# Development of New Motor for High Powered Plug-in Hybrid Vehicle

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In recent years, increasingly strict fuel economy regulations have required further improvements in vehicle efficiency, while at the same time, global demand for electrified vehicles has continued to grow. In response to these trends, we have developed its sixth-generation plug-in hybrid vehicle series. This paper describes a newly developed motor for the new SUV.

For the first time in the new series–parallel hybrid system applications, an electromechanical integrated architecture was adopted. To package the invereter and the DC–DC converter (DCDC) within a single unit, the motor shaft was positioned lower than in previous designs. Compared to the previous motor, the new motor achieves higher output while targeting lower losses and reduced size through improvements to the stator structure, magnetic circuit, and cooling configuration. Figure 1 shows the layout of the Inverter, DCDC, newly developed motor, and generator.

In addition, new high-strength electrical steel sheets were developed to meet the operating conditions of the stator and rotor cores. The new motor employs both a rotor core with refined grain size to ensure high strength and a stator core with coarsened grain size after annealing to achieve lower iron loss. As a result, high rotor strength and low stator iron loss were successfully achieved simultaneously, leading to the realization of a motor with both high output and high efficiency.

In the newly developed motor and generator, by adopting fractional pitch windings and shortening the stripped length at the coil-wire welding joints, the coil-end height was reduced by 12% in the motor and 20% in the generator (Figure 2). Insulation between adjacent coils, which becomes more challenging with this height reduction, was ensured by fully encapsulating the coil ends with a resin material. Furthermore, the thickness of the foamed insulating paper used to fix the coils and the core was reduced by 50% through manufacturing process improvements. This led to a 3.2% increase in the slot fill factor, enhancing the torque density and enabling motor downsizing.

By adopting the motor rotor cooling structure (Figure 3) and the newly developed cooling system (Figure 4) , cooling issues associated with high-output motors were addressed while enabling compactness and high efficiency.

As a result of the new motor development, motor losses were reduced by 14% compared with the previous model, and power density was improved by more than 22%.

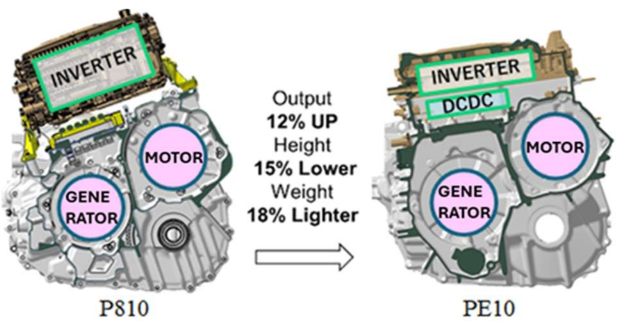


Fig.1 Comparison of Unit Specifications for P810 and PE10

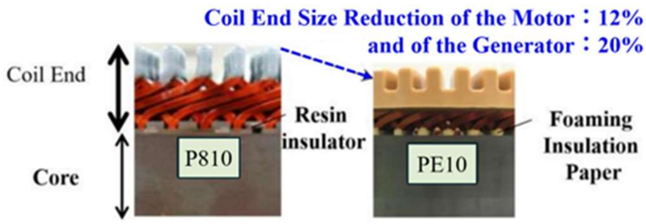


Fig.2 Comparison of Coil End Height between P810 and PE10

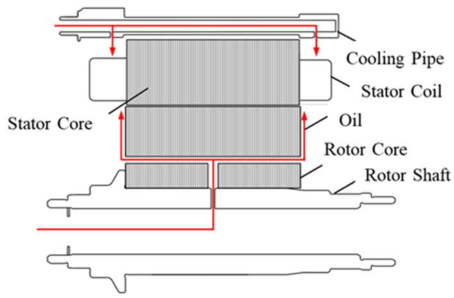


Fig.3 Rotor Core Cooling Structure

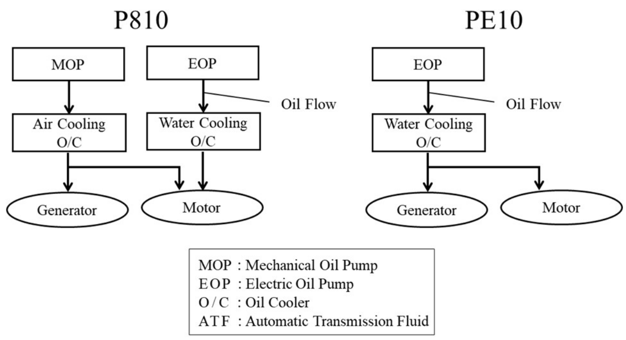


Fig.4 Cooling System Comparison of P810 and PE10