

# Movement of Traction Drive Motor for EV/HEV

## - High Performance Design-concept and Issues of Permanent Magnet Motor for Toyota Prius -

Ryoji Mizutani

Hybrid Vehicle Advanced Technology Engineering DIV., TOYOTA MOTOR CORPORATION

Permanent magnet motors were improved remarkably, after Nd-Fe-B magnets were invented in the first half of the 1980's, and high power semi-conductor has made progress. Since then permanent magnet motors for EV/HEV traction drive have been developed rapidly with high performance of output. The reason is because it is attempting the optimization of the system-wide driving force which included the final gear ratio of running drive of cars such as engine and reduction gear in addition to motor design technique as electrical appliance. Figure 1 shows the cut model photograph of the trans-axle which introduced into Toyota Prius from the 1st generation to the 3rd generation, and the concept of the motor downsizing. The motor size is 38 % smaller in the 2nd generation and moreover 74 % smaller in the 3rd generation than that in the 1st generation. We have make progress in downsizing with the three concepts as follows. The first is Nd-Fe-B magnets with high performance, the second is higher system voltage, the third is higher rotation speed. In the motor specification of the 3rd generation Prius, the system voltage is 650V and the maximum rotation speed is 13500rpm.

The issues for realizing the three concepts are as follows;

- (1) Insulation technology for higher system voltage: That keeps distance among coils or between coil and stator.
- (2) Design to downsize high speed reduction gears, to strengthen rotor against centrifugal force at the highest speed and to reduce losses of motors for higher rotation speed: The improved design of machine elements is shown in Fig.1. And the improved design of motor is shown in Fig.2.
- (3) Cooling technology: Traction motor is cooled by ATF (Automatic Transmission Fluid) because the motor and reduction gears are in the same trans-axle case. The cooling system using ATF is shown in Fig.3.

It is composed of differential gear which is slinging ATF, catch tank, oil pump which deliver ATF to the heating site and water jacket

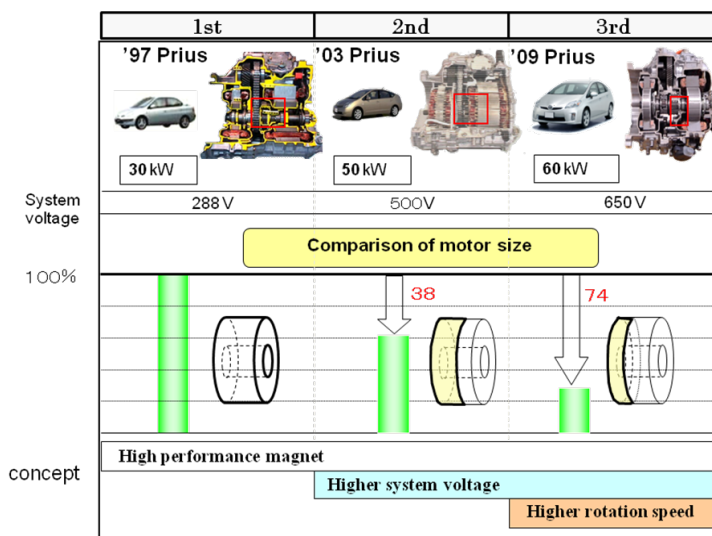
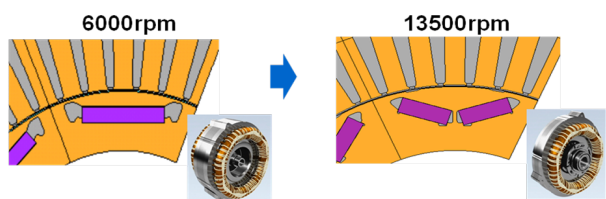


Fig. 1 Concept and Characteristics of Trans-axle Unit for 1st-3rd Prius



(1) 2nd Prius (2) 3rd Prius (V-Shape)

Fig. 2 Arrangement of Rotor Magnets for 2nd and 3rd Prius

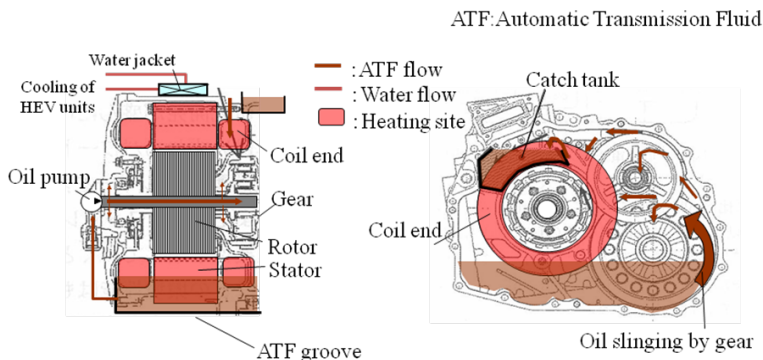


Fig. 3 Cooling system using ATF