

Study on the Application and Development of Monorail Transit System

LIU Xi

School of Mechatronics &
Automotive Engineering
Chongqing Jiao-tong University
Chongqing, China

SUN Huan

School of Mechatronics &
Automotive Engineering
Chongqing Jiao-tong University
Chongqing, China

LIU Fang-gang

School of Mechatronics &
Automotive Engineering
Chongqing Jiao-tong University
Chongqing, China

Abstract—This article describes the development of vehicle monorail transit system and its present situation, the application and classification of monorail vehicles has been studied, and take the monorail transit system vehicles in Japan and China as example, discusses the development and application of monorail transit system in the of urban rail transit system. From the history of monorail vehicle angle, by comparing the monorail transport system of urban rail vehicles with conventional vehicles, and discusses the advantages and defects of monorail transit system, and discussed the future develop direction of the monorail transport system

Keywords—monorail; urban mass transit; development; automatic orientation

I. INTRODUCTION

Since the 1880s, the city traffic step into the rapid rail transit times, with its convenient, energy saving and environmental protection, and efficient transportation, etc. [1]. The rapid rail transit system has been rapid development all over the world. It not only promotes the improvement and integration of public transport networks, but also enhance the liquidity and attractiveness of the city, and gradually formed a combination of underground, ground and air from the three-dimensional public transport system. Rail traffic has greatly improved the problem of urban traffic congestion and transport capacity of the unit, but because of its almost rail line mode are used to go into direct contact with the drum, will bring the inevitable wheel-rail vibration, noise and wear on the smooth running of the ride comfort and greater impact. In this case the use of tire rubber tire rail system came into being. Monorail transport system with rubber tires to replace the traditional steel wheels, or will adopt different from the traditional steel wheels, rail systems rail systems. However, due to the restricted monorail transport system carrying capacity and the critical speed for heavy rail and unable to adapt to high-speed rail system, so the application rate is not high.

Urban rail transport is divided into: subway system, light rail systems, monorail systems, trams, maglev system, automatic guide rail system and regional express rail system. Among monorail transportation system included in the urban rail transit system, if it can be divided according to the guide way on both sides of the guide, the central orientation, central groove-oriented and cross-sit-oriented, Besides general monorail transportation system of urban rail transit vehicles

punctuality, comfort, economy, etc., but also with low wheel-rail noise, strong adaptability line, curve radius and so on [2].

II. MONORAIL VEHICLES DEVELOPMENT OVERVIEW

British people P. H. Palmer began the study in 1821 on the monorail railway and obtain patents. Monorail Transit refers to the transportation vehicle straddle or driving on the track which is band shaped beam. Vehicle light weight, a medium volume of transport, the use of inflatable rubber tires. Modern monorails depend on a large solid beam as the vehicle running surface. There are a number of competing designs divided into two broad classes, "straddle-beam" and "Suspension type" monorails. The most common type of monorail in use today is the straddle-beam, in which the train straddles a reinforced concrete beam in the range of two to three feet (ft.) (~0.6-0.9 meters (m)) wide. A rubber-tired carriage contacts the beam on the top and both sides for traction and to stabilize the vehicle. The straddle-beam style was popularized by the German company ALWEG. There is also a form of Suspension type monorail developed by the French company SAFEGE in which the train cars are suspended beneath the wheel carriage. In this design the carriage wheels ride inside the single beam.

1. Straddle type monorail transit

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. 1 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.2.

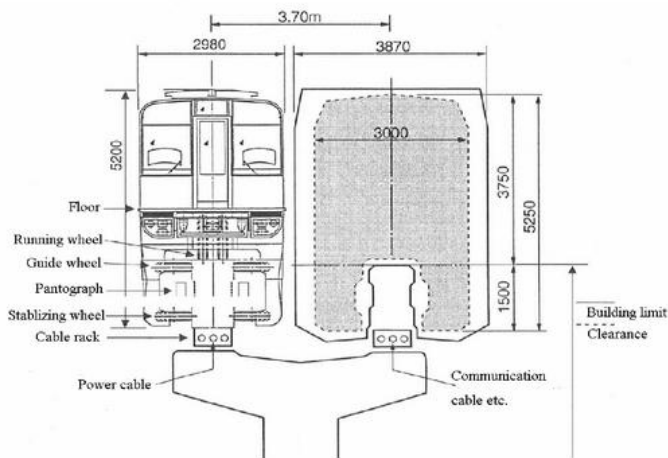


Fig.1. Straddle type monorail vehicle topology diagram



Fig.2. The structure renderings of straddle type monorail vehicle bogie

Because of the straddle type monorail vehicle using the rubber tires, the vehicle operation low noise, and wheel rail vibration is small, but its capacity constraints. The car body design by using aluminum alloy monologue structure, in order to meet the requirements of lightweight. The rail beam in the support body and constrained vehicle at the same time, but also a carrier of traction network, signal systems and other equipment^[4]. Relative suspension, the straddle type monorail vehicle bogie running outside the track beam, has the advantages of simple structure, easy maintenance features. But the track beam surface will be affected by rain and snow and other weather factors, the wheel rail adhesion decreased, should be non-slip handle. Sectional view of straddle type monorail vehicle structure as shown in Fig 3.



Fig. 3. Sectional view of straddle type monorail

At present the technology of straddle type monorail vehicle has step into the mature development stage, and the successful use in Japan, United States, Australia, Britain and other countries of Leah. According to the loading capacity of the vehicle type is divided into small type, standard type, and high type. As shown in Fig. 4, operating in Australia Leah of Sydney straddle type monorail vehicle, the running gear is provided with a walking wheel and a guide wheel, and the use of non-steady wheel design. The car uses 7 knitting group, vehicle length 32120 mm, width 2060 mm vehicles, the vehicle height of 2600 mm, the running speed of 33km / h.



Fig.4. Running monorail in Sydney

In 2004, Chongqing successfully introducing Japanese Hitachi company production of straddle type monorail line and trial operation, become the only one with cross sit type monorail car city, makes up the blank of the city track traffic in the straddle type monorail car in China. As shown in Fig.5., the straddle type monorail vehicle operating in Chongqing, the length of the car body is 15500 mm, width is 2980mm, height is 5300 mm, walking wheel diameter of 1006 mm (dynamic diameter 982 mm), walking wheelbase is 1500 mm, axis heavy 11t, the most high. Speed of 75KM / h, the high slope of 60 %, and the small curved line through the semi diameter 50m^[5].



Fig. 5. The line 3 of Chongqing monorail system

2. Suspension type monorail of monorail transit

Suspension type rail transit originated in 1901 in Germany has a "Suspension vehicle city" Wubotaer line, dating back more than 112 years of history. As shown in Fig.6. The oldest suspension type monorail running in Germany Wubotaer city car, the length of the suspension type monorail line is 13.3km, a total of 18 stations, the whole vehicle is grouping of three car, and maximum running speed is $60\text{km/h}^{[6]}$.



Fig. 6. Schwebebahn Wuppertal, the oldest monorail in the world

For suspension type monorail transit, the vehicle bogie running on the surface of the track beam and the vehicle body suspended running at the bottom of the track beam, most of the track beam's structure are the lower opening of the steel box girder structure, which containing collector shoe, communication cable, the guide track. Department of walking wheel and guide wheel are all arranged in the box girder vehicle and walk along the beam is arranged in the rail road. The running system of suspension type monorail vehicle as shown in Fig.7.

The high suspension part of the whole system of Suspension type monorail consists of track beam, the switch beam, the pier column and foundation group, according to the line

condition can adopt Y, inverted L type (as shown in Fig. 8) or door frame form.

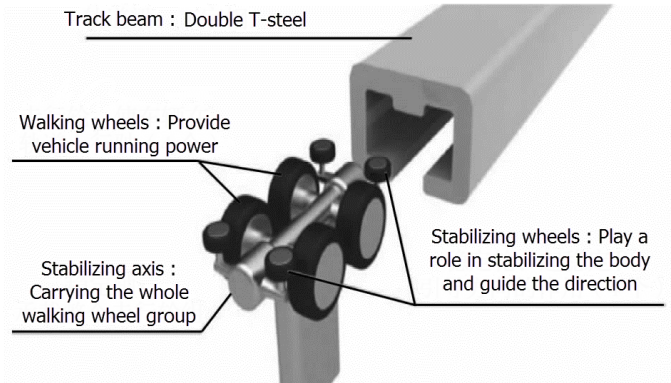
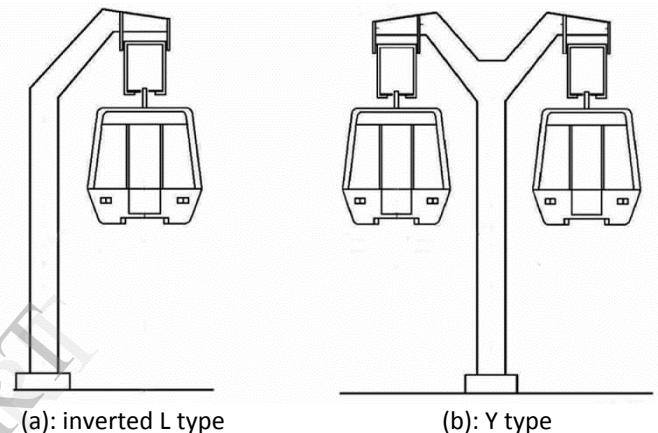


Fig. 7. The running system of suspension type monorail vehicle



(a): inverted L type

(b): Y type

Fig.8. The different ways of suspension of suspension type monorail transit system

In comparison with straddle type, Suspension type monorail bogie in the open type box type steel beam operation, bearing, avoiding the weather factors on wheel rail adhesion effect. But because of its truck and rail lines in a relatively sealed box type steel beam in the operation, maintenance and rush to the car insurance brought inconvenience^[7].

Suspended type monorail vehicle in Germany, Japan and other countries to be widely used, the technology is mature, safe and reliable. The country is also no relevant technical introduction of Suspension type monorail car, but according to its characteristics, combined with Chinese current standard and specification analysis research, the manufacture cost is low, construction period is short, to shape adaptation can point force, in China has good prospect in using good^[8]. As shown in Fig.9. Operation suspension type monorail in Chiba, the Urban Flyer 0series, simply called "UFO". The control method using VVVF, effectively improve the energy utilization and ride comfort degree. Car inner part is provided with a wheel chair empty room and rest areas, car head is changed into the room to look, plate surface of the glass manufacturing, give people more passengers feel strange.



Fig. 9. The running Urban in Chiba, Japan

III. CONCLUSIONS

Monorail transit system in city rail transit development history is not long, is still a relatively new research field. The present straddle type monorail and hanging monorail transit system in various countries including Chinese, development and use, but the related technology and related materials research on it is very limited. This article through to the domestic and foreign monorail traffic system of vehicle development and application in the research and analysis, the monorail transit system and the traditional city track traffic system compared with the advantages: The optimization track radius of curvature of curve, increased as far as possible, reduce the track super elevation and slope. To improve the surface quality of track beam and construction precision, thereby improving the monorail vehicle running conditions.

- (1) Low manufacture cost, short construction period.
- (2) Small interaction force between the wheel and track, low running noise.
- (3) Because the adhesion coefficient between wheel and track is big so the monorail vehicle good climbing ability, that can adapt to different road conditions.
- (4) Having small radius of running through the curve track.

Meanwhile, it also has obvious defects :

- (1) Monorail vehicles generally use the rubber tires, but the limited carrying capacity of rubber tire resulting in a small amount of carrying passengers;
- (2) The rubber tire wheel abrasion problems become more prominent, deposit in exchange rate is high, cause maintenance costs increase;
- (3) Low adaptability of bad weather such as hail and snow for monorail vehicle
- (4) Because of the popularity of monorail transit system rate is low, poor compatibility with the standard, and the weak traditional steel wheel traffic system, at present only as a major mode of transportation assistance and supplement.

Currently, the monorail transport system is one optional type for requires from the development of urban rail transit system. Through the research on the vehicles of monorail transit system, and gradually improve the construction and promotion of monorail transportation system in the future. Supplemented by conventional means of transportation at the same time, and gradually form a diverse city urban rail transit system has its own characteristics, which marks the direction of future urban transportation development.

REFERENCES

- [1] Telliskivi T, Olofsson U. Contact mechanics analysis of measured wheel-rail profiles using the finite element method [J]. Proc Instn Mech Engrs, 2001, 215 (2) : 65-72
- [2] Zhong Jian-hua, Chongqing straddle type monorail transportation[J]. Urban Rapid Rail Transit, 2004, 17
- [3] UIC 510 -5, Technical approval of monobloc wheels Application document for standard EN 13979-1. 2nd edition[S].
- [4] Lee C H, Kawatani M, Kim C W, etc. Dynamic response of a monorail steel bridge under a moving train [J]. Journal of Sound and Vibration, 2006, 294(3): 562-579.
- [5] Li Gang Li Pei. Overview of the development and use of a vehicle tire track system [J]. Railway Locomotive & Car.2013,33 (10),53-58.
- [6] Zhuan Ji-de. Technology of vehicle tire[M]. Beijing: Beijing university of technology press, 2006.
- [7] Xiao Jun. Analysis on the adaptability of monorail transit [J]. Electric Locomotives & Mass Transit Vehicles, 2013, 36(4): 20-23
- [8] Wang Wei-jie. Analysis of influence factors of straddle type monorail vehicle tire life[J]. Urban Rapid Rail Transit, 2009, 22(4): 89-91.