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EXPERIMENTAL IDENTIFICATION OF THE IDEAL REGIME AT THE INDUCTION MACHINE

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ABSTRACT

The magnetisation inductance as well as the iron metal looses of the induction machine are experimentally determined by the idle running test of the induction machine or by ideal idle running test. Theoretically by achieving the ideal idle running test, the precision of the looses determination in the iron metal and of the magnetisation inductance is higher than in the case of a real idle running test if the determination precision of the idle running is sufficiently high.

This paper work presents a method of accurate determination of the slipping O for the induction machine linked to a continuous current machine without to be necessary extra elements compared to a classical diagram of ideal idle or loaded running testing of induction machine on a stall equipped with continuous current machine.

KEYWORDS:
Induction machine, ideal regime, experimental identification, inductance

1. INTRODUCTION

The magnetisation inductance as well as the iron metal looses of the induction machine are experimentally determined by the idle running test of the induction machine or by ideal idle running test [1,2]. Theoretically by achieving the ideal idle running test, the precision of the looses determination in the iron metal and of the magnetisation inductance is higher than in the case of a real idle running test if the determination precision of the idle running is sufficiently high. In general is considered that $s = 0$ when the stator current Is minimum but in the slipping range the current is slightly dependent of the slipping, so the experimental detection of the minimum current is affected by the measurement errors.

This disadvantage can be eliminated by linking the machine with a synchronous machine with the same number of poles [3], but in most cases the stalls are equipped with continuous current machines. This paper work presents a method of accurate determination of the slipping O for the induction machine linked to a continuous current machine without to be necessary extra elements compared to a classical diagram of ideal idle or loaded running testing of induction machine on a stall equipped with continuous current machine.

2. THE DESCRIPTION OF THE WORK

In figure 1 is presented a classic diagram of idle running testing.

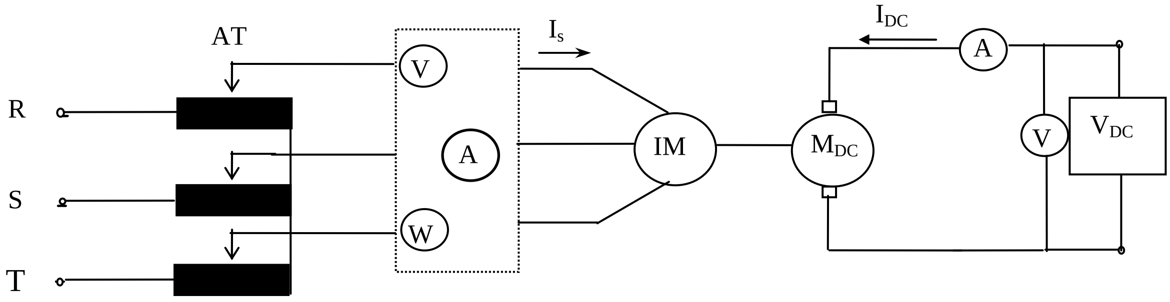

Figure 1 Classical diagram of idle running testing

The continuous voltage source is a variable continuous voltage source having the possibility of a continuous adjustment or in very close steps. (For the experimental determinations within this work, were used two electronic serial connected sources having the possibility of a fine adjustment from 0,1 in 0,1 V until 40 V and I max = 5 A.

The electromagnetic couple expression of the induction machine is:

$$M_I = \frac{pmU_1^2}{\omega_1} \cdot \frac{\frac{R_2^{'}}{s}}{\left(R_1 + C_1\frac{R_2^{'}}{s}\right)^2 + \left(X_1 + C_1X_2^{'}\right)^2}. \quad (1)$$

The expression of the electromagnetic couple for the continuous machine at constant flux is:

$$M_{cc} = k_T \cdot I_{DC} = k_T \frac{U_{cc} - k_e \cdot n}{R_{cc}}. \quad (2)$$

The mechanical equation of the system from figure 1 is:

$$M_I + M_{cc} - M_R = J\frac{d\Omega}{dt}, \quad (3)$$

where M_r - the resistive couple produced by the mechanical looses and by ventilation of the continuous current and induction machine and the equivalent couple in the iron metal from the continuous current machine.

In stationary regime $\frac{d\Omega}{dt}=0$ and so:

$$M_I + M_{cc} = M_R, \tag{4}$$

$$\frac{pmU_1^2}{\omega_1}\cdot\frac{\frac{R_2^{'}}{s}}{\left(R_1+C_1\frac{R_2^{'}}{s}\right)^2+\left(X_1+C_1X_2^{'}\right)^2}+k_T\cdot I_{DC}=M_R \quad ,(5)$$

$$I_{DC}=\frac{1}{k_T}\left[M_R-\frac{pmU_1^2}{\omega_1}\cdot\frac{\frac{R_2^{'}}{s}}{\left(R_1+C_1\frac{R_2^{'}}{s}\right)^2+\left(X_1+C_1X_2^{'}\right)^2}\right]. \tag{6}$$

If the supplying voltage of the induction machine is modified, the couple produced by the induction machine is also modified. The new stationary regime will be decided for another value of the rotation. The modification of the rotation produces the modification of the supplying current of the continuous current machine.

If s = 0 the couple produced by the induction machine is zero indifferent of the supplying voltage and so the modification of the voltages will not produce or a modification of the rotation, and in consequence neither of the current I_{DC} that is a more sensible variable.

The resisting couple is in general dependent of the rotation but considering only small changes of the rotation around the synchronic value, M_r can be neglected, to a better explanation of the method.

If s>0 then $M_I\Big|_{s=ct}=k_I\cdot U^2$. If U increases and M_I will also increase.

As Mr is presumed to be constant, results that I_{cc} decreases. To produce s = 0, the voltage must be increased.

If s<0 then $M_I\Big|_{s=ct}=-k_I\cdot U^2$. If U increases then I_{DC} will increase too.

If at the increasing of U is noticed I_{DC} increasing, results that the supplying voltage must be decreased.

Finally the voltage U_{DC} is settled to a value in such a way that the current I_{DC} to remain constant for a U variation from 0 to U_N.

For a determined value of U_{DC} is experimented the ideal idle running testing.

The method is particularly sensitive. If during the testing, are noticed: modifications of the current I_{DC} caused by the slipping changing as a result of the network frequency variations and continuous current heating of U_{DC} time variations (because of the heating or other reasons), then U_{DC} is registered in such a way that for high variations of U, I_{DC} to remain constant.

3. THE DESCRIPTION OF THE EXPERIMENTAL EQUIPMENT USED

For the measurements were used the following machines:

Synchronous machine: P = 1,1kW; U_N = 220/380V; Y/Δ: 4,82/2,77; $n_N = 1410\frac{\text{rot}}{\text{min}}$.

Continuous current machine with permanent magnet having: $n_{max} = 2000\frac{\text{rot}}{\text{min}}$; U_{max} = 118V; C_p = 180N·m; I_p = 321A; I_N = 36,2A; k_E = 0,56V·s/rad.

Supplying current sources 40V/5Ax2, the accuracy adjustment is 0,1V and a adjustable auto transformer.

4. EXPERIMENTAL RESULTS

As a result of the experimental testing resulted the following characteristics:

$I_{gol} = f(U)$; $P_{Fe} = f(U)$; $L_m = f(\psi_1)$

The approximate value of f(x) as a sum of exponential values:

$$L_{1m} = C_0 + \sum_{i=1}^{5} C_i e^{-2\cdot i\Psi_{1m}^2} . \tag{7}$$

5. THE SENSIBILITY OF THE METHOD COMPARED WITH THE IS MINIMUM METHOD

$$s_{ds} = \frac{\partial I_{DC}}{\partial s} = -\frac{1}{k_T}\cdot\frac{pmU_1}{\omega_1}\cdot\frac{-\frac{R_2'}{s}\left[\left(R_1 + C\frac{R_2'}{s}\right)^2 + \left(X_1 + CX_2'\right)^2\right] - \frac{R_2'}{s}\cdot 2\left(R_1 + C\frac{R_2'}{s}\right)\cdot C\cdot\left(-\frac{R_2'}{s^2}\right)}{\left[\left(R_1 + C\frac{R_2'}{s}\right)^2 + \left(X_1 + CX_2'\right)^2\right]^2} =$$

$$= \frac{1}{k_T}\cdot\frac{pmU_1}{\omega_1}\cdot\frac{\frac{R_2'}{s^2}\cdot\left\{\left[\left(R_1 + C\frac{R_2'}{s}\right)^2 + \left(X_1 + CX_2'\right)^2\right] + 2\frac{R_2'}{s}\left(R_1 + C\frac{R_2'}{s}\right)\cdot C\right\}}{\left[\left(R_1 + C\frac{R_2'}{s}\right)^2 + \left(X_1 + CX_2'\right)^2\right]^2} \tag{8}$$

$$I_{SAC} = \frac{U_1}{\sqrt{\left(R_1 + C\frac{R_2^{'}}{s}\right)^2 + \left(X_1 + CX_2^{'}\right)^2}}, \tag{9}$$

$$S_{I_{SAC}} = \frac{\partial I_{SAC}}{\partial s} = -\frac{U_1 \cdot \left[\left(R_1 + C\frac{R_2^{'}}{s}\right)^2 + \left(X_1 + CX_2^{'}\right)^2\right]^{-\frac{1}{2}} \cdot \frac{1}{2} \cdot 2\left(R_1 + C\frac{R_2^{'}}{s}\right) \cdot C \cdot \left(-\frac{R_2^{'}}{s^2}\right)}{\left(R_1 + C\frac{R_2^{'}}{s}\right)^2 + \left(X_1 + CX_2^{'}\right)^2} =$$

$$= \frac{U_1 \cdot \left(R_1 + C\frac{R_2^{'}}{s}\right)^2 \cdot \frac{R_2^{'}}{s^2}}{\left[\left(R_1 + C\frac{R_2^{'}}{s}\right)^2 + \left(X_1 + CX_2^{'}\right)^2\right]^{-\frac{3}{2}}} \tag{10}$$

$$I_{DC} = f(s)$$

$$I_{SAC} = f(s)$$

To compare is calculated:

$$s_{I_{DC}}[\%] = \frac{\partial I_{ds}}{\partial s} \cdot \frac{1}{I_{ds0}} \cdot 100,$$

$$s_{I_{SAC}}[\%] = \frac{\partial I_s}{\partial s} \cdot \frac{1}{I_{s\,min}} \cdot 100.$$

It is noticed that the invariable method of I_{DC} is $\dfrac{\frac{\partial I_{ds}}{\partial s} \cdot \frac{I_{s\,min}}{I_{dso}}}{\frac{\partial I_s}{\partial s}}$, more sensible than the minimum current determination method.

6. CONCLUSIONS

It was founded a analytical experimental relation for $L_m = f(\psi_m)$, a more specific separation of the iron metal looses.

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