Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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GENERAL INFOMATION

The Need for Balance and Co-operation in Railway Technologies *Nobuyuki MATSUMOTO* 127

ARTICLES

Development of Contact-Wire/Battery Hybrid LRV *Masamichi OGASA* ...128
Human Factor Analysis Method for Improving Safety Management *Yumeko MIYACHI* 129
Evaluation of Compression Behavior of the End-Structure of Intermediate Car *Tomohiro OKINO* 130
A Properties Measuring System for HTS Wires *Masafumi OGATA* ...131

Special Issue: WCRR2008 in Seoul

A Report on WCRR 2008 *Tetsuo UZUKA* 132
Damage Evaluation of Railway Structures Based on Train-Induced Secondary AE Parameters *Xiu LUO* 133
Development of an Assisted Steering Bogie System for Reducing Lateral Forces Exerted on the Track *Shogo KAMOSHITA* 133
Experimental Reproduction of Wheel Thermal Cracks *Kazuyuki HANDA* 134
Study of Under-Floor Air Flow to Reduce the Phenomenon of Flying Ballast *Atsushi IDO* 134
Vibration Reduction Methods for Superconducting Maglev Vehicles *Erimitsu SUZUKI* 135
Effects of Current Collection Noise and Lineside Obstructions on GPS Signal Reception *Haruo YAMAMOTO* 135
A Method to Measure the Pantograph Contact Force on the Overhead Catenary System *Takayuki USUDA* 136
Development of Friction Moderating System to Improve Wheel/Rail Interface in Sharp Curves *Shinya FUKAGAI* 136

The Need for Balance and Co-operation in Railway Technologies

Nobuyuki MATSUMOTO
Deputy Director, International Affairs Division & Marketing and Business Development Division

Today, the advantages of railways are being re-evaluated in various countries of the world from the point of view of environmental impact and from the point of view of how to reduce the cost of resources. Railways are also being viewed as a way to mitigate the effects of road traffic congestion in urban areas. Many mass media have reported on and highlighted this phenomenon as a renaissance of the railway age. I am delighted to see, as a railway engineer, the current promising situation for railways which has become very reliable and stable.

In these circumstances, I think it likely that railway related industries across the world will seize this opportunity to enhance their business. We should welcome this development to build up a high performance and efficient railway system based on the principle of competition. I should like to suggest, however, that the safety of rail transport is vitally important and not to be compromised by rough-and-ready decisions made for economic reasons. I should also like to emphasize the need to avoid feelings of frustration in terms of technical development likely to arise in a monopoly market which emerges as the result of mergers and acquisitions in the manufacturing industry.

Moreover, regarding the international standardization of railway technologies now in progress, I should like to mention that appropriate degrees of freedom are essential to facilitate the future development of railway technologies, although I agree that certain technical unifications are required. It may sound extreme, but if systems are unified or standardized too much in pursuit of the convenience offered by interoperability, for example, no new or innovative technologies will be born in the future. This will ultimately lead to stagnation in the development of new railway technology - you could even say that it would become an endangered species.

I believe that promotion of the continuous development of similar technologies in several different locations with balance and variations is necessary for the future development of railway technologies in the world, although this may not be strictly economic. In order to enhance technical development, information and personal exchanges are important between engineers in the same fields. The Railway Technical Research Institute is making efforts to facilitate such international exchanges by receiving 200 to 300 overseas visitors and sending almost the same number of its researchers abroad. The Division the author belongs to is implementing and supporting such activities along with collaborative research with overseas railway organizations and universities. It would give me the greatest pleasure if I have the chance to meet you at these situations in the near future.

Development of Contact-Wire/Battery Hybrid LRV

Masamichi OGASA
Senior Researcher, Laboratory Head, Traction Control, Vehicle Control Technology Division

Contact-wire/battery hybrid vehicles run on a hybrid power source that enables energy to be fed from contact wires and/or onboard batteries. Regenerated energy is returned to the contact wires and/or onboard batteries during braking in track sections, thereby ensuring the effective utilization of energy (Fig. 1). In track sections where no contact wires are installed, such vehicles can run using energy supplied only from the onboard batteries (Fig. 2).
In electrified track sections, hybrid running saves energy because regeneration cancellation does not occur, thereby improving the reliability of the regenerating brake. Additionally, running in non-electrified track sections (which offer savings in terms of contact wire installation and maintenance costs) prevents the degradation of urban landscapes to preserve the value of sightseeing resources and improves passenger convenience by enabling through-operation to/from electrified track sections.
As one of the targets of this study, the Traction Control Laboratory developed a contact-wire hybrid car and had it manufactured. The data of running distance after one spell of charging using only energy from the onboard batteries, and energy consumption during hybrid running in actual track sections compared with that of existing inverter vehicles was acquired. And the battery performance in low-temperature areas was also checked.
As another target, the laboratory developed a method of charging to quickly supply energy to the vehicles in midway stations distributed at intervals of several kilometers, while aiming at continuous running in non-electrified track sections using only energy from the onboard batteries.
The purposes and results of the study are outlined below.

(1) The Traction Control Laboratory developed the various element technologies required to enable continuous battery driving. It adopted, for example, a system for contact charging through a pantograph from rigid contact wires, and conducted a stationary test at a charging current of 1,000 A to confirm that the contact point would not melt. It also developed a structure to cool the onboard lithium ion batteries (thereby suppressing increases in their temperature), determined the interval between the cells in the battery module, and ascertained the required volume of cooling air through tests and thermal simulation. The laboratory then installed a cooling fan with a maximum capacity of 5 m/sec on the vehcile. It also developed a dual-voltage contact-wire hybrid exchanger with a quick-charge function and a capacity of 600 kW, suitable for application both to 1,500 V and 600 V DC voltages.

(2) The Laboratory had a contact-wire/battery-type hybrid car manufactured that reflected the element technologies developed, including those introduced above, in its design (Fig. 3).
In consideration of the number of batteries to be mounted for running in non-electrified track sections, the car was designed with an onboard battery system featuring a nominal capacity of 72 kWh at a nominal voltage of 600 V. It was demonstrated that batteries and a charger could be mounted in a compact formation on the LRV carbody with the smallest dimensions of all LRV cars in Japan.

(3) The laboratory implemented a test on quick charging from rigid contact wires for the LRV car developed (Fig. 4). In this test, the onboard batteries were charged over a period of about 60 seconds at a charging current of 1,000 A with enough energy to run 4 km or more (Table 1). The test therefore proved the feasibility of quick charging with no melting at the contact point and restriction of the temperature increase in the onboard batteries to 3° C.

(4) The LRV car developed was put into test on a commercial service line of Sapporo City's Transport Bureau. It ran 25.8 km on an actual operation diagram while heating the passenger room without power from external sources, and recorded a regeneration ratio of 41% (the volume of regenerated power divided by the power consumed in running) (Fig. 5). During running in electrified track sections while charging the batteries, energy consumption was cut by 30% over that of existing inverter cars.

This study was promoted under a contract with the NEDO (New Energy and Industrial Technology Development Organization).

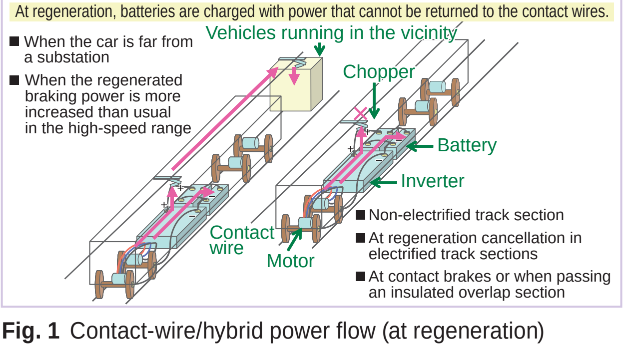


Fig. 1 Contact-wire/hybrid power flow (at regeneration)

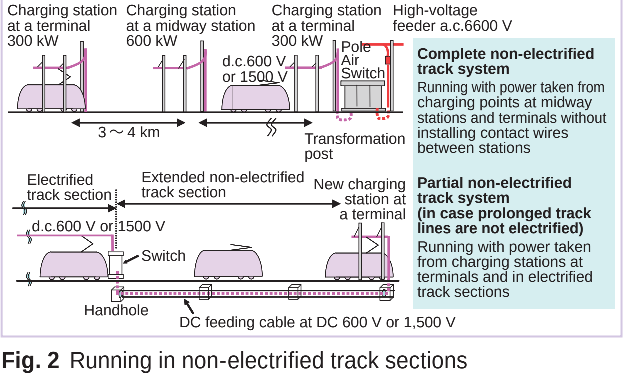


Fig. 2 Running in non-electrified track sections

Fig. 3 Contact-wire/battery hybrid LRV

Fig. 4 Quick charging from rigid contact wires

Table 1 Energy obtained by quick charging

Battery charging current and duration	Power charged at battery terminals	Running distance after a one short time of quick charging (without air conditioning)	Running distance after a one short time of quick charging (at the maximum air conditioning load)
1,000 A x 61 sec	13.7% of the capacity	Equivalent to 7.9 km	4.0 km or over
500 A x 3 min and 16 sec	21.9% of the capacity	Equivalent to 12.7 km	6.4 km or over

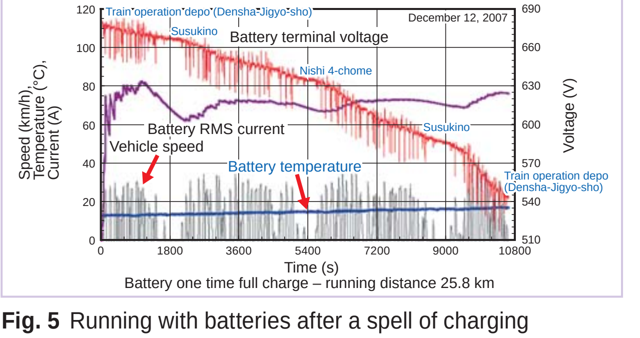


Fig. 5 Running with batteries after a spell of charging

Human Factor Analysis Method for Improving Safety Management

Yumeko MIYACHI
Senior Researcher, Safety Analysis, Human Science Division

It is thought that there are problems related to the safety system or safety climate of an organization even when an accident is triggered by the result of an individual's work. To solve these problems, an organization needs to make an assessment to determine how to deal with the issues. To prevent accidents caused by human errors, we have to assess what the events (human errors) are that make the accident and what factors (human factors) influence on the occurrence of events. We have therefore developed a technique for on-site level of railway organizations. This is aims to analyze the background factors behind human errors rightly and easy. Three analyzing processes integrate into this (Fig.1).

In the first stage, we clarify what actions (human errors) are the events that lead to accidents. Therefore, we put related elements such as work content (S), the actions of workers and inspectors (L) and machine conditions (H) in time series expressions (Fig. 2) in time series expressions (Fig. 2). The range of investigation includes the contents of instructions and plans to examine whether there are problems that may have caused human errors. Time series is place in order of PDCA cycle (Plan-Do-Check-Action). The PDCA cycle is a management concept to improve the quality of an organization or work performance and to draw continuous improvement. To ensure that the results of the action of a worker (D) are appropriate, the plan and instructions (P) at the preceding stage must be appropriate. Moreover, to ensure that the plan and instructions (P) are appropriate, the check and record (C) and any action taken to deal with trouble (A) at the preceding stage must also be appropriate.

In the second stage of the analysis, we track the cause (background factor) that generates the events (human errors) linked with accidents by means of "why and why analysis." It is thought that, in the background of a problem event, there are multiple reasons which may lead to the event. Further, there may be deeper background factors that lie behind these reasons. When we pursue an accident event to its root cause, we repeat the analysis on "why it has become so" several times to determine a clue for solution. To avoid the repetition of irrelevant questions "why," it is important that "what the problem event is as the object of analysis" is definitely grasped at the first stage. Furthermore, we check whether the viewpoint for analysis has multiple aspects and whether tracking efforts have reached the management factors. To implement multi-viewpoint analysis, it is advisable to deploy multiple analyzers.

After collecting information in depth on the background factors at the first and second stages, we finally discuss accident prevention measures. We select functions out of number of conceivable candidate concepts and combine to achieve maximum effectiveness. Even though the contents of measures may have no faults, those who implement them are human beings. To prevent unexpected problems caused by new measures, therefore, it is more important than the measures contents that the reason why they are being implemented is understood throughout the organization.

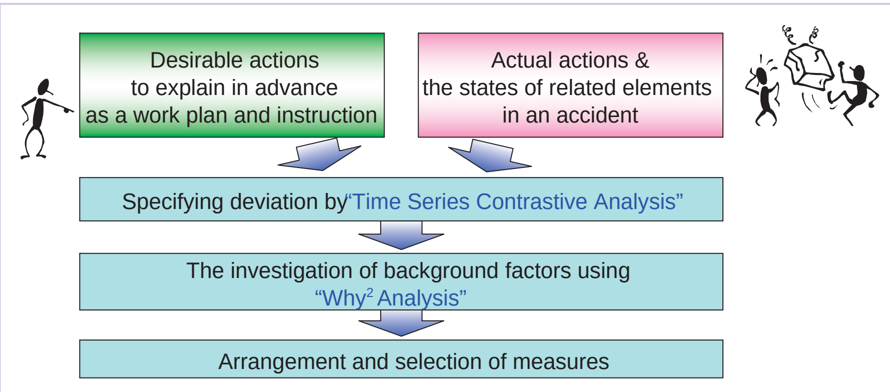


Fig. 1 Three procedural steps in human factor analysis

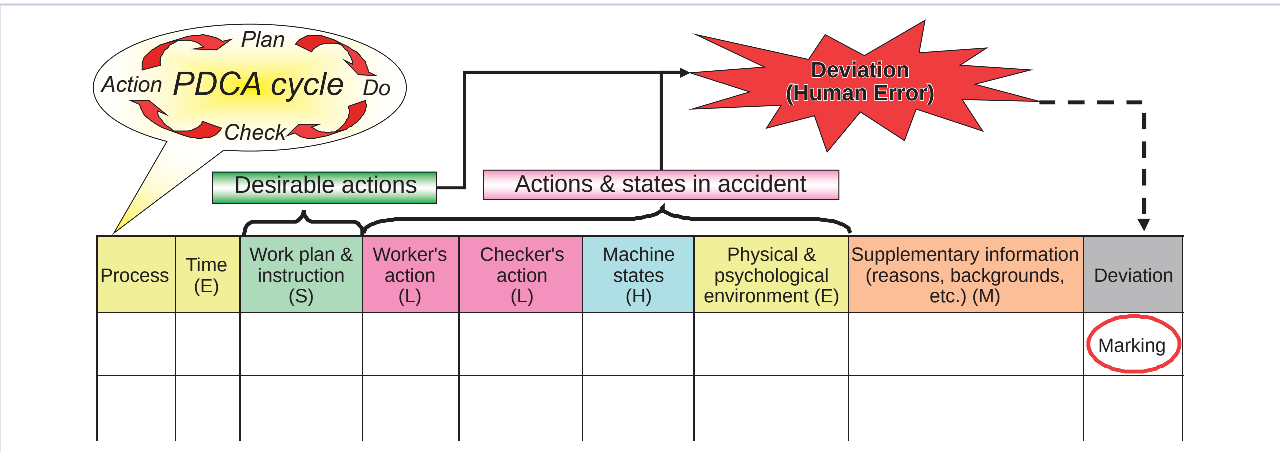


Fig. 2 How to describe "Time Series Contrastive Analysis"

Evaluation of Compression Behavior of the End-Structure of Intermediate Car

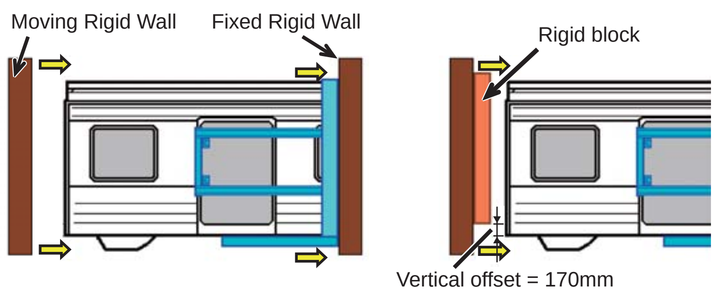
Tomohiro OKINO
Assistant Senior Researcher, Vehicle & Bogie Parts Strength, Vehicle Structure Technology Division

When a moving train collides with an obstacle, it is often the case that not only the leading car but also the intermediate cars are subjected to an impact that may destroy the end-structure. As the strength of the car body underframe is higher than that of other parts, it is supposed that the car body deformation modes are significantly different when the underframes of two adjacent cars collide with each other at the same height and when the underframe of one car overrides the underframe of the other. In discussing the safety features of a train in a collision, therefore, it is important to clarify the collision behavior of the end-structure of intermediate car in the trainset. To assess the compression behavior of the end-structure of intermediate car, therefore, the Railway Technical Research Institute (RTRI) implemented static compression tests for part car bodies of actual size.

Specimens prepared by cutting the end section of a stainless steel car body were subjected to the test under two conditions: full-lap and vertical offset conditions (Fig. 1). Under the full-lap condition, the whole car body end plate surface was pushed by a rigid wall. Under the vertical offset condition on the other hand, the car body end plate was pushed by a rigid block that was set 170 mm higher than the bottom of the car body to override the 150 mm-high underframe. Figures 2 and 4 respectively illustrate the deformed shape and the relationship between the load and deformation for each test case thus obtained. Under the full-lap condition, the end-structure deformed with the end plate remaining almost flat. The load rapidly increased after the value of deformation exceeded 70 mm, eventually reaching a maximum of about 2,400 kN. Under the vertical offset condition on the other hand, the underframe remained almost intact and the parts above the underframe, which are the end plate, side plate, roof plate and other superstructures deformed because the welding joints between the end plate and the underframe were ruptured. No conspicuous peaks appeared in the load, which was about 900 kN at the maximum. These findings clarify that, when the collision between the coupled end-structures of intermediate cars occurred, the deformation mode and the generated load depend significantly on whether or not one car overrides the other car.

The RTRI also implemented FEM analysis equivalent to the static compression test. Figures 3 and 4 respectively show the deformed FE models obtained by the calculations and the relationships between the compression load and deformation, which were obtained from the test or the analysis. The deformed shapes indicate that FEM analysis reproduces the test results of the actual car body, in that it expresses not only the bending of plates and beams but also a rupture at the welding joints between the end plate and the underframe. The relationships of load versus deformation are also in good agreement with the test results for each condition. Therefore, it is conclusive that the analysis reproduces the test results satisfactorily.

This research was subsidized by "Japanese Ministry of Land, Infrastructure and Transport" and conducted as part of "Research to Improve Railway Vehicle Crashworthiness."

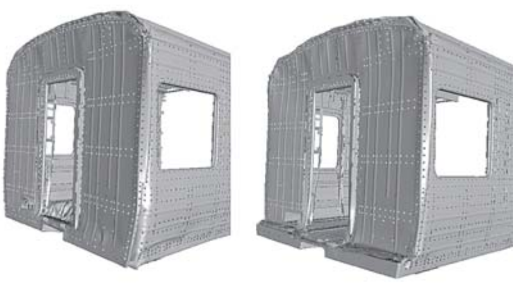


Full-lap condition Vertical offset condition

Fig. 1 Testing condition

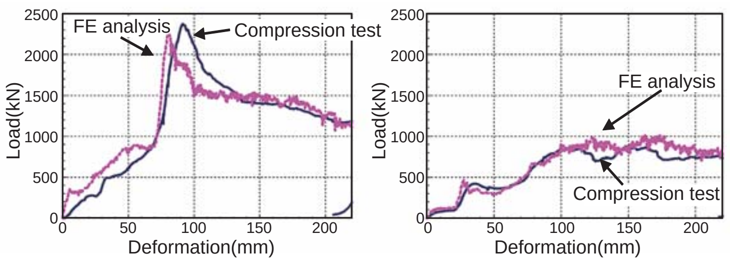
Full-lap condition Vertical offset condition

Fig. 2 Testing results of deformed shape



(a) Full-lap condition (b) Vertical offset condition

Fig. 3 Deformed FE models



(a) Full-lap condition (b) Vertical offset condition

Fig. 4 Comparison of the compression load to deformation curves between testing and numerical results

A Properties Measuring System for HTS Wires

Masafumi OGATA
Senior Researcher, Cryogenic Systems, Maglev Systems Technology Division

Twenty years have passed since the discovery of the phenomenon of high-temperature superconductivity. Studies have now shifted away from basic research and are focusing on the field of application. At the same time, remarkable progress has been in the field of high-temperature superconducting (HTS) wires made of rare earth (RE) coated materials featuring high values of critical current in the environment where the temperature is higher and the magnetic field is stronger than ever.

In this context, the Railway Technical Research Institute (RTRI) has started a study on the application of RE coated wires to HTS magnets for the magnetic levitation railway system (maglev system). In this study, it is important to examine thoroughly the properties of the wire to be used and reflect them in the design of superconducting magnets. Therefore, the RTRI has developed an HTS wire testing device to evaluate the conductivity characteristics of HTS wires in detail under arbitrary temperature and magnetic field conditions.

Figure 1 shows a schematic diagram of the device. It is constructed so that a specimen holder housing a sample wire can be inserted into the magnetic field generated by a superconducting coil. The sample wire, an actual 100 mm-long superconducting wire, can be cooled down to about 10 K degrees by a two-stage GM refrigerator or kept at an arbitrary temperature over 10 K degrees with a heater. The sample wire can be loaded with a maximum current of 1,000 A and a magnetic field up to 5.5 T in a direction selected from five angles. To ensure a stable low-temperature environment, the sample space is covered with a radiation shield cooled by a one-stage GM refrigerator and housed in a vacuum vessel supported with an adiabatic member. Table 1 shows the principal specifications of the device.

Figure 2 shows an example of the test results with a commercially available HTS wire, which illustrates the value of critical current in three dimensions with the set temperature and the strength of loaded magnetic field as parameters. Through this study, the RTRI has confirmed that the properties of the temperature and the magnetic field at the critical current can be realized by using an actual wire.

The RTRI will now use this device to evaluate the properties of different superconducting wires and utilize the knowledge thus obtained to discuss the applicability of RE coated wires to the superconducting magnets for the maglev system.

This research has been carried out with financial support from the Ministry of Land, Infrastructure and Transport, Japan.

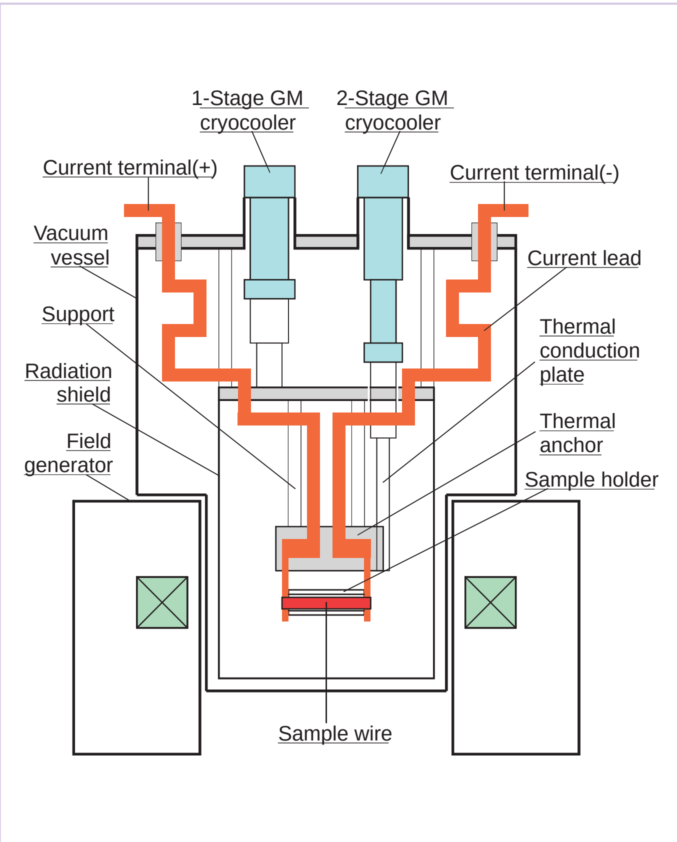


Fig. 1 Schematic diagram of properties measuring system for HTS wires

Table 1 Specifications of properties measuring system for HTS wires

Current	0 ～ 1000 A
Temperature	10 K ～
Magnetic field	0 ～ 5.5 T
Sample length	100 mm (electrodes distance of holder)
Field angle	0˚, 30˚, 45˚, 60˚, 90˚ (c-axis)

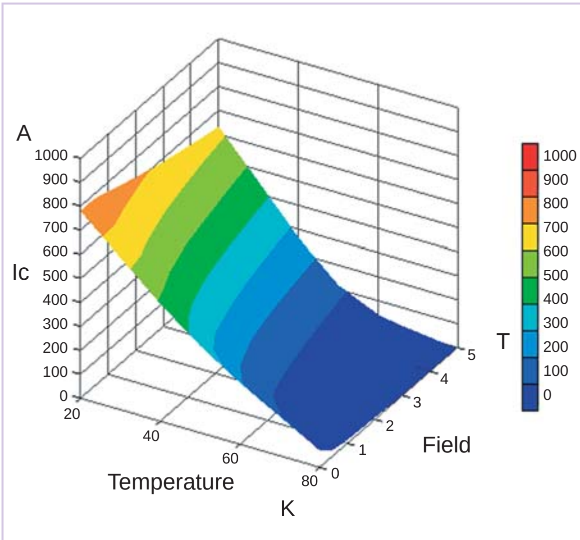
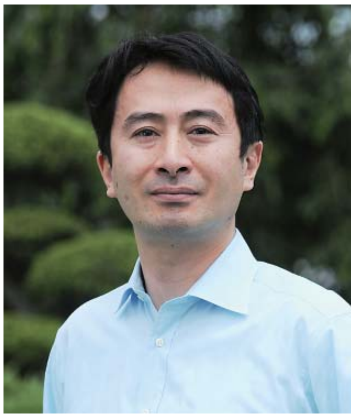


Fig. 2 Test result of Ic profiles on temperature and magnetic field for a commercial HTS wire (B⊥c-axis)

A Report on WCRR 2008

Tetsuo UZUKA
General Manager, International Affairs, International Affairs Division



The 8th World Congress on Railway Research (WCRR 2008) was successfully held in Seoul, Korea, from May 18 to 22, 2008, under the auspices of the Korea Railroad Corporation (KORAIL), the Korea Rail Network Authority (KRNA) and the Korea Railroad Research Institute (KRRI) with the full support of the country's railway industries. Approximately 800 members from 35 countries participated in the Congress, whose 49 sessions were contributed to by a total of 290 theses. The principal theme of the Congress was *Towards a Global Railway.* The Railway Technical Research Institute (RTRI) sent 23 members to make oral presentations and poster sessions. At an exhibition held in parallel, the RTRI ran "RTRI JR GROUP" booth to introduce advanced technologies using JR group brochures, posters and videotapes. Three RTRI members also presided over a session each.

Mr. Masao Uchida, RTRI Exective Director, gave a keynote speech entitled *Technology Innovation and its Implementation around the World* at the plenary session to introduce a wide range of technologies in Asia on the topics of high speed, safety, passenger convenience, infrastructure maintenance and conservation of the global environment.

The following pages summarize the theses contributed to the Congress by eight speakers from the RTRI.

The RTRI JR GROUP booth at WCRR 2008

RTRI Exective Director Masao Uchida speaking at the WCRR 2008 plenary session

Presentations from RTRI

Session		Presenter	Paper Title
I.3.1.1	Infrastructure - Effect of Climate Change & Natural Disaster	Hiroyuki SAKAI	A Long-Term Observation System for Protecting Railroad Services from Natural Disasters against Climate Changes Causing Heavier Precipitation
G.1.4.4	Global Railway Issues - Sustainable Development Strategy I	Naoki AIHARA	Evaluation of Modal Shift by Extension of the Tohoku Shinkansen Line
I.2.1.1	Infrastructure - Condition Monitoring & Inspection II	Hirofumi TANAKA	Estimating Method of Wheel Load and Lateral Force Using Axle-box Accelerations
I.3.3.6	Infrastructure - Electrification & Catenary II	Mizuki TSUNEMOTO	The Effect of Resistance at Supporting Point on Tension and Current Collection Performance of Overhead Contact Line
I.2.3.1	Infrastructure - Structures: Bridges	Xiu LUO	Damage Evaluation of Railway Structures Based on Train-Induced Secondary AE Parameters
I.2.3.2	Intrastructure - Electrification & Catenary I	Takehiro KOBAYASI	Transition Structures between Rigid Conductor Line and Catenary Overhead Contact Line
R.2.4.3	Rolling Stock - Comfort & Ride Quality	Akihito KAZATO	Measures against High-Frequency Vibration for Next-Generation Tilt Control System
R.3.3.3	Rolling Stock - Components Design II	Shogo KAMOSHITA	Development of Assist Steering Bogie System for Reducing the Lateral Force
R.2.4.7	Rolling Stock - Vehicle Maintenance	Kazuyuki HANDA	Experimental Reproduction of Wheel Thermal Cracks
R.3.3.7	Rolling Stock - Maglev	Erimitsu SUZUKI	Vibration Reduction Control Methods for Superconducting Maglev Vehicles
S.2.3.4	System Interaction - Aerodynamics	Atsushi IDO	Study on Under-Floor Flow to Prevent Ballast-Flying Phenomena
S.3.1.4	System Interaction - Electromagnetic Compatibility	Haruo YAMAMOTO	Effect of Current Collection Noise and Interception in Running on GPS Signal Reception
S.2.4.4	System interaction - Aerodynamic & Aeroacoustics	Mitsuru IKEDA	Evaluation of Aeroacoustic Noise Source Structure around Panhead of a Pantograph in High-Speed Railway
S.1.4.3	System Interaction - Pantograph / Catenary Interaction	Takayuki USUDA	The Pantograph Contact Force Measurement Method in Overhead Catenary System
S.2.2.4	System Interaction - Wheel / Rail Interface II	Sinya FUKAGAI	Development of Friction Moderating System to Improve Wheel/Rail Interface in Sharp Curves
Poster		Tetsuo UZUKA	Integrated Simulator for AC Traction Power Supply
Poster		Shunsuke SHIOMI	Development on Analysis Model for Shinkansen Switch-and-Lock System
Poster		Yasuhiro UMEHARA	A study of Virtual Running Test of Railway Vehicle
Poster		Tamami KAWASAKI	Hygienic Environment of Railway Stations - Investigation and Countermeasures for Reduction of Microbial Volatile Organic Compounds (MVOCs) Generated by Fungi in Railway Stations -
Poster		Keiichi TAKEUCHI	An Estimation Method of the Possibility of Constructing High-Speed Data Transmission Lines Using Metallic Cables along Railway Lines
Poster		Fumio OKIMOTO	A Study for Reducing Wear of Contact Wire at Stations of High Speed Line by Using Wear Map of Wire
Poster		Kenichi OGAWA	Energy Efficiency and Fuel Consumption Rate of Fuel Cells Test Railway Vehicle
Poster		Naoki AIHARA	Inventory Analysis of Transport in Japan Based on Input-Output Tables

Damage Evaluation of Railway Structures Based on Train-Induced Secondary AE Parameters

Xiu LUO
Senior Researcher, Earthquake & Structural Engineering, Structures Technology Division

A difficult task for the maintenance of existing railway structures is to evaluate using non-destructive methods the structural integrity of invisible structures whose foundations are in the ground. If visual methods are used, it is generally necessary to excavate the subgrade soil surrounding the foundations. With railway structures this kind of excavation is impractical, because it is expensive and it may also affect the operational safety of trains.

If active inspection methods such as ultrasonic testing or X-ray radiography are applied to the foundations, the input power has to be strong enough to cope with the problem of the high damping effect of a concrete mass and soil around the foundations, which is also impracticable.

Therefore, we have developed a passive inspection method taking advantage of secondary AE (Acoustic Emission) generated in the sections of structures that may be subject to damage, which is induced by trains in service (see Fig.1). In fact, the train-induced AE technique has the potential to evaluate damage occurring not only in the super-structures but also in the sub-structures as the considerable load exerted by the train can overcome the high damping caused by the mass of concrete in the foundation and the surrounding soil.

To verify the adequacy of the proposed method, a fundamental study into the characteristics of secondary AE has been conducted based on AE experiments with model piles. To improve the applicability of the secondary AE technique, a considerable amount of in-situ AE monitoring using railway bridges as test objects has been carried out (Fig.2). Based on these experiments, some practical indices to quantify the degree of damage to the structure, such as RTRI, Caml and Ib-value have been proposed.

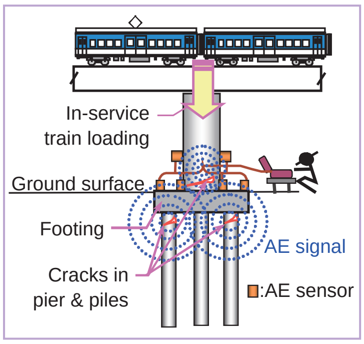


Fig. 1 Proposed AE inspection

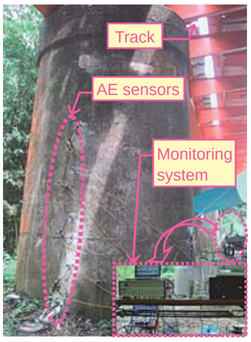


Fig. 2 In-situ AE monitoring

Development of an Assisted Steering Bogie System for Reducing Lateral Forces Exerted on the Track

Shogo KAMOSHITA
Senior Researcher, Vehicle Noise & Vibration, Vehicle Structure Technology Division

Japanese narrow gauge lines, exhibit many tight curves with short transition curves because they have been laid mostly in mountainous regions or along coastal areas. To shorten travel times for passengers it is therefore very important for trains to be able to run faster through curves.

However, running faster in curved sections tends to increase the lateral forces exerted on the track at the point of contact between wheel and rail. Many problems arise from the increased lateral force in curved sections such as derailments, or wear of wheel and rail.

Because of this, many types of steering bogie have been tested in Japan. For example, a bogie angle linked steering truck that changes the attack angle corresponding to the bogie angle has already been developed and used in commercial service. This system is very effective in circular curves, but its performance in transition curves is relatively poor because the curvature of the transition curves gradually changes, and the steering angle of the wheel-sets does not change at the same time as the curvature.

Given this situation, the authors studied a system that supplements the active steering force of the ordinary bogie angle linked steering mechanism and carried out running tests on the RTRI's test track. We call this an "assisted steering bogie system".

We examined two types of assistance actuators that were arranged on the steering beam and the axle boxes (Fig. 1). Hydraulic cylinders are used to drive the assistance actuators of this system, and they are controlled by a Direct Drive Volume Control unit with pressure control. The actuators assist the steering force in the transition curves, and they are then released so that they have no effect on other sections of track as this could obstruct the motion of the bogie angle linked steering.

The results of the studies show the effect of the assisted steering bogie system and its ability to reduce the lateral force by almost half on transition curve sections (Fig. 2). We are considering whether to extend the use of these steering bogie systems to practical applications with a fail-safe function and much improved performance on curved sections.

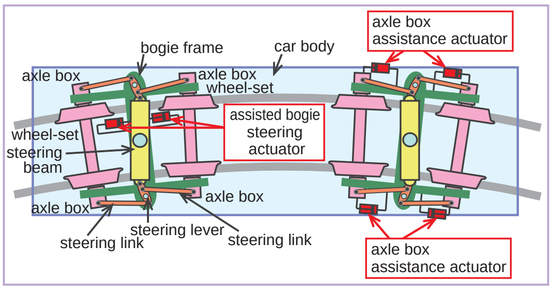


Fig. 1 Components of assisted steering system

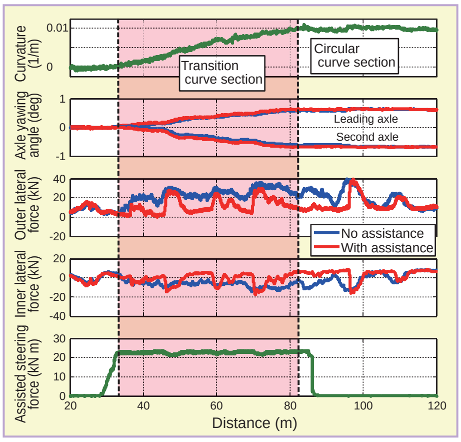


Fig. 2 Test result of assisted steering

Experimental Reproduction of Wheel Thermal Cracks

Kazuyuki HANDA
Assistant Senior Researcher, Frictional Materials, Materials Technology Division

Thermal cracks initiating in the wheels of vehicles equipped with tread brakes cause an increase in rolling noise and a deterioration in ride comfort. Not only that, but they reduce the service life of the wheel because of the larger cutting depth needed when reprofiling the wheel. However, the crack initiation process and mechanism are complicated, and a fundamental solution has therefore not yet been found.

In addition, cracks equivalent to the thermal cracks found on the actual vehicle wheel had until now not been recreated in a stationary bench test, so we had no testing methodology to examine the phenomenon. In the present study wheel tread thermal cracks have been experimentally reproduced using full-scale brake test apparatus. Factors affecting the initiation of thermal cracks as well as the wear of the wheel tread are specified by the observational analyses. We estimate that thermal cracks in the wheel initiate under conditions of both repeated heat input from the brake shoe and from rolling contact with the rail. Judging from the area of crack initiation and growth, load cycles caused by rolling contact with the rail as well as the heat input cycle generated by the brake shoes greatly affect the growth of thermal cracks in the wheel.

We have also shown the probability that the nature of the wear of the wheel tread is not simple wear caused by friction with the brake shoe but plastic deformation of the wheel material whose temperature has risen as a result of the friction caused by the brake shoes.

The knowledge obtained in the present study will be of considerable importance in reducing maintenance costs and in optimizing the friction brake system designs.

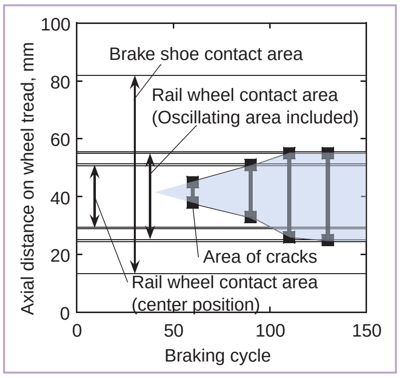


Fig. 1 The condition of crack initiation and growth

Study of Under-Floor Air Flow to Reduce the Phenomenon of Flying Ballast

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Complex air flows arise between the underside of trains and the track caused by the interaction between them. The flow is one of the main causes of the phenomena of flying ballast and of snow building up on the underside of the cars. Snow adheres to the underside of the train and drops in lumps on to the track, also causing ballast to fly up.

To study the under-floor air flows, we measured it in field tests on the track (Fig. 1, Fig. 2) and confirmed that smoothing the underside of the cars reduced the velocity of the air flow (Fig. 3).

To investigate the possibility of reducing the impact of the flow by modifying the shape of the underside of the cars, we carried out tests in a wind tunnel.

By comparing the air flow measured in the on-track tests with that in the wind tunnel tests, we were able to verify that the flow in the on-track tests was reproduced in the wind tunnel tests. We measured the velocity profiles of the air flow beneath the cars.

We understood that the velocity of the flow decreased as we smoothed the shape of the under-floor area. Furthermore, we developed a model running facility that enabled us to estimate the velocity of the flow above the ground as the train passes over it.

Next, we carried out a study on a new measure (passive control of the air flow using deflectors fitted to the car bodies to reduce the build-up of snow on the underside of trains. Using wind tunnel tests, we confirmed that the deflectors reduced the velocity of the flow and that the velocity reduction effect was related to the angle of the deflectors. To verify the effect of the deflectors in reducing the build-up of snow we carried out the wind tunnel tests using artificial snow particles. We found out that the snow particle flux decreased near the bogies thanks to the deflectors and that the effect of reducing the snow particle flux extended over a large area near the bogies.

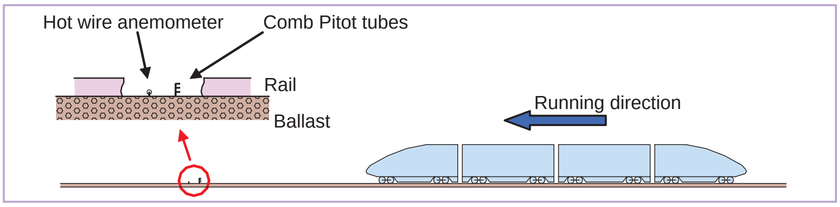

Fig. 1 Measurement of air flow above the ballast

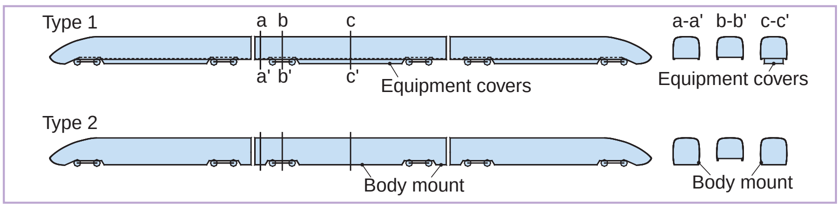

Fig. 2 Under-floor shape of the car

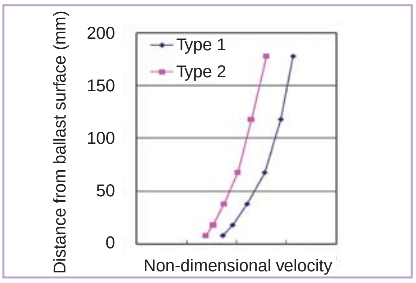

Fig. 3 Velocity profiles of the air flow above the ballast

Vibration Reduction Methods for Superconducting Maglev Vehicles

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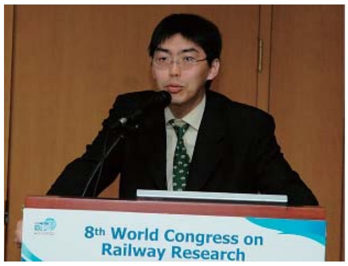
Senior Researcher, Electromagnetic Applications, Maglev Systems Technology Division



A study was conducted on the effectiveness of applying vibration control methods to the primary and secondary suspension components in a three-car model of the vertical and pitching motions of a superconducting Maglev train.

A linear generator device has previously been demonstrated in full-scale vehicle running experiments to generate on-board power. This device was also able to effectively apply additional electromagnetic forces to the primary suspension and reduce vibrations of relatively higher frequencies that are otherwise difficult to reduce by controlling only the secondary suspension.

The Maglev train set has an articulated bogie arrangement, in which all bogies are evenly spaced along the train set. Utilizing these properties, techniques for preview control of the secondary suspension are examined that measure external disturbances at the front of the Maglev train set and feed the data to the rear of the train set, to enhance the ability of the vehicle to efficiently minimize the impact of irregularities in the guideway ground coil alignment.

The figure shows an example of the results of simulations for a Maglev vehicle traveling at a constant speed of 500 km/h. Case A represents a frequency-shaped optimal preview control of the secondary suspension, and Case B represents the combination of Case A and maximum force control of the primary suspension. Case A, which controls only the secondary suspension, has significantly reduced the middle car body vertical acceleration power spectral density (PSD) peak at around 1 to 2 Hz, while only slightly reducing the peak at around 4 to 5 Hz. Case B, which controls both the primary and secondary suspension components, has significantly reduced both PSD peaks.

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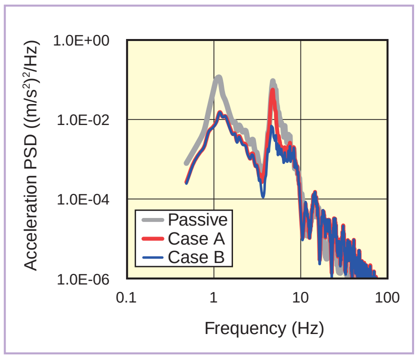

Fig. 1 Middle car body vertical acceleration power spectral densities

Effects of Current Collection Noise and Lineside Obstructions on GPS Signal Reception

Haruo YAMAMOTO
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In the future we would like to integrate the onboard location detection function of GPS/GNSS with CBTC (Communications-Based Train Control). However, GPS signals are often obstructed by topography and structures, and this is a common problem for land transport. This especially affects railways, where various structures such as road bridges and truss bridges, and concrete electrification masts, exist adjacent to the tracks, making the receiving environment unfavorable. Moreover, on electric railways there is concern that radio noise generated from the contact wire and the pantograph affect the frequency bandwidth (GHz band) which is used by GPS. Therefore, we commenced research to investigate the GPS signal receiving environment on railways and the effects on GPS positioning.

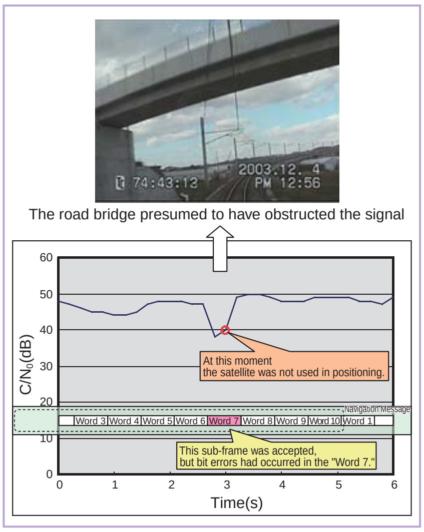

Fig. 1 C/N_0 deterioration and navigation message error at passing under an overbridge

In on-track tests, GPS antennas were temporarily installed at two locations on the roof of an electric railcar, which runs on a line electrified at 1,500 V DC. One antenna was installed as close as possible to a pantograph to measure adverse effects due to the current collection noise, and other equipment was temporarily installed in the cabin. The outputs of the GPS receivers were recorded, and the intensity of radio noise in the central frequency (1.57542GHz) of the GPS usage band was measured at the receiver input edge. Furthermore, video recordings were made from the front and rear driver's cabs to record obstructions such as bridges along the line that might shield the GPS antennas. The test train made two round trips of approximately 43km over an existing line (partly single track) at less than 95km/h.

The following observations emerged from the tests.

Since GPS is performing data transmission by spread spectrum, it is conceivable that the adverse effects of radio noise generated from the contact wire and the pantograph have little direct effect on the accuracy of the positioning. However, it is preferable to position a GPS antenna on a roof away from the pantograph if possible.

In addition, it became evident that GPS signals may be obstructed when the train is running by structures and installations adjacent to the track; this not only causes the positioning rate to degrade but also leads to errors in the navigation messages (Fig. 1). If such irregularities in navigation messages are ignored, it is possible that there will be a serious effect on the positioning which could be of critical importance. In applying GPS to safety systems such as train control, adequate measures are essential to eliminate this type of hazard by ensuring that the navigation messages are received in duplicate.

A Method to Measure the Pantograph Contact Force on the Overhead Catenary System

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RTRI is developing a method to measure the contact force exerted by all pantographs passing through a specified area where sensors located on the catenary. In this paper, we report the numerical and experimental results of the contact force measurement.

The theory of this contact force measurement method is indicated in Fig. 1. The contact force is calculated from the inertia force of the contact wire, from dropper forces and from the vertical component of the tensile force. The inertia force of the contact wire can be evaluated using accelerometers, and dropper forces can be measured by strain gauges. The vertical component of the tensile force can be calculated from the gradients of the contact wire at both ends of the measurement area by means of two pairs of accelerometers.

An example of the experimental results is shown in Fig. 2. This result indicates that this method can accurately measure the contact force in the frequency range of DC - 15Hz. Using this method, we will quantify the effects of the contact force of the pantograph on the contact wire wear in order to clarify the mechanism of contact wire wear. This measurement method is also useful for pantograph monitoring tools.

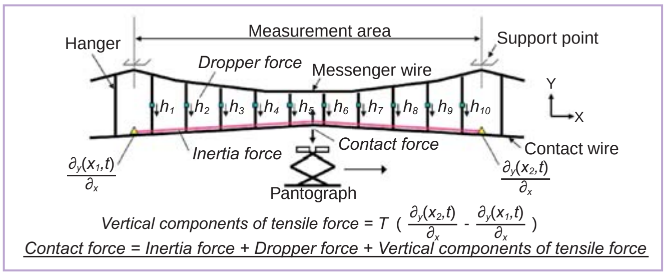

Fig. 1 Contact force measurement in Overhead Catenary System

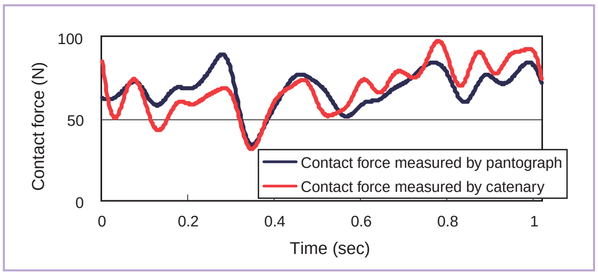

Fig. 2 Measurement results of contact force in experiment

Development of Friction Moderating System to Improve Wheel/Rail Interface in Sharp Curves

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Railway vehicles negotiate sharp curves with large lateral forces interacting between the wheel/rail interface and the angle of attack of the leading axle of a bogie; these forces depend on the bogie's steering performance. In terms of running stability and/or safety, such a large lateral force is one of the main factors contributing to wheel-flange climb derailment at low speeds. In terms of material integrity, it is also a major cause of low rail corrugation, thin flange wear of the wheel and gauge face wear of the rail, and as an environmental issue it is a particular cause of the squealing noise found on urban railways.

In the last decade, there has been a focus on lubrication of the interface between the wheel tread and the top of the low rail to reduce large lateral forces at the wheel/rail interface, to reduce low rail corrugation and to mitigate wheel squeal. However, such lubrication involves a certain risk of wheelslide due to the low traction coefficient it causes, which demands that the friction in the interface is appropriately controlled. RTRI has developed a friction moderating system (FRIMOS) that consists of a solid lubricant called a friction moderator, a device installed on the vehicle that applies the friction moderator to the wheel tread/top of the low rail interface and an application control system. The friction moderator is a solid dry lubricant and is made of carbon. The moderator application device is used to deliver a jet of the friction moderator to the interface between wheel and rail. The application control system allows adjustment for optimal delivery of the friction moderator in terms of timing and volume together with a curve detection system.

The effect of FRIMOS in reducing lateral forces was investigated in running tests using a vehicle equipped with FRIMOS, and the friction moderator was applied only to the low rail side of the track. Figure 1 shows the results of lateral forces of the low rail and high rail as measured at the track site. In the figure, the reduction of lateral forces achieved by use of the friction moderator is apparent.

A further study of an automatically controlled system for applying the friction moderator is expected to provide practical information on optimal timing and volume of the application, and it will also identify the potential of the friction moderator to prevent corrugation forming on low rail during a long period of operational service.

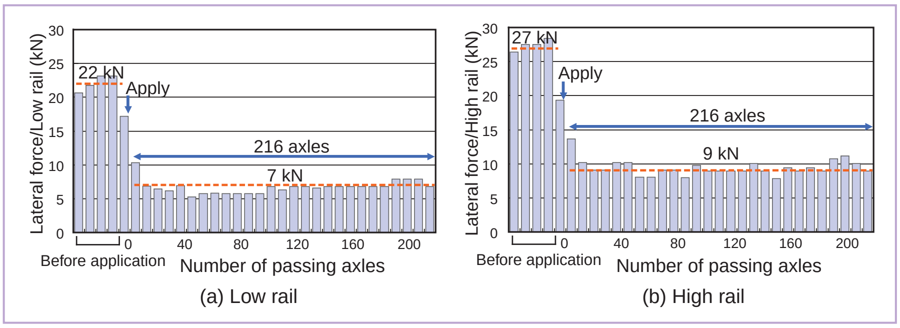

Fig. 1 Effect of the friction moderator on decreasing lateral force