Net Shape Reactor Core Using Newly Developed Insulating-Lubricant

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1 Abstract

Recent years have seen a world-wide increase in the demand for energy savings, not only in the commercialization of new power generation systems (such as photovoltaic generation), but also in the commercialization of electric vehicles (EV) and hybrid electric vehicles (HEV).

Soft Magnetic Composite (SMC) effectively suppresses eddy currents by using insulating film for electrical isolation between metal magnetic powders, resulting in superior magnetic characteristics in the high frequency range. Recently, pure iron SMC cores have begun to be applied, and show great promise for miniaturization and for handling large capacities.

However, pure iron SMC has high ductility, which tends to cause problems in plastic flows. As a result of the high ductility, insulating film may be destroyed in the compaction process, and the desired original characteristics become unavailable because of increasing eddy current loss. To avoid such problems, we started development of a specialized lubricant for SMC cores.

This paper describes the effectiveness of the newly developed lubricant.

2 Characteristics of the New Product

- Insulation breakdown in the surface layer of a reactor core is suppressed, based on core-loss suppression technology that is based on Hitachi Chemical's independently developed new lubricant.
- Mass production of high-capacity small reactor cores based on a pure iron pressed powder magnetic core material was achieved by using net shape forming.

3 Background of the Development

Our company has developed pressed powder magnetic core materials for many years. Currently, magnetic characteristics equivalent to ingot steel are obtained through the development of high-compression forming technology, high purification of powder, and fine powder manufacturing methods. In addition, insulation processing technology for magnetic powder has evolved, and its application to motor cores[1,2] and reactor cores[3] has increased.

In recent years, inverters have been installed in photovoltaic power generation systems, HEVs, etc., which represents significant technical progress, and the reactor cores contribute to voltage boosting and rectification. Although silicon steel sheets have generally been used as conventional core materials, the pure iron pressed powder magnetic cores with high inductance values are attracting attention because of the requirement for lower iron loss associated with higher frequencies, and the need for miniaturization and larger capacities.

In pure iron materials with high ductility, however, plastic flow is generated during forming, and the insulating film is easily destroyed. The resulting increase in eddy currents was a problem, because such eddy currents made it impossible to obtain the original magnetic characteristics. Although there are various methods for removing plastic flow, such as etching, it has been impossible to use the advantage of pure iron materials because additional processing is required regardless of the method. Consequently, we focused on shaped lubricants and started the development of multi-functional lubricants capable of improving lubrication performance and protecting the insulation properties of film with the goal of achieving net-shaped reactor cores.

4 Technical Details

Figure 1 shows the concepts related to the developed lubricant.

(1) A lubricant with high cleavability is selected. The lubrication-component filling between metal particles prevents plastic flow.

(2) A special insulator, prioritized for adherence and maintenance on an insulation film during sliding, is selected to improve electrical resistivity on a surface layer.

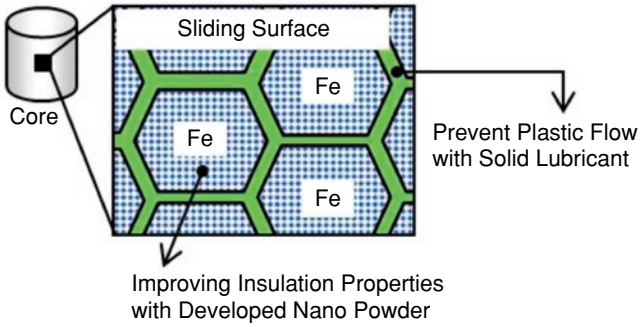

Figure 1 Concept of developed lubricant

Figure 2 shows the influence of electrical resistivity due to the use of the developed lubricant. The use of the developed lubricant provides the electrical resistivity of a sliding surface equivalent to that of a compaction surface.

This technology enabled the realization of a net-shaped pure iron pressed powder magnetic core and achieved mass production of reactor cores for photovoltaic power generation (**Figure 3**). Die lubrication molding is essential as the technology for the pressed powder magnetic cores requiring high pressure forming. This technology is also effective for motor cores exposed to higher frequencies and we believe it will be able to contribute to business expansion of soft magnetic parts hereafter.

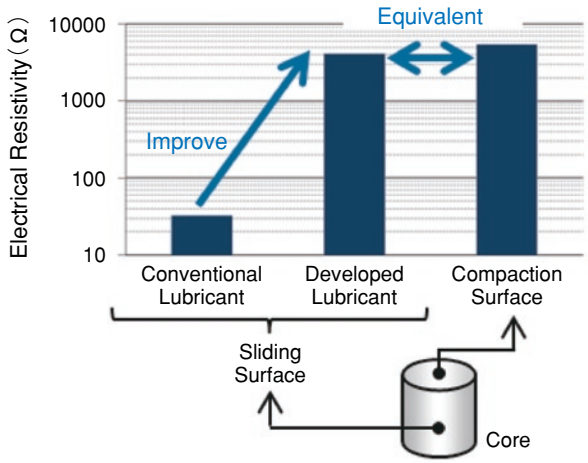

Figure 2 Electrical resistivity of sliding surface

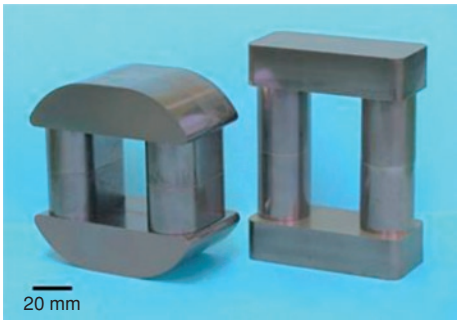

Figure 3 Appearance of reactor core for photovoltaic system

5 Future Business Development

・Apply the new technology to reactors used for on-board inverters, such as in HEVs or EVs.

[References]

1) M. Suzuki, T. Nakamoto, Proceedings. JSAE Annual Congress, 90, (2002) 17-20
2) U. Enomoto, H. Tokoi, K. Kobayashi, H. Amano, C. Ishihara, K. Abe, The transactions of the Institute of Electrical Engineers of Japan. D, A publication of Industry Applications Society, 129, (2009) 1004-1010
3) M. Sugiyama, T. Yamaguchi, S. Okouchi, H. Kishimoto, T. Hattori, T.Saito, SOKEIZAI, 51, (2010) 24-29

[Related patent]

Patent application 2015-508695, Patent application 2015-539285 and Unexamined patent application 2016-189441