ABSTRACT

Level Set based Topology Optimization in Magnetic Field

Sang-in Park

(Directed by Professor Seungjae Min, Ph. D.)

Department of Automotive Engineering

Graduate School

Hanyang University

Topology optimization which determines optimal distribution of material has been widely applied to design magnetic devices. The element based topology optimization method has resulted in mesh dependent boundaries and gray scale elements due to numerical instabilities. These features have great influence on the performance of magnetic devices due to discontinuity of magnetic flux. Level set based topology optimization has emerged recently as an attractive alternative to overcome shortcomings of the conventional method. Thus, the goal of research is to develop a novel design methodology for optimum structural design of magnetic devices using a level set based structural optimization method where the level set method can represent the precise boundary shape of a structure and also deal with complex topological changes during

the optimization.

Level set method is introduced to represent boundaries between a ferromagnetic material domain and another domain filled with air. The magnetic quantities are calculated by linear magneto-static finite element analysis under the assumption that the material property has linear relationship between magnetic field intensity and flux density. To formulate the optimization problem the objective function is set to maximize the magnetic energy in a specified domain to maximize magnetic flux density or magnetic force and the amount of material used in the domain is constrained to limit its weight. It is necessary to define the normal velocity on material boundaries in order to change in level set based topology method. The movement of the implicit moving boundaries of the structure is driven by a transformation of the objective and the constraint into speed functions that govern the level set propagation. The normal velocity is derived from optimality and convergence conditions of level set equation and calculated using sensitivities of the objective function and the constraint where the adjoint variable method is employed since the objective function has implicit dependency with level set function.

The proposed method is applied to design structural layout of a C-core actuator and a magnetic coupler in order to the maximize magnetic force, and a magnetostrictive sensor in order to maximize the magnetic flux density. The results show that it is possible to design a magnetic device with clear boundaries and it is conformed that higher performance and lighter weight design than initial one can be achieved by verifying the optimal design with commercial software.