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Wind or Hydro Homo-Heteropolar Synchronous Generators: Equivalent Magnetic Circuit and FEM Analysis

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Abstract. In an effort to introduce a low cost (PM less), low power electric wind or hydro generators, this paper reports on preliminary design aspects, equivalent magnetic circuit and 3D FEM analysis of a 2.5 KVA, 250-1000 rpm, reactive homo-heteropolar brushless synchronous machine (RHHBSM).

1 Introduction

One of the main disadvantages of the classic synchronous machines is the armature's excitation winding which determines a great rotor weight and inertia and involves the sliding contacts' existence (brushes and slips rings). Reference [1] presented a new form of heteropolar linear synchronous machine that is capable of providing both thrust and lifting force at relatively high efficiencies and power factor. In [2] is presented a rotary reactive homopolar synchronous machine with stator excitation which removes the disadvantages of the classic synchronous machines.

Conception constraints on electro-technical devices require numerical simulations to be as close as possible to its actual operating conditions. Then, it is necessary to have coupled physical models of devices, especially, for electrical, magnetic and mechanical coupled models which allow the simulation of loaded rotating machines [3].

Finite elements method (F.E.M.) allows such coupling for 2D plan modeling devices. Nevertheless, it requires a lot of calculation time. Its use for three dimensional typical machine has never been done until nowadays and calculation time will be even longer [4].

In order to obtain the best results in designing of the special electric machines, it should be used both the classic methods and the numerical calculation methods. The calculation should be based on a mathematic model as accurate possible. Based on this model are determined by simulation the characteristics of the machine in non-saturated and saturated regime [2], [5].

The designing particularities of these types of generators are linked to the axial character of the magnetic field distribution. The field calculation in the machine can be achieved by the finite elements method [6], or by field tubes method [2], [5], [7-10]. Taking into consideration the axial distribution of the machine field, it is necessary a three-dimensional modeling of the machine field. For this three-dimensional model is required a specialized software that needs a performance computer, and the calculations time could be high.

2 The constructive elements

The reactive homopolar (RHBSM) and homo-heteropolar brushless synchronous machines (RHHBSM) which we'll analyze further are rotary machines. In order to understand their constructive elements, in Fig.1 is presenting a longitudinal section. The excitation coil has a ring shape and is placed in the windows of the U or E-shaped laminations stack (Fig. 1 a, b), and, at passing of the rotor poles, the field is closing, having by this a rectangular variation form. When the rotor pole is not under the laminations stack, the field is practically null.

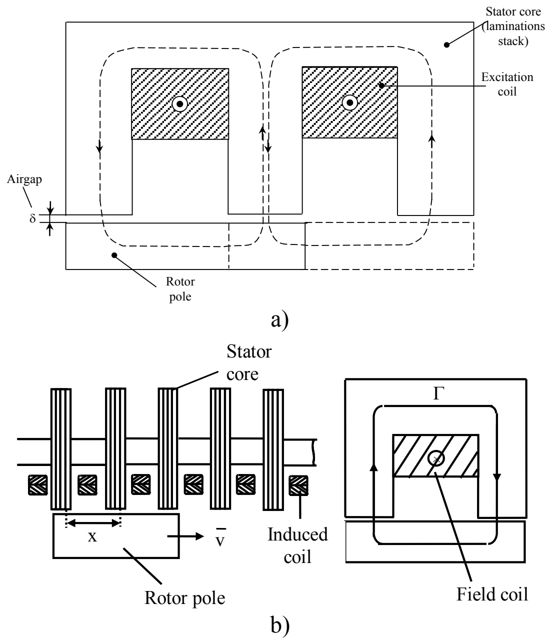

Fig. 1. Longitudinal magnetic circuit section in: a) homo-heteropolar synchronous machine; b) homopolar synchronous machine.

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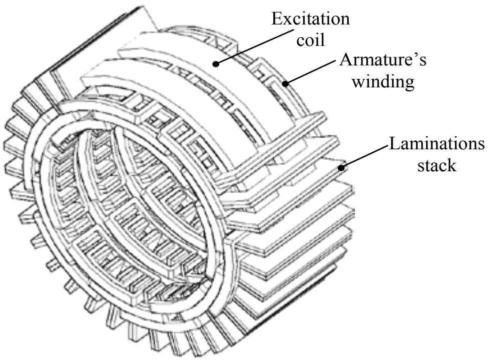
The constructive elements of the novel RHBSM and RHHBSM, are presented in Fig. 2, 3 and 4 in a 3D and 2D view.



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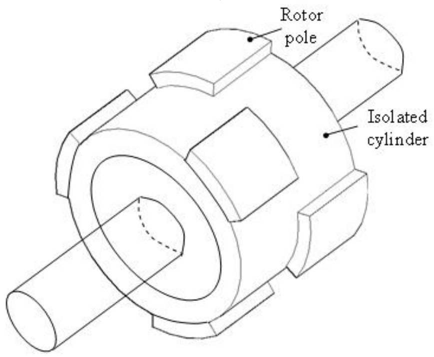

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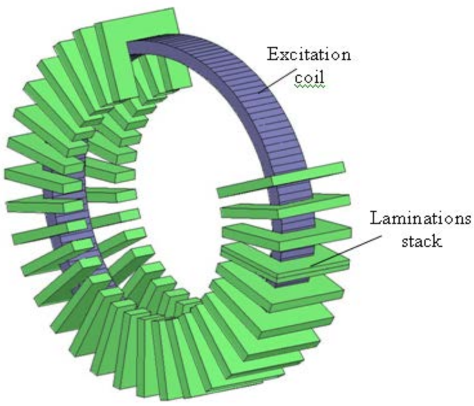

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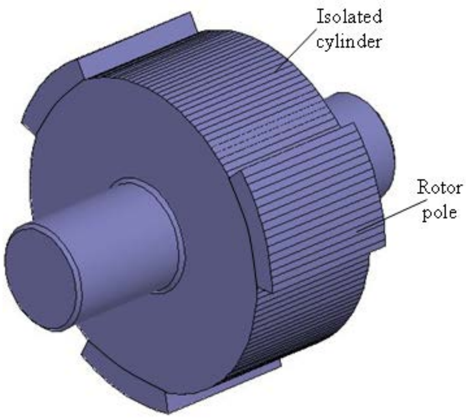

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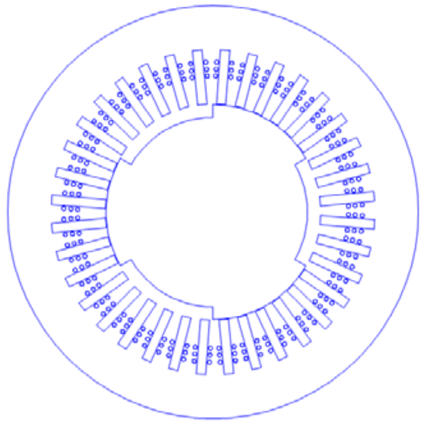
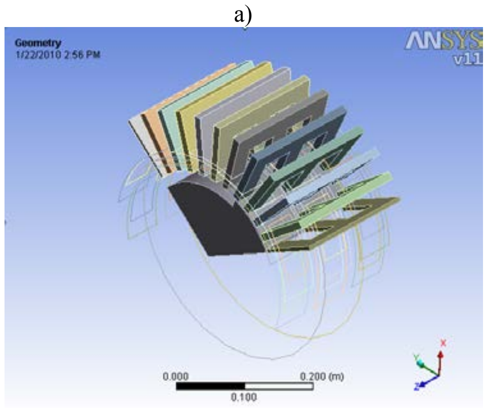
Fig. 2. a) 3D representation of stator magnetic circuit with excitation and phase winding coils of RHHBSM; b) 3D representation of the rotor of RHHBSM; c) 3D representation of the stator magnetic circuit with excitation coil of RHBSM; d) 3D representation of the rotor of RHBSM.



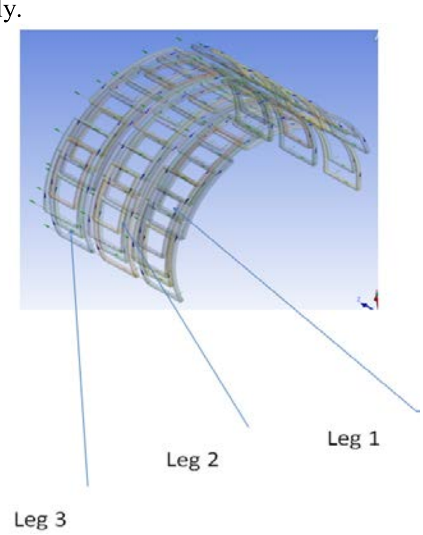
a)



b)

Fig. 3. RHHBSM: a) 2D representation of stator and rotor magnetic circuit, with armature phase winding coils. b) 3D geometry representation.

The excitation coils has a ring shape and are placed in the windows of the E-shaped laminations stack. The armature AC winding is placed in the open slots, formed between the pockets of lamination stack. To design the three dimensional magnetic structure of the RHHBSM is necessary to identify the flux distribution of the machine. The geometry of the RHHBSM poses a challenging problem because of the various cross-couplings between the rotor and stator. The flux distribution caused by the AC winding and by the DC excitation is investigated separately.



a)