

# Airgap Force Control in Direct Drive Generator

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## Research Aim

- Advance the understanding of armature reaction control in generator.
- Explore the structural and electromagnetic forces in airgap and parameters influencing them.
- Analyse the idea of having modular stators.
- Develop a model to achieve armature reaction control locally and globally throughout the airgap, validate it in FEA platforms and finally by building a prototype.

## Methodology

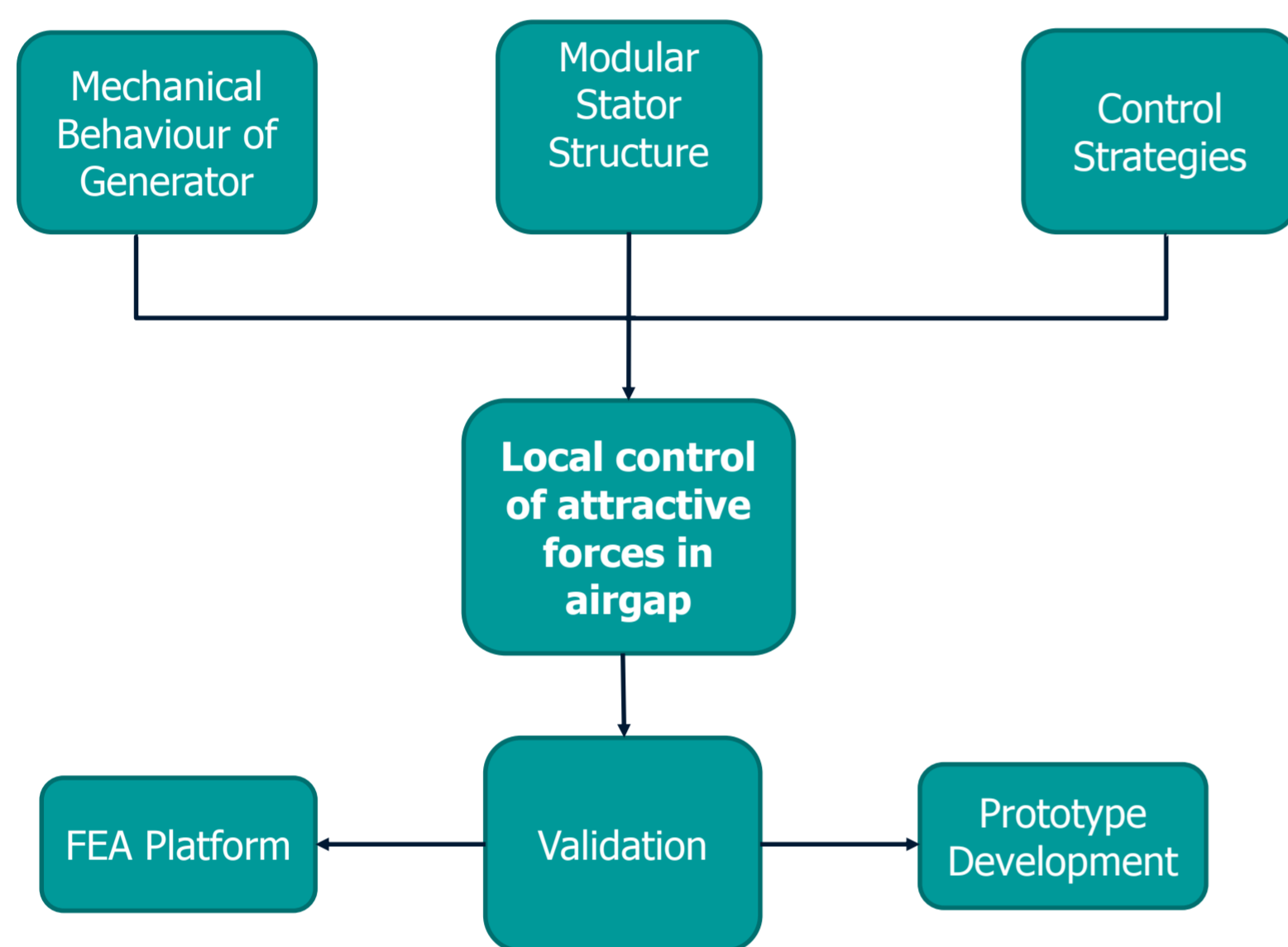


Figure 1: Block diagram of general methodology

The number of modular current carrying parts depends on the number of degree of freedom of deformation we want to deal with and the geometry of the machine.

## Theory

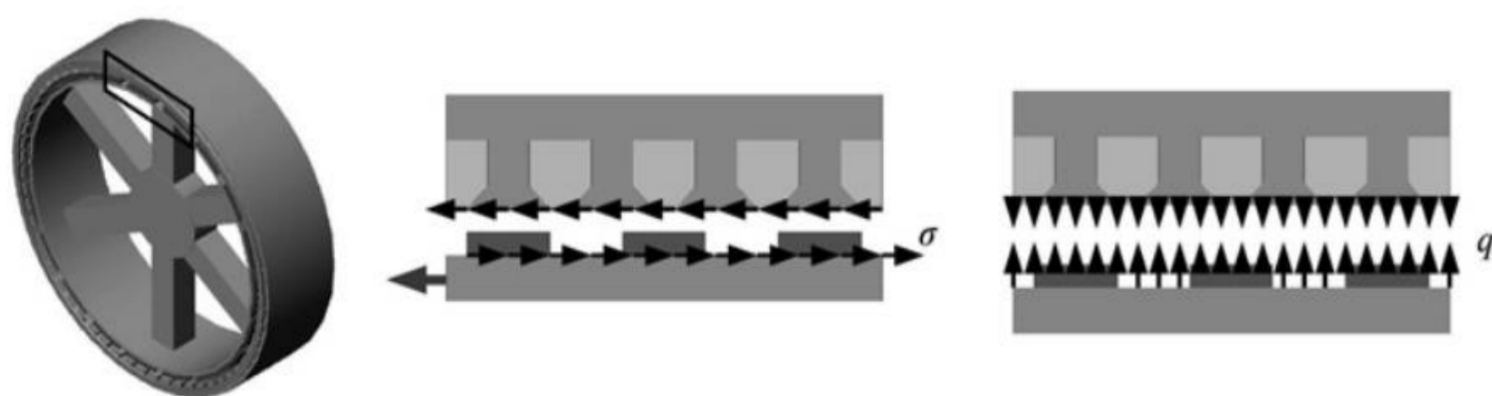


Figure 2: Radial flux machine, a generic section of stator and rotor with shear stress,  $\sigma$  and normal stress,  $q$ .

The electromagnetic forces in air gap can be derived for the normal component of Maxwell equation.

$$F_a = \frac{B^2 A}{2\mu_0}$$

Where  $B$  is the magnetic flux density in the air gap,  $A$  is the above surface area  $\mu_0$  is the permeability of vacuum.

## Machine Modelling

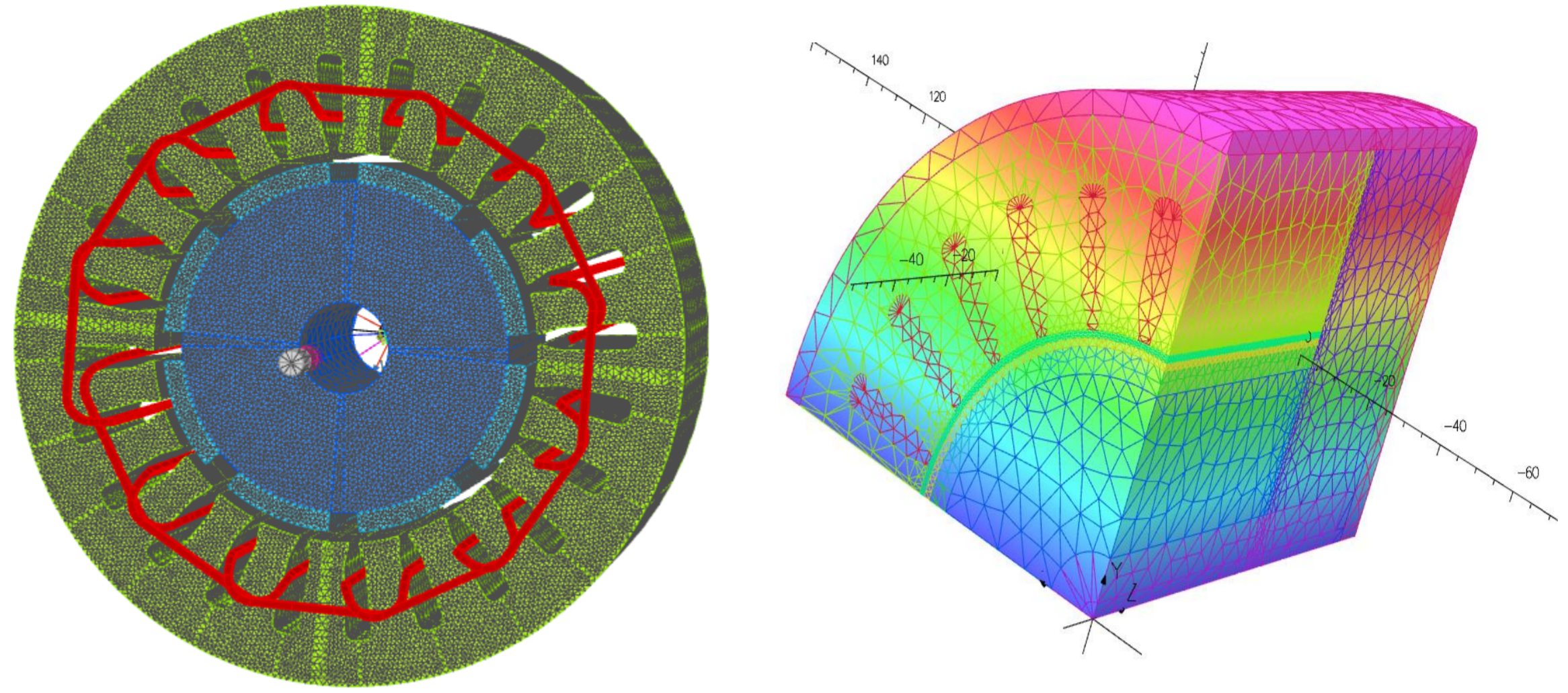


Figure 3: Modelling sample Generator and analysis of its symmetrical section in FEA software

## Results

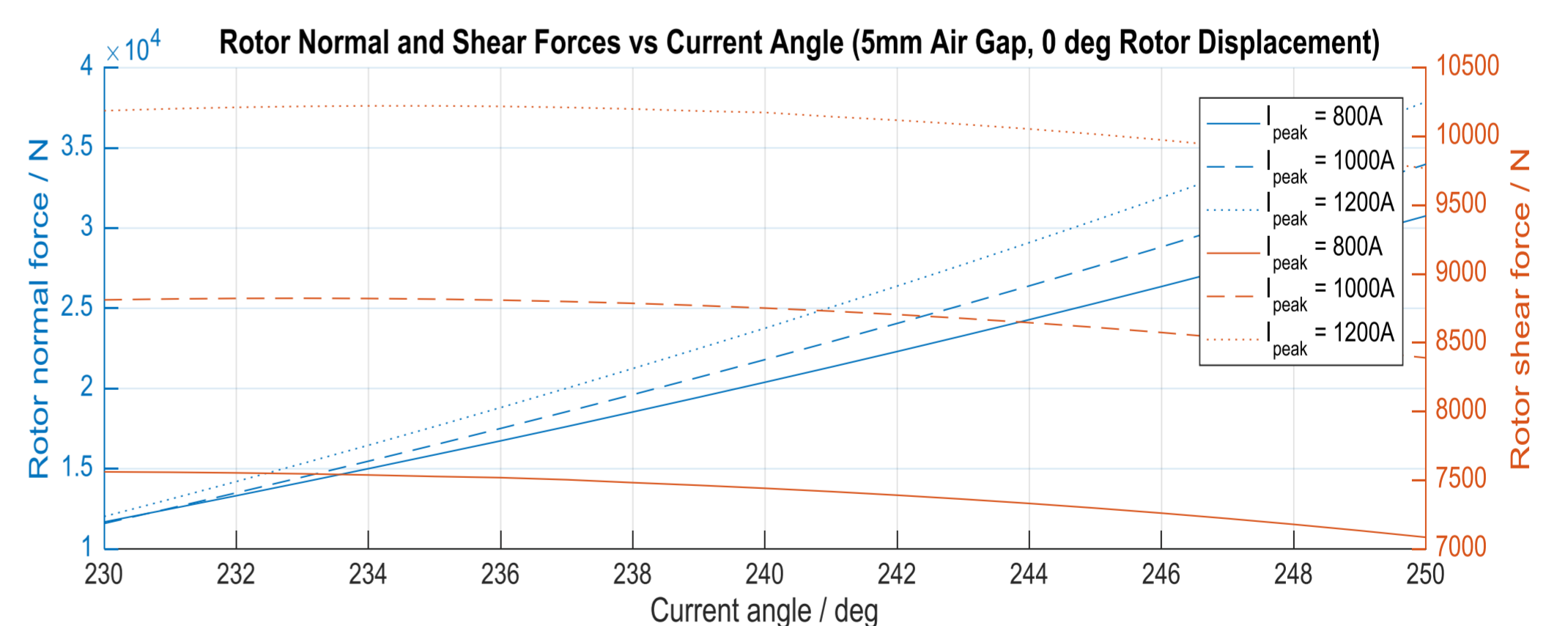
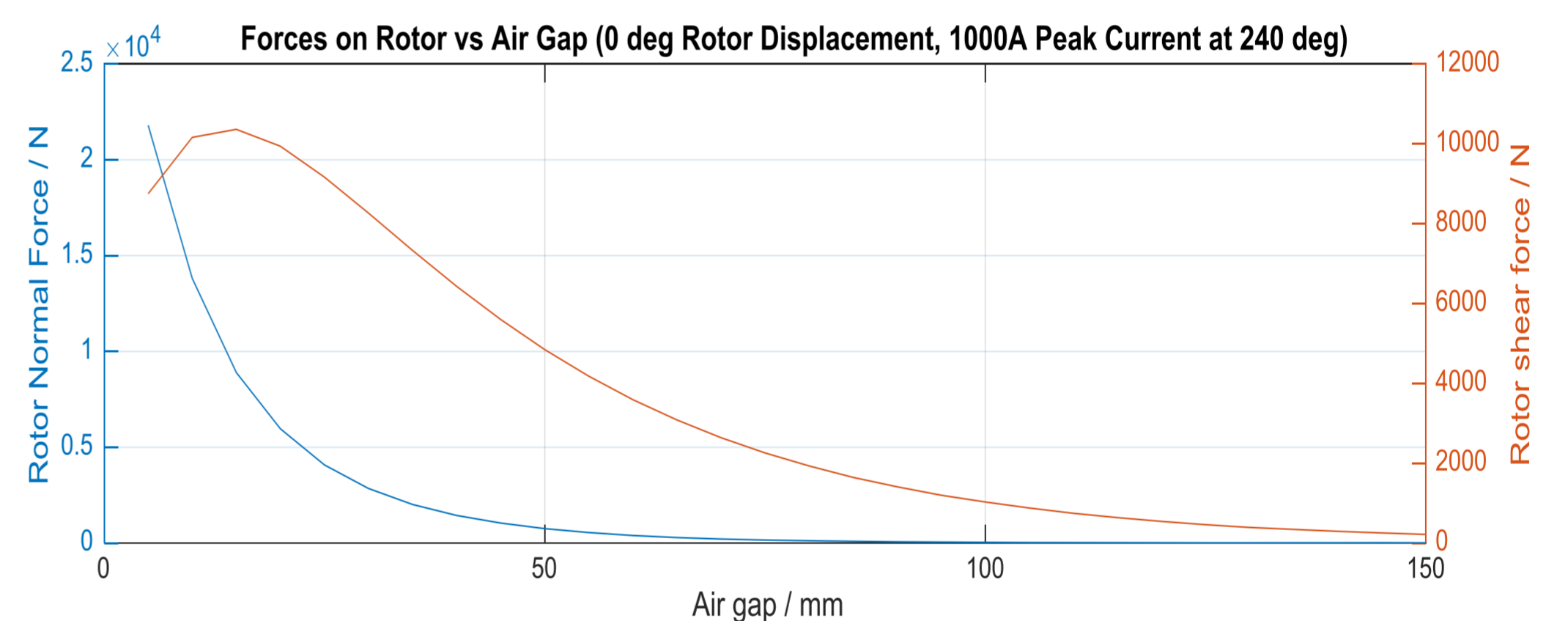


Figure 4: Variation of airgap forces with airgap distance and phase angle in stator windings for a pole pair section of machine

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- [1] M. Scuoto, H. Polinder, and M. Huizer. Modelling and controlling attractive forces in permanent magnet machines. In International Conference on Electrical Machines, Chania, Greece, 2006.
- [2] A. McDonald, M. Mueller and H. Polinder, "Structural mass in direct-drive permanent magnet electrical generators," IET Renewable Power Generation, Vol. 2, no. 1, pp. 3-15, March(2008)
- [3] Jaen-Sola, P. and A. S. McDonald. "Structural analysis and characterization of radial flux PM generators for direct-drive wind turbines." Renewable Power Generation Conference (RPG 2014), 3rd. IET, 2014.