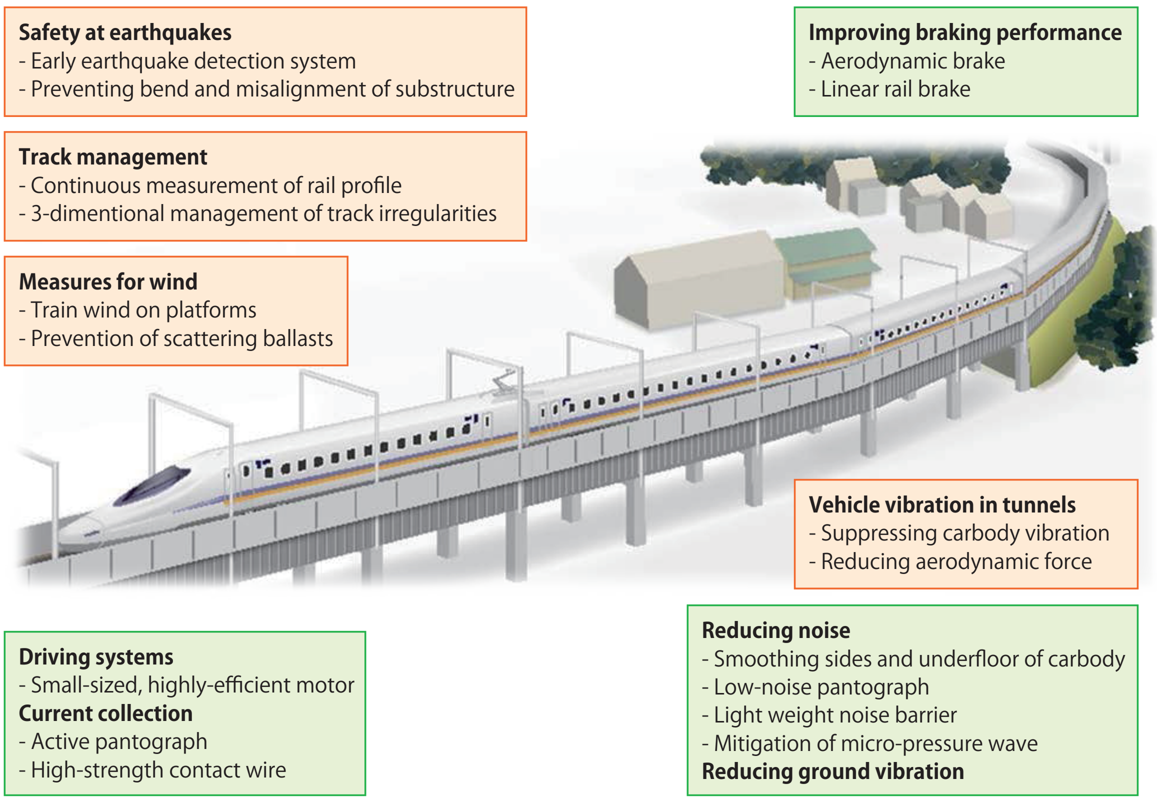
The Necessity of Trains Becoming Faster, More Comfortable and Energy-efficient



Technical challenges for higher speed train

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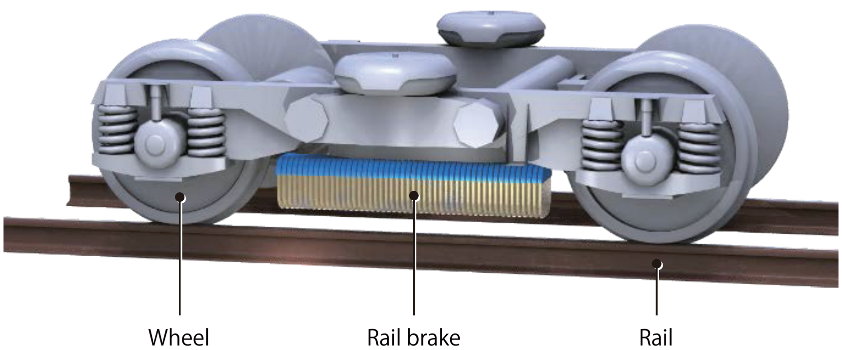
Superiority of railway over other modes of transportation

Railway transportation offers quicker delivery than motor vehicles and marine vessels and operates at higher energy efficiency and greater transport volume than motor vehicles and airplanes. While trains cannot travel as fast as airplanes, airports are often located a considerable distance from city centers, which can put trains on a par with airplanes in terms of the total time spent traveling between cities. In Japan, travel by rail has a higher share than airplanes as the preferred means of transportation where it takes no more than 4 hours by rail to travel from one city to another. This is called "the 4-hour factor."

At a time when global warming is an issue that needs to be tackled, railways offer high energy efficiency. To further enhance the competitiveness of rail travel, it will be crucial to make additional progress in cutting travel time and improving comfort, especially in the case of high-speed



Rail brakes

railways. *Ascent Vol.4* deals with some of these endeavors and other related research and development programs currently being pursued at RTRI.

Technologies indispensable in achieving higher speeds and improving the quality of service

Technologies for achieving higher speeds and more efficient operating practices

Improvement in braking performance

Trains may be designed to run faster, but they must also be able to stop safely. Therefore, higher speeds must be supported by sufficient braking force. At RTRI, programs are underway on the improvement of disc brake performance as well as on the development of aerodynamic braking and rail braking, neither of which relies on wheel/rail contact. By combining these non-contact brakes with electric and mechanical brakes, RTRI aims to develop a brake system that offers a desired braking distance even with a higher initial braking speed.

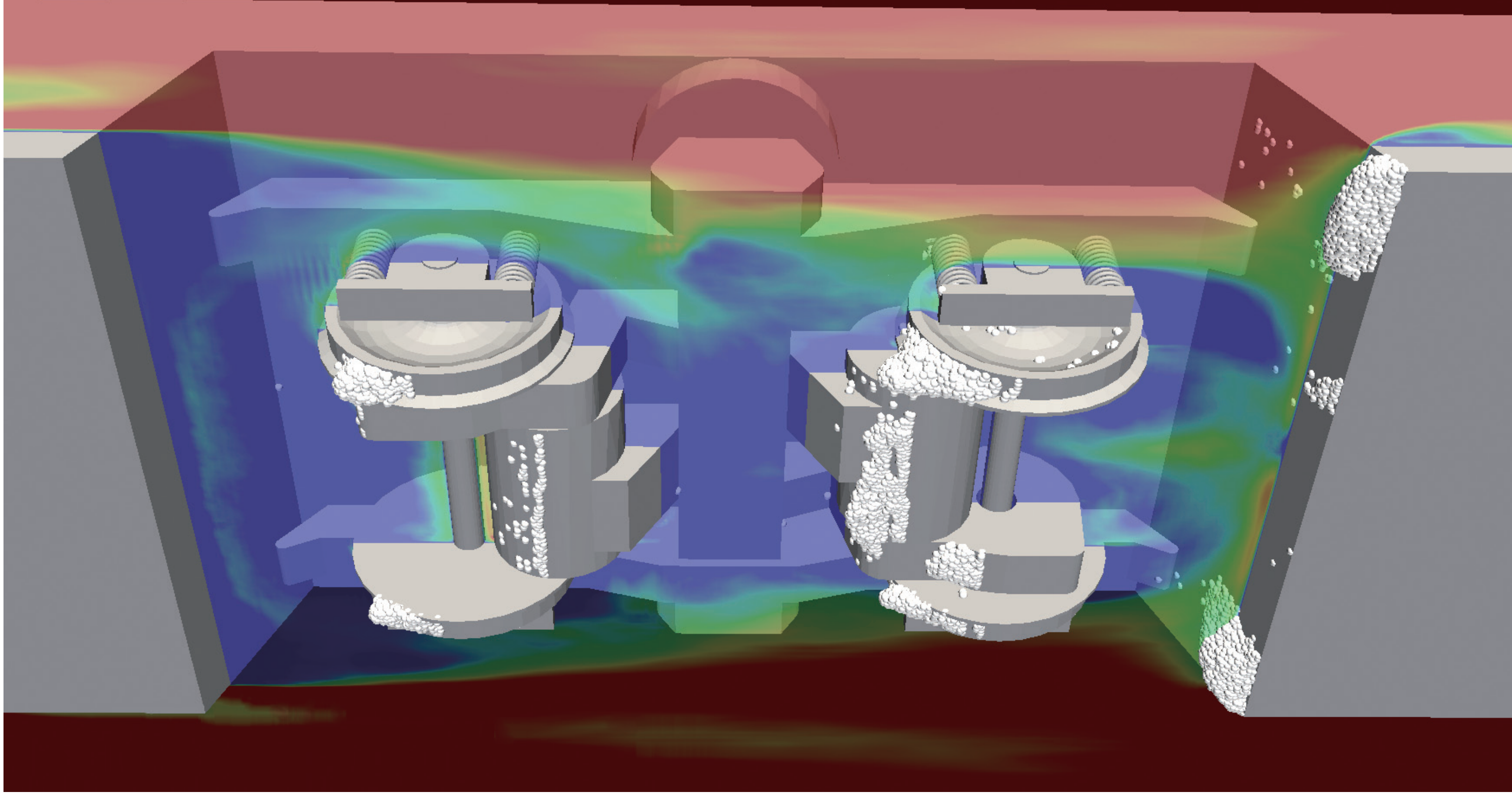
Improvement in current collection performance

Trains cannot run faster than the wave velocity of contact wire, which is a function of wire tension and structure. To increase wave velocity to allow trains to run faster, stronger contact wire needs to be erected and tensioned more tightly. In the case of pantographs, on the other hand, they need to be able to follow the movement of contact wire being shaken, and, at high speed, offer stable aerodynamic upward force and low noise at the same time, two conflicting aerodynamic requirements. As the Shinkansen system is required to meet the stringent environmental quality standards in place here in Japan, achieving higher running speed will also require pantographs to meet their corresponding requirements regarding both current collection and low noise.

Improvement in environmental performance

As trains run faster, they generate greater noise and more intense vibration. While the frequency and power of noise vary depending on the source of the noise, higher running speeds can create new types of noise. Measures have been taken to reduce aerodynamic noise such as by reshaping pantographs and the surrounding areas and by smoothing out the upper surfaces of vehicles. Measures have also been taken to reduce the noise of wheels rolling on rails such

Tunnel entrance hood



Simulation modelling for a railway vehicle running in snow is now developping. It is not practical to conduct tests with a running train on site in a specific snow-wind condition. Numerical simulations are useful to grasp the phenomena of snow accretion on a bogie-part in detail.

as by smoothing out rails and wheels. More recently, there arose the need to reduce additional types of noise including aerodynamic noise emitted from the cavities in bogies.

With non-ballasted tracks such as slab tracks, when a train enters a tunnel, compression waves are generated, traveling through the tunnel without being attenuated and emitting an impact noise as they radiate from the exit. The phenomenon, called "micro-pressure waves", has been an issue of concern. To help resolve the issue, tunnel entrance hoods have been installed and the front end of vehicles have been reshaped. Further improvement, however, will be needed.

Technologies for improving the quality of service

Improvement in ride comfort

While technologies for reducing braking distances and mitigating noises are indispensable in achieving faster running speeds as discussed above, it is also important to improve ride comfort to stay competitive against other means of transportation. Normally, as running speed increases, track-generated vehicle vibration accelerates and with that the elastic vibration of car bodies and cabin noise also increase. With Shinkansen, car-body tilting systems for curves and active suspensions, both using air springs, help improve lateral ride comfort. At RTRI, efforts are being made to develop a vibration control system that combines variable attenuation dampers with actuators to improve vertical ride comfort.

In addition to the wayside noise reduction measures discussed earlier, cabin noise reduction measures are also important for ride comfort. Cabin noise can be classified generally as structure-borne sound from the bogies and sound transmitted through the cabin walls. At RTRI, development programs are underway on a suspended cabin floor to separate the floor from the bottom of the car body for noise insulation and on vibration damping elements that would be installed in vibration transmission routes between the bogies and the cabin.

Measures for cold weather operations

In Japan, a heavy-snowfall country by world standards, snow and ice have been a problem since the opening of the Tokaido-Shinkansen Line. If snow or ice that has accumulated on car bodies falls during high-speed operation, trackside facilities, and even wayside buildings and automobiles, can suffer damage as a result. Delays and other disruptions related to snow have been reduced substantially through the installation of water-sprinkling, snow-melting equipment and the improvement of track structures. However, with the Hokkaido Shinkansen Line being extended in cold and heavy-snowfall regions, developments are planned for further anti-snow measures. Specifically, simulation modeling is underway to reproduce snow accumulation on bogies and the surrounding areas and, in combination with related wind tunnel tests and model experiments, improve

A scale model of half cross-section of double-skinned bodyshell made from a flame-resistant magnesium alloy

the shapes of bogies and the surrounding areas to limit the accumulation of snow.

Snow control measures on the ground include snow removal, snow melting, wetting of snow by water-sprinkling, and snow storage. Related measures on the vehicle include snow accumulation prevention measures and snow melting accomplished by heating. In the inland areas of Hokkaido where temperature can drop to -30℃ (-22℉), water-sprinkling cannot be used as the water used will freeze. Therefore, each district will need to adopt snow control measures that are appropriate for the unique local weather conditions.

In cold districts, issues related to low temperatures are anticipated to occur more frequently, including the performance deterioration of lubricating oils used in various parts of the vehicles, wheel/rail adhesion, and frost formation on the contact wire resulting in contact loss. RTRI has been pushing R&D efforts to be able to appropriately address these issues.

R&D for reduction in energy consumption

To further enhance the superiority of railways, mentioned at the beginning of this paper, over other means of transportation, reduction in energy consumption and increased running speeds are a must.

Energy consumption can be reduced by making vehicles lighter. RTRI developed a press-forming, weight reduction method for bodyshells based on a structure optimization algorithm. RTRI has also been pursuing bodyshell weight reduction using a flame-resistant magnesium alloy.

Along with car body weight reduction, RTRI has been trying to cut energy consumption through the efficient use of electric power. Specifically, for efficient use of regenerative energy, RTRI has been conducting development programs on train acceleration/deceleration control across an entire railway network, delivery voltage control at substations, reduction of feeding loss using superconductive feeders, and a flywheel energy storage system using superconducting magnetic bearings.

Conclusion

High-speed rail service successfully debuted in 1964 with the opening of the Tokaido-Shinkansen Line. Today, high-speed trains form the backbone of intercity transport, primarily in Europe and East Asia. On the other hand, competition with other means of transportation has been intensifying, namely low-cost airlines who have been experiencing a rapid market growth and a network of expressways which has been extending its coverage. Fifty-four years ago, RTRI's predecessor, the R&D arm of Japanese National Railways, opened the door for high-speed rail service. Continuing with the creative spirit, RTRI will vigorously keep developing innovative technologies to further enhance the competitiveness of rail travel.