High-efficiency Design of Magnetic Actuator considering Thermal-magnetic Properties of Permanent Magnet

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ABSTRACT

Permanent magnet (PM) actuator with Nd-Fe-B magnet has been widely used in household electric appliances and automotive applications because of its high power density. Unfortunately, since Nd-Fe-B magnet has a demagnetization characteristic at a high driving temperature [1], an unexpected reduction in magnetic performance of actuator occurs frequently in actual driving circumstance [2].

This paper proposes a new design method of PM actuator for improving driving performance with considering the demagnetization characteristic of magnet. Magnetic performance of actuator at high temperature is determined by using both reversible and irreversible demagnetization properties of PM. The optimization problem is formulated to minimize the PM area where the remanent flux is reduced on the load state at a high temperature while satisfying the target magnetic performance within the limited material usage. A level set based topology optimization method [3] is employed to obtain an innovative optimal design of PM. The level set functions, which has a sign for distinguishing the different material domains, are used as design variables to represent the structural boundaries of the PM and the ferromagnetic material (FM) in the actuator.

A design example of PM actuator with two loading conditions, a closed-loop and open-loop, is adopted to demonstrate the effectiveness of the proposed method. The performance reductions, 1.4% on a closed-loop and 76.0% on an open-loop, of a reference model at a high temperature are observed due to the demagnetization of PM. The optimal design derived by proposed method has a same PM area against the reference model but the magnetic performances are increased, 1.36% on a closed-loop and 76.5% on an open-loop, at high temperature.

It is confirmed that the proposed method is valid for finding the optimal design of demagnetization problem of PM

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