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COMPARATIVE ANALYSIS OF TRANSVERSE FLUX GENERATORS DESIGN

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Abstract: This paper deals with the comparision of different transverse flux machine designs with disk rotor. Five designs were proposed compared to a basic design. The aim is to achieve a high level of efficiency combined with low manufacturing effort. Three-dimensional models of each design were created in ASCON KOMPAS-3D software. ANSYS Maxwell software was used to calculate the electromagnetic processes in each generators design. According to simulation results the two-rotor-transverse-flux-generator is the best design.

Keywords: TFM, transverse magnetic flux generator, U-shaped core, magnetic flux, design, electromotive force, coil, permanent magnet.

A transverse magnetic flux generator (TFG) with a disk rotor is an electrical machine with two stators and a disk rotor. The rotor with permanent magnets (PMs) is placed

between this two stators. Each stator consists of a ring coil and U-shaped cores wich are called the stator poles (Fig.1).

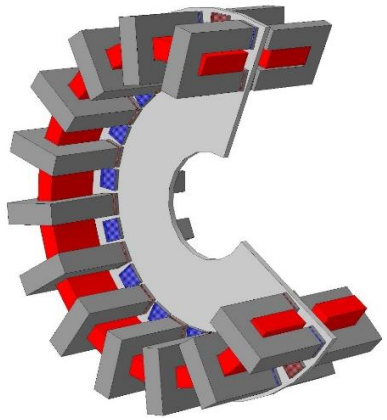

Fig. 1. 3D TFG model with a disk rotor

During the design process a question of getting the maximum power at constant machine size arises. A typical feature of the transverse flux machine (TFM) is the possibility of realizing different numbers of stator poles with the same diameter. However, an increase the number of U-shaped cores, with a constant diameter, leads to a proportional decrease of their thickness and to increase the frequency, iron losses and, as a result, the magnetic flux leakage of permanent magnets [1].

The principle of TFG working like any other generator is based on the re-magnetization condition of the stator poles. To ensure these conditions it is necessary to place the permanent magnets in staggered arrangement. One pare of PMs corresponds to one U-shaped sator core. To meet the stator core re-magnetization requirements it is necessary that the PMs pare number are twice as much as the U-shaped stator cores [2].

The basic design of TFG magnetic system consists of 32 U-shaped cores and a disk rotor with 128 permanent magnets for one phase, the air gap is 1 mm. The outer diameter of the stator is 300 mm and the length of the machine is 75 mm, The winding is placed into the stator slot with 250 number of turns, so that in all next proposed designs the number of turns was varied in proportion to the slot section.

Different TFG designs become possible in case of mounting the additional cores and coils in place between the existing cores. This design option allows us to place an additional coil and obtain an additional source of EMF. However this idea requires some changes in the stator geometry and in the additional U-shaped cores or a simultaneous changes in primary and secondary cores geometry for the both coils.

Five different TFG designs have been considered and compared with the basic TFG design in no-load mode. The U-shaped core designs are shown in Fig. 2.

3D TFG models were created using ASCON Kompas-3D software and the electromagnetic processes calculation was held by finite element method using the ANSYS Maxwell software.

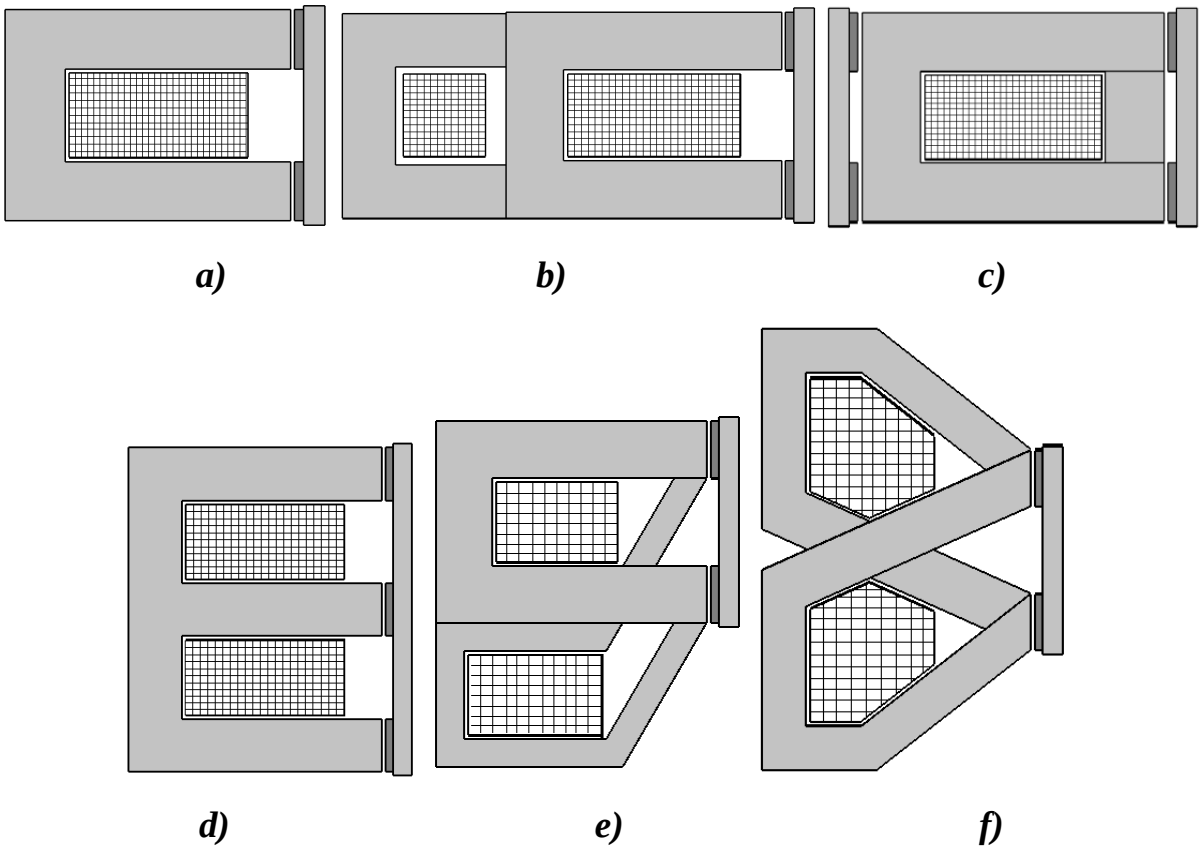

Fig. 2. TFG U-shaped cores design

a) – basic TFG design; *b)* – extra coil with long core design;

c) – two rotors design; *d)* – an additional coil over the main coil design;

e) – additional coil under the main coil design; *f)* – «Butterfly» design with extra cores.

The simulations were carried out with the following persisted conditions:

- the geometric dimensions and number of permanent magnets, U-shaped cores and ring coils are unchanged for each of the options;
- the rotor speed is 20 rpm;
- residual flux density of a permanent magnet is 1.3 T;
- permanent magnets type is – NdFeB N45.
- ferromagnetic material of the stator core – is M350 steel type.

The design and the rotor size are identical for each TFG designs variety, except the TFG design with E-shaped stator core (Fig. 2, d). The electromagnetic processes

simulaton was carried out for one stator core and for one fourth of the TFM model just to increase the calculation speed but without the calculation errors.

3D simulation results for all TFG design options are shown in the Table 1.

Based on the simulation results the two rotors TFG design (Fig. 2, c) has a higher EMF value by 250 % with increased the mass-dimensional indicators only by 60% in comparison with the basic TFG design.

Table 1

Simulation results

TFM design	Number of turns		Amplitude EMF value induced in one stator coil, V		Weight of one stator, kg	External diameter of the generator, mm	Length of generator, mm
	Basic coil	Extra coil	Basic coil	Extra coil			
Classic design (*a*)	250	–	32	–	12,6	300	75
Extra coil with long core (*b*)	250	120	13	19	22,4	300	115
Modification with two rotors (*c*)	250	–	83	–	20,1	300	88
Extra coil over the main coil (*d*)	250	250	42	13	24,7	370	75
Extra coil under the main coil (*e*)	180	200	32	28	17,3	300	75
«Butterfly» design (*f*)	250	250	45	38	23	358	75

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