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Core Loss Calculation of Permanent Magnet Machines Using Analytical Method

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Permanent magnet (PM) machines are becoming popular as a key technology for applications such as home appliances, industrial tools, and electric vehicles. This is because of their high efficiency, high power density, and low maintenance costs. It is very important to consider the power losses in the initial design stage itself, because they determine the efficiency of the machine and have a significant influence on its operating cost. More importantly, the power losses determine the operating temperature of the machine, and hence its rating or output power that may be obtained without undue deterioration of the insulation and PMs. The copper losses of the stator winding, rotor loss, and the mechanical losses due to windage and friction are well known. The remaining loss is the core loss of the stator. This is caused by the changing flux densities in various parts of the iron structures in the machine. Some of these core losses can be significant during high-speed operations. It is imperative to consider the core losses during the design stage. The purpose of this paper is to analytically predict the core loss of the PM machine at the design stage. The process followed in the proposed method is given below.
Step-1: Rearrangement of the core loss data.
Step-2: Deduction of the core loss coefficient by curve fitting.
Step-3: Analytical modeling with a search coil for calculating the flux density.
Step-4: Calculation of the core loss using the obtained core loss coefficients and flux density.
The core loss obtained by the analytical method is compared with those obtained using the finite element method and experiments. In order to verify the core loss results obtained using the proposed method, an experimental system was implemented with a commercial PM machine, power analyzer, and the manufactured test PM machine.

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