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論　文　要　旨
Thesis Abstract

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主論文題名　（Title）

The Magnet Operating Point Estimation using Flux Linkage Observer and Magnetic and Thermal Equivalent Circuit in PMSM

内容の要旨　（Abstract）

Electric vehicles (EV), which are currently being studied and interested with various cases as eco-friendly vehicles, are heavily applied with electric machines along with batteries. Many automakers adopt an interior permanent magnet synchronous motor (IPMSM) as an electric machine for EV, as it is easy to realize, higher-power density, and higher-efficiency. In addition, a variable flux interior permanent magnet synchronous motor (VF-IPMSM) with low coercive force magnet have been studied to achieve a wide speed region. To identify and control the magnetization status of the permanent magnet, a study to estimate the magnet operating point representing the current magnetization state is required.

In this study, an effective combination of methods to estimate the magnet operating points in a permanent magnet synchronous motor (PMSM) is proposed. First, a method of estimating the magnetic flux density of a permanent magnet is designed to estimate using a magnetic equivalent circuit reflecting the value of the estimated magnet temperature. Second, the proposed Flux Linkage Observer is that motor parameters can be estimated independently using the modified model reference adaptive system with additional current sampling points. Finally, the magnet temperature estimation is compensated with the estimated magnet loss based on the error between the estimated magnet temperature obtained using the thermal equivalent circuit and the estimated magnet temperature obtained using the Flux Linkage Observer. The stator iron loss is also compensated based on the error between the measured winding temperature and estimated winding temperature obtained using the thermal equivalent circuit. Unlike the rotor temperature, the stator and winding temperature can be easily measured, and the magnet operating point estimation can be designed as a more accurate and error-resistant estimation method. Furthermore, the simulation and experimental verification demonstrate the effectiveness of the proposed method.

The proposed method is relatively simple and can identify the operating point of the permanent magnet in real time. Therefore, it is expected that this study will

help in terms of the protective logic design for permanent magnet and an improvement of efficiency in PMSM. In addition, using the estimated temperature and magnetic flux density of the magnet, moving the magnet operating point can improve the precision of the torque control of the motor and the efficiency of the system.

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