Effect of the Numbers of Slots and Barriers on the Optimal Design of Synchronous Reluctance Machines

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Abstract

The present paper analyses the impact of the numbers of stator slots and rotor layers on the optimal design of synchronous reluctance (SyR) machines. Eighteen SyR machine examples are designed by means of a multi-objective optimization algorithm (MOOA) and finite element analysis (FEA) [1], all for having maximum torque and minimum torque ripple. Fig. 1 shows the results of MOOA analysis. Twelve to forty-eight slot stators are considered, associated to rotors with four-poles and one to six flux barriers per pole. According to [2], rotors with equally spaced rotor barriers and with the number of stator slots (ns) and equivalent rotor slots per pole pair (nr) following the rule:

\[ n_s = n_r \pm 4 \]  

(1)
can minimize the torque ripple. These machines are called “conventional rotor” ones in the paper.

The paper shows that some slot/layer combinations force the optimization algorithm to produce nonconventional barrier distributions, some of those with promising performance (Fig. 2). Two types of FEA are used: a fast one for the evaluation of thousands of candidate machines during optimization, and one accurate transient with motion analysis including iron loss evaluation, for the off-line characterization of the final designs. The results of the comparative analysis show that high numbers of slots and layers are beneficial for maximizing the torque and the power factor, and that torque ripple and iron loss minimization require precise matches between the slots and the layers, that are not necessarily the same [3] for the two purposes (Fig. 3).

![Fig. 1 - Pareto fronts of five MOOA runs](image)

![Fig. 2 - cross section of a) “conventional”, b) “non-conventional” motor](image)

![Fig. 3 - Overall comparison of a) average torque, b) torque ripple, c) iron losses for different stator/rotor combinations](image)

References

