Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

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GENERAL INFORMATION

ARTICLES

Technical Support Extended to Local Railways

Akira YONEZAWA
Executive Director

In Japan, we have about 90 operators that conduct railway business in not-so-populated local areas. They provide services on passenger railways other than Shinkansen railways, conventional main lines, and railways operating in greater metropolitan areas. These passenger railways vary in size, for example from a short railway line of 5 km to a relatively long railway line of up to about 100 km. They play an important role as a means of transport not only for residents living along the lines but also for tourists.

However, there are problems in facilities and equipment used in these local railways. There are many tunnels and bridges that are 50 years or older and vehicles that have been in service for 30 years or more. Along with a decrease in the number of railway users, those operators are working hard to cope with the difficult management environment. For this reason, the central government and local governments provide financial aid to cover part of renewal costs of facilities and equipment. However, the operators have been reducing the total number of employees, retaining only a minimum number of engineers and technicians for maintenance.

RTRI organized a special unit dedicated to offering technical support for these local railway operators, as it has for about 20 years. The requests from local railway operators have been directed to RTRI through e-mails or by telephone. RTRI researchers respond to these requests usually by conducting field surveys and investigations or by providing technical information. During fiscal 2013, we handled almost 100 requests in total. They were related to track, civil engineering structures, electrical equipment, signal equipment and communication facilities, vehicles, and various other topics. To cite three examples; we took up a site investigation and guided an operator in taking measures against rail wear in a curved section; advised an operator in rectifying a problem with unusual wear of a wheel; and performed a soundness degree diagnosis of a bridge.

For our technical support, local railway operators express great appreciation to RTRI. We will continue to take advantage of our technical capabilities to extend more support to them.

Technical Meeting of Joint Research with SNCF

RTRI received six researchers from SNCF (Société Nationale des Chemins de fer Français). They visited us for a meeting on June 17-18 to discuss joint research as a Japanese and French partnership. In the meeting, the researchers from SNCF and RTRI, specializing in fields of overhead contact lines and pantographs, discussed various technical issues such as a contact wire wear, fatigue of contact wire, and maintenance of overhead contact lines. Although the shapes of contact wire wear differ in France and Japan due to the difference in contact strip materials, we have found that some of the wear characteristics have similarities in overlapping sections. The participants of the meeting also exchanged opinions in an active discussion on fatigue of contact wire caused by stress working on a contact wire as well as maintenance issues.

Discussion in technical meeting

RTRI Stand at InnoTrans 2014

InnoTrans is the world's largest trade fair of the global railway industry. It is held every two years in Berlin, Germany, and this year InnoTrans 2014 was held from 23 to 26 September. It is the fourth time that we have participated in InnoTrans under the name of RTRI. Since InnoTrans 2014 coincided with the 50th anniversary of the Tokaido Shinkansen in Japan and RTRI is a research center that has assumed a key role in the technical development of Shinkansen bullet trains, we introduced activities RTRI has carried out from the time of early development of Shinkansen to the present day. We also presented recent results of RTRI's research and development. Visitors to the exhibition stand of RTRI in InnoTrans 2014 had various comments and questions for RTRI. By having the stand and by responding to these types of questions and inquiries, we hope we have helped boost RTRI's global presence.

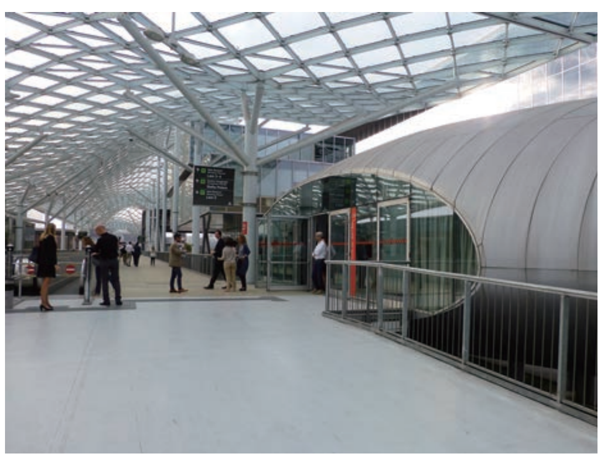
The Exhibition Stand of RTRI

The Venue of InnoTrans 2014

WCRR 2016 in Milan

WCRR 2016, World Congress on Railway Research 2016, will be held in Milan, Italy, from May 29 to June 2, 2016. As a member of the WCRR Organizing Committee, RTRI has been actively supporting its preparation. At the congress, under the main theme "Research and Innovation from today towards 2050," presentations will be made in the two categories: "Vision and Future" in which innovative ideas on future railways are to be proposed using a long-term perspective and "Today Research" for presentations to address challenges that railways are facing today. Call-for-Papers information will be available early next year and the deadline for abstract submission will be in May 2015.

For further details, please see: http://www.wcrr2016.org/



Fiera Milano in Milan, Italy, Venue for WCRR 2016

3D-DEM Simulation of Ballasted Layer Deformation

Akiko KONO
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1. Introduction

Ballasted tracks have "weak areas" where there is differential settlement or ballast flow. These issues hinder maintenance cost reduction efforts.

Identifying influential factors through experiments is necessary to fully understand such local deterioration phenomena. However, there are limits to the external force conditions that can be simulated by using experimental equipment. Additionally, detailed observation of the behaviour of constituent particles that induce plastic deformations of ballasted layers is difficult with the current measurement technologies. RTRI have begun numerical study by using 'DEMCS', a Discrete Element Method (hereinafter "DEM") code developed by University of Tsukuba (1).

2. Studying the ballasted layer using a Discrete Ballasted Track Model

Figure 1 shows the "Discrete Ballasted Track Model around Rail Joint" simulating a general layout of sleepers around the rail joints of narrow gauge tracks in Japan. If an external force, including high-frequency components that occur when a train passes through a rail joint is input into the elements of the sleepers arranged here, the deformation of a ballasted layer under these complex external force conditions can be simulated.

Figure 2 shows the distribution of inter particle contact forces in a ballasted layer at the moment when the front axle passes immediately above the joint. The upper chart shows the distribution when no countermeasures are taken, and the lower one shows the results after applying a resilient rail pad and a rubber mat as countermeasures. It was verified that these actions led to a significant decrease of inter particle contact forces immediately below the rail joint.

Figure 3 shows the movement of ballast particles before and after the passage of one bogie. The upper chart shows the movements in the case where no countermeasures are taken, and the lower one shows the results after taking the countermeasures mentioned above. The countermeasures caused the behaviour of ballast particles immediately below the joints to be restrained, although the movements of ballast particles are slightly increased under the adjacent sleepers.

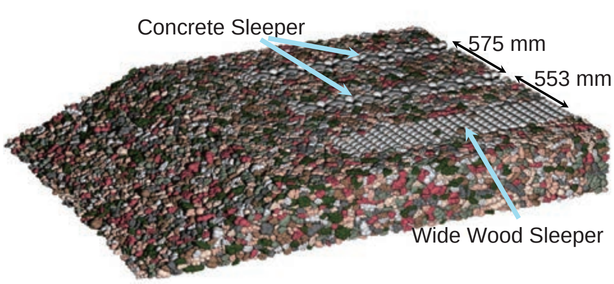

Fig. 1 Discrete Ballasted Track "Model around Joint"

3. Future application

DEM simulation enables researchers to focus on the inter particle contact forces responsible for degradation and on the movements of ballast particles which are responsible for ballast settlement. We would like to validate the mechanism causing complex local deteriorations of ballasted tracks by complementing the results of our experiments with this simulation.

(1) T. Matsushima & H. Saomoto . 2002 . Discrete Element Modelling for Irregularly-Shaped Sand grains, Proc. of Numerical Methods in Geotechnical Engineering, pp. 239-246

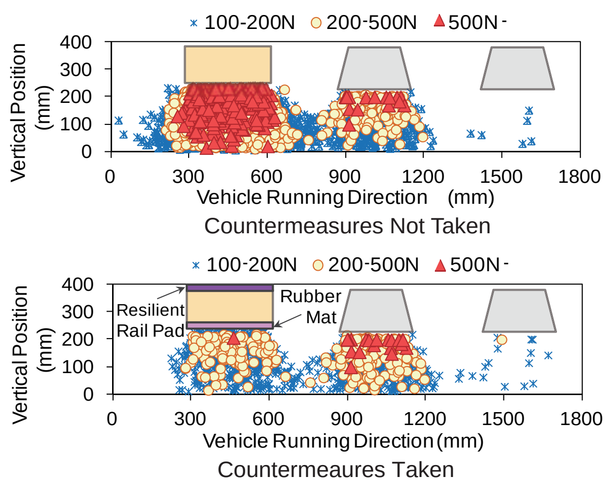

Fig. 2 Change of Contact Forces Distributions in Ballasted Layer

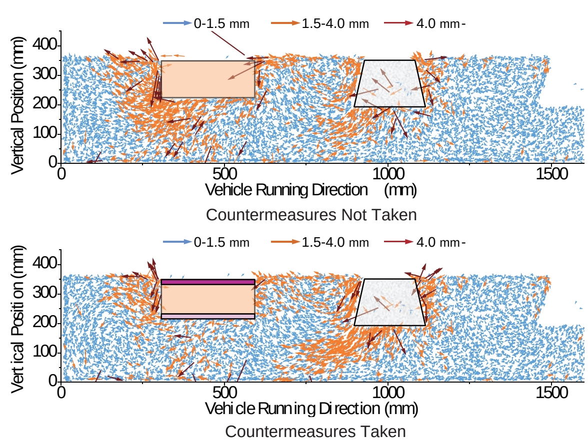

Fig. 3 Change of Particle Movements in Ballasted Layer

Development of Improved Method for Predicting Noise along High-speed Railways

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1. Introduction

When a train runs, noise generated from the train is transmitted to the area along the railway line. Reducing such wayside noise is important task. To reduce the noise from sources, it is necessary to improve the accuracy of noise prediction and to develop more effective measures. Thus, we are developing a noise prediction method that considers the various conditions along the wayside that affect noise propagation. This method is based upon the existing noise prediction methods for Shinkansen, but it is more applicable to actual wayside conditions.

2. Overview

When a Shinkansen train runs, the major sources of Shinkansen noise are considered to consist of four components: noise from the lower parts of vehicles such as rolling noise; aerodynamic noise from the upper parts of a vehicle; pantograph noise; and bridge noise (Fig. 1). The wayside noises are affected by sound attenuation in distance, reflection, diffraction and other factors of sound transmission from sound sources to sound receiving points. Accordingly, we evaluated the effects of the conditions surrounding railway lines on the noise transmission using an acoustic test with scaled models and developed the prediction method by using the test results. Our efforts so far have made it possible to predict train noise as affected by the surrounding conditions, such as the buildings and bridges around railway lines, cut sections, and tunnel portals.

3. Example of prediction result

Whenever a road bridge crosses over a railway line, the wayside noise level caused by a running train is affected by the underside of the overbridge and it is changed in the area around the overbridge. Figure 2 illustrates the basic principles of a noise prediction method for the area along a Shinkansen railway by considering reflections from the underside of the overbridge. Figure 3 shows an example of the prediction result and indicates that the wayside noise is locally increased due to the noise reflections on the underside of an overbridge. Thus a quantitative evaluation of the noise increase caused by an overbridge and the affected area enables appropriate and efficient noise control measures to be taken.

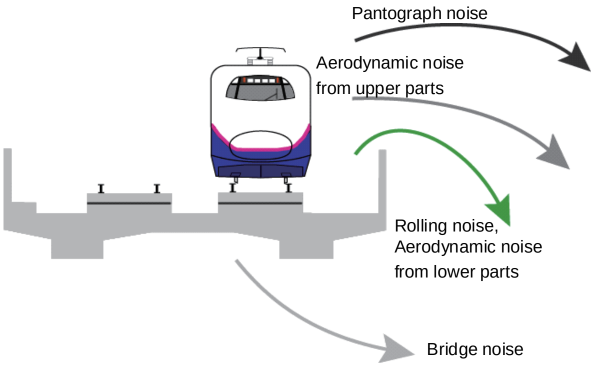

Fig. 1 Shinkansen Noise Sources

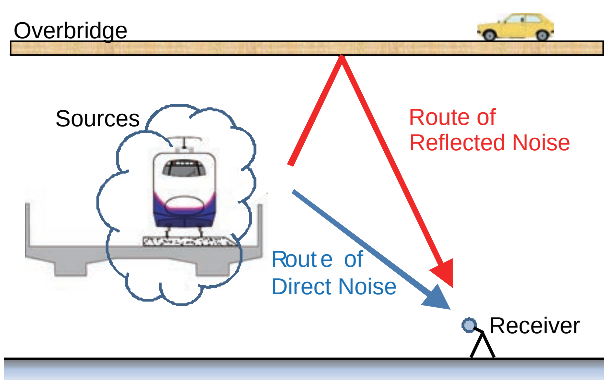

Fig. 2 Prediction Model for Sound Reflection on Undersurface of Overbridge

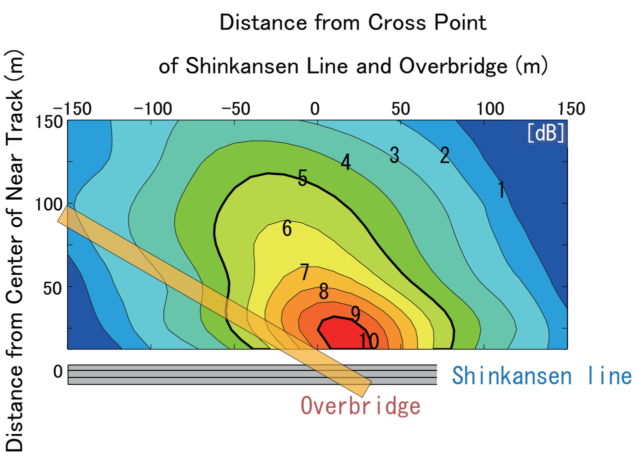

Fig. 3 Noise Difference of Sound Reflection on Surface of Overbridge (Train Speed: 300km/h Train runs on far track.)

Evaluating the Health Effects of Magnetic Fields

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1. Introduction

In the electric railway environment, it is known that magnetic fields (MF) in the range between zero Hz and several kHz is generated due to equipments such as overhead contact lines and on-board electrical units. And, socially there are voices of concern over the MF's adverse health effects such as carcinogenesis. The World Health Organization (WHO) started the International EMF Project in 1996 to scientifically evaluate the health risks of electromagnetic fields (EMF). The WHO indicated lack of scientific knowledge regarding the intermediate frequency (IF) EMF in the Environmental Health Criteria No. 238 in 2007. Accordingly, RTRI has conducted research to evaluate the health effects of the IF-MF.

We have used mammalian cells, microorganisms and other biological specimens to assess the static MF (0 Hz), power frequency MF (50 Hz), IF-MF (2, 10 and 21 kHz) and their concurrent exposures, and evaluated their effects such as those on genes in relation to carcinogenicity, on cell differentiation at an early stage of development, etc. This article provides an example of the research we have conducted in recent years to evaluate the effects of the IF-MF exposure.

2. Evaluation procedure

The figure below shows an example of the experimental procedure for evaluating the safety of MF. RTRI is using strong MF as possible for the evaluations because the energy of a MF is usually extremely weak to detect its effect. The IF-MF exposure apparatus that we have developed lately is achieved suitable culturing conditions for mammalian cells under uniform and strong MF conditions more than 100 times higher than the reference value defined for the general public by the International Commission on Non-Ionizing Radiation Protection.

A uniform and strong MF can be generated only in a limited space. Therefore we are using mainly the mammalian cells and microorganisms to which a MF can be exposed in a tight space. Moreover, we sometimes use such specimens as susceptible organisms which lack essential ability to maintain normality to evaluate the mode of action of a MF precisely.

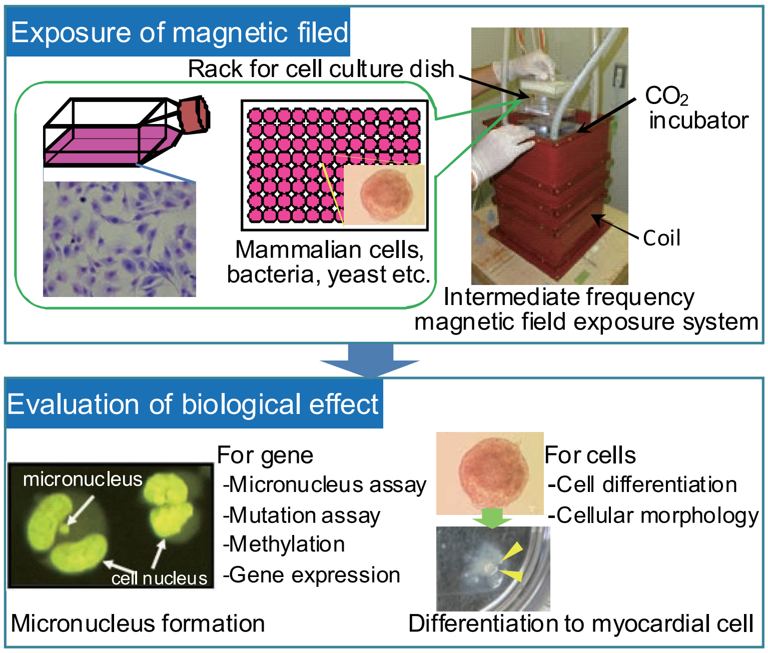

Fig. Example of Experimental Procedure for Safety Evaluation of Magnetic Field

3. Evaluation on effects of IF-MF

As the results of exposing the 21 kHz IF-MF of magnetic flux density of up to 3.9 mT (=mWb/m^2) to mammalian cells, no effect was observed on mutagenicity (potential carcinogenicity) or cell differentiation at an early stage of development (potential teratogenicity).

Considering these results and the experimental results obtained so far for other frequency MF, we conclude that the possibility that the MF generated in the railway environment will cause adverse effects against organisms is extremely low or hardly recognizable in general consensus of safety assessment.

I would like to add that a part of this research was carried out with financial support from the Health and Labour Science Research Grants of the Ministry of Health, Labour and Welfare.

Development of kW-class Magnetic Heat Pump Aimed at Application to Rolling Stock Air-Conditioning System

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1. Introduction

Conventional refrigeration is based on the compression and expansion of chlorofluorocarbons (CFCs) or hydrochlorofluorocarbon (HCFC). HCFCs are greenhouse gases and will be discontinued in 2020. Thus, the use of natural refrigerants and research on new refrigeration technologies are making rapid progress. One such technology, known as magnetic heat pump technology refers to refrigeration technology that exploits the phenomenon (magneto-caloric effect) of heat being generated and absorbed when a magnetic field is introduced to a magnetic material. The magnetic refrigeration has many advantages: the heat cycle efficiency of magnetic refrigeration is higher than gaseous refrigeration and thus reduces energy consumption; it is environmentally friendly without the need for CFCs or HCFCs; and it is quiet with low levels of vibration because compressors are not used. Thus magnetic refrigeration is expected to find applications in future air conditioners and refrigerators. Our research aims to apply this magnetic heat pump technology to rolling stock air-conditioning systems and this article describes our initial work towards that goal.

2. Development of kW-class magnetic heat pump

The rolling stock air-conditioning systems are relatively large (25-50 kW class) systems and there was no magnetic refrigeration system with cooling capacity exceeding 1 kW in Japan before our development. Therefore, we made an initial goal to develop a unit with a cooling capacity that exceeds 1 kW by using a magnetic refrigeration method to validate the feasibility of a kW-class magnetic refrigerator. We built a "ring-shaped Halbach arrayed permanent magnet" having magnetic flux density of up to 1.5 Tesla, developed by RTRI, into the kW-class magnetic heat pump and installed gadolinium alloys as the magnetic material (Fig. 1).

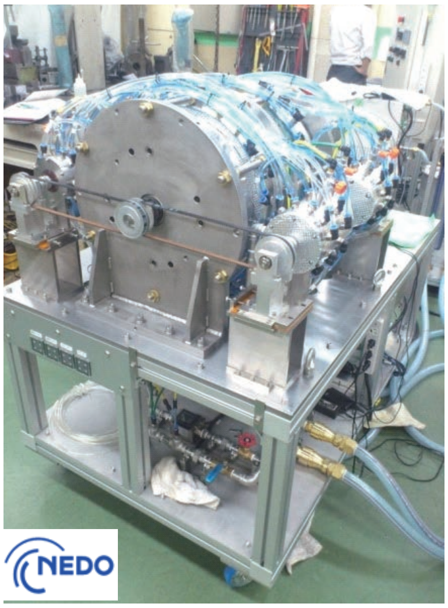

Fig. 1 kW-class Magnetic Heat Pump

3. Cooling capacity

The cooling capacity reached 1.4 kW at room temperature and exceeded the initial target (Fig. 2). Since this magnetic heat pump system has introduced the ring-shaped Halbach array, it has a larger cooling capacity per unit mass magnetic material than conventional magnetic refrigerators and, consequently, is advantageous in terms of downsizing (Fig. 3). The results of our latest development have indicated the applicability of magnetic heat pump technology using magneto-caloric effect to large refrigeration and cooling systems. We aim to apply this technology to rolling stock air-conditioning systems by further enhancement of refrigerating performance and efficiency and by downsizing and incorporating weight saving measures in the future.

This work was supported by New Energy and Industrial Technology Development Organization (NEDO).

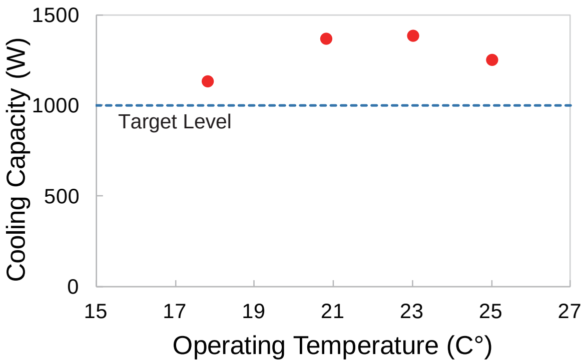

Fig. 2 Cooling Capacity Dependencies on Operating Temperatures

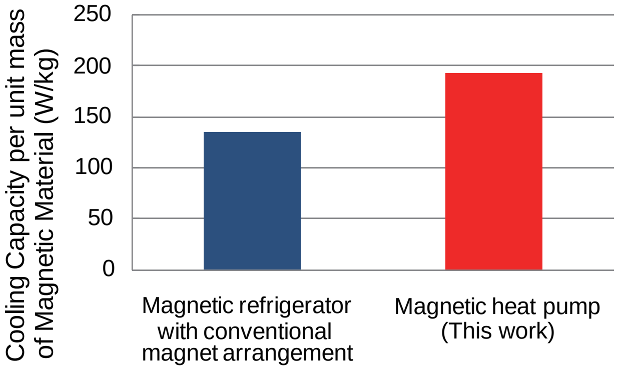

Fig. 3 Cooling Capacity per unit mass of Magnetic Material