AN EXPERIMENTAL ANALYSIS ON LIFE CYCLE OF TYRE RETREADING

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ABSTRACT

With the rapid development of automobile industry, scrap tyres producing substantially, the tyre retreaded has become a way of valuable and environmental recycling technology internationally recognized, and the need of promoting the energy conservation and emission reduction and the green recycling economy developing. However, the retreaded tyre lacks of systematic research in terms of technology theory, craft and detection, so the retreaded tyre of brings the destruction and failure of the tread, sidewall, ply, buffer layer and bead delaminating and cracking. The destruction and failure brings about the malfunctions of the tyre burst out of control, and the traffic accident of the moving vehicle. This seriously influences the application market of the retreaded tyre, and the person safety. The aim of this paper is to investigate the life of new and retreaded tyre. Retreading is one of the best process to increase the life of tyre. In practice, firms involved with commercial vehicles exploitation have to decide whether to retread used tyres or not, depending on the number of retreading of used tyres and travelled distances after each retreading. Analysis is performed on database of tyre's exploitation from a company of public passenger transportation and the statistical results are used as inputs to the proposed model. The results obtained according to the proposed model provide a good basis when it comes to making a decision whether to retread or not a used tyre. The experimental results show that retreading cost is 28% and life is 75% compare to new tyre. This paper gives the better approach of energy conservation.

Keywords : Retread, Buffing, Building,Vulcanised

I. INTRODUCTION OF TYRE

The tyres are required to carry the load of the automobile. The tyres may be with tube or tubeless. In the former, the tube is inside the tyre and contains air at high pressure. In tubeless tyre there is no tube and tyre itself contains air at high pressure. They also transfer the braking and driving torque to the road. The motion of the automobile becomes possible only when the friction acts between the tyre surface and the road surface. This friction is required for the stability of the moving automobile. The friction must not go beyond a particular limit as it will cause wastage of power output from the engine and loss of money in the form of wastage of fuel. The tyres also absorb the vibrations due to the uneven road surface. The road may be dry or wet, it may be a concrete road, or may be paved with gravel or asphalt. Sometimes automobile may be required to move on a 'rough' road. The tyres must be capable of providing stability to the automobile in all these varying conditions.

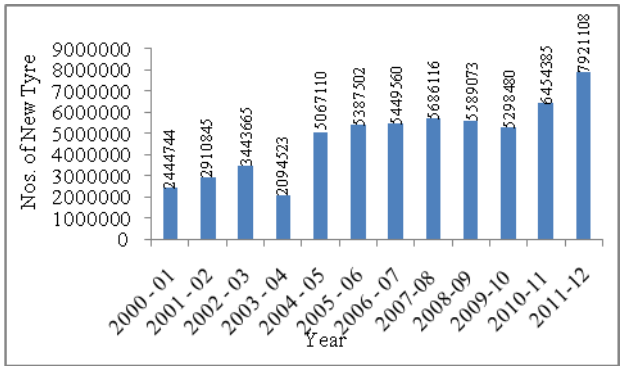

Fig. 1Total nos. of New Tyre Production in India for F-2000-01 to F-2011-12 [30]

1.1 Types of tyre [1]

1. Tyre with Cotton (reinforcement) Carcass

In the starting phase of proper Bias or Cross ply tyre, cotton plies were used as main reinforcing material (end of 19th and early 20th Century). Cotton reinforcing material had inherent problems of low strength and high moisture regainer. Leading to large number of plies to get the requisite casing strength for the tyre weight of the tyre and poor heat dissipation. This, in turn, gave an adverse impact on Tyre weight and buck rendering poor performance.

2. Tyre with Nylon (reinforcement) Carcass

Persuent to development and introduction of Polymide (Nylon) the strength and flexing behavior of reinforcing materials improved substantially resulting in further reduction of number of plies, consequently the weight of the tyres. This development substantially improved the heat and impact resistance of the carcass leading to better tyre performance and higher durability. Nylon casing gave a boost to retreadability. Thus effective cost of the tyre in operation became much more economical.

Development of Tyre Technology due to change in Reinforcing material is basically in the case of Cross Ply or Bias Tyres. Bias tyre has cotton, Rayon or Nylon Cords, bound as plies and each ply (i.e. Cords) cross each other at a definite angle anchoring at the bead.

3. Radial (Construction) Tyre - Textile/Textile belt (Rayon/Nylon/Polyester)

Inspite of continuos development in Bias Tyre Technology, inherent problem of high heat development and poor life remains a continuos challenge.

In early 1950s new concept of Tyre design was developed namely "RADIAL" wherein plies were made highly flexible by keeping the cords at 90 and in order to improve tyre life, inextensible (stiff) belts were placed on the top of the Carcass under the tread. This led to stiffer tread portion, leading to higher Tread life (Mileage) and much more comfortable ride due to flexible carcass. This was the beginning of 'Revolution' in tyre technology.

Initially Radial tyres were introduced with Casing Plies as well as belt material of textiles.

Continuos development in Radial Concept led to further improvements as explained below.

4. Radial (Construction) Tyre - Textile/Steel belts

Once Steel Tyre cord got developed it found its immediate application in Belt material, keeping casing plies of Textile, to further improve durability.

5. Low Aspect Ratio (Cross Ply or Bias) Tyre

A new concept of low aspect ratio (ratio between section height and section width) of the tyre in cross ply construction was introduced for higher speed and better performance.

6. Tubeless Tyre (Cross Ply)

Concept of tubeless tyre in cross ply construction wherein an inner liner compound based on chlorobutyl or Halo Butyl which is impermeable to gases, was introduced eliminating the usage of tubes. However, Tubeless tyres are produced for Export Market. Gradually this concept will become fully acceptable with the advent of new generation vehicles and improved service facilities.

7. Radial (Construction) Tyre - All Steel

In developed countries, Radial Truck/Bus tyres use steel wires in casing as well as in Belts to achieve the optimum advantage of radial construction. In India also this construction was tried since late 1970s by Indian Companies using tyres of collaborators. This could not succeed.

Indian companies started experimentally since late 1980s (themselves or with collaborators) which continues and the product has found gradual entry into low load application.

II. TYRE RETREADING

It is very essential to know the meaning of 'tread'. The grooves which are cut on the tyre surface are called tread. These treads ensure the gripping action between the road surface and tyre. After the use of tyre the depth of treads becomes less and a slippery action takes place between road surface and tyre. The co-efficient of friction becomes less. A tyre is in no more condition to be used again. Now, here becomes the choice either to replace the tyre with a new one which is very expensive or to retread the tyre which is less expensive as compared to the cost of new tyre.'Retreading' means taking a worn casing of good structural quality and putting it through a process which completely renews the tread of the tyre and sometimes the sidewall rubber. The rebuilt tyre is then subjected to a curing process where the new rubber is vulcanized to the casing and the tread pattern is formed. Retreading process can also rectify minor cuts or defects on the side walls of tyre, beads and punctures in a single stage. A tyre can be retreaded or not this is entyrely dependable on the type of use of tyre and condition of tyre for example car tyres, 2 or 3 times; Light truck tyres 4 to 5 times; Heavy truck tyres 8 to 9 times; Air craft tyres upto 14 times. [3]

2.1 Why it is Required?

Over the years tyre manufacturers have invested heavily in product development to deliver tyres that not only have a 'first life' but are also designed to perform equally as well in subsequent second and even third lives. Stronger casings, improved re-manufacturing techniques, a variety of specialist rubber compounds, coupled with the need to recycle and reduce the negative impact on the environment has lead to a sustained growth in the retread industry.

Also to reduce the new manufacturing of tyre by using the old tyre. It gives an approach for energy conservation by saving the energy, material, man power, machine power and reduce the air pollution.

2.2 Benefits

- Commitment to the environment
- Reduce pollution
- Conserve oil
- Less energy
- Conserve resources

A retread tyre starts life as a worn tyre, where perhaps the tread is down to 2-3 mm and may have been previously re-grooved, or one that's been punctured and needs a repair.

Fig. 2 Effect of Tread Depth on Fuel Consumption Fuel savings at various tread wear level [24]

2.3 Process of Retreading [23]

1. Conventional Process (also known as 'mould cure' or 'hot cure' process)
2. Precure Process (also known as 'cold cure')

2.3.1 Conventional Process

a) Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.

b) Tyre is left for some time so that it may dry or a drier can be used for this purpose .

c) Initial inspection is carried out to verify that casing is acceptable for retreading process or not. It is thoroughly examine inside and outside and marked with yellow coloured crayons.

d) Buffing :- The primary objective of buffing is to prepare the worn out tread surface of tyre to receive a retread. The original tread design and the some of the under tread is also removed to provide the casing with required dimensions and surface texture. In other words it increases the co-efficient of friction of untread surface of tyre so that it can hold firmly the cushion and sole of new tread.

e) A tyre is continuously rotating and a painting brush depth in vulcanized rubber solvent is placed over the surface of tyre. In this way it spreads uniformly. Take another dip of solvent if required. After the application of sufficient solvent a cushioning strip is fixed and tyre is slowly rotated so that complete circumference of tyre is covered and uncured tread compound is extruded or applied as a strip of sufficient length directly to the casing.

f) The tyre is placed in a mould and air pressure is maintained so that it expands uncured material takes the position of the mould temperature of 150. C the tread and after some time the mould is opened and tyre is taken from the mould. These mould are used in the manufacture of new

tyres. For every size of tyre a new mould is required so it is a expensive process and almost obsolete now a days.

A modern approach has been made in this section since last 20 - 25 years cols process retreading process has been becoming more popular and efficient due to is low cost, easy handling and more profit margins.

2.3.2 Precure Process

a) Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.

b) Tyre is left for some time so that it may dry or a drier can be used for this purpose.

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applied as a strip of sufficient length directly to the casing.

f) Now tyres are unloaded from the machines and hanged over hangers. The tyre envelope under a cover so that in the premould process the uncured cushion has to be vulcanized while pre mould tread has to be kept in position. Tyres from hangers are moved by hoists and chains and placed in fixed position in horizontal Autoclave. (Autoclave is a type of furnace). The air pressure nozzle tip is connected to envelope air pressure is maintained and lid of furnace is closed. A push button is switched on. A temperature of 99.C is maintained for 3-4 hours. This action creates an adhesive action between vulcanized coating, cushion pad and sole of treads. After 4 hours the electric supply is switched off and allow to cool in the furnace for 1 to 2 hours. The tyre is removed from the furnace and allowed to cool till the operator become able to remove the envelope.

g) Final inspection:-To ensure that all the defects which were assigned before the process have been removed or not. If tyres pass the final inspection then; they are kept in warehouse for the requirement of supply.

III. EXPERIMENTAL ANALYSIS

3.1 Test Method

In order to find out the life cycle of retreading tyre, a novel test setup was designed and prepare by fabrication for particular tyre. The test setup is based on a tyre on tyre principle, which makes the setup quite simple and less expensive. Moreover, the tyre rolling deformation approaches better the deformation of a tyre rolling on a flat road. The test setup performs highly repetitive and controllable impact excitation tests under various operating conditions.

Fig. 3 Experimental Test Rig

The tyres used in the tests are radial tyres with symmetrical tread pattern of size 175/65R15 and the steel rims are rigidly clamped at the wheel hub. Figure 3 shows the test setup with the one tyre mounted. Since one identical tyre is used, the tyre deformations equal to the deformation of a tyre rolling on a flat road. The tyre is driven by a 2HP, three-phase induction motor.

The tachometer is used to measures the rpm of the wheel against different time in sec and load in mm. The tyre is mounted on the axle spindle which is connected to motor shaft with the help of pulley variac. The rotation speed is controlled by a pulley variac. Different speed was given by pulley and at different speed , the tyre was rotated and wear was measured in mm at different interval. Same procedure was done for new and retreaded tyre. I got tread wear against different speed and different load and compared the result for both tyre.

3.2 Test Results and Analysis

Table I. Input Parameter for Testing

Input Parameter For Testing	
Friction Coefficient (For rubber and dry smooth surface), μ	0.6
Aspect ratio	65
Tyre width, mm	175
Rim diameter, Drim (mm)	381
Tyre O.D, Dtyre (mm)	608.5
Tread Depth (New), mm	8
Tread Depth (Retread), mm	8

Fig 4-5 show plots of travelling distance and tread wear. The normal pressure is distributed symmetrically around the centerline. The tyre surface and the track surface are both considered smooth.

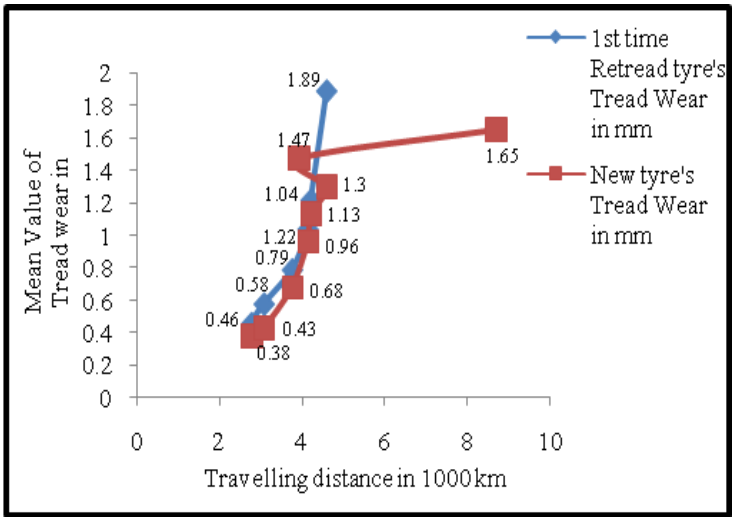

Fig. 4Trend Line Representing the Mean Value of Tread Wear in mm for Different Travelling Distance of New and 1st Time Retreaded Tyre

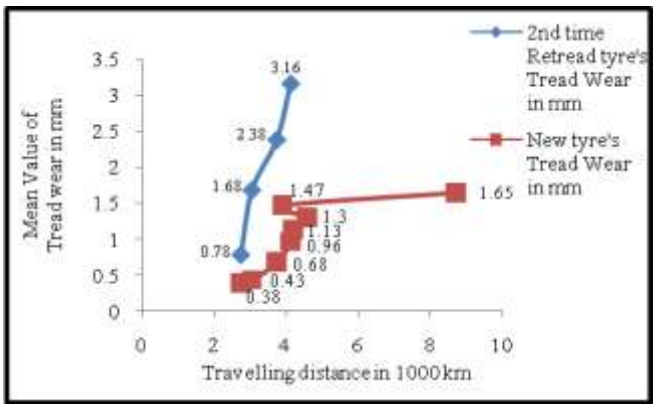

Fig.5Trend Line Representing the Mean Value of Tread Wear in mm for Different Travelling Distance of New and 2nd Time Retreaded Tyre

From above graphs it is concluded that the for same travelling distance of new and retreaded tyre, the tread wear is different, i.e the tread wear for new tyre is less than the retreaded tyre. Because the rubber ply is hard for new tyre and also the wear resistance is high for it. Whereas for retreaded tyre, the rubber ply is soft compare to new tyre and also the wear resistance is low for it.

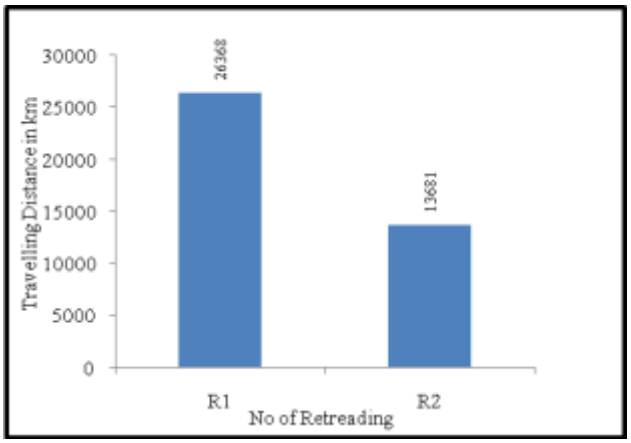

Fig. 6 Trend Lines Representing the Sum of the Total Travelled Distances in Function of Number of Retreading

By analysing the Fig.6 it can be noted that the travelling distance is decreasing by increase of number of retreading.

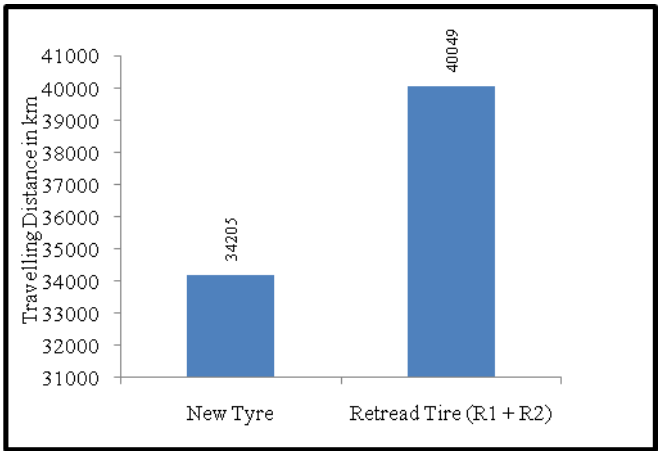

Fig.7 Comparison for Total Travelling Distance of Retreading and New Tyre

By analysing the Fig.7 it can be noted that the total travelling distance of retreaded tyre is more than that of new tyre.

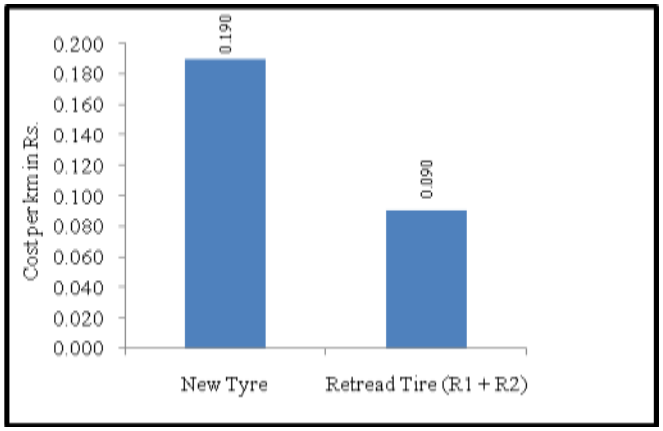

Fig. 8 Comparison for Total Cost Saving on Retreading and New Tyre

By analysing the Fig.8 it can be noted the cost per kilometer is less for retreaded tyre compare to new tyre because of we can do retreading on same tyre for number of times. Also the cost of retreading is 25-30% of the new tyre. So that the total travelling distance is more and cost per kilometer is less for retreaded tyre.

3.3 Model Limitation

The purpose of the model is to provide a simple approximate solution in situations. The difficulty arises because the displacement at any point in a contact surface depends on the pressure distribution throughout the whole contact. This difficulty is avoided if sets up the contact as a foundation of springs or bristles, and ignores the interaction between them. The contact pressure at any contact point then depends only on the displacement at that point. The contact calculations can thereby be done much easier and faster. The compliance of the two surfaces involved in the contact (in this case only the tyre that deforms) is not so well modeled, since the deformations outside the contact is neglected. The jerk between tyre and track is negligible during whole experiment.

3.4 Further Improvements

Further improvements in accuracy can be made. A more accurate contact pressure distribution in both longitudinal and lateral direction, would give an improved model. In this paper, the tyre is considered to be cylindrical with equally distributed contact pressure in lateral direction. In reality, the pressure is higher in the sidewall area than further into the contact. The distribution also depends on aspect ratio and tread pattern. Road roughness should also be included in the contact calculations to increase the accuracy.

IV. CONCLUSION

• Retreading is an established and well-regulated process for producing high quality remanufactured tyres. Retreaded tyres are subject to stringent quality certification that matches new tyre regulations.

• Because tyre casings are so thoroughly inspected and tested and because the precured tread or mould cure rubber compound is chosen with the projected use in mind, retreaded tyres often have a longer life than new tyres and can have a lower rate of failure.

• Tyre retreading saves raw material that is rubber. A tyre is made up of 100% rubber approx. as main ingredient 20% is only used in worn out tyres rest 80% is tyre carcass.

• The retreading cost can be about 28% of the new tyre. Also the retreaded tyre have 77% life from 28% cost compare to new tyre and 2nd time retreaded tyre have 40% life from 28% cost.

The presented results show that the test setup performs highly repetitive and controllable impact excitation tests under various operating conditions. Although the test setup is limited to high speeds, the most important mechanisms and influences can be studied. A tyre model, based on modal parameters, should take into account this softening effect which is dependent on the tyre construction.

• From above graphs it is concluded that the total travelling distance of retreaded tyre is more than new tyre and the cost per kilometer is less than new tyre. Because we can do number of times retreading on same tyre. So that by using the retreaded tyre we can save the energy which is using to manufacturing the new tyre. Also with the help of this we can control the pollution.

• The retreaded tyre is not used for costly and precise item's transportation for safety point of view.

V. ACKNOWLEDGMENT

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