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Design and Optimization of Spoke Rotor Type Brushless Direct Current Motor for Electric Vehicles Using Different Flux Barriers

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Abstract : Today, with the reduction in semiconductor system costs, Brushless Direct Current (BLDC) motors have become widely preferred. Based on rotor architecture, BLDC structures are divided into internal permanent magnet (IPM) and surface permanent magnet (SPM). However, permanent magnet (PM) motors in electric vehicles (EVs) are still predominantly based on interior permanent magnet (IPM) motors, as the rotors do not require sleeves, the PMs are better protected by the rotor cores, and the air-gap lengths can be much smaller. This study discusses the IPM rotor structure in detail, highlighting its higher torque levels, reluctance torque, wide speed range operation, and production advantages. IPM rotor structures are particularly preferred in EVs due to their high-speed capabilities, torque density and field weakening (FW) features. In FW applications, the motor becomes more suitable for operation at torques lower than the rated torque but at speeds above the rated speed. Although V-type and triangular IPM rotor structures are generally preferred in EV applications, the spoke-type rotor structure offers distinct advantages, making it a competitive option for these systems. The flux barriers in the rotor significantly affect motor performance, providing notable benefits in both motor efficiency and cost. This study utilizes ANSYS/Maxwell simulation software to analyze the spoke-type IPM motor and examine its key design parameters. Through analytical and 2D analysis, preliminary motor design and parameter optimization have been carried out. During the parameter optimization phase, torque ripple a common issue, especially for IPM motors has been investigated, along with the associated changes in motor parameters.

Keywords : electric vehicle, field weakening, flux barrier, spoke rotor.
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