Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

March 27, 2013 No.42

Railway Technical Research Institute
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Editorial Office: Ken-yusha, Inc.
URL: http://www.kenf.jp/en/

ISO Institutes New Technical Committee ISO/TC 269 Railway Applications

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The International Organization for Standardization (ISO) approved the institution of a new Technical Committee (TC) for railway affairs, ISO/TC 269 Railway Applications which was proposed jointly by Germany and France. Its first Plenary Meeting was held in October 2012 in Berlin. ISO/TC 269 is served by Mr. Rűdiger Wendt as Secretary and I am highly honored to be the committee's first Chairman.

The environment-friendly characteristics of railways are now being reviewed in greater detail as people become more concerned about climate change caused by the increase in the volume of greenhouse gas emissions in recent years.

In the meantime, in developing countries, the rapid, mass transportation capacity of railways has attracted more and more attention as a booster of economic development, and many railway construction projects including high-speed rails, urban transit systems and freight railways are currently being planned around the globe.

However, there still remain a number of developing countries that have never been graced with the advantages specific to railways such as high-level safety, environmental compatibility, convenience and cost efficiency. International standardization activities are important to help disseminate the benefits of railways extensively in different countries in the world. In this context, it is of utmost importance to maintain the transparency, openness and impartiality of activities as advocated by ISO, thereby translating the policy of Global Relevance into reality.

The ISO/TC 269 Plenary Meeting had a two-day session, attended by the representatives of 15 countries, chairpersons of the International Electrotechnical Commission (IEC)/TC 9 and the European Committee for Standardization (CEN)/TC 256 and representatives of UIC. The Plenary Meeting determined the title and scope of TC 269, discussed the Strategic Business Plan, structure of TC, liaising with other TCs/organizations and roles of the Chairman Advisory Group, presented a proposal for candidate new work items and instituted four Ad-hoc Groups to discuss these from now on.

ISO/TC 269 is charged with dealing with those fields not included in the scope of IEC/TC 9. This assignment is extremely extensive with significant responsibilities. To respond to the expectations of railway operators, infrastructure trustees, manufacturers, construction work contractors, competent government agencies, the governments of different countries and other stakeholders, we will make concerted efforts to promote ISO/TC 269 activities while appreciating the cooperation extended by those concerned.

At the invitation of Japan, TC 269 decided to convene its second Plenary Meeting in Tokyo in November 2013.

What Can We Do to Develop Railway Technologies in Asia? - Railway Technical Discussion at RTRI on October 25, 2012

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The Railway Technical Research Institute (RTRI) has a rich history. Prior to its incorporation in 1986, it was the research arm of Japanese National Railways (JNR) during which time it created a new transportation system, named Shinkansen, in 1964. This was the first system of its kind in the world, designed to transport a huge, rapidly increasing number of passengers during a period of high economic growth and steadily increasing population after World War II. As RTRI is located at the birthplace of Shinkansen, RTRI's address was renamed Hikari-cho after "Hikari," the name of the first Shinkansen trains. Hikari means "shine" or "expectation" in the Japanese language indicating the wish for a train running at high speed like light to bring us hope for the future after the war. Since the introduction of Shinkansen on the revenue lines of Japanese National Railways, seven further types of Shinkansen rolling stock have been introduced by old JNR and the current Japan Railways to provide our customers with easier and more comfortable high-speed rail transportation services between urban cities. Since RTRI developed the first type of Shinkansen, RTRI has been leading the research projects on the improvement of the Shinkansen high-speed rail systems and assisting other Japan Railways companies with the application of the fruits to Shinkansen operations. For the last 30 years in particular, after TGV was developed by French National Railways, competition has been tense in introducing the most well-known two systems in the world, Shinkansen and TGV, into countries where no such a system has been implemented. Eventually, Shinkansen was delivered to Taiwan while TGV was successfully introduced in Korea. Three high-speed rail systems were also introduced in China from Japan Railways, French National Railways and German Railways to develop high-speed rail networks at a service speed over 200 km/h in the country. By the turn of the century, most of the engineers in railroad technical fields were caught up in trying to increase train service speed and spread high-speed rail networks across the world. In accordance with such trends, we have been developing technologies specific to high-speed rail. However, the global economic recession originating from the US in 2008 has unfortunately depressed the enthusiasm and passion to introduce high-speed rail networks in countries desiring high-speed rail transportation. There are still a number of plans to build up such rail systems around the world even though they are not necessarily financially guaranteed. But, the goals to develop railway transportation systems are no longer focused solely on high-speed rail development.

Another major effect to consider is the changing demographics in most countries, including Japan where we have started to see an aged society with decreasing population and a reduction in the number of young people. This has caused mass transportation service industries to lose customers and has led to some questioning whether such transportation systems are still suitable for Japan in the future. Technologies for conventional railway systems enabled the invention of the Shinkansen high-speed rail system and have been applied to its operation even after the Shinkansen system was installed. Thus, all fundamental elements of railway technologies, regardless of high-speed operation or not, have originated from conventional railway systems. Indeed, improvement of conventional local lines in depopulated provinces in Japan is one of the research and development targets for Japan Railways. Thus, it might be appropriate to consider the original motivation for high-speed rail development and find other goals to direct railway system development in situations where primary high-speed rail systems have been established and commonly used in now mature or aged, developed countries. This thought process led to the desire to understand the circumstances experienced in other countries where cultures and histories are unlike those in Japan but where situations are similar to those in Japan 50 years ago when Shinkansen was installed and while we were struggling to establish such a high-speed rail system after we decided to develop it.

Given our strong interest in understanding what some Asian countries lack, need, want and expect in railway operations, RTRI organized an international meeting not just to show topics but to drill down on technical issues in our respective railway operations. The State Railway of Thailand, Taiwan Railway Administration and Vietnamese National Railways sent seven engineers to the meeting in total. We were together at the RTRI Headquarters for a day in October 2012 to discuss such topics, amounting to 11 in number, brought by the speakers from the railroad companies. The papers covered most of the railway technical fields, including operation, rolling stock, power and facilities. We discussed each topic for 30 minutes after a five minute presentation was completed each time. Thus, we were able to avoid one-way presentations from speakers to the audience as is often the case at international conferences, especially where non-native English speakers are participating. 150 engineers and scientists in total joined the meeting from RTRI to activate the discussion and respond to the speakers. They gave their own knowledge and experience obtained through research at RTRI to contribute to the goal of the meeting to find opportunities to develop practical solutions.

As an example, one of the speakers showed the current situation where railway facilities are not well maintained. The complicated maintenance standard system originating from three different countries conflicts with different designs that the workers have to use to maintain their civil engineering facilities. RTRI engineers stressed in this case that the most important point is not to introduce sophisticated new technologies calling for large-scale budgets to fully repair damaged elements of the facilities quickly, but to observe the progress with the damage at regular intervals and eliminate malfunctions on a step by step basis.

Another topic discussed concerned the preparation to accommodate a large number of passengers due the improvement of rail transportation systems in urban areas. The railway has already installed prepaid fare ticket systems to automatically collect fares from customers. However, a few different types of systems have been introduced without the capability for expansion expected in the future. The engineers from RTRI suggested that a good opportunity to unite different systems should be when the current systems are renewed due to the expiration of the life. It is not practical to combine all the current systems into one common system for customer convenience. However, now is a good time to start preparation for successful system unification, which normally takes a long time for careful planning for the future. This is not necessarily technical advice but clearly indicates how important it is to be prepared for such a large-scale system change or immediate increases in rail capacities.

Another rail operator has experienced some vehicles getting easily derailed right after their tires are carefully inspected and repaired. The vehicles come off the rails just on the way from a rolling stock workshop with their conditions properly tuned up according to their standards. They feel the phenomenon is peculiar because the rolling stock should be in the best condition right after being subjected to full inspection and maintenance services. RTRI researchers suggested that not roughness but freshness of the surface of the metal tires resulting from machining can increase the friction coefficient and induce the tire to climb up the rail. Thus, the machined tires should be protected with grease to avoid such friction. This is not to reduce the noise coming from the interface between tire and rail but to prevent the fresh tire surface from direct contact with the rail surface. The suggestions given by RTRI researchers were of practical use and significance but not of an inspiring nature. This was unexpected by those who brought these topics to the meeting. They supposed that, because RTRI is known for developing leading-edge technologies, the RTRI researchers would display that high-level knowledge at the discussion. The researchers, however, were pragmatic and displayed no unnecessarily glamorous technological solutions. RTRI thought that the engineers from the rail operators should learn fundamental technical solutions and follow logical technical steps. There are no miracle stories or magic procedures, especially as railway systems have been organized by combining independent technologies in various kinds of fields.

Thus, our discussions eventually provided a common realization that there is a difference between what the engineers from the railroad companies expect and how RTRI researchers have come to feel or think about issues. Then, we recognized that direct discussions can suggest goals that are different to the trend of trying to increase train service speed and develop high-speed train networks. This experience at the meeting awakened and stimulated the participants to start thinking about where they should go under the circumstances where the global economy is not stable and populations begin shrinking in already-developed countries. The tips found through the discussions are priceless possessions for the engineers from the railroad companies to assist themselves in overcoming their technical issues and also for RTRI researchers to help themselves in finding a direction in which they should go in the future.

Fig. 1 Mr. Kumagai, Vice President of RTRI, is giving a welcome speech to receive all speakers from railroad companies in Asia and researchers from RTRI to encourage them to achieve constructive and practical discussions at the RTRI Discussion

Fig. 2 All the speakers from railroad companies in Asia and researchers from RTRI joining the meeting are together to remember how they enjoyed the discussion at this opportunity

Development of a Fault Point Locator for the Freight Train Command Line

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Freight trains are equipped with an automatic air brake system. Under this system, however, the longer the train set (also known as a consist) is, the more time is required until the required brake force is established throughout the train set (consist). This makes it difficult to run trains at high speeds. To solve this problem for high-speed freight trains in Japan, an electromagnetic automatic air brake system is used. This is similar to the electronically controlled pneumatic (ECP) brake systems used in other countries. The system uses a command line running throughout a train set and electromagnetic valves installed on the brake pipe to send brake commands to each car to apply the brakes evenly on all cars in the train set. The continuity of the command line is checked in the inspection after a train set has been marshalled. However, when a break in the command line is detected, it can take several hours to locate the fault point thus resulting in potential delay or cancellation of train operation.

Each freight car has several cables connected to jumper connector receptacles and thus the cables are laid along the whole length of the train. Locomotives have brake notches called “release,” “service brake” and “emergency brake.” According to the selected notch position, the corresponding electromagnetic valve is activated. The train command line is used as a power source to activate the electromagnetic valves. Figure 1 shows the composition of the command line circuit viewed from the end of a freight train set. An example of a break point is marked “X” on the command line. Figure 2 shows a diagram of the electric circuit network to calculate the combined resistance of the command line based on Fig. 1. Figure 2 shows just two cars although there are a maximum of 26 cars in a train set. The elements of the command line of each car are the resistance r of the command line for a one-car length and the resistance R of the coils of electromagnetic valves. The voltage E for resistance measurement and the current I (A) are shown at the end of the freight car (the left side in Fig. 2). Calculations of (1) the current I through the analysis of the circuit network and (2) its ratio to the applied voltage E give the theoretical combined resistance between the command line and the ground conductor.

Figure 3 shows the results of a static test to simulate a break of the command line. As shown, the combined resistance is smaller for longer train sets. Figure 3 demonstrates that the values of the resistance measured and calculated based on a model of the circuit network are approximately in agreement. Based on this finding, we developed an algorithm to locate the fault point on the command line from the end of a freight train set by concentrating on the combined resistance of the command line, as shown in Fig. 4. We also developed fault point locators, a portable and car-borne type (Fig. 5), used to determine whether and where a command line break exists. We developed a car-borne type fault point locator assuming the installation on locomotives in revenue service operation and a portable one to be applicable to the present inspection service.

A command line break simulation test proved that it is possible to accurately locate the fault point within 30 seconds up to approximately 20 cars from the end of a train set. For the 21st car and beyond, however, an error of one car or so occurred. This is because the difference of the combined resistance between the fault-suffering car and adjacent ones is 5% or less, due to the effect of the accuracy of the current sensor and/or the coil resistances. Regarding the car-borne type on the other hand, we performed a command line break simulation test on a freight train set running for test purposes to confirm that it is possible to locate a break on the command line from the locomotive without being affected by the activation of electromagnetic valves. The results of this study indicate that the application of this locator improves the reliability of the electromagnetic automatic air brake system and supports positive operation of high-speed freight trains to ensure stabilized freight transport.

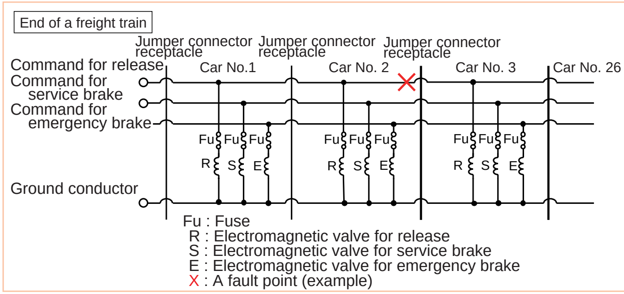

Fig. 1 Composition of the circuit of the train command line for freight train sets

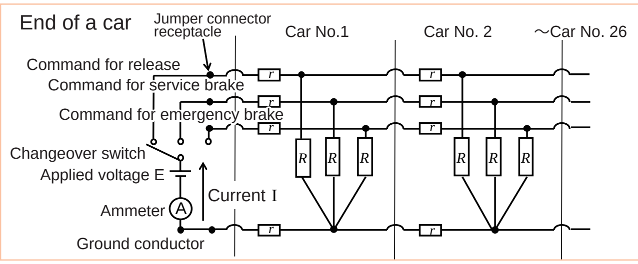

Fig. 2 Model of the electric circuit network for the command line

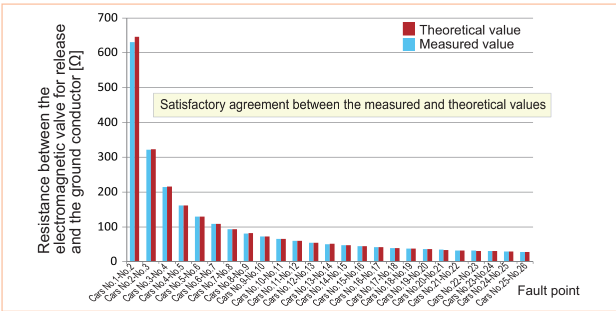

Fig. 3 Results of a test to simulate a command line break

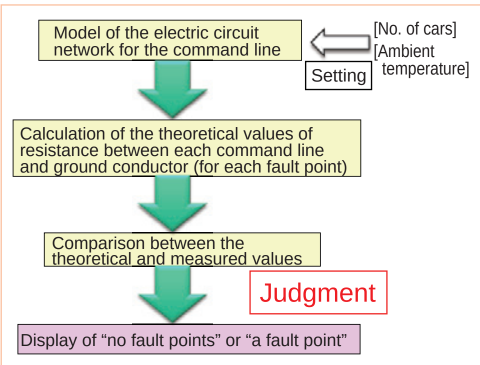

Fig. 4 Flow chart to locate the fault point

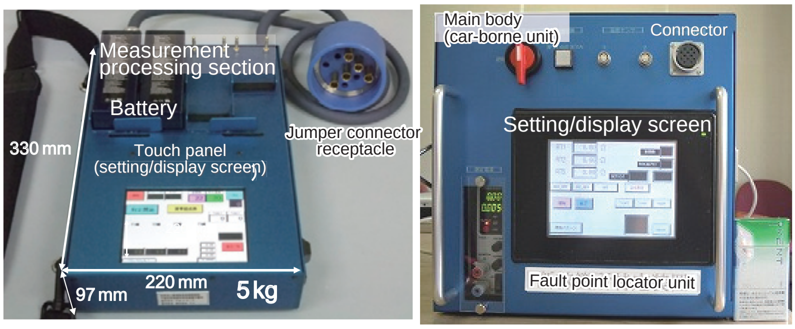

Fig. 5 Fault point locator unit (left: portable unit, right: car-borne unit)

Development of a Switch Rail with Improved Wear Resistance

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1. Introduction

Switch rails quickly wear and require replacement at extremely short frequencies in turnouts where a number of cars run on the diverging route. Development of a new switch rail that will retard wear and extend the replacement frequency will cut maintenance and replacement costs. Thus, we developed a new switch rail featuring improved wear resistance and tested it in turnouts on a revenue service line.

2. An outline of the wear resistant switch rail

One method to suppress the wear of switch rails is to increase hardness by heat treatment. However, increases in hardness can lower toughness to cause switch rails to break. In setting the conditions for heat treatment for the wear resistant switch rail, therefore, we aimed at increasing hardness of the surface layer to improve wear resistance and suppressing hardness below the surface to ensure toughness. As the raw material to manufacture the wear resistant switch rail, we used the HH340 rail material (existing heat-treated rail) because of its heat treatment characteristics. Figure 1 shows the distribution of hardness of the switch rail subjected to heat treatment under the newly set conditions. According to Fig. 1, hardness has been attained in the surface layer and suppressed below the surface as targeted. To suppress plastic deformation and decrease the contact pressure at the contact surface with wheel flanges, we profiled the cross section of the wear resistant switch rail above the gauge line to the same inclination as that of wheel flanges.

3. Tests of the wear resistant switch rail installed at the turnouts of a revenue service line

Figure 2 compares the changes over time in the wear depths of the wear resistant rail (hereinafter referred to as the "new switch rail) and the existing switch rail installed at the turnout of the same category. Immediately after installation, wear tends to quickly progress with the existing switch rail but not with the new switch rail. After about 200 days, the wear depth of the new switch rail is only half of the wear depth of the existing switch rail. Regarding the worn rail profile, the existing switch rail shows plastic deformation on the rail top surface and at the side of the head, while no plastic deformation is seen with the new switch rail. See Fig. 3.

As a next step, we measured the wear depths of four new switch rails installed for test purposes at several places. See Table 1 for the particulars of the switch rails surveyed in this study and Fig. 4 for the results of the wear depth measurement. The first new switch rail signified by the symbol A in Table 1/Fig. 4 (hereinafter referred to simply as the "switch rail A") survived for 349 days until it was replaced. This represents a life that is approximately 2 times longer than the average time (days) in which the existing switch rails of the same category had been in use, according to the data on the replacement frequency during the past 10 years. The new switch rail B has been in use for 354 days and will have approximately 1.5 times longer life than existing switch rails when it is replaced in the near future. The other two new switch rails C and D have survived for approximately the same time as the average time (days) of existing switch rails in the same category of turnout (according to the 10-year-record in the past), and yet the wear depths are only half or less of the replacement standard of 6 mm.

Base on the above findings, it is thought that the newly developed switch rail featuring high wear resistance will extend the replacement frequency to 1.5 to 2 times that of the existing switch rails.

4. Conclusion

The newly developed wear resistant switch rail is thought to:

(1) Suppress wear, thereby extending the replacement frequency previously limited by wear.

(2) Prevent horizontal splits and breaks at the top due to plastic deformation, thereby extending the replacement frequency previously limited by damage.

(3) Cut maintenance costs as a result.

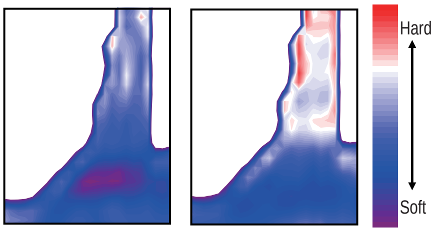

Fig. 1 Distribution of hardness

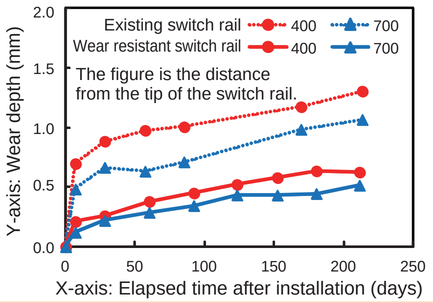

Fig. 2 Progress of wear depth

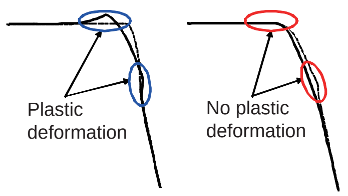

Fig. 3 A comparison of the worn rail top profiles

Table 1 Switch rails surveyed in the study

Symbol	Turnout No.	Time in use (days)	Average time in use (days) *	Remarks
A	8	349	181	Replaced
B	12	354	237	To be replaced
C	8	182	190	
D	8	174	180	

* Records of the existing switch rails of the same category in the past 10 years.
Note: Switch rails A,B, C and D are new switch rails

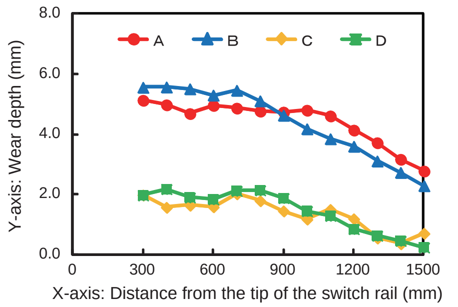

Fig. 4 Results of the survey of wear depths of the new switch rails

A Technique to Detect Overheated Switchboards with a Gas Density Detector

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Overheated wires are cited as one of the most important causes of switchboard failures. When wires or electric instruments, including their insulating materials are overheated the volatile organic compounds (VOCs) of plasticizers are emitted. Thus the damage due to overheating will potentially be mitigated if VOCs can be detected early and before a fire begins.

We have been discussing a technique to detect VOCs with gas chromatograms. One or two categories of characteristic components (such as 1-dodecanol and 2-ethyl-1-hexanol) used as plasticizers are mostly mixed in the base material and, when volatilized, their emissions can be detected from the vinyl sheath, a component element of wire sheathing materials. A comparison of the relative volumes of the component of each category volatilized at different heating temperatures indicates that the peaks of the detected volumes quickly increase at heating temperatures higher than 100ºC. The emitted volume is small at the normal operating temperature and large when they are overheated. Given these special features, VOCs are thought to be an ideal substance to monitor in order to detect abnormalities.

The above-mentioned 1-dodecanol and other substances are a type of VOC that can easily be detected, if a suitable sensor is available. Therefore, we manufactured a prototype gas density monitoring unit using a semi-conductor gas sensor to detect VOCs emitted from deteriorated wire sheath materials. The prototype gas density unit is composed of a sensor head and a data processing device as shown in Fig. 1. The unit detects airborne materials utilizing convection principles and makes measurements on a real time basis to suit the application to routine monitoring.

To verify the performance of the unit, we wound a specimen vinyl sheath material (cross sectional area, 22 mm^2) for a 6,600V CV power cable, rated at AC current 140 A, around a conductor and placed it in a testing case. We then fed a 200 A current to the conductor to heat the specimen.

As a result, we were able to confirm that the detected volume of VOCs gradually increased as the cable surface temperature increased. As shown in Fig. 2, we found that the detected volume of VOCs rapidly increased at cable surface temperatures higher than 145 ºC. Figure 3 shows how the cable sheath softened under test as the temperature increased.

Based on these findings, we confirmed that it is possible to use a gas density monitoring unit to detect the VOCs emitted from the cable surface when it is overheated. The fact that the detected volume of VOCs rapidly skyrockets when the cable surface temperature exceeds a certain threshold value suggests the possibility of its application as an index to trigger the alarming relay mechanism under routine monitoring.

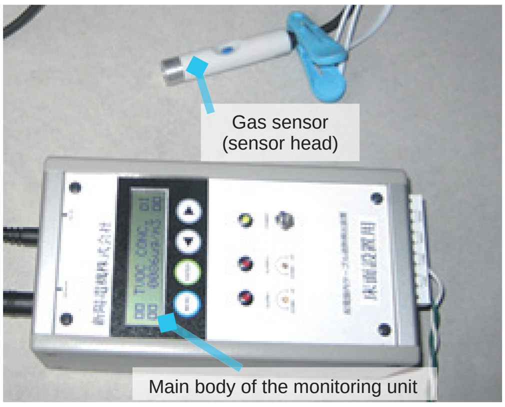

Fig. 1 Gas density monitoring unit

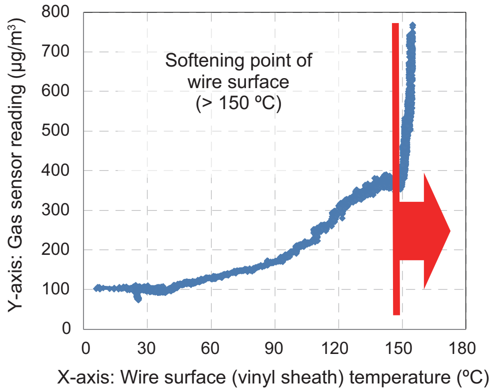

Fig. 2 Volume of VOCs detected with the gas density monitoring unit

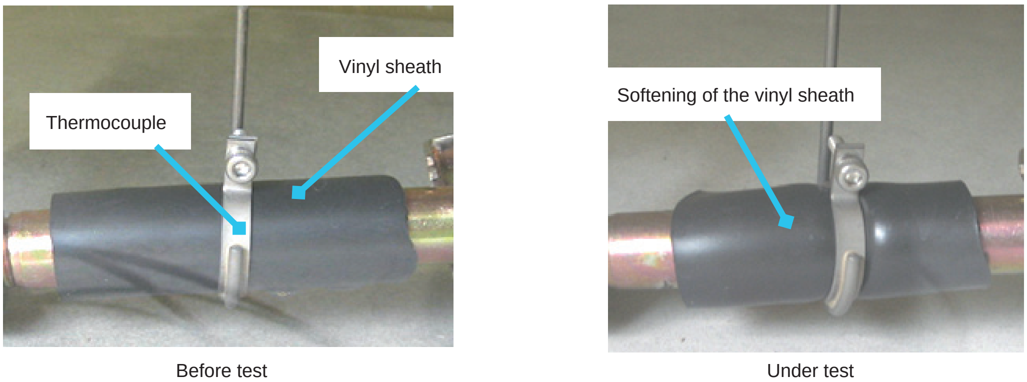

Fig. 3 Vinyl sheath under test

Measurement of Wheel Flange/Rail Gauge Corner Contact Conditions

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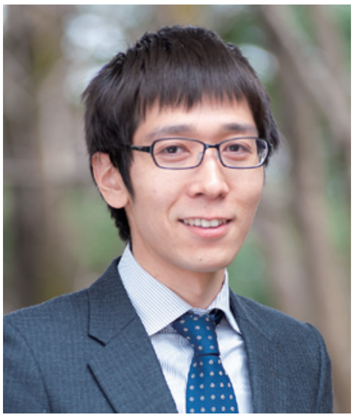
The wheels and rails used in railways, while playing a fundamental role in supporting rolling stock, transmit driving (traction) forces, guide trains in the running direction. They are also important to operation of the signal system and feeding circuits (track circuits). Knowledge of the phenomena taking place at the contact point between wheel and rail enables railway operators to establish measures against various problems such as vibration, noise, wheel skids and slips, and derailment. To investigate certain phenomena such as flange climb derailment, wear and noise, etc., occurring at the wheel/rail gauge corner contact point when trains pass sharp curves or turnouts, we are now developing a technique to measure the contact area and the distribution of contact pressure at the contact point. This technique is currently being used in laboratory studies by applying an ultrasonic measuring method.

Figure 1 shows the principle of ultrasonic measurement and the measuring system used in this study. The sound wave radiated from an ultrasonic probe transmits to the contact area, reflects at the non-contact area and returns to the probe. The intensity of the reflected wave (known as the “echo height”) decreases as the contact pressure increases, and thus we are able to estimate the contact conditions between two surfaces. Two-dimensional scanning in parallel to the contact surface with a probe gives the contact area configuration and the distribution of contact pressure.

In this study, we used a wheel/rail contact unit testing machine. Figure 2 illustrates the testing machine and installation of measuring instruments. The testing machine uses an actual wheel and a short length of rail placed upside down on its top. To achieve a wheel/rail loading condition, the rail is hydraulically loaded in the axial load direction to generate an axial (vertical) load up to a maximum of 50 kN. A maximum force of 40 kN can be applied in the lateral direction. We radiated an ultrasonic wave from a notch machined on the flange back surface. The position of rail was adjusted to contact the wheel flange on the straight portion.



Regarding the area where the wheel flange and the rail gauge corner are statically in contact, Fig. 3 compares the experimental result obtained with the ultrasonic method with that obtained from pressure sensitive paper and that calculated by applying Kalker’s exact theory. The contact area measured with pressure sensitive paper is larger than that obtained by the ultrasonic method, presumably because the former presents a configuration that is affected by the thickness of the pressure sensitive paper. On the other hand, a comparison of the results of calculation and ultrasonic measurement indicate that the two are comparatively in good agreement, though the former is a little smaller.

We also measured the distribution of contact pressure between flange and rail in the cases (i) where cutting traces (turning marks) remain on the wheel surface and (ii) cutting traces are worn due to the contact between wheel and rail (see the top of Fig. 4). The measurement results using the ultrasonic method are shown at the bottom of Fig. 4. A comparison between the two cases shows that the pressure distribution is comparatively smooth in (i), while it presents a saw-toothed configuration in (ii). It is thought in qualitative terms that the pressure contribution changes to a great extent within the contact area that is affected by the rolling of the cut (turned) wheel.

We will improve the measuring technique further and study the wheel flange/rail gauge corner contact phenomenon in the case where the wheel is rotating and generates a tangential force.

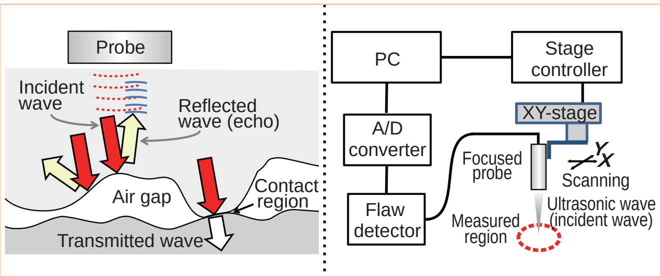


Fig. 1 Principle of ultrasonic measurement and a measuring system

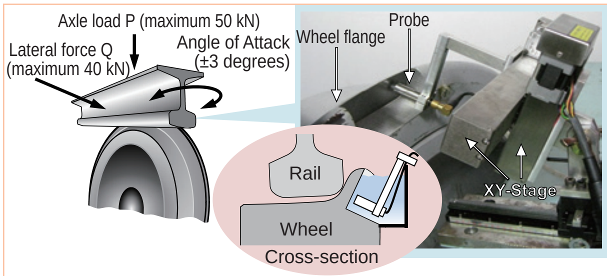


Fig. 2 Testing machine and installation of measuring instruments

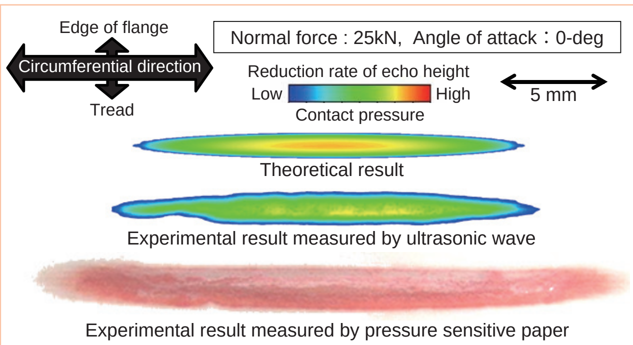


Fig. 3 Results obtained through calculation, measurement with pressure sensitive paper and application of the ultrasonic measuring method

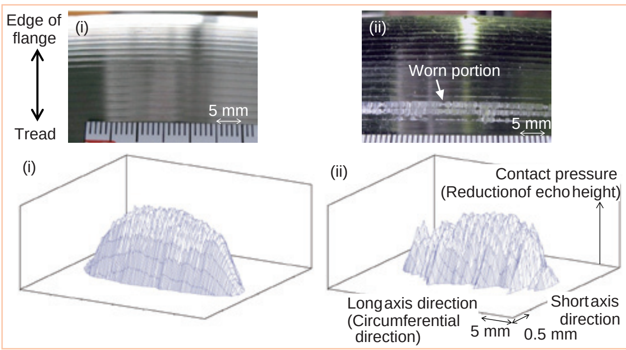


Fig. 4 Pressure distributions at the flange/rail contact point in the case (i) where cutting traces remain on the wheel surface and (ii) where cutting traces are worn due to the contact between wheel and rail