



Newsletter on the
Latest Technologies
Developed by RTRI

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RTRI's Promotion of Research and Development in Recent Years

Ikuo WATANABE

Director, Research & Development Promotion Division

RTRI is now promoting research and development based on its Master plan for research policies, RESEARCH 2010, covering the period from 2010 through 2014. Research targets adopted include the improvement of railway safety and convenience, harmony with the environment and cost reduction in view of recent railway accidents/disasters and the current severe economic circumstances.

(1) Improvement of railway safety

Railways place the highest priority on safety. Therefore, RTRI is promoting a number of research projects to prevent natural disasters caused by earthquakes or strong winds and ensure the safety of passengers and rolling stock in operation as well as other measures to guarantee the safety of railways.

RTRI has developed a technique to estimate earthquake disasters at high precision using an algorithm to reflect the vibration amplifying characteristics of the ground. This is based on the perennial micro-vibration data in addition to that obtained with seismographs installed on the ground. RTRI also has developed a technique to extract the risk of the reduction of earthquake resistance of individual sections along the route, with structures represented by simplified models.

(2) Harmony with the environment

Research is under way to save energy and evaluate the effect of noise, vibration and electromagnetic fields generated by railways on the wayside environment and passenger car compartments. The research also includes determining measures to reduce the detrimental effect of these nuisances. RTRI has already developed high-efficiency induction motors to reduce losses by about 30% in medium and high-speed ranges.

(3) Cost reduction

To cut the operating costs, RTRI is promoting research projects to improve the efficiency of maintenance work and methods for designing and construction work. RTRI has already completed an image processing program to evaluate the occurrence of cracks in tunnels.

(4) Improvement of convenience for customers

To improve the convenience of railways, RTRI has developed



technologies to raise the train speeds of Shinkansen and narrow-gauge lines and also to improve transport services as a whole. Furthermore, RTRI is developing a linear motor type rail brake technology and a technique to predict passenger flows when transport has been disturbed.

(5) Construction of simulators railway engineering

RTRI is making efforts to develop models to analyze the high-frequency vibration and interaction between wheel and rail at their contact point in detail and improve simulation technologies to analyze the motion of railway cars after derailment.

In view of the aftermath of the Pacific Off-Shore Earthquake (Magnitude 9.0) that hit the Tohoku Area in March 2011, RTRI will also set/promote new themes in the future to predict the magnitudes of tsunamis after very large earthquakes.

渡辺 郁夫

The 11th China-Korea-Japan Railway Research Technical Meeting

Kazuhide YASHIRO

Manager, R&D Planning, Research & Development Promotion Division

The China Academy of Railway Sciences (CARS) hosted the 11th China-Korea-Japan Railway Research Technical Meeting in Beijing, China, on November 16th to 17th, 2011. Since 2001, the meeting has been held annually and hosted in rotation by the three railway research organizations, i.e., CARS, Korea Railroad Research Institute (KRRI) and Railway Technical Research Institute (RTRI). Over 60 persons joined the meeting this time, including Mr. Kang, President of CARS with 39 participants therefrom, Mr. Hong, President of KRRI with 10 and Mr. Ichikawa, Executive Director of RTRI with 11 (Fig.1).

To fully exchange information on our latest respective research work at the meeting, keynote speeches were made by representatives from each organization. They reported on what is going on with their research activities. At the workshop, three sessions were organized individually in the categories of civil engineering and environmental issues, rolling stock technologies, and safety improvement. At the session on civil engineering, technologies developed by CARS and KRRI to reinforce railroad tracks and embankments were outlined for high-speed rail. Even in railroad industries, environmental management has become an issue. Railroad premises have been polluted with chemicals including heavy metals and petroleum used in railroad operation for a long time. China Railway, Japan Railways and KoRail have the same problems with railroad track pollution. KRRI and RTRI have developed screening methods for heavy metal and petroleum combined with a soil sampling technology to quickly find hot spots in railroad tracks.

At the rolling stock session,

KRRI and RTRI presented technologies to observe the conditions of the contact between pantograph and catenary. The issue is one of the hottest topics in high-speed train operation within the three countries. At the safety session, we discussed strategies for safer railroad operation. We tried to

find a way to successfully organize analysis of incidents and accidents taking place in railroad operation.

At the meeting, we decided to close six research themes at the end of 2011, promote two current projects and launch two new ones. We will meet in Tokyo in the autumn of 2012 to summarize the research results for the next year and encourage all researchers from the three organizations.



Fig.1 The participants in the 11th China-Korea-Japan Research Technical Meeting at Beijing in November 2011



Fig.2 Casual exchanges over drinks after the discussions at technical sessions



Fig.3 Discussions with co-workers in the meeting

A Method to Measure the Contact Force of Pantographs through Image Processing

Tatsuya KOYAMA

Assistant Senior Researcher, Current Collection, Railway Dynamics Division

The contact force between pantograph and contact wire (hereinafter referred to as the “contact force”) is used as a criteria to evaluate contact performance (in the standard IEC 60913, for example), while research and development is being conducted to diagnose overhead catenary system conditions by utilizing contact force measurements. To improve the current collecting performance and reduce the aeroacoustic noise of pantographs, smooth-shaped panheads with complicated inner structure are increasingly used for high-speed pantographs. In the conventional contact force measuring method, panheads have built-in accelerometers and other sensors. But, the installation of sensors and wiring in the smooth-shaped panhead is difficult due to the spatial limits. To eliminate these drawbacks, RTRI has developed a contact force measuring technique which can replace the whole or part of the built-in sensors with some image processing sensors. This technique uses line sensor cameras with high-level time and spatial resolution. These are placed on the rooftop of the train near the pantograph. The system determines the contact force by evaluating the inertia force and supporting spring forces of the panhead using the image information obtained from the line sensor cameras. However, some pantographs requires built-in sensors in the panhead to measure non-linear forces such as stopper touching forces or friction forces working at the vertical guide of the panhead. These cannot be measured through image processing due to their non-linear characteristics. In that case, the new system needs far fewer built-in sensors only to measure such non-linear forces as compared with the conventional contact force measuring system. To verify the measurement precision of the new system, RTRI performed a calibration test for a pantograph which

is free from effect of non-linear forces. In this case, measurement of the contact force can be done with only three line cameras. See Fig. 1 for the configuration of the test apparatus. Figure 2 (a) shows the frequency characteristics of the contact force measurement accuracy of this technique, where the X-axis indicates frequency and the Y-axis the ratio of the measurement value to the true value. Figure 2 (b) illustrates the time history waveforms of the estimated and true values of the contact force when the panhead is subjected to 10 Hz excitation. Figures 2 (a) and 2 (b) demonstrate that the image processing technique measures the contact force between pantographs and contact wires at high precision.

This technique has been developed through a joint study with Meidensha Corporation. Meidensha has a project to supply a contact force measuring system based on this technique to Taiwan High Speed Rail.

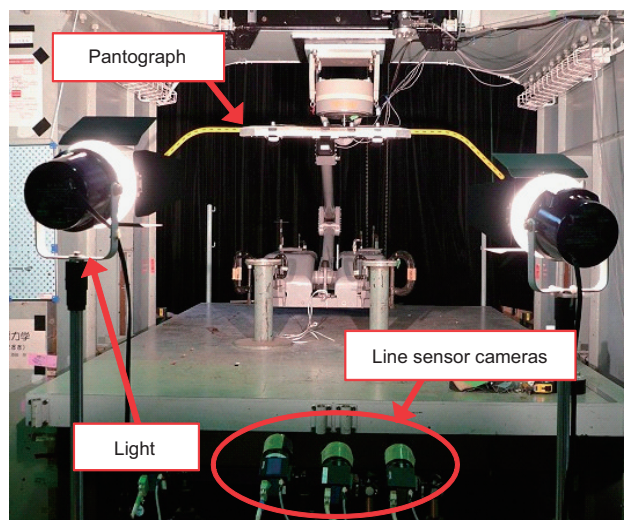
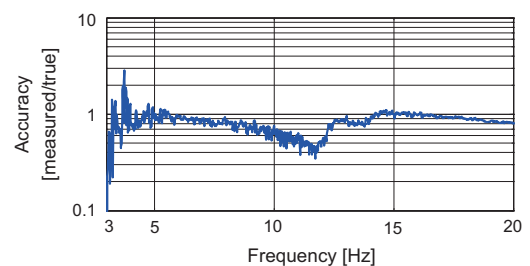
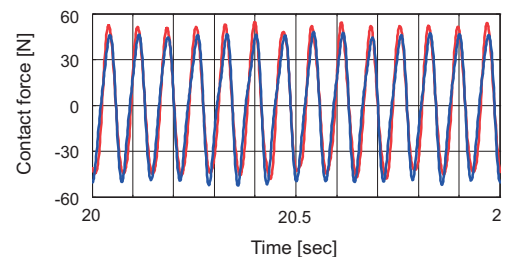


Fig. 1 Composition of the contact force measuring system using image processing



(a) Frequency characteristics
(excitation waveform: pseudo random wave)



(b) Time history response
(excitation waveform: sinusoidal wave (10 Hz), red true, blue estimated)

Fig. 2 Results of a excitation test

Wind Tunnel Test on Windbreak Fence Installed on Railway Lines

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To improve the safety and stability of railway transport under windy conditions, windbreak fences have been installed on more and more parts of railway lines in wind-exposed areas in Japan. To effectively and economically install windbreak fences, we need to know the relation between the perpendicular distance from a windbreak fence to the track and reduction in aerodynamic forces on railway vehicles. For that purpose, we conducted a wind tunnel test to measure the aerodynamic forces that act on a vehicle located at different perpendicular distances from the windbreak fence.

We conducted the test for the 1/40 scale vehicle model of narrow gauge train series 103 under atmospheric boundary layer condition where representative wind speed is 30 m/s, using a large-scale low-noise wind tunnel (measurement section $5 \times 3 \times 20$ m) at the Maibara Wind Tunnel Technical Center, RTRI. We installed a windbreak fence having a porosity of 40% at a height of 2 m (in full-scale dimensions) from the rail level on the windward side of a bridge/viaduct. A three-component aerodynamic force balance inside the vehicle model measured the side force and lift working on the model and the roll moment around the car-body center. The bridge model was actually composed of two sets of single-track bridges placed in parallel, the distance between the two of which could be varied. For the test on viaduct, we made several models with different widths. See Fig.1 for a photograph of the wind tunnel test on a viaduct.

Figure 2 shows the relation between the side force coefficient (non-dimensional side force coefficient based on vehicle side area and dynamic pressure of wind) on an intermediate vehicle and the perpendicular distance from the windbreak fence. Where there are no fences, the coefficient of side force is approximately 1.4 both with bridges and viaducts. Where a fence exists, the value of

the coefficient at a distance of 7 m from the fence is less than half that measured when there are no fences. At a distance of 13 m or over, the coefficient is larger with bridges than with viaducts, presumably because the two sets of single-track bridges are placed apart to allow air to flow in between.

In the present wind tunnel test, we used the models of vehicle and bridges/viaducts all set in a static state. Accordingly, the relative motion of the vehicle and the bridges/viaducts, which occurs in full-scale situations, was not simulated in the test. We will further study this effect of the relative motion on the estimation of the effectiveness of windbreak fences.

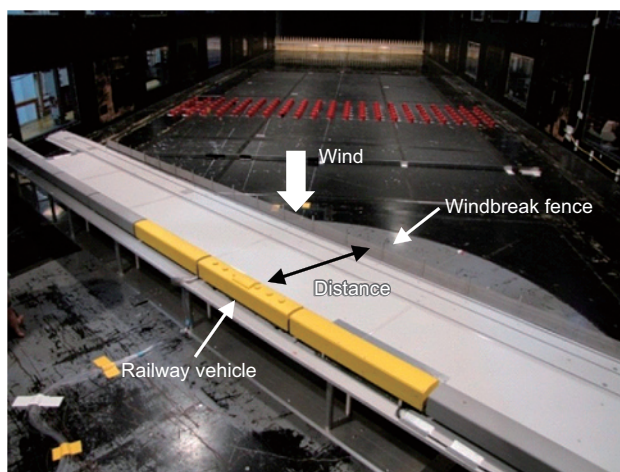


Fig. 1 A photograph of the wind tunnel test on a viaduct

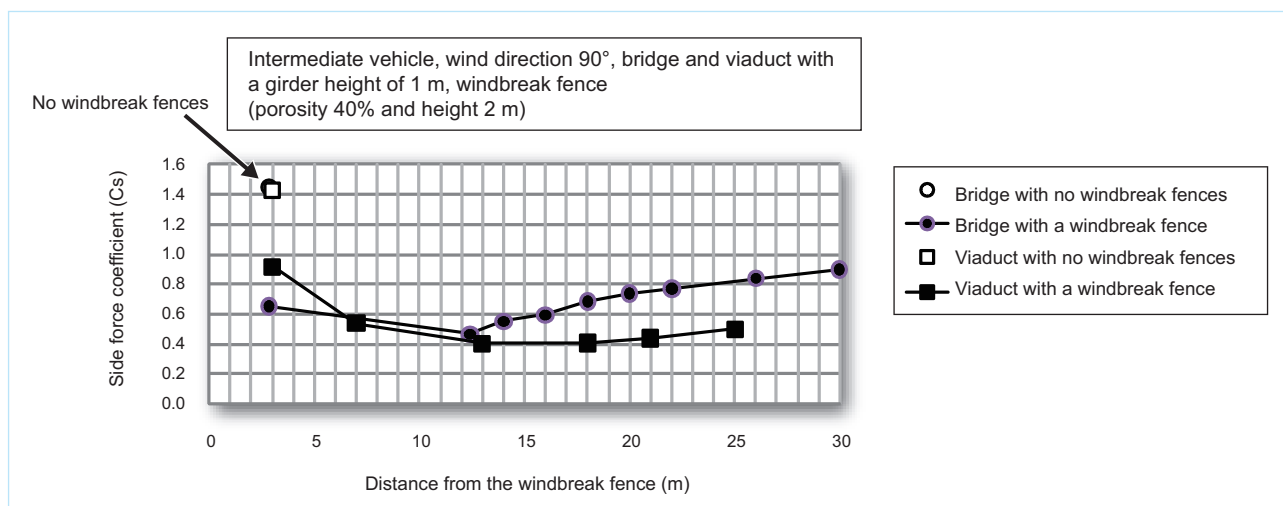


Fig. 2 Relation between the distance from the windbreak fence and the of side force coefficient (for bridge and viaduct)

A Ride Comfort Evaluation Method to Reflect the Effect of High-Frequency Vibration

Chizuru NAKAGAWA

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The ride comfort level (RCL) is a typical index used to evaluate the ride comfort of trains in Japan railways. When applied to the evaluation of high-speed rolling stock in recent years, however, the existing method of calculation yields results that do not always agree with the sensation felt by humans. This is because the high-frequency components (about 30 Hz) that are characteristic of the vibration of recent high-speed trains are not properly reflected in the RCL obtained by the existing method. These higher frequencies have a considerable effect on ride quality felt by humans.

Thus, we investigated human reaction (called “human sensibility”) to vibration in the 1 to 50 Hz band using “discomfort feeling” as a ride comfort scale using Electrodynamics vibration system (Fig. 1) to confirm that (1) human sensibility to high-frequency vibration is stronger than assumed in the existing RCL and (2) it tends to change to a certain degree irrespective of seat categories (Fig. 2) or seating postures. Based on these findings we have adopted new ride comfort filters that have been improved to emphasize the effects of high-frequency components of vertical and longitudinal vibrations (Fig. 3).

To verify the validity of the improved ride comfort filters, we implemented a running test of a Shinkansen car boarded with 30 test subjects to examine the correlation of the test results obtained with the new filters with those recorded through subjective evaluation. As a result, we confirmed that the RCLs determined with the new filters are higher than those determined with the existing filters in all evaluation sections, are in good agreement with human sensation and correlated better with human sensation than those determined by using the existing filters (Fig. 4). Additionally, through another test on a vibration system to reproduce the vibration of Shinkansen and narrow-gauge cars in service, we again confirmed that the RCLs evaluated by using the new filters are larger than those obtained by using the existing filters and produced improved correlation with the results of subjective evaluation when vibration contains high-frequency components in quantities similar to Shinkansen cars. However, we also found that where there are few high-frequency vibration components, such as in narrow-gauge cars, the RCLs obtained with the new filters are approximately the same as those obtained by using the existing ones. We also investigated the effect of the noise in 30

to 100 Hz band existing in the same frequency band as that of vibration to clarify that low-frequency has virtually no effect on the evaluation of running vibration in wide frequency bands. Based on the above findings, we have reached the following conclusions.

To apply the existing ride comfort evaluation method in practice to obtain evaluation results in agreement with human sensation, it is sufficient enough to replace the existing ride comfort filters with the improved ones, while using the existing scales and calculation methods. When the vibration to be evaluated contains few high-frequency components, the values obtained by using the new filters are comparable with those obtained in the past when using the existing filters.

This study has been promoted in part with the subsidies from the Ministry of Land, Infrastructure, Transport and Tourism.

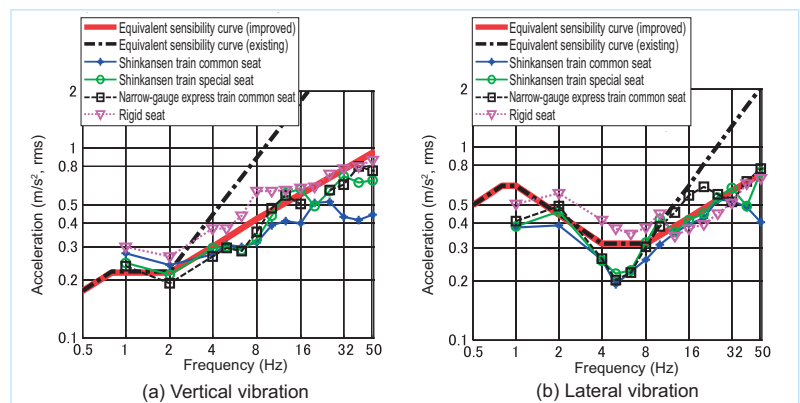


Fig. 2 Average allowable limits (test results) and the equivalent sensibility curve

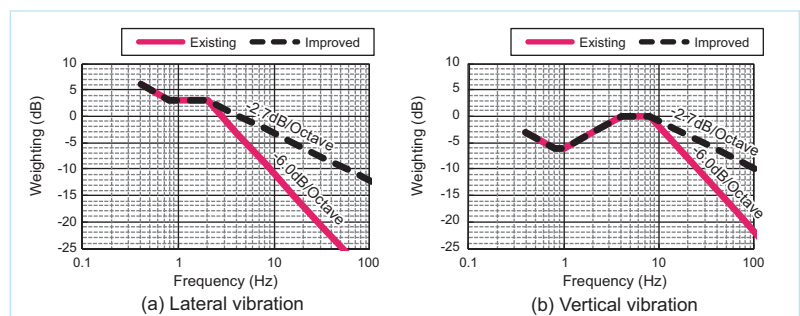


Fig. 3 Ride comfort filters (existing and improved)

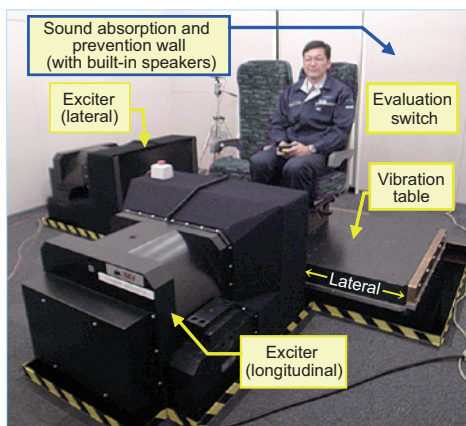


Fig. 1 Electrodynamics vibration system and a subject sitting on a double seat

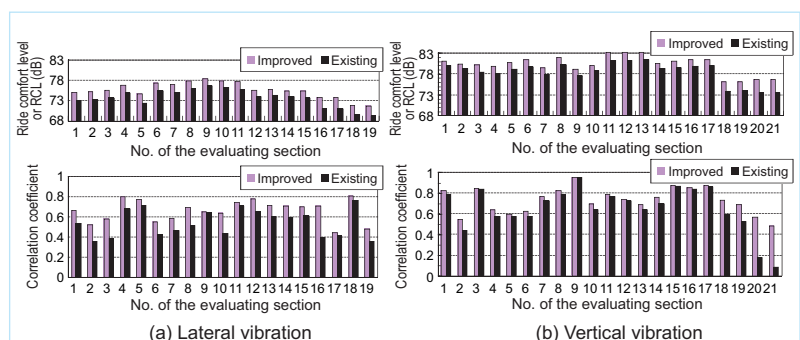


Fig. 4 Correlation coefficient between the ride comfort levels obtained through subjective evaluation and measured in running tests

A Study of Non-Contact Power Supply Systems

Takayuki KASHIWAGI

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A non-contact power supply system has many potential advantages compared with a normal (contacting) power supply system. A non-contact system significantly eliminates the danger of electric shocks or leaks and has low-noise and maintenance-free features. However, the transmission of energy through space tends to drop the energy supply efficiency and adversely affect system surroundings with leakage fluxes. Thus it is important to develop a higher efficiency system.

We have started the development of a non-contact power supply system for rolling stock. As the energy storage equipment installed on battery EMUs and hybrid DMUs constitutes a significant portion of the total weight of the trains, it is important to make the equipment as lightweight as possible. A potential way to satisfy this requirement is to reduce the energy storage equipment capacity necessary for a day by frequently charging the equipment through the non-contact power supply system whenever trains stay at stations.

Major factors that drop the efficiency of the non-contact power supply system are the loss caused by the ON-resistance of the power converter to generate power for transmission and the copper loss in the power transmission/reception coils. Inverters using silicon carbide (SiC) for power elements are now being commercialized as power converters, and these are expected to reduce loss and improve efficiency. While reduction of loss is not expected much for coils, research to improve coil efficiency and reduce costs is proceed-

ing. Indeed, we have already confirmed that it is possible to improve efficiency and reduce costs by adopting sets of thin wires used for power cables of household appliance in place of Litz wires, or the special wires used for high-frequency purposes (see Fig. 1).

To apply the non-contact power supply system to railways, it may be possible to install power supply coils between the bottom of cars and rails to ensure the precision of installation. Unfortunately, as rails are magnetic and are close to the coils, the power supply characteristics are affected. The rails attract the magnetic fields and the resulting eddy currents cause significant losses. It may be possible to reduce the nearest leakage magnetic field, however, by using coils of the low-leakage magnetic field type that contains bipolarity within the gauge (see Fig. 2).

Based on the results of these discussions, we will manufacture a power supply test machine aiming at commercialization of the system in the near future, implement power supply and running tests by using RTRI's hybrid railway test vehicles with fuel cells and batteries (see Fig. 3) and establish the characteristics of non-contact power supply equipment that suits railway applications.

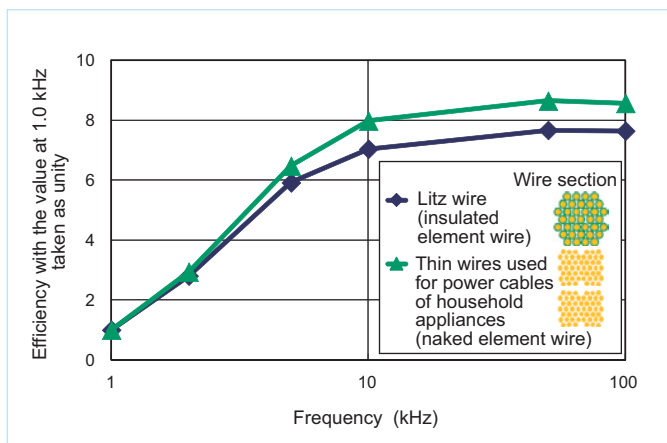


Fig. 1 Efficiency of the system using different materials



Fig. 3 Hybrid railway test vehicles with fuel cells and batteries

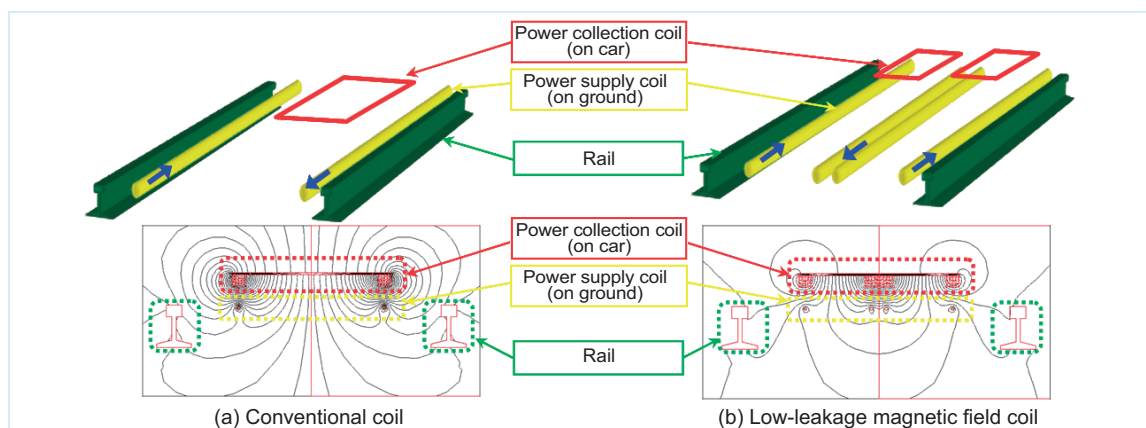


Fig. 2 A case of magnetic field analysis and analysis models (flux line diagram)