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Influence of the magnetic anisotropy on electrical machines

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Abstract **– Non grain-oriented electrical steel has an inherent anisotropy, which is normally neglected in the calculation of electrical machines. Moreover, the magnetic anisotropy is usually measured in small material samples. Due to the cutting effect, the magnetic anisotropy in the machine is not the same as in the sample. In this paper, the magnetic anisotropy is considered as a global problem. A measurement method is presented and its influence on the electromagnetic and mechanical behavior is considered through the example of an induction motor.**

Introduction

Non grain-oriented electrical steel and hence electrical machines have an inherent anisotropy due to the variation of the magnetic properties in rolling and perpendicular to rolling direction. Moreover, the cutting process has a different influence in these two directions. Therefore, the standard procedure of measurement of the anisotropy in samples of the material [1] and not directly in the machine is not appropriate for a detailed study. The influence of the anisotropy in the magnetic losses of the machine has already been widely studied [2]. But the anisotropy acts also like an eccentricity with double periodicity and, therefore, generates harmonics in the air gap, which influence the torque and the radial force on the stator i.e. the acoustic behavior of the machine. These effects have been treated only briefly in the literature [2][3]. This paper presents a global view on the problematic of the magnetic anisotropy. A test setup to measure the anisotropy directly on the stator of the machine is presented. Measurements are conducted in an induction motor. The influence in the electromagnetic and mechanical behavior of the machine is studied analytically and through FE simulation.

Test setup and measurements

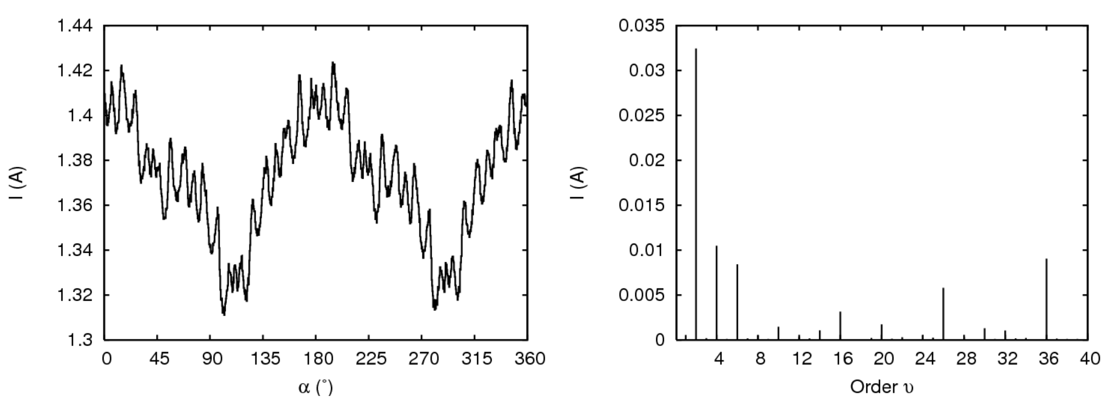

Fig.1 Measurement of the magnetic anisotropy in space and frequency domain.

A variation of the differential method presented in [4] is used here to measure the magnetic anisotropy of the stator of an induction motor. A 2-pole rotor is built, so that the magnetic flux flows in and out the stator through teeth with the same angle to the rolling direction. The rotor is driven by a stepper motor at $0.025s^{-1}$ and the magnetic anisotropy is measured through the change of the current in the rotor winding, which is fed with a constant 50-Hz voltage. This frequency component is filtered on-line in order to acquire only the changes in the rms of the current. Fig. 1 shows the measurement in space and frequency domain for a stator with 36 stator slot and 26 cutting notch. These both orders appear clearly in the measurement but they do not mask the 2^{nd} order, which corresponds to the magnetic anisotropy. For α=0° the rotor is aligned with the rolling direction, where the magnetic resistance is minimal. Then the inductivity of the rotor winding is also minimal and, therefore, the current is maximal.

Electromagnetic and mechanical simulation

The influence of the anisotropy in the electromagnetic behavior of the machine is studied analytically and through FE simulation. The results of the electromagnetic simulation are used together with an analytical mechanical model for the study of the deformation in the machine. Figure 2 shows the torque and the deformation of the stator of the machine. The magnetic anisotropy has a significant influence in both cases.

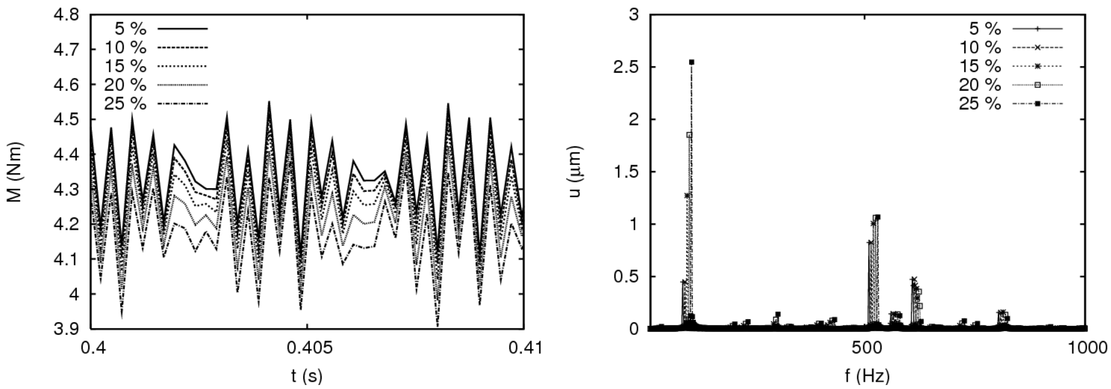

Fig.2 Torque and deformation of the induction machine for different values of the magnetic anisotropy.

Conclusions

This paper has shown that the magnetic anisotropy of non grain-oriented electrical steel has an influence in the electromagnetic and acoustic behavior of an induction machine, although this effect is normally neglected. Furthermore, a test procedure is presented to measure the magnetic anisotropy directly in the stator of the machine. Further and detailed measurements and results will be presented in the full paper.

References

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