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Designing and Prototyping Permanent Magnet Generators for Wind Energy

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Abstract : This paper introduces dual rotor axial flux machines with surface mounted and spoke type ferrite permanent magnets with concentrated windings; they are introduced as alternatives to a generator with surface mounted Nd-Fe-B magnets. The output power, voltage, speed and air gap clearance for all the generators are identical. The machine designs are optimized for minimum mass using a population-based algorithm, assuming the same efficiency as the Nd-Fe-B machine. A finite element analysis (FEA) is applied to predict the performance, emf, developed torque, cogging torque, no load losses, leakage flux and efficiency of both ferrite generators and that of the Nd-Fe-B generator. To minimize cogging torque, different rotor pole topologies and different pole arc to pole pitch ratios are investigated by means of 3D FEA. It was found that the surface mounted ferrite generator topology is unable to develop the nominal electromagnetic torque, and has higher torque ripple and is heavier than the spoke type machine. Furthermore, it was shown that the spoke type ferrite permanent magnet generator has favorable performance and could be an alternative to rare-earth permanent magnet generators, particularly in wind energy applications. Finally, the analytical and numerical results are verified using experimental results.

Keywords : axial flux, permanent magnet generator, dual rotor, ferrite permanent magnet generator, finite element analysis, wind turbines, cogging torque, population-based algorithms
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