FASTECH360 Shinkansen high-speed test trains require comfort improvement and environmental compatibility on top of assured safety and reliability as they run at a high speed of 360 km/h. We have thus conducted a range of development using FASTECH360 such as that on the current collection system, drive system, and control system to be able to handle high-speed running. New technologies were also employed for the car body structure. We have verified those through running tests and confirmed that they could sufficiently withstand high-speed running and be effective in reducing tunnel micro-pressure waves and on-train noise.

Keywords: Shinkansen, FASTECH360, Car body cross section, Running resistance, Sound insulation

1 Introduction

In order to achieve a maximum commercial operation speed of 360 km/h, development on a car body structure to handle such high speed is necessary just as with the current collection system, drive system and control system. Since fluctuation of pressure on the car body and noise on the train were expected to increase in conjunction with higher speed running, we developed car body structural components and a car body sound insulation structure that can deal with those and verified those in running tests.

3 Car Body Airtight Structure

When Shinkansen trains pass each other in tunnels, the pressure in the tunnel fluctuates considerably. The pressure fluctuation by trains passing at 360 km/h is approx. 1.7 times larger than that at 275 km/h, so a car body structure strength resistant to such a pressure fluctuation (structure airtight strength) is required for fast-running Shinkansen cars.

Using FASTECH360, we carried out simulation of the pressure fluctuation that would be received by the car body structure in the tunnel when high-speed Shinkansen trains at 360 km/h pass each other and when a Shinkansen train of rolling stock in operation passes a high-speed Shinkansen running at 360 km/h. We decided on the structure airtight strength based on those results.

3.1 Running Test Results

In order to insulate noise generated at pantographs, we have installed retractable pantograph noise insulation plates on the FASTECH360Z. And we have also employed a structural cross section that reduces the effective width of part of the interior of the car to secure space for interior cabling and piping.

We decided to reduce car body cross sectional area for FASTECH360 in order to reduce tunnel micro-pressure waves and handle car body tilting by a body tilting system. That needed to be done, however, while maintaining in-cabin comfort. The cross sectional area of the FASTECH360S exclusive for Shinkansen is 96% that of series E2 Shinkansen cars, and the cross sectional area of the FASTECH360Z for through service on Shinkansen and conventional lines is 91% that of series E3 cars.

The car body structure (Fig. 1) is basically composed of large structural members with a hollow truss-type cross section, and we have adopted two types of such members. One of those has thicker roof components on which stress would concentrate due to airtight load as well as thinner wall components. The other has largely the same thickness for both roof and wall.

Fig. 1 Car Body Cross Section of FASTECH360

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4 Running Resistance

Fast running Shinkansen trains need large main circuit output. In order to minimize the output and allow downsizing the equipment, running resistance should be made as small as possible. The faster a train runs, the larger the ratio that air resistance makes up of total running resistance. Reducing air resistance of the rolling stock as much as possible is thus effective for reducing running resistance.

With FASTECH360, installing bogie side covers and smooth full covers between cars and making sliding doors and cabin window glass smooth successfully reduced air resistance.

4.1 Running Resistance Measurement Results

We measured running resistance by coasting operation where deceleration is measured when making a train coast. The running resistance per ton of the FASTECH360S running at 360 km/h was lower by 4 - 11% in open sections and by 4% in tunnels compared to that of an E2-1000 Shinkansen train. The value for the FASTECH360Z was also lower by 9 - 14% in open sections and 15 - 23% in tunnels compared to that of the series E3 Shinkansen train.

5 Car Body Sound Insulation Structure

A level of quietness where passengers can talk as usual on the train even at 360 km/h is necessary to achieve the world’s most comfortable high-speed train. We thus improved sound insulation and absorption by the car body structure and lowered the noise level at noise sources.

5.1 Floor Structure

For the FASTECH360S, we decided to use airtight floor plates of single skin structure to reduce weight on the center of the car and of double skin structure to improve sound insulation at the both car ends. For upper floor plates, aluminum honeycomb plates were mostly used, and honeycomb floor plates with rubber and aluminum plates with resin foam core that have higher sound insulation performance were used near noise sources such as bogies (Fig. 2). The floor plates were installed with two types of rubber supports for a floating type interior floor. In order to reduce solid-borne sound, cuts were made in some of the supports of the floor plates to make jointing between airtight floor panels and floor plate supports weaker. Airtight floor plates for the FASTECH360Z were of single skin structure with large members.

5.2 Window Glass Structure

We employed cabin window glass of a structure having an air layer between the outer glass and inner glass to improve quietness. For outer glass, three types of glass were applied: multi-layer glass with and without an air layer in between and single polycarbonate glass. Those were made smooth with the surface of the car body to reduce noise outside of the car (Fig. 3).

5.3 Ceiling Structure

We employed two types of structures for the cabin ceiling. One is a structure where aluminum inside panels is directly fixed on the ceiling of the car body with resin sound absorbing foam that also works as heat insulation affixed over the entire interior face of that structure. The other is the structure where the panels are attached on the ceiling via rubber (interior elastic fastener, Fig. 4) with light heat insulation that also works as sound insulation affixed over the total area of the interior of the cabin.

Similarly, on the walls of the cabin, sound insulation that also works as heat insulation is affixed.

6 Conclusion

We were able to reduce tunnel micro-pressure waves with FASTECH360 compared to that with Shinkansen rolling stock in operation by improving nose shape and reducing car body cross sectional area. But, in order to reduce micro-pressure at around 360 km/h, those improvements have to be combined with wayside equipment improvement. We also confirmed that applying elements that improve sound insulation performance to floors, windows and ceilings secures quietness in the cabin. As a result, the FASTECH360S test train exclusive for Shinkansen has successfully achieved a noise level when running 360 km/h equal to or less than that of series E2 Shinkansen rolling stock running at 275 km/h.