Rubber Science, **25**(2): 253-268, 2012 COMMENTARY PAPER

INDIAN RETREADING SCENARIO - OPPORTUNITIES AND CHALLENGES

P. K. Mohamed and P. K. Unnikrishnan

Apollo Tyres Ltd., B-25, Sipcot Industrial Growth Centre, Oragadam, Sriperumbudur, Tamil Nadu, India

Received: 25 September 2012 Accepted: 10 October 2012

Mohammed, P.K. and Unnikrishnan, P.K. (2012). Indian retreading scenario – Opportunities and challenges. Rubber Science, **25**(2): 253-268.

INTRODUCTION

Most consumers often consider tyre as a commodity product and make purchasing decisions solely based on price without knowing that the tyre is really a complex product to manufacture. There are more than 50 raw materials and 20 or more components with large differences in that go into the making of a typical radial tire. Massive amount of machinery and processing are involved in creating the finished product. Tires are highly engineered structural composites, whose performance is designed to meet the vehicle manufacturers' criteria for ride, handling, and traction, plus the quality and performance expectations of the customer. Meeting these requirements become really challenging because of possible variations in performance influencing factors such as inflation pressure, road and service conditions.

Generally, the tyre manufacturers design tyres with more strength than the minimum specified limits to withstand service abuse and to facilitate multiple retreaded lives. By applying a new tread over the body of the worn out tyre, a fresh life is given to the tyre, at a cost which is less than 40% of the price of a new tyre (Fig. 1). This process is termed as tyre retreading.

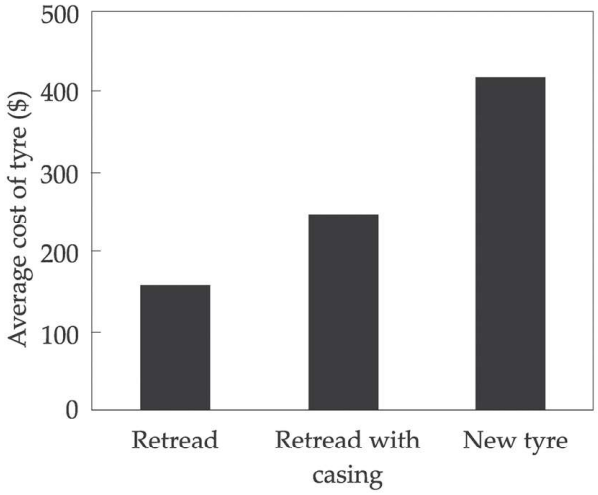

Fig. 1. Average cost of retreated and new tyres in US

Practice of retreading is popular in markets with good infrastructure and strict adherence to specifications and performance. The general notion in India is, *"if luck prevails, I can retread the tyres and defer the buying of new tyres, still have to pray for the retreaded tyre to perform without failure in service"*. This myth is due to various reasons, like the poor service conditions in which the tyre is exposed to

improper maintenance of the tyre and vehicle, delayed or untimely retreading, the retreading process *etc*. Hence a paradigm shift is required in the outlook and general awareness about retreading and this article is an attempt to throw light on these aspects which are often not noticed by an untrained eye.

Below, we discuss the retreading history, benefits, safety, international and Indian scenarios, opportunities and challenges in India *etc*. The history of Indian retreading industry is discussed with special reference to retreading plant and performance of retreaded tyres. The purpose of each operation and the machineries required in the retreading process are also discussed.

History

John Boyd Dunlop is credited with invention that "rubber could withstand the wear and tear of being a tire while retaining its resilience" which lead to the discovery of the pneumatic tire in 1887. The history of tire retreading is also almost as old as the history of tires and started in 1904 in the US. The shortage of tyres during World War II and the discovery of synthetic rubber were the major factors in the development and growth of the tyre retreading. Retreaded tires were utilized by military in war situations.

Widespread tyre retreading began in the 1980s and the retreading technology and manufacturing process have seen a steady development since. Now the retreaded tires are serviced and warranted in essentially the same fashion as new tires in many countries.

Benefits of retreading

Retreading is an environment friendly process doing a great service to our nation

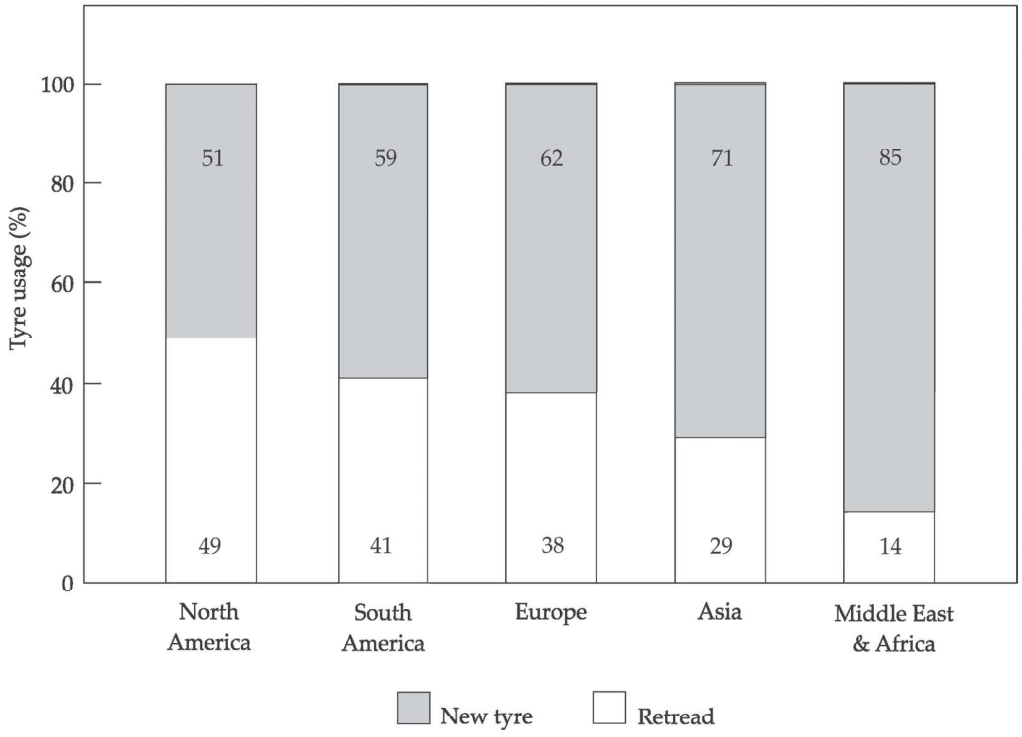

Fig. 2. Consumption of new and retreated tyres in America, Europe, Asia, Middle East and Africa as of 2011

by saving multi-billion rupees. On an approximate estimation, one third of all replacement commercial truck tyres in India are retreaded tyres. Without retreaded tyres, the cost of every product or goods we consume would go up as transportation cost would rise significantly.

It takes 83 liters of oil to produce a new tyre, whereas 26 liters of oil to retread the same tyre. The retreading industry saves several million liters of oil per year, not to mention keeping millions of tyres annually out of landfills. As per a recent study by Tellus Institute for the Blue Green Alliance (Tellus Institute Notes, 2011) a 75% recycling rate in North America would reduce carbon dioxide emissions by 276 million metric tons by 2030, equivalent to closing 72 coal-fired power plants or taking 50 million cars off the road. The industry also generates abundant employment opportunity. A national recycling rate of 75% would create nearly 1.5 million jobs in the U.S. according to the study.

Safety

Tyres retreaded by proven re-treading process are safe, durable and comparable in performance to new tyres. The fact that 80% of all commercial aircraft landings are on retreaded tyres and these tyres can often be retreaded as many as 11 times is proof of the safety aspect of retreaded tyres.

International scenario

The following graph depicts the usage of new and retreaded tyre across major geographies (Statistics (b), 2011). In North America, almost half of all replacement commercial truck tyres are retreaded tyres. In South America and Europe, the retread usage is 41% and 38% respectively as of 2011. In Asia, the retread consumption is estimated at 29%, where as Middle-East and African countries have about 14% usage each (Fig. 2).

In the US, 15.3 million truck tyres were retreaded in 2011. The retread market in Europe is slightly more than half the size in the US, *i.e.* 7.5 million units per year. Several Presidential Executive Orders support the use of retreaded tires, including Executive Order 13149 (Greening the Government Through Federal Fleet and Transportation Efficiency) which states, in part: *"agencies shall acquire and use United States EPA-designated Comprehensive Procurement Guideline items, including but not limited to retread tires, when such products are reasonably available and meet applicable performance standards."* In the developed economies, retreading is considered as a manufacturing process. Major tyre manufacturers are driving the retread concept as part of after sales service.

Consolidation of industry

In the US, retread industry is highly consolidated to fewer number of major

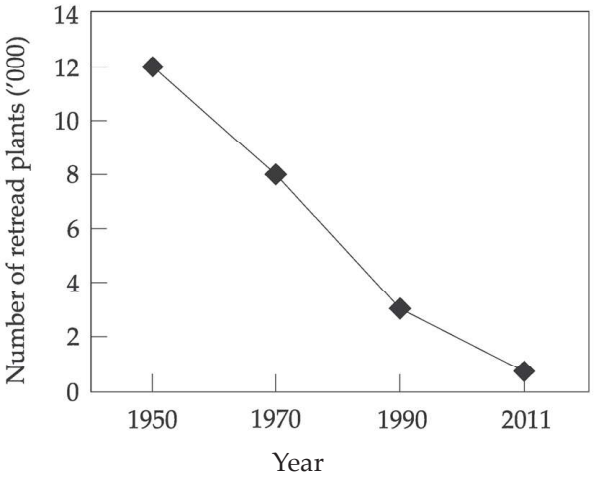

Fig. 3. Though the number of retreading plants declined, the number of retreaded tyres steadily increased during the period, 1950-2011

players with high volume production. Automated manufacturing with process control systems similar to new tyre manufacturing has become the norm in developed countries.

Consolidation of the retreading industry in the US is given in Fig. 3 (Tirecon, 2012). By the end of the 1950s, there were nearly 12,300 retreading facilities in North America and most retreaders were focused on passenger tires. But in 2011, the estimated number of retread plants in the US stood at nearly 700 with 18 plants producing large OTR retreads' 5 producing aircraft retread tyres and 4 producing passenger car retread tyres. 680 plants in the US produce truck retreads and 15.3 million truck tyres were retreaded in US in 2011.

As of 2009 the EU had about 450 active retread plants with Germany having the most, with 80 to 100 plants. Nearly two million of the EU's retreads are directly produced by new tire manufacturers. Passenger retread production, which is nearly obsolete in the U.S., makes up a sizeable percentage of the EU's total annual retread output at approximately 1.5 million units (Manges, 2009).

Entry of tyre majors into retreading in tie-up with leading brands accelerated the consolidation in the industry. One of the main reasons for this consolidation is the regulations, their strict adherence and monitoring mechanism. The retread tyre regulations in US and EU are the following:

US regulations: Department of transportation - Retreaded pneumatic tires -*Federal Motor Vehicle Safety Standard No. 117.*

ECE Regulations: *Uniform provisions concerning the approval for the production of retreaded pneumatic tyres for* motor cars and their trailers (No. 108) and commercial vehicle and their trailer (109).

In North and Latin America, normal industry practice is to buy the casings, retread and sell as branded retreaded tyres. In EU customers, generally prefer to get the retreading done on their own casing (Tirecon Asia, 2012). Cold method of retreading has become the major choice of processing in US. Almost 94% retreading is done through cold process in the US (Tirecon Asia, 2012). Another important part of tire retreading is repairing. Thirty-nine per cent of truck tires that come in for retreading require repairs in the US.

With sustainability as the key mantra in all spheres of life, there is a new found vigor all over the world in recycling and regenerating natural resources. It is imperative that India will also follow the developed world for a steady increase in retread consumption.

Indian scenario

The importance of retreading was known to Indian truck industry and hence the same has been practiced for decades in India. Domestic availability of new truck and bus tyre in India in 2011 was 17.7 million, with 67% of it being catered to the replacement segment (Statistics (a), 2011). The potential volume of tyres that could get retreaded is enormous. Apart from this, large number of tyres in other segments such as LCV, SCV, farm, and industrial category are also likely to get retreaded.

However, retreading and retreaded tyres are seen in the bad light by certain sections of the society. This could be due to the bad experience or perception with retreaded tyres. Over 80% of the Indian re-

treading industry is fragmented, comprising of numerous un-organised participants and poor quality standards by a few of them can spoil the image of the whole industry.

Retreadability enhancement

To achieve the desired level of retreadability in India, a multipronged approach is required:

(a) proper education of the customer, on the economic and environmental benefits of retreading

(b) maintenance of proper inflation pressure in the tyres (This is the major reason for premature failure or sub-optimal performance of tyre).

(c) proper maintenance and alignment of vehicle to prevent uneven wear and cord exposure

(d) timely repair in case of damage (Damages due to road pick-up or foreign object penetration is a common cause of tyre defect in Indian condition. Timely nail-hole repair or section repair would help in maintaining the casing integrity).

(e) timely removal of tyres for retreading (Tread wear indicator (TWI) is mandatorily given on tyres by the tyre manufacturer. Tyres are to be removed from the wheels when any tread portion along the circumference is worn up to the TWI marking. Yet certain customers continue to utilize the tyres, till all the grooves are completely worn out owing to the lack of confidence in retreading).

(f) selection of good retreading facility with proper infrastructure (Trained manpower with knowledge of standardized operating procedure, availability of necessary equipment and usage of proper material are imperative for a good retread).

Favorable factors

Momentum for retreading is gaining in India. The main factors which encourage retreading are:

- better road conditions, Express and National Highway Projects connecting the North-South and the East-West corridors, especially Golden Quadrilateral reading to reduced damage to tyre casing.
- better driving habits (getting more mileage even from retreaded tyres)
- control in overloading.
- growth in commercial vehicles segment, especially in multi axles.
- radialisation of commercial vehicle tyres (From the current level of 20%, radialisation in commercial vehicle tyre segment is projected to reach 40% by 2015-16).
- higher raw material cost and escalating price for a new tire

While more and more customers opt for retreading, the retreading facility has to upgrade to align with the technological challenges of radial retreading. To promote the use of retreaded tyres, we need to ensure that we deliver a quality product that meets the customer needs. This will ensure that customers will continue to use retreaded tyres as part of their overall tyre management programme. We also need to continue our investment in technology and ensure adherence to high production standards.

Retreading facility

Some of the retreaders in India use obsolete technology and machinery for

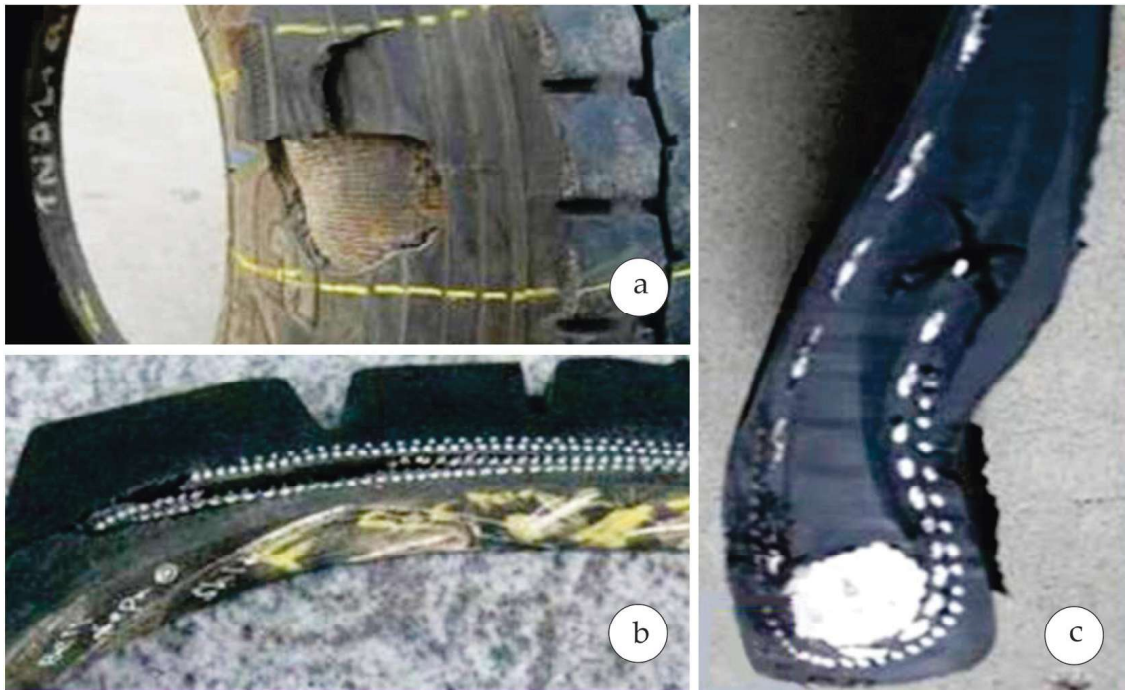

Fig. 4. Radial tyre defects a) Ply Separation at Shoulder, b) Belt Separation C) Turn

retreading bias tyres and the same facility is extended for retreading of radial tyre as well. The operations such as buffing, building and curing in retreading are to be carried out in the inflated condition without causing any distortion to the original casing. However, in many retreading units, the standardized equipment and machinery are not available.

As truck and bus radialisation is growing and cold retreading method being the most suited for TBR in India, especially for the cost conscious customer, the following discussion is limited to this particular segment.

Radial tyre is a composite and complex product, made up of numerous intricate components utilizing more than 50 raw materials. It contains more components than a corresponding bias tyre. Some typical radial tyre defects are shown in Fig. 4. Retreading of radial truck and bus tyre has to be viewed in an entirely different perspective compared to bias tyre retreading, because various processing factors affect the steel–rubber bond strength in the casing which will determine the subsequent service life.

Moreover, due to the supple sidewall of radial tyres, the shape of the casing is to be maintained by inflation in every step of retreading. The virtually non-expandable belt prevents the tire from expanding to meet a large diameter mould, resulting in insufficient curing pressure. Owing to the limited ability to expand or decrease the diameter of the tyre, conventional two piece moulds cannot be used for vulcanizing.

Inspection

Determination of casing quality and the selection of casing for retread are the initial critical operations. Superficial defects such

as injuries, cuts, damages can easily be identified on visual inspection. However, determining the internal flaws of casing is very difficult and if any are unidentified and retreaded, the probability of tyre failure in service is very high.

No tires should be accepted for retreading having any one of the following conditions or injuries which require repairs beyond the limits of the recommended Practice for tire repair (Industry Recommend Practices, 2010).

1. External

a. ply separation beyond repairable limits
b. tread separations which cannot be removed during buffing
c. broken, damaged, kinked or exposed bead wire
d. excessive oxidation (weather checking) extending to the body plies or deeper than 1.5mm
e. bias ply truck tires worn to the body plies on more than 10% of the worn tire circumference
f. radial truck tires worn to expose belt wires on more than 10% of the worn tire circumference, unless a protector belt is to be removed or damaged belts are to be replaced
g. circumferential cracking
h. radial truck tires with rust or corrosion beyond repairable limits
i. any sign of weakness or non-repairable injury (*e.g.,* ripples, bulges, porosity, softness) in the sidewall – particularly in the upper sidewall
j. crunching or popping sounds when flexed
k. surface cuts which exceed the size of a repairable injury and penetrate the cord body
l. radial cracking

Table 1. **Comparison of the plant facilities in typical overseas and Indian retreading plants**

Sl. No.	Typical overseas plant	Typical Indian plant
1	Capacity of a typical plant 1,000 to 10,000 tyres/month	100 to 1000 tyres/month
2	Inspection process (a) Visual inspection (b) Automatic Nail Hole Detector (c) Shearography	Visual inspection By tapping
3	Buffing Computerized automatic system	Manual & Semi-automatic
4	Cushion gum application Hot application	Cold application
5	Building Automatic application/ uniform stretch Seamless ring tread	Manual applicatiojn
6	Vacuuming envelope Snap seal system	Not established Conventional, MEPC
7	CuringLow temperature curing Electric oven/indirect steam heating	High temperature curing Direct steam/electric oven

2. Internal

a. injuries to the body plies in the non-repairable bead area

b. loose cords on the inside ply or evidence of having been run under-inflated or overloaded

c. non-repairable damage to the inner liner or bead area on tires identified as tubeless

d. open inner liner splices which expose cord

e. flex breaks, X breaks or impact breaks

f. porous or loose inner liners

g. previously installed repairs found to be defective and non repairable

h. suspected of potential zipper rupture

- cuts, snags or chips exposing body cords or steel
- distortions or undulations (ripples and/or bulges) visible when using an indirect light source which will produce shadows left by any sidewall irregularities
- creasing, wrinkling, cracking or discoloration of the inner liner
- soft spot(s) in the sidewall flex area
- protruding filaments indicating broken cords
- any popping sound when feeling for soft spots or when rolling the tire

Inspection of radial casing is normally done in "shearography" machines abroad (Table 1). Increasing awareness of such machines is growing in India and in the absence of such infrastructure, the following aspects assume greater significance

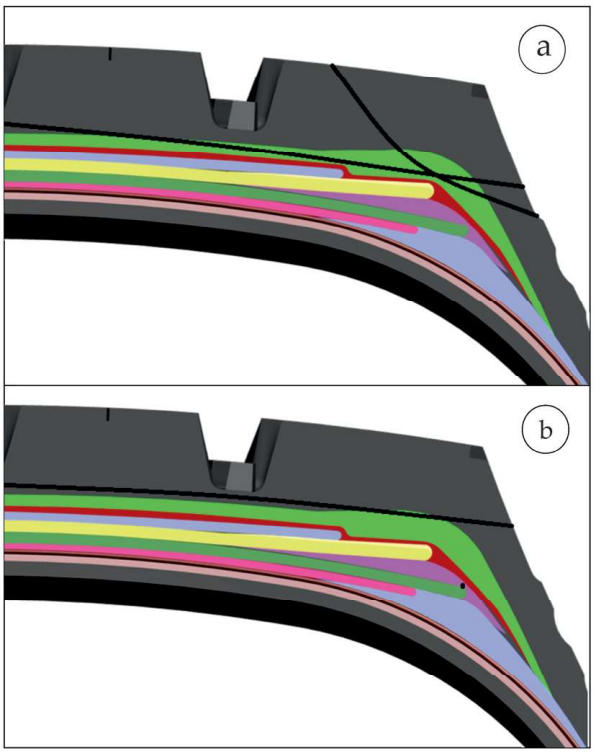

Fig. 5. a. Right buffing– Proper buffed width & tread width –Running forces are transmitted down the sidewall as the tyre was designed b. Wrong buffing - Buffed too narrow or to the wrong tread width - Running forces are transmitted in to the belt edge causing excessive wear and casing stress

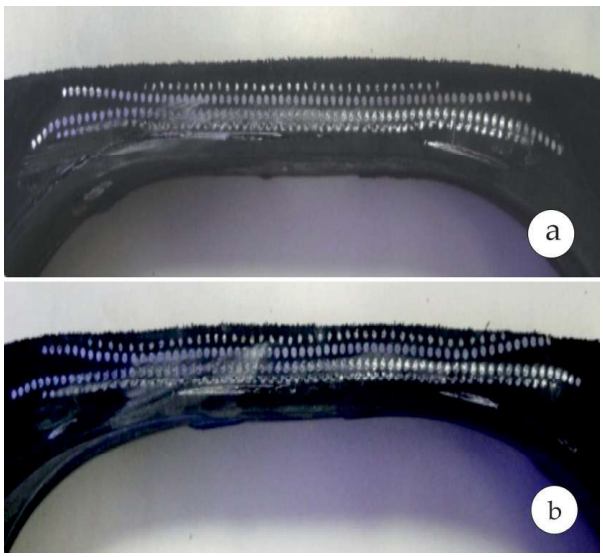

Fig. 6. Cross section of buffed TBR casing crown – Proper buffing (a) & Improper buffing (b)

- highly skilled manpower for casing inspection
- a separate spacious sound proof cabin with sufficient lighting
- inspection spreader having provision to open bead without buckling on crown, tyre rolling system and a bright inspection/grazing lamp

Buffing

A common complaint in pre-cured tires is that the center wears out faster while half of the tread pattern remains at the shoulder.

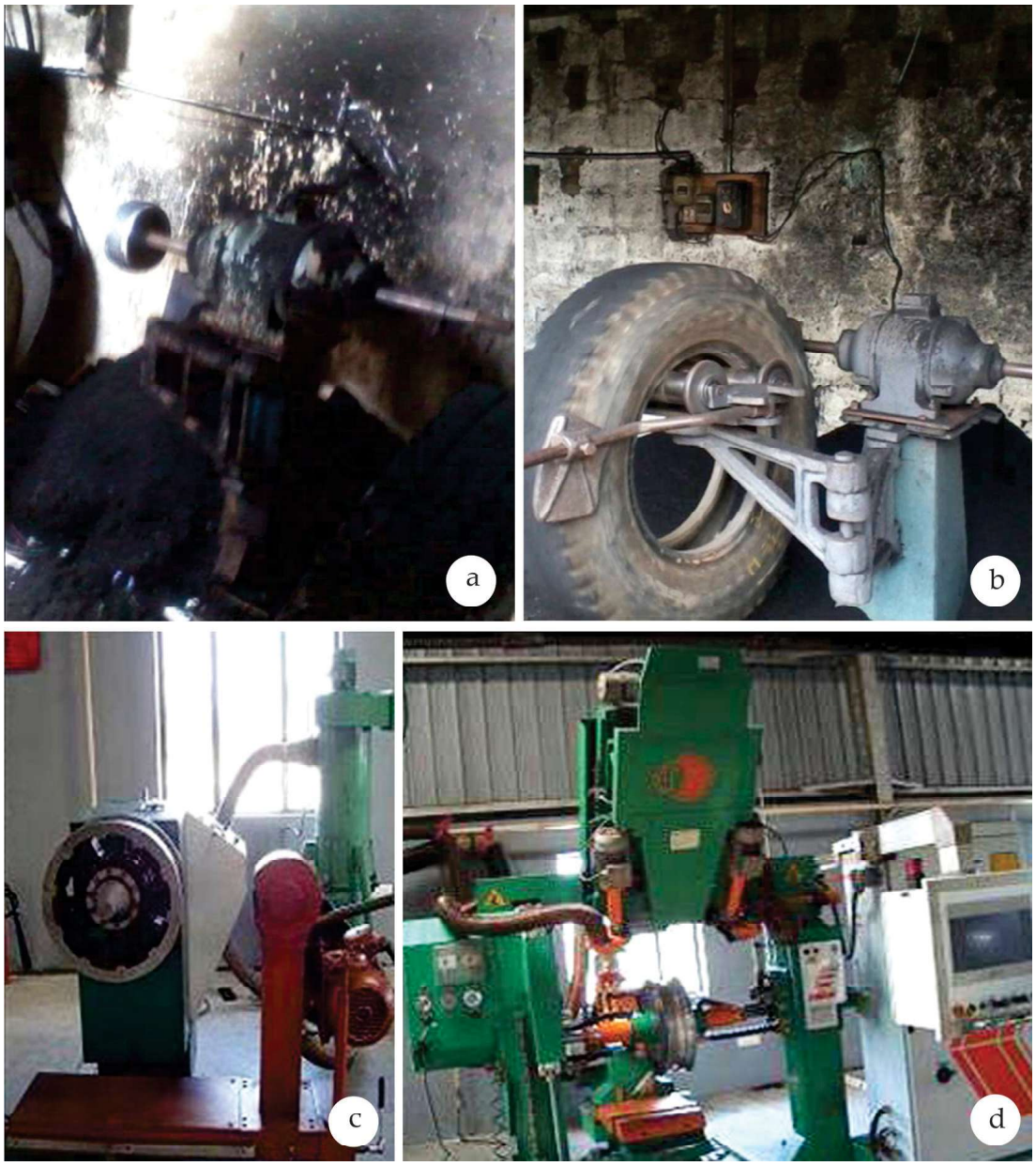

Fig. 7. Various types of buffing machines. Simple machines (a, b), semi-automatic (c) and fully automatic (d) machines

The problem stems from the wrong tread arc radius. The potential mileage is significantly reduced when the retread is made with the wrong tread radius (Figs. 5 and 6).

Buffing of tires for retreading has three major objectives – size, shape and texture.

a) To size the tire to fit a particular mould or width and diameter of pre-cured tread rubber. Very accurate diameter measurements should be made of inflated casings on the buffer by wrapping a steel tape around the center of the buffed radial tire.

b) To shape the tire to the properly buffed contour, or the crown radius for a pre-cured tread application. Its shape affects the finished tread radius of the tire when it is mounted and inflated, and influences how the tire will perform in service.

c) To prepare the surface texture for the application of the new tread rubber to attain proper adhesion. For retreading, the buffing texture should be RMA 3 or 4 for crown. Proper texture can be obtained by manipulation of the buffing machines and the careful selection of rasps.

It is high time the retreaders realized the potential loss due to improper retreading. Else the discerning customer would eventually be the choosers.

Still some retreaders rely on the simple buffing machine as given in Fig. 7 (a & b) below. Casings in the deformed shape are buffed-off without inflating to the required rim width and pressure. This is very detrimental to the casing strength. Understanding the significance, many retreaders are now turning to semi-auto buffing machines (Fig. 7c). This is a cost effective machine, through which reasonably satisfactory buffing is achieved and can easily satisfy the cost conscious customer. Realizing the importance of buffing operation a few retreaders have, installed the fully automatic buffing machines (Fig. 7d) where information about the tread arc radius, tread arc width, circumference etc are saved in the system for each tyre size. The output will be a perfectly buffed casing with uniform dimensions and texture with the least manual interface.

Uniform rubber gauge of minimum 1mm to maximum 3 mm over the belt is vital for the radial casing durability. The best retread adhesion is obtained by bonding new rubber to original rubber. Highest adhesion is not obtained to bare cords. Excessive under-tread will cause the retreaded tire to run hotter. So recommended tread arc radius should be set to get the desired tread width and gauge. One can ensure these gauges by measuring the buffed circumference and pilot skiving.

Radial tyre is supple at sidewall and rigid at tread area when compared to a bias tyre. Hence radial casing has to be mounted on a suitable rim, inflated to the recommended pressure to achieve proper structural dimension before buffing.

This inflation of casing also helps in spotting undetected pin holes or nail holes during the inspection stage. If unattended, rust and loose filaments at these holes will become a weak spot which affect the casing integrity. The casing should be centered properly and rotated at specified speed without eccentricity during buffing. All these important aspects of radial tyres call for an automatic or semi-automatic buffing machine.

Repairing

Buzz outs result from road pick up like nails, glass, rocks etc, which cut into the tyre. Buzz-out/skive-out is the single most neglected or mishandled detail and this is one of the major causes of radial retread failure. Never buzz or skive out any nail holes that will be filled with a plug type repair. Any damage larger than 10mm to the first working belt requires a section repair and damage to the #2 or #3 belt greater than 10mm may require a section repair. Proper precautions are to be taken during this critical operation.

In radial tyres, use low speed (2,000 to 2,500 RPM) tools for buffing/skiving out rubber. Avoid scorching rubber or overheating wire with high speed tools, as this will impair adhesion. Buzz out steel cord with high speed tools (25,000 RPM). Any exposed wire should be cleared of frayed or shredded ends. Be sure to remove "fuzz" from frayed wire. Any exposed steel in buffed tyre must be cemented immediately to prevent oxidation and rusting.

Radial tyres, with no visible rust, should be probed at the injured area for any sign of separation or loose wires. If the area is tight, do not buzz or skive out. Radial tyre casings with rust stains should be probed for loose wires. When close to the wire, use an encapsulated wire brush. Fill cavities after adequate drying time with repair gum and stitch firmly.

It is not recommended to use bleeder yarns, which is a common practice in bias tyres. Bleeder yarns, if present in radial casings can absorb moisture. This results in rusting and degradation of steel wires if both are in close contact.

A section repair spotter with automatic time and temperature control unit is recommended to prevent unwanted heating of whole tire. For bias casing, a single tool may be sufficient, but for proper repairing of a radial casing, the recommended low/high speed tools and other accessories are very much necessary. Puncture repairs should be limited to the tread area only and not exceed 10 mm diameter after preparation

Wider sidewall repairs should be shorter in length. Maximum number of section repairs in a tyre should be limited to two for high way application and three for regional application (Table 2).

Cement and cushion gum

The main objectives of cementing are to:

- ✓ improve temporary adhesion
- ✓ hold the buildup unit together until it can be cured
- ✓ provide protection to the buffed surface to prevent oxidation and vapour contamination during storage periods
- ✓ provide sealing of cord ends in skived and buffed repair cavities

Table 2. **Maximum section repair limits for radial truck tires**

Tire Type and Size	Sidewall width mm	Sidewall length mm	Shoulder diameter mm	Crown diameter mm
Medium Truck	10	95		
7.50–10.00	15	95	15	25
8–11	20	60		
21575 –286/75	25	50		
Heavy Truck	10	130		
11.00–16.00				
12–16	20	125	25	40
296/80–445/65	25	100		
435/50–495/50	40	75		

This operation should be done immediately after buffing/rasping to prevent oxidation of steel wires. Ensure that enough time is allowed to dry completely, normally 30- 40 min. Meantime the tread for the tyre should also be cemented and allowed to dry.

The cushion gum is the most important material in pre-cured retreading and must be carefully checked before use. It is the unvulcanised rubber compound which forms the vital intermediate layer to give the required bonding between the already cured casing and the new tread rubber. In established plants overseas, cushion gum is applied in hot condition using extruders to ensure proper fresh bonding and even filling of buzz outs. In India, calendared cushion gum rolls are outsourced like the tread rubber.

Cushion gum must be fresh, with close attention paid to its shelf life. It should be stored in cool, dry conditions, as higher temperatures will cause premature curing, known as set-up. This will prevent cushion flow resulting in poor adhesion. Polythene should be easily removable without tearing or brittleness. However, it has been noticed that very low quality material is also being used in the industry badly affecting the reputation of the retreading sector.

Tread selection and building

Precured tread is best suited for radial retreading in Indian condition due to low temperature curing. Selection of tread is based on the buffed casing width, circumference and eventual tyre service and application. Base width of the tread rubber should not exceed the buffed width of the casing. It should be equal or maximum 5 mm less than buffed surface for truck/bus casings. Usage of lesser base width tread may result in low mileage and belt edge failure due to stress concentration.

Tread rubber should be centered around the tire +/- 3.0 mm from the centerline. Tread stitching should be performed in such a way as to avoid trapping air, pulling the tread off

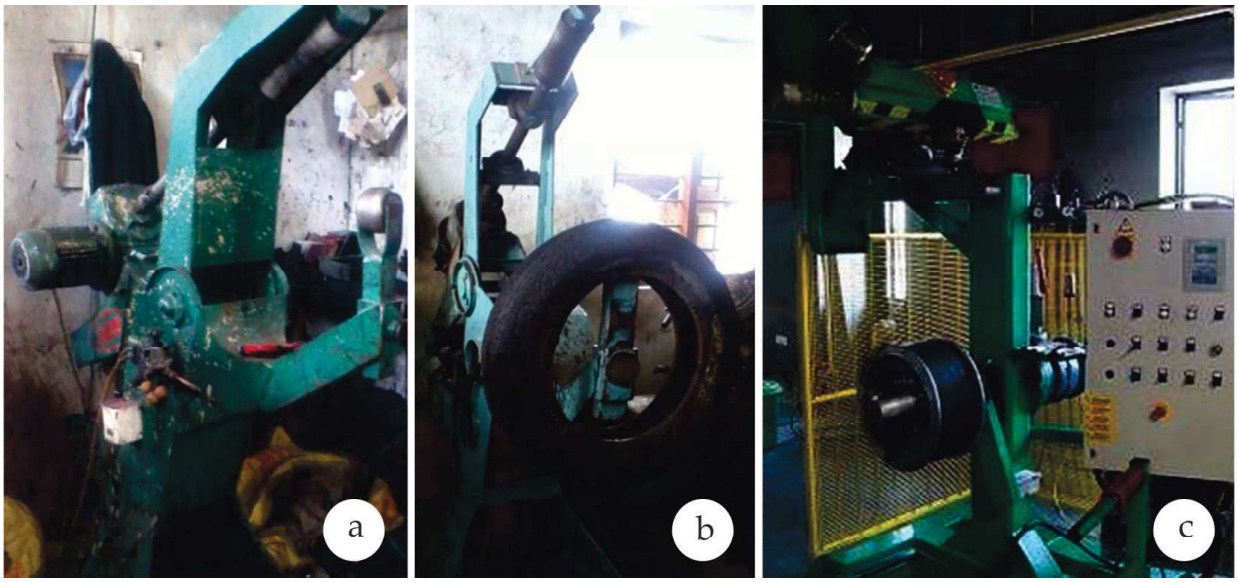

Fig. 8. Building machines (a and b) Improper manual system(c) Proper semi-auto system

center, and distorting, folding or wrinkling at the shoulders. For a good PCTR radial building machine, features like dual speed motor for slow and fast rotation, forward and reverse rotation of the tyre, variable stitching and inflation pressures, guillotine tread cutter *etc*. are desired.

However, some retreaders still apply tread using a supporting structure as shown in the Fig. 8 (a,b). Casings in the deformed shape without inflation and control mechanism to feed the tread over shaped casing will lead to imbalance in the tread mass. Semi-automated system measures proper feed of the tread over the casing (Fig. 8c)

The tread should be cut to the same length, depending on pattern match, as the measured buffed circumference, which will allow for a slight tension during application and ensure that the shoulders will grip into the cushion. A tread, which is cut longer than the measured circumference, would result in air trapping and which is cut too short will increase the tension and could result in the splice opening. After tread application, wicking pads are to be attached to bleed out air and ensure a quick proper vacuum after enveloping.

Enveloping

Envelope insures uniform pressure and temperature, and promotes uniform curing and complete integration of repairs from the crown to the beads. It prevents the prepared tyre from direct exposure to hot air and also holds the tread in position while curing. Hence it should be leak free.

There is a practice among certain retreaders to apply polypropylene cross woven fabric over tread. This prevents the proper penetration of envelope into the tread grooves, resulting in poor consolidation, cushion gum accumulation and subsequent bulge out. This practice is not recommended in radial retreading

Other factors affecting radial tyre casing strength

Owing to the limited ability to contract or expand radial tyres diametrically, conventional two piece moulds are not suitable and which is more suited for bias tyres of rounder cross section.

Since radial tyre essentially is a rubber–steel composite, exposure to conditions affecting the bonding strength beyond desirable limit is detrimental to the tyre casing integrity and durability. With increase

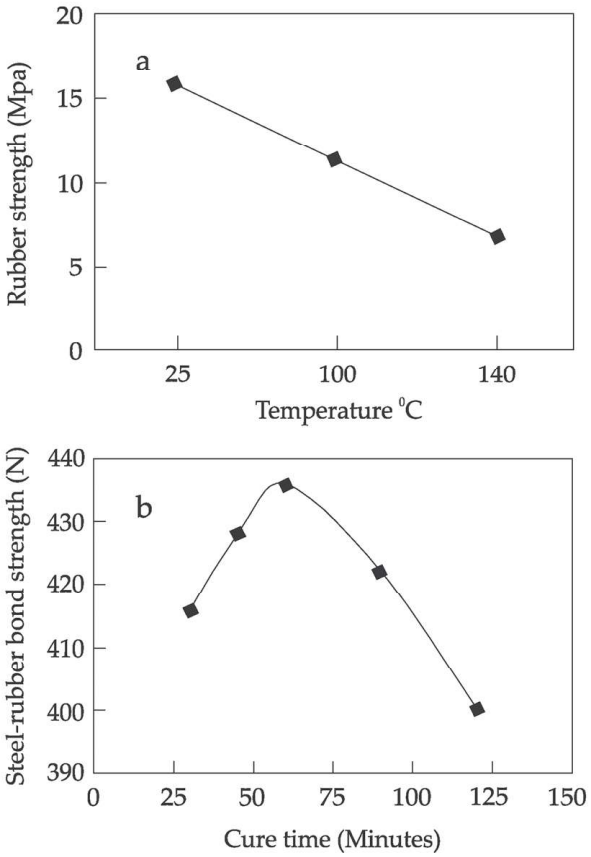

Fig. 9. Graph depicting the effect of higher temperature on rubber strength (a) and effect of cure time on steel-rubber bond strength (b)

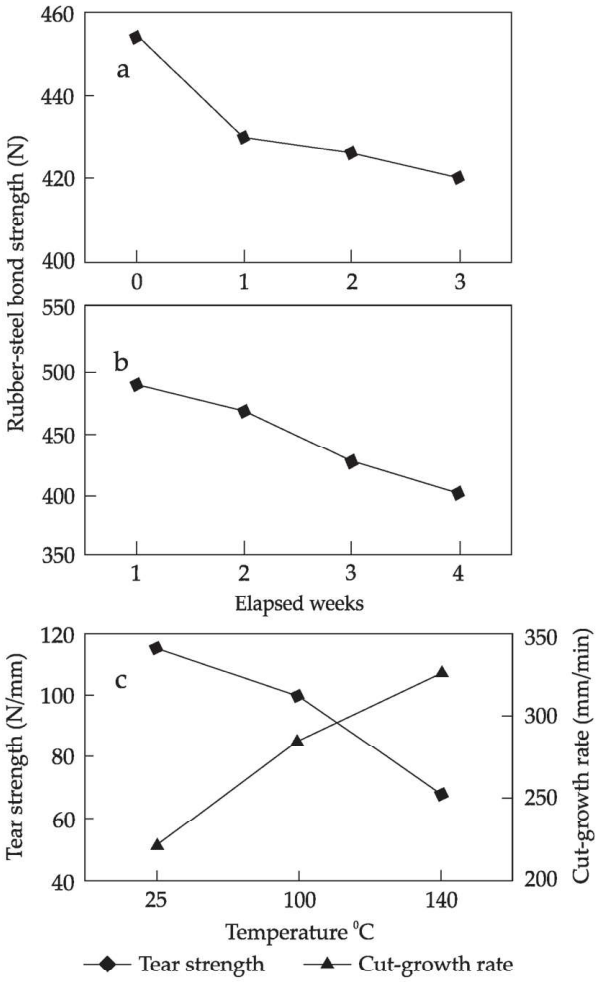

Fig. 10. Graph depicting the effect on rubber-steel bond strength due to salt water exposure (a) exposure to moisture (b) and effect of temperature on tear and cut growth resistence of cured rubber

of temperature rubber strength decreases remarkably and rubber to metal bond strength in maximum at epitomise (Fig. 9)

As seen Fig. 9 and Fig. 10 in the above graphs, factors such as longer exposure to higher temperature, humid conditions and salt water are detrimental to the Rubber-Steel bonding strength as also the tensile properties of rubber. So, utmost care should be taken in maintaining the standard curing conditions. Buffed tyres should not be exposed to longer duration and any cuts or rust should not be left unattended.

Suitable curing method for radial tyres

The hard fact is that heat is the biggest killer of rubber and tyres. The recognized temperature that affects the adhesion of rubber to the casing material (rayon, nylon, steel etc) is 118 °C. Hence "cold retreading" at low temperature is more suitable for radial tyres than "hot method". Moreover, the quality and performance of cold process is consistent and gives life almost like a new tyre.

Higher temperature, steam condensate, vapour, humid conditions etc have adverse effect on rubber-steel bonding strength; Direct steam heating facility (Fig. 11) is not recommended for radial retreading because of the following reasons:

a) Very high temperature at the desired chamber pressure in a steam chamber.

Steam pressure (gauge)	Steam temperature
6 PSi	110 °C
19 PSi	125 °C
60 PSi	151 °C
85 PSi	163 °C

Fig. 11. Steam Chamber (Direct exposure to steam

Steel radial tyres require higher pressure for proper consolidation during curing than bias tyres. Normal inflation pressure is 110 PSi and a chamber pressure of minimum 60 PSi to maximum of 85 PSi is required to get the proper consolidation. To achieve this pressure, the resultant temperature is very high in a direct steam heating system.

b) Dimensional variation during curing. As pair tyres are pressed together at the sidewall during curing in steam bonder, with the excessive/uncontrolled flange/ lid tightening, tread arc radius changes during the curing.

c) Chances of cuts/repairs & cushion gum getting exposed to steam/condensate

Hence an electric oven or an indirect steam method, where pressurized hot air is the curing medium, is recommended for radial tyre retreading. (Fig. 12)

Maintaining the curing temperature (preferably low temperature curing) and time as recommended by the cushion gum supplier should be strictly adhered to, for achieving the desired casing durability.

Bias tyres made with nylon are required to be cooled down in Post Cure Inflation after retreading; whereas PCI is not required for radial tyre.

Envelope vacuuming is the best way to ensure the proper consolidation of tread grooves to the casing (Fig. 13). As this is not quite popular in India, an alternative method, based on the principle of pressurizing the void space between envelope and casing with a 10 to 20 psi lesser pressure than the chamber pressure commonly known as "MEPC – Modulated Envelope Pressure Curing" or "DPC – Dual pressure curing" is

Fig. 12. Electric chamber

recommended. This method is also best suited in hot air curing medium.

Another method, using wider envelop to cover up to the bead area with out employing rim, curing bag etc, popularly called as "Snap Seal" or Quick Seal" or "A R Seal" system is more common for radial retreading in abroad. This method enhances productivity and reduces cost, but is also possible only with hot air curing medium.

HOT method of radial tyre retreading is also good, provided heating is restricted

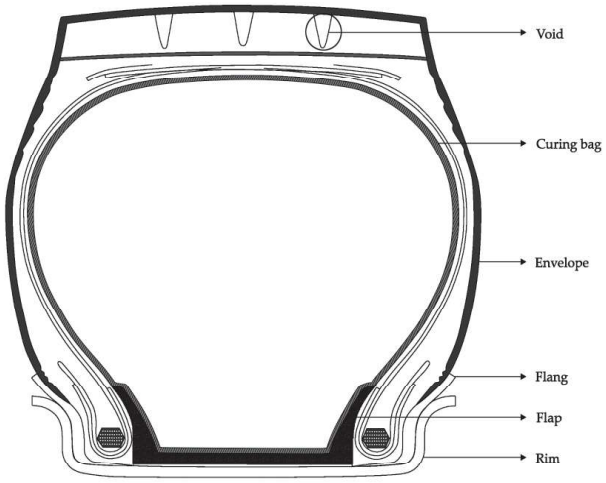

Fig. 13. Cross sectional view of a radial casing assembled with tread on rim fitted with other accessories

only to the tread portion. Suitable heavy duty curing press with segmented moulds that close around the tire is required in this case. By closing around the tire, this system eliminates tire distortion during the loading and unloading

Final Inspection

Examine all cured tires for light spots and do not place into service any that are found to be improperly filled out or where any porosity is evident. Chamber cured tires should be inspected for any evidence of under-cure, or loss of pressure during cure, at the exposed rubber junctions.

CONCLUSION

With the proper understanding of the basic functional requirement of radial retreading system, utilization of the recommended machinery and equipment and proper procedures, casing life can be achieved to the fullest.

Apollo radial tyres are manufactured in the state of the art plant with precision engineered in to the best technology. The service life of Apollo TBR tyre can be more than 150 million flex cycles qualifying the tyres for multiple retreads. Following the recommended retread processes and usage of quality retreading materials are the deciding factors other than the service conditions to ensure the desired level of performance.

In brief, a reputed retreader provides a safe tyre similar to a new tire, but at a far lower price than a comparable new tire. By doing so, he also participates in conserving the environment because retreading is recycling and retreads are far friendlier to the environment than new tires.

Many small retreaders using primitive equipment will simply not be able to retread radials with their existing equipment. Unless they are willing and able to upgrade their plants by making the necessary investments, they will fall by the wayside.

To promote the use of retreaded tyres, we need to ensure that a quality product that meets customers needs is delivered. Once the benefits are realized, they will continue to use retreaded tyres as part of their overall tyre management program. We also need to continue our investment in technology and make sure that we adhere to the required production standards.

REFERENCES

"An Overview of The US Retread Market And The Use of Advanced Technology To Improve Retread Quality" (2012). Tire Retread and Repair Information Bureau- Tyre Industry Conference, Shanghai, China "Tirecon Asia 2012".

"Industry Recommended Practices for Tire Retreading and Tire Repairing" (2010). (http://www.retread.org).

Manges M., (2009). Retreading: A European Perspective. (http://www.moderntiredealer. com).

Statistics (a) (2011). Category Wise Supply of Tyres to Various Segments. (http://www.atmaindia. net).

Statistics (b) (2011). Usage of New and Retreaded Tyre Across Major Geographies http://www.bandag.com.

Tellus Institute With Sound Resource Management (2011). More Jobs, Less Pollution: Growing The Recycling Economy in the U.S. (http://www.bluegreenalliance.org).