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Improvement of drivability in sport driving by cooperative control of engine and CVT

Inoue Suguru[1)] Katsurano takehiko[1)] Kakuta Yoshito[1)] Ishida Takumu[1)] Waki Takaaki[1)] Nagaya Hiroyuki[1)] Terajima Tomotaka[1)]

1) SUBARU Corporation 3-9-6 Osawa, Mitaka, Tokyo, 181-8577, Japan

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Since the '90s, several car manufacturers have been making efforts to add good drivability and driving pleasure to CVTs with excellent fuel economy. We have combined gasoline turbocharged engine and CVT (Continuously variable transmission) to meet this demand. In recent years, sporty cars are required to balance dynamic and environmental performance at much higher level than before. After comparison of drivability with competitors which equip ATs or DCTs, we found that our previous vehicle had behind in sportiness caused by lack of powertrain response. To make our next generation sporty car competitive, we focused on powertrain response and worked on improvement of three elements descrived below.

1. Engine torque response

In a Tip-in condition, it is necessary for shock reduction to moderate increasing rate of engine torque (Tip-in control). Too much moderation conflicts with engine torque response. Therefore, shock reduction and response are in trade-off relation. To balance these performances at higher level, we developed new Tip-in control using spark retard in addition to throttle. Fig.1 shows the impact of this new control. Without Tip-in control, remarkable shock occurs. New control improves engine torque response and keeps same shock level as previous.

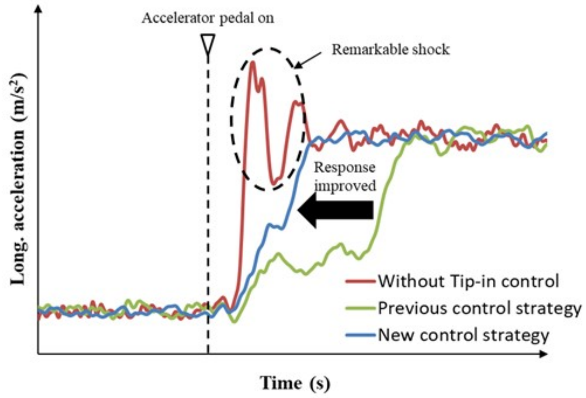

Fig.1 Improvement of engine torque response with new Tip-in control strategy

2. Shift speed

To make shift speed faster, we have newly developed cooperative control of gasoline engine and CVT. Regarding up shift, previous control used only throttle for torque adjusting. To adjust engine torque more quickly, new control uses fuel cut and spark retard in addition to throttle, on demand of transmission control unit. Regarding down shift, previous control did not coordinate engine and transmission. To cancel inertia torque, new control uses engine blipping on demand of transmission control unit. Fig.2 shows improvement of downshift speed. New control reduces time taken to down shift by 50% compared to previous control. Faster shift speed leads to increase wear of CVT hydraulic control valve. To reduce this wear, hydraulic force is optimized by design of valve spool.

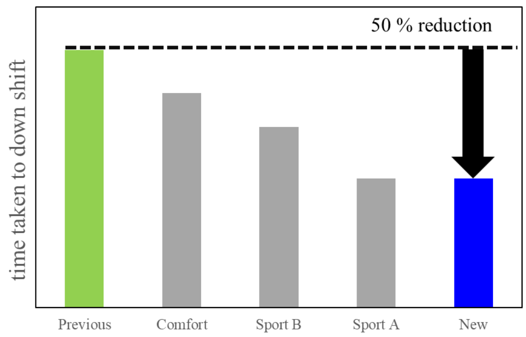

Fig.2 Comparison of time taken to down shift

3. Acceleration during sport drive

Adoptive control activates brake down shift (down shift in braking condition). In previous control, vehicle had unexpected deceleration during down shift because of inertia torque, and operating area of brake down shift was limited to stabilize the vehicle behavior. In new control, blipping in down shift absorbs inertia torque, and cancels unexpected deceleration. Utilizing this advantage, we expanded operating area of brake down shift. Fig.3 shows improvement of acceleration from braking. Previous control activates down shift after pedal-on. New control activates brake down shift to keep responsive engine speed and starts acceleration just after pedal-on.

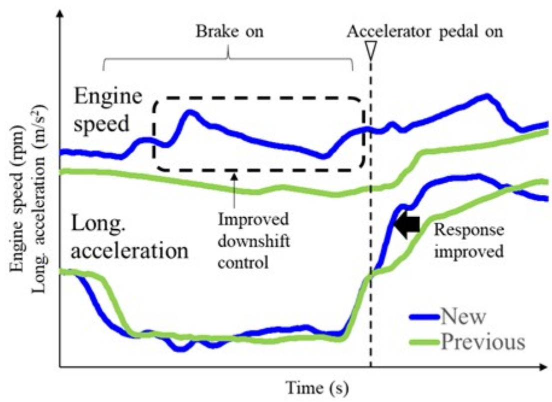

Fig.3 Improvement of acceleration from braking

By developing cooperative control of gasoline engine and CVT descrived above, we improved powertrain response and drivability in sport driving to the top level in the same class.