講演番号	136

文献番号	20226136

Development of Dual Boost Hybrid System

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KEY WORDS: **EV and HV system, motor drive system, system technology (A3)**

The electric vehicle, including hybrid vehicles, has been drawing increasing attention year by year to achieve mobility needs in a carbon neutral society. Toyota has newly developed the hybrid system for front wheel drive vehicles with 2.4L-turbo engine (Fig.1) in order to increase the range of choice of the vehicle and especially customers seeking driving pleasure.

The objective for the new hybrid system is to realize high performance for the reacceleration response and acceleration elasticity from high vehicle speed, by combining the high torque of the turbo engine for a wide range of engine speed with high torque from low motor speed and quick response of the motor. Furthermore, the aim is to realize vehicle posture control by implementing precise 4WD control, where the high output rear motor is employed and it enables the friction circle of the front and rear tires to be maximized.

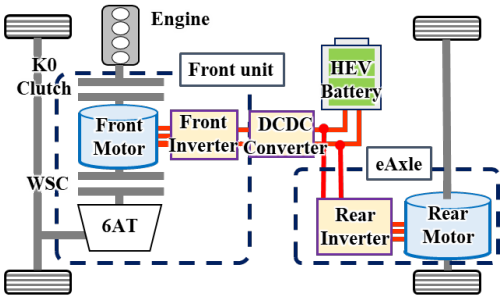

Fig.1 Schematic diagram of the HEV system

In low to middle vehicle speed areas such as urban and winding driving, the motor torque assists in compensation for the reacceleration response delay of the turbo-charged engine. High engine torque area can be used, thanks to centrifugal pendulum absorber and front motor torque assistance. The acceleration without down shift with low to middle load area and the prevention of frequent shifting when drivers' accelerator pedal operation is fluctuating, have been achieved. In the driving scene, such as merging to and overtaking on highways, where high drive force is used, engine power is transformed to electric power by front motor generation and re-distributed to the rear electric motor proactively to reduce the engine torque fluctuation transmitted to the drive shaft and fully utilize high torque characteristic for wide range of engine speed from low speed. Because of this control, this system can use more engine torque by about 2 times than front-wheel drive conventional vehicles with same engine. In addition, the electric power assistance provided by the high-output battery realized both powerful driving with low engine speed on par with a large engine displacement (3.0L-turbo engine) and quietness (Fig.2).

Vehicle dynamic performance has been enhanced by expanding the use of rear driving force distribution by the high output motor, eAxle, which uses is water-cooled, not only on low-mu roads, but also on high-mu roads. The basic concept of driving force distribution control is feed-forward based on information such as the driver's accelerator pedal, steering operation, and so on, so that driver can sense natural handling performance without delay of the vehicle moving response. The torque distribution ratio between front and rear tire is controlled in accordance with the inner tire load of front and rear, where the friction circle is smaller than outer tire load, for the purpose of maximizing vehicle dynamic performance while cornering with high lateral G. Thanks to enhancing the cooling performance and high output rear motor, the system enables the friction circle to be enlarged by around 25% at high lateral G while accelerating by distributing the torque to the rear tire, compared to the previous model (Fig.3).

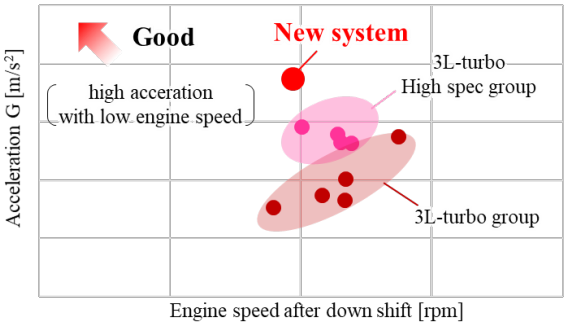

Fig.2 Acceleration in high load area

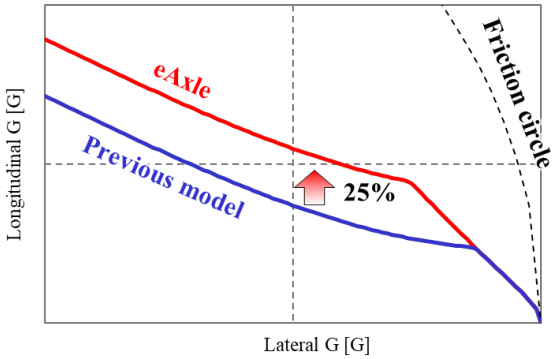

Fig.3 Vehicle Dynamics Performance