Advanced Train Technology and New Development for Global Markets

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OVERVIEW: As a manufacturer of rolling stock, Hitachi has developed and produced rolling stock for high-speed and commuter trains in Japan, and has made numerous advances in railway technology to satisfy a wide range of needs. The total number of Hitachi's A-train rolling stock supplied in Japan has already passed 2,000, and development is ongoing in response to new requirements, including energy efficiency measures such as the use of LED lighting. For the UK market, to which Hitachi gained access through the development of the Class 395 trains for that country's High Speed 1 line that commenced commercial services in December 2009, Hitachi has built the AT-100, AT-200, and AT-300 platforms that feature greater compliance with standards, has developed a lightweight carbody for local manufacturing and lightweight inner frame bogies, both of which are key components, and has made progress on optimizing rolling stock information and control systems as well as the traction system.

INTRODUCTION

AS railways have gained increasing attention in recent years for their role as a form of public transportation with excellent energy efficiency, in addition to things like shorter travel times and improved comfort, requirements have also emerged for further reducing the load that rolling stock place on the environment.

In response, Hitachi has sought to reduce the load on the environment and to cut life cycle costs while also enhancing design and functionality by comprehensively revising the materials, structures, and production techniques it uses based on the next-generation A-train aluminum rolling stock system concept. Features of the A-train include cars built primarily from lightweight and easily worked aluminum alloy and an interior constructed from independent modules. The family of models has been steadily growing since 1999, with the concept being applied to rolling stock ranging from commuter to intercity trains.

Meanwhile, the high-speed Class 395 trains for the UK's High Speed 1 line commenced commercial services in 2009. Based on the A-train concept, this rolling stock took the technologies for light weight and high speed that Hitachi had developed in Japan and applied them to a railway system in the UK. Hitachi is also working on the development of the Global A-train with the aim of expanding its A-train business globally.

This article reports the latest information about the A-train in Japan and describes the development concept and results for the Global A-train.

LATEST A-TRAIN TECHNOLOGY

The total number of A-trains delivered in Japan reached 2,000 in November 2011. Hitachi has been responding to customer requirements in a variety of ways, including providing cars with see-through glass end sections and enlarging the interior space and designed front-end mask. The following section describes the new measures Hitachi is adopting to increase future sales.

In response to the need for energy savings that has arisen in recent years, Hitachi has developed and commercialized light-emitting diode (LED) interior lighting for rolling stock. When used for indirect

Fig. 1—Series 817 Rolling Stock Supplied to Kyushu Railway Company and its Interior LED Lighting.
The interior uses light-emitting diode (LED) lighting in place of the fluorescent lighting used in the past.

lighting, the LED lights provided energy savings of approximately 20% compared to previous rolling stock. The three different types of lighting are indirect, direct, and a mixture of the two. Systems have been supplied for approximately 100 cars to date, including the Series 9000 rolling stock supplied to Hankyu Corporation, the Series 817 rolling stock supplied to Kyushu Railway Company, and the Series 8000 rolling stock supplied to Keio Corporation. Hitachi is also planning to extend use of LEDs to other applications such as headlights for leading cars and, to satisfy customer needs, is currently developing systems that include a backup function in case of light failure as well as overcoming the long-standing problem of needing to make frequent light replacements (see Fig. 1).

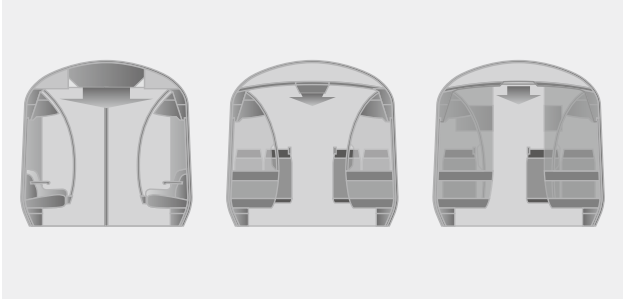

Fig. 2—Platform Combining Flexibility and Standardization. The AT-100, AT-200, and AT-300 (left to right) share the same base structure.

GLOBAL A-TRAIN DEVELOPMENT CONCEPT

To facilitate the global deployment of the A-train, Hitachi has included the following points in the development concept for the Global A-train.

(1) Business considerations
  (a) Local manufacturing
  (b) Lower cost
  (c) Local procurement
  (d) Standardization strategy

(2) Technical considerations
  (a) Acquisition of local certification
  (b) Technologies for lighter weight and energy efficiency that reduce life cycle costs
  (c) System integration to achieve high levels of reliability
  (d) Easier maintenance

One aspect that differs from the approach taken in past rolling stock developments is the inclusion of business considerations in the development concept. With a view to producing the Global A-train outside Japan, this has included designing the rolling stock for easy assembly by workers who may not be highly experienced, and also taking steps to revise and standardize the supply chain.

Technical considerations include taking the development concept of the original A-train as a base and making further technical enhancements, including the obtaining of certifications. Engineers from Hitachi Rail Europe Ltd. have participated from the earliest stages to ensure that development work takes account of the needs of European customers.

GLOBAL A-TRAIN STRATEGY FOR UK AND EUROPE

Global A-train development aims to achieve both maximum compliance with standards and flexibility of car configuration so that customers can enjoy the diverse advantages of selecting Hitachi rolling stock. Hitachi has built the AT-100, AT-200, and AT-300 platforms (where “AT” stands for A-train)

Fig. 3—AT-100 Trains.
These trains feature a crashworthy structure that complies with the European Conventional Rail Technical Specifications for Interoperability (CR-TSI) standards.

for the UK market based on standards-compliant key components[1] (see Fig. 2).

(1) AT-100

Intended for commuter services, the AT-100 has a maximum operating speed of 160 km/h. Although intended primarily for use with longitudinal seating, other configurations are also possible, and a mixture of longitudinal and transverse seating can be used. To maximize the efficiency of passenger entry and exit, each AT-100 carbody can be fitted with up to three doors per side (see Fig. 3 and Fig. 4).

(2) AT-200

The AT-200 is intended for longer suburban services and like the AT-100, has a maximum operating speed of 160 km/h. Features include transverse seating, luggage space, and tables. With two doors per side, the AT-200 only needs a dwell time of 60 to 90 seconds at major stations during commuter rush hours (see Fig. 5).

(3) AT-300

The high-speed AT-300 rolling stock have a maximum operating speed of 225 km/h, with an option to increase this to 250 km/h. A wide range of different interior layouts and door configurations are possible to meet the needs of intercity passengers. The highly regarded Class 395 rolling stock for the High Speed 1 line in the UK are based on the AT-300 (see Fig. 6 and Fig. 7).

Fig. 4—AT-100 Interior.
Intended for commuter services, the interior combines both longitudinal and transverse seating.

Fig. 5—AT-200 Interior.
Intended for longer suburban services, the interior uses transverse seating.

KEY COMPONENTS OF GLOBAL A-TRAIN

Hitachi has been developing the key components of the Global A-train so that they can comply with standards. The sections below describe details of this development work.

Lightweight, Locally Manufactured Structure

Using the aluminum structure already proven on A-trains in Japan as a base, Hitachi undertook the following developments (see Fig. 8).

(1) Compliance with European standards

The development of the Global A-train includes compliance with the European Conventional Rail

Fig. 6—AT-300 Trains.
The AT-300 has the same front-end shape as the Class 395.

Fig. 7—AT-300 Interior.
The layout is designed for intercity services.

Fig. 8—Carbody.
The carbody has a lightweight aluminum structure that complies with CR-TSI.

Fig. 9—Lightweight Inner Frame Bogie.
A lightweight and compact design was achieved in which all components of the bogie are inside the plane of the wheels.

Technical Specifications for Interoperability (CR-TSI). Although this covers a wide range of areas, carbodies must comply with the structural standards related to static strength and the crashworthiness of the structure.

(2) Local manufacturing

The Class 395 uses aluminum extrusions made in Japan for its structural components. With a view to manufacturing these locally in the future, the potential use of aluminum supplied from European producers in particular was allowed for from the very beginning of the new development.

(3) Lighter weight and lower cost

Optimization of the design reduced the number of components in the structure by 30% and its weight by 18% (relative to the Class 395).

Lightweight Inner Frame Bogie

The best way of dealing with the top priority issue of reducing the load on the railway track is to reduce the weight of the bogie and suspension. Accordingly, Hitachi has developed a lightweight inner frame bogie for the Global A-train, in which the bogie frame is entirely contained within the plane of the wheels (see Fig. 9).

(1) Drive system

To achieve both a top speed of 160 km/h and the fast acceleration and deceleration needed by commuter trains, the drive system has a 240-kW traction motor and a gear ratio of 5.13. The drive system is designed for small size, with smaller diameter 830-mm wheels and two-stage gearing as well as a flatter traction motor, allowing it to fit in the restricted space available on the bogie frame, which does not extend outside the plane of the wheels.

(2) Mechanical brake

Use of wheel tread brakes on the motor cars was made possible by optimizing the motor car:trailer car ratio for the trainset configuration. The trailer cars use wheel tread brakes and two disk brakes per axle.

(3) Bogie frame

In addition to structural optimization and lighter weight, the bogie frame design with side beams made of welded steel plate and cross beams made of pipe has the strength to comply with British Standards and other European standards.

(4) Bogie weight

Excluding the traction motor, each bogie weighs 5.2 t. This is approximately 2.5 t lighter than normal outer frame bogies that comply with European standards.

Traction System

As part of development, Hitachi undertook to optimize the entire system, including the bogie, drive, traction converter, and traction motor, to ensure the best possible traction circuit and system for the trainset configuration. In addition to using a two-stage, side-by-side cardan reduction gear and developing a new traction motor with a smaller external dimensions to fit in the lightweight inner frame bogies described above, the traction converter also uses a newly developed inverter that features small size and high efficiency.

Rolling Stock Information and Control System

Hitachi has developed a flexible, high-quality, next-generation autonomous train integration (ATI) system for rolling stock information and control that incorporates general-purpose technologies, including using Ethernet as the main network technology. For the Global A-train, Hitachi intends to equip this next-generation ATI system with functions, such as maintenance, that are specific to overseas markets.

CONCLUSIONS

This article has reported on the latest information about the A-train in Japan and described the development concept and results for the Global A-train. By incorporating the latest technologies, Hitachi intends to make further enhancements to the A-train to deliver rolling stock that match the needs of the time.

In addition to developing the product for the UK market described in this article, Hitachi is also undertaking more work aimed at creating platforms for the Global A-train that take account of potential projects in continental Europe and emerging nations.

REFERENCES

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