Abstract

This thesis represents a culmination of the studies that have been taken place in the last few years. The increase in automation leads to the electrification of several existing systems, e.g. transportation system, which require electrical machines (EMs) as primary power equipments. Permanent magnet (PM) machines currently prevail as a primary choice for high-performance electrical machines (EMs) because of their high torque/power density and high efficiency. However, the limited resources and the unstable cost of rare-earth metals, and the fault-tolerant issues of PM machines appeal to the researchers for an attractive alternative to PM based motors. Switched reluctance motors (SRMs) are gaining attention because of their simple construction, low cost, ability to work in harsh environments, absence of PM and wide-speed operation. Unipolar current excitation encourages the design of low-cost inverters for SRMs, requiring only one controlling switch per phase. However, low torque/power density, low efficiency, high torque ripple and high acoustic noise demand further improvements in such motors. Using high silicon steel or amorphous steel and improving slot-fill factor enhance the efficiency of SRMs. The emersion of the double-stator SRMs (DSSRMs) as a new SRM topology with two stators and a segmented rotor exhibits significant improvement in torque density. Such machines have lower values of the normal component of air-gap flux density, which results in lower vibration and lower acoustic noise. The single-tooth winding add-on further improves its compactness and high-efficiency speed range. High torque ripple of such motors is a key issue that limits their adaptability in industrial applications. Many active and passive techniques are developed to reduce the torque ripple for the different topology of SRMs. However, this specific topology still lacks such effective techniques.

In this thesis, firstly, the design concepts of single-tooth winding radial-flux DSSRM are presented. The torque equation of this topology is derived. The calculation of stator poles and rotor segments arc angles for high output torque, selection procedure for slot/segment combination and the effect of winding polarities on motor performance are discussed in details. It is observed through finite-element method (FEM) analysis that such motor possess high torque ripple. Therefore, some design modifications are investigated for such motor topology for reducing the torque ripple. In the presented work, shifting of the rotor segments and stator/rotor surfaces are investigated to reduce the torque ripple. In this regard, the finite-element models are developed, and their static and dynamic responses are simulated. The effect of these shifts on the magnetic flux distribution in different parts of the motor is studied, and their influences on motor performance are analyzed. Besides these, the design of a new DSSRM is proposed, which has a significantly low torque ripple in a higher speed range when single-pulse control mode is active. Many of the torque ripple reduction techniques are only effective in the current chopping control mode, which is only possible in a lower speed range. In the proposed motor, the outer stator is shifted by half of the stroke angle compared to the inner stator. The respective phase windings of the inner and outer stators are excited parallelly with the same phase shift. Each rotor segment is constructed with two half rotor segments, and a wide non-magnetic region is inserted between them. In this regard, the modifications are carried out in the outer stator poles and outer half rotor segments. The efficacy of the proposed motor is investigated through FEM based simulation results. The proposed motor shows significantly reduced torque ripple for a higher speed range when single-pulse control is active.