

Development of Comfortable Operating Sound for Power Seats

- (First Report) Optimization of Gear Meshing Force for Reducing Power Seat Operating Noise -

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With the recent advancement of vehicle electrification, significant progress has been made in the reduction of powertrain noise, resulting in the increased perceptibility of various operating sounds within the vehicle cabin that had not previously been noticeable to occupants. In particular, the operating sound of power seats, which are frequently used in daily situations, requires not only noise reduction but also improvements in sound quality and perceived comfort. In addition, the environment surrounding product development has become increasingly demanding in recent years, and as development periods are shortened due to the diversification of market needs and intensified competition, the importance of front-loading development—where performance is predicted and evaluated at the early design stage—has been increasing, moving away from conventional development processes that rely on post-prototype evaluations.

In this study, attention was focused on torque fluctuations caused by gear meshing, which is one of the primary factors contributing to power seat operating noise. From the perspective that reducing these torque fluctuations contributes to the suppression of vibration and radiated noise as well as to improvements in sound quality, the objective of this study was to establish a method for reducing operating noise through the optimization of gear meshing force. Specifically, a simplified 1D-CAE model capable of reproducing gear meshing behavior in the power transmission path from the motor to the seat in a power seat system with a fore-aft adjustment mechanism was developed. Worm gears and bevel gears were considered, and multiple design parameters—including backlash, face width, lead angle, helix angle, and pressure angle—were selected as design variables (Fig. 1).

Using this model, the power transmission process from motor torque generation based on input voltage through the gear mechanism was simulated, and output torque fluctuations under each design condition were calculated as time-series data. In addition, FFT analysis was applied to quantitatively evaluate the characteristics in the frequency domain. Furthermore, by automating these analyses and applying a design optimization method in which each parameter was varied within a certain range based on baseline design values, repeated calculations were conducted to efficiently identify optimal combinations of gear specifications that contribute to the reduction of torque fluctuations (Fig. 2). As a result, a significant reduction in the fundamental mesh frequency component caused by gear meshing was confirmed, and the amplitude of output torque fluctuations was also substantially suppressed. In particular, reductions of approximately 62% for worm gears and 66% for bevel gears were achieved, demonstrating that the dominant components of operating noise can be effectively reduced (Fig. 3). These results indicate that the optimization of gear design parameters is highly effective for reducing vibration and noise as well as improving sound quality.

Therefore, the proposed 1D-CAE model and optimization method are effective for predicting and reducing power seat operating noise at the early design stage. In addition, they contribute to improving development efficiency and are expected to contribute to improved passenger comfort and perceived product quality.

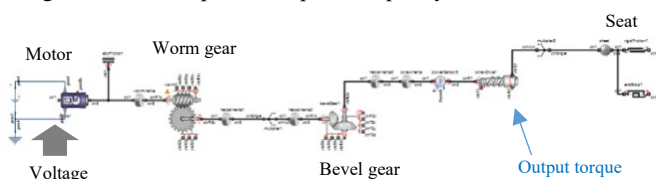


Fig.1 1D-CAE model of power seat system

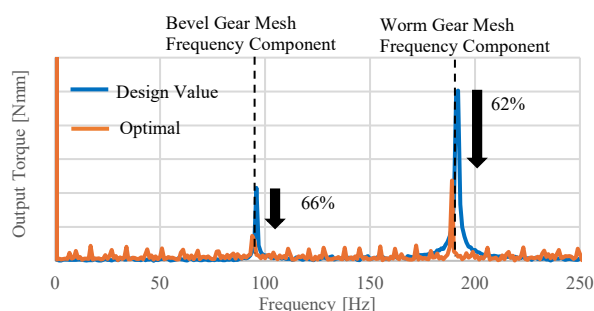


Fig.3 Comparison of output torque fluctuation

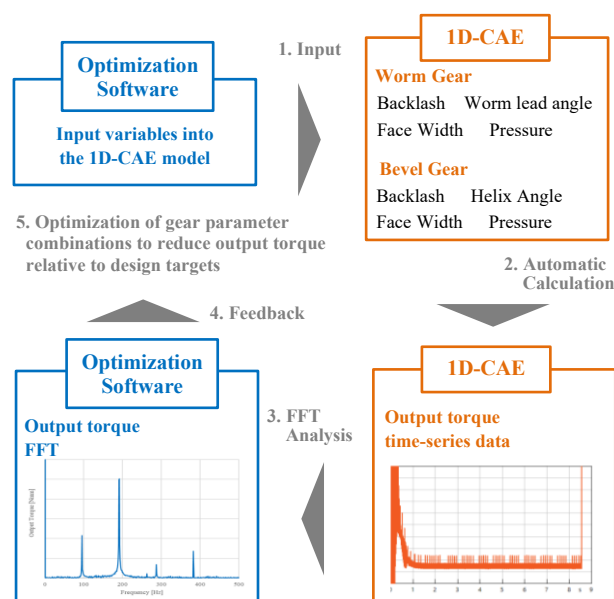


Fig.2 Optimization flow of gear meshing force