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CREATING THE EQUIVALENT CURRENT OF ASYNCHRONOUS MOTOR WITH CONTROL ACTION MODULATION

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Abstract. Based on the fact that asynchronous motors go out of service for different reasons (through the overloads, adverse environmental conditions, low quality of power supply and so on) the necessity of carrying out of complex repairs was determined. As a result, it's possible to re-exploit the engine for a long time. The most weak point of electric motor during the repair works was identified. Considering the previously known publications that indicate the possibility of research real characteristics of repaired motor, there was provided the qualitative analysis, including existing deficiencies that would be reduced with help of the proposed system. Consequently, several solutions are proposed for motor windings electromagnetic energy change that help to load the motor excluding the possibility of mechanical influence to the shaft. These circumstances are substantiated by the formulas of the frequency, voltage and torque change. The graphs of artificial and natural mechanical characteristics with all work points indication are given for representation of electric motor full load cycle. The system was simulated with full cycle of loading and the results are presented in the form of phase coordinates oscillograms. The value of static load was chosen, according to the compliance terms of the rated current and sticking to nominal torque of the asynchronous motor. It was further defined and illustrated on oscillogram the loss power for showing benefit on the part of economy. As the research purpose was not only to produce a universal model, but also to make it economically profitable, the power loss was also determined and presented in an oscillogram form.

Keywords: asynchronous motor, frequency, the form of voltage, modulation, load, power, synchronous speed.

Introduction. As we know, asynchronous motors (AM) is one of the most common type of electrical motors, which are widely used in different fields [1, 5, 10]. That's why they are submitted high demands to reliability and operating time which increases responsibility of electrical repair enterprises. At repair AM the most vulnerable point in terms of changing its properties are electrical steel. The package of electrical steel changes its characteristics and integrity because of mechanical and thermal effects [2, 3]. The most influential factor is the process of temperature effects on the package during the roasting of windings for their removal. On another hand, quality of repair by technological parameters doesn't correspond to the level of production technology because of lack of universal equipment for research «random» motor [8, 9]. In this manner, the characteristics of fully repaired IM are different from the basic product, although exploitation is focused to the average factory indexes and in process of repeated exploitation breaks down soon [4, 6, 7, 11].

Materials and Methods. There are works in which the possibility of load AM without influence to the motor shaft by alternation operation modes of engine and changing the kinetic energy are considered [12]. Besides, there is a work based on the system thyristor voltage regulator – asynchronous motor (TVR-AM) in which load of AM was created under the influence of current and voltage harmonic components [13]. But the main disadvantages of this system are voltage distortion and the appearance of higher current harmonics in the network.

The main purpose of the article is the research of modulating type method by system frequency converter – asynchronous motor (FC-AM), which helps to realize current load of AM stator windings. On the other hand, the system must meet all requirements for ease of implementation, universality and efficiency of use.

Results. For changes the electromagnetic energy of windings, which is determined by the current of circuit magnetization, there are three approaches:

- influence on the shape of the voltage supply (amplitude modulation);
- influence on the frequency of the voltage supply (frequency modulation);
- influence on the shape of the field (polyharmonic loading).

Due to the fact that for the FC together with change of the supply voltage frequency we must regulate the supply voltage amplitude (for avoiding the magnetic system saturation) – loading by the amplitude modulation and frequency modulation represents one process. Changing frequency process going according the formula

$$f(t) = f_0 + \Delta f \cdot \sin(\Omega_к \cdot t), \qquad (1)$$

where f_0 - is the constant component of the frequency, Δf - is the increase of voltage supply frequency, $\Omega_к$ - is the angular frequency of changes the increase of the network frequency.

In this way, the synchronous speed of the motor field

$$\omega_0(t) = \omega_0 + \Delta\omega \cdot sin(\Omega_к \cdot t) = \omega_0 + \frac{2 \cdot \pi \cdot \Delta f}{p} \cdot sin(\Omega_к \cdot t). \quad (2)$$

The form of supply voltage described by the expression

$$U = U_0 \cdot \sin(\omega_0 \cdot t) \cdot (k + m \cdot \sin(\Omega \cdot t)), \quad (3)$$

where U_0 - is the amplitude, k, m - are the modulation coefficients, Ω - is the angular frequency modulation of amplitude.

Then, the torque of AM, which develops in conditions of equality rotor speed and the main magnetic flux

$$M = M_1 \cdot \cos(\Omega \cdot t) + \frac{M_2}{2} \sin(2 \cdot \Omega \cdot t) == \Phi_1 \cdot I_{2m} \cdot \cos(\Omega \cdot t) + \frac{\Phi_2 \cdot I_{2m}}{2} \sin(2 \cdot \Omega \cdot t), \qquad (4)$$

where I_{2m} - is the amplitude of rotor current, Φ_1 - is the main flux, Φ_2 - is the amplitude of pulsating flux.

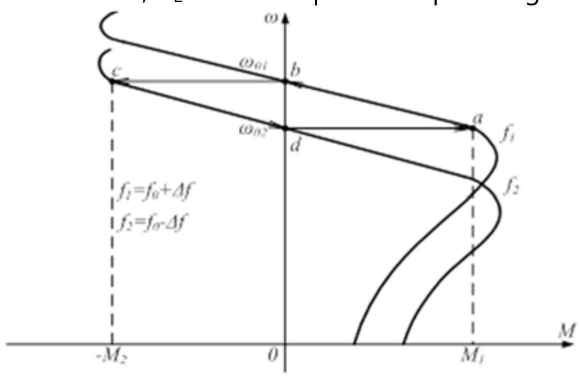

Figure 1. The cycle of load with frequency modulation of supply voltage

In case of frequency modulation, AM works in modes of motor and generator. The loading cycle is illustrated in Fig. 1. Point «*a*» is the nominal motor mode; the line «*bc*» is the generator mode with transmission to the artificial characteristic; the line «*da*» is the transmission to the natural characteristic; the line «*ab*» is the acceleration to the nominal speed.

Parameters f_0 and Δf are chosen so that the motor current and load torque should not extend nominal value (to avoid overheating). Asynchronous motor 4AM180S2 ($P_н$ = 22 kW, $n_н$ = 3000 rad/s) was chosen for simulation.

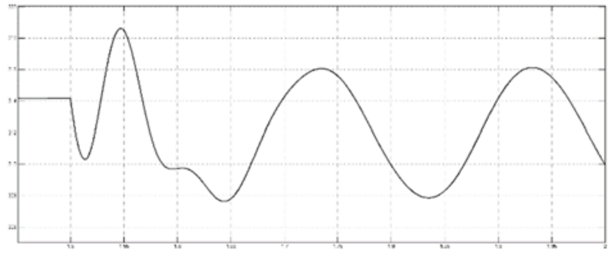

Figure 2. Oscillogram of rotor rotation speed with controlled influence 30+40·sin(31,4·t)

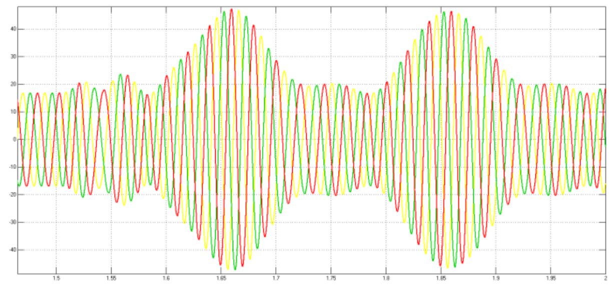

Figure 3. Oscillogram of the current in the three phases with controlled influence 30+40·sin(31,4·t)

Fig. 2 illustrates the oscillogram of rotor rotation speed with controlled influence 30+40·sin(31,4·t). One can see that rotor speed oscillations with a frequency about 5 Hz.

Fig. 3 illustrates three phase currents I_A, I_B, I_C. In this case the difference between the maximum values of the currents is:

- negative half-wave – 3,5%;
- positive half-wave – 2,6%;
- RMS currents value – 1,9%.

The RMS values of the load currents: $I_{д(A)}$ = 33,15 A; $I_{д(B)}$ = 32,91 A; $I_{д(C)}$ = 33,55 A, which is 76,8; 76,2; 77,7 % according to the nominal value.

It's necessary to note, that for modulation type load system the repetition period of current curve is the period of modulation, which is defined by

$$T_\Omega = \frac{2 \cdot \pi}{\Omega}, \qquad (5)$$

In this way, the effective value of the current, which determines the heating of AM, it is necessary to determine for the period of time T_Ω.

Forming of alternation sign torque is illustrated on fig. 4. In this case an amplitude of the torque is 89,64 N·m (positive part: 70 N·m; negative part: 19,64 N·m) at nominal value 70,06 N·m.

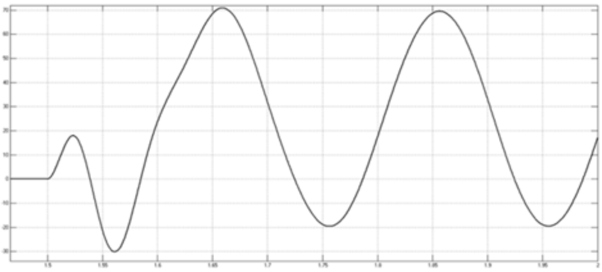

Figure 4. The torque of induction motor with controlled influence 30+40·sin(31,4·t)

Such factors are uniformity of phase loads, the possibility of rotor circle loading and economic effect determine effectiveness of using modulation type load for (FC-AM). If this system maintain the first two parameters, the problem of economy must be investigated.

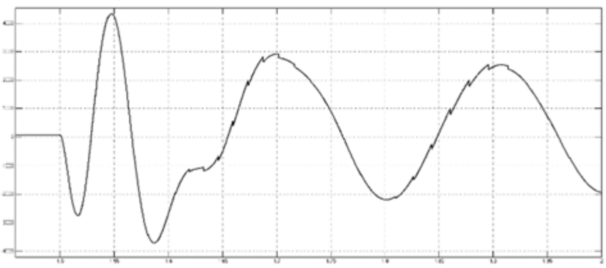

Figure 5. Loss of power in induction motor with controlled influence 30+40·sin(31,4·t)

The losses of power in AM depend on the load and defined as the electromagnetic energy and power on the motor shaft (fig.5). Moreover, the negative half-wave indicates the regenerative breaking.

Conclusions. On the basis of the researches we can conclude that with a help of using FC-AM system we may provide the load of «random» motor without influence to the shaft. Changing the frequency and amplitude of supply voltage make it possible to vary the level of stator circle load by the pulsed current. For confirmation the efficiency of the system it was conducted modeling of static load and determined the value of the loss of power which gives representation of the qualities of both economically and technically.

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