Newsletter on the Latest Technologies Developed by RTRI

Railway Technology Avalanche

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Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN
URL : http://www.rtri.or.jp
E-mail : iainfo@rtri.or.jp

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

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Foreword

Fuminao OKUMURA
Executive Director

I was appointed as Executive Director on June 13, 2013, to oversee three Divisions of RTRI: Compliance, International Affairs and Marketing/Business Development. Previously I had made my best efforts to facilitate smooth management for four years in the Administration Division, firstly as Deputy Director and then as Director. Now I will devote myself to my duties at the new post and vigorously promote exchanges with outside organizations, domestic and abroad, bearing in mind the benefits of enhancing the image of RTRI all the time.

Regarding international affairs, I believe it is most important to collect and transmit global information, assess the development of railway technologies and research across the world and tactfully transmit the results of RTRI's research and development activities. In this context, it is fortunate that joint research initiatives are being launched one after another with universities and research institutes in foreign countries. Exchanges of researchers shall be intensified in various forms to raise the presence of RTRI on a global basis.

RTRI's international activities shall also be strengthened to contribute to the establishment of a worldwide network of researchers. Therefore, RTRI shall increase human resources that will be welcomed everywhere in the world.

Since the inauguration of RTRI, 26 years have passed. In the meantime, superior researchers have been successfully recruited or developed to make RTRI a research organization embracing robust researchers. I believe that an advantage of RTRI is its researchers are highly specialized in a wide range of disciplinary areas. We need to continue to polish the capabilities of individuals and create research outcomes beyond imagination to surprise the world through collaboration among those in different fields.

Fuminao Okumura

The 10th WCRR 2013 Held in Sydney

The 10th World Congress on Railway Research (WCRR 2013) was held at the Sydney Convention and Exhibition Centre, Australia, on 24 to 28 in November 2013.

WCRR is an international congress managed by Organising Committee composed of the members of International Union of Railways (UIC) and railway-related personnel from Japan, France, Germany, Italy, UK and US, of which Japan is represented by the Railway Technical Research Institute (RTRI) . More than 550 people (including 88 from Japan) attended WCRR 2013 from over 30 countries worldwide. There were 188 paper presentations (13 from RTRI) and 133 posters were presented (22 from RTRI).

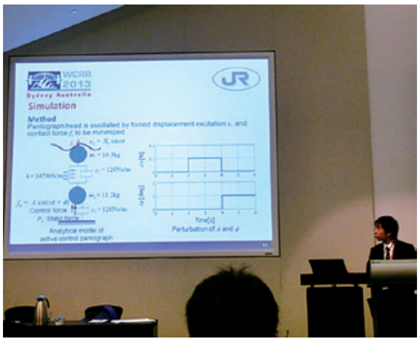
Dr. Norimichi Kumagai, President of RTRI, participated in a panel discussion on “the role of Rail Research in shaping rail operations” in the plenary session.

WCRR 2013 was held in conjunction with AusRAIL PLUS 2013, the largest exhibition and railway conference forum in Australia. At the exhibition venue, RTRI opened a JR group booth. Japan Overseas Rolling Stock Association (JORSA) opened a booth and demonstrated their technologies with Tokyo Metro Co., Ltd., Kyosan Electric Manufacturing Co., Ltd., NIPPON SHARYO, LTD. and Mitsubishi Electric Corporation. MEIDENSHA CORPORATION also opened their own booth and showed their technologies.

At WCRR 2013, under the theme of “Keeping Ahead of the Curve through Sharing of Knowledge,” eight sessions were organized in different fields. In the field of rolling stock, a paper prize was awarded to Dr. Seiji Kanamori, Chief Research Engineer, General Technology Division, Central Japan Railway Company.

It has been decided to hold the next WCRR at the end of May 2016, in Milano, Italy.

Panel discussion



Presentation by a RTRI researcher


JR group booth

Japan to Cooperate on Sweden’s Plans for High Speed Rail

“The Swedish High-Speed Seminar (Workshop)” was held on 24 to 27, September, in Stockholm. It was a workshop for interested parties from Sweden and Japan and was sponsored by the Ministry of Enterprise, Energy and Communications of the Kingdom of Sweden. Japan sent a sizeable delegation headed by Mr. Hao, Deputy Director-General, Railway Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The delegation included members from Japan Railway Construction, Transport and Technology Agency (JRTT), East Japan Railway Company (JR East), RTRI and organizations associated with high-speed railways.

Dr. Okumura, Executive Director, RTRI, introduced Shinkansen technologies and research and development activities on railways in Japan to railway-related personnel in Sweden, before lively high speed rail discussions spread among participants at the venue.

As Sweden has a plan to launch construction of high-speed railways for the section between Järna and Liköping and some other sections in 2017, the country had previously sent government officials to Japan. The Swedish party showed keen interest in the high-level railway technologies of Japan through study tours in the recipient country. In May, 2013, Sweden and Japan adopted a memorandum to cooperate with each other in railway affairs at the government level and decided to promote exchanges of personnel between the two countries for three years.

RTRI is now promoting joint research with Chalmers University of Technology, Sweden and highly respects the country for its active deployment of research and development on railway technologies. RTRI has been nominated as a counterpart by the University in research and development. RTRI appreciates the nomination, accepts it as a great honor and wishes to promote the exchange of researchers and administrators alike to help realize the plan for high-speed railway construction.


Executive Director Okumura with Swedish infrastructure minister

Improving Reliability of Thermite Head Repair Welding

Hajime ITO
Researcher, Rail Welding, Track Technology Division

1. Introduction

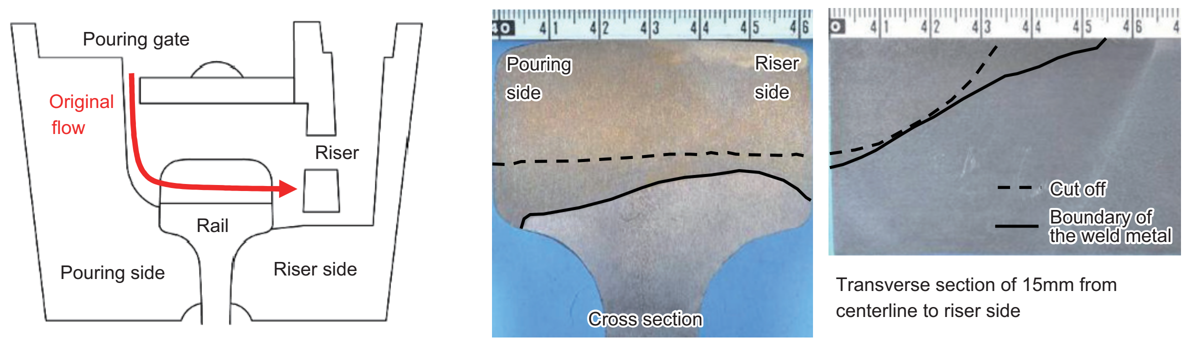
Recently, rail failures have occurred occasionally due to rail head damage such as squats. In Japan, the damaged rails are replaced with the new rail and two welding executions are necessary. Thus, railway companies spend much time and cost on these repairs. If it is possible to repair the rail head damage without rail replacement, maintenance time and cost can be saved.

2. Outline

We took note of the Thermite Head Repair (THR) welding, technique that is performed speedily. THR have been performed in the U.K. In this method, only the damaged part of the rail is cut off and the thermite weld metal is cast in the mold set up on the repair part. Execution time of THR is roughly the same as conventional thermite welding and its estimated cost is one fifth of rail replacement. We examined several problems for the application of THR for JIS rails. In this article, we report on the influence of molten steel flow on the penetration to the repair part.

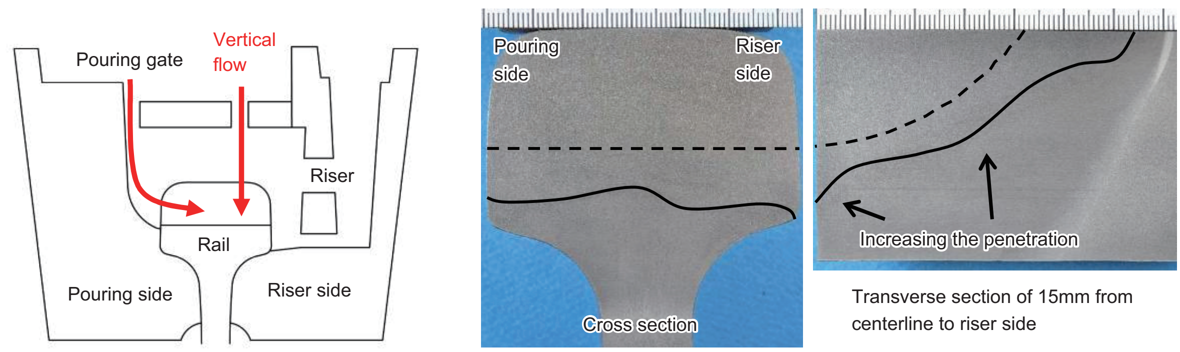
3. Test results

Figure1 shows the flow of molten steel and a typical shape of the penetration by the original THR mold for JIS rail. As shown in Fig.1, penetration is insufficient on the riser side, because the flow of molten steel occurs in only one direction from the pouring gate to the riser. In order to improve penetration, the flow of molten steel was examined with a view to optimizing the flow. We developed a new mold system which can provide vertical flow to the previously insufficient area of penetration. Figure 2 shows the flow of molten steel and a typical shape of the penetration achieved by the new system. Uniform shape of the penetration was achieved by the vertical flow from a circular hole in the pouring plug. Some test welds were evaluated by means of rolling contact fatigue test and bending fatigue test with horizontal tensile force. As a result, it was identified that all test welds had adequate strength for practical use.



(a) Flow of molten steel (b) Typical shape of the penetration

Fig. 1 Flow of molten steel and a typical shape of the penetration by original THR mold



(a) Flow of molten steel (b) Typical shape of the penetration

Fig. 2 Flow of molten steel and a typical shape of the penetration by the new system

A Risk-Based Technique to Support Decision-Making on Falling Stone Preventive Measures

Osamu NUNOKAWA
Senior Researcher, Geo-hazard and Risk Mitigation, Disaster Prevention Technology Division

1. Background and purpose

As railway lines are regularly subjected to falling stone (also known as rock fall or landslide) disasters, railway operators are now determining the priority order of falling stone preventive measures based on different empirical indices of (1) the risk of falling stone and (2) the loss assumed when a falling stone incident has taken place. The empirical nature of the methodology creates uncertainty for operators. Mindful of limited railway budgets we established a more effective methodology to determine the priority order of preventive measures. This methodology can be used to support the decision-making process. It uses a quantitative index based on evaluating the danger of falling stone as a risk. An outline of the methodology is presented below.

2. Evaluation of the risk of falling stone incidents

We first summarized the events that would lead to falling stone incidents in an event tree formation (fault tree), while setting uncertain phenomena, such as rock falls, rocks reaching a railway track and damage to railway facilities, as probability events shown on the right side of Fig. 1. We then calculated the predicted frequency of events (Pi) from (1) the predicted stone falling frequency based on inspection results obtained by railway operators, (2) the probability of stone reaching a railway track by using a falling stone simulation model and (3) the probability of the damage to railways. We also determined the loss at an incident from the results of statistical analysis of disasters in the past. Based on the predicted frequency P_i (times/year) thus obtained and the loss C_i (yen/event) of each event, the risk R (yen/year) of falling stone incidents is given as $R = \sum P_i \cdot C_i$

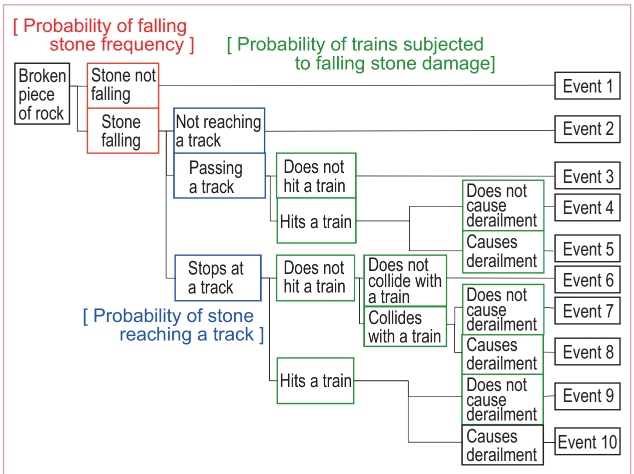


Fig. 1 Events assumed at stone falling incidents

Fig. 2 Results of an experimental risk calculation for falling stone incidents

3. Decision-making supporting technique for disaster prevention

Figure 2 illustrates a risk calculation applied to three falling stone (rock fall) incidents. The analysis helps the operator to determine the priority order of falling stone preventive measures by evaluating the danger of falling stone. Figure 3 illustrates the results of a risk calculation before and after the application of preventive measures. As both the cost C_T and the effect of risk reduction ΔB differ with different measures, we calculated the ratio of ΔB to C_T ($\Delta B/C_T$). This index clarifies which preventive measures have the greatest cost effectiveness. This means that a comparison between the risks before and after application of preventive measures determines advantageous preventive measures in quantitative terms. Thus application of risk evaluation results help to support decision-making on prevention of falling stone incidents.

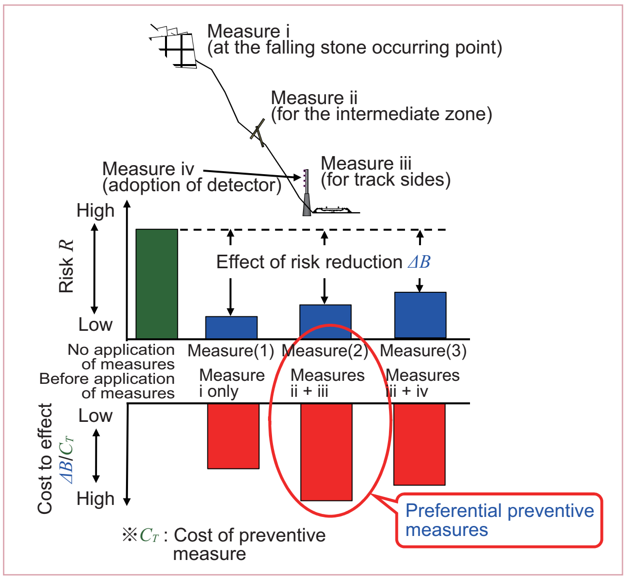


Fig. 3 Results of experimental risk calculations for falling stone incidents before and after application of preventive measures

Estimation of the Probability of Lightning Hazard on Railway Signalling Systems by Observing Induced Overvoltage

Hideki ARAI
Senior Researcher, Laboratory Head, Signalling Systems, Signalling and Transport Information Technology Division

As electronization progresses for railway signalling systems, components that are intrinsically prone to overvoltage are often damaged by lightning strikes. Little knowledge is available so far, however, on the relation between the damage caused to a signal system having arbitrary anti-lightning performance and the magnitude of the lightning strike relative to the distance from the striking point. A technique is described below to estimate the probability of the occurrence of damage to a signalling system due to a lightning strike based on the observed overvoltage when the system has been subjected to an impact.

1. Observation of lightning overvoltage

In the summer of 2010 to 2012, we observed the lightning overvoltage caused in the basic components of signalling systems on the ground, such as rails, signal cables and overhead power supply wires, and determined its correlation with the “condition of the lightning strike” defined as I/r, the ratio of the lightning current (I) to the distance (r) from the striking point. Data points corresponding to this relationship are shown in Fig. 1. As a result, we are now able to use the formula for estimation in Fig. 1 to determine the condition whereby a lightning strike may damage signal systems connected to overhead power supply lines. (Other formulae can be determined from Fig 1 for signal cables and rail.)

As an example of the use of the formula, for a signal system having anti-lightning performance of 30kV being connected to overhead power supply wires, the formula predicts that a lightning strike will take place when the lightning condition is 195.7kA/km or greater (point A in Fig 1). This is equivalent to a case where a lightning strike of 31kA, which is an average magnitude, strikes the system in the area within a radius of 158m. We have confirmed that this estimation is approximately in agreement with survey results of actual lightning damage.

2. A technique to estimate the probability of the occurrence of lightning strikes on signal systems

We are able to estimate the probability of the occurrence of lightning strikes on a signal system by taking into account the number of lightning strikes and the condition to cause lightning to hit the area where the signal system is installed. This methodology is outlined in Fig. 2.

The example in Fig. 2 is for a signal system with anti-lightning performance of 30kV located in a heavily stricken area where the frequency of lightning strikes within a radius of 10km is 1,000 times a year. In this case, the probability of the occurrence of lightning strikes is estimated to be 0.37 times a year under the assumption that the lightning attacks are uniformly distributed. This technique allows estimation of the anti-lightning performance required for signal systems to reduce the frequency of lightning strikes to the targeted level and makes it possible for signal system engineers to discuss effective measures against lightning hazard.

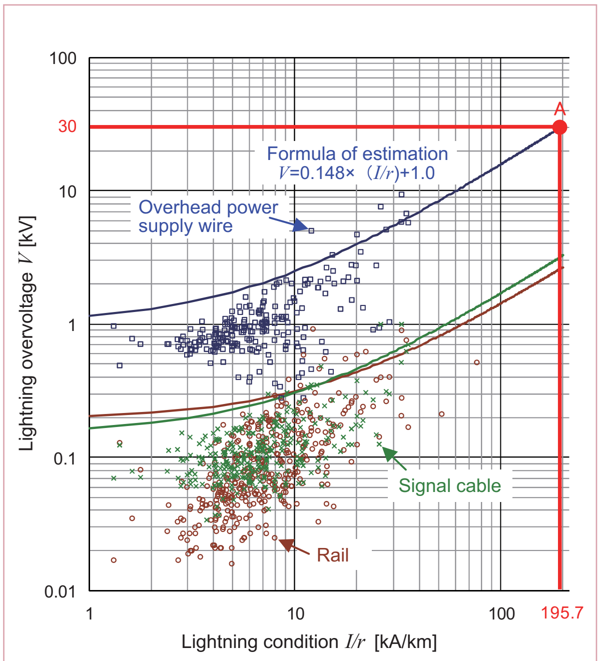


Fig. 1 Estimation of the condition of lightning strike to cause damage

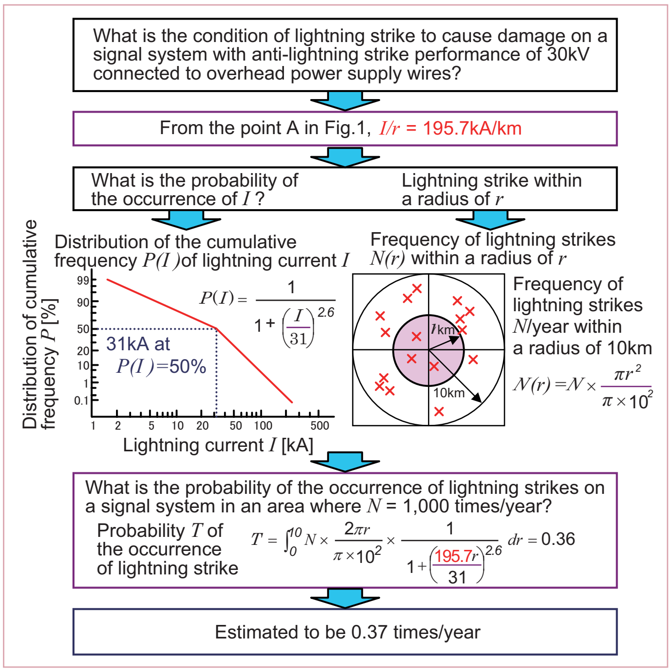


Fig. 2 A methodology to estimate the probability of the occurrence of lightning strikes

Friction Stir Welding Technology to Apply Flame-resisting Magnesium Alloy to High-Speed Rolling Stock

Hisashi MORI
Senior Researcher, Frictional Materials, Materials Technology Division

1. Introduction

To manufacture lightweight car body structures and parts for high-speed rolling stock, as flame-resisting magnesium alloy is more lightweight than aluminum alloy, it might be a more effective material to use to join different members. For its actual application, however, joining technology for this alloy must be investigated in detail, in addition to studying its material properties and ease/difficulty of processing. Thus we are currently researching basic joining techniques and evaluating metallurgical properties of joint faces. Friction Stir Welding is thought to be the most promising technique to join flame-resisting magnesium alloy.

2. Friction Stir Welding conditions for flame-resisting magnesium alloy members

In friction stir welded members of flame-resisting magnesium alloys, calcium added to yield fire resistance reacts with the aluminum in the alloy thereby producing new compounds that affect joint properties. Therefore, we had three flame-resisting magnesium alloys (Mg-Al-Zn-Ca alloy) manufactured for test purposes. These test members had different volumes of aluminum (3, 6 and 9 mass % aluminum) to study the relation between the joining speed and the volume of aluminum. Two members were joined successfully at a joining speed of 1 to 10mm/s. When the joining speed was increased to 15mm/s or over, however, cracks were observed on the joint face of the alloy containing 9% aluminum (Fig. 1).

3. Metallurgical characterization of Friction Stir Welded joint parts

We observed a cross-section of joined alloy by optical microscope to find that a circular plastic metal flow had emerged on the cross-section of joint part, with its area increasing in proportion to joining speed. We also found that there were fine precipitations in the metal flow pattern (Fig. 2). We measured the hardness of the cross-section and examined the relation between hardness and joining speed. As shown in Fig. 3, the hardness of the cross-section was higher for alloys with larger volumes of aluminum, presumably because of the increased precipitations in volume. However, in one case the hardness decreased with volume at the joining speed of 15mm/s. This may be a factor that caused cracking.

4. Conclusion

In discussing the application of friction stir welding of flame-resisting magnesium alloy, extensive basic studies are required on joining conditions, such as joining speed and materials to be joined. We will further study joining conditions in detail, while studying the strength and other characteristics of joint parts in the future.

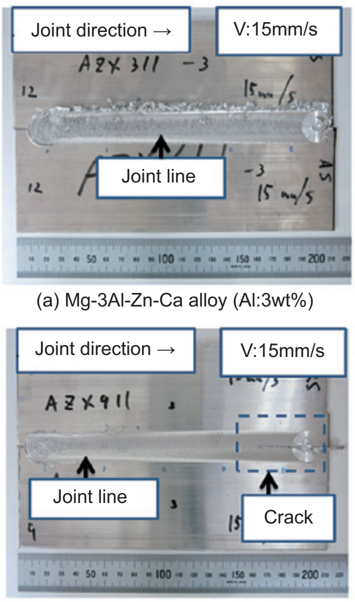


Fig. 1 An appearance of a flame-resisting magnesium alloy for friction stir welding (joining speed: 15mm/s)

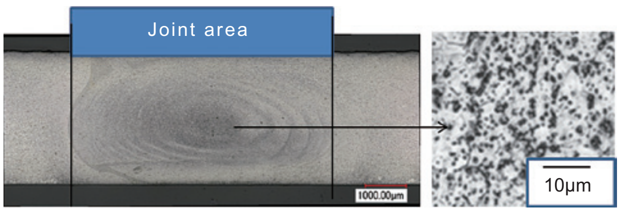


Fig. 2 Cross-section of the joint face of a flame-resisting magnesium alloy (Mg-6Al-Zn-Ca alloy) (joining speed: 5mm/s)

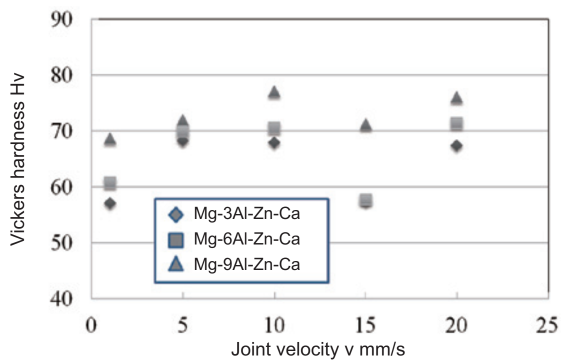


Fig. 3 Relation between joining speed and the maximum hardness of the cross-section of a fire-resistant magnesium alloy