

A Literature Review on Life Cycle Analysis of Tyre Retreading

Vankar Bharat A¹ Gosai Dipak C²

^{1,2}Department of Mechanical Engineering
^{1,2}SVMIT, Bharuch, Gujarat, India

Abstract— This paper describes the literature review of a Life Cycle Analysis (LCA) of Tyre Retreading study. Over the last 20 years there has been an exponential rise in the number of reports in the area of Tyre Retreading. In a recent publication, the authors surveyed the major findings and conclusions on this subject. The present paper is a summary of that publication. It is designed to assist one in quickly becoming acquainted with the significant findings and landmark publications on the many different aspects of Tyre Retreading. Also LCA study covered two different retreading options of used tyres. The review was conducted by three-member review panel. It should be noted that the preliminary administrative tasks took more time than expected. Many questions or comments were answered, which contributed to the improvement of the LCA report concerning methodology, data quality and clarity aspects, and to highlighting some research directions.

Key words: LCA, Retreading, Buffing, Building, Vulcanized

I. INTRODUCTION

'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.

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 led to a sustained growth in the retread industry.

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.

A. Process of Retreading

- Conventional Process (also known as 'mould cure' or 'hot cure' process)
- Precure Process (also known as 'cold cure')

1) Conventional Process [1]

- Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.
- Tyre is left for some time so that it may dry or a drier can be used for this purpose .
- 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.

- 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.
- 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.
- 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) Precure Process [1]

- Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.
- Tyre is left for some time so that it may dry or a drier can be used for this purpose.
- 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 colored crayons.
- Buffing: - The primary objective of buffing is to prepare the worn out tread surface of a 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.

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- 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 allows 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.
- 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.

II. LITERATURE REVIEW

I found that very few researches has been done on tyre retreading and among these papers I describe overview of some selected research papers.

A. Retreading of Tyres [1]

- 1) *Objective* –
 - How to save natural rubber tree and reduce the pollution.
 - How retreading is profitable business activity in an India.
- 2) *Conclusion* –
 - 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. It save 28 liter of crude oil use in manufacture of a new tyre and 5.5 liter. is used in retreading tyre.
 - Small scale industries and large scale industries are profitable. thus retreading is a all round development process which creates job opportunities. Small enterprise can also start a business with Rs. 1028,000 for the production of 1680 Truck tyres.

B. Note on the critical review of the study “Life Cycle Assessment for the different used tyres recycling methods” [2]

- 1) *Objective* –
To describes the “a posteriori” critical review process of a large Life Cycle Assessment (LCA) study with the help of nine different recycling options of used tyres as per ISO 14040/44 guideline.
- 2) *Conclusion* -
The advantage of the interactive or accompanying review, as recommended in the first LCA Guideline (Society of Environmental Toxicology and Chemistry-1993). ISO 14040/44 gives no guidance on that respect.

C. Trade and recycling of used tyres in Western and Eastern Europe [3]

- 1) *Objective* –
To investigate to what extent international policy measures on foreign trade, international recycling and harmonization of legislation can contribute in effectively reducing environmental pressure caused in the truck tyre life cycle.
- 2) *Conclusion* -
Several conclusions can be drawn from the model simulations.

- The consumption stage is accounts for the majority of the overall external effects of truck tyres. Trade has no impact on the consumption stage.
- Domestic disposal fees need to be increased and safety regulations need to be strengthened to avoid used tyres to be dumped on their landfill sites.

D. Tyre Hazardous, Disposal & Recycling [4]

- 1) *Objective* –
 - To gives a general view about the existing situation of tire recycling disposal and tire maintenance activities in many parts of the world and in Middle East particularly.
 - To gives the ideal way of tire exploitation to guarantee maximum safety and tire time life of functioning.

2) *Conclusion* -

- It was observed that availability of information on tires hazardous as new or worn is extremely poor, with a general absence of monitoring, information management systems and regular reporting.
- Severe lack of finances to provide human and physical resources of workshop waste disposal

E. Review of Waste Tire Reuse & Recycling in China [5]

- 1) *Objective* –
 - To expounds the current situation on waste tyre generation and recycling in China.
 - To analyses the existing problems and causes in industry of waste tyre recycling and propose countermeasures and suggestion on promoting a healthy waster tyre industry.
- 2) *Conclusion* -
 - Waste tyre reuse & recycling industry has high economic and environmental benefits and it is a very important part of circular economy development of China.

- China has a great potential in waste tyre reuse & recycling and a brilliant prospect.

F. Applying a mathematical approach to improve the tire retreading process [6]

1) Objective –

Analysis is performed on database of tyres' exploitation from a company of public passenger transportation and the statistical results are used as inputs to the proposed model.

2) Conclusion -

By analyzing it can be noted that traveling distance is decreasing by increase of number of retreading; it has been confirmed that, in practice, if a developed model is applied, it is possible to make the right decision for each tire whether to retread it or discard it after it has been worn out.

G. The economics of tire remanufacturing [7]

1) Objective –

- To describe the value adding operations in the tire production process and in the tire retreading process.
- The economic values of heat generation in electric plants and in cement kilns are discussed.

2) Conclusion -

- In this paper author identifies the value-added in each step of the tyre production.
- A single retreading event attributes the value of \$11.87 to used tyre. When a tire is incinerated in a power plant, it is attributed the value of \$0.62; in a cement kiln, just \$0.24.

H. Study on the Prediction Technology of the Retreaded Tire Residual Life [8]

1) Objective –

To propose the method which can predict the residual life of old tyre matrix without being renovated and identify whether the retreaded value of old tyre or not, which bring a scientific basis for tyre retreaded companies when choosing old tyre matrix.

2) Conclusion -

The conclusion indicates that the method proposed in this paper can predict the residual life of old tyre matrix without being renovated and identify whether the retreaded value of old tyre or not, which bring a scientific basis for tyre retreaded companies when choosing old tyre matrix, which can provide a theoretical reference in predicting the life of the retreaded tyre matrix and using safety performance.

I. Determination of Time Delay and Rate of Temperature Change during Tyre Curing (Vulcanizing) Cycle [9]

1) Objective –

- To attain an optimal state of cure for tyre for better quality of product and to minimize the cycle time requires fluid flow analysis inside the tyre bladder.
- To minimize the temperature difference and for finding out the delay time in OTR tyre curing process, the simulations were carried out using CFD software package ANSYS FLUENT 13.

2) Conclusion –

It was found that the results from the CFD simulation and experiments are in good agreement. Finally, the temperature difference in LTHW circulation is reduced to 4°C from 38°C by changing the flow rate at outlet from 15m³/hr to

38m³/hr and delay time is reduced from more than 60 minutes to the 20 minute. Reduction of delay time will improve product quality as well as it reduces utility cost.

J. Biocrude Production through Pyrolysis of Used Tyres [10]

1) Objective –

This paper presents a literature review of the pyrolysis Process with a focus on the characteristics of used tyres materials and methods of recycling, types and principles of pyrolysis, properties of the pyrolysis products, effects of process parameters, and kinetic models applied to pyrolysis.

2) Conclusion –

- From the literature, the proximate analyses of tyre rubber show that it is composed of about 28.6wt.% fixed carbon, 62 wt.% volatile material, 8.5 wt.% ash, and 0.9 wt.% moisture. Elemental analyses reveal that tyre rubber has an estimated value of 82 wt.% of C, 8wt.% of H, 0.4 wt.% of N, 1.3wt.% of S, 2.4wt.% of O, and 5.9wt.% of ash.
- Thermogravimetric analysis confirms that the pyrolysis of used tyre at atmospheric pressure commences at about 250°C and completes at around a temperature of 550°C.

K. Vehicle Lateral State Estimation Based on Measured Tyre Forces [11]

1) Objective –

To propose a method to evaluate the lateral state of a vehicle based on measured tyre forces with the help of virtual tyre sensors.

2) Conclusion –

The vertical forces vary between 1,000 N to 7,000 N. For the lateral forces, peak values for the left front tyre sensor are actually overestimated, due to sensor-lens setup nonlinearities, which were found at the edge of the operating area during high vertical force.

L. FE simulation of tire wear with complicated tread pattern [12]

A finite element tire with complex tread pattern instead of

1) Objective –

Conventional smooth tread was modeled according to mathematic model based on Archard wear theory and find out wear depth and wear mass to assess the wear quantity.

2) Conclusion –

On free rolling condition, there is tiny wear on tire due to little slip rate and increases linearly with the increase of mileage.

M. Study on the Ground Mechanical Characteristics of Load Vehicles Retreaded Tires [13]

1) Objective –

To provide the rich theoretical basis for the failure mechanism of retreaded tire. In terms of the retreaded radial tire of IIR22.5 load carrying vehicle, its mechanical parameters' were studied, the dissertation explores the applicable feasibility of the established models, develops the methods to test the material properties of the tread layer, the buffer layer and the matrix layer, such as elastic modulus, and acquires the required parameters.

2) Conclusion –

The pressure of retreaded cord radial tire on the ground regional center is the smallest. On the other hand, the pressure on both sides parts of the tire shoulder increases. This trend is the same as the new tire.

III. CONCLUSION

From the literature review and all other aspects, some highlights of finding are below.

- 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. [17]
- 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. [17]
- Bias retreaded tyres have life of approximately 20000KM and radial retreaded tyres have life of approximately 35000KM for smooth bitumine road. [17]
- Retreads are very widely used, primarily on non-steering, rear axle locations.
For example, you pay Rs.16000 your new tyre, it lasts 100000 km, you pay Rs.475 for regrooving service & Rs. 3500 for retreading service. You will pay in total Rs.19975 for estimated 195000 km. So your total cost per tyre per 1000 km is Rs.102. You save 36% compare to scenario 1 (new tyre only - one life). [18]
- Life cycle analysis of tyre retreading for heavy vehicle, light motor vehicle and two wheels automobile is not carried out.
- After retreading how much fuel consumption is reduced, that is not found.
- Retreading is safe or not that is also not found.
- How many times retreading can be done on same tyre, that is not found.
- Which process is best for improving the life of retreaded tyre that is also not found

ACKNOWLEDGMENT

On the day of presenting literature review report on “LIFE CYCLE ANALYSIS OF TYRE RETREADING”, I hereby take this opportunity to express my thankfulness towards all the persons who either knowingly or unknowingly helped my cause.

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