Advanced Train Technology and Train Design Creating New Value

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OVERVIEW: As a railway vehicle systems manufacturer, Hitachi creates new value by developing and manufacturing high-speed trains that feature the latest technology. Hitachi also supplies train designs and other products for commuter trains. Hitachi has also developed various new technologies to improve the running performance, environmental performance, and comfort of the E5 Series Shinkansen for the East Japan Railway Company's Tohoku Shinkansen service. In the field of commuter train design, Hitachi is contributing to improvements in railway technology from many different perspectives including proposing people-friendly designs for the next generation of commuter trains that take account of universal design considerations and are based on the "next-generation A-train aluminum railroad transportation system" concept.

INTRODUCTION

RAILROAD transportation gets attention as a very energy-efficient form of public transport. Currently, development of technology is underway to meet the varied needs of the increasingly diverse range of forms that railroad transportation is taking and there is a need to take action toward creating new value in order to achieve further progress in railroad transportation technology.

Recognizing these requirements, Hitachi is acting to deal with the issues that need to be overcome including not only, in the case of the Shinkansen (bullet train), working toward shortening travel times by increasing speed, but also things like improving comfort and ensuring reliability when operating at high speed and considering the impact on the surrounding environment.

In the case of commuter trains, Hitachi is further enhancing its A-train* technology and is proposing designs that take account of both the form and function of the interior, exterior and other parts of the train as well as human-friendly designs. We develop comfortable and relaxing interior spaces based on

* The "A" in "A-train" stands for the key attributes: advanced, amenity, ability, and aluminum.

(a)

(b)

Fig. 1—E5 Series Shinkansen Belonging to East Japan Railway Company and 30000 Series Train Belonging to Seibu Railway Co., Ltd.
The E5 Series Shinkansen (prototype model) (a) of the East Japan Railway Company features latest train technology and the 30000 Series train (b) of Seibu Railway Co., Ltd. incorporates a new design concept.

human engineering principles and manage to achieve user-friendly designs for passengers by adopting universal design.

This article describes the work being undertaken on technological solutions for use in Hitachi-supplied trains including new technology for Shinkansen trains and designs for the A-train.

TECHNOLOGY FOR HIGH-SPEED SHINKANSEN TRAINS

Increasing Speed of Commercial Trains of Shinkansen

Increasing the Shinkansen's operational speed is essential to improving the efficiency of inter-city transport in Japan. The issues associated with increasing the Shinkansen's speed include improving the environmental performance of the vehicle, for example reducing the external noise, maintaining train stability at high speed, and improving comfort during long-distance trips.

The East Japan Railway Company is planning to introduce the new E5 Series Shinkansen at the end of March 2011 following the opening of Shin-Aomori Station for the Tohoku Shinkansen in December 2010. The E5 Series will be the first train in Japan to have a maximum speed in normal operation of 320 km/h. The prototype model of the E5 Series (see Fig. 1), completed in June 2009, is currently being used for test runs to verify its operational performance and in the future it will be used for commercial services on the Tohoku Shinkansen line.

Improvements in Operating Performance to Achieve Faster Speeds

To improve the operating performance of the E5 Series, the main devices and the housing for the main circuit system unit are being upgraded to make them smaller, lighter, and quieter than existing units and suitable for high-speed operation.

Consideration for Environmental Performance of High-speed Trains

In increasing the speed of the Shinkansen, a strong emphasis is being placed on environmental performance. The main items are as follows.

(1) Train shape designed to be smoother and to fully cover side of bogies

Measures adopted to increase train speed included using covers around the full circumference to eliminate any discontinuities in the gaps between cars with the aim of reducing noise, making the rolling stock shape smoother, and minimizing the noise from the bogies by making them fully enclosed.

Fig. 2—Side Cover with Sound Absorbing Material on E5 Series Shinkansen (Prototype Model).
Fitting sound absorbing material to the lower part of the side structure reduces external noise.

Fig. 3—Pantograph and Noise Reduction Plate on E5 Series Shinkansen (Prototype Model).
The pantograph fitted on the roof-top of the high-speed Shinkansen train and its surrounding pantograph noise reduction plate were developed to reduce wind noise.

(2) Acoustic absorption covers fitted on lower part of side structure

As the noise produced by the lower part of the Shinkansen side structure becomes a source of external noise when it reverberates against noise reduction walls, sound absorbing material was attached to the side covers used on the lower part of side structure to reduce this noise (see Fig. 2).

(3) Noise reduction measures for rooftop equipment

Developments undertaken to reduce the noise from the rooftop equipment included a low-noise pantograph designed to reduce wind noise and a pantograph noise reduction plate (see Fig. 3).

(4) Optimization of front-end shape

The front-end shape was optimized to minimize the impulsive pressure waves that occur when the train passes through a tunnel by adopting a long-nose design with a total length of 15 m.

(5) Improved train stability

The suspension system, dampers, and other bogie components were optimized to ensure adequate stability at high speed.

(6) Reduced rolling stock weight

The rolling stock weight was reduced to reduce the level of vibration transmitted from the bogies when traveling at high speed.

Improvements in Comfort of High-speed Trains

In developing the E5 Series, Hitachi has improved the comfort of the passenger cabin to ensure that passengers can travel in comfort even over long-distance journeys. Not only are materials with better sound absorbance characteristics used between the chassis and interior fittings to make the cabin quieter, full active vibration damping control, vehicle tilting, and other systems are also used to achieve improvements in comfort including less swaying at high speed and better ride on curves.

For the No. 10 car in particular, a “super green car” (provisional name) is to be introduced on the trainsets used for commercial operation based on the concept of “providing world-leading speed together with a peaceful and soothing experience.”

COMMUTER TRAIN TECHNOLOGY

Train Design and Function

The “next-generation A-train aluminum rolling stock system” is intended to achieve a fundamental improvement in the rolling stock materials, structure, and production processes with the aims of minimizing the impact on the environment, reducing life cycle cost, and reducing the number of skilled workers in the future. The number of model families that use the A-train concept is growing steadily with the system being applied to various different types of rolling stock from commuter through to express trains. The A-train rolling stock system meets the requirements of railway operators by providing a high degree of flexibility in train design along with the ability to produce variations that are distinguished by their design despite having a common structure, this being a feature of the system.

Because of the importance placed on comfort in recent commuter trains, internal fittings based on human engineering that are comfortable and easy to use have been selected for use on the A-train.

The next section describes what Hitachi is doing in the fields of rolling stock design and these fittings based on human engineering.

A-train Design

As public facilities in which anyone can ride, rolling stock need a design that will remain well-loved over the long term. To achieve this, a new design that can symbolize the railway operator is produced by considering a wide range of factors including the brand image of the railway operator and the message they seek to convey as well as surveys of the areas alongside railway tracks, users, and current trains.

We attempt to make use of A-train characteristics in detailed design. As the front end of the car based on A-train technology has a metal structure, it provides better flexibility allowing anything from rectilinear through to complex curved shapes to be adopted without compromising strength, and when it comes to exterior design, these diverse forms allow the front-end design to represent the character of each railway operator.

More detailed and easy-to-understand design proposals can be considered by using techniques such as CG (computer graphics), models for prototyping shapes, and CG simulations of the area near the railway line or station building. This design work is undertaken in consultation with the railway operator (see Fig. 4).

For the interior design, the availability of various different modules, such as the types of luggage racks and seating, and a flat and domed ceiling structure, is one of the characteristics of the A-train, and it is possible to select options that are appropriate to the type of operation intended by the railway operator based on the total design concept for the trains.

In terms of the use of color, Hitachi offers rolling stock that take account of universal design and that use color both for areas that appeal to the feelings, such

Fig. 4—A-train Design.
A-train exterior design model and actual train exterior derived from surveys of the areas alongside the railway line and the current situation, and the image, message, and other aspects of the railway operator.

Fig. 5—Universal Design.
The visibility of floor colors being assessed by experts and priority seating for the elderly or disabled that takes account of barrier-free considerations.

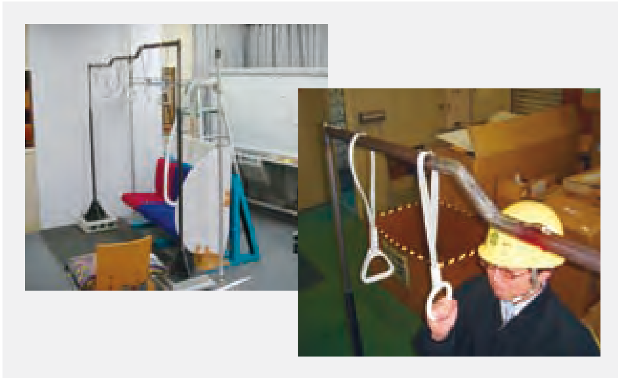

Fig. 6—Testing of Handstraps.
A mock-up was used to test the height and length of handstraps which were developed from the perspective of universal design to be positioned at a convenient height.

as the freshness of the rolling stock or conveying a feeling of openness to passengers, and in a functional way such as on the floor of areas where passengers get on and off the train or for barrier-free purposes such as using different colors on priority seating for the elderly, disabled, and so on (see Fig. 5).

Testing of Handstraps

The handstraps were investigated from the perspective of universal design to ensure they had a suitable shape and height for passengers.

A mock-up was used to test the shape, attachment height, orientation, and length of the handstraps. Based on the fact that most passengers stand in line with the direction of train movement and that the most frequent swaying direction is the direction parallel to the train movement, the handstraps were oriented so as to be easy to grasp when standing this way so as to reduce the load on the passengers' bodies. The length of the handstraps was determined to minimize the weight placed on the passenger's hand and shoulder and also foot and waist by the swaying that occurs when the train is moving, and the optimum height was also chosen (see Fig. 6).

Development of Seating

Because having a deep and low seat is inappropriate on commuter trains where passengers standing up or sitting down occurs comparatively frequently, the A-train's standard seat height and depth dimensions are used as before.

The height of the backrest was adjusted to ensure that the seating provides adequate back support and the angle was adjusted to make it easy to sit with correct posture. To ensure that the backrest is high enough to provide appropriate back support, the backrest was made higher than in the A-train's standard dimensions. A wrap-around curved shape was selected for the overall seat back design based on the view that providing backrests with a shape that gives lumbar support will help maintain good posture.

A loose bucket shape was used for the cushions to improve the fit around the buttocks. A mock-up was created based on design theory, measurements were

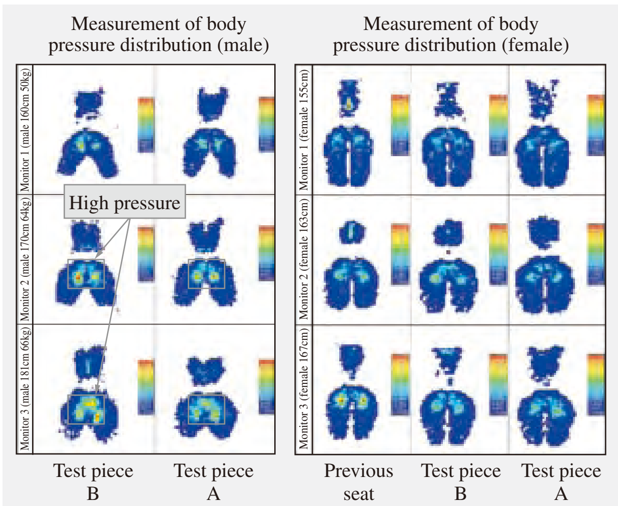

Fig. 7—Measurement of Seated Body Pressure Distribution.
Measurements were made of body pressure distribution and seats developed that feel stable but not uncomfortable.

made of the pressure distribution around the body of the seated passenger to determine which parts of the body were subject to pressure and to what extent, and the results indicated high pressure on the buttocks. This occurred because the buttocks come into contact with the cushion over a wide area, and test item A was selected for use in production trains because of the improvement in stability and softness achieved by layering the cushion filling to alter its hardness (see Fig. 7).

CONCLUSIONS

This article has described the work being undertaken on technological solutions for use in Hitachi-supplied trains including new technology for Shinkansen trains and designs on the A-train.

Rolling stock, whether they are for Japanese or international markets, are recognized as a form of public transport that can shorten travel time and achieve a high level of energy savings and this is a field in which further progress is expected. In the future, Hitachi intends to continue making progress on developing technology for new rolling stock and on designs that emphasize function and form to meet diverse needs.

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