Finite Element Modeling of Five Phase Brushless Motor for High Power Density Application

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Introduction: COMSOL multiphysics is used in predicting the output of a five phase Brushless DC motor. The software is found to be reliable where the simulation helped in predicting the flux path, magnetic flux density, back emf generated and in computing the torque before fabrication and hence exploring the advantage of a multiphase topology.

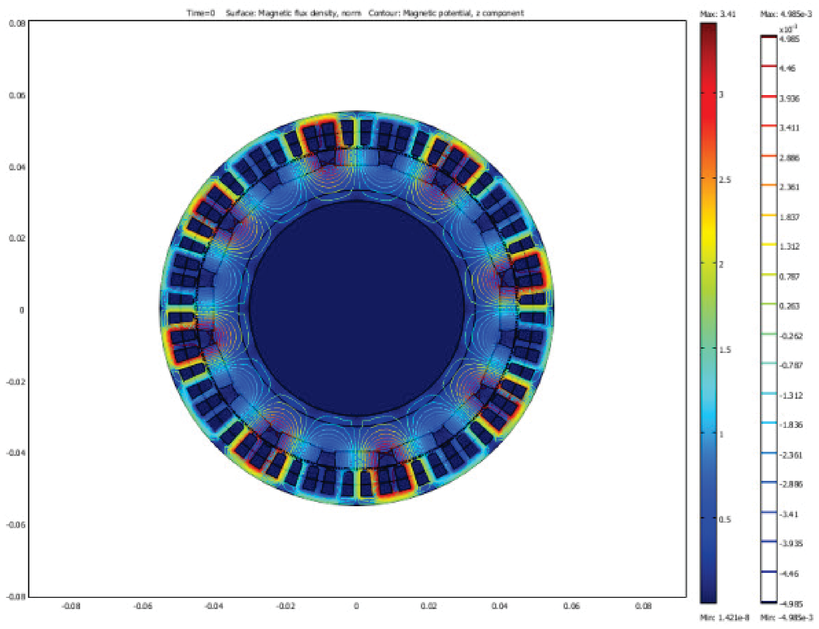

Figure 1. flux distribution

Computational Methods: The FEM of motor is modeled within the AC/DC module, rotating machinery. The stator contains the five phase windings . The rotor consists of the permanent magnets . The material properties of both stator and rotor are given through the subdomain settings. The flux density in the airgap, back emf generated, torque are computed in the analysis. The emf generated is solved by:

$$V_i = NN \sum_{windings} \frac{L}{A} \int E_z \, dA$$

The model of the meshed motor is shown below.

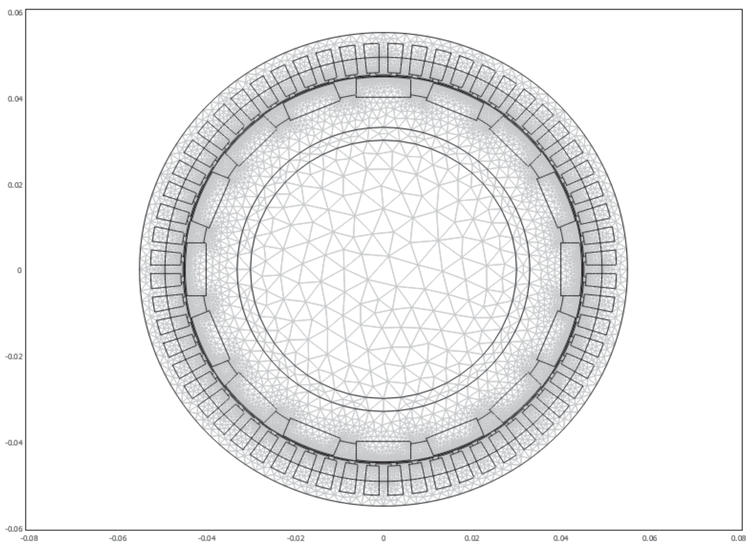

Figure 2. meshed 2D model of proposed five phase motor

Results: The simulation is carried out in order to study the performance of the proposed five phase motor . This helps in understanding whether the design could meet the requirements. The simulated waveforms are shown as below

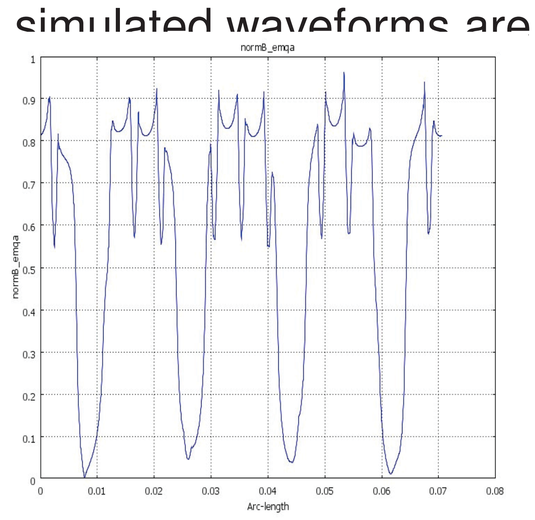

Figure 3. Airgap flux density

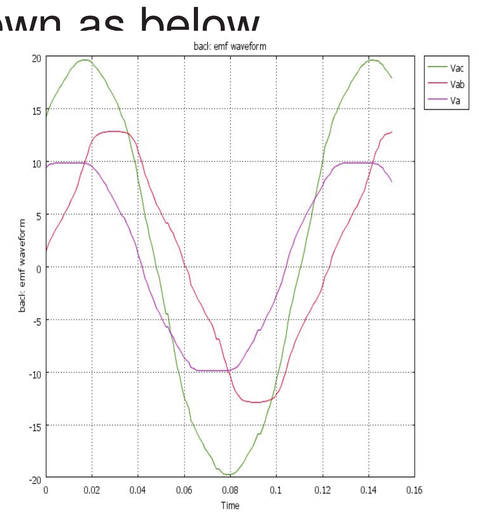

Figure 4. comparison of voltages

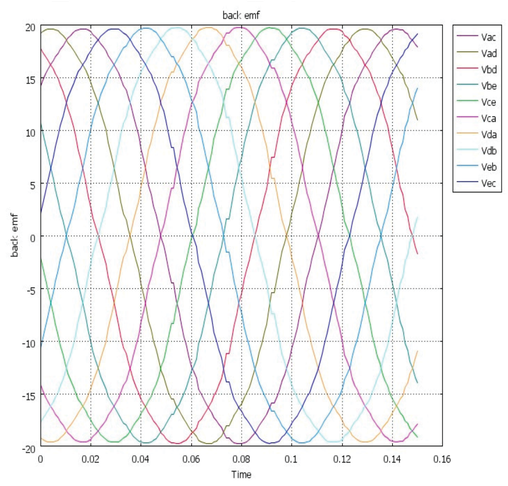

Figure 5. 5ϕ voltage waveform

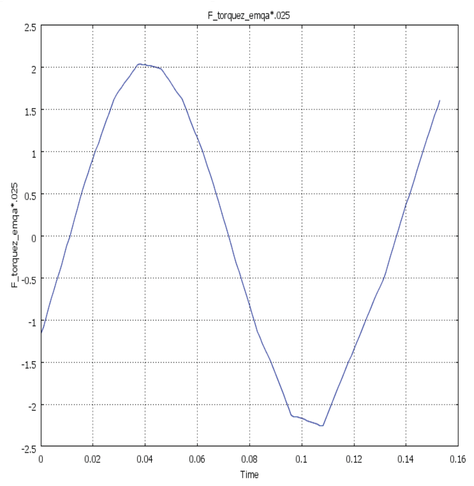

Figure 6. torque

Conclusions: From figure1 and figure 6, the airgap flux density and torque wave is studied. Figure 5,It can be seen that the ripple amplitude has reduced and the frequency of pulsation has increased. Figure 2, it is seen that the voltage across adjacent and non adjacent phases are different. These reveals the characteristics of a multiphase topology.

References:

[1] Marco Villani, Marco Tursini, Giuseppe Fabri, and Luca Castellini, High Reliability Permanent Magnet Brushless Motor Drive for Aircraft application", *IEEE transactions on industrial electronics,* vol. 59, no. 5, May 2012.

[2] M. Villani, M. Tursini, G. Fabri, L. Castellini," Fault-Tolerant PM Brushless DC Drive for Aerospace Application", XIX International Conference on Electrical Machines - ICEM 2010, Rome.

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