

## Technologies for Railway Transportation Systems

## Management and Control of Operations and Energy in Railway Systems

MIYATAKE Masafumi

## Toshiba Railway Solutions Supporting Reduction of Global Environmental Impact

ISHII Hideaki

Energy saving and the reduction of power consumption have become increasingly important issues in Japan, as countermeasures against both global warming and the shortages of electricity since the Great East Japan Earthquake. To achieve a low-carbon society through the use of renewable energy and efficient management of energy, the concept of smart communities has progressed in recent years. With these trends as a background, railway transportation systems, as an environmentally friendly means of transportation, are contributing to lower electricity usage with the latest developments in power electronics technologies and information and communication technology systems. Toshiba is committed to delivering railway solutions that can optimize an overall urban transportation system by positioning the railway system as a key element in a smart community aimed at reducing the environmental burden.

## Railway EMS Realizing Effective Energy Management of Entire Transportation System

MIYOSHI Miyako / SUMIYA Akihiko / KIKKAWA Kenichi

Although railways are considered to be an energy-efficient form of transportation, further reductions in energy consumption and measures for the lowering and shifting of peak energy usage have become necessary for protection of the global environment and harmonization of electricity supplies. Management and control of energy consumption are therefore required, to grasp the actual situation of energy consumption and respond to power-saving requirements and electricity usage regulation. Toshiba is promoting the development of technologies for a railway energy management system (EMS), including train station energy solutions, battery-powered light rail transit (LRT) solutions, freight transportation solutions, and simulation technologies, in order to maintain the service level of a railway system while achieving a balance between its transportation and energy requirements by circulating energy through the application of regenerative inverters and battery systems.

## Cloud-Based Transportation Planning System

SUZUKI Tatsunori / KUBO Hideki

Toshiba has been engaged in the development of a variety of railway transportation planning systems, including a train timetable planning system, a trainset utilization planning system, a depot service scheduling system, and a train crew utilization planning system. To meet customers' requirements for each type of service operation, there is a tendency to spend a larger portion of costs on the development of customized specifications than on standard specifications. To rectify this situation, we have prepared packaged modules for each planning system based on the experience and know-how that we have obtained from past development results, and developed a cloud-based transportation planning system that offers enhanced versatility by utilizing a cloud system as the platform. This system makes it possible to provide customers with low-initial-cost and highly efficient service operations by reducing the initial hardware costs and using standardized function modules.

## System Technology for Rolling Stock Offering Smart Operation and High Energy Efficiency

KAMO Yushi

Energy-saving approaches to railway systems are being offered not only through the development of high-efficiency equipment, but also the reduction of total energy consumption by the integrated optimal operation of each item of equipment and subsystem.

In order to realize smart operation and high efficiency of rolling stock systems, Toshiba has been developing a rolling stock energy management system (EMS) based on collaboration between equipment installed in the rolling stock and the railway system. We are also engaged in the research and development of practical applications including an automatic train operation (ATO) system using the optimal operation pattern, and an energy-saving rolling stock system based on operation supported by the rolling stock EMS and feedback from the railway system.

## Energy-Saving Technologies for Rolling Stock

KAWAGUCHI Osamu

To enhance energy conservation in rolling stock, high-efficiency electrical equipment is crucial for proper functioning of the railway energy management system (EMS) that manages and optimizes the total power consumption of the rolling stock. Toshiba has developed and released the following high-efficiency electrical equipment in this field: (1) a permanent magnet synchronous motor (PMSM) propulsion system as the core technology for energy saving, (2) an inverter-type auxiliary power supply (APS) system pursuing higher efficiency, (3) light-emitting diode (LED) equipment that is gradually coming into use, and (4) an energy-saving air-conditioning unit with improved cooling capacity. We are continuing our efforts to apply silicon carbide (SiC)-based insulated gate bipolar transistor (IGBT) power devices to inverters for further improvement of energy efficiency.

## PMSM Propulsion System for Rolling Stock

TASAKA Yosuke

Although induction motors (IMs) have been spreading into the mainstream of traction motors for rolling stock in the Japanese market since the 1990s, higher efficiency permanent magnet synchronous motors (PMSMs) have begun to be introduced not only in commuter trains but also in high-speed trains and locomotives since the late 2000s to improve energy efficiency. Toshiba has developed a PMSM propulsion system for rolling stock based on its long accumulation of development experience in this field. The PMSM propulsion system consists of the following equipment capable of replacing the equipment of conventional IM propulsion systems: (1) high-efficiency fully enclosed PMSMs corresponding to the requirements of almost all type of rail lines in Japan, and (2) compact and lightweight 4-in-1 variable-voltage variable-frequency (VVVF) inverters.

## Technologies for Rolling Stock Systems and Electrical Equipment Supporting Evolution of Shinkansen Trains

YOSHIDA Kenji

Although almost half a century has passed since the Tokaido Shinkansen Line started operation, the Shinkansen trains continue to evolve for the benefit of social and economic infrastructures through the adoption of new technologies to realize an advanced transportation system with ever-improving punctuality, stability, speed, and energy efficiency. Improvement of the performance of devices such as semiconductors is also supporting the development of electrical equipment for Shinkansen trains. Furthermore, a gauge changeable train, which can run on the gauges of both conventional railway lines and Shinkansen lines, is being developed in parallel with the construction projects for new Shinkansen lines. Toshiba has been actively participating in the development of Shinkansen train systems, including rolling stock systems, power systems, traffic control systems, and maintenance management systems, to assure safe, secure, and comfortable operation as a core manufacturer from the start of the Shinkansen project. We are making continuous efforts to supply electrical equipment for Shinkansen trains using state-of-the-art devices as well as information and communication technologies, and are working toward the practical realization of the gauge changeable train.

## Toshiba's Approach to Development of Technologies for Hybrid Locomotive Systems

KATO Jin / YAMADA Masahiro

Hybrid railway vehicle technologies have recently been attracting considerable attention as a solution for reducing the environmental burden and enhancing energy conservation in both the domestic and overseas railway industries. At InnoTrans 2012, the world's largest exhibition related to the railway industry, various types of hybrid locomotives were presented including both series and parallel models powered by diesel engines and battery systems, as well as a model incorporating a pantograph and diesel engine. Toshiba exhibited conceptual designs for both a series-type hybrid shunting locomotive powered by a diesel engine and electric motors, and a main battery system incorporating SCIB<sub>TM</sub> battery modules. We are continuously focusing on the development of the hybrid shunting locomotive, which is expected to reduce the environmental burden and operating costs of the railway industry.

## Space-Saving Substation Equipment for Shiodome Subsectioning Post

MIYAJIMA Hiroki / ONISHI Mitsuru

To replace the aging equipment at the Hamamatsucho Frequency Conversion Substation (FC) of the Tokaido Shinkansen line, the electronic frequency conversion function was moved to the Oi FC constructed in the Oi Railway, and the power supply classification function of the main line between Tokyo Station and Shinagawa Station was moved to the newly constructed Shiodome Subsectioning Post (SSP).

Central Japan Railway Company and Toshiba have adopted space-saving equipment for the Shiodome SSP to be installed in a limited area. The Shiodome SSP started operation in February 2013 and is operating as planned.

## Railway Power Supply System for Futagoyama Substation on Kisei Line of West Japan Railway Company

INADA Tomonari / KIKUCHI Noriyuki / FUKUDA Yasuyuki

In the renewal of aging railway substations in recent years, requirements have come to include the adoption of environmentally friendly equipment, downsizing of equipment, and reduction of running costs through easy maintenance.

To meet these requirements, Toshiba has developed an optimal power supply system for substations in existing DC single-track regions based on our experience and technologies cultivated through the development of a large number of substations. The system consists of an environmentally friendly silicone-liquid-immersed transformer, compact rectifier equipment, and a new-type monitoring and control panel that can reduce running costs. We have delivered the new system to the Futagoyama Substation on the Kisei Line of West Japan Railway Company. This system is expected to be applied to medium-scale railway substations.

## Web-Type Sales Data Collection System Offering High Reliability and Low-Cost Operation

EBARA Kenichi

In the conventional railway station sales data collection system, the server installed in each railway station is responsible for gathering sales data from the station service equipment and managing the total income. Demand has recently been increasing among railway companies for improvement of the reliability and reduction of the operating costs of sales data collection systems when such systems are introduced or replaced.

Toshiba has responded to this demand by developing a Web-type sales data collection system in which a central server manages the data of the station service equipment at each station, and each station is provided with Web applications for income management. The Web-type sales data collection system realizes high reliability due to the redundancy of central server equipment, high maintainability as a result of the centralized data management, and cost reduction by using general-purpose equipment such as PCs with Web browsers.

## Trends in International Standardization of Railway Engineering and Toshiba's Activities

YAMAMOTO Hajime

International standards have become increasingly important in the field of railway engineering as the basis of global business. In the European Union (EU), as each country strategically utilizes standards for its business operations, standardization activities are directly linked to EU-funded research and development results. Developed technologies are therefore standardized at an early stage. In Japan, the Railway International Standards Center (RISC) of the Railway Technical Research Institute (RTRI) was established in 2010 to implement an organized and strategic approach to international standardization activities.

Toshiba has been actively participating in these international standardization activities. In cooperation with RISC, we are contributing to the development of international standards for railway engineering and enhancement of the competitiveness of Japanese railway technologies.

## Large-Scale Crack Propagation Simulation Technologies to Improve Reliability of Electronic Devices

MONDA Tomoko / OMORI Takahiro / HIROHATA Kenji

Thermal stress on the solder joints of ball grid array (BGA) packages used in electronic devices such as solid-state drives (SSDs) has recently become greater due to miniaturization.

In response to this trend, Toshiba has been engaged in research and development of a fatigue design method using large-scale crack propagation simulation technologies in order to improve the reliability of electronic devices, and we have succeeded in identifying solder joints that are at high risk of fracture by utilizing a large-scale finite element method (FEM) simulation technology. We have also developed a new design method to estimate the thermal fatigue life of solder joints in BGA packages by applying damage path simulation, our proprietary crack propagation simulation technology. This technology can simulate the phenomenon in which solder joints fracture sequentially from the corners to the center during thermal cycles.

## Development of Low-Pt-Loaded Electrocatalyst for Polymer Electrolyte Fuel Cells

FUKAZAWA Taishi / MEI Wu / SUZUKI Naotoshi

Polymer electrolyte fuel cells (PEFCs), which have notable features such as compactness and running at high current density, have already been applied to the ENE-FARM residential fuel cell system, and their full-fledged dissemination in PEFC-based fuel-cell vehicles is expected in the near future. However, a serious issue exists in terms of the tradeoff between the reduction of platinum (Pt) usage for the Pt nanoparticles supported by carbon particles (Pt/C), which are generally used for the conventional PEFC cathode electrocatalyst, and the performance of the fuel cell.

As a solution to this issue, Toshiba has developed a novel electrocatalyst synthesis process using a sputtering method that eliminates the need for supporting materials. We have conducted galvanodynamic polarization tests and confirmed that both the single-cell performance and durability of the novel electrocatalyst are superior to those of conventional Pt/C-based cathode electrocatalysts.

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