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3-D computation and analysis of magnetic field in the end-region of turbo-generators

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Abstract— This paper presents a 3D finite element model of the end region of a large turbo-generator. The analysis focuses on the axial magnetic field distribution, and its sources. This axial component may cause severe deterioration of the stator core (insulation breakdown, overheating).

I. INTRODUCTION

The edge effects in the large turbo-generators end-region induce high electrical, thermal and vibratory stresses that cause aging and deterioration of the stator core. In particular, the magnetic field includes an axial component that in comes transversely to front part laminations. It causes in-plane eddy currents, inter-lamination voltages, additional losses, overheating and hot points. The analysis of the field in this region aims at analyzing the behavior of the field with regard to the operating conditions, and then preventing deterioration.

The behavior of magnetic field in the end-regions is complex and 3-dimensionnal [1]: the axial component of the magnetic field comes mainly from the air-gap fringing across the core end and from the stator and rotor end-winding currents [2]. Moreover, the geometry of the stator end region is very complex (Fig. 1) and meshing laminated materials (and skin effect) raises well-known problems.

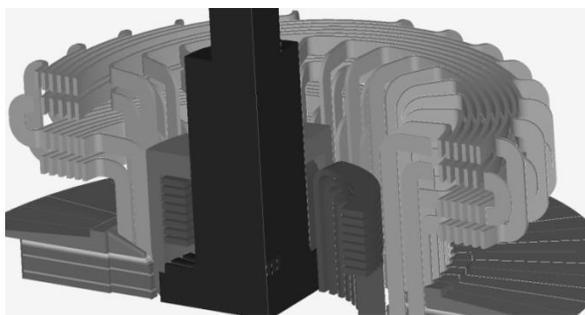


Fig. 1. Finite element model of the 125 MW turbo-generator end-region.

II. FINITE ELEMENT MODEL

The Finite Elements method simulations are run with code_Carmel3D which is based on Whitney's elements and is developed by the LAMEL (common laboratory between EDF R&D and L2EP).

The end region of an actual 125 MW turbo-generator has been fully modeled and meshed, including:

- the steps of the stator core and the wedge notches (the tooth slits are neglected)
- partially: the stator segments with regard to their lamination direction, the butt-joints between segments and the staggering between layers

- the actual stator and rotor end-windings geometry
- the press fingers, cooling ducts, frames.

This led to a heavy mesh, with 60 stator inductors and 16 rotor inductors. The simulations are linear, and the laminated core is taken into account using anisotropic (homogenized) domains: the permeabilities are function of the three directions. Rough typical values are $\mu_{\text{lam}} = 30,000$ in the lamination direction, $\mu_{\perp\text{lam}} = 3,000$ perpendicular to the lamination direction and $\mu_{\text{trans}} = 30$ transverse to the sheets. The transverse conductivity is arbitrary chosen so that $\sigma_{\text{trans}} \ll \sigma$ (e.g. $\sigma_{\text{trans}} = 100$ S/m), the actual value does not have a major impact.

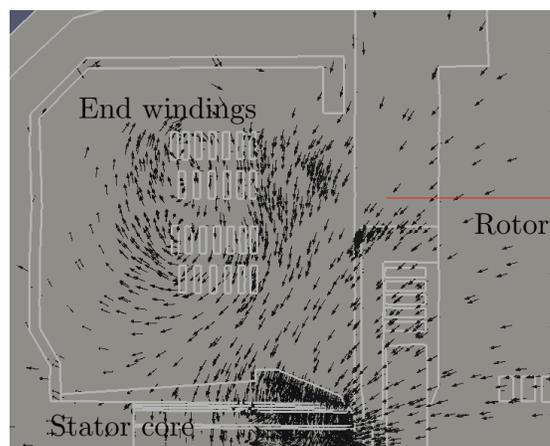


Fig. 2. \mathbf{H} field map in the end-region of the turbo-generator (cf. figure 1).

III. RESULTS

In Fig. 2, the magnetic excitation \mathbf{H} is shown on a cut plane (with imposed currents through the stator bars only, and fixed rotor), the incoming transverse field may be observed upon the end laminations.

In the full version, its distribution in the whole end-region, including the penetration in the first laminations, will be analyzed carefully. Notably, some teeth carry higher magnetic flux (over one period) than others. The relative influence of each source of axial component (end windings, air fringing) will be evaluated.

IV. REFERENCES

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