Hybrid excited axial flux electromechanical energy converter

Abstract

The last two decades have seen a large number of publications related to the problem of excitation flux control of permanent magnet machines operating in a wide speed range. This issue is extremely important, e.g. in electric vehicle drives, because the range of speed and efficiency of the electrical drive depend on the flux control characteristics of permanent magnet motors. Despite significant technological and scientific progress in the electric machine modern structures and their control systems, there is still a need to develop more effective flux control methods for permanent magnet motor drive.

In this dissertation, analytical, simulation and experimental studies have been carried out on a axial-flux machine with permanent magnets and an additional source of excitation. The machine is excited by permanent magnets located on the rotor, and by an additional excitation source. The ability to control the excitation of a permanent magnet machine provides obvious advantages, since flux weakening, at a constant supply voltage, allows the motor speed to be increased. On the other hand, increasing the excitation flux, e.g. in a generator at increased current load, allows to stabilize the amplitude of the output voltage at its terminals.

Given the high cost of building a prototype motor with permanent magnets, the important thing at the design stage is the selection of the design parameters of the magnetic circuit for the flux-control. The geometry of the magnetic circuit of an axial-flux machine, in which there are at least two independent excitation sources, requires special attention.

In this dissertation, analytical models and three-dimensional field models of a hybrid-excited double axial-flux machine with an internal toroidal double-slotted stator with 3-phase distributed winding have been presented. On the basis of the 3D FEA results, the influence of the magnetic circuit geometry, the type and direction of magnetization of the magnets mounted on the rotor, on the flux control range of machine, electromagnetic torque and no-load back-emf, as a function of the phase winding and the additional coil current load.

In the following section of the paper, thermal analyses and temperature distribution results obtained on three machine models in liquid or air cooling system, and temperature measurement results performed on the prototype were presented.

The this dissertation also proposes a new concept of mechanical excitation flux control of a axial-flux machine with a moving magnet exciter system.

Finally, in order to assess the usefulness of machine magnetic cirrcuit, a machine prototype was built and experimental tests were performed.

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