講演番号	014

Effect of pitch damping moment due to internal torque in propeller shaft-type AWD

Shinya Konishi[1)]　Shingo Koumura

1) TOYOTA MOTOR CORPORATION
1, Toyota-cho, Toyota, Aichi, 471-8572, Japan

KEY WORDS: **vehicle dynamics, chassis/component, motion control,** Internal torque effect in the propeller shaft [B1]

In propeller-shaft-type four-wheel-drive vehicles, internal circulating torque is generated between the front and rear axles during pitching motion due to front-to-rear operational constraints; however, the temporal variations of this torque and its effects on vehicle dynamics under actual driving conditions have not yet been fully clarified. In this study, we experimentally investigate the circulating torque during actual driving and verify the pitching damping effect caused by this internal torque using both experiments and a 3-DOF vehicle model.

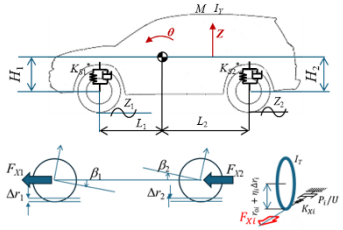

Fig. 1 3-DOF Vehicle model

To measure the internal torque of an AWD system under actual driving conditions, we conducted experimental measurements of the torque distribution between the front and rear wheels on undulating roads using an AWD vehicle in a state equivalent to a locked center differential.Furthermore, we performed analysis using a 3-DOF(Vertical, Pitch and longitudinal behaviors of sprung mass) vehicle model .(Fig.1) We verified, through both calculation and experimentation, that pitch oscillations are reduced in AWD vehicles compared to 2WD vehicles.

The following results were obtained from a close examination of the effects of propeller shaft type AWD on vehicle dynamics, both on the simulation and in the actual vehicle.

1. Internal torque is generated by the propeller shaft due to the pitching motion of the vehicle under actual driving conditions (Fig.2)
2. The torque on the front and rear shafts is equal in magnitude but opposite in phase. The torque on the rear shaft lags the pitch angle by about 90 degrees.(Fig.3)

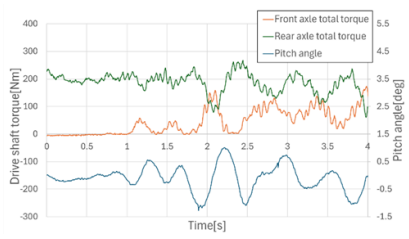

Fig. 2 AWD internal torque in actual drive

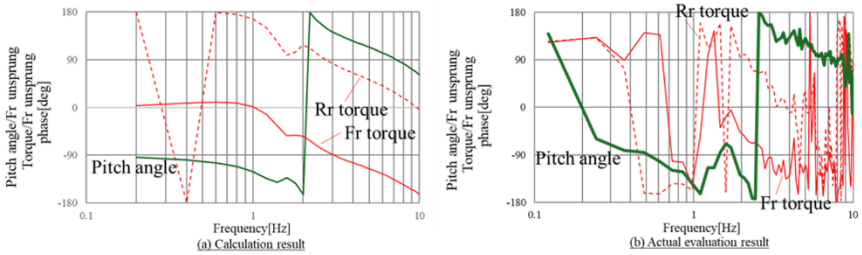

Fig.3 Comparison of Calc/actual(pitch angle,drive shaft torque/Z_1)

3. Internal circulation torque acts as an element with a negative spring constant in the pitch direction.(Fig.4)
4. Due to the difference in suspension geometry between the front and rear wheels, a pitch damping moment caused by internal torqueis generated.

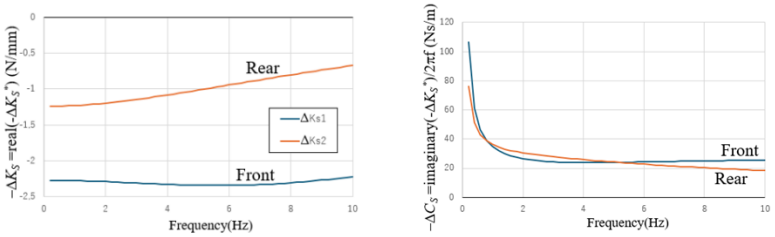

Fig.4 Simulation results (ΔK_S, ΔC_S)

Its effect is mechanically equivalent to adding a “pitch stabilizer” or “skyhook-type pitch damping.”In vehicles with propeller shaft-type AWD, this effect—which demonstrates that internal circulation torque functions as a practical pitch damping mechanism—is a key mechanism that contributes to the simultaneous improvement of ride comfort and handling stability.