Special edition paper

Countermeasure Against Snow




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Tests of countermeasures against snow were conducted using FASTECH360 Shinkansen high-speed test trains to secure safety in snow and prevent damage caused by snow dropping off from the car body so as to enable increased Shinkansen speeds. Measures against snow accretion and dropping could not be sufficiently evaluated in FY 2006 due to little snowfall in that winter, so the tests were continued to FY 2007. In those tests, we have confirmed that self snowplowing performance to secure running safety in snow is sufficient for running at up to 320 km/h in natural accumulation of snow. In terms of the measures against snow accretion and dropping, we have confirmed that snow melting heaters are effective for bogie end covers and bogie covers to which much snow adheres. We also confirmed that snow could be melted by exhaust of air conditioners.

●Keywords: Self snowplowing test, Prevention of snow accretion and dropping, Snow melting heater, Air conditioner exhaust

1 Introduction

JR East's Shinkansen rolling stock runs in regions of heavy snowfall and snow accumulation. When the track is covered with snow, the rolling stock thus needs to have sufficient self snowplowing performance to secure high speed running safety.

In such regions, much snow adheres to and around bogies and to surfaces of cars near the couplers. Dropping of adhered snow off cars in high speed running sometimes scatters ballast and breaks car window glass. Much snow adheres particularly to cars for through service between Shinkansen and conventional lines because the trains run on conventional lines that run in areas with much snowfall. To prevent carrying such snow into Shinkansen lines, adhered snow is removed manually at Morioka and Fukushima Stations from trains that enter from conventional lines at those stations in times of heavy snowfall. Many types of snow accretion prevention methods have been applied to Shinkansen rolling stock up to now. Those include snow accretion dummys[1] attached to cars that simulate the shape of snow adhered to cars, car body coating and use of heaters.

This article will report the verification results of running tests using FASTECH360 Shinkansen high speed test trains to secure safety in high speed running and prevent damage by snow dropping off from the train.

2 Self Snowplowing Performance

On Shinkansen lines, speed restriction is performed for safety when the track is covered with snow over 9 cm or thicker on the rail top surface. That speed control related to snow accumulation is specified only to the current maximum commercial operation speed range of up to 275 km/h, so verification is needed for speed increase greater than that.

2.1 Self Snowplowing Running Test

The self snowplowing running performance was evaluated in tests whereby artificial snow accumulation (snow bed) is placed on the Tohoku Shinkansen between Sendai and Kitakami. The running safety, car body vibration and bogie strength were measured when the train passed over the snow bed that was 9 cm thick on the rail top surface and 20 m long.

We carried out self snowplowing running tests using the FASTECH360S Shinkansen-exclusive test train in February 2006 and tests using the FASTECH360Z for through service on Shinkansen and conventional lines in February 2007. The results proved that there were no problems up to 320 km/h with natural snow accumulation of 9 cm thick on the rail top surface (Fig. 1).

Fig. 1 Self Snowplowing Running Test

3 Study of Measures Against Snow Accretion and Dropping

When a train runs in snow, snow kicked up by phenomena such as train draft adheres to and around bogies and to surfaces of the coupled cars. Dropping of snow from cars due to factors such as temperature rise leads to problems such as scattering of ballast that breaks window glass. To prevent carrying such snow into Shinkansen lines by rolling stock for through service between Shinkansen and conventional lines, adhered snow is removed manually at stations before entering Shinkansen lines.

In light of those circumstances, we developed measures to prevent snow from adhering to and around bogies and to surfaces of the coupled cars.

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4 Development with a FASTECH360 Shinkansen High-speed Test Train

Dropping of snow and ice adhered to Shinkansen cars in running might damage wayside equipment and structures along the line. The damage is expected to be more severe as Shinkansen trains run faster. Thus, using the FASTECH360Z, we developed measures to prevent snow accretion and dropping starting in FY 2006. The developed measures include snow melting by heaters and exhaust from underfloor equipment and snow removing boots that expand from air pressure.

4.1 Snow Melting Heater

Heaters were already confirmed effective at the basic study phase.[2) 3)] To actually install them on cars, we need to secure power supply for the heaters and to check if the heater cables interfere with attachment/removal of bogie end covers (protective plates on the car body in front of and behind bogies). We thus selected an efficient heater and studied its placement with the FASTECH360Z test train for through service.

4.1.1 Snow Melting Heater for Bogie End Covers

Much snow kicked up by train draft around bogies adheres to bogie end covers and often drops off from cars in some places due to factors such as temperature rise. Since guards with sound insulation material were employed to reduce noise from bogies, we selected a heater effective in prevention of snow accretion and dropping and studied its placement (Fig. 2).

The running tests confirmed the snow melting effect of heaters. No difference in melting snow on the cover surface was found between heater types, so we could not determine what type of heaters were superior (semiconductor type or far infrared type). Issues such as checking durability in long-term use and cost also remain.

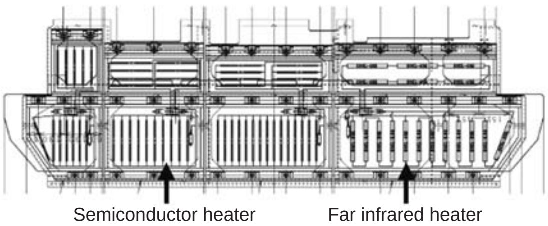

Fig. 2 Snow Melting Heater for Bogie End Covers

4.1.2 Bogie Cover Snow Melting Heater

Bogie covers are effective in reducing noise from bogies and are necessary for speed increase. But snow adheres to the inside of the covers when running with snow on the rails, and those covers end up holding the snow in them.

We thus verified the snow melting effect of heaters also for bogie covers. Running tests were carried out with bar type heaters on the reinforcing angles of the covers, and we found a localized snow melting effect around heaters. However, the heaters could not melt snow on the surrounding area (Fig. 3).

Tests have confirmed the effect of the heaters in the installed areas. But the issues of securing strength of bogie covers and effectively placing heaters still remain.

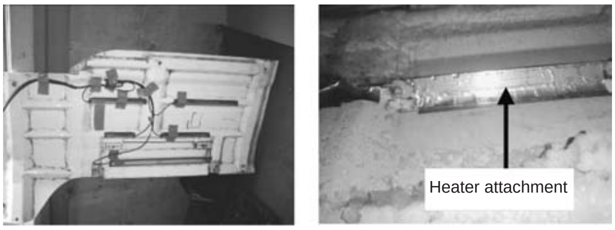

Fig. 3 Bogie Cover Snow Melting Heater

4.1.3 Snow Melting Heater for Side Sliding Door

With current Shinkansen rolling stock, side sliding doors for passengers sometimes freeze up and cannot be opened, disrupting operation. We thus installed heaters on the car body near sliding doors with the FASTECH360Z and verified snow melting effect of the heaters (Fig. 4). Doing so clarified that it was difficult to control the temperature of the heaters to be just right for snow melting.

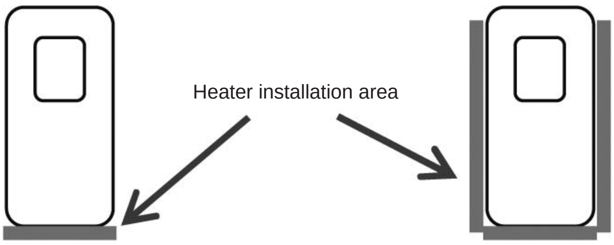

Fig. 4 Location of Heaters for Side Sliding Doors

4.2 Snow Melting by Exhaust or Warm Air

Running test results proved the effect of snow melting heaters, but there are issues in securing power supply, maintainability and cost. We thus conducted development for snow melting methods not relying on heaters.

4.2.1 Snow Melting by Air Conditioner Exhaust

Exhaust air is emitted from the cabin by air conditioner ventilators. As the temperature in cabin is set to a level at which passengers feel comfortable, the temperature of that air is higher than the outside temperature in winter. We thus developed a snow melting system using the exhaust air as the heat source.

We installed a duct between the air conditioner and a bogie end cover to lead air conditioner exhaust air to the air space on the bogie end cover and prevent snow accretion (Fig. 5). We were able to confirm the snow melting effect of the exhaust air. While this method has advantages of using no power source and in cost, it is applicable only to the limited area that meets the conditions that the air conditioner or other equipment blowing warm exhaust air is located nearby and that there is room to place a duct of appropriate length.

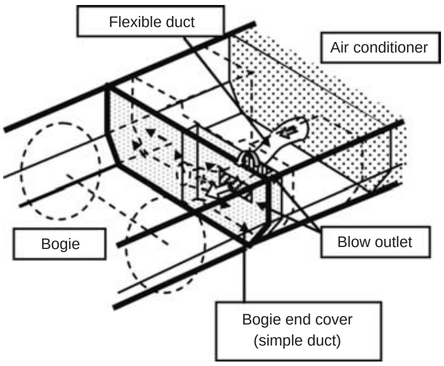

Fig. 5 Snow Melting Using Air Conditioner Exhaust

4.2.2 Snow Melting by Traction Motor Exhaust

Much snow adheres to the area of the bogie in which a traction motor is located, but the complex shape of that area makes it difficult to install a heater there. A traction motor is cooled with a blower since it generates heat, so we tested prevention of snow accretion by leading traction motor exhaust through a duct to the area of the bogie to which much snow often adheres (Fig. 6).

We confirmed the effect of snow melting by that exhaust, but it was difficult to shape the duct. We reached the conclusion that applying this method to rolling stock in commercial service would be difficult.

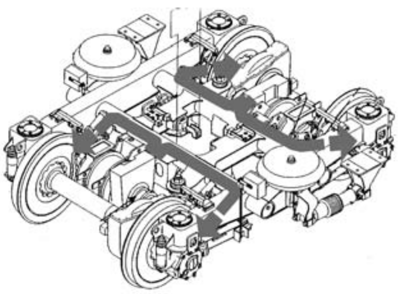

Fig. 6 Use of Traction Motor Exhaust

4.2.3 Defroster Hot Air and Compressed Air

Onboard antennas that receive signals from wayside equipment are installed under the floor of the nose of the lead cars of Shinkansen rolling stock. Rolling stock is thus designed to have no metal within a specified area from the onboard antennas to avoid interfering with such signal receiving. In light of that, we expected that we would not be able to install heaters to the bogie end covers of both noses. We thus verified the effect of snow melting by defroster hot air and compressed air blow as a measure other than using heaters against snow accretion and dropping (Fig. 7).

In this measure, we aimed to increase the snow melting effect by using defrosters as a hot air source and combining that with compressed air. We confirmed the snow melting effect by hot air blow at bogie end covers located to the front in the direction of travel, but snow adhered to bogie end covers located to the rear, showing no snow melting effect.

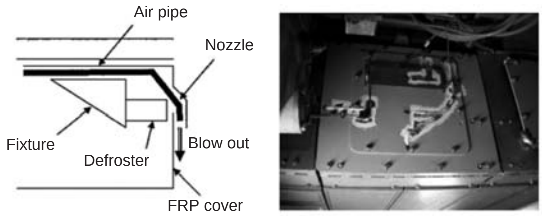

Fig. 7 Snow Melting by Hot Air Blow and Compressed Air

4.2.4 Countermeasures Against Car Sliding Door Freezing Using Air Conditioner Warm Air in Cabin

We had devised a measure of installing heaters to the car body around sliding doors as previously explained, but much of the heat from heaters is transferred to the car body. We thus developed a countermeasure against sliding door freezing other than using heaters.

We aimed to prevent freezing by leading hot air of air conditioners into door pockets to warm up the inside pockets as a whole (Fig. 8). No doors froze up in the tests, so we found no difference between door pockets with and without warm air blow from air conditioners. But the effect would be small because we could not find a temperature rise in the sliding door pockets.

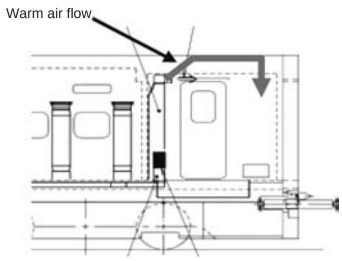

Fig. 8 Use of Air Conditioner Warm Air

4.3 Countermeasures against Snow Accretion and Dropping by Vibration

In addition to the above-mentioned countermeasures using heaters and exhaust to melt snow and ice, we also tested measures of shaking off snow adhered to bogie end covers.

4.3.1 Deicer Boots

We developed a measure of pushing off adhered snow by expanding and contracting deicer boots installed on the bogie end covers (Fig. 9). The test results showed that the boots had a large effect on dropping large volumes of snow by the snow's own weight through expansion of the boots. But small volumes of snow or soft snow followed the movement of the boots and most of the snow remained on the boots.

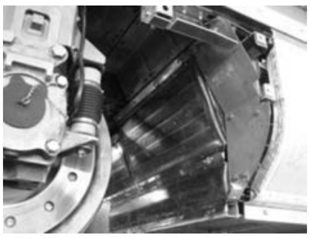

Fig. 9 Deicer Boots

4.3.2 Bogie End Cover with Vibrator

In addition to the aforementioned countermeasures using defroster hot air and compressed air against snow on the lead car bogie end covers, we also developed a measure of shaking off snow by vibrating bogie end covers using small vibrators installed on the inner surface of the covers (Fig. 10). We tested that method with different frequencies applied to the covers, but we found that it could not shake off snow on the bogie end covers.

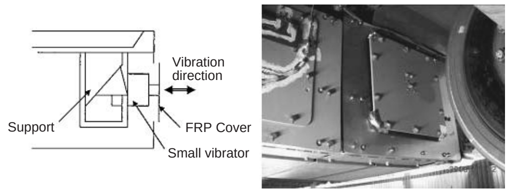

Fig. 10 Bogie End Cover with Vibrator

5 Car Underbody Shape that Prevents Snow Accretion

Based on aerodynamics, we studied by numeric fluid simulation a car underbody shape on which it is difficult to pick up snow. As a result, we expect that installing both bogie covers and underfloor snow accretion dummies could prevent snow accretion around bogies. Verification of numeric simulation using an actual train confirmed pressure change at the bogie end covers differed from the simulation results, but the wind direction of the actual train matched that of the simulation. We thus have to improve the simulation accuracy.

Next, we used the FASTECH360Z to develop, focusing on air flow, a car underbody shape around bogies on which it is difficult for snow to adhere. We subsequently conducted verification for this measure.

5.1 Bogie Cover

The FASTECH360Z also has full covers on the side of the car body to reduce noise from bogies in high speed running. Those full covers have an effect of preventing snow intrusion to the bogies from the side of the car body, but snow adheres to the inside of the covers once it enters and builds up there. In order to prevent the covers from holding snow while maintaining the noise reduction effect, we shortened the length of the covers and changed to partial covers with inside reinforcement of a shape that it is difficult for snow to adhere. Then we verified those in running tests (Fig. 11).

The partial covers ended up holding snow inside as the full covers did. We therefore could not verify a snow accretion prevention effect by changing to partial covers and improving the shape of inside reinforcement.

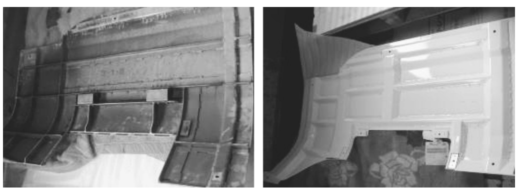

Fig. 11 Change of Bogie Cover Shape (Left: Full cover, Right: Partial cover)

5.2 Bogie End Cover Bottom Shape Change

We aimed to prevent snow from entering and adhering to the bogie inside by making the bottom end of the bogie end covers diagonal (Fig. 12). Since this measure was tested at the same area as we tested snow melting using air conditioner exhaust due to testing constraints, we could not evaluate the effect of this shape change alone.

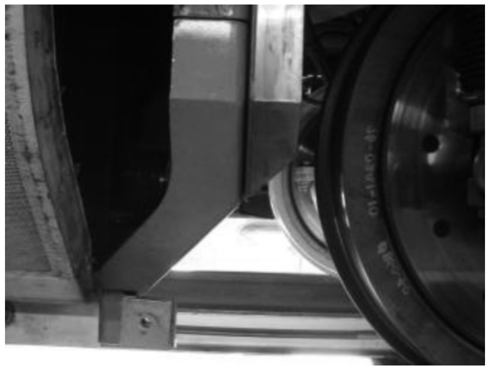

Fig. 12 Change of the Bottom End Shape of the Bogie End Cover

6 Conclusion

We have confirmed the effectiveness of the snow melting heater and air conditioner exhaust as measures to prevent snow accretion and dropping off. The issue of restricted location for installation remains, however, for use of air conditioner exhaust. And for snow melting heaters, we still have to confirm their durability and make attaching/removing bogie end covers easier because cabling for heaters is required. In order to solve those issues, we are verifying practical use of snow melting heaters using series E3 rolling stock in commercial service.

Preventing snow accretion on bogies is also an important issue. We expect that raising the atmospheric temperature around the bogie using exhaust heat will be effective, but there are still issues such as the structure of the duct for the exhaust. We thus need to continue with development.

Reference:

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