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CREATION OF COMPUTER MODELS OF PROCESS UNITS USING THE EXAMPLE OF AN UNDERGROUND DIAMOND MINING MINE

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Keywords: modeling, MatLab, electric drive, engine, process unit, underground mine.
Abstract. The article considers issues related to modeling electric power and electrical engineering systems. The MatLab package was selected as a modeling program. The Simulink/SimPowerSystems application was used to implement physical models. The necessary parameters for modeling were calculated. Computer models of electric drive systems of typical industrial units were created using the example of an underground diamond mining mine. The modeling results were obtained, showing the direct start of an asynchronous motor, rheostat start of a DC motor, and start of a synchronous motor. The obtained results were analyzed.

СОЗДАНИЕ КОМПЬЮТЕРНЫХ МОДЕЛЕЙ ТЕХНОЛОГИЧЕСКИХ УСТАНОВОК НА ПРИМЕРЕ АЛМАЗОДОБЫВАЮЩЕГО ПОДЗЕМНОГО РУДНИКА

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Ключевые слова: моделирование, MatLab, электропривод, двигатель, технологическая установка, подземный рудник.
Аннотация. Рассмотрены вопросы, связанные с моделированием электроэнергетических и электротехнических систем. В качестве программы моделирования выбран пакет MatLab. Для реализации физических моделей использовано приложение Simulink/SimPowerSystems. Произведен расчет необходимых параметров для моделирования. Созданы компьютерные модели систем электропривода типовых промышленных установок на примере подземного алмазодобывающего рудника. Получены результаты моделирования, показывающие прямой пуск асинхронного двигателя, реостатный запуск двигателя постоянного тока, пуск синхронного двигателя. Проанализированы полученные результаты.

Introduction. Industrial production in our country is the main consumer of electrical energy (about 65% of all generated). Currently, electrical energy systems (power supply systems and electric drive systems) of industrial enterprises are becoming more complex and energy-intensive. Some, for example, mining enterprises are very energy-intensive (the installed capacity of consumers can reach 50 MW). Therefore, the development and design of their electrical energy systems is difficult without the use of computer and simulation modeling programs [1]. The development of so-called digital twins will allow you to boldly experiment with various parameters of electrical equipment to select the optimal one from the point of view of the technological process [2].

Methods and techniques. The SimPowerSystems block library is one of many additional Simulink libraries of the MatLab software package, focused on

modeling electromechanical and electric power systems and devices. SimPowerSystems contains a set of blocks for simulating electrical devices. The library includes models of passive and active electrical elements, energy sources, electric motors, transformers, power lines and other equipment. There is also a section containing blocks for simulating power electronics devices, including control systems for them. Using the special capabilities of Simulink and SimPowerSystems, the user can not only simulate the operation of devices in the time domain, but also perform various types of analysis of such devices. In particular, the user has the ability to calculate the steady-state mode of the system on alternating current, calculate the impedance of a section of the circuit, obtain frequency characteristics, analyze stability, and also perform harmonic analysis of currents and voltages [3].

Some problems that arise in the development of computer simulation programs for electric drive systems or power supply systems for process installations at mining enterprises, which are addressed in this paper [4]:

– complexity of mathematical models – some of them are multi-loop or multi-channel, contain a large number of cross-connections, which complicates or makes impossible their use in the development of control systems: solved by moving from structural to simulation (physical) modeling;

– accounting for the dynamic properties of the electric drive – some models do not take into account the dynamic properties of the electric drive, while others present simplified models of the mechanical part of the system: solved by using the MatLab software package, which models dynamic systems well;

– ensuring smooth starting and braking – the electric drive system must ensure smooth starting and braking with acceleration limitation, smaller torque fluctuations and limitation of the electric motor current during start-up: can be solved by using variable-frequency electric drive systems, not used in this paper;

– accounting for the quality of electricity – in the process of frequent switching (on/off) of electrical equipment, transient processes may occur that affect the quality of electricity, also powerful power equipment can generate harmonic distortions in power supply systems: solved by using ideal keys (switches) in models, as well as by using compensation units.

Object and subject of research. The study covers the electric drive systems of the main technological units of the diamond mining mine, such as the fan, pump, compressor, skip and cage hoisting units, as well as the mining combine. These six units are among the most powerful single consumers of the mine. They use all types of electric drives: asynchronous, synchronous and direct current.

1. The main ventilation system at the mine is needed for continuous ventilation of the mine workings and creation of normal atmospheric conditions in them.

2. A pumping unit in an underground mine is needed to pump out accumulated water, which poses a threat to equipment and personnel, increases the risk of accidents and reduces productivity.

3. The compressor unit of an underground mine is designed to supply compressed air to the working units of pneumatic machines and mechanisms.

4. A skip hoist is required for transporting minerals or rock in skips along rail tracks from quarry levels.

5. The cage lifting installation is designed for moving minerals, rocks, people, materials and equipment in cages.

6. A mining combine is a combined mining machine that separates minerals from the massif while simultaneously loading them onto a face conveyor.

The external appearance of the above-mentioned technological installations of the underground mine is shown in Figure 1.

Fig. 1. External view of process units: a) fan, b) pump, c) compressor, d) skip, e) cage, f) mining combine

Creating models and simulation results. The computer model (Fig. 2) is an analogue of a basic electrical circuit consisting of AC or DC voltage sources, an AC or DC motor unit, a unit for measuring the main parameters of the motor, an oscilloscope for measuring current, torque and speed.

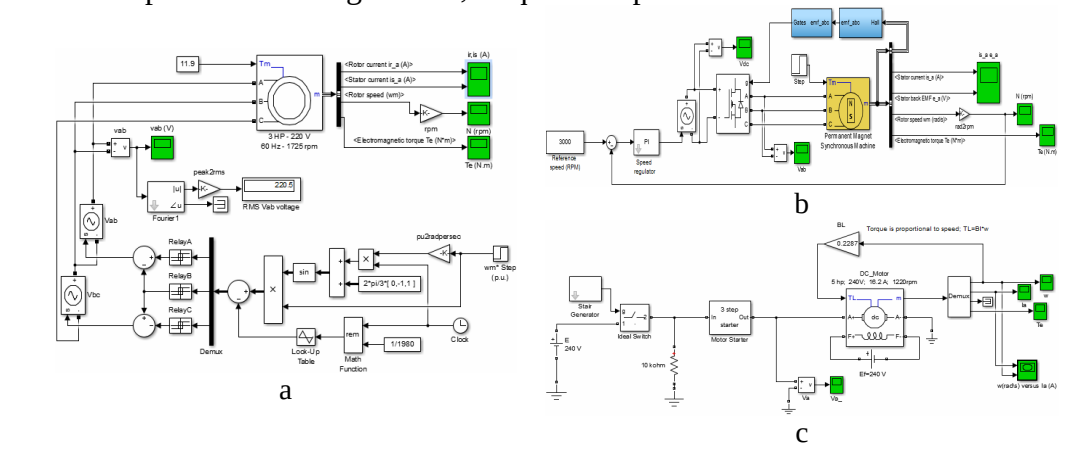

Fig. 2. Engine model: a) asynchronous, b) synchronous, c) direct current

To simulate the engines of the corresponding technological units, we will calculate the missing winding data using the method of Professor I.V. Chernykh [5]. We substitute the calculated parameters into the engine block parameter window. Having simulated, we take the current, angular velocity and torque readings.

The simulation results are graphical dependencies of the current, rotation frequency and torque of an AC or DC electric motor on time. For clarity, we will summarize the obtained results in Table 1.

Tab. 1. Simulation results

N	Parameter	Asynchronous motor	Synchronous motor	DC motor
1	Current, A	12	4.5	15
2	Rotation speed, rpm	1720	3000	1220
3	Torque, H·m	17.5	3.5	26
4	Start time, sec	0.8	0.15	7

The simulation results show that, with approximately the same parameters, the most preferable in terms of current and torque, as well as start-up time, is a synchronous motor. However, it is more expensive and metal-intensive compared to an asynchronous motor, which also showed good simulation results. A DC motor loses in all parameters, and in fact, DC-motor-based electric drive systems are currently used less and less in mining plant process units.

Conclusion. In conclusion, it is worth noting that issues related to the modeling of electric power and electrical engineering systems were considered. The MatLab package was chosen as the modeling program. The Simulink/SimPowerSystems application was used to implement physical models.

Computer models of the electric drive system of typical process units were created and tested using an underground diamond mine as an example. The modeling results were obtained in the form of time dependencies of current, angular speed of rotation, and engine torque.

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