RESEARCH OF SOFT STARTING SYSTEMS OF AN INDUCTION MOTOR WITH AN INDUCTION RHEOSTAT IN FAN MECHANISMS

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Annotation. This article provides information on the use and control of an adjustable asynchronous electric drive with an induction rheostat. Theoretical calculations and study of motor starting modes for various asynchronous electric drive schemes are presented.

Keywords. Adjustable electric drive, asynchronous motor, induction rheostat, control systems, speed control, control characteristics, mechanical characteristics.

Regulating the rotation speed of the electric drive of fan mechanisms is a rather complex electromechanical system, including elements (thyristors, IR, etc.) with different laws of parameter change. Satisfying certain requirements with an electric drive is associated with changing the parameters (usually electrical and mechanical) of these elements as a function of time, rotation speed and other regulatory parameters of the system. Therefore, the justified use of an adjustable electric drive requires studying its operation not only in stationary modes, but also in dynamic ones.

Start-up processes are integral elements of the operating cycle of any electric drive. To take into account the influence of start-up processes on the operating mode of the production mechanism, it is necessary to know their duration and the nature of their occurrence.

One of the options for the starting circuit is a fairly simple circuit with a frequency-dependent induction rheostat (IR) connected to the rotor circuit [1-8]. An induction rheostat (IR) is a three-phase a device consisting of a massive magnetic circuit and phase windings. There are different designs of the magnetic circuit of induction resistances operating in starting mode at a rotor current frequency of 50 to 4-5 Hz, with the most common design containing three hollow tubular rods connected by a yoke. Due to the surface effect that determines electromagnetic processes in massive ferromagnetic bodies, the wall thickness of the tubular magnetic circuit is about 10 mm [1-4]. The winding is located on tubular rods and is usually single-layer. The principle of induction resistance is based on the phenomenon of absorption of electromagnetic energy by a massive magnetic circuit and its conversion into thermal energy. The higher the frequency of the current flowing through the windings of the IR, the higher the power absorbed by the magnetic circuit, which determines the electrical parameters of the induction resistance. The nature of the change in frequency and current magnitude in the IR windings determines the value of the complex active-inductive resistance of this device and affects the characteristics of the electric motor [9-11].

The starting characteristics of an electric drive are closely related to their operating characteristics. In the developed electric drives, with increasing resistance IR, the starting current decreases to the value $I_{n} = I_{n}$ and at the same time the starting torque M_{n} increases compared to the rated torque M_{n} to a certain value $r'_{irr(c)}$; $x'_{irr(c)}$. The next increase in $r'_{irr(c)}$; $x'_{irr(c)}$ leads to a decrease in M_{n} compared to M_{n}, but does not play an important role during startup pneumatic conveyor, because the nature of the load: $M_{C} \equiv n^2$.

With thyristor-induction-rheostat control of the electric drive of a pneumatic conveyor, of particular practical interest is the determination of starting characteristics for the cases:переменных U, фиксированных $r'_{upp}; x'_{upp}$;

variables r'_{irr}; x'_{irr}, fixed U;

variables r'_{irc}; x'_{irc}, r'_{irr}; x'_{irr}.

In the first case, on the stator side, the voltage is regulated using a thyristor regulator at certain values of the IR resistance in the rotor circuit. As U decreases, the starting current of the motor also decreases, since in this case

$$I_п = \frac{U}{\sqrt{(r_1 + r'_2 + r'_{irr})^2 + (x_1 + x'_2 + x'_{irr})^2}} \quad (1.1)$$

For this case we obtain the expression for the starting torque

$$M_п = \frac{m_1 U_1^2 (r'_2 + r'_{irr})}{\omega_o [(r_1 + r'_2 + r'_{irr})^2 + (x_1 + x'_2 + x'_{irr})^2]} \quad (1.2)$$

Let us consider the case of determining the starting characteristics for the value of the thyristor control angle α at constant values of the active and inductive resistance of the rotor. In Fig. 1.1. the dependences $I_{p}=f(\alpha), M_{p}=f(\alpha)$ are shown. Solid lines indicate cases for $\delta 2 = 0$, and dotted lines indicate cases for $\delta 2 = 2$.

It is clear from the curves that by increasing or decreasing the angle α in the range $\varphi \leq \alpha \leq 180°$, you can smoothly adjust the values of starting currents and torques from maximum to zero, i.e. By changing α you can smoothly start and stop the engine.

In the second case, the resistance IR is adjusted in the rotor circuit. The values of starting current I_{p} and starting torque M_{p} are determined by formula 1.1 and 1.2.

The best starting characteristics are obtained by reducing the voltage at the stator terminals and at the same time increasing the IR resistance in the wound rotor circuit. In Fig. 1.3. a;b the dependences of the starting torque and starting currents are given for various U_d and δ_{2}.

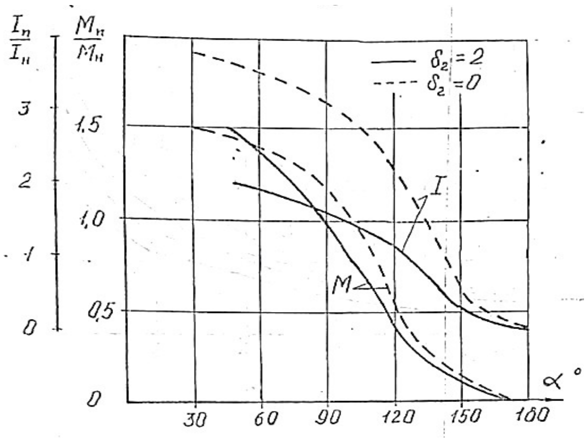


Рис. 1.1

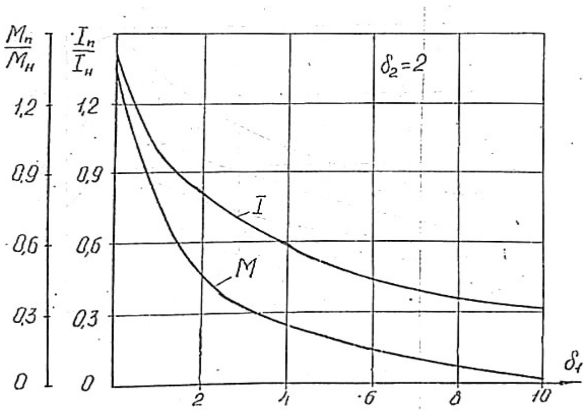
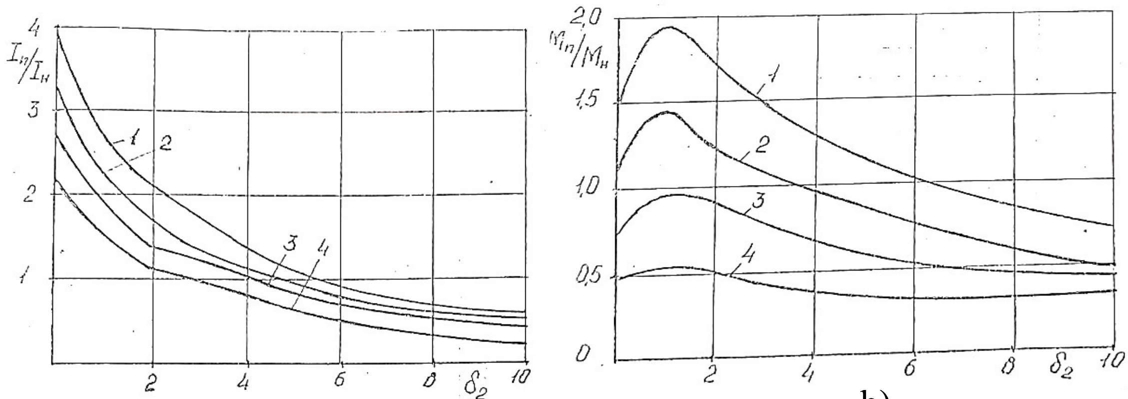
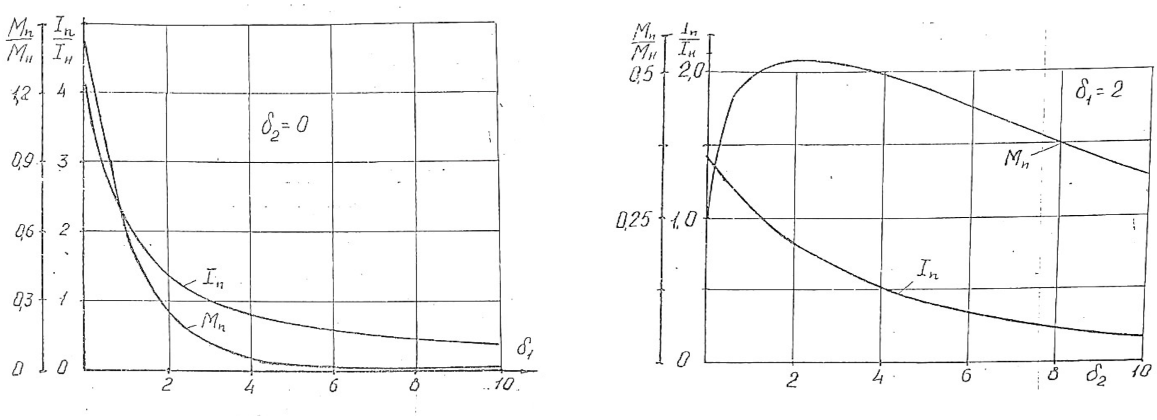


Рис. 1.2



a) b)

Рис. 1.3



a) b)

picture.1.4

In picture. 1.2. the dependences of the starting torque and starting currents are given at $\delta_1=0…I0$; $\delta_2= 2$

As you can see, when changing r'_{irs}, $x'_{(irs)}$ with the help of thyristors for different resistances of the stator circuit, it becomes possible to regulate the starting torques of the engine. Maximum increase in $M_{(p)}$ and

$I_{(p)}$ at $\delta_1 = 0$; $\delta_2 = 0$.
The curves show that optimal values of r'_{irr} remain in the rotor chain; x'_{irr} = const and using a thyristor controller by changing the values of r'_{irs}; $x'_{(irs)}$ you can adjust the values of $M_{(p)}$ and $I_{(p)}$ in a wide range.
In Fig. 1.4 a; b; the dependences $M_{(п)}$ and $I_{(п)}$ are shown for different values of $\delta_{(1)}$; $\delta_{(2)}$. From the curves it is clear that from $\delta_{(1)}$ and $\delta_{(2)}$ the starting current and starting torque are regulated in a wide range. In this case, a non-contact method ensures a smooth start, but, however, the method leads to complication of the electrical circuits of the electric drive.
The paper discusses the implementation of a soft start of an asynchronous electric drive with an induction rheostat connected to the rotor circuit. Which makes it possible to limit the starting current at the moment of starting, and as a result, control the starting torque of the electric motor. Smooth acceleration with a given starting torque is ensured. However, for electric drive systems that require speed control, an induction rheostat is more suitable as a frequency-parametric device.

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