Optimization Study on the Influencing Factors for Tire Wear in Chongqing Monorail Transit Line 3

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***Abstract*—Aiming at the running quality of straddle-type monorail vehicles affected by tire wear, this paper introduces the operation of the monorail transit in Chongqing Then, relying on the principles of technology of vehicle tire, and takes Chongqing monorail line 3 as an research object. The author contrastive analysis of the different influencing factors for tire wear in Chongqing monorail transit line 3 according to the tire wear phenomenon of the monorail vehicle operation in the past years, focuses on the situation of tire tread wear, puts forwards some solutions and suggestions to extend the life circle of the monorail vehicle wear and plays a positive role to the development of the straddle type monorail transportation system.**

Keywords—monorail; tire wear; influencing factors; running quality

I. INTRODUCTION

In the urban rail transit system, straddle type monorail transportation as a new mode of urban rail traffic (As shown in Fig.1), has unique advantages and characteristics. Such as small turning radius, line covers an area of small, strong climbing ability, low noise, comfortable ride, broad vision, good safety, the potential geological disaster, low cost (only for the 1/3 to 1/2 of subway), strong adaptability of terrain. Characteristics of straddle type monorail transportation decisions it has become one of the preferred rail transit for mountain city, small city and coastal city [1]

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Figure 1. Straddle type monorail vehicle

However, in the straddle type monorail vehicle running process, the running system composed of walking wheel, steering and stabilizing wheels which not only ensures the low noise and small radius against derailment, at the same time because "space over closed and static" causes the tire wear speed increases, life circle low, trades the embryo to be frequent, tire expense astonishing and other questions during the running process. In addition, severe tire wear will cause the tire adhesion ability greatly reduced, bring the problem of low efficiency of vehicle driving, long braking distance[2].which seriously affect the vehicle running safety and energy economy and restrict the application of the straddle type monorail transit.

Therefore, this paper This paper takes Chongqing monorail line 3 as an research object and made a preliminary analysis of the factors that affecting the monorail vehicle tire's life, and propose some possible solutions to this problem

II. THE STRUCTURE OF STRADDLE TYPE MONORAIL VEHICLE AND BOGIE

The urban straddle type monorail vehicles are different from the road car and also have the obvious difference with traditional steel wheel rail vehicles. Fig. 2 shown straddle type monorail vehicle's topology. It consists of a car body the two bogies, the bogies for monorail vehicle are bolster less bogies which have special structure and located in the vehicle's front and rear part. The central suspension system (also named secondary suspension) which consists of air spring, the center pin, the center pin seat, horizontal hydraulic shock absorber, traction rubber pile and lateral stop plays an important role to connected car body and the bogie frame in the vertical, the lateral and the vertical directions. Bogies straddled on the PC track beam and traction electrical machinery drives the traveling wheel (filled with nitrogen pressure of 880kPa tubeless bead rubber tire) rotation. Through the steering wheel and stabilizing wheel (filled with nitrogen pressure of 980kPa oblique cutting nylon rubber tire with inner tube) which installed on two sides of the bogies frame to realizes the function of guidance and stable vehicle [3]. During the running process, the traveling wheel and the top surface of the track beam is consistently keep contact. The structure of Straddle type monorail vehicle bogie as shown in fig.3

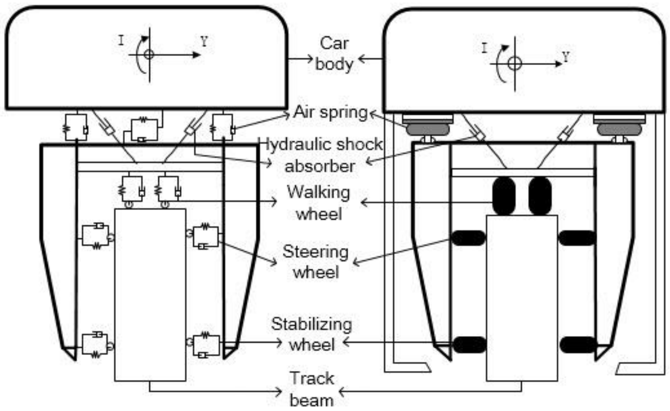

Fig.2. Straddle type monorail vehicle topology diagram

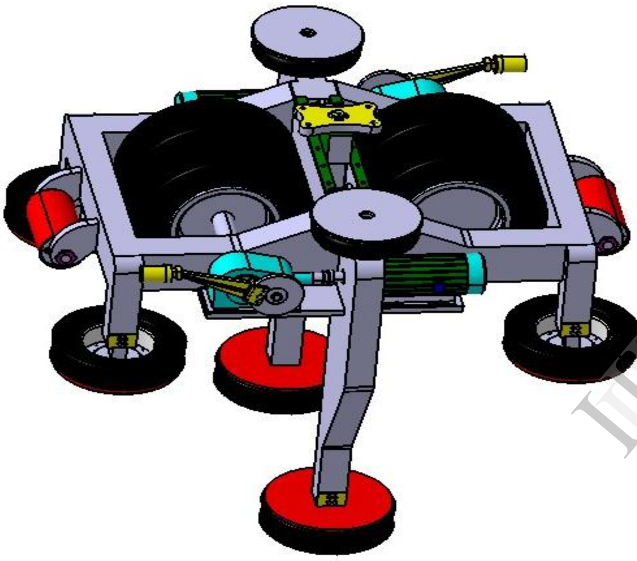

Fig.3. The structure renderings of straddle type monorail vehicle bogie

III. FACTORS INFLUENCING THE TRIE LIFE CIRCLE

Found in the process of tire changing, the main failure mode of monorail vehicle tire are the eccentric wear of the tire shoulder and the irregular wear of the central tire tread This paper will combine the movement mechanism and working conditions of monorail vehicles, This paper will combine the movement mechanism and working conditions of monorail vehicles, analyze various factors influencing the monorail vehicle tire's life circle from a qualitative point of view [4].

A. Frequent start and brake

For the traction force, regardless of is the driving force or braking force, the results will lead to tire wear rate increased [4]. While the straddle type monorail vehicle which running in the city was required frequent start and brake because of the short distance between adjacent stations. This will greatly increase the burden of the vehicle tire undoubtedly

When the train started, sliding friction on tire production will make the tread crimping wear, so as to shorten the service life of tires. When braking, tire tread and rail beam surface hard rubbing mill can make tread instantaneous high temperature, thus exacerbating the rubber aging, resulting in severe local abnormal wear; and an emergency brake, in addition to the matrix stress greatly and cause damage, wear is to tread (equivalent to normal driving 3 000~5 000km)[5].

Although the start and brake of vehicles are inevitable, but the specification of driving and the reasonable operation of driver during the acceleration and deceleration process, will undoubtedly reduce the tire load and effectively prolong the service life of tire.

B. Effects of the track line conditions on tire life

In order to adapt to the terrain, and facilitate passengers aboard and convenient construction, straddle type track lines will form some corners and ramps. Tire wear degree in the bend and the ramp track sections will be far more than in the straight track sections [6].

C. round the corner

Due to the rigid structure frame, when monorail vehicle running on curve track section occurs lateral deviation phenomenon, resulting in the side slip angle. The side slip angle of tire refers to the angle between the plane of the rolling tire and the actual direction. Lateral force is one of the most unfavorable factors influencing the tire tread wear, the tire will bear obvious lateral force, is perpendicular to the plane of the tire tread shear stress, the shear stress of hard Polish grinding can cause unilateral tire shoulder of the abnormal wear. Lateral deviation and side slip angle as shown in fig 4.

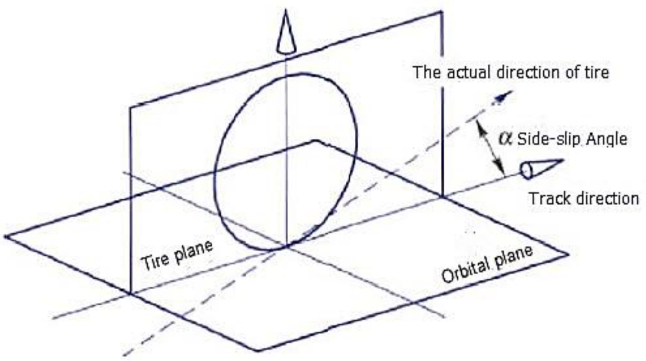

Fig.4. Tire cornering figure

What's more, due to the limit of the complicated structure of the monorail vehicle bogie, the steering wheel is unable to realize the differential function when monorail vehicle running on the curve track sections, therefore the vehicles in process of round the corner, will cause relative sliding between the side surface of track beam and the inner side walking wheel, then this sliding friction will cause the huge damage to the tire. Further causes the tire partial attrition to be serious in tire shoulder (as shown in Fig. 5). Some tire edges have had shape anomalous "snake-shaped attrition" (as shown in Fig. 5(b)).

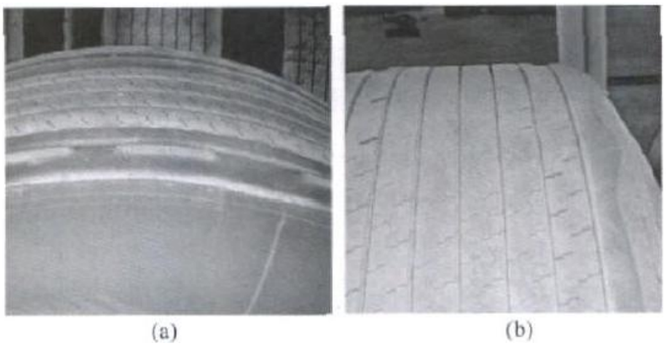

Fig. 5. Monorail vehicle tire wear phenomenon

D. The ramp and the track superelevation

Changes in vehicle traction on the downhill can cause the tire slip, thereby accelerating the tire wear, this phenomenon is particularly serious in the long and steep track sections. Takes Chongqing monorail transit line 3 as an example, the minimum curvature radius curve is 100m, the maximum gradient of 60 ‰, the slope up to 500m, according to the relevant data, this data can produce obvious effect on the tire life circle [7].

Moreover, to ensure the stability of monorail train when turning corners, the track beam should have a certain track superelevation. Therefore, the monorail may cause the tire uneven stress in turn, can cause uneven tire wear, which will lead to the tread of the unilateral wear.

The Chongqing monorail transit line 3 is the single track line built with the terrain, crooked road and slope appears Frequently, line complex aggravated the monorail train tire burden. Therefore, straddle type monorail line in the planning, can suit one's measures to local conditions, optimization of line, to reduce the tire abnormal wear. Table 1 for the monorail transit line 3 in Chongqing and Japan Okinawa monorail line parameters comparing.

Table 1. The parameters comparing between Chongqing line 3 and Okinawa line

	Chongqing monorail transit line 3	Japan Okinawa monorail line
Track beam type/(mm×mm)	1500×850	1400×800
Maximum slop/ ‰	60 ‰	60 ‰
smallest curve radius/(m)	100m(Positive line),250m(Station)	62m(Positive line),300(Station)

E. The quality of the turnout, finger plate and the track surface

When the vehicle through the joint turnouts, due to the lateral irregularity of the joint turnouts, lead the steering wheel and wheel stabilizing in joint turnouts beam will generate transverse undulations, and then the transverse force transfer to the bogie, cause the bogie transverse sliding on the track beam, resulting in partial abnormal wear of the monorail vehicle tire.

As finger plate is used for connecting two sections of track beam, the cohesion irregularity between the finger plate and the track beam will cause the tire force generated by mutation, thereby causing the monorail vehicle tire tread pressure damage and wear.

In addition, besides track irregularity caused by the turnout and finger plate, the cement casting quality of the top surface of track beam is also one of the factors that determine the vehicle tire wear degree. Experience shows that, the tire wear will increase with the increasing of the road surface's roughness degree[8] .In the aspect of track beam surface quality, there is a big gap between China and other developed countries, and the quality of the surface of track beam has become an important reason for the Chongqing monorail tire life is not ideal. Therefore, in the monorail track line construction should try to improve casting quality track beam and construction precision, to reduce tire wear rate, and improve the running stability.

F. Clean of the track beam surface

Nearby the platform either the inhabited area, due to natural or anthropogenic causes of orbital plane debris may cause the monorail tire tread with stroke damage. Monorail vehicle high speed through the track surface, sharp objects easily scratched or bad bar train tire, causing the tire abnormal damage, serious when can cause the train outage. According to reports, the Chongqing monorail transit system in the running process had a similar accident, therefore, the track beam surface cleaning problems cannot be ignored, should strengthen the management to prevent such things from happening again.

IV. CONCLUSIONS

Through the above analysis, the monorail vehicle tyre wear is mainly caused by the line conditions, driving performance, operation and quality of track surface factors. Take some measures to reduce tire wear, prevent normal wear and damage, prolong the service life of the tire, to reduce operating costs by monorail transit system, improve economic efficiency, so it is significant to ensure the running safety. This can be considered from the following points:

(1) The optimization track radius of curvature of curve, increased as far as possible, reduce the track superelevation and slope. To improve the surface quality of track beam and construction precision, thereby improving the monorail vehicle running conditions.

(2) Try to use flexible turnouts and adopt slotting, plus coating and other ways to increase the adhesion coefficient of the turnouts and finger plate.

(3) The driver should keep the reasonable operation, correct driving, strictly observe the speed limit during the ramp and curve track sections

(4) Regularly detect the pressure of the walking wheel and horizontal wheel pressure, so as to maintain reasonable pressure.

(5) Besides the regular inspection of track condition, the operator should appeal to the public love track facilities, so as to ensure the safe operation of the monorail vehicle.

Monorail transit system depends on its advantages, the vigorous development of monorail transportation is at home and abroad. With the construction of monorail line, the study on monorail vehicle tire wear issues will become increasingly important. Based on this, this article through the research on the Chongqing monorail tire wear, analysis the main factor influencing the monorail vehicle tire life, and puts forward some possible solutions, plays a positive role to the development of the straddle type monorail transportation system.

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