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Design of hybrid excited axial flux machine

Abstract*. The paper presents design of an innovative field-controlled hybrid excited axial-flux surface-mounted permanent-magnet machine. Based on three-dimensional finite-element analysis (3D-FEA) field-control characteristics of the machine have been predicted and discussed. Moreover, simulation results of no-load back-EMF waveforms performed at the different DC field excitation coil currents have been obtained and compared with experimental results.*

Keywords: axial-flux electrical machine, hybrid excitation, permanent magnet machine, field-control, 3D-FEA , adjustable speed application.

Introduction

Nowadays, the fast and large-scale development of unconventional electrical machines used for variable speed drive applications is observed [1]. Permanent magnet (PM) electrical machines with high power density features are developed and still improved. Among the PM machines an axial-flux permanent magnet (AFPM) machines have been gaining popularity in drives where the used conventional machines are not appropriate, such as generators in wind turbine and other direct drive applications [2].

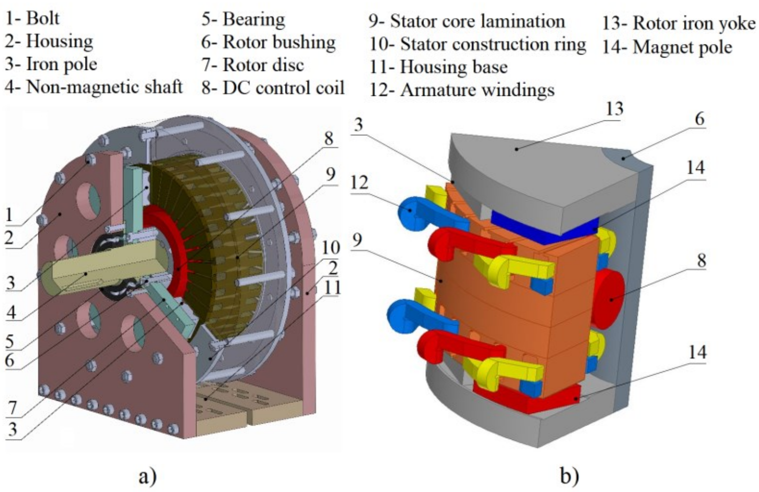

Fig.1. Design (a) and 3D-FEA model (b) of the FCAFPM machine.

Figure 1a shows a novel design of field-controlled axial-flux PM machine (FCAFPM-machine) with field-strengthening (FS) and field-weakening (FW) capabilities. The FCAFPM-machine concept is based on a dual-rotor single-stator AFPM machines with an additional DC control coil (8) fixed on the stator machine, accordingly as shown in

Fig.1a. It should be noted that, the presented machine concept has already been investigated in [3-5] and it will be optimized in further stages of research.

The stator magnetic circuit consists of two (alternatively- one common) toroidal stator cores (9) with an additional DC control coil excitation winding (8) which is arranged in the central part of the machine. The magnetic circuit of the rotor is formed by two yokes of rotor (13) with PM poles (14) connected by a toroidal rotor core-rotor bushing (6). Typical for rotor construction is that, the poles with PM (14) of one part of the rotor are magnetically polarized in accordance with the poles with PM of the second part of the rotor. There are iron poles (3) between poles with PM.

In view of the spatial asymmetric magnetic field distribution [6,7] of the machine a simulation study was carried out by using three dimensional finite element analysis (3D-FEA). Figure 1 b shows 3D-FEA model of the FCAFPM machine developed in 3DFlux software package. One of the most important scientific tasks was to develop machine structures with appropriate capabilities to machine flux-control (FC). A quality of FC indicator has been defined as a ratio of the FS at loading current I_{DC+} to the FW at I_{DC-} of the additional DC control coil current.

Conclusion

Preliminary simulation results indicate that developed machine concept can achieved good flux-control range (3:1 at least). The presented machine design of FCAFPM has a big application potential in the development of variable speed drive applications.

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