

Development of a Prediction Method for Vehicle Vibrations During Driving Caused by Constant Velocity Joints

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In constant velocity (CV) joints, axial forces known as induced thrust forces are generated by rotational motion during driving and act as excitation sources for vehicle vibration. When the frequency of the induced thrust force coincides with the resonance frequency of the powerplant, lateral vehicle vibration, commonly referred to as judder, may occur.

In this study, a component-based Transfer Path Analysis (TPA) using 6 degrees of freedom (DOF) virtual points that allow the induced thrust force of the CV joints to be treated as blocked forces is employed to investigate the contribution of each vibration transmission path from the CV joints to a vehicle evaluation point during driving. Furthermore, based on the obtained vibration transfer characteristics, a simplified prediction formula for vehicle vibration at the evaluation point is constructed. Using induced thrust force of the CV joint calculated by kinematic analysis as the input, the magnitude of vehicle vibration is predicted and compared with measured results.

The target CV joint is a tripod-type joint. Due to its structure, which consists of three rollers equally spaced in the circumferential direction, the tripod-type CV joint generates third-order component of induced thrust force during rotation. Since the CV joints are connected to the vehicle through both the powerplant and the knuckle, the induced thrust forces generated at the CV joints are transmitted through these components and appear as vibration at the evaluation point (seat rail).

Component-based TPA using 6 DOF virtual points is applied to a vehicle equipped with the CV joints, and vibration transfer functions are obtained through impact hammer tests. The impact hammer test results show that the natural frequency of the powerplant in the lateral direction is 11 Hz. In addition, vehicle road tests show the lateral vibration at the evaluation point has a peak at a rotational speed of approximately 220 min⁻¹ (11 Hz). Since this frequency coincides with the lateral resonance frequency of the powerplant, it is confirmed that the resonance behavior of the powerplant contributes to lateral vehicle vibration (judder) during driving.

Figure 1 shows the results of the TPA analysis. At the rotational speed of 220 min⁻¹ (11 Hz) the measured lateral vibration acceleration level at the evaluation point agrees well with the response synthesized by the component-based TPA and the contribution of the lateral input from the powerplant (Contribution of PP_y). These results indicate that, at the resonance frequency, the lateral vibration at the evaluation point is dominated by the effect of the lateral input from the powerplant. Furthermore, it is confirmed that the lateral vibration acceleration at the evaluation point can be reasonably reproduced using only the lateral input of the powerplant.

Based on this knowledge a simplified vibration prediction formula is constructed using only the lateral input of the powerplant and the corresponding transfer characteristics to the evaluation point. The vibration acceleration levels predicted by the proposed formula fall within the range between the maximum and minimum measured values, showing good agreement with experimental results (Fig.2). These results demonstrate that the proposed method is effective for predicting vehicle vibrations induced by constant velocity joints.

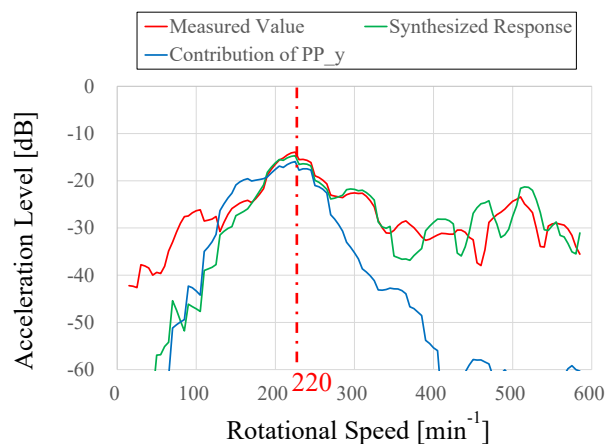


Fig.1 TPA Analysis Results

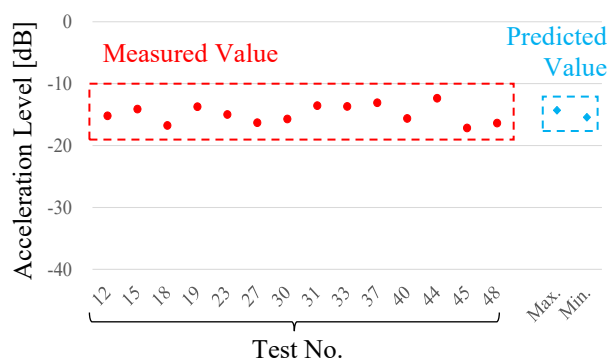


Fig.2 Comparison of Measured and Predicted Values