Influence of Excitation Currents on Parameters of Hybrid Claw Pole Machine

Marcin WARDACH

Department of Power Engineering and Electrical Drives,
West Pomeranian University of Technology, Szczecin, Sikorskiego 37, 70-313 Szczecin, Poland

Abstract. This paper presents the simulation and chosen experimental results of a claw pole electric generator, with a hybrid excitation, i.e.: a coil located between two parts of the rotor and additional permanent magnets fixed on rotors' claw poles. The results show that the permanent magnets generate an additional excitation flux, but don't influence the control properties of the machine. This article especially shows an impact of currents in the excitation coil on the voltage pulsations and cogging torque of the machine.

1 Introduction

The paper presents a model, simulation and experimental results of hybrid excited claw pole generator (HECPG), which can be used in small wind power plants and electric vehicles. The structures of generator having claw poles are well known, i.e. in automotive alternators. In order to generate a magnetic flux, an additional coil located between two parts of the claw pole rotor has been used but in the proposed model, an additional permanent magnets on the rotor claw poles have been used. Some results of the machine are shown in [1]. This article primarily presents how the excitation coil current affects on parameters of HECPG (including cogging torque and back-emf values).

2 Claw pole generator with hybrid excitation

Many technical designs of hybrid excited machines, including claw pole machines with permanent magnets, have already been described in the literature [2-5]. Some of these solutions are highly technically complicated and others require introduction of special regions to reducing flux leakage. The proposed machine (table 1) contains a rotor with the excitation coil and claw poles wherein permanent magnets are mounted. Figure 1 shows the simulation model of the machine, representing 1/6 of the entire device. Figures 2 and 3 shows back-emf waveforms and cogging torque distributions depending on the current in the rotor excitation coil.

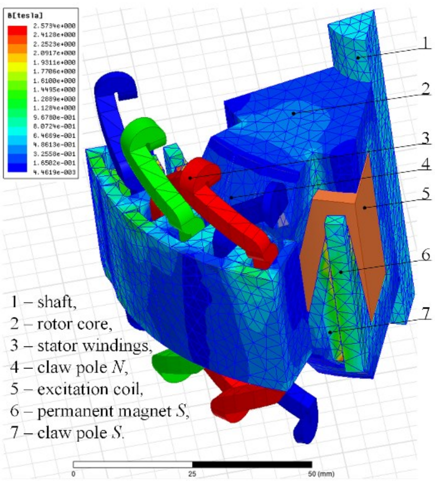

Fig. 1 3D simulation model of HECPG

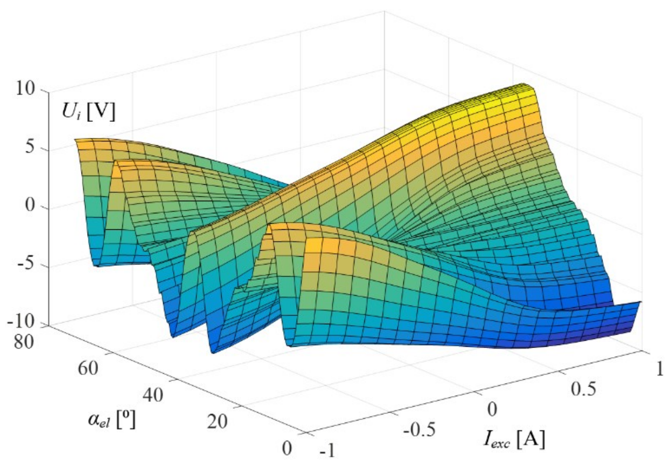

Fig. 2 Back-emf waveforms

Table. 1. The main data of the machine

	Parameter	Value	Unit		Parameter	Value	Unit
Main	Nominal power	1000	W	Rotor	Outer diameter	101	mm
Main	Maximal speed	3000	rpm	Rotor	Axial length	30	mm
Stator	Inner diameter	102	mm	Rotor	Number of poles	12	-
Stator	Axial length	30	mm	Rotor	PM type	NdFeB	
Stator	Number of slots	36		Rotor	PM B_r	1.2	T
Stator	Number of turns	2 x 6		Rotor	PM μ_0	1.05	-
					Air gap	0.5	mm

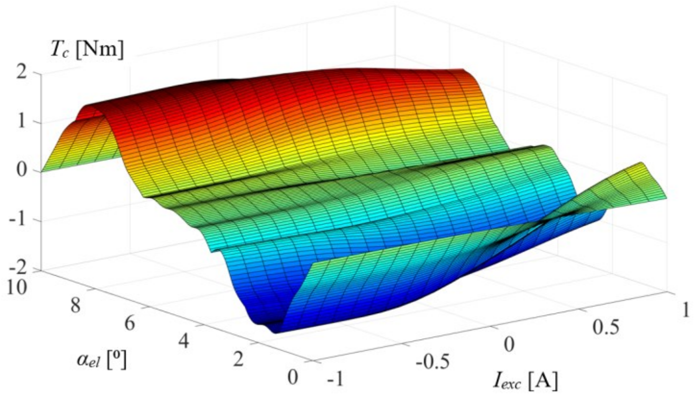

Fig. 3 Cogging torque distributions of HECPG

3 Conclusion

In the article the influence of excitation coil current on HECPG parameters was presented. The research shows that the current in the excitation coil strongly influences on the shapes of the cogging torque and above all on the back-emf. The next step of the research will be to find the best structure of the magnetic circuit where the pulsations will be minimized. The research will be conducted with using polarization modifications [7] and magnetic wedges placement.

Acknowledgements

This work has been supported with the grant of the National Science Centre, Poland 2015/17/B/ST8/03251.

References

[1] 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.

[2] P. Di Barba, M. Bonislawski, R. Palka, P. Paplicki, M. Wardach, *Design of Hybrid Excited Synchronous Machine for Electrical Vehicles, IEEE Transactions on Magnetics*, Issue: 99, DOI: 10.1109/TMAG.2015.2424392, (2015).

[3] L. Melcescu, M. V. Cistelecan, O. Craiu, M. Popescu, *Numerical Analysis of Claw Pole Synchronous Machine with Hybrid Contactless Excitation*, Electrical Review, 7b/2012, pp. 106-109.

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

[5] 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.

[6] S. Shinnaka, T. Sagawa, *New optimal current control methods for energy-efficient and wide speed-range operation of hybrid-field synchronous motor*, IEEE Transactions on industrial electronics 54(5), pp. 2443-2450, 2007.

[7] 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.