

Management Strategies for Electric Bicycle in Urban Traffic System

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Abstract: Electric bicycle has gradually become one of the main tools for people traveling because of the convenience, environmental protection, flexible mobility and low cost. Public travel distance and frequency gradually increases and the people's income level is still not very rich. Then, in the background, the electric bicycle better solves the problem of travelling especially for low-income groups. With the development of electric bicycle, negative influences have brought into urban traffic system such as illegal traffic behaviors, confused traffic order and serious traffic accidents. How to implement effective management of electric bicycle, and can better serve the people's travel service, which is a problem to be solved urgently. Through the analysis of the electric bicycle situation in Huai'an, two aspects of measures are proposed to improve the management level of electric bicycle. First, countermeasures to solve the problem from macro perspective are including perfect infrastructure construction, enough parking transfer facilities, optimized traffic network signal control and normative enterprise production. Second, traffic design and management are discussed from microcosmic view. One of the typical intersections simulation model is established to test the control strategy the results are analyzed in detail. These measures and management methods could be used to support the sustainable development of electric bicycles in China.

Keywords: *urban traffic, electric bicycle, traffic simulation, traffic control and design*

I. INTRODUCTION

Reasonable structure of the transport network is the need for urban development. In addition to private cars, public transport and other fast transportation system, the non-motorized traffic is also needed to support the traffic system. The popularity of electric bicycles just caters to this trend. Electric bicycle has the characteristics of low cost, environmental protection and easy to use. Low-income groups have become the largest use of electric bicycle. Electric bicycle has become a way of travel cannot be ignored [8].

As the electric bicycle widely used, great negative impact have generated for unclear positioning and flaws in the traffic management which are the safety hazard in the modern city transportation. Much more traffic accidents occurred in the process of driving or violation of traffic rules. Running during in red light period, driving in inappropriate speed and too much loading led to the occurrence of traffic accidents frequently. Parts of the motor vehicle traffic accident are also induced by electric bicycle [12]. Inappropriate traffic behaviors of electric bicycle have seriously affected the road network traffic capacity and increase traffic congestion in the intersection. However, electric bicycle has obtained the consistent advocate both in china and abroad as one of the low carbon environmental protection transportation. Someone highlights the electric bicycle as the main causes of accidents happened in mixed traffic. Instead, someone believes that electric bicycle is the key to build the comprehensive transportation network [3]. In order to promote the development of electric bicycle and build a more balanced transportation system, we need more sophisticated traffic design and traffic management for the urban traffic system.

It was analyzed both in macro and micro aspects to establish more appropriate system of electric bicycle. Constructing electric bicycle infrastructure, improving the parking transfer system, training traffic participants and regulating the behavior of electric bicycle enterprise have been discussed to put forward control scheme from the macroscopic aspect. In micro aspect, traffic control design was carried out for a concrete intersection in Huai'an city using traffic simulation software VISSIM. In the end, electric bicycle traffic management strategy was established based on the two aspects.

II. LITERATURE REVIEW

Since the 1990s, with the emergence of electric bicycle, many countries kept the energy conservation and environmental protection as key research objects. As a kind of environmental transportation, electric bicycle began to get a large-scale promotion and development. Electric bicycle is regarded as a kind of traffic tools similar to the motorcycle in the United Kingdom. The output power should be less than 250W, maximum

travelling speed is 15km/h and the quality is not more than 40kg. In order to ensure the safety, the users of electric vehicles should be at least 13 years of age. In Singapore, electric bicycles and motor vehicles have the same management model. A total of more than 70 thousand motor vehicle across the country and about 50 thousand is electric bike [2].

Ulrich combines the technical main subsystem with the vehicle performance, and estimates the cost and weight of the vehicle which mainly solves the technical design limitations of the private electric vehicle. Parker introduces the electric bicycle market in Japan, China, Australia, United States and other countries. He indicates that the Australia could be benefiting at least two aspects. One is meeting the needs of the elderly in Australia, and the other is reducing the dependence on oil. In order to achieve the two aspects of benefits, the Australian authority first needs to regulate the use of electric vehicle from the legislative point of view. Cherry Chris, professor of University of California at Berkeley, studied the impact of E-bike on China's environment. He also discussed the impact of traffic safety, the electric vehicle on the accessibility and mobility of residents systematically [4-7].

Electric bicycle has not been used in large scale in foreign countries where the bicycle is generally regarded as a tool for short trips or leisure fitness. Therefore, there is no systematically study on traffic management and traffic control design for electric bicycle which is just deemed as a kind of ordinary traffic tools. In China, most of the electric bicycle is fully control by electric power which is different from foreign driving mode. Vehicle performance and the traffic characteristics are the main research aspects and the management strategies about electric bicycle are relatively few.

From the perspective of macro traffic characteristics, Zhou analyzed the impact of electric power assisted vehicle on urban traffic structure. He concluded that the advantage of the electric bicycle falling in the travel distance between 5 and 20 kilometres by calculating the generalized travel cost. Lu mentioned that the users are able to ride electric bicycle do not need training and examining which resulted in weak safety awareness, seriously negative impact on driving and disturbed the normal traffic order [10].

There are no uniform standards and regulations for the electric bicycle management in China. Different regions cannot reach a consensus in the management style and regulations. Departments of the state have actively formulated the relevant laws and regulations on electric bicycles, but these cannot keep up with the social development, economic development and travel demand. Meanwhile, these laws and regulations cannot clear constraint electric bicycle industry development and solve traffic safety issues which lead to the conflicts between the market and management and being the main reason why different cities take different management measures. Conflicts between electric bicycles and motor vehicles are analyzed using crowd characteristics, vehicle characteristics, road environment and other influencing factors [1]. The safety problem of the electric bicycle is analyzed qualitatively and some suggestions are put forward in combination with the actual situation of urban road traffic in China [9]. Based on the long time observation of the road and intersection, the traffic conflicts and the influence between the motor vehicle and the non motor vehicle is studied. Some improvement measures are also put forward by the simulated results. Using the same method, differences between bicycle and electric bicycle are analyzed especially in the type of traffic conflict. Level of traffic safety is also analyzed and evaluated in the intersection [11, 13].

In summary, it is urgent to do more research on the safety of electric bicycle in China. At present, the researches on the safety of electric vehicles mainly focus on the electric vehicle itself. More research on electric bicycles for traffic control design is needed to improve the safety level on the road. Based on the present situation and the existing problems in Huai'an city, management strategies and traffic control design has been carried out in an intersection using VISSIM. The result can provide a theoretical support for the corresponding management of electric bicycle in China.

III. CHARACTERISTICS OF ELECTRIC BICYCLE

As the substitutes of bicycle and ordinary two wheeled motorcycle, the characteristics of electric bicycles are very clear which have a strong advantage in modern traffic system. The consumers trust the electric bicycle very much.

First of all, in terms of environmental protection and energy saving, electric bicycle power is provided by the battery which is not likely to produce any emissions and cause pollution to the environment in the course of using. During the work, the motor also will not cause noise pollution. Compared with motor vehicles and motorcycles, electric bicycle drive system is relatively simple. It is easy to repair, maintenance or maintenance for the electric bicycle. The average energy consumption per hundred kilometres is only about 1 KWH that could not cause a greater burden on society.

Second, electric bicycle has the strong convenience and practicality. Electric bicycle can travel more than 50 kilometres only charging once, and 3 to 5 days later it just need to charge again. These characteristics of electric bicycle can be very good to meet the needs of short distance travel. Electric bicycle is particularly easy to learn and also without the need to apply for a driver's license which are fit for the majority of the consumers.

However, electric bicycle safety level is relative low. On the one hand, many electric bicycle eEnterprise's production technology is backward that resulting in the production of electric bicycle is lower quality. On the other hand, protective equipment is not enough to ensure the safety. The injury rate is much higher than other types of vehicles when general traffic accidents occur.

Electric bicycle has the advantages of energy saving, environmental protection, and practical using. It is a kind of traffic tool which can improve the structure of urban traffic organization, adjust people's travel habits, protect the public's travel demand and promote economy development.

IV. THE PROBLEMS BROUGHT BY ELECTRIC BICYCLE

The development of electric bicycle makes the city traffic system more perfect. But we should also be aware that a lot of negative impact has been brought to urban traffic management. If these problems cannot be solved appropriately, they will become the bottleneck of the long-term development of urban traffic.

In the actual process, the electric bicycle should be defined as motorized vehicle or non motorized vehicle, is the topic of public concern. Motorized vehicle refers to the vehicle driven by human or animals, running on the road, and maximum speed, empty quality, dimensions are comply with relevant national standards. According to this definition, electric bicycle should be classified as non motorized vehicle, following the non motorized vehicle management regulations.

However, in the actual operation and management, managers often encounter a dilemma situation. Though the electric bicycle has two independent structures, relying on batteries to provide energy and similar to the appearance of a bicycle, the designed maximum speed, vehicle quality and other technical indicators are far beyond the provision of the national standards. Speed more than 20 kilometres, the quality more than 40 kg and these features makes the electric bicycle more like a motorcycle. It is not fair and will exert a kind of security threat if electric bicycle is treated accordance with the non motor vehicle management approaches.

With the continuous improvement of living standards, people's travel distance, travel frequency and travel demand are increasing greatly which directly leads to result that the daily travel should rely on a variety of ways to achieve. For a long time, the bicycle has established the main position as a short trip tool or transfer tool. However, electric bicycle cannot be simply treated as ordinary bicycle for its mobility and large range of activities. Electric bicycle has many problems in its development process, such as low efficiency, weak safety performance, and occupied the motor vehicle road resources which have hindered the development of electric bicycle. Moreover, electric bicycle will bring a lot of obstacles to the urban traffic system if relevant supporting measures are not in place.

At present, public transport and non motorized vehicles are the main travel mode for most of the residents in Huai'an. This is similar to the situation in many cities of in China. The proportion of non motorized travel in the total travel is more than thirty percent. There is a very obvious characteristic of mixed traffic. In addition, flat traffic is still dominated in Huai'an road system. In the intersection, a variety of traffic participants are also in the same plane which is particularly easy to cause road traffic efficiency and safety level decline. The direct impact of the mixed traffic is that fast, slow and even pedestrian traffic flow mutual interferes with each other which reduce the speed of traffic, cause traffic accidents, slow traffic flow leading to traffic disorder and congestion. With the number of electric bicycles increasing, mixed traffic is much more complex which has brought greater negative impact on urban traffic. Because the speed and weight of the electric bicycle are higher than the ordinary bicycle, a new kind of traffic conflicts emerge which brings more problems to the urban traffic network.

With the development of science and technology, traffic control department greatly improves the management level. Compared to the previous application, measures are full of pertinence and diversity. A wide range of video monitoring system has been established, traffic violations could be disposed in the office which can reduces the intensity and improve the efficiency of traffic control department. Compared to motor vehicles, electric bicycle lacks of registration, so these advanced electronic management cannot be used. It can only rely on the traditional road enforcement and public traffic education. For the lack of traffic police, traffic management can only focus on the key roads and intersections. Moreover, because of electric bicycle high mobility and flexibility, electric bicycle traffic offense can lead to more serious traffic accidents and losses.

V. CURRENT SITUATION OF ELECTRIC BICYCLE IN HUAI'AN

Huai'an is located in the core area of the Yangtze River in Jiangsu province and is also a member of the Yangtze River Delta city group. Huai'an is an important central city in Northern Jiangsu Province. In the northern part of the Yangtze River Delta regional, Huai'an has a unique advantage of location.

Road traffic facilities are generally relatively old in Huai'an. Hierarchy of the urban roads are not reasonable. Sub-arterial and branch roads are too less to meet the traffic needs. Existing sub-arterial and branch can not connected together effectively. There are lacking systematic road planning resulting in the arterial road traffic volume too concentrated.

Three years, from 2011 to 2013, the growth of electric bikes was taken as an example. In 2012, the total number of no motorized vehicle is 2.95 million including 0.58 million electric bicycles. There is about 920 thousand electric bikes increase than 2011. In 2013, the total number of no motorized increased to 3.06 million. The electric bicycles accounted for 22.4% of the total number, an increase of 10.5 compared to 2012. From the above data, we know that electric bicycle increases about 2% every year in Huai'an. If the unregistered could be incorporated into the statistics, the actual growth rate should be much higher than 2% and the growth of non motorized vehicles are basically from the electric bicycle.

According to the statistics, the registered electric bicycles in Huai'an are more than 1 million by the end of 2014. A conservative estimate of the total number should be more than 1.5 million.

In 2014, the traffic share rate of bus service is only about 30% in Huai'an, and the ideal value should reach 50% to 70%. The car and non motorized vehicles are the main resident traffic mode in which the non motorized traffic share rate about 35%. According to growth and development of electric bicycles, its traffic share rate is about 20%.

VI. STRATEGIES OF ELECTRIC BICYCLE BASED ON MACRO PERSPECTIVE

At the present stage, the traffic congestion in Huai'an city is increasing, the public transport system is not strong, and the public economy income is generally not high, so the electric bicycle is irreplaceable in the daily life of travel needs. For better development of electric bicycle, the positioning of electric bicycles in the urban transport system is the core issue must be solved firstly. Reasonable, healthy and orderly development for the electric bicycle should be guided by the government departments depending on effective policies and regulations to support the traffic development and social economic construction services in Huai'an. Due to the electric bicycle problems in the course of development, some suggestions are put forward.

The road infrastructure affects the safety of electric bicycles to a certain extent. There are many objective factors that lead to the frequent occurrence of electric bicycle traffic violations such as unreasonable road function design, poor traffic environment, and scarce parking facilities and so on. Relevant management departments should implement people-oriented concept to fully protect the traffic participant's rights. More attention should be pay to fairness and rationality to ensure the passageway not only for vehicles but also ample space for electric bicycles. Related issues such as improving the traffic environment and safety level, constructing more non motor vehicle parking facilities and solving the of electric bicycle parking problem are good for the development of electric bicycles. In order to improve traffic safety, independent electric bicycle lanes should be established though electric bicycles are classified as non motor vehicle which actual driving in speeding condition.

Electric bicycle should have clear marking of queue location at the intersection to avoid confusion. The second thing to do is identifying the parking space in branch road to facilitate the transfer. Advanced parking technology can be adopted to realize the intelligent management of electric bicycle.

The intersection itself has a lot of traffic pressure, and the increase of electric bicycles also make the traffic pressure more serious and complex. Based on the traffic signal control, specialized signal phase for electric bicycle could be established to guide, control or change the driving trajectory. Because of compact and convenient, changing the route can make electric bicycle reach the destination more safety and efficiency while saving the limited road resources. Due to the regularity of travel time, in the morning and evening peak period, electric bicycle can follow the example of motor vehicles, has a certain one-way traffic roads to improve traffic capacity.

Electric bicycle has a lot of brands, and there is also a bad competition among enterprises. Relevant departments have no effective supervision during the production process. These are the important reasons that result in the disorder development for the electric bicycle. In the process of production, some enterprises are blind to cater to consumers ignoring the consumer's life and property safety. Some enterprises are even misleading and deceiving consumers that make the interests of consumers' serious damage.

Many aspects of the market should be involved to ensure that the production of electric bicycles is in line with national standards. When the various functional departments had play a good management, the electric bicycle industry could be survived and keep development in the furious competition.

VII. TRAFFIC CONTROL AND DESIGN BASED ON MICROSCOPIC FIELD

VISSIM is a microscopic, time step and behaviour based simulation model developed to model urban traffic and public transit operations. The program can analyze traffic and transit operations under constraints such as lane configuration, traffic composition, traffic signals, transit stops, etc., thus making it a useful tool for the evaluation of various alternatives based on transportation engineering and planning measures of effectiveness.

A typical intersection was selected as the example which was located in the Huaihai road and Mei Cheng road. As the urban arterial road, Huaihai road covers multiple districts and bears a lot of traffic flow.

Meicheng road locates in the core area of Qingpu new town. An appropriate research object is provided by the two road intersection for traffic control design and research of electric bicycle. Detailed road layouts were shown in Figure 1 and Figure 2.

VISSIM can provide a variety of parameters to evaluate the traffic management. The study focused on electric vehicle and the interaction between electric bicycle and motor vehicle. Therefore, a typical intersection was selected as the case study. Speed change was taken as one of the evaluation parameters.

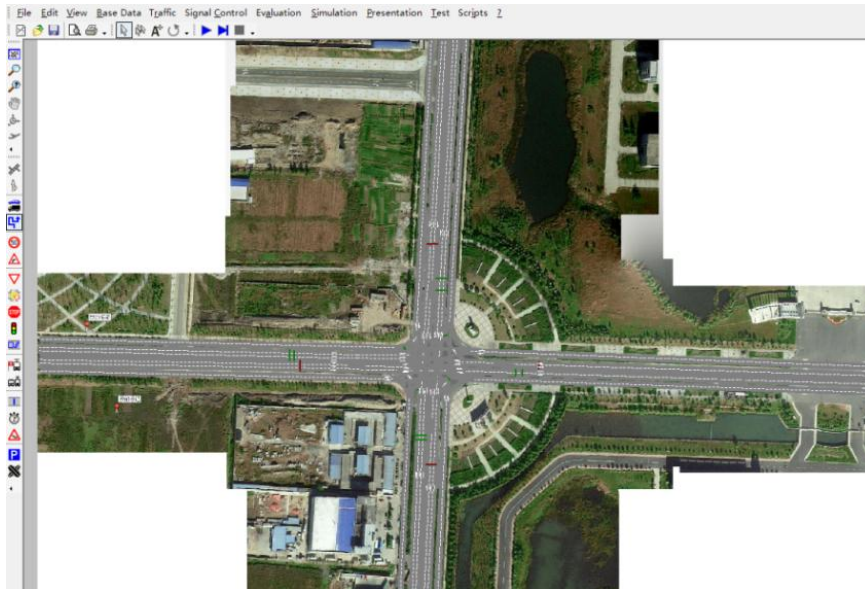


Fig. 1 - Microscopic simulation model of the intersection

Data collecting points were set both in upstream and downstream in the VISSIM for the study. As the arterial road of Huai'an, Huaihai road has taken a lot of traffic, so traffic operation state in two directions were analyzed. In addition to the data analysis, it is also necessary to evaluate the performance of the whole network. The evaluation content includes average delay time, average delay, average speed, average parking delay and total delay.

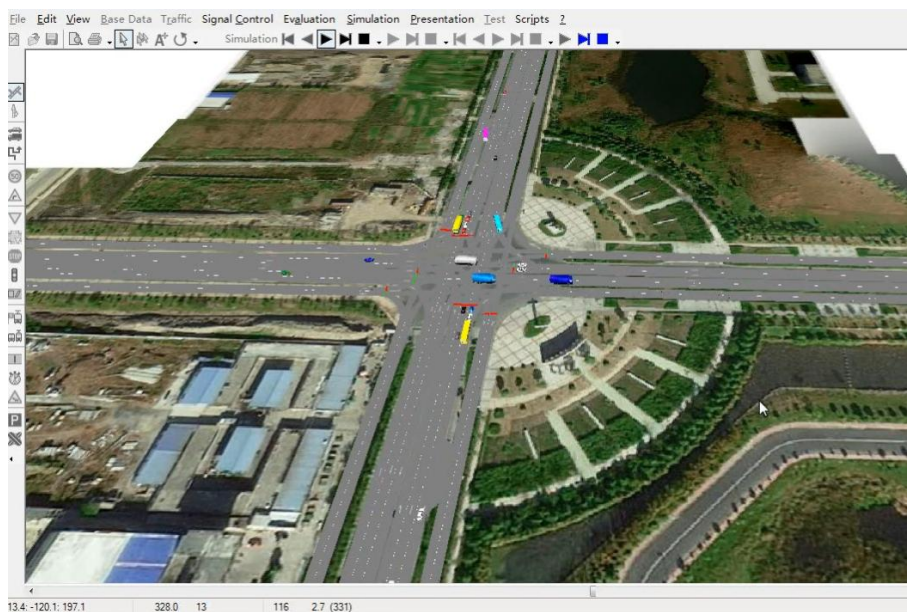


Fig. 2 - Diagram of simulation running

In order to truly get the speed of the vehicles approach and departure the intersection, the detection period of the data is set to 60s, the detection start time is at 600 seconds, and the end of time is at 7200s. Speed change rate is used to describe the intensity of the speed change and the results were shown in Figure 3 and Figure 4.

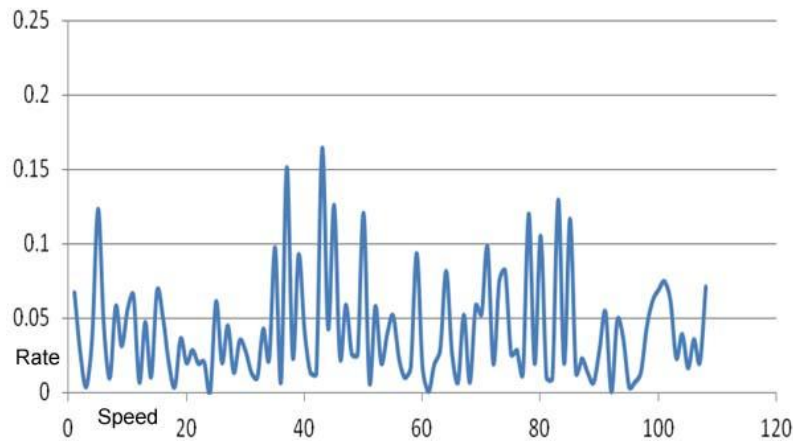


Fig. 3 - Speed change rate of motor vehicle

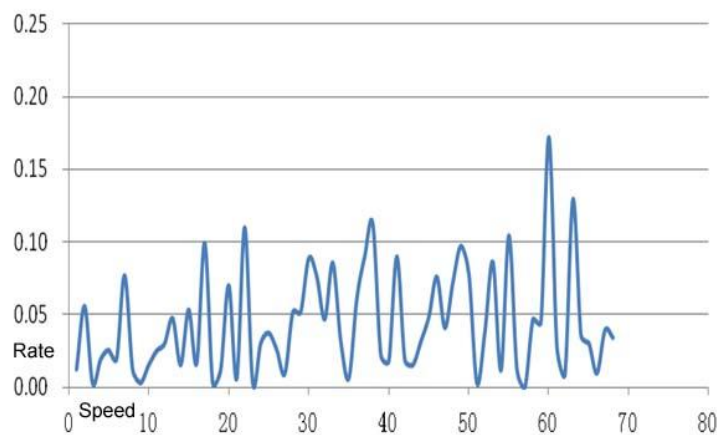


Fig. 4 - Speed change rate of electric bicycle

Motor vehicles and electric bicycles speed change rates were 3.92% and 5.36% respectively, which had been greatly reduced after traffic control design and management. The simulation results shown that the fluctuations of speed change are decreased which would help to enhance the driving safety level, reduce the accident risk and improve traffic efficiency.

VIII. CONCLUSIONS

An analysis about electric bicycle is made from different angles. Macroscopic and microcosmic measures could be adopted to improve the management level of electric bicycle. Based on in-depth study and traffic control design for electric bicycle, accident risks could be decreased in a certain extent. The findings can also provide some suggestions to the traffic administrative department of the electric bicycle management, so as to promote the electric bicycle to a better development.

The inadequacies of the research are that influence brought by the bus station optimization is different for the traffic when the traffic model had been established in the simulation software. How to quantify the impact of the optimization on traffic is a very complicated problem. On the other hand, through the signal timing optimization, the electric bicycle gets three priority seconds to pass the intersection which is a good way to reduce the risk of accidents and improve traffic safety. However, how to evaluate the impact of these traffic designs on other modes of transportation is a very important research topic in the future.

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