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The study of the electric drive with indirect control of the output variables of the asynchronous motor

Yu.N. Dementyev, A.D. Umurzakova, K.N. Negodin

The department of electric motor drive and electrical equipment
National Research Tomsk Polytechnic University
Tomsk, Russia

Abstract* — *The article gives a mathematical* model *of an asynchronous motor with a device of indirect control of the output variables of the asynchronous motor in the electric drive that allows to prove on its basis the method of monitoring the electromagnetic torque and the angular velocity of the asynchronous electric motor.

Index Terms* — *an asynchronous motor, an electric drive, indirect control

I. *HEADING*

The drives of conveyors, transporters, dosing apparatus, lift mechanisms, when the liquid is transported for water supply and sanitation of settlements and industry, moving the oil and oil products from the fields to the processing enterprises [1] and so on, require the implementation of a high-speed motor control electromagnetic torque and it is necessary to control the speed of movement and developing force.

It should be noted that the use of rotor speed sensor provides a relatively simple and qualitative control of the asynchronous motor. However, the presence of these sensors considerably degrades the performance characteristics of the electric drive, and their use may not be possible under the terms of the electric drive functioning.

In this regard, the industrial enterprises widely use the devices and methods allowing to monitor the engine load, parameters of general industrial machinery of the technological process and maintain the speed within a predetermined range without torque and speed sensors, when the necessary information is calculated by indirect methods.

Thus, the development and research of the asynchronous electric drive with the indirect control device of the output variables of the asynchronous motor is relevant and allows you to control the output variables, providing the specified technological parameters.

II. SETTING OBJECTIVES

The control of electromagnetic torque and angular velocity of an asynchronous motor is possible to carry out using the known motor nameplate data and easily measured values - the phase currents (i_a, i_b) and voltages (u_a, u_b) [1-7].

$$\begin{cases} M(t)=\sqrt{3}\cdot p_n\cdot\left[i_a(t)\cdot\int\limits_0^{1/f}\left[u_b(t)-z\cdot i_b(t)\right]dt-i_b(t)\cdot\int\limits_0^{1/f}\left[u_a(t)-z\cdot i_a(t)\right]dt\right] \\ \omega(t)=\omega_{и}(t)\cdot\left[1+\Delta\omega_{инт}(t)+\Delta\omega_{диф}(t)\right] \end{cases}$$

In accordance with the developed methods of control of the electromagnetic torque and the angular velocity of the asynchronous motor [1-7], a generalized functional chart shown in Figure 1is designed.

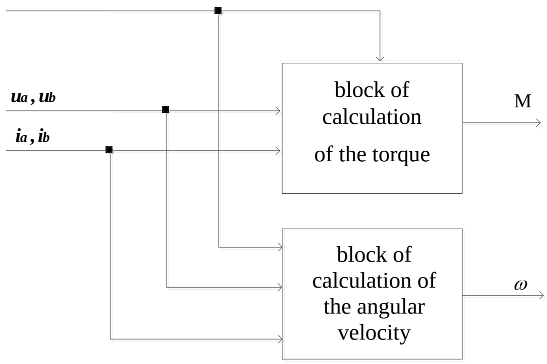

Figure1 - A generalized functional chart of control of the electromagnetic torque and the angular velocity of the asynchronous motor

For the mathematical description of the indirect control of the electromagnetic torque and the angular velocity of the asynchronous motor, you can use the expressions given in [1-5], using the given mathematical description in [1-5], you can define the output variables of the asynchronous motor by measuring the voltage, the stator phase currents and data of the electric motor for monitoring their current values.

III. EXPERIMENTAL STUDY

To test the developed methods of indirect control of the output variables of the asynchronous motor there was an experimental study on a special stand, where they used AIR71V2U3 asynchronous motor with the power P_n = 1.1 kW, the synchronous speed n_n= 3000 rev / min and the rated voltage of U_{n1} = 220 V. Figure 2 shows the experimental stand and its components.

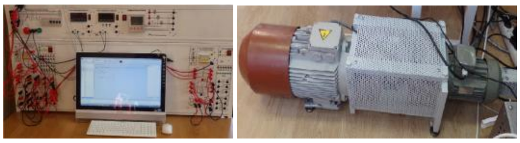

Figure 2 - The experimental stand and its components

The stand includes a three-phase power supply, a test motor, a digital multimeter, devices for calculating the torque and speed, an AC converter with QMS1.1 measuring device, a measuring unit, a load DC generator, the starter and protective switching unit, current and voltage sensors, a rotor speed sensor and personal computer with a multichannel analogue-digital converter and also special software.

Three-phase power supply is designed to supply the control units of the asynchronous motor with three-phase voltage of 380 V and also all other units with single-phase voltage of 220 V.

The digital multimeter unit includes a DMG800 digital multimeter and sensors that measure currents, voltage, power, cosφ, harmonic composition of currents and voltage, and other parameters of the AC mains connected to the unit.

The torque and speed display unit performs the display of the current values of torque and speed at the motor shaft.

The AC inverter unit with QMS1.1 measurement unit contains the voltage and current sensors for connection to the ADC block.

The converter block includes a three-phase circuit breaker; a manual control unit; three-phase bridge frequency converter with a rectifier and DC link; a braking resistor; an exit sine wave RC-filter; the exit to the asynchronous motor.

The exit filter consists of three inductors of 1.6 / 3.1 mH inductance each, and three capacitors of 20 mfd / 400 capacity each.

QMS1.1 measurement unit includes: a 16-channel module of analog-digital conversion with QMS10 USB-interface; current sensors (25 A); voltage sensors (500 V); auxiliary power supply unit + 24V, + 15V, -15V.

QMS10 ADC unit transmits the digitized signals to a computer. The accompanying computer program allows you to monitor the signal waveforms and store the data in an array for later processing. The DC converter unit with QMS1.2 measurement unit includes: a three-phase circuit breaker; a manual control unit; a 380V/208V step-down power transformer; a three-phase bridge frequency converter with a rectifier and DC link; a 220V power source of excitation; a braking resistor; the exit to the DC motor with separate excitation; current sensors (25 A); voltage sensors (500 V). The applicable types of sensors are strain gauges.

In experimental studies the asynchronous motor of AIR71V2U3 type of power P_n = 1.1 kW, nominal speed n_n = 3000 rev / min has been used.

The data processing has been performed on a personal computer in a MatLab software environment using Mex Bios software product with the integrated set of services for the electric motor control.

Mex Bios is a visual environment for development and simulation of the embedded software for control systems of electric motors with technological systems, programmable logic controllers, which allows you to create your own programs for the electric motor control, technological systems, to carry out the simulation of program work and electromechanical facilities and systems; to debug the program loaded into the microcontroller; to install components libraries for new microcontrollers.

To minimize inaccuracies in determining the electromagnetic torque and the angular velocity, the set of experimental studies has been conducted. The serial devices, used in the experimental unit, have been tested and meet the standards of accuracy.

Figure 3 shows the general diagram of the simulation model, made in MatLab programming environment, which allows to determine the value of the electromagnetic torque and the angular velocity obtained from the actual electric motor and indirect control device of the asynchronous motor.

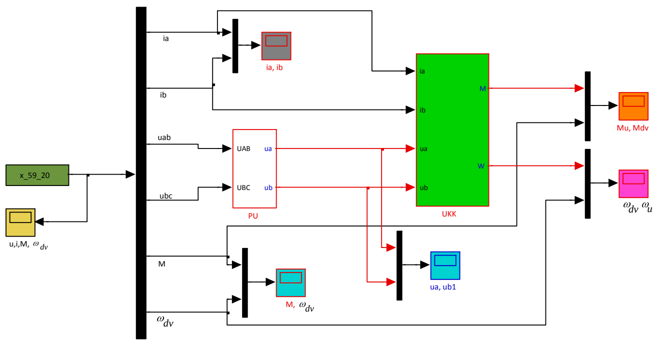

Figure 3 - The general scheme of the simulation model with the indirect control device of an asynchronous motor

The scheme comprises a unit with a data obtained during experiments and the unit of the indirect control device of the asynchronous motor. The results of conducted studies on the experimental unit (for the asynchronous motor of AIR71V2U3 type) are shown in Figures 4 and 5.

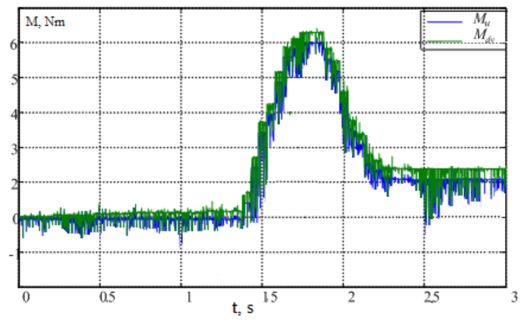

Figure 4 – The scheme of the torque from the electric motor M_{dv} and the indirect control device M_u

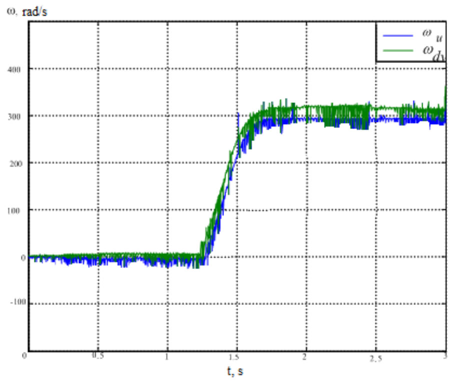

Figure 5 – The scheme of the motor speed ω_{dv} and the indirect control device ω_u

The analysis of the schemes of the electromagnetic torque and the angular velocity obtained in the experimental device shows that the difference between the obtained schemes of the torque and speed from a real motor and the indirect control device of the asynchronous motor is not more than 10%, which confirms the adequacy of the mathematical description of the asynchronous motor with the developed device of indirect control of the output variables of the asynchronous motor for the electric drive of general-purpose devices.

IV. Conclusions

The obtained results of experimental studies on the laboratory stand confirm the adequacy of the theoretical statements of the mathematical description of the electric drive with the indirect control device of the electromagnetic torque and the angular velocity of the asynchronous motor.

Using Mex Bios visual environment in the experimental studies enables to carry out the design, preliminary simulation, debugging embedded software, adjusting the regulators of the motor control digital system in one product, which is the advantage of the experimental stand.

It has been found that the discrepancy of the obtained values of electromagnetic torque and the angular velocity at the exit of the asynchronous motor and indirect control device on the experimental stand in the simulation does not exceed 10%, which is acceptable in engineering calculations.

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