Current Status of JR’s Maglev Development

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The running tests at the Yamanashi Maglev Test Line verified the engineering characteristics of JR’s Maglev and the necessary functions as a means of transportation. The technical evaluation committee of the Ministry of Transport reported an evaluation result to the effect that the reliability of the system for commercialization has been proved from the engineering viewpoint though there are problems to be further studied on the durability and economy toward the verification of the system.

Keywords: Maglev, JR’s Maglev, Yamanashi Maglev Test Line

1. Introduction

The running tests at the Yamanashi Maglev Test Line started by using an 18.4 km guideway in April 1997. These running tests verified the characteristics of levitation and guidance, dynamics of two trains to pass each other at high speed, and the performance of train control system. A maximum speed of 552 km/h has been attained in these running tests.

The technical evaluation committee of the Ministry of Transport on JR’s Maglev has evaluated the test results obtained so far. The committee also reported the evaluation result to the effect that the reliability of the system for commercialization has been proved from the engineering viewpoint though there are problems to be further studied on the durability and economy toward the verification of the system.

This paper describes the current status of the development of JR’s Maglev system.

2. Development at the Yamanashi Maglev Test Line

2.1 Test transitions

After the running tests started in April 1997, various tests have been completed as scheduled in the original plan. See Fig. 1. The project team increased the speed of the 3-car train while confirming the performance and the characteristics in levitated running, and attained the designed maximum speed of 550 km/h in December 1997. After that, the body of the middle vehicle was exchanged with a long body which had a larger seating capacity. At the same time, the train was equipped with elastic suspension bogies and an on-board linear generator as a power source.

Since June 1998, two trains were used to confirm the performance of multiple train control system and vehicle dynamics when they pass each other at high speed. See
75,427 km have been attained. As of March 31, 2000, a maximum speed of 552 km/h, a relative maximum speed of 1003 km/h for two trains to pass each other, and a cumulative running distance of 420 km/h is satisfactorily in good agreement with the design requirements of the Yamanashi Maglev Test Line.

2.2 Test results

(1) Characteristics of levitation and guidance

The bogie installed with superconducting magnets runs at a vertical displacement in levitation running. The displacement, which was almost a constant value, didn’t depend on the guideway conditions or running speed. Rubber tire wheels support the bogie in the low speed stage, because the levitation force decreases and therefore the displacement increases.

When the train passes a curve section, the force due to the cant set in the section and a centrifugal force act on the vehicle in the lateral direction. Therefore, the vehicle deviates outward more at high speed than at the balancing speed. At low speed on the other hand, the train deviates inward. The lateral displacement when the vehicle passes a curve section where the balancing speed is 420 km/h is satisfactorily in good agreement with the design requirements. The rubber tire wheels guide the bogie in the low speed stage as the guidance force decreases.

(2) Stability of superconducting magnet

The oscillation of the superconducting magnets in high-speed running was satisfactorily smaller than the allowable limit. The refrigerators on the vehicle have been operated to recycle helium for a long time.

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(3) Performance of speed control

The inverters installed at the power conversion station automatically control the train speed by adjusting electric power supplied to the linear synchronous motor. They controlled the train speed to compensate for the effects of grade, tunnel and vehicle weight. The run curve obtained agreed with the reference pattern. The deviation from the reference position was considerably smaller than that allowable limit of 150 mm when the train stopped at a platform.

(4) Brake performance

The system at the Yamanashi Maglev Test Line has three types of electric brakes and two types of mechanical brakes. To stop the train, the regenerative brake is normally used to recover the kinetic energy of the vehicle with inverters. The dynamic brake that consumes energy by the resistors at the power conversion station is actuated at inverter failure. The coil short-circuit brake is actuated to connect all propulsion coils in parallel by the feeder section switches at feeding system failure.

The train is equipped with aerodynamic brake that spreads the braking plates installed at the upper part of the vehicle body, and the wheel-disk brake that operates at wheel travel motion. These mechanical brakes are actuated at electric brakes failure. It was verified that the performance of each brake system satisfies the original design.

(5) Backup brake system

The backup brake system has the primary safety brake which consists of electric brakes mainly and the secondary safety brake which consists of two mechanical brakes on the train, as shown in Table 1. Each safety brake is actuated when train speed exceeds the allowable limit, or when the critical arrangement breaks fail. The function and performance of this backup brake system were confirmed by repeated brake application tests.

Table 1 Configuration of the backup brake system

<table>
<thead>
<tr>
<th>Type</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary safety brake</td>
<td>Dynamic + coil short-circuit + wheel-disk</td>
</tr>
<tr>
<td>Secondary safety brake</td>
<td>Aerodynamic + wheel-disk</td>
</tr>
</tbody>
</table>

(6) Influence of the environment on the guideway line

The noise, ground oscillation and magnetic fields on the guideway line in the train passage satisfied the targetted values for environment preservation as shown in Table 2. The noise decreased about 10 dB more from that at the Miyazaki Test Track due to the smoothed and sharpened vehicle bodies. The ground oscillation was sufficiently small, and the magnetic fields were at the earth magnetism level.

The micro atmospheric wave which appeared at the time of tunnel rush didn’t reach the value to cause trouble as an effect of the tunnel entrance hood. The noise voltage of the communication wire induced by the inverters was lower than the allowable limit.

(7) Low-frequency air oscillation

A new phenomenon that the fittings of the houses around the tunnel entrance oscillate occurred in the speed range beyond 400 km/h. It was found that this phenom-
enon was caused by the low-frequency air oscillation when the train passes the side holes inside the tunnel. This phenomenon disappeared when the side holes were closed. The tunnel entrance hood was built to decrease the low-frequency air oscillation at tunnel rush. In this regard, tests had been performed to study the entry shape and its effect.

(8) Two-train crossing test

An appropriate distance is necessary between two travel motion ways because aerodynamic force acts on the vehicle body when two trains pass each other. The vehicle dynamics, noise and low-frequency air oscillation on the guideway line were confirmed by running two trains to pass each other at the relative speed of 1003 km/h at open and tunnel sections.

The vehicle oscillation, riding comfort and pneumat-ics fluctuation in the vehicle were at the presumed levels, but some items became clear to require improvement. The magnetic field received from the passing train was at a lower level than the desired value, and decreased as the relative speed increased due to the magnetic shield on the body.

(9) Control of the multiple power conversion station

The control system of the power conversion station proved that the operation control function could be changed during the travel motion between the power conversion stations. The fluctuations of the speed and acceleration were small, and the influence on the utility system didn’t occur in the tests.

(10) Control of multiple trains

On a commercial Maglev line, there will be trains that stop or don’t stop at a station. This requires shunting a train to make another overtake at stations. For this purpose, the switch control, safety function and traffic control were verified by using two trains.

### Table 2 Influence of the environment on the guideway line

<table>
<thead>
<tr>
<th>Item</th>
<th>Measurement conditions</th>
<th>Targeted value for environmental preservation</th>
<th>Measurement results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>25 m distant, 1.2 m height</td>
<td>75 WECPNL or lower</td>
<td>74.5 WECPNL or lower</td>
</tr>
<tr>
<td>Ground oscillation</td>
<td>9.5 m distant</td>
<td>70 dB or lower</td>
<td>54 dB or lower</td>
</tr>
<tr>
<td>Magnetic field</td>
<td>4 m distant, Under an 7.8-m-high elevated section</td>
<td>20 Gauss or lower</td>
<td>19 Gauss or lower</td>
</tr>
</tbody>
</table>

3. Research at the Kunitachi Institute

Basic researches on the superconducting magnet, ground coil, magnetic shield and low-frequency air oscillation are being continued at the Kunitachi Institute. Application of a high temperature superconducting material is being studied to reduce evaporation of the liquid helium that refrigerates the superconducting magnet. The Institute is also studying the ground coil configuration which has the functions of levitation, guidance and propulsion, and the superconducting magnet to exert these functions. The designing method is being studied about the magnetic shield of the vehicle by applying the optimization technique.

4. Conclusion

The engineering characteristics of JR’s Maglev and the necessary functions as a means of transportation were verified by the running tests at the Yamanashi Maglev Test Line. The technical evaluation committee of the Ministry of Transport reported the evaluation result to the effect that the reliability of the system for commercialization has been proved from the engineering viewpoint though there are problems to be further studied on the durability and economy toward the verification of the system. This committee also reported that the tests for five years more were necessary to verify the durability of the system, lower the costs and improve the aerodynamic characteristics.

Central Japan Railway Company, Japan Railway Construction Public Corporation and Railway Technical Research Institute will continue the development of JR’s Maglev under government subsidies.

Reference