Development of High Density and Low Loss Powder Magnetic Core for Reactor in Hybrid Vehicles

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Automobile usage has expanded throughout the world in recent years and has become one of the foundations of human society and economic activity. However, one of the repercussions of this trend is environmental issues such as global warming due to CO_2 emissions and air pollution. Consequently, there is a growing need for the development of hybrid and other low-emission vehicles. As part of these efforts, Toyota is working to popularize hybrid vehicles (HVs) by developing lower cost technology to help provide reasonably priced vehicles for the customer.

The subject of this presentation is the reactor, which is a part used in the boost converter inside the power control unit (PCU) in HVs. The purpose of the reactor is to increase the output of the HV system while lowering costs by reducing the required battery capacity of the vehicle. A reactor must be capable of stably achieving the inductance required for boosting the voltage of the system. At the same time, a reactor must also prevent overheating and achieve low core loss and low vibration to reduce noise inside the vehicle. For these reasons, the optimum core material is thin (t=0.1 mm) electrical steel sheets with low magnetostriction. These sheets have low core loss and generate extremely low amounts of magnetostriction. However, since these sheets are expensive, a lower cost core material needed to be developed.

A new type of powder was developed for the reactor and a high density powder compaction technique was adopted[1)]. We focused on a high density powder compaction using net shaping, which is a technology capable of reducing manufacturing process and increasing material yields.

(1)The particle shape of the Fe-Si magnetic powder was controlled to a spheroidal powder.
(2)The surface of the powder was coated with a newly developed SiO_2 insulator.
(3)The high density compaction technique increased the strength of the powder magnetic core.

As a result, the magnetic flux density was increased by approximately 35% and core loss was reduced by approximately 40% (Fig.1). The reactor core with equivalent electromagnetic characteristics to electrical steel sheets, for which is difficult to achieve with conventional powder magnetic cores, was developed and a great cost reduction was achieved. This is the first powder reactor core in the world to be installed in a vehicle (Fig.2, the third generation Prius that was launched in 2009).

Reference

1) T. Hattori, M. Sugiyama, H. Kishimoto, and T. Saito: “Development of High-Density and Low-Loss Powder Magnetic Core for Reactor in Vehicles” (in Japanese). Annual Congress (Autumn) of the Japan Society of Powder and Powder Metallurgy, 80 (2013).

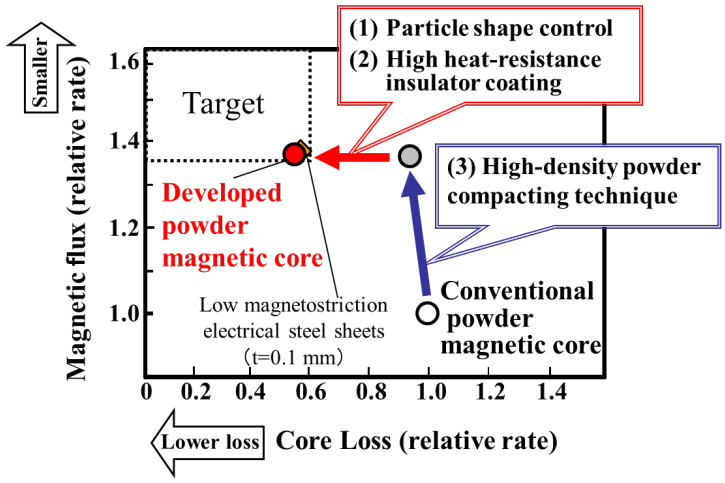

Fig.1 Positioning of Developed powder magnetic core

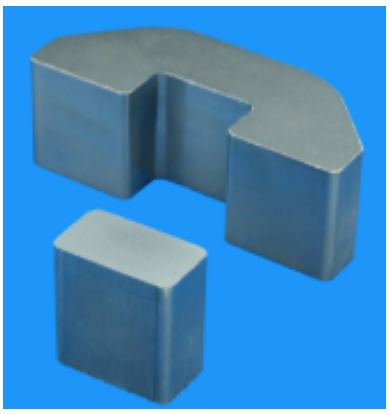

Fig.2 Developed reactor core