Cogging Torque in Hybrid Claw Pole Generator

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***Abstract*—This paper contains results of the Hybrid Claw Pole Generator (HCPG) simulations. The test machine has claw poles on two rotor sections, between which an excitation control coil is placed. The novelty of this machine is permanent magnets placement on claws of one part of the rotor. The paper presents the construction of the machine and analysis of the influence of the current in the excitation control coil on the cogging torque. Simulation studies have shown that the cogging torque decreases at the weakening stage, while at the strengthening stage it's value firstly increases and then decreases.**

***Index Terms*—Cogging torque, Electric machines, Hybrid excited generator, Permanent magnets, Wind turbine.**

I. INTRODUCTION

Nowadays, different technical solutions of hybrid excited machines, including the claw pole machines with permanent magnets [1-3], are known. Many of these claw pole machines have some serious limitations – the excitation flux is non-controllable and it is necessary to introduce special areas within the machine to limit the magnetic flux leakage. This paper proposes a new structure of the claw pole machine, where the permanent magnets are placed on claws of one part of the rotor [4].

II. MACHINE TOPOLOGY AND RESULTS OF EVALUATION

Simulation studies of HCPG machine (Fig. 1) were performed. They show the impact of the current in the excitation coil I_{exc} on the cogging torque. The shape of the cogging torque is shown in Fig. 2, and in Table 1 the maximum and the root mean square values of the cogging torque are presented.

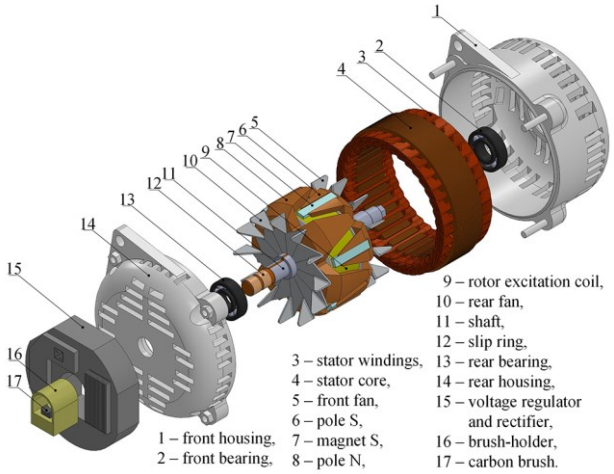

Figure 1: Parts of the HCPG structure.

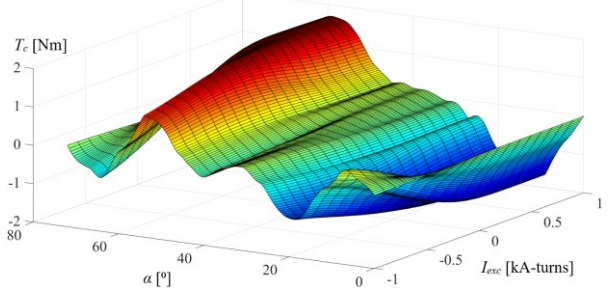

Figure 2: Cogging torque for different field excitations.

TABLE I
COGGING TORQUE

I_{exc} [A-turns]	$T_{c\,max}$ [Nm]	$T_{c\,rms}$ [Nm]	I_{exc} [A-turns]	$T_{c\,max}$ [Nm]	$T_{c\,rms}$ [Nm]	I_{exc} [A-turns]	$T_{c\,max}$ [Nm]	$T_{c\,rms}$ [Nm]
-1000	1,17	0,52	-300	1,67	0,84	400	1,76	1,06
-900	1,23	0,54	-200	1,72	0,90	500	1,76	1,05
-800	1,30	0,57	-100	1,75	0,95	600	1,75	1,04
-700	1,37	0,61	0	1,77	1,00	700	1,74	1,04
-600	1,46	0,66	100	1,78	1,04	800	1,73	1,03
-500	1,54	0,72	200	1,78	1,06	900	1,72	1,02
-400	1,61	0,78	300	**1,77**	**1,07**	1000	1,71	1,01

III. CONCLUSION

The obtained values of the cogging torque are relatively high. Various techniques for reducing pulsations are known, including the use of magnetic wedges [5,6]. In the final work, it is planned to select and develop an optimum construction of the claw pole machine with permanent magnet in which the cogging torque will be minimized.

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REFERENCES

[1] B. Zhang, A. Wang, M. Doppelbauer, "Multi-Objective Optimization of a Transverse Flux Machine With Claw-Pole and Flux-Concentrating Structure", *IEEE Transactions on Magnetics*, vol. 52, No. 8, DOI: 10.1109/TMAG.2016.2554562, 2016.

[2] Y. Burkhardt, K. Schleicher, M. Klöpzig, "A novel hybrid excited synchronous machine for (H)EV applications", *IEEE Xplore*, 2014.

[3] V. Leroy, V. Foveau, "Claw rotor equipped with an insulator for an excitation coil and magnets, and rotary electrical machine equipped with a claw rotor", patent US 20130009504 A1, 2013.

[4] M. Wardach, "Hybrid excited claw pole electric machine", Proceedings of the 21th International Conference MMAR, pp. 152-156, DOI: 10.1109/MMAR.2016.7575124, 2016.

[5] M. Wardach, P. Paplicki, R. Palka, P. Cierzniewski, "Influence of the rotor construction on parameters of the electrical machine with permanent magnets", *Przeglad Elektrotechniczny (Electrical Review)*, vol. 87, no. 11, pp. 131-134, 2011.

[6] M. Wardach, Cogging torque reducing in electric machine by poling modification of magnetic circuit, *Przeglad Elektrotechniczny (Electrical Review)*, vol. 85, no. 2, pp. 131-133, 2009.