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The Aeolian Asynchronous Generator

The production of the electric energy with lower costs could be realized with the help of the aeolian electric central. In these centrals we can use the squirrel cage asynchronous generators, because these machines are the most safety in function and easy exploited. This work show the function analyzing of the asynchronous generator having on involving torque depending on the square wind speed, the air-density and on the construction of the wing spiral.

Keywords: *asynchronous generator, orthogonal model, transient regime, involving torque, function characteristic.*

1. Introduction

The function analyzing of asynchronous generator is made using the two axes theory, in which the machine equations are written according with the time, the electrical parameters being steady.

In the two axes theory, the three phase asynchronous machine is equivalent with an asynchronous machine having the statorical and the rotorical windings disposed in "*d, q*" electrical quadrature system, figure 1.

The equivalent machine has the same electromagnetic torque, the same electromagnetic power changed at the terminal with the supply every moment.

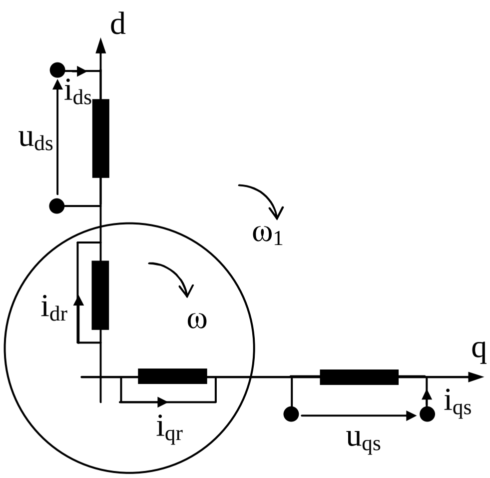

Figure1. The asynchronous machine in orthogonal model for the generator regime

2. The mathematical model

We are considering the reference system "*d, q*" axes from the two axes theory fixed against the spinning magnetic field of the stator, which rotated with angular speed ω_1.

In this condition and for the asynchronous generator regime with squirrel cage rotor, the equations for the stator and the rotor are the following:

$$\begin{aligned} u_{ds} &= -R_1 i_{ds} - \frac{d\psi_{ds}}{dt} + \omega_1 \psi_{qs} \\ u_{qs} &= -R_1 i_{qs} - \frac{d\psi_{qs}}{dt} - \omega_1 \psi_{ds} \\ 0 &= R_2 i_{dr} + \frac{d\psi_{dr}}{dt} - (\omega_1 - \omega)\psi_{qr} \\ 0 &= R_2 i_{qr} + \frac{d\psi_{qr}}{dt} + (\omega_1 - \omega)\psi_{dr} \end{aligned} \qquad (1)$$

where the magnetic flows of the rotor are the following:

$$\begin{aligned}\psi_{ds} &= L_{1\sigma} i_{ds} + L_{1h}\left(i_{ds} + i_{dr}\right)\\ \psi_{qs} &= L_{1\sigma} i_{qs} + L_{1h}\left(i_{qs} + i_{qr}\right)\\ \psi_{dr} &= L_{2\sigma} i_{dr} + L_{1h}\left(i_{ds} + i_{dr}\right)\\ \psi_{qr} &= L_{2\sigma} i_{qr} + L_{1h}\left(i_{qs} + i_{qr}\right)\end{aligned} \qquad (2)$$

The electric parameters involved into (1) and (2) equations are the following: R_1 - the resistance of the stator phase; R_2 -the resistance of the rotor phase reduced at the stator; $L_{1\sigma}$ -the dispersion inductivity of the stator phase; $L_{2\sigma}$ -the dispersion inductivity of the rotor phase reduced at the stator; L_{1h} - the main inductivity; ω_1, ω - the angular speed of the magnetic field of the stator, and of the rotor.

At the relation (1) we are adding the movement equation:

$$M + M_m = \frac{J}{p}\frac{d\omega}{dt} \qquad (3)$$

where the electromagnetic torque is:

$$M = pL_{1h}\left(i_{qs} i_{dr} - i_{ds} i_{qr}\right) \qquad (4)$$

and M_m represents the involving torque whick can be express by the relation (3):

$$M_m = \frac{1}{2}\rho\pi R^3 v^2 C_M \qquad (5)$$

In relations (5), ρ is the air density depending on the environment temperature, R is the length of the wing spiral, v is the air speed, C_M is the torque factor.

Therefore the mathematical model which defines the asynchronous machine function in generator regime is:

$$u_{qs} = -R_1 i_{qs} - L_{1\sigma}\frac{di_{qs}}{dt} - L_{1h}\left(\frac{di_{qs}}{dt} + \frac{di_{qr}}{dt}\right) - \omega_1\left[L_{1\sigma} i_{ds} + L_{1h}\left(i_{ds} + i_{dr}\right)\right]$$

$$0 = R_1 i_{dr} + L_{2\sigma}\frac{di_{dr}}{dt} + L_{1h}\left(\frac{di_{ds}}{dt} + \frac{di_{dr}}{dt}\right) - (\omega_1 - \omega)\left[L_{2\sigma} i_{qr} + L_{1h}\left(i_{qs} + i_{qr}\right)\right]$$

$$0 = R_2 i_{qr} + L_{2\sigma}\frac{di_{qr}}{dt} + L_{1h}\left(\frac{di_{qs}}{dt} + \frac{di_{qr}}{dt}\right) + (\omega_1 - \omega)\left[L_{2\sigma} i_{dr} + L_{1h}\left(i_{ds} + i_{dr}\right)\right]$$

$$pL_{1h}\left(i_{qs} i_{dr} - i_{ds} i_{qr}\right) + M_m = \frac{J}{p}\frac{d\omega}{dt} \tag{6}$$

With the help of the (6) equations system we can obtain the time variation of $i_{ds}(t)$, $i_{qs}(t)$, $i_{dr}(t)$, $i_{qr}(t)$ şi $\omega(t)$, from where we can determinate the real current of the machine:

$$i = \sqrt{\frac{3}{2}}\left[i_{ds}\cos(\omega_1 t) - i_{qs}\sin(\omega_1 t)\right] \tag{7}$$

3. Case study

For simulation we consider the case of a three-phase squirrel cage induction machine, having a nominal power $P_N = 4\ kW$, nominal rotation $n_N = 1438\ rot / min$ and a nominal supply tension $U = 380\ V$ and a frequency *50 Hz*.

The electric parameters of the machine are:

$R_1 = 1,694\,\Omega$; $R_2 = 1,124$

$L_{1\sigma} = 7,39.10^{-3}\ H$, $L_{2\sigma} = 8,05.10^{-3}\ H$,

$L_{1h} = 0,189\ H$, $J = 0,024\ kg.m^2$

We presume that the asynchronous generator works in parallel with the low-power supply energetic system. For a aeolian electric central having $R = 1$, and a wind speed equal with *4 m/s*, the involving torque $M_m = 16,014\ Nm$.

In fig. 2 are shown the time behavior of the stator current *i*, rotation n and electromagnetic torque *M*, considering the initial speed, the synchronous one.

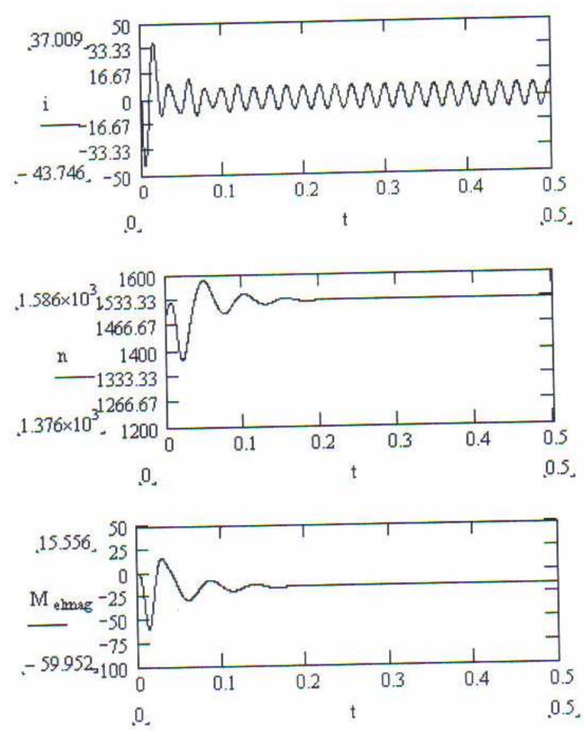

Figure 2. The function behavior for an asynchronous generator

4. Conclusion

The involving torque allow a load for the generator at *5.73 A*. The transient regime is lasting *0.15 s*, the rotation at its low limit is *1376 rot / min*. After the end of the transient regime the rotation remain steady at *1533 rot / min*.

This work wants to be a beginning of the aeolian central with asynchronous machine study, where in addition to generator simulation is necessary the frequency converter simulation.

References

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