FIELD ORIENTED CONTROL
OF A TWO PHASE INDUCTION MOTOR

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Abstract. In this paper we will simulate the operation of a two-phase induction machine with a relation interlock after the rotoric field orientation principle, taking into account the highlightening of de main aspects characteristic to these system, problems that may occur during the simulation and also the multiple possibilities that the Matlab-SIMULINK simulation can provide.

Key words: two-phase induction machine, two-phase model, field oriented control.

INTRODUCTION

The specific problems that the induction machine can rise, especially a two-phase induction machine (MAB), in the operation systems with rotation interlock which must be adapted to the characteristics of the induction machine, and on the other hand to the structure and the construction of the supply source, respectively to the frequency static convector.

The interlock with orientation after the field principle appeared from the necessity to simplify the operating of the d.c. machines. The appliance of this principle enable the easy control of the electromagnetic torque with high performances, subsequently, a short answering period, without oscillations.

But, the main advantage of the control application after the orientation after the field principle, consists of the control isolation of the magnetic values from the mechanical ones. The magnetic flux direction is the one which determines the two components of the statoric current supply, namely the active component attached to the mechanical phenomena and the reactive component attached to the electromagnetic phenomena. The separated control of the two components of the current implies the separation of the mechanical phenomena control from the magnetic one.

In this paper we will simulate the operation of a complete system of the relation interlock according to the orientation after the rotoric field principle, taking into account the highlighting of de main aspects characteristic to these system, problems that may occur during the simulation, as well as the multiple possibilities for analyzing that the simulation in Matlab-SIMULINK can offer.

THE MATHEMATICAL MODEL

The orientation after a rotoric flux is the most often treated method due to the simplicity of the interlock loop and the operation magnitudes calculus. In case we neglect the rotor loop leakage inductance (Biro 1997; Boldea 1983), the flux in the electrical gap (measured or calculated) may be the same with the rotoric flux after which the orientation must be followed.

MAB is supplied directly from a tension source which supplied the necessary statoric current to each winding, after the command received from the interlock. The structure of the supply source of the machine used in this example is perfectly achievable from a physical point of view, in contrast to the instance when the source is a CSI which represents in fact an idealization.

Our option was to maintain as a command of the implementation element the statoric current, taking into account that under the circumstances it can be obtained a more reduced number of calculation and, moreover, the influences determined by the estimation errors, or by the variation of the statoric circuit parameters are avoided. The supply source is an inverter with the width modulation, PWM. The value of the continuous power stay constant.

The block scheme of the system, including its main components is shown in Figure 1. Although The value proper which commutes represents the supply tension of the winding, because the value measured by convectors represents the statoric current value, a control of the statoric current is finally reached.

The implementation of the command system is a two-phase induction machine (MAB) having the following parameters:

$$\begin{array}{lll} P_n = 35W; & U_{1n} = 220V; & R_S = 415\Omega; \\ f_{1n} = 50Hz; & n_{1n} = 1500rot/\min; & R_R = 295{,}72\Omega; \\ Z_S = 16; & Z_R = 17; & \\ p = 2; & J = 3{,}3 \cdot 10^{-5} Kg \cdot m^2; & \end{array} \quad (1)$$

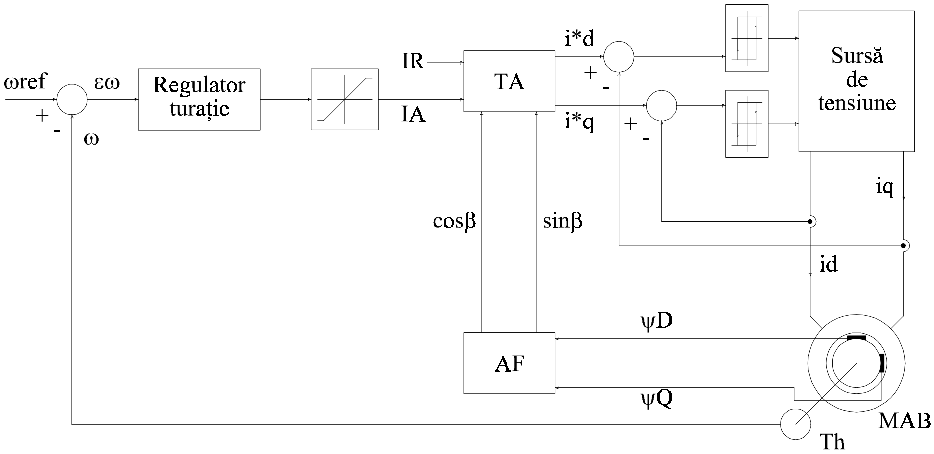

Fig.1

The two-phase linear model was used for its modeling, and its voltage equations are,

$$\begin{aligned} U_d &= R_S i_d + L_{\sigma S}\frac{di_d}{dt} + \frac{d}{dt}[M(i_d + i_D)] \\ U_q &= R_S i_q + L_{\sigma S}\frac{di_q}{dt} + \frac{d}{dt}[M(i_q + i_Q)] \\ 0 &= R_R i_D + L_{\sigma R}\frac{di_D}{dt} + \frac{d}{dt}[M(i_d + i_D)] + \omega L_{\sigma R} i_Q + \omega M(i_q + i_Q) \\ 0 &= R_R i_Q + L_{\sigma R}\frac{di_Q}{dt} + \frac{d}{dt}[M(i_q + i_Q)] - \omega L_{\sigma R} i_D - \omega M(i_d + i_D) \end{aligned} \quad (2)$$

a system in which, if we do not take into consideration the saturation, the inductance M is constant.

For a MAB, the two-phase model is a natural one and it practically keeps the statoric winding parameters unchanged. For a complete description we should add the equation which characterize the mechanical values, such as the electromagnetic torque and the motion equation. Thus, the electromagnetic torque has the form,

$$T_e = p \cdot \left(\Psi_d \cdot i_q - \Psi_q \cdot i_d\right) \quad (3)$$

and the balance equation of the torques at the machine shaft is,

$$T - T_r = J \cdot \frac{d\omega}{dt} + F_S \cdot \omega \quad (4)$$

where T is the electromagnetic torque developed by the machine (the active torque), T_r is the resistant torque and F_S is the resistant viscous torque.

A PI interlock has been used, and it has been provided with unsaturation elements of the integrating component. The amplification factor and the time constant of integration are the global parameters which can be modified by the user of the program after his necessities.

The equivalent circuit of the interlock system on which the simulation in Matlab-SIMULINK is realized, is presented with all its component elements in Figure 2.

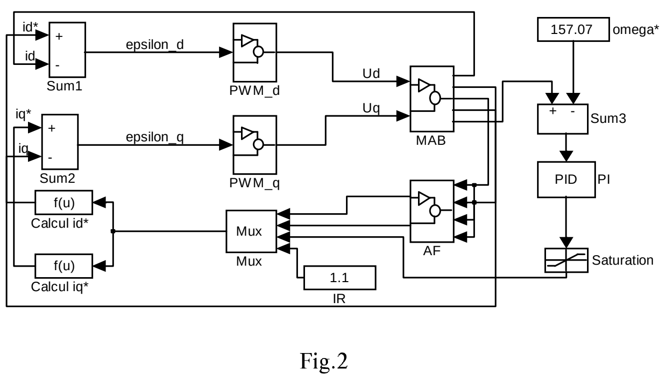

Fig.2

In order to check the correctness of the suggested program, we made a series of simulations for different rotations prescribed for a MAB, whose parameters are known, 35W; 1500 rot/min and it has been notice that the system stabilized itself at the imposed value, Figure3 and Figure 4, but this is true only for values which are close to the nominal speed. It has also been noticed that when there are smaller imposed values of the rotation, the stability of the system is smaller and smaller, Figure 5.

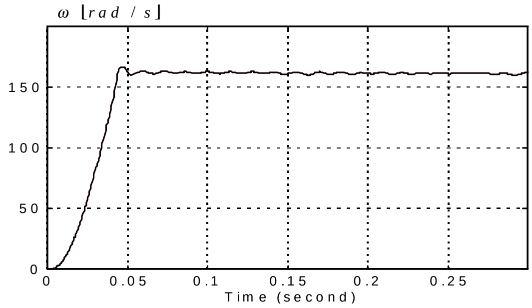

Fig.3

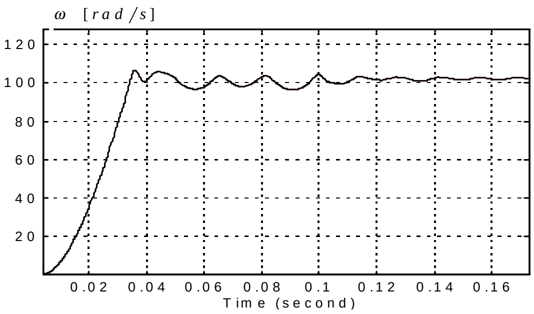

Fig.4

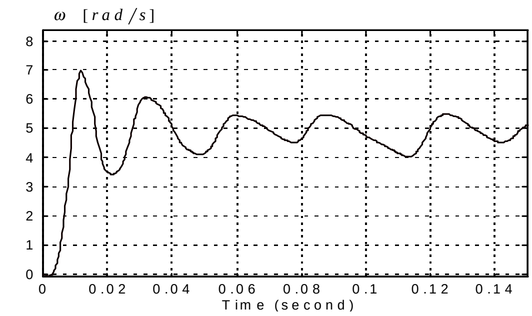

Fig.5

In the above example there was simulated the transitory process to start the MAB. In the first 0.05s there takes place an idly of the machine, and then a resistant torque of $T_{rez} = 0{,}02Nm$ is applied. Besides, the characteristic parameters of the interlock have been maintained at the values $K_R = 0{,}6$ and $T_i = 0{,}75$. These values ensure good performances to the automatic system. The value of these parameters which characterizes the interlock can influence the quality indexes and thus, we will analyze the processes again, modifying their value automatically The charge of the machine will be considered as a resistant torque of $T_{rez} = 0{,}02Nm$, which has been applied after 50ms from the idly starting of the MAB.

In Figure 6 and Figure 7 were emphasized the influence of the interlock parameters on the system output when we apply an entry rotation of 157,07rad/sec in a stabilized regime. Figure 6 shows the influence of the amplification factor on the system output. The time integrating constant of the interlock has been maintained at a value $T_i = 0{,}75s$. The lower the amplification factor is, the more difficult the rotor accelerates, and the rotation stabilizes itself more slowly at the stabilized regime value, the super-regulation is more obvious, and the effect of the integrating component is more powerful. We can appreciate that an amplification factor value of 0.6 is reasonable. This value can be modified, but, the benefice effects on the stability of the system will disappear.

Figure 7 shows the influence of the interlock integration of the time constant value on the performances of the system. The amplification factor value has been maintained at a value of 0.6, an acceptable value considered from the previous determinations. As it can be noticed, the value of this parameter slightly influences the increase period, but the duration of the transient regime may be prolonged for reduced values of the integration time constant, mainly due to the super-regulation process.

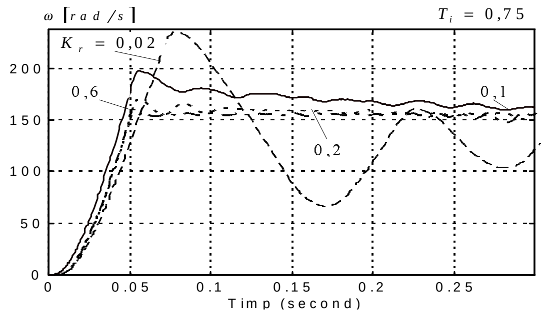

Fig.6

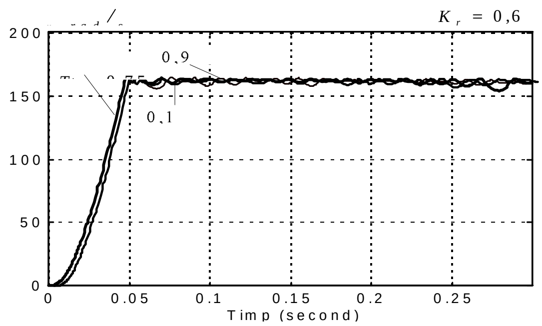

Fig.7

Another suggested method for the simulation of the rotation interlock system using the orientation after the rotoric flux principle is based on the existence of a resistant torque of a viscous type with a reduced value and the application after 10ms of a perturbance stage, namely the modification of the resistant torque. In this situation, too, have been emphasized the influence of the interlock parameters. At the beginning, the integration $T_i = 0{,}75s$ period was maintained constant and the amplification factor K_R was varied. After Figure 8, the increase of the amplification factor K_R leads to an amplitude of the rotation deviation from the lower precise value and a shorter transient period of time. These effects are a result of a more rapid variation of the electromagnetic torque output which succeeds to eliminate more effectively the deviation introduced by the perturbance.

In Figure 9 can be noticed that the value of the integration time constant T_i does not considerably influence the performances of the system. For lower values there increases the duration of the transient regime. After the previous determinations, the amplification factor K_R maintained at a constant value 0.6.

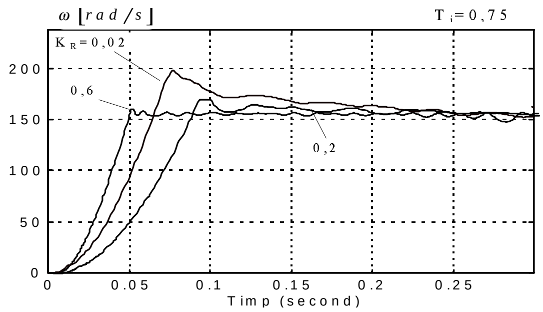

Fig.8

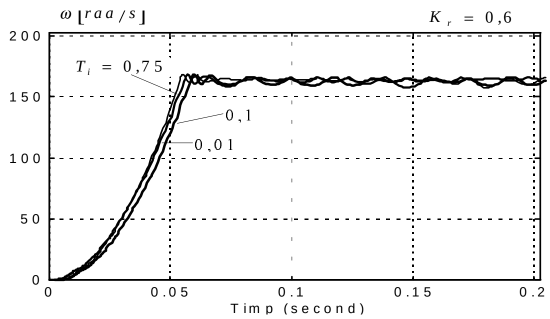

Fig.9

After the study of the influence of the interlock parameters on the quality indexes of the interlock the system, the adoption of an optimal value of 0.6 for the amplification factor K_R is justified, and also for the integration time constant T_i with a value of 0.75s. These values represent a reasonable compromise from the dynamic performances of the system point of view.

CONCLUSIONS

At the end of the paper we can conclude:

- It has been made an analysis of the state values that characterize the system and of the output at stage signal at the entrance and the application of a perturbance type stage for the resistant torque. It has been noticed that the system stabilizes itself at precise values of the rotation close to the nominal speed. For more lower values the system becomes unstable, oscillating round the prescribed value with a great error.

- When compared to three-phase induction machine, MAB also proves to be able for the applications of the interlock with orientation after a rotoric field, as the two-phase model (Craciunas 2000; Kelemen et al. 1989) on which this interlock system is based, represents a natural model for MAB

- The Matlab-SIMULINK utility proves capable to simulate without difficulties the demeanour of a MAB, based on the orientation after the field principle and it can be flexible and easily adaptable after the user's requirements during the simulation process.

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