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Torque Maximization Method of Radial Magnetized Surface-Mounted PM Machine Having Sinusoidal Shaped Pole

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This paper presents a torque maximization method to increase output torque without deteriorating the torque ripple in radial magnetized surface-mounted permanent magnet (SPM) machine having sinusoidal shaped pole by using third-order harmonic (Sine+3rd) shaping method. The optimal value of third-order harmonic injected into sinusoidal shaping can be either scanned out by finite element analysis (FEA) or determined analytically. In accordance with the profile of SPM, it can be classified into SPM with arc magnet and SPM with "bread-loaf" magnet. For all slot/pole combinations of SPM machine with radial magnetized arc magnet, it is already found that the optimal value of third order harmonic injected into sinusoidal shaping is fixed and equal to $1/6$ of the fundamental one. However, such optimal value is varied with pole pair number (p), magnet thickness and rotor radius for machine having radial magnetized "bread-loaf" magnet. Therefore, the developed Sine+3rd shaping method is not accurate enough and invalid for SPM machine having "bread-loaf" magnet pole. In this paper, an analytical model to obtain the optimal value of third-order harmonic injected into radial magnetized SPM machine with sinusoidal shaped "bread-loaf" magnet is derived to achieve maximum torque without deteriorating torque ripple. The accuracy of developed analytical model is verified by FEA. The analysis reveals that the value of fundamental air-gap flux density for SPM machine having Sine+3rd magnet pole is increased more than 10% in contrast to SPM having sinusoidal shaped pole only.

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