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DOMESTIC REFRIGERATORS SINGLE-PHASE ASYNCHRONOUS MOTORS DYNAMIC CHARACTERISTICS SIMULATION

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ABSTRACT

Mathematical simulation of dynamic characteristics for single-phase stator winding asynchronous motors is an essential aspect of motor design. Single-phase stator winding asynchronous motors are widely used in various applications, such as household appliances, pumps, and fans. The dynamic characteristics of these motors determine their performance and efficiency. A system of differential equations of electromechanical equilibrium was compiled on the example of a single-phase asynchronous motor of a household appliance motor-compressor unit, on the stator of which only one phase was wound and based on the mathematical model for its static operating characteristics calculation. According to the proposed mathematical model, the dynamic characteristics of the motor were calculated in the MATCAD software environment using the Runge-Kutta method. The resulting dynamic characteristics are mandatory at the level of a justified engine selection for an automated electric drive system with high requirements for its operation in the mode of transient processes.

Keywords: Single-phase asynchronous motor, Stator winding, Equivalent circuit, Mathematical simulation, Dynamic characteristics

1. INTRODUCTION

As the world becomes more technologically advanced, electric motors are becoming increasingly important in various industries. One of the most widely used electric motors is the single-phase stator winding asynchronous motor. Mathematical simulation is a critical tool for analyzing the dynamic characteristics of these motors. The simulation can help predict the motor's behavior under different operating conditions, including starting, acceleration, and deceleration. It also allows for the optimization of motor performance and design. The simulation model should include the motor's electrical, mechanical, and magnetic properties, as well as the load characteristics. The simulation results can be used to evaluate the motor's efficiency, power factor, and torque. Moreover, the simulation can also help in identifying potential issues, such as overheating or vibration, which can be addressed before they cause any damage. In conclusion, mathematical simulation is a valuable tool for analyzing the dynamic characteristics of single-phase stator winding asynchronous motors and can help in optimizing their performance and design. The use of an asynchronous electric motor integrated into the system of a regulated electric drive must be preceded by a thorough analysis of its reliability performance in the conditions of alterations in those external factors that significantly affect electromechanical processes and need consideration of efforts to ensure system stability requirements. Due to the non-linear structure of AC electric drives, there will always be a need to improve the static and dynamic characteristics of motors. Ensuring built-in accuracy of the electric drive output to the given coordinates of the entire system positioning, especially in the conditions of the electric motor load changing, is the determining indicator of the quality of such a drive, and therefore the development of the mathematical model for calculating the operation characteristics of the motor in dynamics remains relevant.

The subject of the study is a single-phase asynchronous motor (OAM) with a short-circuited rotor, the stator winding of which is arranged into two phases with independent power supply - the main operating and auxiliary starting or capacitor (asynchronous capacitor-run motor - ACM). This OAM is a part of the motor -compressor unit of a household refrigerator or air conditioner (Baidak, Y., 2006). The object of the research is a single-phase asynchronous motor, the stator winding of which is made in a single phase which is unfolded in two sequentially switched coils, placed in the same number of stator grooves with a spatial shift of their axes in 90^0 (OACM) (Baidak, Y., 2006). The spatial shift of the currents is provided by a capacitor branch with a posistor connected in parallel to one of the coils of the stator winding during engine start-up. After starting the engine, the capacitor is de-energized by the posistor which spontaneously, due to heating by the current, increases its own active resistance thousands times and this stops practically the flow of current in the auxiliary branch. In works (Baidak, Y., 2009, 2010) it is emphasized that the motor with such a winding on the stator has a higher specific load index (W/kg), it is not inferior to industrial analogs in terms of operating characteristics and has power efficiency index - in the form of the product of the efficiency by the power factor, at the $\eta \cdot Cos\varphi \geq 0{,}8$ level. All the above-mentioned facts make it more efficient than existing single-phase motors. The mathematical model for the static characteristics calculations of the motor under study, made by the method of symmetrical components, is presented in (Baidak, Y., 2009). The results of numerical calculations of the static operating characteristics of the motor and experimental tests of its manufactured sample proved their convergence and, thus, confirmed the adequacy of the initiated alternate electrical circuit and of the developed mathematical model. The next step in the way of its research can be considered the creation of the mathematical model for the dynamic characteristics calculation.

2. INITIAL DATA FOR SIMULATION OF THE ELECTROMECHANICAL PROCESS OF SINGLE-PHASE ASYNCHRONOUS CAPACITOR-RUN MOTOR STARTING

The main body of the paper will consist of one or more main sections describing experimental designs, test Mathematical simulation of electromechanical processes in any electric machine is carried out based on the winding voltages balance and machine shaft torques equations. The differential form of these equations ensures the simplicity and accuracy of numerical calculations of the electric machine operation transient modes. In general, the problem is solved for currents in the windings of an idealized machine by choosing a common system of coordinate axes - stationary for the stator and movable for the rotor. To write the differential equations of winding voltages balance with constant coefficients at unknown flux linkages and torques, we use an orthogonal coordinate system in which the transformed contours of the stator and rotor windings are mutually stationary. Thus, for an electric machine with a constant air gap, depending on the frequency of rotor rotation and the coordinate axes d, jq which are rigidly connected to it, we apply a coordinate system $\alpha, j\beta$ fixed in space - in which the axis α forms an angle of 45^0 with the axes of the stator winding coils and the rotating coordinate system of the rotor is reduced to the stationary coordinate system of the stator through the phase angle of vector rotation.

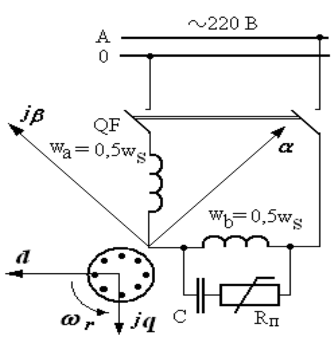

Figure 1: Typical wiring schematic of single-phase asynchronous capacitor-run motor

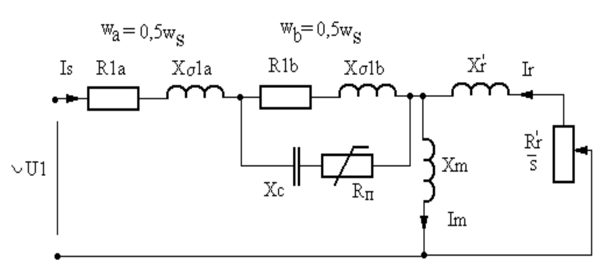

Figure 2: Equivalent circuit of single-phase asynchronous capacitor-run motor with single-phase wiring

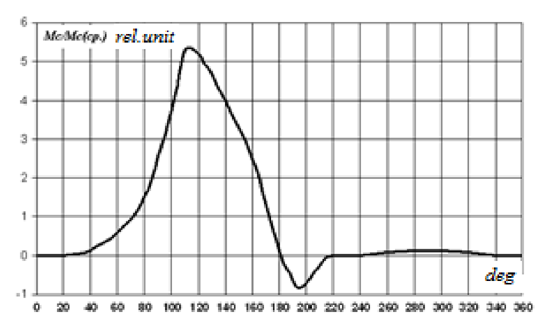

Figure 3: Dependence of the resistance moment of a reciprocating single-cylinder freon compressor on the rotor rotation angle

The typical wiring schematic of a single-phase asynchronous capacitor-run motor switching to a single-phase power supply network and its equivalent circuit is shown in Fig. 1 and Fig. 2. For a sample of the manufactured experimental model of a single-phase asynchronous capacitor-run motor, which intends to work as a part of the refrigerating reciprocating single-cylinder compressor NKV 10-3-K (Ukraine), the typical moment of resistance under variable load on the rotor shaft corresponds to that shown in Fig. 2.
As follows from Fig. 3, the dependence of the moment of resistance on the motor shaft, loaded by the piston system of the compressor, has a significantly nonlinear character, but one that corresponds to the conditions of Neumann and Dirichle and, therefore, can be given in the form of a sine Fourier series.

$$M_c/M_{c(ave)} = 1 + 1{,}73\sin(\omega t - 27^0) + 1{,}39\sin(2\omega t - 150^0) + 0{,}698\sin(3\omega t + 76^0) + 0{,}304\sin(4\omega t - 61^0) + 0{,}189\sin(5\omega t - 18^0) + 0{,}149\sin(6\omega t + 180^0) + 0{,}294\sin(7\omega t + 25^0) + 0{,}075\sin(8\omega t - 116^0) + 0{,}059\sin(9\omega t + 88^0). \quad \text{Eq. (1)}$$

Table 1 summarizes the amplitude values of the harmonics of the Fourier series, including the ninth. Considering that, in the first approximation, the current task of calculating the dynamic characteristics of the motor is linear, it is possible to calculate them by the superposition method, namely separately for the amplitudes of each harmonic component of the resistance moment. If the accuracy of the calculation is not significantly determined, then it is possible to use either only the constant element of the Fourier series or the most significant harmonic in terms of amplitude. In any case, the problem is solvable.

Table 1.The values of the resistance moment harmonic series amplitudes

Harmonic number	0	1	2	3	4
Amplitude, Nm.	0,371	0,642	0,516	0,259	0,113
Harmonic number	5	6	7	8	9
Amplitude, Nm.	0,07	0,055	0,109	0,028	0,022

If the total power consumption of the investigated model of the single-phase asynchronous capacitor-run motor manufactured according to the data set out in [6], $P_{1н} = U_н I_н = 220 \cdot 0{,}7 = 154W$, at the rotor rotation frequency - $\omega_H = \frac{n2}{9{,}55} = 307{,}88 \quad sek^{-1}$, efficiency $\eta_H = 0{,}78$, power factor $Cos\varphi_H = 1{,}0$ and slipping $s_H = 0{,}0195$, then the basic value of the electromagnetic moment will be $M_b = \frac{P_{1н}}{\omega_1} = \frac{154}{314} = 0{,}49Nm$. Since the total consumed power is chosen as the basic power, and not the useful power on the rotor shaft, the relative value $M^* = \frac{M_н}{M_b} = 1$ will correspond to the motor overload in terms of torque. The nominal torque corresponding to the useful power will be

$$M_н = \frac{P_{1н} \cdot \eta_н Cos\varphi_{1н}}{\omega_н} = \frac{154 \cdot 0{,}78 \cdot 1}{307{,}88} = 0{,}39Nm.$$

Usually, the average value of the motor resistance moment is chosen at the level $M_{c(ave)} \le 0{,}95M_н = 0{,}95 \cdot 0{,}39 = 0{,}37Nm$. As for the moment of inertia of the motor rotor, the radius of which is $R_{rot} = 0{,}02m$, and the length is $\ell_{rot} = 0{,}04m$, then its calculated value is $J_{rot} = 7850 \cdot \pi \cdot \ell_{rot} \cdot \frac{R_{rot}^4}{2} = 0{,}79 \cdot 10^{-4}(кg \cdot m^2)$ and is approximately 90% of the total moment of inertia of the motor - compressor unit

$$J = J_{rot}/0{,}9 = 0{,}878 \cdot 10^{-4}(кg \cdot m^2).$$

In relative units, the moment of inertia of the motor is determined by its base value

$$J_b = \frac{P_{2н}}{\omega_1^3} = \frac{154}{(2\pi f_1)^3} = 0{,}527 \cdot 10^{-5} (\kappa g \cdot m^2) \text{, is } J^* = \frac{J}{J_b} = \frac{0{,}878 \cdot 10^{-4}}{0{,}527 \cdot 10^{-5}} = 16{,}64$$

,

and the moment of resistance is

$$M_c^* = \frac{M_{c(ave)}}{M_б} = \frac{0{,}37}{0{,}49} = 0{,}756 \cdot$$

The components of the resistances of the stator winding, established experimentally by the methods of idling and short-circuiting of the motor under study, were: $X_c = \frac{1}{2\pi fC} = \frac{1}{314 \cdot 158 \cdot 10^{-6}} = 20{,}16\ \ \Omega$, $X_{\sigma 1a} = X_{\sigma 1b} = 23{,}8\ \ \Omega$, $R_{1a} = R_{1b} = 19{,}2\ \ \Omega$, $X_r^{'} = 23{,}8\ \ \Omega$, $R_r^{'} = 20{,}1\ \ \Omega$, $X_m = 14{,}1\ \ \Omega$

For the equivalent circuit in Fig. 1 at the moment of motor start-up, the equivalent active and reactive resistances of the stator winding are determined by Eq. (2) and Eq. (3).

$$R_s = R_{1a} + R_{1b} \cdot \frac{X_c^2}{R_{1b}^2 + (X_{\sigma 1b} - X_c)^2}, \qquad \text{Eq. (2)}$$

$$X_s = X_{\sigma 1a} + X_c \cdot \frac{X_{\sigma 1b} \cdot X_c - X_{\sigma 1b}^2 - R_{1b}^2}{R_{1b}^2 + (X_{\sigma 1b} - X_c)^2}. \qquad \text{Eq. (3)}$$

For clarity and the possibility to perform a comparison of the dynamic characteristics of the motor under study with other similar engines, the initial resistance parameters for calculation are given in relative units. So, for the basic unit of resistance $Z_b = \frac{U_1}{I_s} = \frac{220}{0{,}7} = 314{,}3\ \ \Omega$, in which U_1 and I_s - phase supply voltage and current, we obtain: $X_m^* = \frac{X_m}{Z_b} = 1{,}954$; $X_s^* = X_m^* + \frac{X_s}{Z_b} = 2{,}593$; $X_r^* = X_m^* + \frac{X_r^{'}}{Z_b} = 2{,}03$; $R_s^* = \frac{R_s}{Z_b} = 0{,}141$; $R_r^* = \frac{R_r^{'}}{Z_b} = 0{,}064 \cdot$

3. MATHEMATICAL MODEL OF SINGLE-PHASE ASYNCHRONOUS CAPACITOR-RUN MOTOR DYNAMIC CHARACTERISTICS CALCULATION

For the generalized model of the single-phase asynchronous capacitor-run motor, Fig. 3, the system of differential equations for the balance of winding voltages and torques on the machine shaft, given in the stationary coordinate system of the stator $\alpha, j\beta$ for relative units, has the form (4).

The following notations are used in Eq. (4): $X_s^* = X_{s\sigma}^* + X_m^*$, $X_r^* = X_{r\sigma}^* + X_m^*$ - complete reactive inductive resistances of the windings; $X_{s\sigma}^*$, $X_{r\sigma}^*$ - inductive dissipation resistances; X_m^* - inductive resistance of the mutual inductance of the stator and rotor windings.

$$\begin{cases} U_{s\alpha}^* = i_{s\alpha}^* R_s^* + \dfrac{d\Psi_{s\alpha}^*}{dt^*} \\ U_{s\beta}^* = i_{s\beta}^* R_s^* + \dfrac{d\Psi_{s\beta}^*}{dt^*} \\ 0 = i_{r\alpha}^* R_r^* + \dfrac{d\Psi_{r\alpha}^*}{dt^*} + \omega_r^* \Psi_{r\beta}^* \\ 0 = i_{r\beta}^* R_r^* + \dfrac{d\Psi_{r\beta}^*}{dt^*} + \omega_r^* \Psi_{r\alpha}^* \\ \Psi_{r\beta}^* i_{r\alpha}^* - \Psi_{r\alpha}^* i_{r\beta}^* = M_c^* + J^* \dfrac{d\omega_r^*}{dt^*} \end{cases}, \qquad \text{Eq. (4)}$$

The flux linkages applied in Eq. (4) are related to the currents forming them in the projection onto the corresponding axis

$$\begin{cases} \Psi_{s\alpha}^* = i_{s\alpha}^* X_s^* + i_{r\alpha}^* X_m^* \\ \Psi_{s\beta}^* = i_{s\beta}^* X_s^* + i_{r\beta}^* X_m^* \\ \Psi_{r\alpha}^* = i_{r\alpha}^* X_r^* + i_{s\alpha}^* X_m^* \\ \Psi_{r\beta}^* = i_{r\beta}^* X_r^* + i_{s\beta}^* X_m^* \end{cases}, \quad \text{Eq. (5)}$$

Solving Eq. (5) with respect to currents, we obtain

$$\begin{cases} i_{s\alpha}^* = \dfrac{\Psi_{s\alpha}^* X_r^* - \Psi_{r\alpha}^* X_m^*}{D} \\ i_{s\beta}^* = \dfrac{\Psi_{s\beta}^* X_r^* - \Psi_{r\beta}^* X_m^*}{D} \\ i_{r\alpha}^* = \dfrac{\Psi_{r\alpha}^* X_s^* - \Psi_{s\alpha}^* X_m^*}{D} \\ i_{r\beta}^* = \dfrac{\Psi_{r\beta}^* X_s^* - \Psi_{s\beta}^* X_m^*}{D} \end{cases}, \quad \text{Eq. (6)}$$

where $D = X_s^* X_r^* - X_m^{*2}$.

Substituting Eq. (6) into Eq. (4) and writing the resulting equations in the form of a derivative of the form $y' = f(x,y,z,..)$, we obtain the system of five differential equations, in which the flux coupling and the angular frequency of rotation of the rotor $\Psi_{s\alpha}^*$, $\Psi_{s\beta}^*$, $\Psi_{r\alpha}^*$, $\Psi_{r\beta}^*$, ω_r^* become unknown (Eq. (7)).

$$\begin{cases} \dfrac{d\Psi_{s\alpha}^*}{dt^*} = U_{s\alpha}^* - R_s^* \dfrac{\Psi_{s\alpha}^* X_r^* - \Psi_{r\alpha}^* X_m^*}{D}, \\ \dfrac{d\Psi_{s\beta}^*}{dt^*} = U_{s\beta}^* - R_s^* \dfrac{\Psi_{s\beta}^* X_r^* - \Psi_{r\beta}^* X_m^*}{D}, \\ \dfrac{d\Psi_{r\alpha}^*}{dt^*} = -\omega_r^* \Psi_{r\beta}^* - R_r^* \dfrac{\Psi_{r\alpha}^* X_s^* - \Psi_{s\alpha}^* X_m^*}{D}, \\ \dfrac{d\Psi_{r\beta}^*}{dt^*} = \omega_r^* \Psi_{r\alpha}^* - R_r^* \dfrac{\Psi_{r\beta}^* X_s^* - \Psi_{s\beta}^* X_m^*}{D}, \\ \dfrac{d\omega_r^*}{dt^*} = \dfrac{1}{DJ^*} \begin{bmatrix} \Psi_{r\beta}^* \left(\Psi_{r\alpha}^* X_s^* - \Psi_{s\alpha}^* X_m^*\right) - \\ - \Psi_{r\beta}^* \left(\Psi_{r\beta}^* X_s^* - \Psi_{s\beta}^* X_m^*\right) - M_c^* D \end{bmatrix} \end{cases} \quad \text{Eq. (7)}$$

Taking the basic amplitude of the stator supply voltage $U_m^* = 1$, its projections on the coordinate axis are $U_{s\alpha}^* = 1 \cdot Cos\left(t^* + \varphi_u^*\right)$ and $U_{s\beta}^* = 1 \cdot Sin\left(t^* + \varphi_u^*\right)$. To solve the system of differential Eq. (7), we will use the software environment MathCAD.

The input data for the calculation are: the relative values of the resistances of the stator winding X_m^*, X_s^*, X_r^*, R_s^*, R_r^*; the initial phase of the supply voltage φ_u^*; moment of inertia of the motor rotor with moving parts J^*; time t^* in fractions π; supply voltage of the stator winding $U_{s\alpha}^*$, $U_{s\beta}^*$; moment of resistance of a single-cylinder compressor M_c^*. angular velocity of the rotor ω_r^*.

The output data are the time dependences of flux linkages $\Psi^*_{s\alpha}$, $\Psi^*_{s\beta}$, $\Psi^*_{r\alpha}$, $\Psi^*_{r\beta}$, stator and rotor currents $i^*_{r\beta}$, $i^*_{r\alpha}$, $i^*_{s\alpha}$, $i^*_{s\beta}$ in the stationary coordinate system of the stator $\alpha, j\beta$ and angular velocity of the rotor in constant time - $\frac{t^*}{\omega_0}$.

The initial conditions for the calculated parameters are chosen to be zero, which corresponds to the condition of the single-phase asynchronous capacitor-run motor start-up. Adopted in model Eq. (7) indications are the following:

of flux linkages

$$\frac{d\Psi^*_{s\alpha}}{dt^*} = \Psi_0 = U_{n,1},\ \frac{d\Psi^*_{s\beta}}{dt^*} = \Psi_1 = U_{n,2},\ \frac{d\Psi^*_{r\alpha}}{dt^*} = \Psi_2 = U_{n,3},\ \frac{d\Psi^*_{r\beta}}{dt^*} = \Psi_3 = U_{n,4},\ \frac{d\omega^*_r}{dt^*} = \Psi_4 = U_{n,5},$$

of time $t = U_{n,0} / \omega_0$.

The mathematical model for calculation of the dynamic characteristics of a single-phase asynchronous capacitor-run motor for Eq. (7) according to the Runge-Kutta method in the MathCAD software environment has the form Eq. (8)

$$F(t,\Psi) := \begin{bmatrix} U1\cdot\cos(t+fiu) - Rs\cdot\left(\Psi_0\cdot Xr - \Psi_2\cdot Xm\right)\cdot\frac{1}{D} \\ U1\cdot\sin(t+fiu) - Rs\cdot\left(\Psi_1\cdot Xr - \Psi_3\cdot Xm\right)\cdot\frac{1}{D} \\ -\Psi_4\cdot\Psi_3 - Rr\cdot\left(\Psi_2\cdot Xs - \Psi_0\cdot Xm\right)\cdot\frac{1}{D} \\ \Psi_4\cdot\Psi_2 - Rr\cdot\left(\Psi_3\cdot Xs - \Psi_1\cdot Xm\right)\cdot\frac{1}{D} \\ \left[\Psi_3\cdot\left(\Psi_2\cdot Xs - \Psi_0\cdot Xm\right) - \Psi_2\cdot\left(\Psi_3\cdot Xs - \right.\right. \\ \left.\left. -\Psi_1\cdot Xm\right) - Mc\cdot D\right]\cdot\frac{1}{D\cdot J} \end{bmatrix}$$

$$U := rkfixed\ (\Psi, 0, 500, 500, F)$$

Acceleration speed characteristic ofthemotor $\frac{d\omega^*_r}{dt^*} = f(t)$ in relative units, obtained by the results of the calculation, is shown in Fig. 4.

Fig. 4 points out that when the motor is on its speed characteristic has an oscillatory decaying character with a maximum amplitude of 0.07 relative units. At the end of the transient process, the engine reaches a speed of 0.93 relative units (2790 rpm) from the synchronous speed with the resistance moment on the rotor shaft $M_c = 0{,}39 Нм$. Motor acceleration time $t = 0{,}43 сек$.

Fig. 5 shows the dependencies of the flux linkages formed by the stator winding and the short-circuited rotor winding. Their significant discrepancy at engine start-up indicates the phenomenon of pushing out almost 60% of the compatible magnetic field of the stator winding and the magnetic field of the rotor winding to the shorting path in the air gap, which induces speed fluctuations at the beginning of acceleration. After the start of the engine, the relative discrepancy of the flux linkages decreases to 8%, that is a quantitative estimate of the power losses during the remagnetization of the magnetic lines.

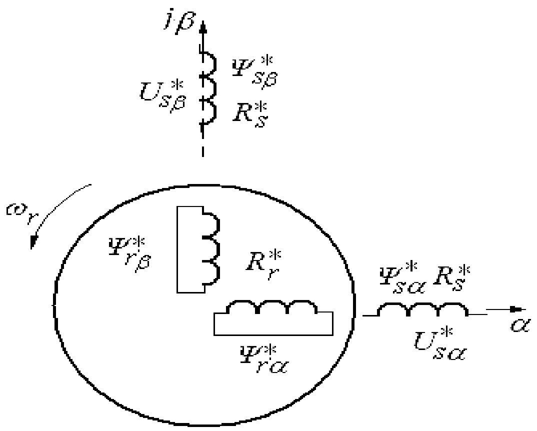

Figure 4: Generalized model of the single-phase asynchronous capacitor-run motor with a short-circuited rotor

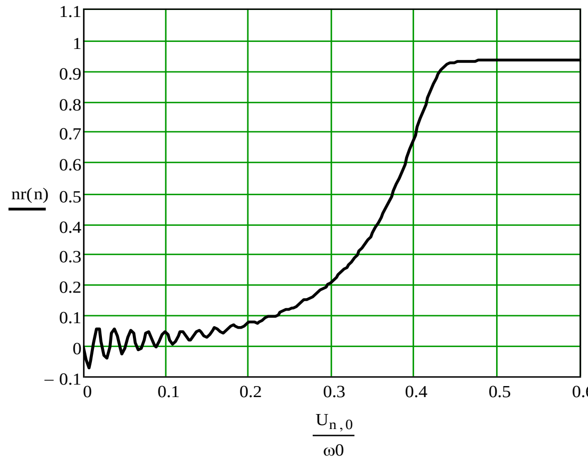

Figure 5: Acceleration speed characteristic of single-phase asynchronous capacitor-run motor with the moment of resistance on the shaft *M_c=0,39 Nm*

Fig. 6 is an illustration of the time dependencies of the current in the stator winding of the single-phase asynchronous capacitor-run motor and reduced to the stator winding currentin the rotor winding. As follows from the dependencies, the starting current is almost four times higher than the nominal value, and the power losses in the windings during motor start-up increase by sixteen times, which should be taken into account when it is operated in a repeated short-time mode with a short stop time. The heat load caused by electrical losses in the motor windings can accumulate and exceed the temperature limit for the applied insulation of the stator wires.

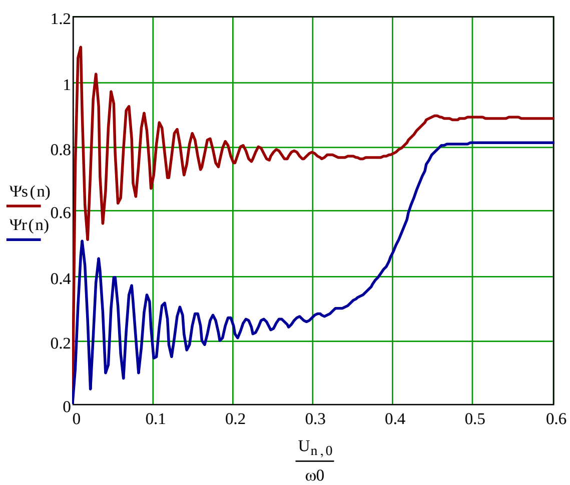

Figure 6: Time dependencies of the flux linkages of the stator winding (top) and rotor (bottom) of the single-phase asynchronous capacitor-run motor with the moment of resistance on the shaft *M_c=0,39 Nm*

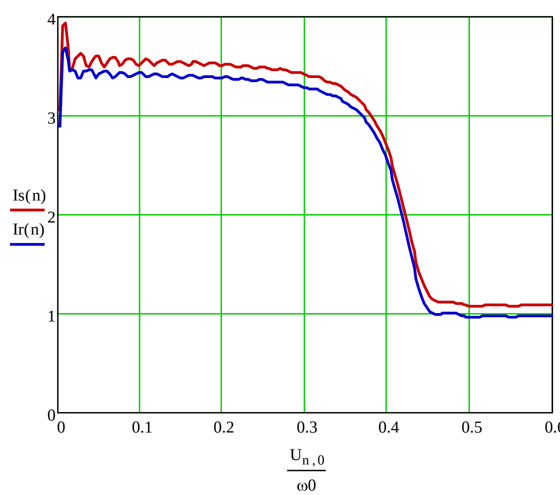

Figure 7: Time dependencies of the currents of the stator winding (top) and rotor (bottom) of the single-phase asynchronous capacitor-run motor with the resistance moment on the shaft *M_c=0,39 Nm*

As for the dynamic and static moments on the rotor shaft, they are calculated by ratios of the form

$$M^* = I^*_{r\alpha} \cdot \Psi^*_{r\beta} - I^*_{r\beta} \cdot \Psi^*_{r\alpha}, \qquad \text{Eq. (8)}$$

$$M_{ct}^{*}=\frac{\dfrac{R_r^{*}\cdot dt^{*}}{\omega_r^{*}}}{\left[R_s^{*}+\left(1+\dfrac{X_s}{X_m^{*}\cdot Z_б}\right)\dfrac{R_r^{*}\cdot dt^{*}}{\omega_r^{*}}\right]^2+\left[\dfrac{X_s}{Z_б}+\left(X_r^{*}-X_m^{*}\right)\right]^2}. \quad \text{Eq. (9)}$$

As can be seen from the static mechanical characteristics, Fig. 7, the starting moment of the single-phase asynchronous capacitor-run motor $M_n^{*}=0{,}811\ \ rel.unit$. at slipping $s=1$ is sufficient to overcome the moment of resistance $M_c^{*}=0{,}756\ \ rel.unit$. Critical value of the static moment $M_{кр}^{*}=1{,}255\ \ rel.unit$ and the oscillation of the dynamic moment ends at the level $M^{*}=0{,}783\ \ rel.unit$ . . The fluctuation of the dynamic torque at the beginning of the motor start-up has almost no reverse braking torque (negative) that is a benefit compared to the existing prototypes of single-phase asynchronous capacitor-run motors.

4. CONCLUSIONS

Mathematical simulation of dynamic characteristics for single-phase stator winding asynchronous motors is an essential aspect of motor design. Single-phase stator winding asynchronous motors are widely used in various applications, such as household appliances, pumps, and fans. The dynamic characteristics of these motors determine their performance and efficiency. The considered method of calculating the dynamic characteristics of a motor with a single-phase winding on the stator does not impose restrictions on the shape of the resistance moment diagram, provided that it is periodic and there are no breaks of the second kind. Usually, with the known law of the moment of resistance, the nominal power of the motor is calculated as the product of the average values of the moment and the angular speed of rotor rotation. The possibility of such an approach is based on the fact that even in the case of a significant change in the instantaneous slip values, the relative change in the angular velocity of the rotor is insignificant. After the engine is designed, the rated power is refined by integrating the nonlinear system of equations (Eq. (3)). In this case, the sought power is calculated as the average value (constant component) of the instantaneous power curve on the rotor shaft during the period of non-uniform periodic load. Calculating the nominal power at the highest limit value of the resistance moment is not appropriate, as it leads to unreasonably overestimated motor dimensions. The divergence between the previous and updated power values will be slight. Therefore, when calculating is based on equations (Eq. (3)), the main task is not to specify the motor power required according to the load schedule but to calculate its power characteristics and power losses, to obtain data for specifying the overheating of the stator and rotor windings, to determine the overload capacity and to find optimal parameter values of the motor within the specified dimensions. Therefore, it is crucial to simulate the dynamic characteristics of these motors to optimize their design and performance. Mathematical simulations involve the use of mathematical models and algorithms to predict the behavior of the motor under different operating conditions. The simulation results can be used to optimize the motor design and control strategies. However, the benefits of this process are significant, as it can lead to the development of more efficient and reliable motors that can meet the demands of various applications.

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