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Toyota's New Hybrid Unit "L4A0"

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Abstract

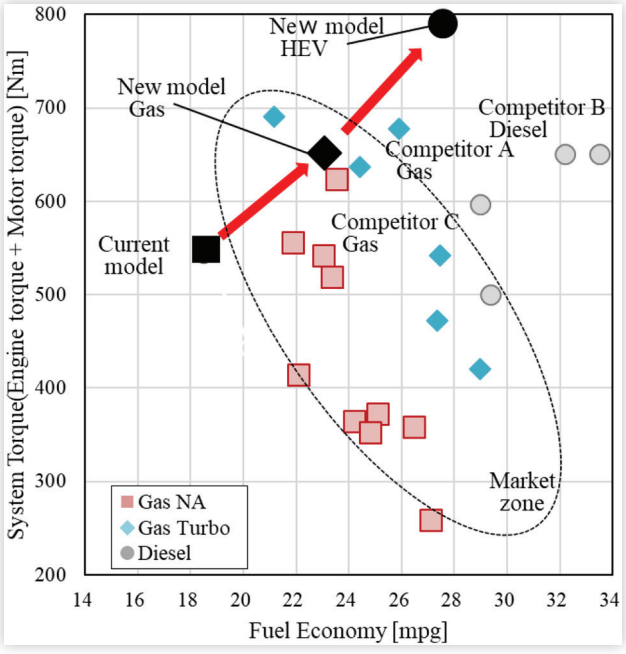
Toyota developed a new hybrid unit "L4A0" for the new Tundra, which creates both good drivability and environmental performance. To ensure off-road, towing performance and typical truck driving characteristics, the unit is based on a transmission with a torque converter and a multi-plate lock up clutch, with a motor-generator and K0 clutch installed between the engine and transmission. The motor-generator and K0 clutch are built into a module, making it possible to create new hybrid units by combining the module with various transmissions. The unit features many different motor controls. For example, in the case of step-in acceleration input, in order to achieve the desired output torque, typically a kick-down shift is necessary [1]; however, by utilizing "L4A0" both high response and high power output is achieved even without a kick-down shift. This is accomplished by assisting the engine with the motor-generator even when the engine torque is delayed at low engine speeds. Simultaneously, this contributed to better fuel economy by allowing the engine to work at optimum speeds [1-3]. Another feature is the high-response and shock-less engine start that is achieved by cranking the engine with the motor-generator via the K0 clutch.

1. Introduction

Toward the target of "Carbon Neutral", Toyota is commencing the preparation of a full line-up of electric vehicles. Toyota thinks that in areas like Europe and America, especially the West Coast, which are rich in renewable energy, the spread of zero emission vehicles (ZEVs) such as battery electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs) should be ideal options. On the other hand, Toyota also believes that it is very important for CO_2 emission reduction to supply hybrid electric vehicles (HEVs) on the currently popular models without impinging on purchasing and production capability [4]. Tundra, as a good representation of such a vehicle, is strongly expected by its users to have good towing capability and off-road performance.

L4A0, which is developed for the new Tundra and adopted a system with one motor-generator between the engine and a conventional AT, is developed as HEV by Toyota after carefully studying various architectures considering fuel economy and performance. The new Tundra's basic concept is "a premium towing machine" and the hybrid system for its upper grade is expected to achieve premium drivability and good fuel economy, simultaneously. Two core principles are used to realize these benefits: enhance acceleration performance by using the assist-boost of the motor-generator [5], and improve fuel economy with EV mode and regenerative braking (Fig. 1).

FIGURE 1 System torque vs fuel economy.



The hybrid portion is built as a module design and is easy to combine with different ATs.

- The modes of EV, HEV etc. offer both good power and fuel economy performance. The high response and shock less engine start during driving using the motor-generator offers a rapid switching between EV and HEV modes to respond to the driver's intention.
- New control optimization of parameters helped achieve fuel economy.
- Besides, it achieved a high degree of silent performance when using the motor-generator by optimization of the hybrid module design.

Toyota will continue developing vehicles using this new system to contribute to CO_2 emission reduction.

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