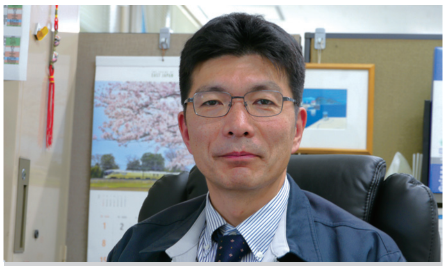
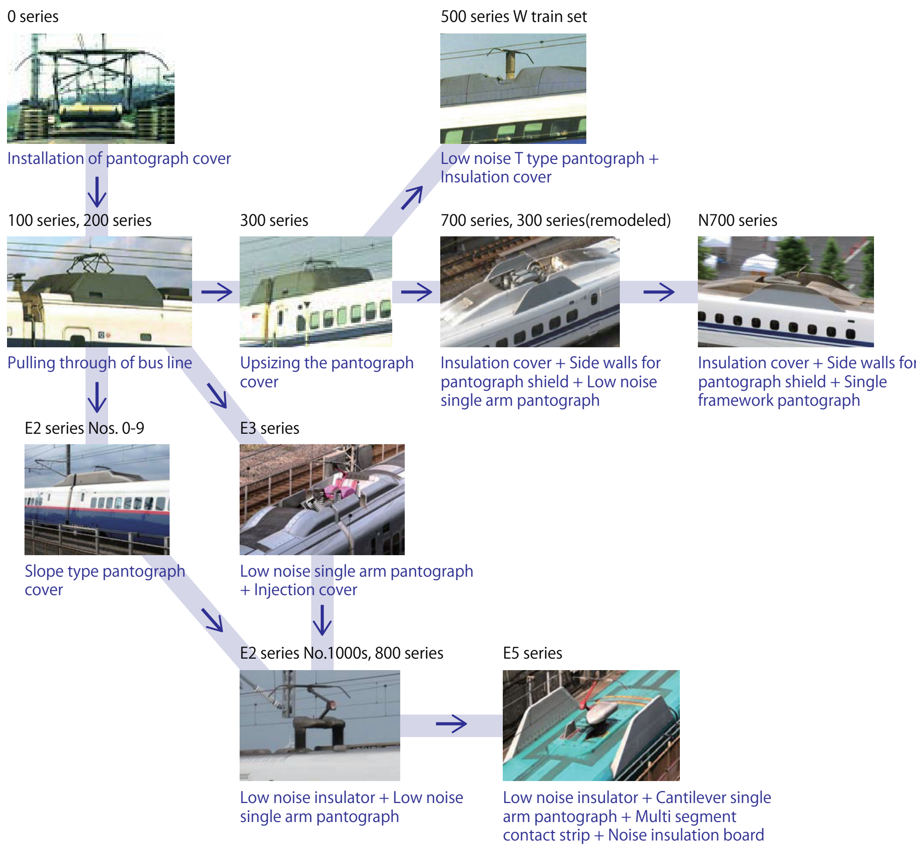
Preservation of Environments beside High Speed Lines



Dr. Mitsuru Ikeda
Director
Power Supply Technology Division

Dr. Takashi Fukuda
Chief Researcher
Heat and Air Flow Analysis



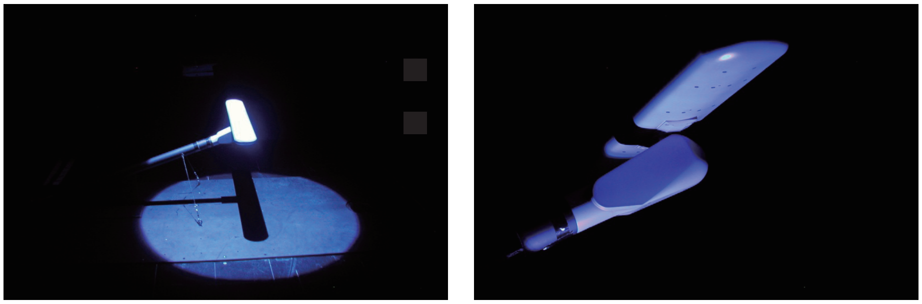
Transition of pantograph for the Shinkansen

Introduction

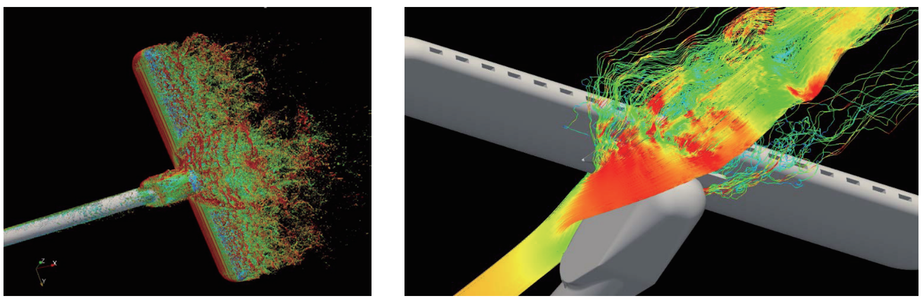
Since the topography of the Japanese archipelago has few plains, the railway has many long tunnels as well as many places where high-speed trains run through densely populated areas. Since both of these affect human life along the railway lines, R&D to address these issues has been continuously conducted; it is not an exaggeration to say that the environmental measures taken with the Shinkansen are always at the top level in the world.

Measures against Overhead Contact Line / Pantograph System Noise

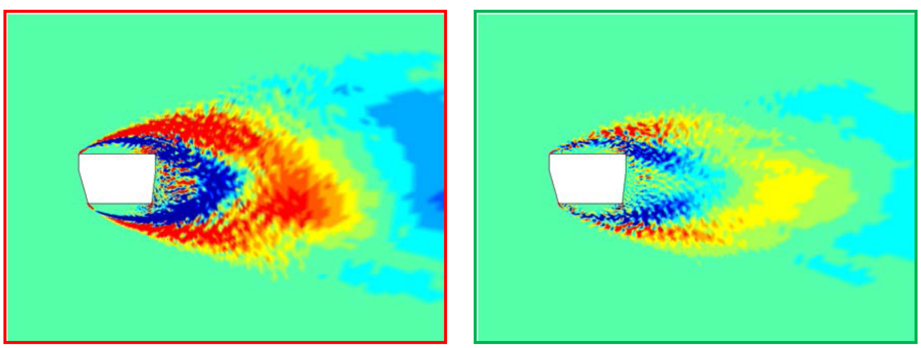
The noise generated from a pantograph, called the current collection noise, is one of the main contributors to noise along Shinkansen railway routes. Therefore, its reduction is an important research subject. The current collection noise contains two main types of noises: arcing noise and aerodynamic noise. The arcing noise is generated due to the arc discharge occurring when the pantograph is unable to maintain contact with the trolley wire, i.e. when a contact loss occurs. Measures against the arcing noise, which has very large energy, are indispensable for reducing the current collection noise. The Shinkansen lends itself to the reduction of the arcing noise because multiple pantographs can be connected to it electrically, even though it uses the AC electrification method. In addition, each Shinkansen train set operated with one pantograph uses a multi-segmented contact strip to prevent contact losses so



Measurement test of pressure distribution on pantograph-head with pressure sensitive paint in the large-scale wind tunnel



Computational fluid dynamics (CFD) has been used for research related to reduction of the aerodynamic noise of Shinkansen pantographs



Without flow-control　　With flow-control

Improvement of aeroacoustic characteristics by using flow-control technique

that the arcing noise can be suppressed.

On the other hand, the aerodynamic noise is generated when unsteady motion occurs in the air while an object is moving at high speed in the air. At present, since the above-mentioned arcing noise is suppressed, the primary cause of the current collection noise is the aerodynamic noise. Reducing the aerodynamic noise is a very difficult task because its energy increases in proportion to the vehicle speed raised to the sixth to the eighth power. The fact that the Shinkansen pantograph appearance has changed greatly over time exhibits the history of various kinds of measures to reduce the aerodynamic noise as speed has increased.

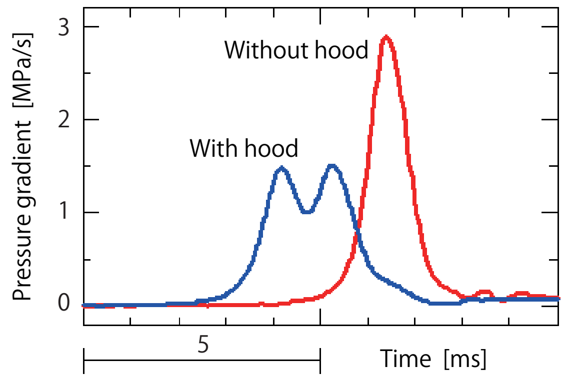
Promoting research and development aimed at reducing the aerodynamic noise needs an anechoic wind tunnel, which lowers the background noise generated and allows the aerodynamic sound from the test specimen to be measured with high accuracy. Thus, in 1996, RTRI started operation of a large scale low noise wind tunnel, which has the world's best low noise performance at the maximum wind speed of 400 km/h. The wind tunnel and various measuring techniques developed by RTRI were used extensively for the development of the Shinkansen pantograph. In addition, recently, computational fluid dynamics (CFD) has been used for research related to reduction of the aerodynamic noise of Shinkansen pantographs.

Although further reduction of the pantograph aerodynamic noise is demanded for further improvement in Shinkansen speed today, the pantograph aerodynamic noise has already been kept to a significantly low level. In addition, there is a constraint that compatibility with improved contact performance should also be achieved. Therefore, RTRI has been conducting research and development aimed at realizing more innovative pantographs by applying control techniques such as pantograph aerodynamic characteristics control and motion control (contact force control).

Mitigation Measures of Micro-pressure waves

The maximum running speed on the Shinkansen commercial lines has been increased to 320 km/h, and even faster speeds are planned. Aerodynamic phenomena become significant in at these high-speeds. In Japan, a largely mountainous country, high-speed railways have many tunnel sections. It is therefore important to consider the aerodynamic phenomena that are generated when trains enter tunnels.

One of these phenomenon is micro-



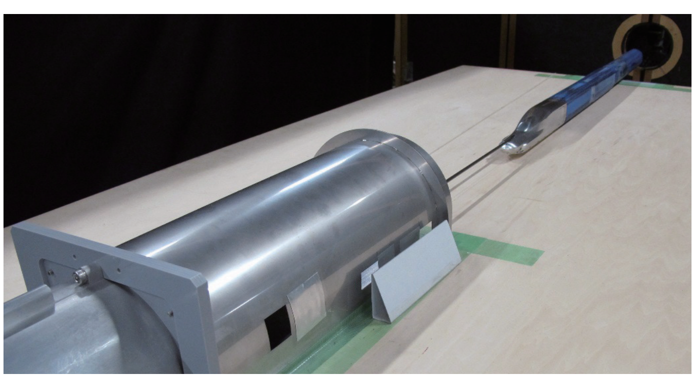
A scale model test demonstrates that the tunnel hood mitigates a spike of micro pressure wave.

pressure waves that radiate from the exit of a tunnel. As the front end of a train enters a tunnel, the air pressure in the tunnel rises, generating compression waves. The compression waves reach the other end of the tunnel and radiate out as pulsating pressure waves. These pulsating pressure waves are the micro-pressure waves. They can sometimes cause problems such as impact noise and shaking of fittings in houses near the tunnel exit.

When constructing new high-speed railways or speeding up existing systems, it is necessary to estimate the intensity of anticipated micro-pressure waves and proactively take mitigation measures. Typical solutions to micro-pressure waves include tunnel hoods that are installed on the entrance of a tunnel and shape optimization of the front end of trains. These measures are intended to reduce the pressure gradient of initial compression waves at the train entry, thereby mitigating the resulting micro-pressure waves.

RTRI has been conducting model experiments using scale models as well as numerical analysis to clarify the phenomenon of micro-pressure waves and develop mitigation measures. As part of the model experiments, a model train is entered into a model tunnel at a speed corresponding to that of a life-size train to measure the compression waveforms. RTRI mostly uses axisymmetric train and tunnel models, and conducts experiments up to a speed of 450 km/h. RTRI is now constructing a new test facility of micro pressure waves that will allow to conduct experiments up to 400 km/h with a trainset model of scale size but really shaped.

As part of its numerical analysis program, RTRI and Boston University in the U.S. developed a rapid calculation of the compression wave that uses acoustic theoretical analysis. With that computation method, results can be obtained on a personal computer faster than with the computational fluid dynamics (CFD) numerical analysis/simulation method run on a supercomputer. This makes it possible to efficiently study micro-pressure waves mitigation measures including tunnel entrance hoods and the shape optimization of the front end of trains.



Experiments using a model train and a model tunnel with the same shapes and dimensional ratios as the real versions

Conclusion

To realize further speed improvement while maintaining a good environment along the railway, the RTRI conducts various R&D activities besides those described herein. The fruits of such R&D have contributed to reducing the environmental impact not only of the Shinkansen but also of high-speed railways all over the world. In cooperation with researchers and railway operators from around the world, we would like to continue to proceed with challenging R&D toward realizing a sustainable railway.