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Enhancing Steering Responsiveness by EPS Using High-Rigidity Torque Sensor

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Electric power steering (hereinafter EPS) is an effective technology for enhancing fuel economy and is installed in a large number of vehicles around the world. On the other hand, compared to the conventional hydraulic system, there is a subject of reduced steering feel due to the moment of inertia of the motor and the friction of mechanical elements. Therefore, efforts are being made to enhance the steering feel by focusing on hardware such as sensors and control technology.

The authors also worked on enhancing the steering feel by enhancing the control response of the EPS system. However, systems were still unable to achieve reduction in delay when turning the steering wheel back, or in delay in response when inputting disturbances.That is because most torque sensors used for EPS detect the angle of torsion of the torsion bar. For further enhancement of steering feel, therefore, it was considered that it would be effective to increase mechanical rigidity. In doing so, increasing rigidity to a high level raised an issue in that it changed the vibration transmission characteristics of the steering system.

This research proposes EPS control that reduces the inertance of changed vibration transmission characteristics, resolving this issue and making possible a torque sensor with rigidity increased to a high level.

The proposed method identifies specific frequency components of torque and adds assistive current based on that signal. By setting the frequency to be identified in the vicinity of the resonance frequency of vibration transmission, a reduction of inertance that is proportionate to gain could be confirmed.

An evaluation was made in actual vehicles of delay when turning the steering wheel back and in delay in response when inputting disturbances. Steering gears with the torsional rigidity of the torsion bar as the only difference between them were installed respectively in the same 1.5-liter front-engine, front-wheel drive (FF) car and subjected to verification under each evaluation item.

First, regarding the delay when turning the steering wheel back, effectiveness was compared using a Lissajous diagram of steering angle and vehicle lateral acceleration in slalom driving at a speed of 100 km/h. The results are shown in Fig. 1. Hysteresis with respect to steering angle was reduced and a reduction in delay in lateral acceleration (movement in the left–right direction in the figure) when turning the steering wheel back was successfully confirmed.

Next, regarding delay in response when inputting disturbances, the vehicle was driven at 180 km/h on a road surface where disturbance input occurs regularly when driving. For the frequency distribution of steering angles during driving, the probability density function is shown as a normal distribution based on the standard deviation of the measured steering angles. The results are shown in Fig. 2. A reduction of the standard deviation in steering angle was confirmed and the frequency of steering angle input, or in other words the reduction in steering corrections, good vibration transmission characteristics, were confirmed.

From the above, by use of the proposed EPS control instead, the possibility of adjusting the changed vibration transmission characteristics was shown and this made it possible to increase the torque sensor rigidity to a high level. Then the steering responsiveness has been enhanced by EPS using a high-rigidity torque sensor.

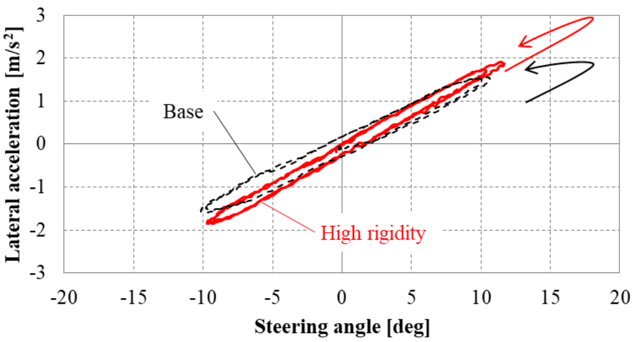

Fig. 1 Lissajous diagram of steering angle and lateral acceleration

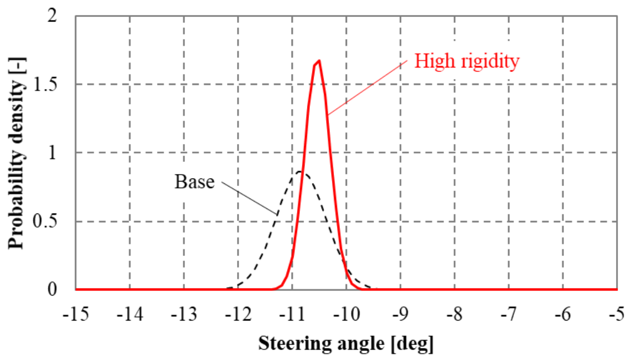

Fig. 2 Probability density of steering angle