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Effect of the eccentricity in the field computation of induction machine by finite element method

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***Abstract*—The aim of this work is to investigate the effect of eccentricity faults on electromagnetic parameters of Asynchronous machine. The model based on finite element (EF) calculation of the field in an induction machine tells us clearly and extensively on the evolution of the field at the air gap. Knowing that changing the thickness of the air gap (eccentricity) may possibly is caused after a certain period of operation of the machinery during the manufacturing processes. Specifically, we consider the analysis of the results the magnetic vector potential. The results obtained by the simulation clearly show the change of that magnitude as the balance of the rotor, either horizontally, vertically or both.**

***Keywords*—Induction machine, modelisation, eccentricity, finite element, simulation**

INTRODUCTION

Induction motors are the most widely used in industry because of their rugged configuration, low cost, and versatility, natural ageing processes and other factors in practical applications, induction motors are subject to various faults, such as rotor faults. These faults can be induced by electrical failures such as the defect or breakage the bar or mechanical failures such as rotor eccentricity. The displacement effect of the rotor (eccentricity) directly affects the course of the magnetic flux (magnetic reluctance) [1]. According to the model developed in this work, we could introduce and study the consequences of the eccentricity phenomenon on the magnetic quantities of the machine through the magnetic vector potential. The complexity related to the spatial distribution of local forces [2] to calculate a resultant force has been surmounted due to the flexibility of our program allows us to consider the effect of changing the rotor position by adjusting its coordinates in the program.

In the following sections, we consider the development of the model and the magnetic vector potential formulation. Then, we present the simulation results and their interpretations.

MODEL OF INDUCTION MACHINE

To determine the field distribution at each time-step, a two dimensional transverse section spanning a pole pitch of the induction motor is represented. In reducing the problem to two dimensions. The transient magnetic field in terms of magnetic vector potential, A, the permeability of air, $\mu_0(4.\pi.10^{-7}\ H/m)$, conductivity, σ, and current density, J_s, can be expressed as [3]:

$$\sigma\cdot\frac{\partial A}{\partial t}+curl\left(\frac{1}{\mu_0}\cdot curl(A)\right)=J_s \tag{1}$$

The constitutive linear relationship of ferromagnetic material is:

$$B=\mu_r\cdot H \tag{2}$$

Where

B: flux density;

H: magnetic field;

μ_r:permeability relative.

To solve the general diffusion equation (1) a classical weighted residual method with first order shape functions we obtain the following integral form [4]:

$$\iint_\Omega \omega_i\cdot\left[(curl(curlA))+\mu_0\cdot\sigma\left(\frac{\partial A}{\partial t}\right)\right]d\Omega=\iint_\Omega \omega_i\,\mu_0\cdot\vec{J_s}\,d\Omega \tag{3}$$

ω_i : ponduration function.

With the following linear approximation for the vector potential:

$$A=\sum\omega_i\,.A_i \tag{4}$$

Then, we obtain the following algebraic form:

$$[K]\cdot\left[\frac{\partial A}{\partial t}\right]+[M]\cdot[A]=[F] \tag{5}$$

$$\begin{cases} K_{ij}=\iint_\Omega \sigma\,\mu_0\,\omega_i\,\omega_j\,d\Omega \\ M_{ij}=\iint_\Omega\left(\frac{\partial\omega_i}{\partial x}\cdot\frac{\partial\omega_j}{\partial x}+\frac{\partial\omega_i}{\partial y}\cdot\frac{\partial\omega_j}{\partial y}\right) \\ F_i=\iint_\Omega \omega_i\cdot\mu_0\cdot J_s\cdot d\Omega \end{cases} \tag{6}$$

SIMULATION AND RESULTS

The purpose of this investigation is to use the finite element model [5,6] described above to evaluate the effects of rotor eccentricity on the air gap vector potential magnetic.
The Figure.1 shows the geometry of the induction machine with four poles, 36 slots in the stator and 32 rotor bars.

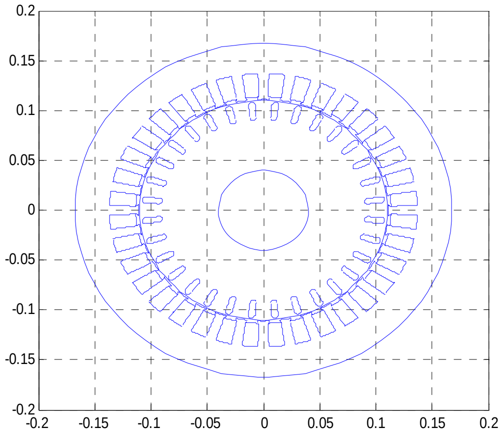


Figure 1. Induction machine geometry.

The discretization of the geometry with finite element is shown in Figure 2.

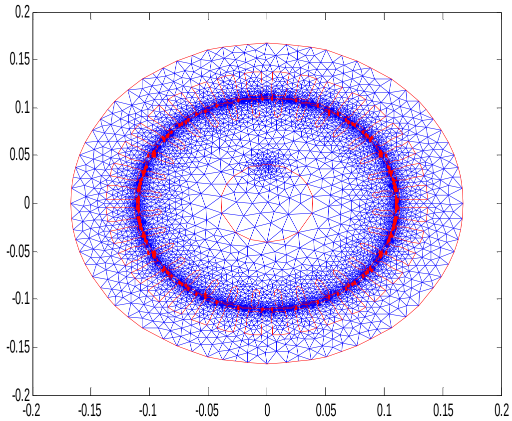


Figure 2. Grid of the domain.

The equipotential of potential vector magnetic is shown by the figure.3.

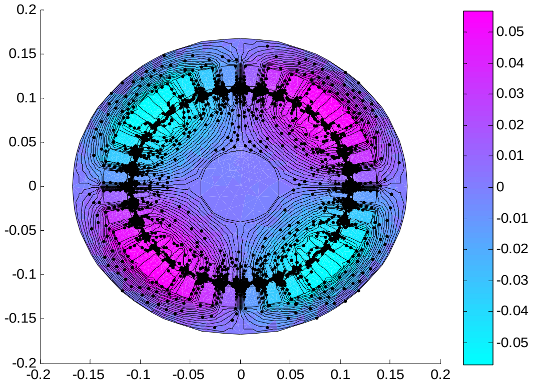


Figure 3. Equipotentiel of potential vector magnetic.

The figure.4 shows the spatial of potential vector magnetic of each element of the geometry.

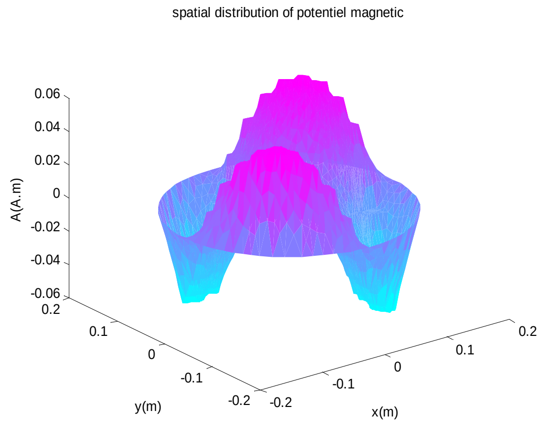
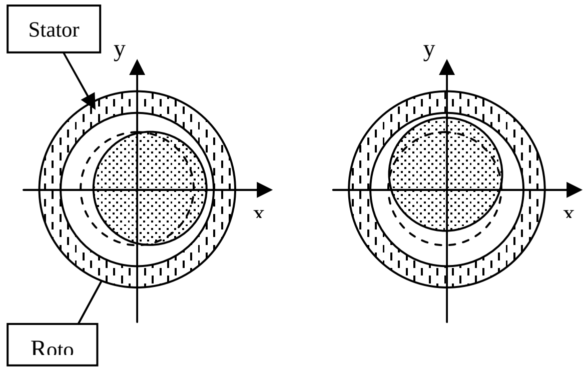


Figure .4. Spatial distribution of potential

- Statement of the Problem



a- balanced of the rotor along x axis.

b- balanced of the rotor along y axis.

Figure.5. Schema explicative.

Our study, is to see the evolution of magnetic variable (magnetic vector potential) along the axis of movement (x and y) of the rotor for 25% of the value of the gap. Comparing the simulation results in the default case (with eccentricity) with those of the healthy case, we can see the impact of eccentricity on the magnetic quantity of the machine.

The displacement of the rotor (eccentricity) affects directly the course of the magnetic flux [7,8], essentially in the airgap. So, the figure.6 show the spatial distribution of potential vector magnetic only in the airgap.

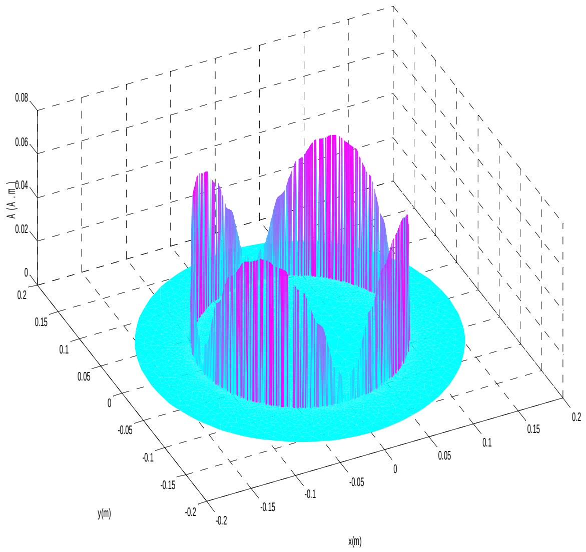


Figure 6. Spatial distribution of potential in the airgap

The projection of the spatial distribution of magnetic vector potential presented in Figure.6 on the plane (zx) in the healthy case, is presented by figure.7.

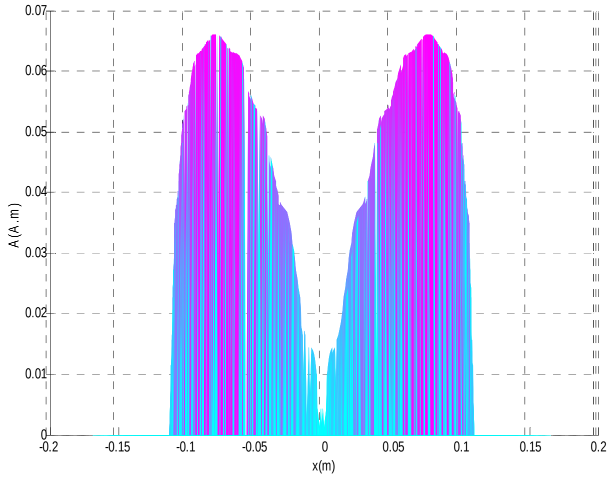


Figure.7. Potential vector (healthy case)

The figures of potential vector magnetic with balanced of the rotor (with fault) in the x and y axis is show by figure.8 and figure.9 respectively.

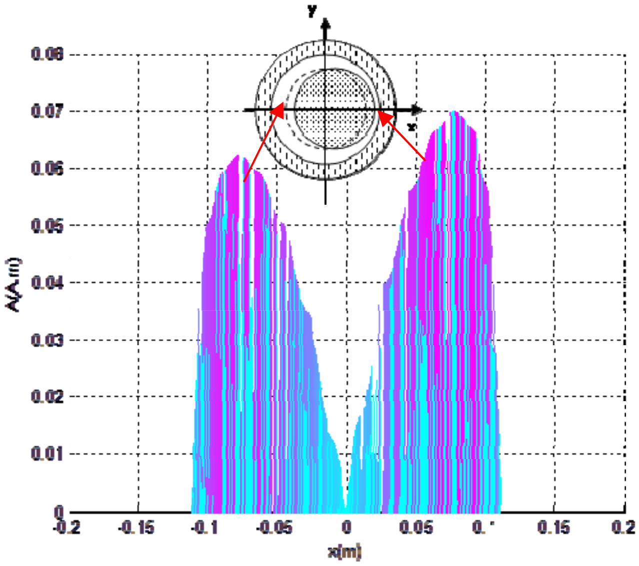


Figure.8. Potential vector along the x axis

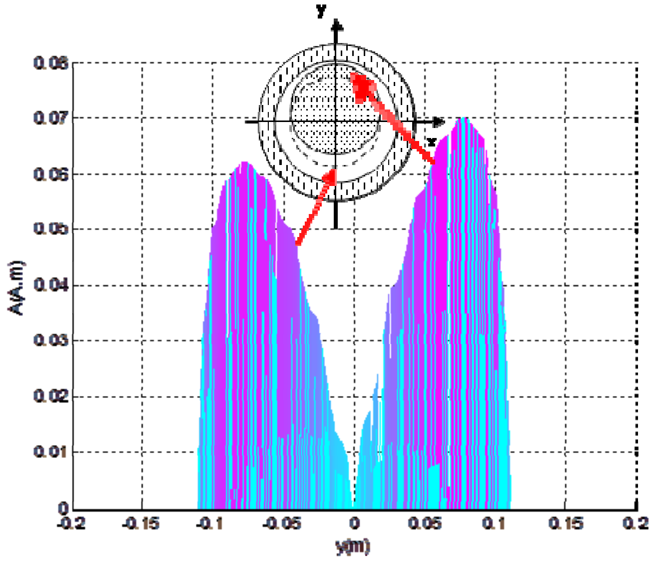


Figure.9. Potential vector along the y axis

The change in the position of the rotor (eccentricity) occurs with the change of magnetic reluctance. Indeed, when the air gap reduces, so, the magnetic reluctance also reduces, therefore the amplitude of the magnetic vector potential increases. By against, when the air gap increases we see the opposite effect.

CONCLUSION

The results of simulations enables us to introduce and clearly see the impact of eccentricity on the magnetic behavior of the machine (magnetic vector potential) for two cases of the rotor position change of 25% from its initial position, as according to x-axis (Figure.8) and to the y axis (Figure.9). These are compared to the healthy case (Figure.7) of induction machine.

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