

Mechanical Properties Experimental Study of Engineering Vehicle Refurbished Tire

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Abstract. The vehicle refurbished tire test system was constructed, got load-deformation, load-stiffness, and load-compression ratio property laws of engineering vehicle refurbished tire under the working condition of static state and ground contact, and built radial direction loading deformation mathematics model of 26.5R25 engineering vehicle refurbished tire. The test results show that radial-direction and side-direction deformation value is a little less than that of the new tire. The radial-direction stiffness and compression ratio of engineering vehicle refurbished tire were greatly influenced by radial-direction load and air inflation pressure. When load was certain, radial-direction stiffness would increase with air inflation pressure increasing. When air inflation pressure was certain, compression ratio of engineering vehicle refurbished tire would enlarge with radial-direction load increasing, which was a little less than that of the new and the same type tire. Aging degree of old car-case would exert a great influence on deformation property of engineering vehicle refurbished tire, thus engineering vehicle refurbished tires are suitable to the working condition of low tire pressure and less load.

1. Introduction

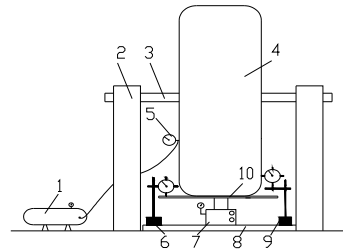
In recent years, mining, construction and other industries have developed rapidly, so that the demand for engineering vehicle tires is increasing day by day. Engineering vehicle tires are usually used in open-pit mining areas such as soil and stone, which are loaded with large, frequent starting and braking, and are affected by the bulge, so the production rate of waste tires is relatively fast and large. The amount of rubber used for an engineering vehicle tire is about 15% of the rubber consumption of the total tire. Therefore, increasing the renovation rate of waste engineering vehicle tire can effectively improve the utilization rate of waste engineering vehicle tire, which saves rubber resources and promotes the green environmental protection, "black pollution" would be turned into "dark energy". At present, the developed countries such as America, Japan, South Korea and China's research mainly focused on the tire refurbished industry state and related policy analysis, technology equipment system development of the loading vehicle tire renovation, the loading vehicle tire renovation technology, product quality evaluation of the loading vehicle tire renovation, and the tire tread modification and enhancement technology of the loading vehicle and so on. Therefore, in this paper, by constructing load- deformation test system of the engineering vehicle refurbished tire, the mechanical properties of the engineering vehicle refurbished tire were qualitatively and quantitatively described and evaluated under the condition of static grounding condition, which provides theoretical guidance for the performance evaluation research.

2. Mechanical properties test analysis of engineering vehicle refurbished tire



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The mechanical properties test system installation of the system composition is shown in fig.1. In this case, the force loader 7 would carry out loading for refurbished tire of different loads, such as 135kN, 145kN, 155kN, 165kN, 175kN, 185kN, etc., and the load plate 10 was used to simulate the road and contacted with the refurbished tires. Inflation pressure of 600kPa, 550kPa, 500kPa, 450kPa was ensured by inflator pump 1 and tire pressure gauge 5, radial deformation degree was gotten by the radial deformation dial indicator 6, side deformation degree was gotten by side deformation dial indicator 9, and tests were performed three times and took the average.



1- Inflation pump 2- Bracket 3-Rotation axis 4-Refurbished tire 5- Tire pressure gauge 6- Radial deformation dial indicator 7- Force loader 8- Platform 9- Side deformation dial indicator 10- Load plate

Fig.1 Test system composition

Test value and simulation value comparing curves of the radial deformation and side deformation are respectively as shown in fig.2 and in fig.3, under the working condition of that the inflation pressure of 26.5R25 engineering vehicle refurbished tire was respectively 600kPa, 550kPa, 500kPa, and 450 kPa, and load was respectively 135kN, 145kN and 155kN and 155kN, 175kN and 185kN. As shown in fig.2 and fig.3, the test values are more consistent with the simulation values when the inflation pressure was $p = 500\text{kPa}$ and $p = 550\text{kPa}$. In the case of the inflation pressure $p = 450\text{kPa}$, $p = 600\text{kPa}$, the error of 5% or so existed between the test value and the simulation value. Experimental results and simulation results show that when the inflation pressure was certain, the radial load increased from 135 to 185kN, both radial deformation and side deformation increased in different degrees, and the radial deformation turned to be increase uniformity and the approximate linear, however, when the inflation pressure was 450kPa and 500kPa, the side deformation was uniform deformation increase and approximate to linear; when the inflation pressure is 550kPa, 600kPa, deformation increase was non-uniform change and tendency was non-linear. The main reason analyzed is that the sidewall layer only contacted with only a layer of steel wire curtain of car-case layer, and there was a certain degree of aging, the load-deformation feature will present a certain irregularity.

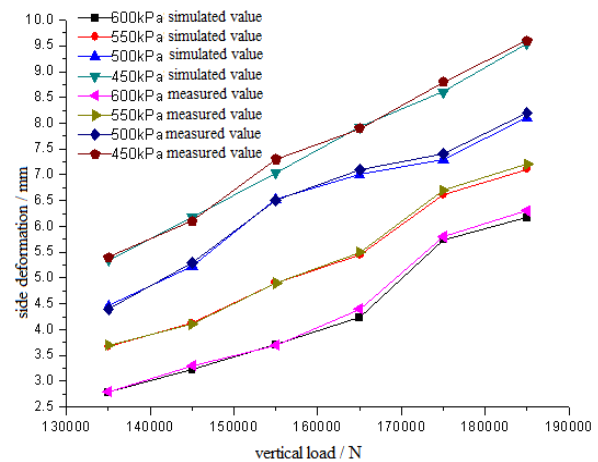
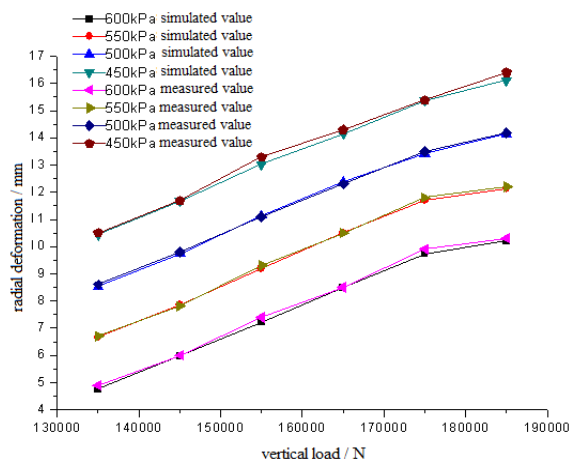


Fig.2 Radial deformation measured value and simulated value Fig.3 Side deformation measured value and simulated value

The radial deformation curve and the side deformation contrast curve of refurbished tires compared with that of the same model and new tires are respectively shown in fig.4 and in fig.5 (R for refurbished tire in the graph, N for new tire). The fig.14 and fig.15 show that the radial deformation features and the side deformation features of engineering vehicle refurbished tires followed the laws close to that of the new tires, the radial deformation and the side deformation were a little less than that of the new tires. The main reason analyzed is that a certain degree of aging existed in the car-case layer of engineering vehicle refurbished tires, thus rigidity was a relatively large under the action of the same radial load, which explains that old tire quality produced larger influence on the deformation feature of the refurbished tires.

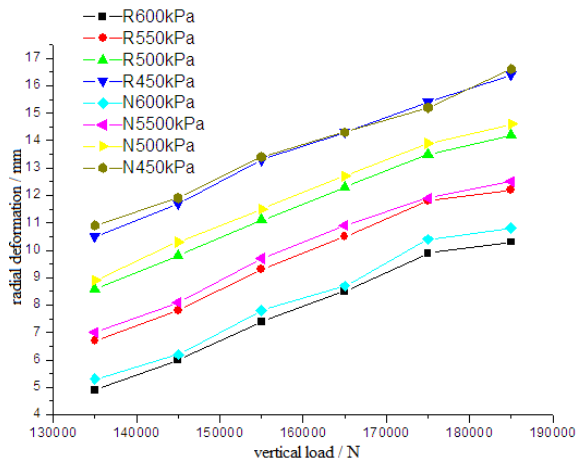


Fig.4 Radial deformation contrast curve

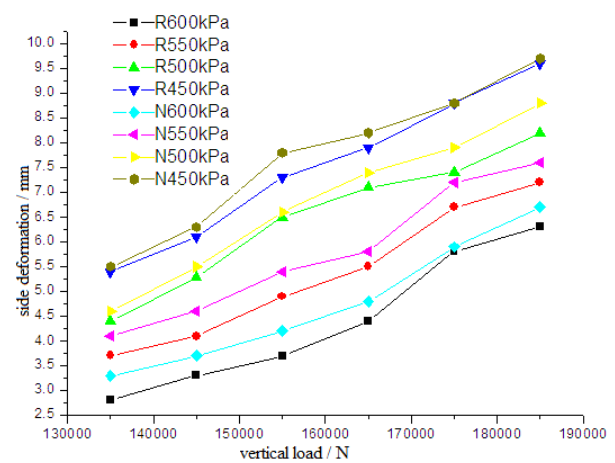


Fig.5 Side deformation contrast curve

The radial stiffness test and the simulation result of engineering vehicle refurbished tire are shown as in fig.6. The results showed that the experiment results were less than the simulation results, and the alignment discrepancy was about 6%. When the inflation pressure was certain, the larger the radial load was, the smaller the radial stiffness was; when the inflation pressure was 550kPa and 600kPa, the decrease was greater, and the trend was nonlinear decrease; when the inflation pressure was 450kPa and 500kPa, the curve was more gentle and less dramatic decrease, which indicates that the radial stiffness of engineering vehicle refurbished tire was greatly affected by the inflation pressure. When the load was certain, the higher the inflation pressure was, the greater the radial stiffness was, and the increase of radial stiffness under low load condition was significantly greater than the high load condition.

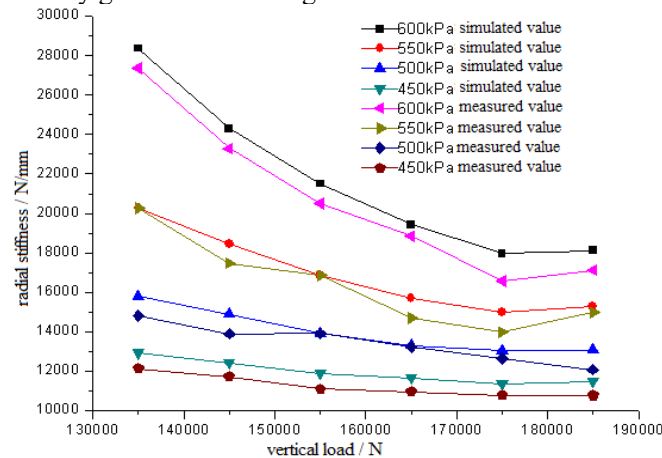


Fig.6 Comparing curve of radial stiffness measured value and simulated value

Compression ratio test results and simulation results of engineering vehicles refurbished tire are shown in fig.7, compression ration comparing curves with that of the same new tires are as shown in fig.8(R for refurbished tire, N for new tires in the graph). Fig.7 and fig.8 show that the refurbished tire compression ratio is basically consistent with the simulation value. When the inflation pressure was certain, the refurbished tire compression ratio increased along with the increase of radial load, approximate to linear trends, and was a little less than the compression ratio of the same model and new tire. When the inflation pressure was 450 kPa and 500 kPa, the refurbished tire compression ratio matched better with that of the same model and new tire, which showed that the elastic effects of engineering vehicle refurbished tire played fully under the condition of low tire pressure, its elastic effects under high tire pressure did not give full play, leading to that the comfort level of the engineering vehicle drivers would be reduced.

The experiment results show that the radial loading deformation of engineering vehicle refurbished

tires is related to radial load and the size of the inflation pressure, and radial loading deformation mathematical model of 26.5 R25 engineering vehicle refurbished tires can be calculated by formula (1), namely:

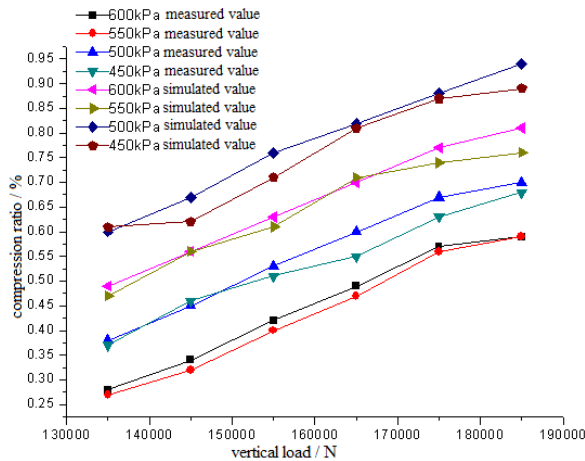


Fig.7 Comparing curves of compression ratio

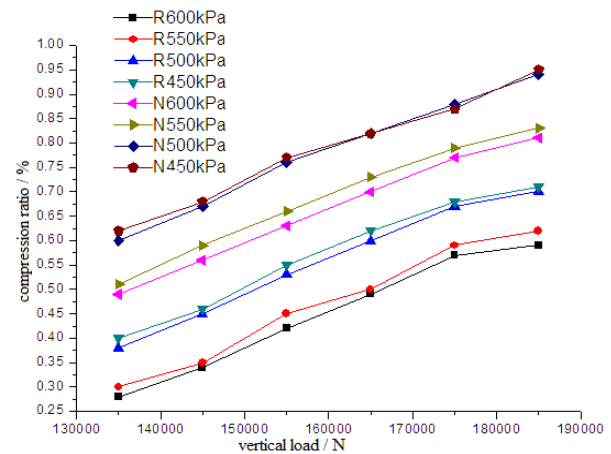


Fig.8 Comparing curves of compression ratio

$$\delta = \lambda \frac{W^b}{10P_i^a} \quad (1)$$

In the case, δ —radial deformation, mm; W —radial load, kN; P_i —inflation pressure, kPa; a 、 b 、 λ —undetermined coefficient

Let's take the logarithm of both sides of formula (1):

$$\ln \delta = \ln \lambda + b \ln W - a \ln P_i$$

The binary regression calculation was carried out using simulation and experiment data, thus coefficients were gotten $a=0.535$, $b=0.941$, $\lambda=0.376$, i.e. radial loading deformation mathematical model of 26.5 R25 engineering vehicle refurbished tire is as shown in formula (2), namely:

$$\delta = 0.376 \frac{W^{0.941}}{P_i^{0.535}} \quad (2)$$

3. Conclusion

The test results showed that the radial stiffness and compression ratio of the engineering vehicle refurbished tire were significantly affected by radial load and inflation pressure. When the load was certain, the higher the inflation pressure was, the greater the radial stiffness was, and the increase of radial stiffness under the low load working condition was significantly greater than that of under the high load working condition. When the inflation pressure was certain, compression ratio showed linearly increase with the increase of radial load, and the compression ratio of engineering vehicle refurbished tires was a little less than that of the same model and new tires, which indicated that the engineering vehicle refurbished tires were more suitable for usage under the working condition of low tire pressure and low load. Building the radial loading deformation mathematical model of 26.5R25 engineering vehicle refurbished tire can provide theoretical guidance for performance evaluation research and renovation process improvement of engineering vehicle refurbished tire.

Acknowledgments

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