Проведенные работы по исследованию износостойкости белых износостойких чугунов в лабораторных и промышленных условиях свидетельствуют, что литье с применением литейных холодильников позволяют увеличить износостойкость деталей «наковальня» дробилки модели KEV 96, не менее, чем на 20%.

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УДК 621.13

WAYS TO CONTROL ASYNCHRONOUS MOTOR WITH PHASE ROTOR OF MINING MACHINES

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The article describes various methods of controlling asynchronous motors with a phase rotor. To solve the problems of controlling speeds and moments in a modern electric drive, two main methods of frequency control are used: scalar and vector. Advantages and disadvantages of scalar and vector control, voltage dependence are given.

Currently, in the existing electrical equipment of mining complexes, asynchronous motors (ADFR) are widely used for powerful (more than 300 kW) mechanisms with difficult conditions for starting electric drives (EP): hoisting-and-transport mechanisms, electric conveyors, etc. Today, the production process is controlled based on the data of electromechanical systems by introducing additional active resistances into the motor rotor circuit. This method of regulation has already exhausted itself due to energy inefficiency [1].

The systems of parametric control of starting and speed control of asynchronous motors with a phase rotor used at the enterprises of the mining and metallurgical industry are uneconomical and do not meet modern requirements for dynamic performance [2].

One of the main ways to increase the energy efficiency of ADFR is to improve control systems designed to operate as part of a frequency-controlled electric drive.

Most modern AC drives for solving various problems are equipped with a frequency converter (IF). Despite the variety of current control algorithms and hardware options for implementing frequency converters, there are typical solutions used by most manufacturers. The structure of frequency converters and the functions they perform are as much as possible unified and standardized.

The adjustable electric drive solves two main tasks: control of the moments and rotational speeds of the electric motor.

The need to regulate the moment on the motor shaft is dictated by the technical and technological requirements for the electric drive. For normal operation of the drive, it is necessary to limit the specified torque and motor current to permissible values in transient processes of starting, braking and applying a load.

Management methods

To solve the problems of regulating speeds and moments in a modern electric drive, two main methods of frequency control are used: scalar and vector.

The most common today is an asynchronous electric drive with scalar control. It is used as part of pump drives, fans, compressors and other mechanisms for which it is important to maintain either the rotation speed of the motor shaft (using a speed sensor) or a process parameter (for example, the pressure in the pipeline, using the corresponding sensor).

The main principle of scalar control is the change in the frequency and amplitude of the supply voltage is expressed by the formula

$$U / f_n = \text{const},$$

где $n \geq 1$.

The specific type of dependence is determined by the requirements for an electric drive with a load. As a rule, the frequency is taken as an independent effect, and the voltage value at a given frequency determines the type of mechanical characteristic, the magnitude of the starting and critical moments (Fig. 1).

Scalar control ensures the constancy of the overload capacity of the electric drive regardless of the frequency of the voltage, however, there is a decrease in the torque developed by the motor at low frequencies (at $f < 0.1$ fnom). The maximum range for controlling the

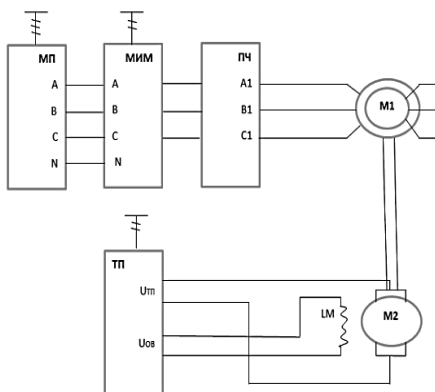rotor speed at a constant torque for electric drives with scalar control reaches 1:10.

Fig. 1 – Scheme of the stand for taking characteristics of the system of the frequency converter – asynchronous motor (FC-AM)

The scalar control method is relatively simple to implement, but has two significant drawbacks. Firstly, in the absence of a speed sensor on the motor shaft, it is impossible to regulate it when the shaft rotates, since the load affects the rotation of the shaft. The presence of a speed sensor solves this problem, however, there remains a second significant drawback - the moment on the motor shaft cannot be adjusted.

In 1971, SIEMENS proposed a vector control method to eliminate the disadvantages inherent in scalar control. The first vector-driven electric drives required motors with integrated flow sensors. This significantly limited the use of such electric drives.

In modern electric drives, a mathematical model of the engine is laid in the control system, which allows calculating the moment and speed of rotation of the motor shaft. In this case, only current sensors of the phases of the stator of the motor are necessary. Thanks to the special structure of the control system, independent and almost iner-tialess regulation of two main parameters is ensured - the torque on the shaft and the rotation speed.

When using vector control, the following advantages are achieved [3, 8]:

– high accuracy of speed control even in the absence of a speed sensor;

– smooth rotation of the motor shaft in the low frequency region;

– the ability to provide a nominal torque on the shaft at zero speed (in the presence of a speed sensor);

– quick response to load changes: during sudden jumps in load, practically no jumps in speed occur;

– providing such a mode of operation of the engine, in which the loss of heating and magnetization is reduced, and therefore, the efficiency is increased engine.
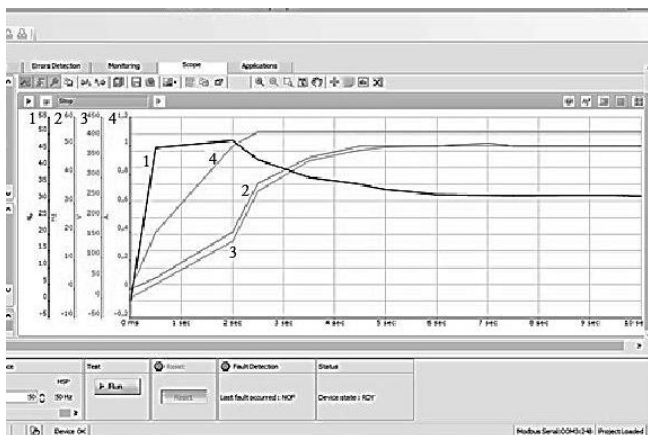

Fig. 2 – Dependences of voltage, current frequency and torque
on the motor shaft on time with scalar control:
1 – moment M; *2* – frequency f; *3* – voltage U; *4* – current I

More economical systems of the asynchronous valve cascade (AVC) on mass hoisting-and-transport mechanisms (PTM) are rarely used, since in difficult working conditions (humidity, steam, high temperature) they are not reliable enough. The introduction of AVC systems is difficult with the trolley power supply of the PTM electrical equipment, since a short-term power interruption is accompanied by a breakdown of the AVC inverter. Many PTM operate in an intensive, intermittent, short-term mode; therefore, conventional AVK systems require additional start-up nodes, and when adjusting speed over a wide range, an AVK drawback is manifested, which consists in a large consumption of reactive current by the inverter when operating at reduced motor speed [3, 4].

The way out of this situation may be the use of high-voltage ADFR control systems according to the scheme of an asynchronized synchronous machine (AFM) with vector control over rotor circuits.

Consider some ways to control blood pressure.

There are two directions for improving the PTM electric drive systems based on an asynchronous motor with a phase rotor:

First: for mechanisms where it is possible to use economical systems built according to the frequency and cascade principles, it is necessary to develop new systems with increased overload capacity, designed to work in repeated - short-term mode.

Second: a promising area is the development of a hybrid circuit that combines the features of cascade and frequency methods of controlling an asynchronous motor. The solution to this problem requires the development of the foundations of the theory of cascade-frequency and cascade-inverter control of an asynchronous motor with a phase rotor.

ADFR-based progressive energy-saving electric drive systems are hybrid systems built on the basis of a frequency and parametric control system with induction resistance (IS), as well as frequency and cascade electric drives that provide mechanical characteristics of the excavator type. For the distribution of these electric drive systems to the PTM, it is necessary to improve control systems and provide the ability to work in intensive, intermittent and short-term operation.

In cascade systems of electric drives, which are used to obtain single-quadrant mechanical characteristics, alternating voltage removed from the contact rings of the ADFR rotor is fed through a rectifier to the DC circuit.

The system of a frequency electric drive, built on the basis of an asynchronous motor with a phase rotor and an IS, provides mechanical characteristics of the "excavator" type with an open control system. In a twin-engine electric drive, parallel connection of the valve-resistor synchronizing block to the IC allows you to equalize the engine speeds.

As a result, systems of a frequency-cascade electric drive, built on the basis of an asynchronous motor with a phase rotor, make it possible to derive the sliding energy from the rotor circuit to the DC link and reuse it to power the stator winding when the voltage is reduced. Compared with traditional AVC systems, the consumption of reactive power from the network has been increased, which is especially important for hoisting-and-transport mechanisms operating in intensive inter-short-time mode.

The electric drive according to the scheme of an asynchronous valve cascade allows for non-contact smooth start-up and speed control of an asynchronous electric motor with a phase rotor, adjusting the amount of slip of the rotor of the electric motor by introducing an adjustable back-emf into the rotor circuit. The regulation of the EMF of the rotor of the electric motor in the AVC circuit is ensured by changing, according to a given law, the opening angle of the thyristors of the corresponding DC converter, which is included in the rotor circuit as an adjustable counter-EMF and operates in inverter mode.

Thus, in the process of AVC operation, the sliding energy of the rotor of the asynchronous electric motor is returned to the supply network, due to which this electric drive circuit has a high efficiency.

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УДК 622.83.023.4:624.121
ДИСТОРТНОСТЬ В ГЕОТЕХНОЛОГИЧЕСКИХ СИСТЕМАХ

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Приведены основные результаты развития теории дистортности на протяжении 25 лет со дня введения нового научного понятия.
Представлена универсальная таблица предельных инвариантов дистортности.

Как связаны друг с другом явления, происходящие в геотехнологических системах? Каким образом можно более достоверно отразить зависимости между определяющими величинами, описывающими эти явления?

Классический аппарат естествознания был создан, прежде всего, на линейной основе равным изменениям. Изменение одной независимой величины должно непреложно отвечать пропорциональной связи с другой зависимой величиной. И хотя примеров линейности нашего мира множество, вся природа, не укладывается в рамки пусть и строгой, но, увы, далеко не идеальной схемы. Вне этих рамок – но ближе к реальности властвует нелинейность. В последние десятилетия, и особенно в последние годы сильно возрос интерес к оценке нелинейных явлений в различных областях знаний. Достижения современной науки и техники невозможны без прочно вошедших в них нелинейных представлений. На них базируется теория нелинейных колебаний и волн, теория динамических систем, теория катастроф, синергетика, современные представления об эволюции в диссипативных структурах. Работы в этом направлении вызвали в науке настоящую революцию, а в терминологии философов появились выражения «нелинейное мышление» и «нелинейная

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