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The development to improve turning trajectory by integrated control system of braking and driving force for vehicle with high power two motors

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In recent times, Electric vehicle which are powered 100% by motor is expanding rapidly. Mostly, each OEM is involved in developing vehicles with high power two motor system to power front and rear axle, abbreviated as EV-AWD (All-Wheel Drive system). EV-AWD has lots of benefit from control point of view. Example. 1) Flexibility of driving force, which can be controlled independently for front and rear motor 2) High response of the motor.

On the other hand, though EV-AWD have good acceleration by high response of the motors, and high power due to front and rear motor, it can easily exceed the grip limit of tire while disturbing vehicle behavior during cornering (acceleration) on slippery road surface. Example. Snow/Icy Road. Considering this scenario, the additional control to suppress tire slip by controlling the driving force based on grip limit of each tire becomes valid for EV-AWD.

However, simply suppressing tire slip during turning will result in loss of acceleration, this is major advantage of EV-AWD. Additionally, during traditional traction control, driver needs corrective operations of acceleration pedal and steering to avoid sudden behavior, to reduce driver's corrective operations, driving torque suppression is required just before detecting tire slip by traction control system. Therefore, this research explains about the development of integrated control system for braking and driving force to achieve both acceleration and traceability, and the test results.

At first, driving force distribution control is optimized for each wheel load, estimated from driving force and lateral acceleration. Then each wheel traction is maximized by controlling driving force distribution while considering longitudinal wheel load transfer, estimated from driver acceleration pedal operation during accelerating. The disturbance of vehicle behavior by loss of inner wheel load is suppressed by controlling driving force distribution while considering lateral wheel load transfer during turning.

Tire grip limit becomes too small while driving on slippery road surface (Snow/Icy). To realize stable trajectory during turning, in addition to the driving force distribution control, an optimized integrated control system of brake and driving force is developed considering each tire grip limit as shown in Fig.1. The system configuration of the integrated control is based on one ideal reference model and target is to control driving force, brake yaw moment, front and rear distribution.

Driving force: This limits to optimum driving force based on estimated friction circle (Not to exceed tire friction circle). With this control, trajectory is improved by suppressing yaw change. (Yaw change occurs because of wheel spin during cornering).

Brake yaw moment: This controls inner brake before causing vehicle behavior disturbance by focusing on front inner wheel slip during cornering (acceleration). A trigger of understeer situation. With this control, understeer situation is suppressed after transitioning to steady state by suppressing front inner wheel slip.

Front and rear driving force distribution: This controls driving force distribution before causing vehicle behavior disturbance by focusing on rear inner wheel slip during cornering (acceleration). A trigger of oversteer situation. With this control, driver steering correction load is reduced by smoothing the yaw jerk when oversteer situation occurs.

To confirm the effect of integrated control system quantitatively, Vehicle test with EV-AWD was carried out in several closed course with corner in winter region. The measured result of average steer angular velocity when driving in closed course and average G vector at cornering is shown as Fig.2. Fig.2 shows that average steer angular velocity with control ON is smaller than the one with control OFF in any course and driver steering correction is reduced. In addition, average G vector is larger during cornering and acceleration while turning is better. The vehicle test has shown that both trajectory and acceleration on slippery road surface is realized by this integrated control system.

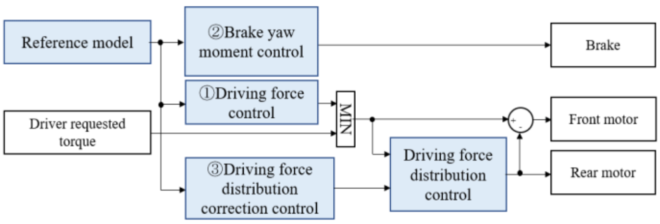

Fig.1 Integrated control block diagram

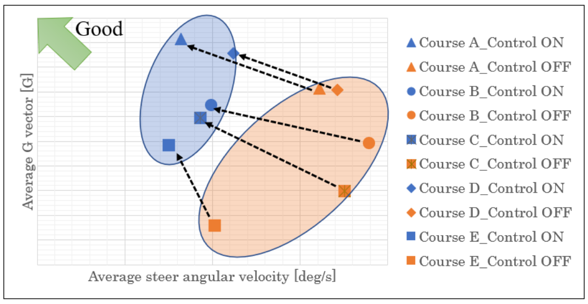

Fig.2 Average of steer angular velocity and G vector

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