Overview of new vehicles for the Yamanashi Maglev Test Line

Noriyuki Shirakuni, Yasukazu Endo (Central Japan Railway Co., Ltd.)
Kiyoshi Takahashi, Katsuya Yamamoto (Railway Technical Research Institute)

On the Yamanashi Maglev Test Line, five years have passed since the start of vehicle running tests in April 1997. During this period, the MLX01 train attained two world records: a single train traveling at a speed of 552 km/h, and two trains passing each other at a relative speed of 1,003 km/h. The cumulative distance covered by the trains reached 210,000 km, and the number of passengers who rode the trains in test rides exceeded 30,000 persons. Vehicle running tests for reliability and durability have been performed, and two new vehicles have been designed and constructed, with attention to reduction of total cost and improvement of comfort and aerodynamics. This paper provides an overview of these new vehicles that are scheduled to begin running on the Yamanashi Maglev Test Line in the summer of 2002.

Keywords: maglev vehicle, Yamanashi Maglev Test Line, superconducting magnet, magnetic levitation, aerodynamics

1. Introduction

On the Yamanashi Maglev Test Line, five years have passed since the start of vehicle running tests in April 1997. During this period, the MLX01 train attained two world records: a single train traveling at a speed of 552 km/h, and two trains passing each other at a relative speed of 1,003 km/h. The cumulative distance covered by the trains reached 210,000 km, and the number of passengers who rode the trains in test rides exceeded 30,000 persons. Vehicle running tests for reliability and durability have been performed, and two new vehicles have been designed and constructed, with attention to reduction of total cost and improvement of comfort and aerodynamics. This paper provides an overview of these new vehicles that are scheduled to begin running on the Yamanashi Maglev Test Line in the summer of 2002.

Fig. 1 Vehicle running test on the Yamanashi Maglev Test Line

2. Basic specifications of the new vehicles

<2.1> Basic specifications

The following ideas were taken into consideration when deciding on the basic specifications of the new vehicles:

(1) leading car (Mc5): special test car for reducing aerodynamic effects.
(2) intermediate car (M4): improvement of comfort, reduction of cost, image of car for commercial operation.
(3) bogie (T11/T12): improvement of durability and reliability.
(4) superconducting magnet: for use on guideway sections with single-layered propulsion coils, to provide large levitation forces.

The main specifications of the new vehicles are shown in Table 1.

Table 1 Main specifications of the new vehicles

Car	Mc5 (MLX01-901)	M4 (MLX01-22)
Classification	leading car facing Kofu	long intermediate car
Max speed	500 km/h (maximum test speed 550 km/h)	
Train set	3 cars / 4 cars	
Train set type	superconducting magnet type, articulated bogie	
Seat	seat pitch: 880 mm, seat width: 455 mm	
Capacity	(16)	68
Mass of loaded car	32.0 t	23.0 t
Length	28,000 mm (nose: 23,000 mm)	24,300 mm
Width	cabin : 2,900 mm, bogie : 3,150 mm	
Height	wheel–supported running: 3,320 mm, levitated running: 3,280 mm	
Air-tight load	-20 to +13 kPa, -17 to 11 kPa × 10^5	
Facility	crew cabin, auxiliary power source room	facility for test-ride toilet
T11 T12	SCM-rigidly mounted bogie, heavy-load wheel & tire & support gear	
	Super-conducting magnet	responding for single layered propulsion coil, offer a high levitation force
	on-board refrigerator	non-refuel liquid nitrogen and liquid helium system

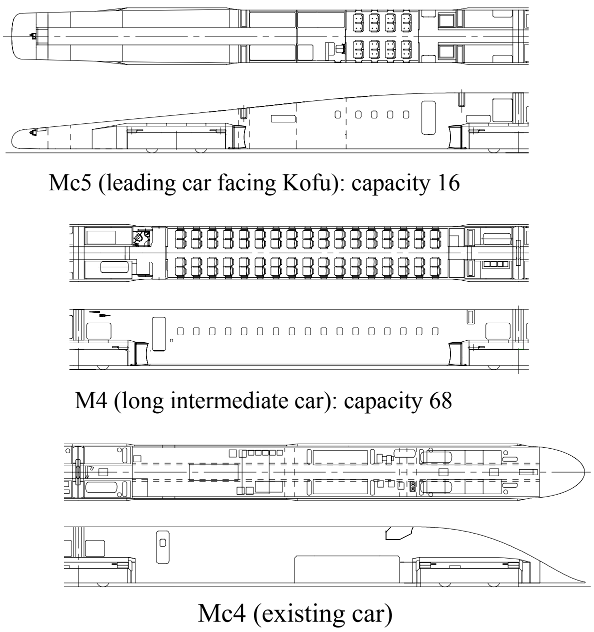


Fig. 2 Overview of new train set (3-car train set)

<2.2> Improved performance of the T11 and T12 bogies

In T11 and T12, we changed the axle loading capacity from 22 tons to 24 tons in consideration of weight margin for the future passenger service accommodations in commercial line. Concretely to put it, we upgraded the strength of tire, wheel and landing gear, depending on revision of the gap between superconducting magnet and ground coil (-10 mm), and improvement of magnetmotive force (700 kA to 750 kA).

We selected the static support system for bogie type (the system of non-relative motion for up-and-down direction between the frame mount superconducting magnet and the frame mount devices) from the reduction of weight, constructing cost and maintenance cost.

<2.3> Alteration of cross section of vehicle

The results of running test shows that the airflow occurred from incoming and outgoing to guide way are the results from the difference of the cross section between car-body and bogie. It is observed that the velocity of airflow increases at the bogie part and that air vibrations occur at intervals of the bogie.

We changed the cross sectional shape of the car-body at bottom section, from sub-round shape to square one (Fig. 4). From this modification, the change of cross section area between the car-body and the bogie becomes half, therefore the above-mentioned phenomena can be suppressed. In addition we have estimated that the aerodynamic drag around intermediate cars will be reduced by approximately 12 % compared with the conventional type.

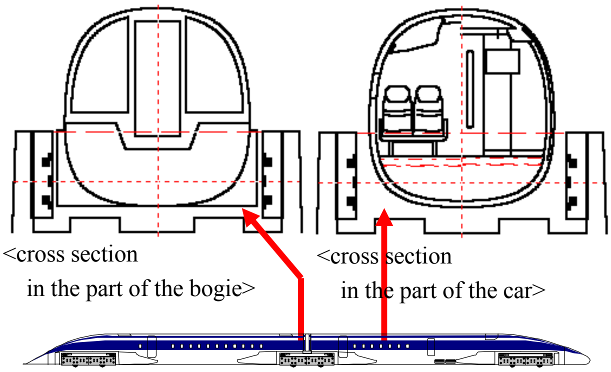


Fig. 3 Comparison of cross sections

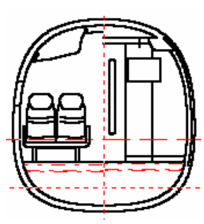
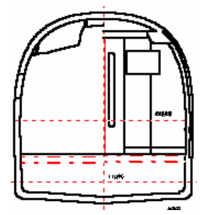
	Conventional sub-round	New model square shape
Shape of cross-section		
Cross-sectional area	7.8 m^2	8.1 m^2
Concept	Priority on structure for air-tight load	Priority on aerodynamic performance: approximation to the cross section of the bogie

Fig. 4 Comparison between subround and square shape

3. Leading car facing Kofu (Mc5)

Mc5 is a test type model of the leading car that we designed aiming at the extreme aerodynamic performance, apart from the image that should be in the commercial service.

<3.1> Reduction of micro-pressure wave

Considering the decrease for micro-pressure wave on commercial line, it is essential to reduce total costs above the optimization for the balance between vehicle and the facility on the ground. In accordance with this concept, we have developed this leading car named Mc5 as a case study in case, we have tried every way possible to extend the nose length from 9.1 m to 23 m within a car.

Based on the result of the running test until now, we have developed the nose shape primarily intended to reduce the micro-pressure wave using full-scale the Vwall-theory denoted references 1, 2 for the first time. With the result , the nose-shape in Mc5 shown Fig. 6 is able to halve Vwall value as compared with the before nose-shape, then it is expected that the micro-pressure wave reduce drastically.

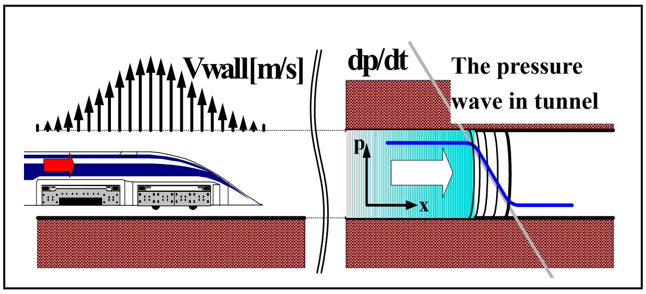


Fig. 5 Conceptual diagram of Vwall theory

<3.2> Reduction of aerodynamic drag

We have obtained the pre-calculated result that aerodynamic drag reduce in excess of related vehicle according to new long nose-shape and the shift of fore-bogie to rearward of vehicle.

We expected that this change contribute the reduction of energy consumption with the consistent with the modification of the base cross-section shape.

<3.3> Reduction of aerodynamic noise

According to the tendency of external noise, the noise level is highest around the front bogie, and it have proved generally that aerodynamic noise raised to the 6^{th} power in proportion to the aerodynamic velocity. Therefore we were thoughtful that it become to be flow velocities lower as much as possible in the area that air flow get directly such as the edge of the bogie.

Due to the improvement of the nose shape of Mc5 as such, it should be considered that the aerodynamic velocity is lower compared with the double-cusp shape in the past. Furthermore we expect the reducing effect for noise by the long slope shown Fig. 6 ahead of the front bogie more than the modification of the nose shape.

Though the front bogie rearranged backward for the improvement of the aerodynamic characteristics, the anterior-posterior weight balance made progress compare with the vehicle in the past.

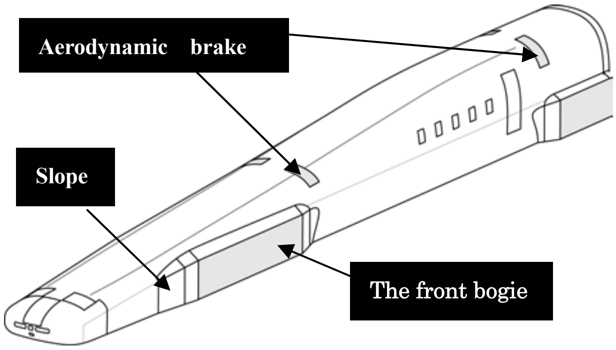


Fig. 6 Overview of Mc5, leading car facing Kofu

4. Long intermediate car (M4)

M4 is designed to realize the image of intermediate cars in the commercial service, main design concept of which is to improve ride comfort, to suppress the noise level in the passenger room, and to reduce the fabrication processes.

<4.1> Improvement of ride comfort

According to the result concerning the vibration in car body, there are comparatively large vibrations involved in high frequencies around the first resonant point of the car-body, which is attributed to the distinctive ground coil allocation in Yamanashi Maglev Test Line. Therefore, M4 is designed to obtain a high vertical and lateral flexural rigidity 1.6 times as much as that of the previous car.

<4.2> Improvement in fabrication processes

It is essential that the production cost of vehicles should be reduced to a reasonable level at the stage of construction of a commercial line. From this point of view, each fabrication process was reviewed to eliminate surplus ones.

In the previous fabrication process, each outer panel on which stringer panel was fastened with rivets, was jointed each other with rivets using spliced plate. These structures were quite time consuming for processing. Consequently we employed the extrusion integral skin which is combined a outer panel with a stringer, and in the combine process of outer panels, we also adopted Friction Stir Welding process, which eliminates the usage of surplus splice plates providing a benefit of weight reduction. The junctions of outer panel are shown in Fig.7. The elimination of splicing at the junction contributes in reducing many fabrication processes.

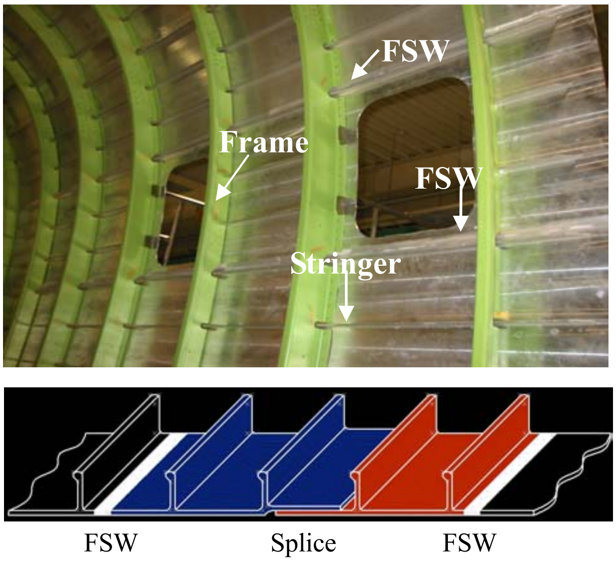


Fig. 7 Construction of outer panel by section plate and Friction Stir Welding (FSW)

<4.3> Reduction of internal noise

From measuring the internal noise level in a passenger room, it is observed that external noise is transmitted through the side-windows in the cabin. According to the investigation of this cause, it has been realized that the transmission loss around 300 Hz is lowered than expected, due to the thin airspace clearance between double glasses at the side window. As a countermeasure to enlarge the transmission loss at around 300 Hz, we adopted a new type of side window in which the internal air-gap between double glasses is expanded (shown in Fig8), otherwise, it is difficult to lower the noise level around 300 Hz by adding sound insulating material.

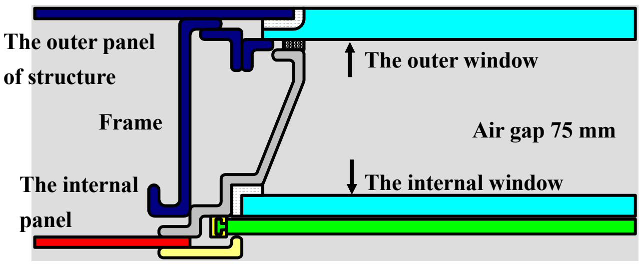


Fig. 8 Construction of cross section for duplication of side window (secured the air gap)

5. Improvement concerning simplification and reliability

<5.1> Pop-up type aerodynamic brake

We have developed the new aerodynamic brake in which the panels are moved simply up and down, which we call pop-up type, by air pressure source. In the conventional brake, the unfolding mechanism is applied and the hydraulic source is adopted because the brake panels must be unfolded overcoming against air pressure at 500 km/h. By changing the moving mechanism, the air pressure source was substituted for the hydraulic source. By virtue of these changes, the troublesome maintenance of the hydraulic source is eliminated and moreover, the production cost was handsomely reduced.

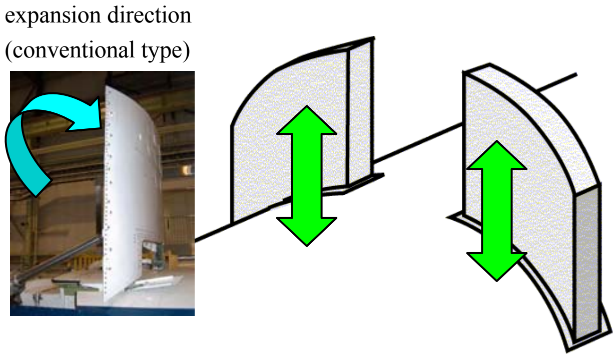


Fig. 9 Conceptual diagram of the pop-up type aerodynamic brake

<5.2> Stretchable fabric fairing

Fig.10 shows the new stretchable fabric fairing attached on the existing vehicle. As the previous type of fairing was composed of several components and had some concern in reliability, we adopted the new stretchable fabric fairing. The structure of the new fairing becomes quite simple so that reliability has been improved.

Fig. 10 Stretchable fabric fairing

6. Conclusions

The main specifications newly employed to the coming new vehicles were discussed.

Using the new train set including these new vehicles, test runs are scheduled to begin in the summer 2002 at the Yamanashi Maglev Test Line. With these new vehicles, we are going to verify the higher degree of performance in aerodynamic characteristics concerning maglev vehicles.


Fig. 11 Image of Mc5 car (MLX01-901)

Acknowledgment

This work is financially supported in part by the Japanese Ministry of Land, Infrastructure and Transport.

Reference

[1] T.Ogawa,K.Hujii "Prediction of Wavefront of Compression Wave Generated by a Train Moving into a Tunnel with Steady Flow", Transactions of the Japan Society of Mechanical Engineers,1995,Vol61 No.586 pp170-176

[2] T.Ogawa, K.Hujii "Theoretical Algorithm to Design a Train Shape for Alleviating the Booming Noise at a Tunnel Exit", Transaction of the Japan Society of Mechanical Engineerings,,1996,Vol.62 No.599 pp139-146

[3]K.Takao,M.Yoshimura,N.Tagawa,Y.Matsudaira, A.Inoue, "Development of the Superconducting Maglev Vehicle on Yamanashi Test Line", MAGLEV'95,1995,pp233-238

[4]T.Kitamori,A.Inoue,M.Yoshimura,Y.Matsudaira,S.H osaka,"Outline of the second train set for the Yamanashi Maglev Test Line",MAGLEV'98,1998,pp214-219