

Size and Weight Reduction Technology for a Hybrid System

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ABSTRACT

A small hybrid system was developed for the 2009 model hybrid vehicle. The Intelligent Power Unit (IPU), which consists of a high-voltage battery and a Power Control Unit (PCU), occupies 19% less volume and is 28% lighter than the previous model⁽¹⁾.

In order to reduce the size and weight of the IPU, the number of nickel-metal hydride battery modules was reduced, enabling the battery box to be made smaller and lighter. In order to provide the necessary output with fewer battery modules, the length of the battery electrodes was increased, thus raising the output from each battery module. The volume and weight of the PCU were reduced by integrating the inverter, DC-DC converter, and ECU into a single package.

The size reduction of the IPU enabled the IPU to be installed at the bottom of the luggage compartment. As a result, the available space in the luggage compartment is the same as that of a conventional vehicle.

INTRODUCTION

As a result of the issue of CO₂ emissions in recent years and recent increase in the price of crude oil, additional interest is being shown in hybrid vehicles that have good fuel economy. However, compared to a conventional vehicle, a hybrid vehicle, additionally, has a hybrid system consisting of a motor, high-voltage batteries, PCU, and so on, resulting in higher costs. Consequently, in order to expand sales volume of hybrid vehicles, it is necessary to reduce the additional cost as much as possible. Like previous hybrid systems, the hybrid system developed here was a parallel type of simple construction in which the motor was installed between

the engine and the CVT, the IPU was installed in the luggage compartment, and the motor and IPU were connected to each other with a power cable (Fig. 1). However, in the current development, various innovations such as reducing the number of batteries were carried out, resulting in a significant cost reduction.

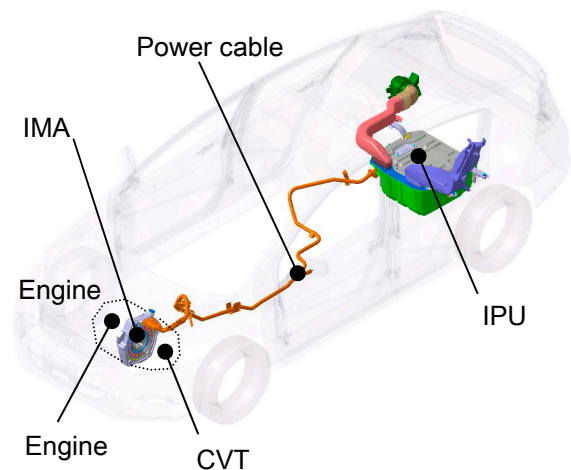


Fig.1 Construction of hybrid system

Another issue attendant to a hybrid vehicle is the significant increase in the weight of the body compared to that of a conventional vehicle. In order to overcome this as well, the newly developed IPU was 28% lighter than the previous one, enabling the weight increase to be minimized.

Also, because the heavy high-voltage batteries are installed behind the rear seat to previous model, the center of gravity of the vehicle is high, resulting in the issue of drivability. To overcome this, the newly developed IPU was reduced in size, and installed at the

bottom of the luggage compartment, as shown in Fig. 2, thus enabling the center of gravity to be lowered.

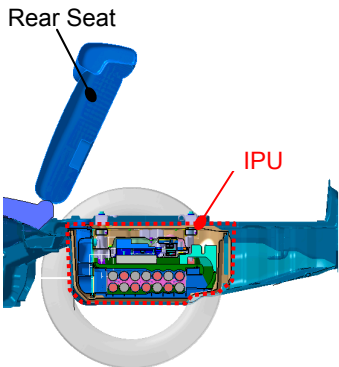
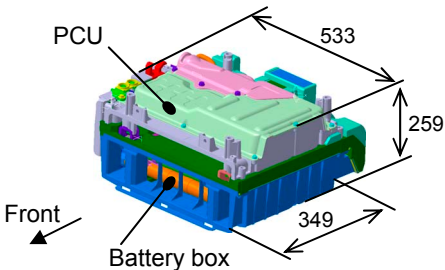
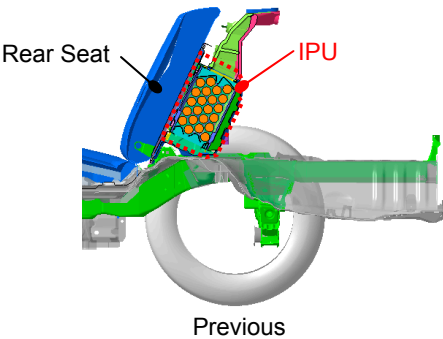
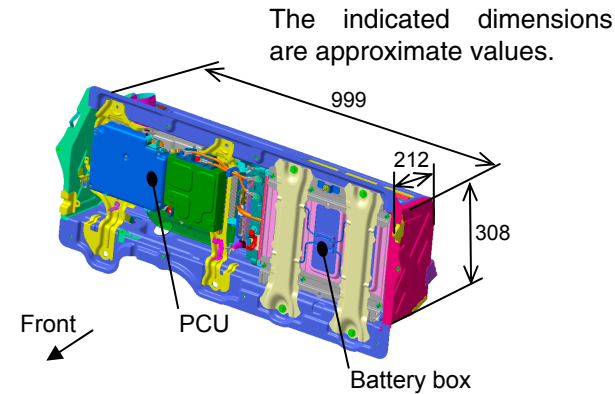


Fig.2 Construction of IPU

In order to minimize the abovementioned increase in the weight of the system, and to ensure that there is sufficient luggage space, the development targets for the weight and volume of the IPU were set as follows.

Table 1 Target weight and volume of IPU

	Previous	Developed
Weight	53 kg	38 kg (28% Down)
Volume	59 L (Actual)	48 L (19% Down)

1. BATTERY

The output from the nickel-metal hydride battery was increased by 30% compared to the previous one. This increase in output was utilized to reduce the number of battery modules, and a system voltage of 101 V was set for this model instead of the previous voltage of 158 V. As a result, the weight of the battery box was reduced by 35% and its volume was reduced by 31%.

1.1 HIGHER BATTERY CELL OUTPUT

The battery cell specifications are shown in Table 2, and its construction is shown in Fig. 3. In order to increase the output from the cell, the length of the electrode was increased by 30%. By using a longer electrode, the reactive area increased, and the internal resistance fell by 23%.

Table 2 Comparison of battery cell

	Developed/previous
Electrode length	1.30
Electrode thickness	0.77
Internal resistance	0.77
Output	1.30
Energy capacity	1.00

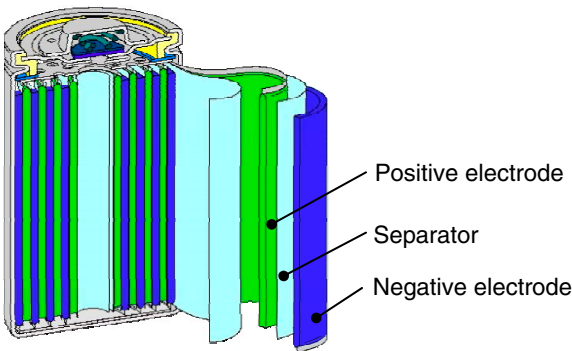


Fig.3 Construction of battery cell

The materials of the electrode and separator were changed, enabling the thickness of the electrode to be reduced by 23%. As a result, the output of the cell increased by 30% without having to change the cell size or energy capacity.

1.2 HIGHER BATTERY BOX COOLING EFFICIENCY

Figure 4 shows an outline of the battery box.

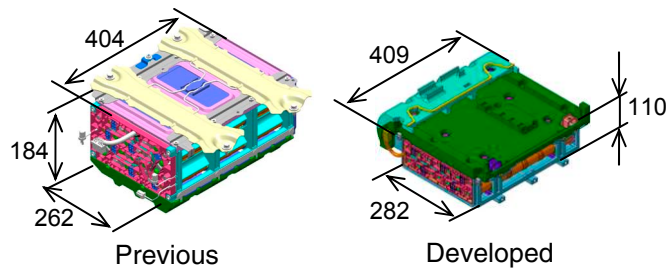


Fig.4 Construction of battery box

The cylindrical battery modules were installed in two rows. As a result, the height dimension was reduced, and the cooling air velocity increased, thus raising the cooling efficiency.

Also, as shown in Fig. 5, the cross-sectional shape of the part of the battery box that constituted the cooling air passage was changed from the air intake side to the air exhaust side. The flow path at the air exhaust side was narrowed in an attempt to reduce the battery temperature at the air exhaust side.

The battery was controlled within the temperature range for longer battery life. It was necessary to limit input and output power of the battery if one of those battery modules were in high temperature, thus it is important to make temperature differences of each battery modules as small as possible. In the case of the previous structure, air deflectors were installed at both the air intake and air exhaust sides, aimed at reducing temperature differences between the battery modules. In contrast, the construction of the new battery box enabled the temperature differences to be reduced to less than that of the previous battery box without the use of air deflectors. Table 3 shows a comparison of the temperature differences between the previous and newly developed battery modules.

Table 3 Temperature variations between battery modules

	Previous	Developed
Temperature differences between batteries	5 deg	3 deg

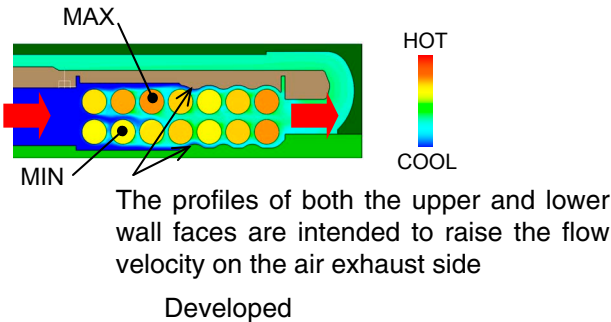
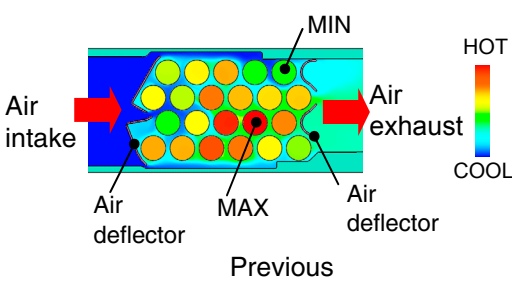


Fig.5 Cooling construction of battery box

2. PCU

The PCU consists of an inverter, DC-DC converter, and ECU. Figure 6 shows the configuration of the previous PCU and that of the newly developed PCU. Previously, the inverter, DC-DC converter, and ECU were each contained in a separate metal case. In the newly developed PCU, these component parts have been arranged together inside the PCU case, eliminating the need for separate metal cases for the each component parts. The newly developed PCU is shielded by the PCU case and cover, suppressing the propagation and radiation of electromagnetic noise that is generated by the inverter and DC-DC converter. As a result of redesigning the system and reducing the size of each component, the weight of the entire PCU was reduced by 31%, and its volume was reduced by 10%.