419-20115373 Development of a New Parallel Hybrid System

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Nissan has developed the world's first one-motor two-clutch parallel full hybrid system without a torque converter. New to the passenger vehicle segment, this system is expected to yield higher fuel economy and a more direct experience in terms of vehicle performance. Part of Nissan's "Pure Drive" green label, it has been given the name Intelligent Dual Clutch Control in Japan, and Infiniti Direct Response Hybrid™ for the Infiniti brand. The system provides the following advantages.

1. Significant improvement in fuel economy including highway mode
2. Better response and a more direct driving experience
3. Lightweight and low-cost

The actual fuel economy improvement is 1.9 times that of conventional gasoline applications when tested under Japan's 10-15 mode test cycle. It is at top-of-class in the hybrid segment (15.8 km/L), and almost at the same level as a compact car.(Fig.1)

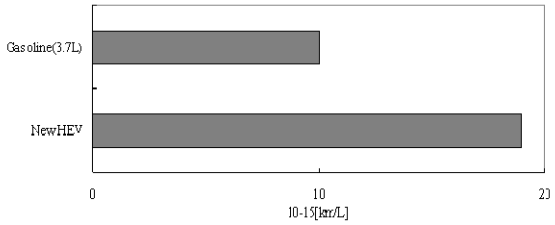

Fig.1 Fuel Economy(JPN)

In terms of driving experience, partial load acceleration response and feeling are similar to the V8 engine class by virtue of the motor assist with higher gear ratio. Direct and rhythmical driving feel is attributable to the seven-speed step automatic transmission (AT) with unique clutch and motor control design in place of a torque converter. Full-load acceleration (0-100 km/h) is comparable to a conventional 3.7 L gasoline engine.

Figure 1 shows the hybrid transmission layout. The motor has a soft mount architecture, unique to hybrid systems, that acts to suppress motor noise. Clutch 2 (wet multi-plate) is commonized with clutches used in conventional seven-speed ATs, resulting in significant cost savings and compactness. Clutch 2 performs comparably to typical seven-speed ATs also in terms of shifting, and it functions as a starting element in place of the torque converter. Furthermore, it helps stabilize driving torque during engine start operation when there are momentary fluctuations in engine and motor torque.

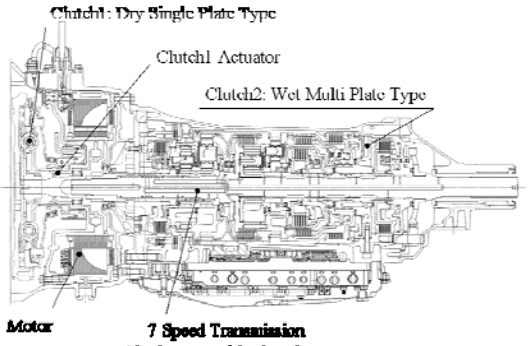

Fig.2 Skeleton of hybrid transmission

The successful development of this system hinged on breakthroughs in the following areas.

1. Smoothness at engine start and gear shifting from EV mode
   Technological breakthroughs include the high-speed and precise motor control strategy and the high-output lithium-ion battery, which is capable of immediate charge/discharge.
2. Smoothness and reliability of the wet start clutch (WSC)
   Figure 3 shows the basic control architecture of WSC, which is characterized by high-response motor controls and clutch controls that utilize motor torque. Control characteristics for clutch slip speed are achieved by the high-response motor controls. Torque control performance for Clutch 2 is secured by the control architecture by utilizing high-accuracy motor torque to predict the torque of Clutch 2. To further enhance reliability, a system called motor WSC was developed to solve the issue of clutch heat by means of reducing the slip speed of Clutch 2, resulting in decreased load.
3. Battery SOC management based on the use of a single motor
   The technical solution for battery SOC management lies in the high-speed charging capability of the lithium-ion battery and its control system.
4. Reduced NVH, including motor and inverter noise
   The key contributer to reduced noise and vibration is the soft mount motor architecture.

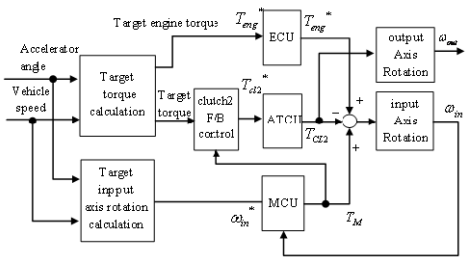

Fig.3 WSC Basic Control System

In support of these new technologies, and to ensure sufficient marketability, durability of all major components, including the lithium-ion battery, the motor, and the clutches, was validated in proving ground and dyno testing as well as in actual fleet testing in the U.S. market.