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Analytical Calculation for Rotor Eddy-Current Losses in Permanent Magnet machine

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High-speed permanent magnet (PM) machines are used in applications such as machining spindles, generation and storage of energy in vehicles, gas blowers, and other specialized applications. High-speed PM machines exhibit high efficiency, energy density, and dynamic capability. However, in these machines, overheating in rotors due to power loss can lead to problems because, unlike stators, rotors are more difficult to cool. Cooling of rotors is restricted by a small air gap and lack of heat transfer through sleeve materials. Overheating may cause demagnetization of PMs, sleeve failure, or bearing drying. In high-speed PM machines, rotor losses constitute a larger than typical proportion of total losses in the case of conventional low-medium speed machines. Rotor losses are generated by induced eddy currents in rotor materials. The major causes of eddy currents can be divided into the following three categories: (1) No-load rotor eddy current losses caused by existence of stator slots. (2) On-load rotor eddy current losses caused by high magnetic motive force (MMF) winding harmonics. (3) On-load rotor eddy current losses induced by the time harmonics of pulse width modulation (PWM) inverter fed phase current. To maintain the mechanical integrity of a high-speed PM rotor intended for high-speed operation, the rotor assembly is often retained within a carbon-fiber/epoxy composite or metallic sleeve. The sleeve is primarily exposed to magnetic fields produced by a stator from either the slotting or the MMF harmonics that are not synchronous with the rotor. These nonsynchronous fields cause significant rotor losses. As there is no trivial method to remove the heat generated in the rotor assembly including PMs, accurate prediction of these rotor eddy current losses is particularly important. This study addresses the calculation of rotor eddy current losses in high-speed PM machines, based on the subdomain analytical method.

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