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STRUCTURAL OPTIMIZATION OF PERMANENT MAGNET MOTOR FOR RESONANCE AVOIDANCE

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Abstract
Since the resonance of a motor system reduces the machine's durability and causes the driving noise, the avoidance of mechanical resonance is the basic design target in the development of permanent magnet (PM) motor which is widely used in many industrial applications due to high power density. The resonance of motor is generated by the interaction between the harmonic component of electromagnetic force and the natural frequency of the motor structure. Hence, many studies have performed design optimization with two objectives: one is the elimination of certain harmonics of the exciting magnetic force and the other is the adjustment of structural frequencies to avoid the resonance band. Unfortunately, by previous design methods using the experimental data and parametric study, the optimal solution for resonance avoidance can bring the great change of the motor structure such as the pole-slot combination and an increase of the motor size. However, since the magnetic and mechanical behaviors of PM motor are highly sensitive to the structural boundaries of PM and ferromagnetic material (FM), the simple optimal design for satisfying both two design objectives can be obtained if a designer can handle a detailed change of motor configuration.
This paper proposes a new design method which can guarantee localized geometrical change for avoiding resonance of PM motor. Several level set functions are employed as design variables to express boundaries of PM, FM, copper coil and air in PM motor and obtain an innovative optimal design. To calculate the magnetic force and the eigenfrequency which is varied due to the motor configuration, both magnetostatic and modal analysis are performed with material properties such as magnetic reluctivity and elasticity, which are defined by level set functions. The optimization problem is formulated to minimize the harmonic component of magnetic force which creates the resonance band according to the rotating speed, and maximize the natural frequency of motor structure. The optimal motor shape is obtained by implicit boundaries of level set function which is moved by the design sensitivity. The proposed method is applied to the structural design of PM motor with consideration of its speed range and resonance band. It is expected that the proposed method can provide the novel structural design of both the rotor and stator for avoiding the motor's resonance in the conceptual design stage.