wide range of high-performance primers and topcoats, our aim is to simplify processes and reduce costs for our customers wherever possible, without compromising quality.

Our developments have therefore focused on achieving the same levels of environmental resistance and rubber tear with one-coat Cilbond™ systems.

Not only are material usage rates substantially reduced, but time and resources are also saved by a reduction in application times and subsequent drying times.

KEY APPLICATIONS:

RUBBER TO METAL BONDING FOR DIVERSE RANGE OF COMPONENTS:

- Solid Tyres
- Anti-Vibration Components
- Industrial Tank Linings
- Printing Rollers
- Pump Linings
- Seals and Gaskets
- Suspension Bushes
- Wheels

The Rubber to Metal Bonding technique is used within industry to isolate vibration, reduce shock or to provide a seal for liquids, solids, or gases, in potentially demanding environments.

With Cilbond™, it is possible to achieve an engineering bond capable of surviving extreme environmental attack from chemicals, temperature variations, dynamic stresses, and fatigue.

With a product for every compound type and molding technique (including injection, compression, transfer, and even post-vulcanization), the Cilbond™ range provides the rubber industry with the ultimate combination of performance and versatility.

RUBBER TO FABRIC BONDING

The combination of rubber with fabric reinforcement achieves the ultimate combination of torsional strength and flexibility. These properties are utilized in critical automotive and industrial applications such as power transmission belting, conveyor belting and hoses.

Increased operating temperatures and extended life expectancy of these products is possible due to the superior strength and flexibility of Cilbond™, a fundamental component in recent belt and hose design.

POLYURETHANE TO SUBSTRATE BONDING

The superior properties of polyurethane (PUR) systems mean they are the material of choice for engineers looking for the ultimate performance from an elastomer.

The Cilbond™ range of PUR to substrate bonding agents provide the ultimate in bond strength, with 100 % PUR tear achievable whilst under the toughest environment conditions.

With high performance products available for hot and cold curing castable systems and even injection molded TPUs, H.B. Fuller has established itself as the global market leader in PUR bonding

Key Applications for Polyurethane to Substrate Bonding in include –

- Conveying Rollers
- Wheels
- Marine Bend Restrictors
- Pump Linings
- Suspension Bushes
- Pipe Coating and Linings
- Printing Rollers
- Seals