Application research on Maglev Transportation in Shanghai

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ABSTRACT: The paper briefly introduces the operation status of Shanghai Maglev Demonstration Line and the progress of its extending plan. It summarizes the further development work which has been done to meet the new need for application of maglev transportation, including developing new high speed maglev vehicle, guideway switch, production line of stator pack as well as compiling General Technical Specification for High Speed Maglev Vehicles and Design Code of Maglev Engineering under the cooperative framework of China and German governments. Besides, the paper also describes the research and experiments on urban maglev transportation system in Shanghai since 2005.

1 OPERATION STATUS OF SHANGHAI MAGLEV DEMONSTRATION LINE

Shanghai Maglev Demonstration Line（hereinafter referred to as SMDL）started its trial operation on a single track at the beginning of 2003, began shuttle running on the double track in September of 2003 and completed the test and acceptance at the end of 2003. The year of 2004 witnessed its beginning of commercial operation according to the operation schedule. Currently the train runs at the highest speed of 430km/h in the day and 300km/h in the morning and evening. Up to June 2011, the maglev train on SMDL has covered a mileage of about 9 million kilometer and carried passengers of about 29 million person times. In the past years, the maglev system has undergone bad weather such as hurricane, heavy snow, and typhoon. No accidents that injured people have happened, nor has the operation been interrupted by bad weather. Statistical results of the past years since 2004 show that average operation punctuality rate reaches 99.72% and 99.88% of the operation schedule is fulfilled, as shown in Figure 1. Operation of SMDL has verified that the Transrapid system is technically mature, safe and applicable.

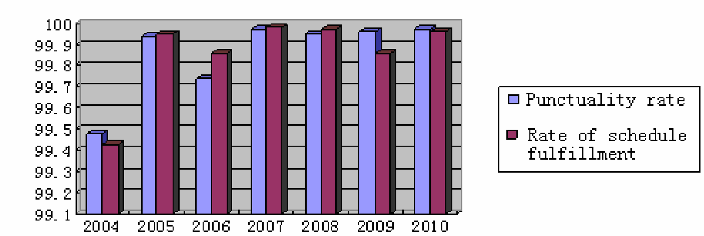

Figure 1. Rate of punctuality and rate of schedule fulfillment on SMDL.

The over 8-year operation of SMDL proves that Transrapid technology is mature and applicable, and can join the integrated transportation system as a high speed land rail transportation tool.

SMDL plays a role more in technology verification and demonstration rather than actual transportation. In spite of the success of technology demonstration, SMDL is confronting difficulties to keep technically sustainable and economically feasibility in operation because of no new application projects in China, Germany or other countries, too small scale of products and market share for maglev operation equipment and lack of enough driving force to maintain technology development.

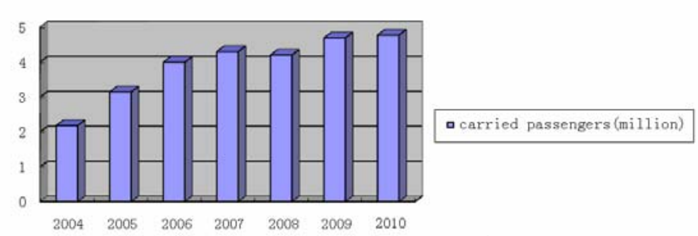

Figure 2. Carried passengers on SMDL in the past years (million).

2 APPLICATION DEVELOPMENT

Since 2006, with the support of Ministry of Science and Technology of the People's Republic of China and Shanghai municipal government, Shanghai Maglev Transportation Engineering R&D Center has been leading the localization research on some operation equipments and optimization research on the guideway components to meet the requirement of new projects.

2.1 Vehicle Development

On the basis of the vehicle technology transferred from the German company ThyssenKrupp Tecknology-Trasrapid(TKT-TR), a 4-section prototype maglev vehicle with the maximum speed of 500km/h is developed and produced in China. Except for the component of Levitation and Guidance System purchased from TKT-TR, the car body, equipments inside the vehicle, subfloor structure, cladding and other components are all produced and assembled in China. The prototype vehicle uses floating floor, newly designed air conditioning system, and new monitoring circuit in battery. Toilets are also installed into the vehicle to meet the requirements of long distance running. Compared to the original vehicles on SMDL, tests show that the prototype vehicle has lowered the in-vehicle noise by 6dB (A), improved the capability of refrigeration by 20% and increased the ventilation by 50%. The new vehicle was put into trial running in February 2011.

Figure 3. New developed maglev vehicle in trial run.

2.2 Production Line for Long stator pack

Crucial techniques and equipment for producing stator pack are developed. The first production line for long stator pack in China is completed, including complete sets of production equipment and test equipment. It is capable of producing 100,000 stator packs per year. The products from trial mass production have passed type test.

Figure 4. Long stator production line.

2.3 High (low) speed switch

On the basis of the transferred technology and the experience obtained on SMDL, the low speed switch with passing speed of 98km/h and high speed switch of 196km/h are optimized, fabricated and tested. Based on the experience of developing the switch, the 8 sets of switches on SMDL that were imported from Germany are upgraded and modified.

Figure 5. Newly developed low speed switch under test.

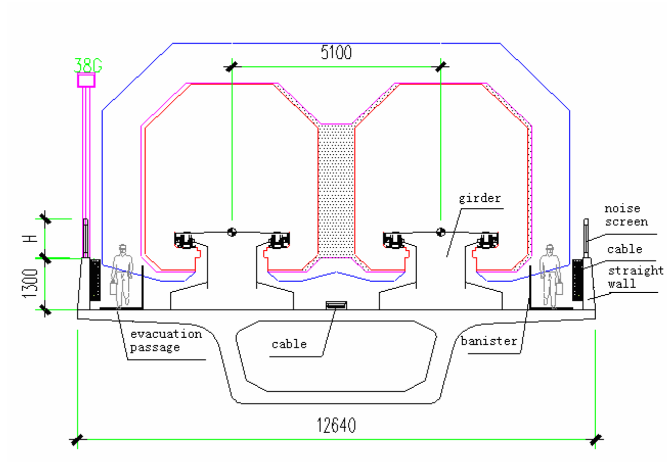

Figure 6. On-bridge girder structure.

2.4 *New Type of girder Structure*

(1) New integral girder structure

An integral type of girder is adopted to make full use of the stiffness of the functional area and reduce the total weight of the girder. Taking a 24-meter girder as an example, the weight could be reduced by about 30t. Compared to the hybrid girder used on SMDL, the integral girder could reduce the cost by 20%. Two such test girders are fabricated, one underwent 3 million times of fatigue and destructive tests in the lab and the other was mounted on Shanghai Maglev Demonstration Line for assessment.

(2) on-bridge girder structure

A new type of on-bridge girder structure is designed to meet the requirements of passenger evacuation in emergency and noise reduction. It went through simulation test according to the actual situation of SMDL.

The structure uses the normal box buttress as the supporting beam, on which the double-track girder is laid out. The maintenance path is set up in the space at the two sides of the box buttress outside the vehicle clearance envelop and could be used for evacuation in emergency. Small straight walls are built at the edge of the buttress. Cable bracket is installed in the inner side of the wall. Cables can be laid on the bracket and in the middle of the bridge. The stator switchgear of the propulsion system can also be laid on the surface of the bridge. Noise screen can be installed on the two sides of the bridge if needed.

The new type of on-bridge girder structure can markedly improve the efficiency of evacuating the passengers in emergency, and thus reduce the grade of vehicle fire prevention requirement and the vehicle cost. Simulation tests were conducted on an at-grade section of SMDL to study the maglev noise screening technology. The on-site collected data and computer model were used to survey the sound field distribution with different noise screens and noise reducing effect at different passing speed especially at high speed. The results show that the noise at the measuring point of the same elevation as the guideway surface and 3.5m-40m away from the center line of the track is reduced by 8~13dB(A) with the noise screening on the on-bridge girder structure when the train passes at 400km/h.

Figure 7 Simulation test of new type of on-bridge girder structure on SMDL.

Figure 8 Aerodynamic Simulation test for noise screening.

(3) Line structure inside tunnel
With in-depth research on the tunnel technology for passing through big rivers and lakes and aerodynamics simulation test and calculation analysis, the solutions are brought out in regards to tunnel structure, subsidence control, fire protection and evacuation, and smoke ventilation.

2.5 Drawing up High Speed Maglev Standards

Under the cooperative framework of Ministry of Science and Technology of the People's Republic of China and Federal Ministry of Transport, Building and Urban Development of Germany and with the support of the related German companies, Shanghai Maglev Transportation Engineering R&D Center compiled two standard drafts, namely General Technical Specification for High Speed Maglev Vehicles and Design Code of Maglev Engineering. The former has already been authorized by Ministry of Housing and Urban-Rural Development of the People's Republic of China and the latter is undergoing the procedure of soliciting comments and is expected to be authorized at the end of this year.

3 PROJECT UNDER PLANNING

The air transport volume into and out of Shanghai has been increasing with the expansion of Shanghai Pudong International airport and completion of the new Shanghai Hongqiao Transportation Hub, which therefore requires the matched and suitable service facilities to be built as soon as possible. As a fast rail transport mode, high speed maglev can not only link the two airports but extend the airport service to the downtown area in higher efficiency.

Currently, the land transport flow into and out of the two airports is increasing rapidly. Though Metro Line 2 was extended to the two airports in 2010, it is still not effective enough to distribute the passengers flow. The maglev airport link, if built, would enable the passengers to transfer in the downtown maglev station and reach the airport faster and thus supplement with Metro Line 2.

In the new adjusted feasibility study, the to-be-built part of the airport link in Pudong area, which connects the existing main track, starts from the new Longyang Road Station, runs westward to Shanghai South Railway Station and ends at Hongqiao Airport Station. The airport link is approximately 61km in total, of which about 34km would be newly built including reconstructing 3km the existing line. The to-be-built part contains about 10km of elevated and at grade track and 24km underground track. It consists a new Longyang Road Station (underground), Shanghai South Station, and Hongqiao Station. The existing Longyang Road Station will be used only for a center of operation dispatching and temporary parking instead of passenger alighting and boarding.

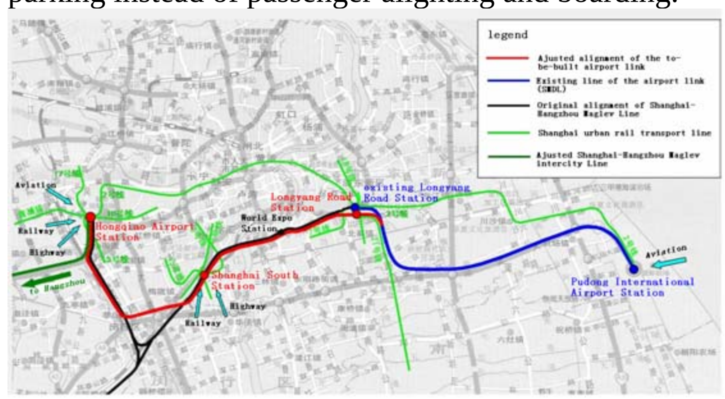

Figure 9 Sketch map of Shanghai maglev airport link.

4 DEVELOPMENT OF URBAN MAGLEV TECHNOLOGY IN SHANGHAI

In the duration from May of 2005 to the end of 2007, Shanghai Maglev Transportation Engineering R&D Center cooperating with Shanghai Electric Group, built an urban maglev test line and assembled a three-section urban maglev train.

The test line contains 1,704m main track, 276m parking line for general assembly and a set of two-way switch. A three-section train was made with the highest design speed of 100km/h. It adopts the normal conductive electromagnetic levitation technology and is driven by short stator linear motor. The smallest curve radius on the line is 50m, the smallest vertical radius 1,500m and the largest longitudinal slope 70‰.

In April, 2008, the train reached its highest test speed of 102km/h. It is verified through system commissioning, trial-operation and tests that it meets the requirements of urban rail transport in terms of its technical indexes such as running noise, electromagnetic radiation, running stability, passenger transport capacity and energy consumption.

It can adapt to the conditions of engineering application in urban rail transportation. At present, research is undergoing on the possibility of realizing an urban maglev line in Shanghai.

Figure 10 Shanghai urban Maglev train and the Test Line.

5 PERSPECTIVE

High speed maglev transportation system provides an economically and technically best choice of land transportation mode within the speed range between high speed wheel-on-rail railway and aviation. In terms of the internationally accepted concept of 3-hour comfort travelling, it is suitable for medium and long distance passenger transport. It can divert the air traffic and lessen the oil consumption pressure in the future.

With mass production and localization of high speed maglev transportation equipment, compared to the wheel-on-rail technology, it will have similar construction cost, a bit lower operation cost under the condition of high speed running, and save more travelling time. Therefore, it will bring about better comprehensive economic benefits within medium and long distance.

High speed maglev transportation stands a room in China’s future modern integrated transportation system. With the mass development of high speed wheel-on-rail in China and in consideration of the general trend of the integrated transportation system and the technical and economic characteristic of high speed maglev transportation, high speed maglev will provide a new planning alternative for the integrated transportation system and improve its service quality and efficiency if it is introduced between the high speed wheel-on-rail and aviation systems.

Under the background of vigorous development of rail transport in China’s big and medium cities, there is a certain room for the urban maglev system to develop. The Beijing municipal government has made the decision that the urban maglev system developed by Beijing Maglev Holding Company and National University of Defense Technology would be adapted to construct an engineering demonstration line in Beijing, which, if succeeded, will further promote the application and development of urban maglev in China.