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Design and Analysis of Outer-Rotor Permanent Magnet Synchronous Machine With Amorphous Stator Core

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Efficiency is an important index to evaluate the performance of an electric machine. Core loss takes a big part of the total losses of an electric machine. Amorphous alloy material (AAM) has much lower core loss than that of traditional silicon steel. An outer-rotor permanent magnet synchronous machine (OR-PMSM) with amorphous stator core is proposed in this paper, which exhibits higher efficiency than conventional PM machine. Based on the electromagnetic characteristics of the amorphous alloy material, the general design of the proposed machine is studied, including the structure parameters and the stator-slot/rotor-pole combinations. The combination principle of permanent magnets and winding turns for OR-PMSM with amorphous stator core is investigated. Based on the 2-D finite element analysis (FEA), the electromagnetic performances of the proposed machine are investigated and compared with an OR-PMSM with silicon steel stator. A prototype is manufactured and tested to validate the FEA results. The design process started from the calculation of the stator and rotor dimensions. Then the numbers of stator-slots and rotor-poles will be choosed after comprehensively considerations of the efficiency goal and the characteristics of OR-PMSM. At last, the winding turns and permanent magnetic flux should meet the requirements of speed range and the power supply voltage limit. To better take advantages of the AAM for reducing the losses, the magnetic loading Bgap can be higher owing to the low core loss of AAM. A higher magnetic loading also means a lower electric loading which is proportional to the copper loss. For the OR-PMSM, to reduce outer-rotor yoke thickness, the mutipolar design is adopted. The slots number should be choosed to fit the concentrated windings form in order to reduce the copper loss. The results show that the OR-PMSM with amorphous stator core has a higher efficiency and wide high efficiency operation region.

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