Discussion on Tire Retreading and Reuse Technology

Wang Qiang*, Jiang Li, Wang Yunlong, Qi Xiaojie and Wang Guotian

School of Automobile and Traffic Engineering, Heilongjiang Institute of Technology, Harbin, Heilongjiang, 150050, China

*Corresponding author’s e-mail: 630702666@qq.com

Abstract. China has basic state policies of developing circular economy and promoting the reuse of waste materials. They are also regarded as important guarantees for the sustainable development of mankind. The recycling of used tire resources has gradually become a consensus among people as a sunrise industry. Countries all over the world attach great importance to the retreading and reuse of used tires, especially in developed countries who have taken used tires as an important industry to save rubber resources. Tire retreading is a way of recycling resources, which can save rubber raw materials, solve the environmental pollution of waste tires, and make full use of the value of tires. There is no 'three-waste' emission during prevulcanization retreading of used tires. It is a green environmental protection industry, which not only can save a lot of rubber, steel wire, petroleum energy and other resources, but also can realize the reduction, reuse and recycling of used tires. Tire retreading is an active way to recycle used tires, it is regarded as extension and processing reuse of the tire industry. They are of positive significance for promoting the comprehensive utilization of resource conservation, transformation of economic growth mode and sustainable development. The characteristics, technological process of tire retreading technology, current situation and development trend of retreading tire are discussed comprehensively in the paper.

1. Introduction

The reuse of used tires mainly includes five modes, such as tire retreading, mechanical pulverization, low-temperature pulverization, combustion decomposition and combustion power generation. Where in tire retreading is the most effective way to reuse used tires. The production of automobile tires is increasing at an average annual rate of 10% all over the world with the rapid development of automobile industry, while the annual production of automobile tires is growing at a rate far higher than the world average level in China, which is 2 ~ 3 times higher than the world average level. The global annual production of automobile tires is expected to exceed 2 billion, and the annual production of Chinese tires is expected to exceed 1 billion by the end of 2020, thereby China will become the world center of tires. Nearly 200 million used tires are produced in China every year, and the number will be increased at a more alarming rate. Used tires have strong heat resistance and mechanical resistance. It is difficult to degrade used tires, thereby resulting in more and more prominent tire 'black pollution' problem. Tire retreading be adopted for saving rubber resources, saving energy and protecting the environment on the one hand, it also also can promote the reuse of waste resources and greatly improve the utilization rate of 'black pollution' on the other hand. The rapidly developed tire retreading industry has low service life due to the lack of technological innovation in China, thereby further affecting the use of retreaded tires and indirectly increasing the environmental pollution[1,2].
2. Characteristics of tire retreading process

Tire is composed of composite materials, such as rubber, cord and steel wire, wherein tire rubber is processed by natural rubber through synthesis. A small amount of additives and assistance are added to form an elastomer. Tire retreading refers to the outer layer of worn tires are polished after repaired (as shown in figure 1), a layer of buffer rubber is pasted, and then the tread rubber is further pasted, and the product is vulcanized finally, thereby obtaining retreaded tires which can be further used. The main structure of retreaded tires is shown in figure 2. The structure of the carcass is the same as that of the new tire. The main difference lies in that a layer of buffer rubber is added to the worn tread and then the tread rubber is pasted[3,4].

1) Tread rubber

Tire outermost layer surface contacted with the road surface is provided with a layer of pattern rubber. Its tread pattern structure and form are different under different road conditions as shown in figure 3. It is made of rubber and additives which are mixed and suppressed. Excellent wear resistance, impact resistance, aging resistance, and high tensile strength, elasticity and tenacity are required.

![FIG. 1 Carcass after polishing](image1.png)

![FIG. 2 Main structure of retreaded tire](image2.png)

2) Buffer rubber

Buffer rubber is used for bonding steel wire cord carcass and tread rubber in the process of tires cold retreading as shown in figure 4. It can buffer and transitioning the impact on the tread, thereby forming ladder-shaped stretching stress match, guaranteeing the stress uniform distribution of retreaded tires under high load, and reducing the stress concentration. Buffer rubber belongs to a bounded transitional layer beneficial to uniform heat dissipation, thereby ensuring the service life of retreaded tires.

![FIG. 3 Tread rubber](image3.png)

![FIG. 4 Buffer rubber](image4.png)

3) Carcass

Wirecord fabric and rubber composite material are mainly used as carcass for radial tires of trucks as shown in figure 1. Wirecord fabric for carcass is mainly used to improve the fatigue resistance and wear resistance. High strength and small diameter steel wires and stable production process are required. The performance of wirecord fabric, rubber performance and the combination performance of the the wirecord fabric and rubber in the used carcass for retreaded tires are lower than that of the new carcass due to the aging phenomenon of rubber.
3. Process specification of prevulcanized tire retreading

The principle of 'repairing before retreading' is generally adopted for the technological procedure of prevulcanization retreading technology, mainly including seven processes such as initial inspection procedure, grinding procedure, external grinding procedure, repair procedure, forming procedure, vulcanization procedure and final inspection procedure. The main process specifications for prevulcanization retreading can be simplified as follows: choose used carcass → used carcass cleaning → used carcass drying → used carcass inspection → local repair (including grinding, coating of rubber cement, gluing, pasting of the reinforcement pad, local vulcanization and other operations for carcass nail hole, caves and other lesions) → used carcass grinding (including tire crown round grinding as well as grinding and dressing for local uneven area) → rubber cement (brushing) coating → pasting of buffer rubber → pasting of pattern prevulcanized tread → installation of package sleeve (including installation of package sleeve ring, or sulfide inner tube and removable rim) → vulcanization in vulcanizing tank → removal of the package sleeve (including removal of the package sleeve ring, or vulcanized inner tube and detachable rim) → finished product quality inspection → storage as shown in figure 5[5,6].

FIG. 5 Main process specification of prevulcanization retreading

4. Status of tire retreading reuse technology

There are two tire retreading technologies mainly currently: mold vulcanization method and prevulcanization tread method, wherein the mold vulcanization method is regarded as the traditional technology. The pre-vulcanized tread represents advanced level and development trend of global tire retreading industry. Intact new tread can be produced by the two tire retreading technologies. The following aspects should be mainly considered for either technology[7].

1) Used carcass quality. Both hot retreading or cold retreading technology can be applied if the tire is retreaded for the first time and it belongs to a radial tire; if the tire is retreaded or the second or third time, excellent results can be obtained through hot retreading technology in most cases. If there are defects in the shoulder or side of the tire, the hot retreading technology should be used.

2) Quality of tread and other raw materials: There are prominent difference in cold or hot retreading technology if the operation level, tread and other raw material quality are the same. However, the tread performance of the hot retreading tire is obviously much better than that of the cold retreading tire if the tire is used in the harsh working conditions such as quarrying plant or construction site.

3) Retreading equipment: The advanced degree and control precision of the retreading equipment have a great impact on the quality of finished products after the retreading of tires.

4) Operator’s technical level: only the correctly trained operators can be competent in each process of retreading, and the operators should have skilled retreading technology and experience.

5) Cost of retreading equipment: the investment for the establishment of a hot treading plant is much higher than the establishment of a cold reading plant of the same scale relatively speaking.
mainly because hot retreading technology requires vulcanization machines, molds, etc., and higher investment is generally required for the equipment.

(6) Cost of tread and other raw materials. The cost of raw materials such as tread used in extruder or winding machine is relatively high.

The following national standards and industry standards are formulated for the production of retreaded tires in China currently, including 'GB7037-2007 Truck Retreaded Tires', 'GB14646-2007 Car Retreaded Tires' and 'HG/ T3979-2007 Construction Machinery Retreaded Tires'. There are following problems in China tire retreading[8].

(1) People have low consciousness to use the retreaded tires, thereby hindering the retreaded tire market. Many tire use enterprises or individuals, especially private car owners, think that there is a serious safety risk of retreaded tires, and there is even a misunderstanding 'retreaded tire is equivalent to suicide', who would rather buy new tires at a high price rather and are not willing to use retreaded tires.

(2) Lack of relevant policies, regulations, guarantee and incentive mechanisms for tire retreading: the state attaches great importance to the development of the tire industry, the industry policy and financial support for retreaded tires are insufficient. Some tire retreaded enterprises are facing difficulties in development due to the lack of policy support and capital support for equipment renewal.

(3) Chaos in used tire sales market and insufficient management standards: there is no effective recycling-reuse system in the sales market of used tires in China, and non-standard management of the sales market leads to the ineffective recycling of used tire resources for tire retreading, and there is no close cooperation between the retreading enterprises and the tire recycling enterprises.

(4) Backward tire retreading process and technology: tire retreading enterprises are basically still in the era of small workshop in china, the equipment replacement cycle is long, equipment technology is backward, and most retreading process is still based on traditional or experienced process, thereby resulting in the unstable quality of retreaded tires, and there are certain safety risks.

The life cycle of tire products will go through the scientific process of 'use - retreading - reuse - scrapping - residual value utilization' with the continuous development of technology so that 'black pollution' is converted into 'black energy'. The tire retreading industry has weak technical force in China fundamentally speaking, and the basic theory of retreaded tires is lacking compared with new tires. Therefore, it is of positive significance for the future development of the tire retreading industry to strengthen the research on the technical basic standards and related basic theories of tire retreading.

5. Development trend of tire retreading reuse technology

The average retreading rate of used tires is 60% throughout the international market, which is as high as 90% in European and American countries and only 15% in China . France, Japan, Italy and the United States have advanced tire retreading equipment and technology all over the world. China is in the medium and lower level. Professional tire retreading enterprises are mostly based on 'cold retreading method'. Some affiliated retread tire factories under new tire manufacturing enterprises are mostly based on the traditional 'hot retreading method'. For example, the ratio of retreading trunk tires through 'hot retreading' and 'cold treading' each year is about 4:1. 90% in the tire retreading factory of Britain Goodyear. 90% of tire treading plants under Michelin in France use the precise 'hot retreading method' developed by the company, and they occupy most tire retreading market in Europe. Bridgestone Japan also uses its own developed precise 'hot retreading method' mostly. 'Cold retreading method' is only used for retreading grade I tires. The ratio of 'hot retreaded' and 'cold retreaded' tires used by Continental Germany is close to 1:1. Car tires and the aviation tire s are nearly not retreaded in China. The trunk tires are mostly retreaded through 'cold retreading method'. Engineering tires are based on tire categories, specifications and use requirements. 'Hot retreading method' is mostly adopted during retreading of large or huge engineering tire retreading. The process technology level is more and more mature. 'Cold retreading method' is adopted for retreading in some tire retreading plants aiming at medium and small-sized engineering tire retreading. Most retreating plants are based on 'hot retreading method'[9].
The technology of engineering tire prevulcanization retreading is developed rapidly in foreign countries, which is developed slowly in China because the engineering tires retreaded through prevulcanization has unstable quality mainly and different performances among engineering retreaded tires. The retreading of engineering tire prevulcanization tread method will gradually replace the retreading of mold vulcanization method with the development of technology. The tread aging degree of prevulcanization tread low temperature retreading method is lowered by more than 50% compared with traditional 150 °C high temperature method, thereby the service life of retreaded tires is comparable to the performance of the new tires, which is especially suitable for long-distance driving. The tire wearing and burst risks of the tires are lowered during normal operation because of fast heat radiation and wear resistance on the one hand, and the rubber layer of the tires can not be softened easily with higher wear-resisting mileage on the other hand, which is more in line with economic principles. Because the retreaded tires made by the prevulcanization tread low-temperature retreading method has the advantages of ‘wire resistance, punching resistance, oil saving, lateral skid prevention and low price’, high retreading rate, easy process, low cost and high energy saving effect. The retreaded tire mileage is equivalent to that of new tires, thereby gradually replacing the former mold vulcanization method retreading technology. It has become the mainstream in the tire retreading technology, which is regarded as the future development direction of retreaded tires[10].

Acknowledgments
Fund Project: Project supported by basic scientific research business expenses of Heilongjiang Provincial Undergraduate Universities (2018CX07); Heilongjiang Natural Science Foundation Project (LH2019E115); Heilongjiang Institute of Technology PhD Research Startup Fund Project (2016BJ02)
Author: Wang Qiang (1981-), male, Harbin, associate professor, doctor of engineering, postdoctor. Research interests: vehicle tire technology, vehicle driving safety.

References
[1] Tang Fan, Lu Lizhu, Li Guang, Qiang Jinfeng, Jiang Shuijin. Analysis on the new mode of high-value comprehensive utilization of waste tires[J]. Tire Industry, 2020,40(02):71-76.
[2] Cui Li Jun. Performance Characteristics and quality inspection of finished retreaded tyres[J]. China's Comprehensive Utilization of Tire Resources, 2019(12):41-48.
[3] Zhang Xiu Li. How to improve the retreading rate of tire —— on the retreading and service of tire[J]. China's Comprehensive Utilization of Tire Resources, 2019(11):13-16.
[4] Pang Shuhua. China's tire recycling industry to forge ahead[J]. China's Comprehensive Utilization of Tire Resources, 2019(10):10-15.
[5] Tian Yansheng, Song Ximei, Liu Shenglei, Huayuan. Application of Microwave PYROLYSIS TECHNOLOGY IN RECYCLING WASTE TIRES[J]. Shandong Chemical, 2019,48(14):87-89.
[6] Zhang Xing. Present Situation and development trend of waste Tire Resource Utilization[J]. Shandong Chemical, 2019,48(14):105,108.
[7] Quan Jia Wei, Yu Jiaxue, Xu Junqing, Xu Junshi, Li Guangming. Recycling and reuse of waste tires[J]. Shanghai Energy Saving, 2019(04):262-270.
[8] Man Hsing, Miyazaki Da. Retreaded tyre compounds and methods of manufacturing retreaded tyres [J]. Modern Rubber Technology, 2019,45(01):39-46.
[9] Cui Lijun, Li Jinwei. The waste tires exert their afterheat —— retreading economy is full of business opportunities[J]. China's Comprehensive Utilization of Tire Resources, 2019(01):29-36.
[10] Li Zhao. The present situation, problems and countermeasures of recycling waste tires in China[J]. China's Comprehensive Utilization of Tire Resources, 2018(12):41-43.