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MATHEMATICAL MODEL OF THE ELECTRIC DRIVE SYSTEM OF THE MAIN FAN INSTALLATION

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Keywords: mathematical modeling, electric drive, technological unit, mining enterprise, MatLab, Simulink.
Abstract. Mathematical modeling of the frequency-controlled electric drive system of the main fan installation of an underground mine for the extraction of diamond-bearing rocks in the MatLab/Simulink environment is considered. The model was developed based on the block diagram of the actually used installation according to the well-known method of Professor Fashchilenko. The authors improved the typical mathematical model by adding blocks that take into account the efficiency of the fan, motor and frequency converter. As a result of the simulation, the values of the angular speed of rotation, flow, pressure and power consumption of the fan installation were obtained with an error not exceeding 5% in relation to the initial data and calculated parameters.

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ СИСТЕМЫ ЭЛЕКТРОПРИВОДА ГЛАВНОЙ ВЕНТИЛЯТОРНОЙ УСТАНОВКИ

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Ключевые слова: математическое моделирование, электропривод, технологическая установка, горное предприятие, MatLab, Simulink.
Аннотация. Рассмотрено математическое моделирование системы частотно-регулируемого электропривода главной вентиляторной установки подземного рудника по добыче алмазосодержащих пород в среде MatLab/Simulink. Модель разработана на основании структурной схемы реально используемой установки по известной методике профессора Фащиленко. Типовая математическая модель была доработана авторами путем добавления блоков, учитывающих коэффициенты полезного действия вентилятора, двигателя и преобразователя частоты. В результате моделирования получили значения угловой скорости вращения, подачи, давления и потребляемой мощности вентиляторной установки с погрешностью, не превышающей 5% по отношению к исходным данным и расчетным параметрам.

One of the most critical and most energy-intensive units of the mine is the main ventilation fan, which serves to create a safe atmosphere for mining operations in mines and mines. The electric drive system of the main fan unit (MFU) consists of a fan, a high-voltage electric motor, a frequency converter, ventilation duct systems for reversing and switching the airflow, as well as control and remote control equipment [1].

Airflow and depression often need to be adjusted to sufficiently large values. The operation of the fan depends on many parameters, so the following must be taken into account: capacity regulation within 10÷15% requires seasonal fluctuation of the environment (pressure and temperature); the required air capacity may increase by 1.5÷2 times over the life of the mine; blasting at the end of shifts requires an increase of 15÷20% productivity (daily rhythm of mining operations); productivity can be reduced to 30÷50% of the working one on holidays and repair days [2].

As we can see, a large area of economical control modes must be ensured during the operation of the MFU. An effective method of controlling the electric drive of such fans is frequency regulation. A change in the frequency of the supply voltage is understood as ensuring the regulation of speed or torque in a given range with the required accuracy. Modern frequency converters (FC) are easily integrated into any automation systems, do not require complex matching circuits and have built-in service capabilities (control of the drive motor speed and current, advanced protection system, etc.) [3].

Modeling of the MFU electric drive system will be performed using the MatLab software product in the Simulink environment based on the block diagram shown in Fig. 1 [4].

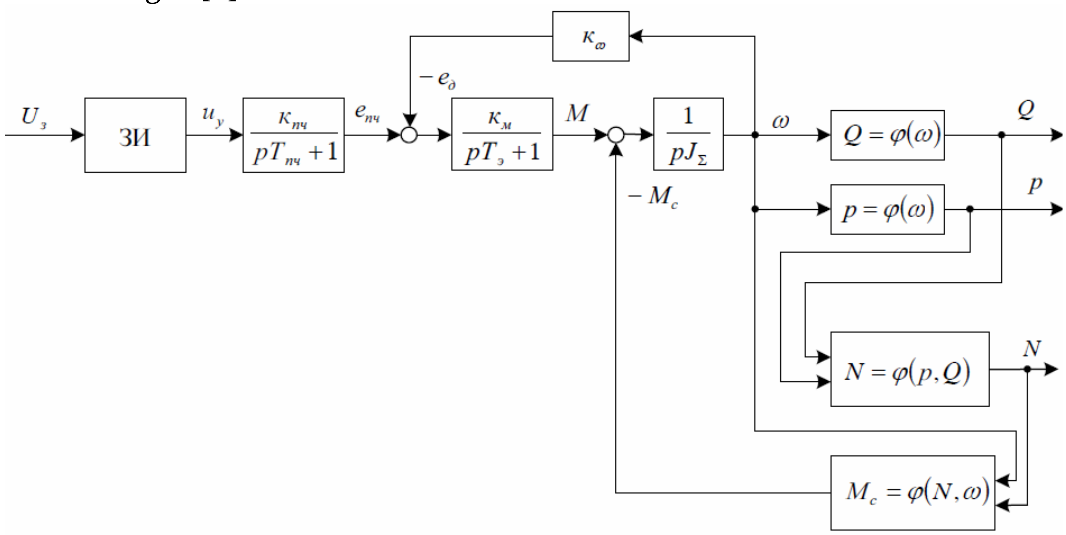

Fig. 1. Structural diagram of the system of FC electric drive of the MFU

Calculation of supply, static pressure, efficiency, power, static moment of resistance of the fan is carried out using the dependencies obtained for calculating the operating parameters of the fan at a variable angular speed of the impeller. The model is built to be able to model different fans to provide different inputs. For perception of the model, it is visually convenient to calculate each of the parameters using subsystems [5].

For a VCD-31.5M fan with an AOD-1600-10U1 asynchronous motor, the functional diagram with the numerical values of the elements of the MFU variable frequency drive (VFD) system is shown in Fig. 2.

All parameters for this model are calculated.

The drive model contains: input device for setting the speed (Constant2); frequency converter model implemented on aperiodic link of the first order (Transfer Fcn1); EMF adder of the frequency converter and internal feedback on the motor EMF; transfer function of the moment link implemented on the aperiodic link of the first order (Transfer Fcn); adder of the electromagnetic torque of the motor and the negative moment of static resistance created by the fan; engine speed link implemented with the help of an integrator (Integrator) and an amplifier (Gain); internal EMF feedback of the motor is implemented using an amplifier (Gain1).

The output coordinate of the variable frequency drive model is the angular velocity, which is recorded using the Display and the Scope [6].

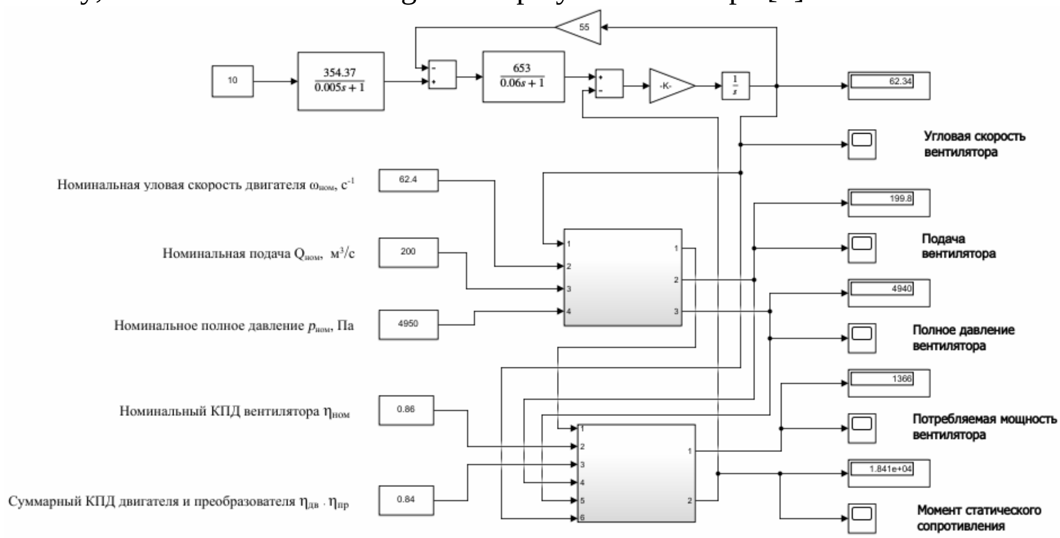

Fig. 2. Functional diagram of the MFU VFD system

The fan model is represented by two subsystems (Subsystem and Subsystem1). The input (initial) parameters of the fan are implemented on five sources of constant action (Constant). The display of the numerical values of the quantities calculated in the model is carried out using Display blocks, and the dynamics of coordinate changes is carried out using Scope oscilloscopes [7].

Graphical simulation results are shown in Fig. 3.

Thanks to the designed and developed mathematical model, it is possible to solve various problems related to different modes of regulation of the MFU VFD system, as well as its energy consumption.

Thus, after successful modeling of the VFD system, it can be said that the electric drive with a frequency converter has a high efficiency of operation, the fan efficiency is not lost during regulation, it has a simple design, it shows an increase in the operation of the economical area and a decrease in power consumption.

It should be noted that the use of an adjustable electric drive additionally provides: lighter operating modes at a reduced rotation speed, thereby increasing the life of the fan; transmission and distribution of electricity, and a reduction in production costs, which is due to a reduction in its consumption by almost half.

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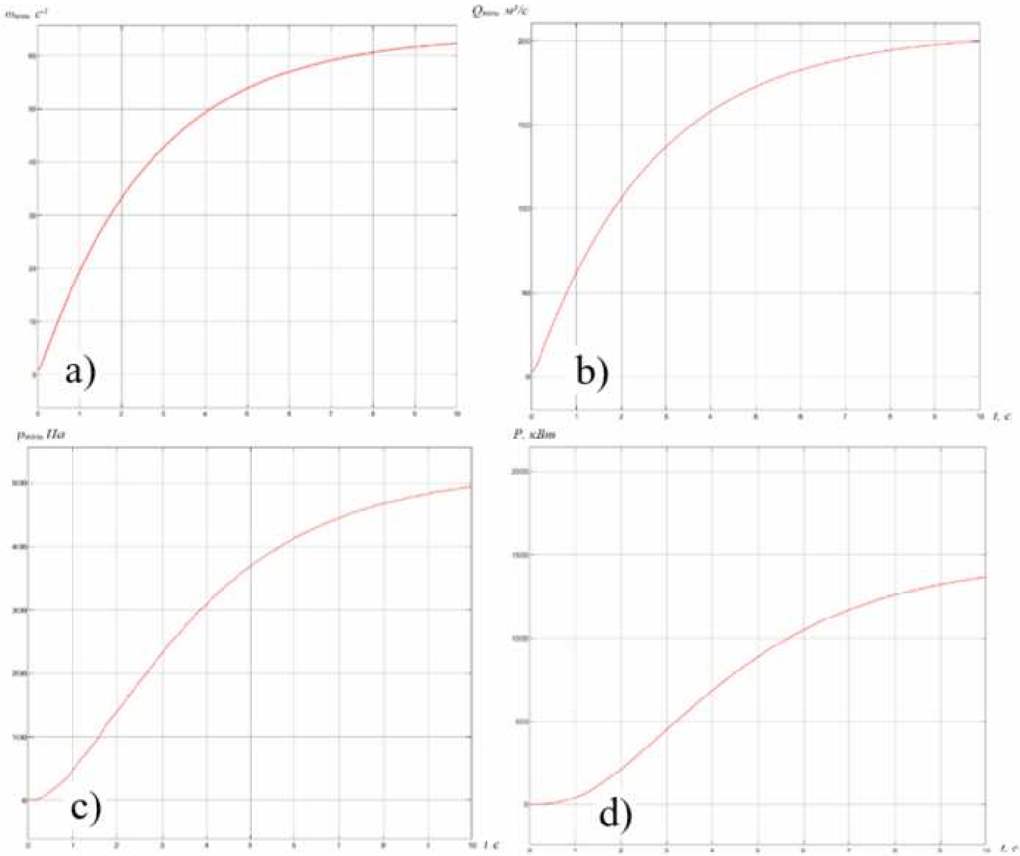

Fig. 3. Graphical results of simulation of the MFU VFD system: a) angular velocity; b) submission; c) pressure; d) power consumption

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