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# Experimental research of internal permanent magnet machine with flux barriers

***Abstract**. The paper presents the results of experimental research of the prototype machine with permanent magnets and magnetic barriers on the rotor. The purpose of using barriers was to obtain the greatest value of the $L_q/L_d$ ratio. During the tests at the test setup, the voltage waveforms and the distribution of the torque generated by the machine were determined.*

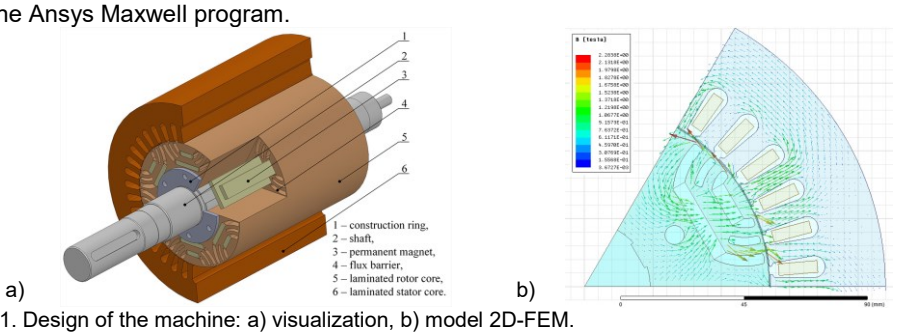
**Keywords:** hybrid excitation, permanent magnets, flux barriers, electric machine.

## Introduction

Nowadays, a large interest in electrical machines with permanent magnets can be observed. This contributes to the development of new non-conventional machines with permanent magnets type NdFeB. These machines have significant advantages: high efficiency, high power density and relatively high electromagnetic torque [1-4]. Thanks to innovative materials, simulations, modern design, development of control systems and power technologies, such electrical machines are continuously developed and improved. A special group of machines are machines dedicated for electric vehicle drives. These can be hybrid machines [1-4], but also special machines wherein a reluctance moment (a high $L_q/L_d$ inductance ratio) is needed. This paper is a continuation of research provided on internal permanent magnet machine with flux barriers, some simulation results of this have already been shown in [5].

## Construction of the internal permanent magnet machine with flux barriers

Figure 1 shows the structure of the proposed machine and a simulation model made in the Ansys Maxwell program.



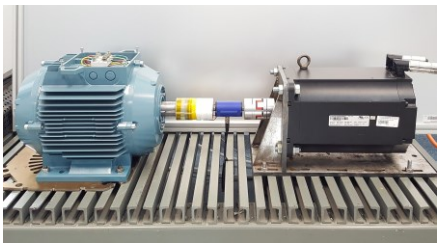

a) b)

Fig.1. Design of the machine: a) visualization, b) model 2D-FEM.

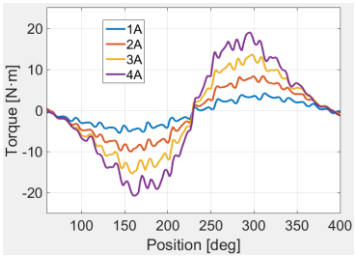
## Results of simulation and experimental tests

Figure 2a) shows the test setup for testing prototype of the machine. During experimental research torque waveforms were determined on the machine shaft

depending on the angular position of the rotor relative to the stator for various stator current values $I_s$. One of the phases was supplied with $I_s$ DC current and the other with $-0.5 \cdot I_s$ and next the rotor was rotated by an additional motor. In this way, the characteristics shown in Fig. 2b) have been determined.



a)




b)

Fig.2. a) Test setup, b) the torque measured on machine shaft.

## Conclusion

The purpose of the research was to develop, execute and test a prototype of an electric machine with a permanent magnet dedicated to drives of electric vehicles. Based on analyzes, a machine with a big *q*-axis inductance to *d*-axis inductance ratio was designed and built. Thanks to this, it was possible to influence effectively the change of the reluctance torque of the machine by the stator current in the *d*-axis. The experimental tests confirmed the correctness of simulation research.

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