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The HEV control developed newly

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In recent years the shift to the electrified vehicle has been accelerating rapidly. It is because not only people all over the world is focusd on the environmental issue but also they are seeking driving pleasure.

Toyota has newly developed the hybrid system to provide the customers with the driving pleasure and contribute to the low-carbon society by electrified technology. The objective of this paper is to explain about the new HEV control technology collaborating with several actuators sophisticatedly for the new hybrid system which has turbo charged engine, the clutch switching transmitted torque, 6 speed automatic transmission (Fig.1).

In addition to the conventional HEV smoothness Toyota has cultivated, we aimed for a powertrain system that greatly enhances vehicle reaction time to driver operation and vehicle dynamics performance for straight-line and cornering driving. In other words, we focused on the reaction time of the vehicle at the reacceleration with "Tip-in front and rear backlash torque compensation control", the acceleration G linearity even with engine starting from EV mode with "connected engine start control", the linear acceleration to the accelerator pedal operation with "marginal acceleration operating point assurance control", and the increase of yaw moment at turning-in with "turning drive force distribution control".

"Tip-in front and rear backlash torque compensation control" optimizes the front torque by adding the compensation torque calculated from the difference of the backlash amount between front driveline and rear. Seamless acceleration is achieved by correcting torque when passing through backlash. The effect of this control is that vehicle G stagnation due to passing backlash in the front and rear is reduced by 40% compared to our mechanical 4WD system and by 10% compared to our conventional HEV 4WD.

“Connected engine start control" enables engine start to be smooth and responsive by implementing the WSC oil pressure reduction control and the prediction control of the cranking timing. At the engine starting, WSC shoud be slipped quickly to make drive force transmitted to the wheel. This HEV control adopts the new WSC oil pressure control that contributes to the reduction of engine start time by 20% by slipping WSC while accelerator pedal is operated. Furthermore, the engine start timing is optimized to have shockless feeling and prevent drive force response from being delayed during engine start control by predicting the required max power at the cranking based on the cranking time and the increasing rate of drive force required by the drivers.

"Marginal acceleration operating point assurance control" realizes linear and powerful acceleration without causing acceleration stagnation even during acceleration that requires a lot of running power. Specifically, by estimating the engine torque that takes into account NV restrictions and supercharging response delays from the engine speed of the current gear position and future gear position, this control selects a proper gear position that does not cause acceleration stagnation based on the battery power that can currently be available(Fig.2).

The distribution ratio between front torque and rear torque is controlled based on the vertical force at the front and rear inner wheel. The friction circle has been maximized with great vehicle dynamic performance by implementing this control mentioned above. Moreover, the front drive force is increased at low lateral G, so that the turning response at the beginning of cornering is enhanced by increasing yaw moment of the front tyres.

The proper operation of these four controls in a series of actions made it possible to realize the system concept. We believe that this has provided new options for our HEV vehicles.

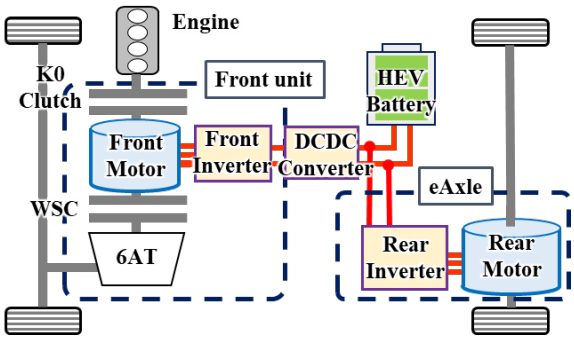

Fig.1 Schematic diagram of the HEV system

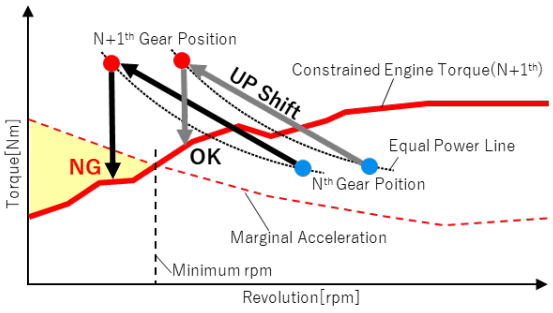

Fig.2 Shift Position Select (Battery Low Power)