Train traffic control system on the Yamanashi Maglev test line

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Abstract

The running tests of the Superconducting Maglev in Yamanashi prefecture have been proceeded steadily since April 3, 1997. The results, the world record of 552km/h on April 14, 1999 and the relative speed of 1,003km/h obtained during passing tests on November 16, 1999, show that the system has no technical problems and is ready for practical use.

The Yamanashi Maglev Test Line system differs from the conventional railway system, the characteristic of the Maglev driving system is long stator system which controls vehicles from the ground, one power conversion system can control only one train and an electromagnetic force levitates the vehicle to enable the train to run at a high speed without even touching the ground based at all. In order to ensure safety and realize high-speed large capacity transport, Train Traffic Control System (Automatic Traffic Control System) is adopted in the levitation railway.

In this paper, we describe Train Traffic Control System for purpose of realizing automatic operation for the high-speed railway.

1 Introduction

The development of the superconducting magnetic levitation system (Maglev) was began by the Japanese National Railways in 1962, and various basic test runs have been conducted at the Miyazaki test track. Since April 1997, more advanced running test runs have been carried out on the Yamanashi Maglev Test Line.

The target on the Yamanashi Maglev Test Line is to carry out a general test for high-speed mass transit that connect approximately 500 km between Tokyo and
Osaka in one hour. And various tests for confirming the practicality of using Maglev technology being carried out under conditions on a commercial line in mind.

Our efforts for the three years led to the world record for maximum manned speed of 552 km/h by the five-car train-set on April 14, 1999 (Figure 1). Moreover, passing test with a relative speed of 1,003 km/h was achieved by two train-sets on November 16, 1999 (Figure 2) and we have acquired various test data. The cumulative total running distance has now reached 75,000 km. As a result, Each technology of the superconducting magnetic levitation system has necessary performance because it comes into being including the safety as a super-high-speed mass transport system. The superconducting magnetically levitated railway technology evaluation committee issued that there are no technical problems for a practical application of the system.

In this paper, we present the facilities in the Yamanashi Maglev Test Line, the train traffic control system for the high-speed train and the train control on a commercial line in mind.

![Figure 1. Run curve of 552km/h](image1)

![Figure 2. Passing test with a relative speed of 1,003 km/h](image2)

**2 Yamanashi Maglev Test Line equipment**

The Yamanashi Maglev Test Line among the mountains is situated on the west that is about 100 km away from Tokyo. Maglev of test line have to keep stable by 500km/h running presumed with the commercial line. So, the test line has a long straight section(18.4 km), a maximum gradient of 40%, a curved section with a radius of 8000m, a tunnel section/ an open section, a test platform and is double track as a commercial line. The Test Centre managing and operating the test, the power substation that supplies propulsion power for the Maglev and the train depot are also installed in this area (Figure 3).
We have two train-sets for the test. The tests using each three-car train-set are normally conducted. Moreover, the tests using five-car train-set that will be used on commercial lines are also conducted.

3 The Train traffic control system on the Yamanashi Maglev Test Line

The Maglev system is differs from the conventional rail-wheel system as train operations are carried out automatically by the equipment on the ground. In this system, the superconducting magnets are installed on the both sides of vehicle, and there are propulsion coils, levitation and guidance coils on the guideway.

The superconducting magnets on the vehicle receive a propellant force by feeding the propulsion coils (figure 4).
adopted in the levitation railway. Train Traffic Control System is consisted of the following three systems and the electric system for the Maglev is shown in the figure 5.

**Traffic Control System**
- Central traffic control
- Regional traffic control
- Train operation control

**Drive Control System**
- Supervise of driving control
- Speed control
- Synchronous control
- Switchgear control

**Safety Control System**
- Train monitoring
- Position detecting

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Figure 5. Train Traffic Control System and Electric System

### 3.1 The traffic control system

The traffic control system is consisted of the central traffic control system, the regional traffic control system and the train operating control system.

The central traffic control system has functions of monitoring the test situation and managing the timetable.

The regional traffic control system has functions of transmitting a running plan between the stations based on the planning timetable to the train operating control system and assigning the power conversion substation. Moreover, it request of route control.

The train operating control system is necessary for a power conversion substation. The running curve is made on bored running plan and a running possible range is calculated by safety control system. Moreover, it is consider of failures about the vehicle of equipment is taken into consideration. It is require a feeding route control in order to realize a boundary block control for the safety control system.
3.2 The safety control system

The safety control system calculates a safety speed curve according to the speed limits and executes a safety brake when the train speed exceeds the safety speed curve.

According to the command of feeding route control from the train operating control system, the block control function makes a block by the change-over switch as keeping the condition of one train control per one power conversion substation.

The train monitoring system watches the conditions of train existence and vehicle if any serious failure occurs, it executes a safety brake.

The station safety control system sets the route according to the request from the traffic control system and adjusts the movement of platform door to the movement of the vehicle door.

The position detecting system calculates a train speed and a train location by the link between train antenna and inductive radio position detecting wire. The information that is calculated by the position detecting system is used for the synchronous control of Linear Synchronous Motor.

3.3 The drive control system

The drive control system is consisted of a part of supervise of driving control, speed control, synchronous control and switchgear control.

This system calculates speed pattern so as to take into riding comfort according to the running curve and output the value of current and phase to the power converter control according to the train speed.

4 The train control on a commercial line in mind.

We can carry out the test in different test mode. “Test Support Mode” is prepared for the function verification tests and “Train Timetable Mode” is prepared for punctuality test, abnormal situation test and multiple train control test.

In this chapter, we present Train Timetable Mode in detail and the tests results.

4.1 The train control for punctuality

In the Maglev system, train operations are carried out automatically by the equipment on the ground. The traffic control system automatically calculates the running curve according to the running time between the stations that is indicated by the dispatcher. The running curve is variable and is calculated by the convergence calculation that realize the time difference between the actual running time and the scheduled running time is within a second. Moreover, the traffic control system executes train tracking and compares the running curve that was calculated with the running result. If the time difference exceeds the reference time, it recalculates new running curve as the running time adjusts the scheduled running time.
It is necessary for punctuality to control the train according to the running curve. In this system, in order to set the acceleration and deceleration capacity, we have to consider running resistance, the ability of power conversion substation, the condition about various equipments (ex. gradient, tunnel and so forth). In other words, we have to consider the acceleration and deceleration capacity limit.

The traffic control system uses Maximum acceleration and deceleration capacity, Normal acceleration and deceleration capacity and Minimum acceleration and deceleration capacity. When it is necessary to recover the delay, it calculates the running curve between Maximum acceleration and deceleration capacity and Normal acceleration and deceleration capacity. When there is time to spare, it calculates the train running curve between Normal acceleration and Minimum acceleration and deceleration capacity.

Figure 6 presents the test results that indicates the train control for punctuality has been carried out.

4.2 The train control when an abnormality occurs

In the conventional railway system, the driver or the dispatcher have to control the train according to the failure information. But in the Maglev system, traffic control system automatically determines how to control the train according to the control method corresponding to the failure factors that is decided in advance. The train controls when an abnormality occurs are as the following:

4.2.1 Immediately stop
The train is stopped by the emergency brake command from the safety control system.

4.2.2 Stop to the specific stop point
The traffic control system calculates the running curve in order to stop the train at the evacuation point when a fire breaks out and at the electric supply point when a power supply breaks down.
4.2.3 Slowdown (levitated running)
When the train can not run at the maximum speed due to the failure of a part of on-board equipment, a new running curve including the limit of train speed is calculated.

4.2.4 Slowdown (wheel supported running)
When the system can not maintain the vehicle levitation running equipment due to the failure of a part of on-board equipment, a new running curve including the limit of train speed is calculated.

Figure 7 presents the running test results that was carried out under the condition that the failure was occurred intentionally and indicates the train control when an abnormality occurs has been carried out properly.

4.3 The train control on a commercial line in mind
A boundary block control system is introduced on the Yamanashi Maglev Test Line. The advantage of this control block system is flexibility of train control and train diagram density.

The Maglev system is long stator system and the change-over control system is adopted. On a commercial line, “Substation cross-over control”(Figure 8), “Boundary extension control”(Figure 9) and “Instant crosses control”(Figure 10) are necessary. Moreover, the traffic control system has to execute train tracking in real-time and calculate various timing to control the train.
In order to confirm the train control on a commercial line, the following multiple train running tests have carried out and confirmed that there is no problem about the train control.

Case 1. The train passes the main track and the next train departs from the passing track.
Case 2. The train passes the main track and the next train arrives at the passing track.
Case 3. The train departs from the passing track, the next train passes the main track.
Case 4. The train passes the main track and the next train arrived at the main track.
Case 5. The train departs from the main track and the next train passes the main track.
Case 6. The train arrives at the passing track and the next train passes the main track.

Figure 11 presents the multiple train running test result in case 6. In this case, the train tracking, boundary extension control and substation cross-over control have been carried out. We can confirm that the next train was forced to reduce the speed according the position of the previous train.
5 Conclusion

The running tests on the Yamanashi Maglev Test Line are advancing smoothly. The function and the ability about the train operation control, the vehicle and the ground equipment have been confirmed. The Committee established by the Ministry of transport presents that the Maglev system has no technical problems and is ready for practical use.

In the future, we will carry out the durability verification tests and the research and development for cost reduction for five years.

References