ABSTRACT

Optimal Design of Interior Permanent Magnet Motor for Torque Ripple Reduction Using Level Set Method

Jeonghu Kwack

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

Department of Automotive Engineering

Graduate School

Hanyang University

IPMSM (Interior Permanent Magnet Synchronous Motor) is widely used for many industrial applications and has relatively high torque ripple generated by reluctance torque which results in noise and vibration. Since the configuration of the motor has great impact on reluctance torque, design optimization is necessary to improve the performance of IPMSM. Most previous works to obtain optimal design for torque ripple reduction have been restricted to size optimization in which design parameters are known in priori and fixed throughout the optimization process. Recently, the level-set based topology optimization has been successfully applied for the design of magnetic devices and is also a promising method for the motor design problems where the precise boundary shape is required to obtain weight reduction and high performance.

This dissertation addresses the development of a novel design methodology for the structural design of IPMSM such as stator, rotor and flux barrier to reduce torque ripples while maintaining the average operational torque compared to the initial design. An interpolation scheme based on the magnetic reluctivity and the level set function is suggested to represent the material boundary. To formulate the optimization problem the objective function is set to minimize torque ripples by handling torque values at given rotor angles to become the constant target average torque value under the specified volume fraction within the design domain. The movement of implicit material boundaries is driven by speed functions that govern the level set propagation. The normal velocity is derived from optimality and convergence conditions of the level set equation and calculated using sensitivities of the objective function and the constraint where the adjoint variable method is employed.

The proposed method is applied to obtain the optimal configuration design of a traction motor of hybrid electric vehicle. Three different components of IPMSM such as a stator, a rotor, and a flux barrier are considered to be optimized and the optimal design of a stator has the most significant effect for both the torque ripple reduction and the average torque increase. The torque curves of the optimized motor shows lower torque ripple and higher average torque with less material. It is accomplished that torque performance of the IPMSM is improved as compared with that of the reference design. The proposed method demonstrates outstanding flexibility of handling geometric changes with the control of volume fraction and degree of automation.