

Quietness Improvement Technologies for 100% Electric Drive Hybrid System C Segment SUV

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100% electric drive hybrid system (e-POWER) have advantage of good acceleration performance and quietness as EV, in addition, charging time is not necessary. e-POWER engine serves as a power generation device, operation is not decided by driver's intension. Therefore, one of the most important point of e-POWER vehicle NV design is to reduce the gap between engine on and off.

e-POWER system is adopted to C segment SUV. Motor torque and power are improved for vehicle size up (B seg hatchback → C seg SUV 280Nm → 330Nm, 85kW → 150kW). Moreover, in order to satisfy the power generation needs, and also coexist the performance of fuel economy and quietness, variable compression ratio (VCR) turbo engine is adopted.

The quietness concepts of C-SUV e-POWER are (1) Enlarge EV zone especially in conditions that engine noise is more likely to be concerned. (2) Design the engine noise to unnoticeable level when engine is on operate in low load scene. (3) Make no discomfort sound when vehicle in acceleration (4) In addition, although the excitation force of a 3 cylinders turbo engine is a disadvantage point for low frequency booming noise and vibration, the solutions in vehicle level like engine mount, exhaust and body are adopted to ensure quietness performance in vehicle level.

(1) To enlarge EV zone, e-POWER system is actively to generate more power in scene with large background noise. For high-speed scene, the engine noise is more easily to be masked by wind noise. For low-speed scene, the system is actively generating more power when it estimates that road is roughly, which engine noise is masked by road noise.

(2) When it is necessary to start up engine for low SOC, engine revolution is set to lower compared to existing e-POWER vehicle to ensure quietness performance. Moreover, by adopting 1.5L VCR turbo engine, the best fuel consumption point is shifted to low engine rpm because VCR engine has low friction compared with NA engine.

(3) In order to make no discomfort engine sound, it is necessary to control engine sound level according to acceleration intention of drivers. The engine revolution increases linear based on acceleration open throttle (acceleration G) and vehicle speed. In order to achieve this, it needs to make use of VCR engine which can generate power in low engine revolution and high torque.

(4) Although it is advantage for decreasing engine noise when generating power, it is necessary to pay attention to low frequency booming noise and vibration considering 3 cylinders high torque engine. Solutions in vehicle level including engine mount, exhaust, body stiffness and engine control are adopted.

(4) – 1 Engine mount. Support lower torque rod is introduced for lower engine mount stiffness (Fig. 1). On the same time, the layout of support lower torque rod is optimized in order to maximize the vector cancel effect of engine mount input for 3 cylinders 1st order excitation force.

(4) – 2 Exhaust. A unique long tube exhaust muffler is designed for e-POWER. It decreases the 1st order tube resonance to low frequency zone which e-POWER does not use (Fig. 2). This e-POWER unique exhaust muffler can decrease exhaust noise level while keep muffler volume compact. It also contributes packing for e-POWER large battery and SUV luggage space.

(4) – 3 Low sensitivity body. Low sensitivity body is a solution not only for 3 cylinders engine, but also for low frequency road noise (drumming) because vehicle quietness performance needs to be achieved by both low engine noise and low road noise. The eigenmodes density in low frequency is decreased. Also, the stiffness is increased to suppress deformation of eigenmodes to make lower noise transfer property.

(4) – 4 Transient vibrations when vehicle takes off. e-POWER vehicle has better drive torque response. As the result, the engine mount quickly bears road reaction force, which engine rigid resonance increases more quickly compared to internal combustion engine (ICE) vehicle and it more easily leads to vibration for take-off. Engine revolution control logic based on engine rigid resonance is introduced to prevent vibration.

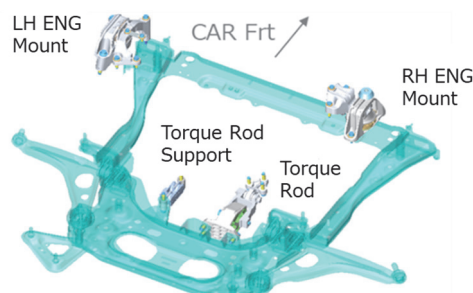


Fig.1 Engine Mounts Layout

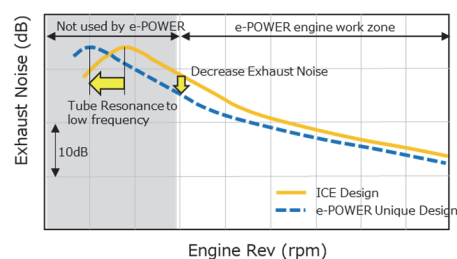


Fig.2 e-POWER Unique Exhaust Muffler Design Concept