

Motor Bearing Rattle in Electric Powertrains

- (Second Report) Development of the Design Method for Rattle Suppression -

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The demand for vehicle quietness has further increased with the advancement of electrification. In electric powertrains, motor bearing rattle caused by the internal clearance of the bearing is a critical NVH issue. The first report clarified that motor shaft dynamic behavior causes changes in the trajectory of the motor rear bearing, thereby affecting rattle generation. However, a practical method for evaluating rattle risk during the design phase has not been established. To address this issue, a rattle suppression design method applicable during the design phase was developed based on the rattle generation mechanism.

Based on the rattle generation mechanism clarified in the first report, avoidance of passing through the bearing clearance and reduction of the pass-through distance were established as the design concepts for rattle suppression. To efficiently evaluate multiple design specifications during the design phase, a design flow combining pass-through judgment using quasi-static analysis and rattle risk assessment using time-domain analysis was developed (Fig. 1). First, the trajectory of the motor rear bearing is calculated by quasi-static analysis, and the occurrence of pass-through is determined based on the bearing trajectory and bearing load. For specifications in which pass-through is determined to occur, time-domain analysis is subsequently performed, and rattle risk is evaluated using collision energy as an indicator. This approach enables efficient specification studies during the design phase.

To verify the effectiveness of the proposed design method, evaluations were conducted on the base specification and several countermeasure specifications. Since pass-through was determined to occur in all countermeasure specifications by quasi-static analysis, time-domain analysis was conducted to evaluate rattle risk. As shown in Fig. 2, the specifications with reduced motor bearing internal clearance and increased outer ring clearance of the gearbox rear bearing achieved collision energy values below the evaluation criterion and were judged to have low rattle risk. In contrast, the specification with increased spline backlash showed only a limited reduction in collision energy and exceeded the evaluation criterion. These results demonstrate that the proposed design method enables quantitative evaluation of the rattle risk of each specification.

Bench tests were conducted for the specifications judged to have low rattle risk by time-domain analysis. The test results confirmed a reduction in the peak-to-peak values within the evaluation range for housing vibration measured near the motor rear bearing. In addition, rattle reduction effects were confirmed through subjective evaluation. These results showed that the trends in the analytical rattle risk assessment results were consistent with those in the vehicle test results, verifying that the proposed design method is effective for selecting specifications that improve NVH performance.

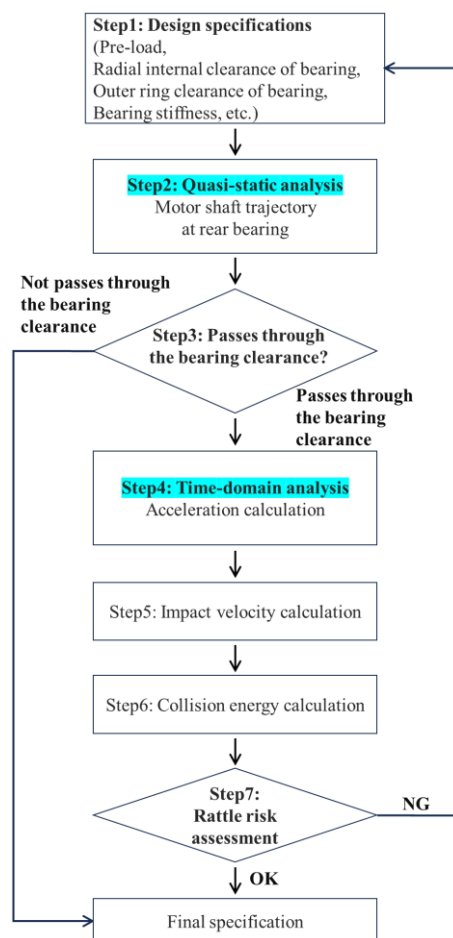


Fig.1 Rattle suppression design flow

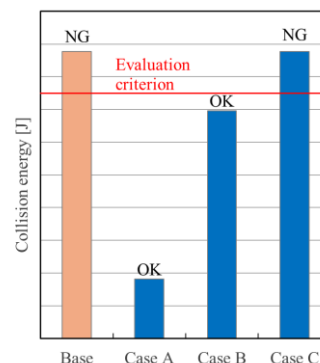


Fig.2 Calculation results of collision energy