Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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GENERAL INFOMATION

ARTICLES

Keywords are “Safety” and “Ecology”

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The Railway Technical Research Institute (RTRI) is conducting research and development (R&D) across the whole field of technology relating to railways, such as vehicles, structures, power supply, signalling and human sciences. In recent years, we have adopted “Safety” and “Ecology” as keywords common to each technical field.

“Safety” is the most important factor in railways and the principal objective of R&D work at RTRI. Among other issues, derailments are a phenomenon inherent in railways, and R&D to prevent derailments is promoted as part of the programme of work in each technical field. The greatest challenge to prevent derailments occurring is elucidation of the tribology phenomenon that acts between the wheel and rail, and we are making every effort to elucidate the mechanism of derailments by combining theories, indoor experiments and experiments in the field.

In terms of R&D relating to vehicles, we are aiming at developing a bogie that will exert only small changes in wheel load on the track by improving the ability of the bogie to follow the twist of the track. This bogie will also exert only a small lateral force thanks to improvement in its turning properties during passage through a curve.

In the recent past, R&D relating to the other keyword “Ecology” has focused mainly on reducing the impact on the wayside environment caused by the noises and vibration that accompanythe increase in the speed of a train. However, in recent years, global warning caused by the increasing emission of greenhouse gases, such as carbon dioxide, has actually happened and railways are supposed to have an advantage in this aspect but are also expected to make further efforts. As specific themes for R&D, mention is made of life cycle assessment (LCA), technical development that takes recyclability into consideration, improvement in the efficiency of drive systems, regenerative power technology, development of fuel cell vehicles, etc.

From the high-speed rail technology that originated in Japan and is now spreading across Europe and the rest of the world, to the intensive commuter transport that supports urban activities, we will continue to make efforts so that railways can contribute to the continuous development of social/economic activities as a very safe and environmentally-friendly mode of transportation.

New Supercomputer System of the Railway Technical Research Institute

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RTRI launched a new supercomputer system into operation in May, 2009.
We selected the most suitable system based on comprehensive evaluation of the following factors:

* Cost performance
* System security and reliability
* Perfect portability of existing programs
* Expandability

Following table shows a comparison between the specifications for the previous system and the new system.

System	Pre System	Cray-XT4	Cray-CX1
System Type	SMP	MPP	PC Cluster
Processor (Number)	Intel Itanium2 1.5GHz Single-core (112)	AMD Opteron 2.3GHz Quad-core (268)	Intel Xeon 3.0GHz Dual-core x2 (6) Intel Xeon 3.0GHz Quad-core (18)
R/Peak(*)	672 GFlops	9.8 TFlops	1.0 TFlops
Main Memory	224 GB	2.0 TB	256 GB
Disk Memory	3.0 TB	21.0 TB	1.5 TB
OS	Linux	Cray Linux Environment	Linux(RedHat + EL5)

(*)R/Peak: Theoretical Peak Performance

While the previous system was configured with a single shared memory parallel computer (SMP: Symmetrical Multi Processor), the new system consists of two different types of computer: XT4 (MPP: Massively Parallel Processor) and CX1 (PC Cluster) from Cray Inc. (USA).
In the new system, we characterize the CX1 system as a platform to operate commercial software for various analytical purposes.
Therefore, we chose the execution environment (Specification) of the CX1 system so that it has a capacity to suit the applications that are currently in use.
However, the CX1 system is a PC cluster configuration system whose performance can be expanded in the future by adding nodes as required.
On the other hand, we treat the XT4 (Fig. 1) as a platform mainly used for the development and running of original user programs.
We consider that the analysis of various complicated railway issues requires large scale computation using a high level simulation technique.
For this purpose, the XT4 system has about 10 times the number of CPU cores and memory capacity, and about 15 times superior theoretical computation performance value compared with the previous system.

Fig. 1 New supercomputer system of RTRI

Improvement of Pantograph Performance by Use of a Variable Stiffness Spring

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The contact performance of a pantograph is often evaluated in terms of compliance characteristics. The compliance characteristics specify, when a pantograph runs along an overhead rigid conductor having sinusoidal irregularities, the maximum amplitude of overhead rigid conductor irregularities with which the pantograph can run without causing a control loss. The compliance characteristics is a frequency response, wherein there is generally a plurality of frequencies at which the compliance characteristics show a peak and a valley. These frequencies are determined primarily by the mass of a movable part of the pantograph and/or the stiffness of a spring element. Fig. 1 shows how the compliance characteristics vary when the stiffness of a pan spring that supports the panhead of the pantograph is varied.

The Railway Technical Research Institute has proposed a technique, whereby the contact performance is improved by matching a principal disturbance frequency acting on a pantograph with the peak frequency of the compliance characteristics curve by allowing the stiffness of the pan spring of the pantograph to be varied and altering the peak frequency as shown in Fig. 1.

The contact performance was investigated by numerical simulation using a simple control to vary the stiffness of a variable stiffness spring in response to the running speed. It was assumed that the dominant disturbance frequency acting on the pantograph would be determined by the running speed and the interval between items of hardware along the wire such as the hangers and supporting points. Then, the stiffness of the variable stiffness spring was controlled so that this frequency agreed with the peak frequency of the compliance characteristics of the pantograph. As a result, it was revealed that there is less fluctuation of the contact force when the stiffness is varied in response to the running speed than when the stiffness is constant regardless of the running speed, and it was confirmed that this technique of improving the contact performance is effective for the catenary-type contact wire (Fig. 2).

Figure 3 shows the variable stiffness spring that was developed and prototyped to implement the proposed technique of improving contact performance. This variable stiffness spring has two air springs arranged so that they are opposite to each other, whereby the stiffness of the variable stiffness spring can be varied by altering the air pressures of both air springs. The change in stiffness is possible in the range of approximately 15 kN/m to 36 kN/m.

The variable stiffness spring shown in Fig. 3 was mounted on a pantograph, whereby the variation in a dynamic characteristic associated with the change in stiffness was confirmed. Figure 4 shows the variations in the dynamic characteristic (compliance=compliance characteristics/static upward force) of the pantograph due to differences in the air pressures of the variable stiffness spring. The air pressures shown in the graph are differential pressures from the atmospheric pressure. As shown in Fig. 4, it is confirmed that the compliance peak frequency varies with the alteration of the stiffness, and it has been shown that the pantograph compliance characteristics can be controlled by the variable stiffness spring.

In the future, pantographs fitted with a variable stiffness spring are scheduled to be run under an actual overhead line to confirm the enhanced effect of the contact performance.

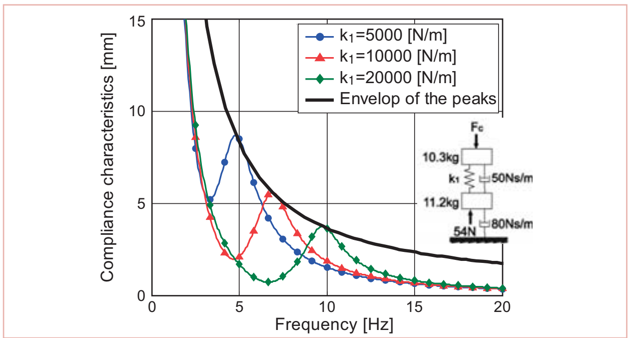

Fig. 1 Variations of compliance amplitude due to differences of pantograph stiffness

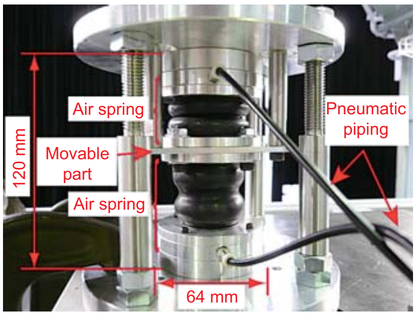

Fig. 3 Prototype of the variable stiffness spring

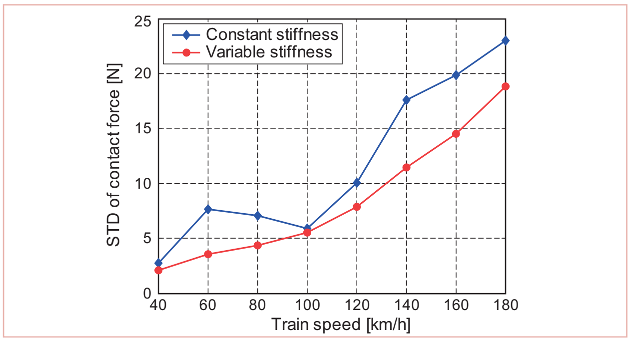

Fig. 2 Difference in the contact performance between the pantograph with a variable and a pantograph with a spring of constant stiffness (Numerical simulation results)

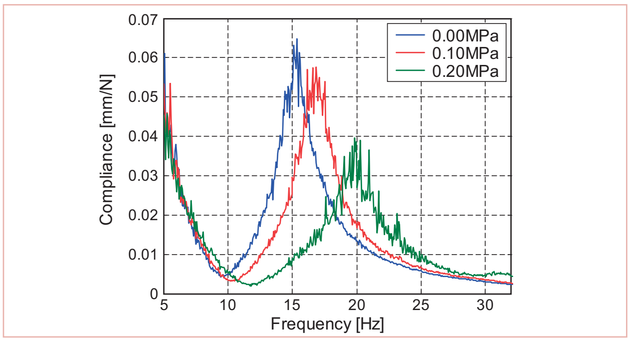

Fig. 4 Dynamic characteristic control of a pantograph with the variable stiffness spring

Evaluating the Emission of "Musty" Smells

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Introduction

You may have experienced "mustiness" when you have smelled particular foods or entered certain buildings. According to my experience, it never seems to be a memory on the "comfort" side. At the Railway Technical Research Institute (RTRI), our group is now carrying out research to establish a technique for evaluating the air quality in railway facilities which includes, among other things, the identification of smells stemming from mould. In surveys carried out in the past to determine the awareness of mustiness among railway users, a number of respondents replied that they were conscious of the atmospheric environment and of smells at stations. They often cited "mould smell" as an example of unpleasant smells 1). Thus, our group decided to keep an eye on the mould floating in the air as a factor for the evaluation of air quality.

High correlation between subjective evaluation and quantity of mould suspended in the air

Figure 1 shows the replies of railway users to a question asking whether they noticed a smell at particular locations when they were guided around the station premises. The X-axis stands for the quantity of the mould floating in the air at the survey points. This Figure shows that the number of respondents who noticed a smell correlates very well with the quantity of mould floating in the air.

Emitters of smell - volatile substances

Next, we collected the mould floating in the air within the station premises, cultured it in our laboratory and examined what substances the mould emits to cause smells. As a result, we found that Cladosporium spp. that is frequently detected (in bathrooms, for example) does not emit smell-related substances much, while Penicillium spp. and Aspergillus spp. do emit smell-related substances in some quantity.

Before implementing a series of analyses, we thought that particular substances related to "mould smell" would exist in the environment. On the contrary, our analysis revealed that there were no specific mould smell substances but that unpleasant smells were caused synergistically by a set of substances existing in nature. It is rather interesting that these substances include "limonene" and similar substances contained in lemons, mandarin oranges and other citrus fruits.

A smell sampling device and instrumental analysis

Indeed, smell is complicated enough to deal with, in that human sensory reaction against a mouldy substance changes from "comfort" to "discomfort" when its concentration becomes high. Even at an extraordinarily low concentration, some substances are offensive to human beings. To analyze smells, therefore, we now perform sensory evaluation with our nose by using a smell sampling device installed on a gas chromatograph (GCMS) (Fig. 2) in addition to instrumental evaluation with the GCMS equipment. If we are allowed to give the conclusion of these analyses first, we found that the human nose is really an excellent sensory organ. Nevertheless, we are now discussing whether it isn't possible to somehow find a way of evaluating smells in qualitative and quantitative terms.

We carried out this study partly with a subsidy by the Ministry of Land, Infrastructure, Transport and Tourism.

Reference

1) Hiroaki Suzuki et al., RTRI Report Vol. 19, No. 1, pp 15 - 20, 2005 (in Japanese)

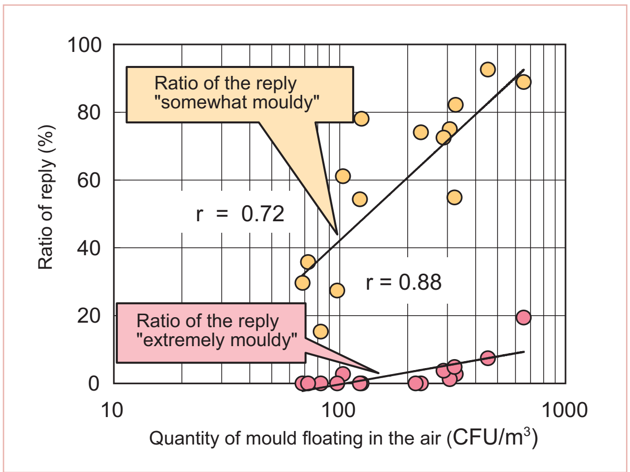

Fig. 1 Correlation between the ratio of reply "mouldiness noticed" and the quantity of mould floating in the air

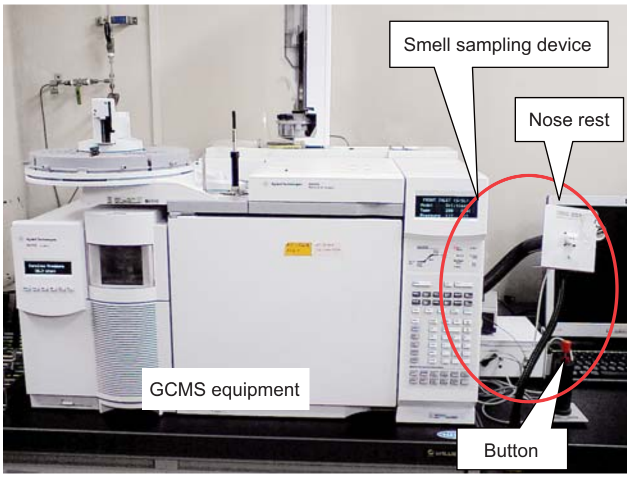

Fig. 2 A smell sampling device and GCMS equipment

An Accident Round-table Discussion (ARD) Method Designed to Increase Safety Awareness

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It is said that opportunities for communication among field personnel tend to be low, and risk-related information such as experience gained and techniques used by individual personnel regarding safety is becoming hard to share in the workplace. The autor conducted a survey of eighty-four deputy managers of a railway, in which they were asked about subjective rates of opportunity for sharing information about hazards observed, incidents encountered, and accident prevention. The result of survey indicates that most participants felt decreasing trend of sharing communication about risk compared with before (Fig. 1).

The author first developed an Accident Round-table Discussion (ARD) method to enable the sharing of risk-related information among field personnel and to increase safety awareness in the workplace by holding discussions in small groups of five or six people on the causes of accidents and measures to prevent them (Fig. 2). Facilitators are employed to conduct the ARD and encourage the participants to talk to one another about their own experience. The method consists of three primary stages: (1) discussion of accident situations, (2) discussion of accident causes, and (3) discussion of accident prevention.

In the first stage, participants discuss the process, situation, and severity of the accident. The aim of the first stage is to raise sensitivity to risk and to recognize the severity of an incident. In the second stage, participants discuss the cause of an accident based on the cause-down analysis method and on the multiple human factors involved. Facilitators ask participants about the cause of the accident and the cause of the cause by repetition of the question “why”. This leads to a detailed examination of the reasons for the accident. The facilitators also ask the participants about many aspects relating to human factors with the use of Hawkins’ SHEL model. Hawkins’ SHEL model includes various human-centered factors; Liveware-Software (procedures), Liveware-Hardware (equipments), Liveware-Environment (working conditions), Liveware (personnel issues), and Liveware-Liveware (interhuman relationships). The aim of the second stage is to raise sensitivity to risk, to share experience of risk, and to sympathize with those experiences. In the third stage, participants discuss accident prevention based on their own efforts. The aim of this stage is not only to share their efforts but also to understand difficulties with accident prevention measures. For this, facilitators encourage the participants to evaluate the accident prevention measures that they discussed.

The author conducted actual trial runs of the ARD at field sites and confirmed its effectiveness by asking participants to fill in a questionnaire. The questionnaire included five items; increasing sensitivity to risk, sympathy with experience of risk, sharing each other’s efforts to prevent accidents, understanding difficulties with accident prevention measures, and improving safety awareness. The answers were graded according to the five point Likert scale; 1.absolutely not, 2.not much, 3.neither, 4.tentative yes, 5.strong yes. The proportion of answers for all items showed that there were about eighty percent positive answers and no negative answers. The result indicates that information sharing among personnel and increased safety awareness can be expected as a result of holding discussion meetings using the system in conjunction with safety activities at field sites (Fig. 3).

Furthermore, to facilitate the introduction of the ARD, the author prepared manuals (in Japanese) and training programmes for the facilitators who will implement it. The purpose of such training is to teach the ARD through simulated discussion meetings. The technique is now being implemented by a number of railway operators.

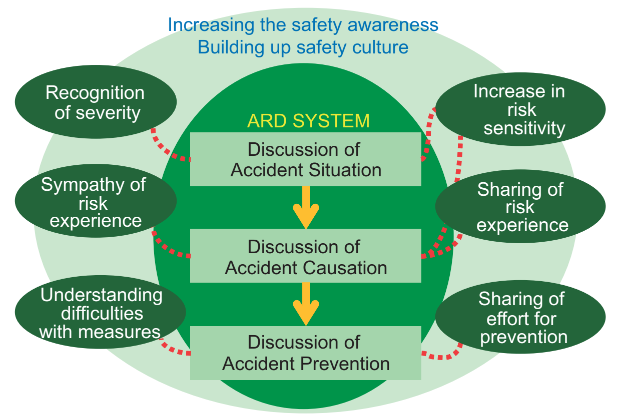

Fig. 2 Flow of Accident Round-table Discussion (ARD) method for raising safety consciousness

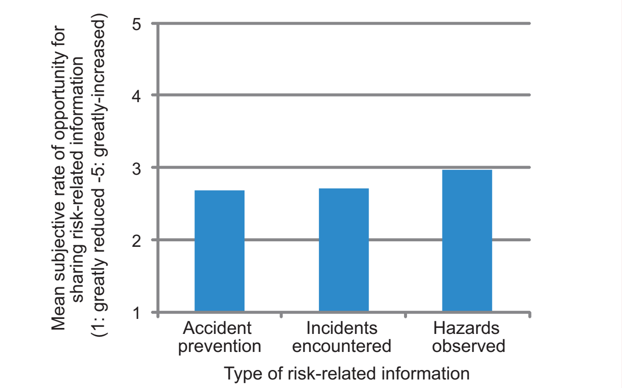

Fig. 1 Mean score of subjective value of sharing risk information in a railway company

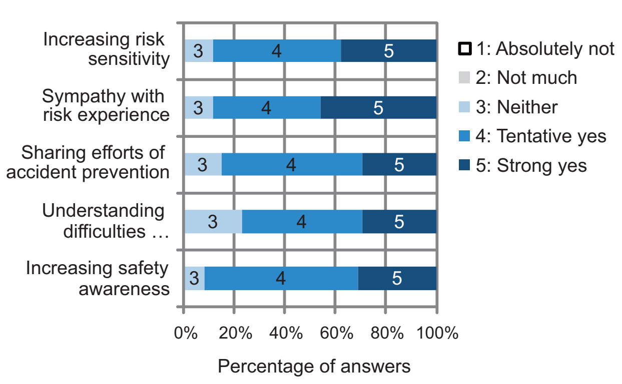

Fig. 3 Percentage of answers of questionnaire about risk sharing and safety awareness after the ARD

Development of an Eddy Current Rail Brake Derived from Linear Motor Technology

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Eddy current rail brakes characteristically guarantee the generation of a stable braking force that is not affected by the conditions of the rail tread surface, as they function without contacting the rails. There are several problems, however, in the application of the eddy current rail brake system. These include a rise in rail temperature when eddy current rail brakes are used, and ensuring the supply of power to energize the brake when the main circuit of the car has failed. For these reasons, the system has not yet been commercialized in Japan. Given this situation, the Railway Technical Research Institute (RTRI) is aiming to solve these problems with the eddy current rail brake system by applying linear motor technology acquired during the development of Maglev systems.

Concept of the linear motor rail brake system

The linear motor rail brake system uses the armature of linear induction motors (LIMs) in place of the excitation pole of the conventional system and generates braking forces by dynamic braking operation, as shown in Fig. 1. This system has the following advantages.

1) For the same braking force, the LIM rail brake does not raise the rail temperature as much as a conventional eddy current brake.
2) The power required for excitation is secured from the kinetic energy of the vehicle.

Figure 2 shows the arrangement of the power supply system. When triggered by a brake command, the inverter starts using the voltage of the auxiliary power circuit and increases the output DC voltage immediately thereafter by relying on the generated power. After reaching a preset DC voltage, it maintains the DC voltage required for its rated operation while maintaining the braking force by controlling the power to balance the power generated and that required for excitation. This method is called the "dynamic braking with zero electrical output." Figure 3 shows the basic energy flow using this control method.

Estimation of the system characteristics with a conceptual model

RTRI calculated the characteristics of the system against the car running speed when it is controlled to keep the generated output power constant, as in the case of dynamic braking with zero electrical output (Fig. 4). Figure 4 shows that the output power and braking force are kept constant when the frequency is approximately constant, irrespective of the running speed.

A prototype of the armature for rail brakes

Given the need to generate power and maximize the braking force density in a limited space, together with the restricted space available for installation, RTRI is now discussing the adoption of a ring-wound armature for rail brakes. To examine the feasibility of this option, therefore, RTRI had a prototype ring-wound armature for the rail braking application manufactured and examined its electromagnetic characteristics in a lock test system with a static tester (Fig. 5). This moves forward the magnetic field alone in the static condition to generate a thrust force in the rails. When the speed of the magnetic field is converted into the car running speed, the value of the thrust force thus obtained gives the characteristics of the braking force when the car is actually running. By repeating various tests, RTRI confirmed that unnecessary magnetic fields, which were expected to occur with a ring-wound armature, did not occur much, with the thrust force (braking force) reaching a peak when the speed of the magnetic field was approximately 100 km/h.

Future development

Through various studies of element technologies for the eddy current rail brake system derived from linear motor technology, the feasibility of the functions and performance proposed by RTRI has been confirmed. In the near future, RTRI will develop rail brakes to be mounted on test bogies and carry out running trials.

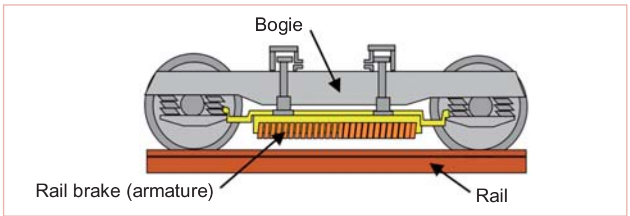

Fig. 1 Schematic of a LIM rail brake

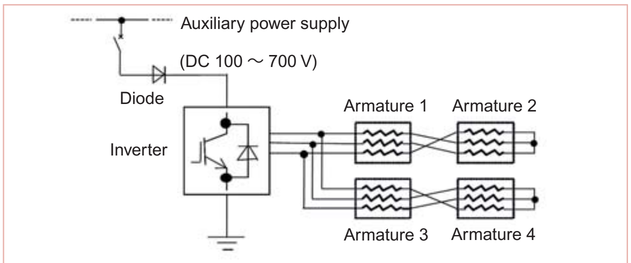

Fig. 2 Example of a power supply system for a LIM rail brake

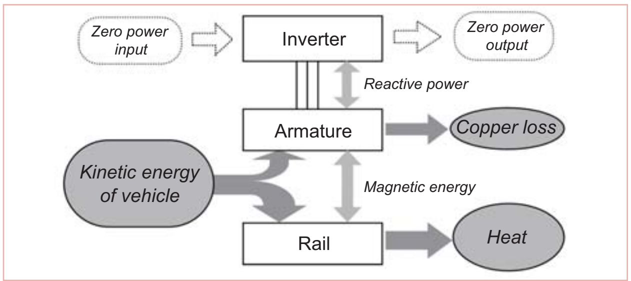

Fig. 3 Energy flow of the dynamic braking with zero electrical output

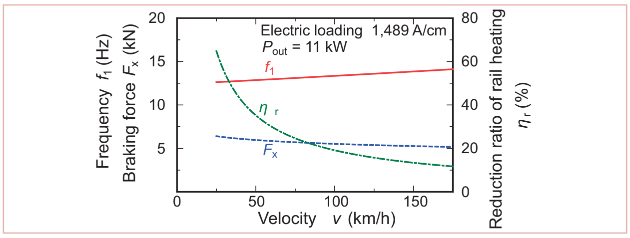

Fig. 4 Velocity characteristic curves of the LIM rail brake under the condition of constant current and constant power generation

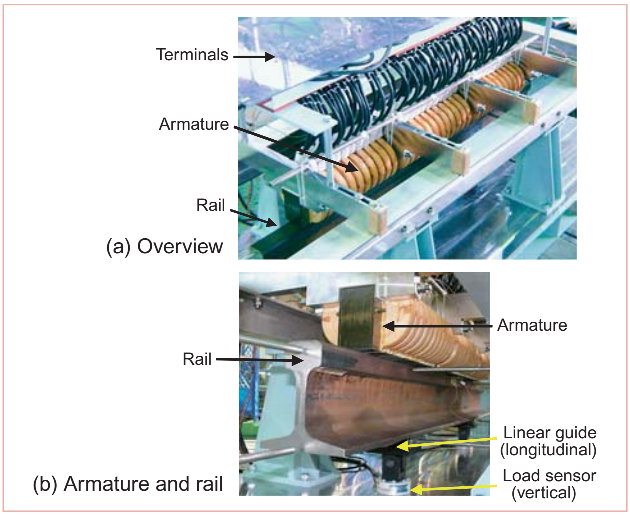

Fig. 5 Testing armature for the lock test