New Technologies for Railway Trains

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Overview: Each of the JR companies has been developing a new type of car that meets its own particular needs. The basic concept for these companies, however, is the same: pursuit of cost performance. Regarding the speed of Shinkansen trains, the target has been achieved by the "Nozomi" Shinkansen 500 series, which can attain a maximum service operating speed of 300 km/h. Now, each company is striving to improve the quality of service, environment, and reliability of the cars based on data compiled through past service operation. The companies are also working hard to construct dignified, high-quality car bodies and interiors for the limited express trains of local lines. This article describes recent technologies that are used in the Shinkansen 700 series developed jointly by East Japan Railway Company (JR East) and West Japan Railway Company (JR West), and the Shinkansen E4 series and the limited express E653 series (local line) developed by JR-E.

INTRODUCTION

THE Shinkansen 700 series [Fig. 1(a)] was put in revenue service in the spring of 1999, replacing the Tokaido and Sanyo Shinkansen 300 series. Data compiled through the service operation of the Shinkansen 300 series has led to the following improvements to the Shinkansen 700 series; adoption of IGBT (insulated gate bipolar transistor) for main circuit, less noise inside the car due to the adoption of a low-noise and low-vibration superstructure, smaller microscopic pressure wave due to improved shape of the nose of the train, and better comfort due to better

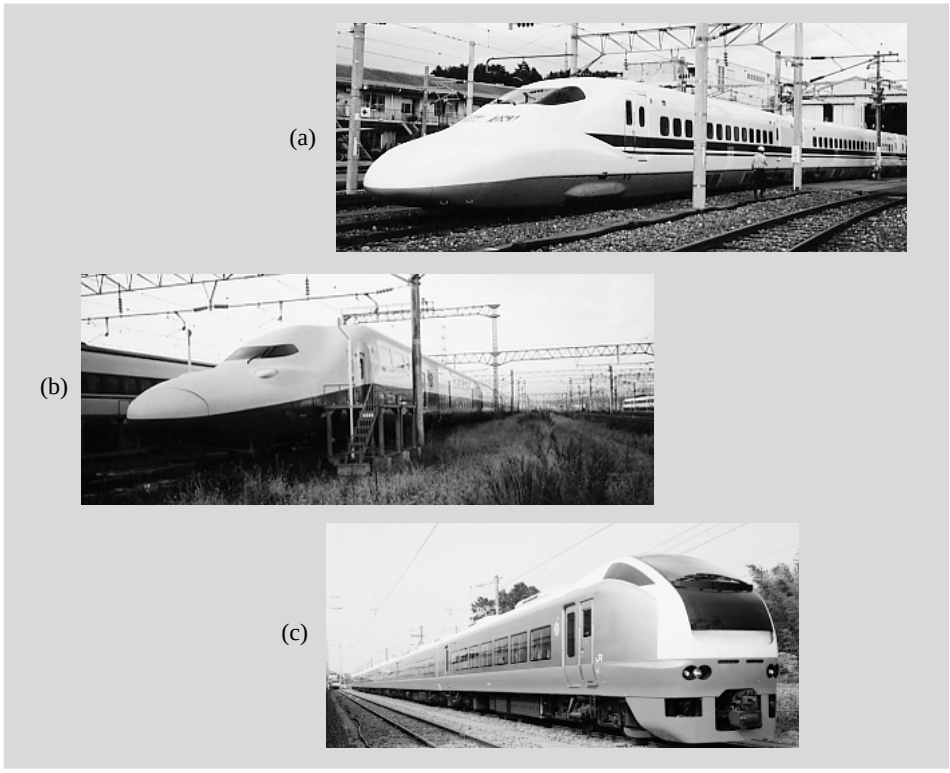

Fig. 1— Recent Shinkansen and Limited Express Trains.
(a) A proto-type of the Shinkansen 700 series is now undergoing test runs in preparation for mass production.
(b) The Shinkansen E4 series was put in revenue service in December 1997.
(c) The limited express E653 series was put in revenue service in October 1997.

air conditioning in strong heat.

The Shinkansen E4 series [Fig. 1(b)] succeeds the Shinkansen E1 series. The E4 series is entirely made up of double-deckers, and is known as "Max." This train has been improved as follows. The E4 series has been made lighter by changing the car body material from mild steel to aluminum alloy, and the microscopic pressure wave and the outside noise of the car have been decreased by lengthening the shape of the nose of the train. This train has separation and coupling equipment to enable it to couple with cars of the Tohoku Shinkansen. The passenger capacity of 16 E4 series cars coupled together is 1,634 persons, the highest for high speed trains in the world. Furthermore, lifting equipment for vending carts and wheelchairs has been installed in all cars for the first time.

The limited express E653 series [Fig. 1(c)] was developed to replace the superannuated limited express 485 series of the Joban line, known as the "HITACHI," and will become the standard limited express for JR-E. The exterior design of each train has a characteristic design and color that symbolizes nature and sightseeing attractions. The superstructure of the car body is composed entirely of a "double-skin" (aluminum hollow extrusion), and interior parts are fitted using a groove, which is like a curtain rail, that runs along the extrusion.

DOUBLE-SKIN CAR BODY AND MODULE TYPE INTERIOR FITTING

Car Body Structure

The double-skin structure has been adopted for the 700 series and E653 series to improve the manufacturing precision and lower the noise level. This double-skin is designed to provide the most suitable thickness for the side plate and truss, pitch of truss considering weight, strength and material availability. Use of the double-skin reduces the number of parts and welding length. Compared with the former of "single-skin" structure, it limits the amount of distortion due to welding. The single-skin structure has an outside panel and frame, as well as a large extrusion with ribs. The single-skin has been partially adopted for the 700 series, but its strength is greater than that of the 300 series because parts have been arranged differently. Fig. 2 shows the car body structure of the 700 series.

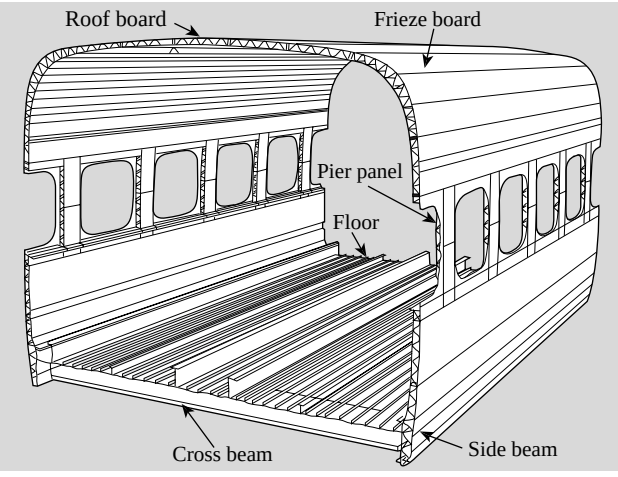

Fig. 2— Car Body Structure of the 700 Series.
Double-skin has been adopted for the roof and side structure of the 700 series.

Low Noise and Low Vibration Technology

The double-skin itself has a large specific area weight and low acoustic permeability. In case of the 700 series, a vibration isolator is also used due to lower acoustic permeability. The transmission of noise and vibration through the roof and sides is reduced because the space inside the double-skin truss has been filled with foamed vibration isolator. Considering the proper weight of the car according to test results shown in Fig. 3, only every other truss (50%) has been filled with the isolator. For the floors, sound arresters have been installed in the airtight floors over the bogies. Furthermore, elastic supports of the upper floor reduce the vibration and noise transmission from bogies.

Module Type Interior Fitting

All sections of the car body of E653 series are composed of double-skin. The double-skin has grooves like curtain rails in which screw pads for installing equipment and interior fittings can be installed. Labor is reduced by fitting interior parts which outworked as small units to these screw pads. This reduction of labor becomes possible by the small distortion of double-skin car body and the dimension accuracy of curtain rails. An advantage of this system is that when any installed fittings become obsolete, they can be easily replaced, in addition to sharp cut of interior fitting time at new manufacturing. Air ducts, luggage racks, passenger seats and so forth are installed using this system. The car body structure of the E653 series is shown in Fig. 4.

REDUCTION OF CAR OUTSIDE NOISE

One of the most important factors to reduce noise outside the Shinkansen is the system for transferring current to the train. This system consists of a

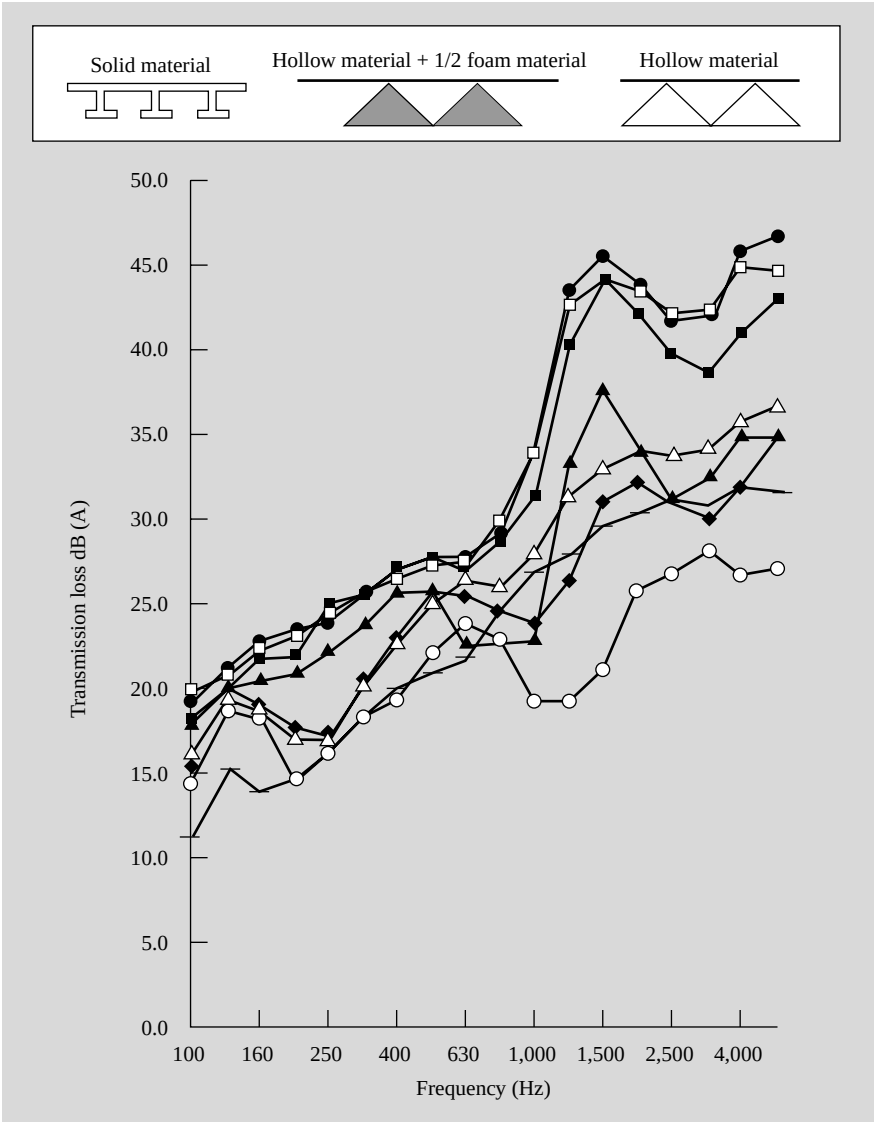

Fig. 3— Element Test Results of Acoustic Permeability.
The difference in acoustic permeability, which depends on the combination of members and vibration isolators, was confirmed by the test.

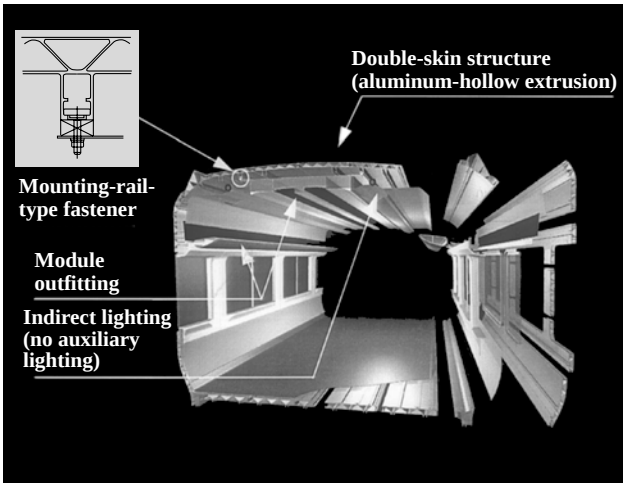

Fig. 4— Construction of the Superstructure of the E653 Series. The method of attaching all double-skin section car body and interior parts by using the groove along the extrusion is shown in Fig. 3.

pantograph and an insulator. The 700 series uses a single arm pantograph, which is effective for reducing noise. The shape and position of the insulator cover for the 700 series have been improved according to data collected from the operation of the Shinkansen 500 series. Concretely, one pantograph was installed in the Shinkansen 700 series, instead of ones extended over two cars in the Shinkansen 300 series. The cover creates a smooth air flow on sides and above the train. Tests were conducted using a wind tunnel to reduce the noise produced by the cover. The outside appearance is shown in Fig. 5.

NEW AIR-CONDITIONING SYSTEM

The cooling capacity of the air-conditioning system in the Shinkansen 700 series has also been improved.

*1: DAMP-SHAPE is a registered trademark of Kobe Steel Ltd.

Fig. 5— Insulator Cover.
The insulator cover has a wineglass shape. One pantograph is installed for every two cars, and both these points help to reduce noise outside the car.

The air conditioner uses a two-step heat exchanger further effectively to the Shinkansen 300 series to keep the inside temperature of the car comfortable even if the outside temperature is as high as 40˚C. When it is hot outside, the temperature of the intake air from outside for ventilation is also high, but the heat exchange works more efficiently. This air is cooled in the first step by using the heat exchanger. Furthermore, the heat of air mixed with circulated air from inside the car is removed in the second-step heat exchanger. In addition, the system is small and saves energy. The two-step cooling system is shown in Fig. 6.

MULTIFUNCTION

Lifting Equipment for Wheelchairs and Vending Carts

In the Shinkansen E4 series, the lifting equipment for wheelchairs and vending carts is installed in car No. 8 Tokyo side. Further, a lifting equipment for vending carts is installed in each deck of each car (for car No. 1, the equipmet is installed only on Morioka side deck, and there is none on car No. 8). There are safety bars installed inside both lifting equipments to prevent wheelchairs from falling and vending carts from slipping. The lifting equipment for wheelchairs is shown in Fig. 7.

Separation and Coupling Equipment

It is possible to couple the E4 series with some of

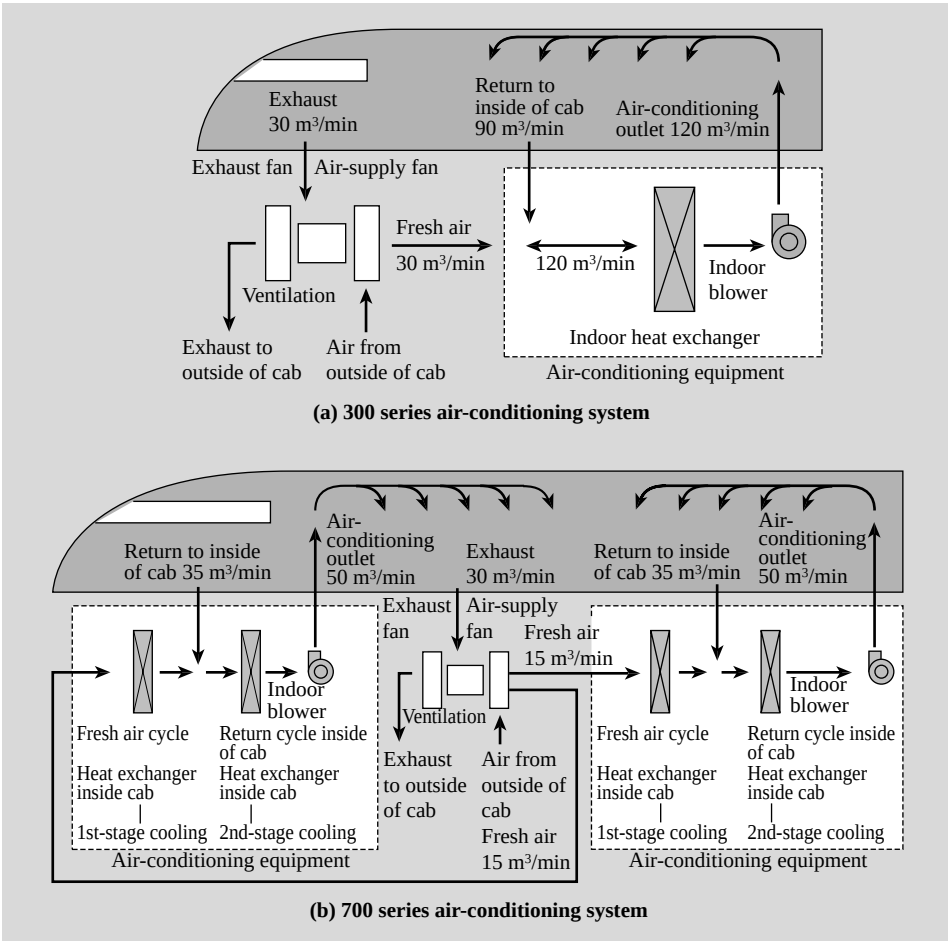

Fig. 6— Air-conditioning Systems of the 300 Series and the 700 Series.
The high efficiency refrigeration cycle which cools the open air of fierce heat by exclusive heat exchanger is adopted.

Fig. 7— Lifting Equipment for Wheelchair.
The picture shows the lifting equipment for raising people using wheelchairs to the second floor. It can also be used for vending carts.

the E2, E3, and 400 series trains to adjust transportation capacity, and rescuing and rescued with Shinkansen 200, E1, and E2 series trains is also possible. Separation and coupling equipment has been installed for these purposes. The separation and coupling equipment of the E4 series is shown in Fig. 8. Smooth coupling is possible because the distance between trains is measured automatically with a distance detector that uses infrared rays. The driver can adjust the train speed according to the distance by monitor picture.

CONCLUSIONS

Described herein is an outline of technology with regard to high quality materials, improvements in recycling, improvements in amenity, and multi-functionality, etc. which were applied to recent Shinkansen "bullet" trains and limited express local trains manufactured by Hitachi, Ltd. As advancements are made in the rolling stock, we expect to move forward in exploring high performance and low life-cycle cost possibilities, and we are intent on resolving these points as it secures reliability.

We at Hitachi, Ltd. continue our intensive research to respond to needs that arise and to bring ideas to realization.

Fig. 8— Separation and Coupling Equipment.
The separation and coupling equipment which couples the E4 series and the E2 series to adjust transportation capacity is installed.

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