Interpretive article

Development of Series E5 Shinkansen Rolling Stock

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A variety of Shinkansen-related development has been progressing for about ten years with a target of completion by the opening of the Tohoku Shinkansen to Shin-Aomori, and currently series E5 mass-production rolling stock is being designed and manufactured. The series E5 will be the core rolling stock of JR East's Shinkansen, optimized for 320 km/h top commercial operation speed upon applying the results of high speed test train FASTECH360 development. The first train sets in that series were inaugurated at the end of 2010. As it would have great increase in speed over current rolling stock, careful confirmation and verification was made in the development process to secure absolute reliability. A total of 59 train sets are planned to be manufactured for the series E5, and those will be introduced on the Tohoku Shinkansen as replacements for rolling stock such as the series E1 and type 200.

1 Introduction

Mass-production rolling stock for the series E5 was developed with a goal of introducing it to service by spring of 2011. Pre-mass production rolling stock was inaugurated ahead of that in June 2009, and various evaluation tests were performed.

A top operating speed of 320 km/h was decided on taking into account cost effectiveness of speed increase. Pre-mass production rolling stock was produced based on the FASTECH360 to verify optimization for 320 km/h top speed operation.

Running tests started in summer of 2009, and we confirmed that basic performance and environmental performance were equivalent to that of the FASTECH360. The go-ahead was thus given for design and manufacture of mass-production rolling stock. Three train sets were inaugurated starting at the end of 2010, and operation with those at 300 km/h between Tokyo and Shin-Aomori is scheduled to start in spring of 2011.

Fig. 1 Series E5 Pre-mass Production Rolling Stock

2 Series E5 Shinkansen Rolling Stock

2.1 Main Points of Development

Passenger capacity and passenger cabin equipment are major factors determining specifications of operating rolling stock. To secure greater passenger capacity than with the FASTECH360, the nose length was shortened from 16 m to 15 m, and the number of cars in the train set was increased from eight to ten. Equipment for increasing air resistance (so-called "cat ears") featured on the FASTECH360 was eliminated, increasing capacity by a five-person row in one location. It goes without saying that necessary braking performance was confirmed to have been secured.

Fig. 2 Basic Brake Device

Verification of safety is another major point. Pre-mass production rolling stock bogies are equipped with innovative basic brake devices (pneumatic calipers, center mounted brake discs, equal-pressure linings). Axle bearings are of two types (oil bath and greased), drive devices are equipped with double helical gears and helical gears and new test factors were added over those of the FASTECH360. That addition was made to reevaluate specs of current rolling stock such as oil bath bearing and helical gears with the reduction in top speed. Innovations such as synchronous electric motors and water-cooled main traction converters were introduced with the traction equipment of the FASTECH360, but those based on the traction equipment of the series E2 Shinkansen were used because of an emphasis put on track record. Detailed studies were done on operability, maintainability and cost reduction. In those studies, a mockup of the driver's cab was built for verification performed by train crew and pre-mass production rolling stock was put in the maintenance line, whereby problems such as those in inspection and repair were verified.

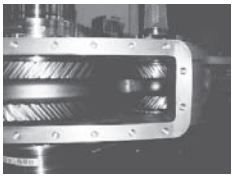

Fig. 3 Double helical Gear

2.2 Evaluation by Running Tests

We conducted running test mainly between Sendai and Kitakami on the Tohoku Shinkansen. The most important evaluation point was that environmental performance be equivalent to that of the FASTECH360S. By changing the nose shape from that of the FASTECH360 and eliminating equipment under the hood of the nose not needed by commercial operating rolling stock, the shape could be optimized. The process by which effects were verified was the same as employed with FASTECH development (wind tunnel testing and simulations).

As a result of running tests, we confirmed that environmental

standards in terms of noise outside the train could be sufficiently met at 320 km/h. There were differences in the generation of micro-pressure waves according to tunnel entrance hood length, and discrepancies from FASTESCH360 results were found at some hood lengths. We found that rolling stock running performance was according to planned values.

We did find some items for which continued verification is necessary. Those were train draft and pantograph performance. Train draft is checked to see if draft pressure generated by a passing train adversely affects wayside equipment. While train draft was generally the same as with current rolling stock in operation, peculiar data was found. We thus verified in detail items such as correlation with the shape of the underpart of rolling stock. To reduce outside noise, we designed on the premise of running using only one pantograph per train set. That pantograph is "<" shaped, with the pointed end facing in the running direction. When the train is operating in the opposite direction, it switches to use of the other pantograph facing the opposite direction. However, if trouble of some sort occurs and the unused pantograph does not lower, the pantograph would need to operate opposite to the running direction. We confirmed that upward force on the overhead contact line becomes large in such cases. For that reason, we studied issues including how to handle such cases.

Fig. 4 PS208 Type Pantograph

2.3 Evaluation of Pre-mass Production Rolling Stock

We confirmed that performance requirements at 320 km/h were met from running test results, and mass-production car specifications were finalized. Items to verify such as changing the bogie full covers to half covers to improve maintainability and reduce costs remain. And final decisions will be made after coupling running tests of the series E5 which must run with the series E6.

Fig. 5 Bogie Full Cover

2.4 Mass-production Rolling Stock

For the series E5, 59 train sets will be manufactured including pre-mass production rolling stock to be introduced for increasing speed and as replacements for the type 200 and series E1. We confirmed performance in tests for the driving devices and axle bearing set as comparative test elements with pre-mass production rolling stock, thus deciding to adopt helical gears and oil bath bearings with mass-production rolling stock. The premise of the basic concept of development leading from the FASTECH360 to series E5 is to verify the situation by means such as evaluating in actual running conditions in addition to calculations and simulations to make sure there are no problems.

For bogies that are one of the most important components in terms of safety, evaluations are made in bench tests with a 1.2 million km load corresponding to timing of general inspection. For pantographs and other moving parts, tests of repeated movement corresponding to timing of general inspection were conducted. For rolling stock as a whole, we made 600,000 km durability tests by FASTECH360, then disassembled those and conducted detailed studies to confirm that there were no fundamental problems. We are also making similar 600,000 km durability tests for the pre-mass production rolling stock. Top speed at the end of FY 2012 will be 320 km/h, 45 km/h faster than the current operating speed of 275 km/h. While the speed increase will be incremental, it will be a major increase in speed in a short period of time. Thus, it is essential to sufficiently identify the status of rolling stock in maintenance and not overlook even minor abnormalities.

Fig. 6 Bogie Bench Testing

3. Series E6 Shinkansen Rolling Stock

Pre-mass production rolling stock for the series E6 was inaugurated in July of 2010. The series E6 is to replace series E3 rolling stock for Komachi trains, and its development was possible due to the technical development results of FASTECH360, just as with the series E5. The issue of reducing noise outside the train, the greatest issue in increasing speed, is proving more difficult with the series E6 than with the series E5. That is because restrictive conditions of rolling stock structural design such as pantograph covers not being attachable due to conventional line clearance issues are more severe. The body height is also lowered compared with the series E3 to reduce micro-pressure waves by relocating air conditioning equipment under the floor. The nose length is 13 m, more than twice that of the series E3 6 m. Securing passenger cabin space thus became difficult, so a seven-car train set is used to secure the same capacity as the Komachi's six-car train set. We plan to build a total of 26 train sets of the series E6 including the pre-mass production rolling stock.

Fig. 7 Series E6 Exterior

3 Conclusion

It will take just over six years to complete the transition from old to new Shinkansen models starting in spring of 2011. There will be many issues to study in that time such as mixed operation of old and new models and how to go about replacement. We plan to operate the series E5 coupled with series E3 rolling stock for Komachi and Tsubasa trains, and we are thus making preparations for modifying current rolling stock. Also, the Hokuriku Shinkansen is planned to open at the end of FY 2014 followed by start of Shinkansen service to Hakodate. This is a period of great change; along with the transition to new rolling stock, we will be providing new services fitting the new age such as the "GranClass" first class cars, improved security, and expanded barrier-free access.