Efforts in Research and Development Related to Maintenance Technology

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Securing safety is a matter of the highest priority for railway business as human lives depend on that. At the same time, there are other important issues such as cost reduction for sound management and improvement of reliability as shown in customer needs for railways to keep train delays to a minimum. Furthermore, in light of environmental problems that are now receiving attention at global level, it is important for railway operations have to take into consideration efforts to be in harmony with the environment. This article will introduce R&D efforts related to maintenance technology for cost reduction, improvement of reliability and harmony with the environment.

1 Introduction

JR East operates as many as 12,600 train runs daily on its commercial network of total approx. 7,500 km that includes Shinkansen and conventional lines. It is the field of maintenance for rolling stock and wayside equipment that maintains the infrastructure for rail transport. In order to offer customers high quality services, efforts are being made day-in and day-out in appropriate upkeep of the infrastructure.

The number of rolling stock and equipment that maintenance takes care of is very large (Fig. 1). How much to minimize expenses for the maintenance of those assets is obviously an important management issue.

In order to secure safe and stable transport, it is important to gradually replace rolling stock and facilities with those that don’t require much maintenance, but those have to keep their functionality while being used by many passenger. Thus, maintenance such as inspection and repair needs to be done to prevent failures. In this context, we can say maintenance technology itself is closely related to improving reliability.

A new important issue has also emerged recently: efforts to combat global environment problems that are a major issue worldwide. Today, those efforts are receiving much attention. The age is also shifting from one of mass-consumption of energy and resources to one of economic activities with attention to the global environment. This is no exception for railway maintenance. We are being asked to create a system that puts less of a burden on global environment.

This article will thus introduce R&D efforts related to maintenance technology for cost reduction, improvement of reliability and harmony with the environment.

2 Efforts in Cost Reduction

2.1 Analysis of Maintenance Expenses

Fig. 2 illustrates the percentage in our total operation expenses taken up by maintenance expenses and a breakdown of those. As shown, maintenance-related expenses, including labor costs for maintenance staff, accounts for as much as approx. 25% of total operation expenses.

We focused on repair costs that account for approx. 54% of those maintenance-related expenses. An analysis of the monetary amount per repair item and types of repairs showed that protection costs and costs for rails and contact wires ranked high; so, we are giving priority to R&D projects for cost reduction of those costs.
Special feature article

2.4 Cost Reduction in Terms of Contact Wires and Pantographs

Maintenance expenses for contact wires and pantograph contact strips (annual replacement costs) amounts to approx. 2.6 billion yen (in fiscal 2007). We are thus carrying out R&D to reduce those huge maintenance expenses.

Expenses related to contact wires accounts for a large ratio of the maintenance expenses for this boundary area. The result of analysis of the causes for replacement of contact wires indicates that partial wear of contact wires accounts for 79% of the need for replacement (cause of replacement of contact wires of conventional lines from fiscal 2001 through 2003, Fig 4); so we thus have to address that issue.

One of the main causes of wear of contact wires is electric wear by arcing caused loss of contact with pantographs. To reduce that, we are developing a high-compliance pantograph that has improved motion characteristics. In the process of the development, we found that the improvements such as weight saving of the pantograph head, reviewing the spring constant and reviewing the stroke of the contact strip are effective. Accordingly, we are studying the use of carbon-carbon composite as the material of the contact strip to reduce weight. Tests using an actual train demonstrated that the contact strips of CC composite significantly reduced contact loss; so, we expect replacement costs for contact wires can be reduced by applying those contact strips.

We are also verifying full-scale implementation of the cold pressure welding system for contact wires to eliminate double ears* that are another cause of partial wear as well.

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* A double ear is a metal joint that connects contact wires to each other.
3 Efforts in Improving Reliability

3.1 Analysis of Inconvenience to Customers Due to Failure of Rolling Stock and Facilities

Fig. 6 shows the change in affect on transport per area within 100 km of Tokyo in the period from April 2002 through May 2008. The affect on transport, an indicator defined by the Technical Center, means the average of the total delay time (the total delay time of trains caused by a single trouble) in 365 day operation caused by a total of approx. 1,900 operation disruptions. Those disruptions include failures of rolling stock and equipment or maintenance of those, excluding causes such as natural disasters.

We consider the affect on transport to be an analysis indicator for troubles to customers. However, it does include some human-related uncertainties such as the dispatcher’s discretion in recovery of troubled train operation to normal timetable and longer travel time of the maintenance staff when they are caught up in traffic jams.

Although the affect on transport showed a gradual decline since fiscal 2002, it changed to a sharp increase at the end of fiscal 2004. The values are particularly high at the failure of switch and lock movement at Tamachi station on the Kehin-Toboku line in March 2007, at the failure of the contact wire at the insulated overlap at Saitama-Shintoshin station on the Toboku main line in June 2007 and at the fire at the Kokubunji substation in April 2008. Those values show serious inconveniences to customers were incurred.

3.2 Present R&D Efforts Based on Analysis

In-detail analysis of those inconveniences to customers per area has revealed weaknesses of rolling stock and facilities. • Rolling stock: Main circuit, braking device • Tracks: Insulation and rail bond, track displacement • Power: Fusing of contact wire at insulated overlap, substation fires • Signals: Switches, lightning damage

Some of those have already been acknowledged and addressed in the field or investment made for improvement. Furthermore, the Technical Center is carrying out development with high priority in addressing fusing of contact wires at insulated overlap, prevention of fire of substations, introduction of a new electric switch and assessment of deterioration of electronic devices for vehicles.

Fig. 7 shows the test installation of TC type insulated overlap parts that we are studying as a countermeasure against fusing of contact wire by arcing.

We carried out running tests using an actual train between Tachikawa and Nishi-Tachikawa on the Ome line in July 2008 and installed TC type parts to the insulated overlap section between Saitama-Shintoshin and Omiya on the Toboku main line. Now we are confirming the effects of that including wearing of the contact wire.

A calculation estimates that the affect on transport will decrease by approx. 70% when each area completes the physical countermeasures on equipment and facilities based on the results of these R&D themes (Table 1). It is thus an important mission to put those results into practical use for the research themes to be thoroughly substantiated.

Table 1 R&D and Countermeasures to Improve Reliability

4 Efforts in Harmony with Environment

4.1 Environmental Assessment Based on Life Cycle Assessment (LCA)

Railways are considered to put less of a burden on the environment than other modes of transport. Even so, JR East accounts for a third of the domestic CO2 emissions in the railway sector (Fig. 8).

We have gone forward with measures such as introduction of energy-saving rail cars and improvement of power generation efficiency; but we have not yet quantitatively identified our CO2 emissions caused by maintenance. In order also to achieve the target...
of 50% reduction of total CO2 emissions from our railway business by fiscal 2030 (compared to fiscal 1990) as stated in our “JR East 2020 Vision —Challenge”—, conducting environmental assessment based on the LCA (Life Cycle Assessment) method of quantitatively identifying environmental burden is important.

In LCA, the emissions of CO2 and hazardous substances of an item in its total life cycle is calculated and assessed from procurement of material, through processing, use and maintenance, up to disposal. The Technical Center is thus examining this assessment method. For an example of the calculation results for railway business based on LCA, the ratios of CO2 emissions from rolling stock and from tracks are presented as follows (Fig. 9).

In terms of rolling stock, the LCA results clarified that emissions in train operation are much larger than in production or maintenance; so, reducing the weight of cars and using regenerative energy will be effective in reducing the environmental burden. As for tracks, the key is to extend life of rails since emissions in production of rails account for a large part of the total.

In the future, we will carry out LCA on the Yamanote line, a typical line in the greater Tokyo area, and make proposals for reduction of the environmental burden. The Yamanote line consists of a contact line system (integrated overhead contact wire system) and DC substations along with E231 series rolling stock and tracks.

4.2 Circulating Use of Resources

Japan enacted its Basic Law for Establishing the Recycling-Based Society in 2000. This law defines the basic framework to promote the establishment of a recycling-based society that puts less of a burden on the environmental. That is accomplished by doing away with the mass-production, mass-consumption and mass-disposal economy; and focusing on the three Rs (Reduce, Reuse and Recycle) instead.

As efforts based on those three Rs, the Technical Center has also carried out activities such as research on a management method to extend fatigue life of rails and reusing brake lining for Shinkansen cars that was previously disposed.

We will continue researching methods of quantitatively identifying environmental assessment of waste disposal. And in the end, we intend to propose an environmental assessment method that integrates environmental impacts of CO2 and other greenhouse gases affecting global warming as well as waste disposed of, hazardous chemicals and other emissions.

I have explained our R&D to solve current issues as covered up to this point.

The Technical Center is also carrying out R&D on topics such as low-maintenance vehicles and equipment and repair using new technologies. From among those, we are developing a system from monitoring wayside equipment from onboard trains as the main theme in improvement of reliability by management of predictive signs (Fig. 10).