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Study of starting modes of synchronous drives of mining and metallurgical enterprises

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ABSTRACT:The influence of the process of starting high-voltage synchronous electric motors of mills on its operating mode is considered. The possibilities of the mode of starting electromechanical complexes with synchronous electric motors have been studied. A mathematical model of an electromechanical complex is presented, which implements various starting methods. It is shown that the start-up of a rubber-lined mill provides a decrease in the start-up time and an easier start-up regime.

KEY WORDS: Start mode, high voltage synchronous motor, ore grinding mill, Park-Gorev equation

I. INTRODUCTION

When operating electrical equipment of mining and metallurgical enterprises in modern economic conditions, non-stop and trouble-free production is of particular importance. Restoring the production cycle, complex technological process and normal operating conditions after a downtime or accident is a difficult task.

The most energy-consuming elements of mining and metallurgical enterprises are high-voltage electric motors of mill installations driven by a synchronous electric motor (SD) with a capacity of 2.5 - 4 MW. When starting high-voltage synchronous motors of mills, the residual voltage on the 6 kV buses reaches 70% or less, which is unacceptable. Also, it becomes impossible to mass self-start of electric motors after voltage recovery on power supplies. Therefore, it is urgent to develop a system for smooth start-up of high-voltage motors, which ensures the electromagnetic compatibility of equipment.

Due to the constant increase in the cost of electricity, it is economically and technically feasible to use variable electric drives. An effective solution to this problem in industrial enterprises is the use of soft start systems, which should provide[1]:

1) the formation of the specified starting characteristics of electric motors (soft start, engine start in conditions of enterprises with a power shortage, reversal, braking and stopping);

2) flexible control of operating modes of electric motors in accordance with technological necessity (optimization of the distribution of loads between mechanisms inside and between adjacent objects);

3) an unlimited number of starts during operation (rational and economical use of equipment, taking into account the electricity tariff);

4) optimization of starting and braking torques for shockless accelerations and stops of driven mechanisms, increasing the service life of bearings, gearboxes, belts and other machine parts;

5) protection of electrical and mechanical equipment from emergency conditions.

Depending on the operating conditions of stationary installations, there must be various restrictions on the part of the working mechanism and the power supply system and the drive motor [1]:

- voltage loss in the power supply system should not exceed the permissible;
- acceleration during the acceleration of the mechanism should not exceed the permissible value both for the mechanism and for the engine itself;

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Vol. 7, Issue 7 , July 2020

- heating of the motor windings during start-up should not exceed the permissible value;
- the deviation of the operating characteristics of electric drives operating in parallel with stationary installations should not exceed the permissible according to the conditions of the technological process;
- the cost of starting equipment should be as low as possible.

There are various ways to start the pumping unit SM: asynchronous; using an overclocking device; autotransformer and reactor; thyristor; frequency. The process of starting the SM can be divided conventionally into two stages. At the first stage, acceleration occurs up to the subsynchronous rotation frequency (up to slip $S \leqslant 0.05$), mainly under the influence of an asynchronous torque. The second stage is the process of getting into synchronicity.

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses to the starting modes of high voltage synchronous motors. A rational start is determined. The study of literature survey is presented in section III, Methodology is explained in section IV, and section Vdiscusses the future study and Conclusion.

III. LITERATURE SURVEY

Baghdasaryan M. proposedthe main energy and technological factors affecting the technical condition of synchronous motors are evaluated. An algorithm for preventing the irregular operation modes of the electrical drive synchronous motor applied in the ore-grinding technological process has been developed and proposed for further application which gives an opportunity to provide smart solutions, ensuring the safe operation of the drive synchronous motor by a comprehensive consideration of the energy and technological factors.

Nøland J.K. et al.presentedWFSM are included in the majority of large power generating units and special high-power motor drives, due to their high efficiency, flexible field excitation and intrinsic flux weakening capability. Moreover, they are employed in a wide range of high-end solutions in the low-to-medium power range. This contribution presents a comprehensive survey of classical and modern methods and technologies for excitation systems (ESs) of (WFSMs). The work covers the fundamental theory, typical de-excitation methods and all the modern excitation equipment topologies in detail. It also includes a description of the state-of-the-art and the latest trends in the ESs of wound-field synchronous motors and generators. The purpose of the paper is to provide a useful and up-to-date reference for practitioners and researchers in the field.

Semenov A. S.et al. presentedthe work carried out theoretical and experimental studies on the measurement of electric power quality indicators at mining enterprises, assessed the effectiveness of the applied compensation instruments for higher harmonics, and developed proposals for creating a system for continuous monitoring of electric power quality indicators. As objects of study, electrical installations of surface and underground complexes of mines connected to 6 kV distribution networks and used in the extraction and processing of diamondiferous ores were considered. The results of the introduction of a system for monitoring the quality indicators of electric power on electric drives and frequency converters of a number of technological units are considered, a feasibility study is made and recommendations are made to improve the energy efficiency of using a frequency-controlled electric drive.

Tasheva Kh. T. provided an assessment of the state of operation modes of mill installations in the mining and metallurgical industry. It is shown that one of the options for increasing the efficiency of electrical energy use is the transition to a variable electric drive.

Mnoyan T.N. studied the relationship between the heating of the winding insulation and the operating modes of the drive motor of the ore grinding mill is substantiated, taking into account the fact that the heating duration is limited based on considerations of the permissible heating of the stator and rotor windings. Changes in the current multiplicity in the asynchronous mode at different values of the load torque, voltage at the motor terminals and the starting current multiplicity are considered. The dependence of the permissible short-term temperature rise of the stator windings on the load torque is investigated for different values of the operating time in the asynchronous mode. The dependence for the study of losses in the rotor and determination of the permissible load of the asynchronous mode of operation of the drive synchronous motor of the ore grinding mill is obtained. The basic requirements are stated to prevent premature

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Vol. 7, Issue 7 , July 2020

failure of the motor caused by heating in the stator and rotor windings. A soft start device is proposed that allows you to select the optimal characteristic for the desired technological mode of the grinding process when starting and operating the engine in asynchronous mode.

Baghdasaryan M.K.et al. proposed the possibilities of operation of a synchronous motor in a short-term asynchronous mode are considered. The main features contributing to the appearance of an asynchronous mode of a drive synchronous motor of an ore grinding mill are stated. In particular, the main sources are listed for which a short-term asynchronous mode can be emergency or operational. The necessity of studying the operating mode of the drive synchronous motor of the ore grinding mill when it falls out of synchronism is substantiated. Taking into account the types of synchronous motors used in the drive system of an ore grinding mill, a method has been developed to study the asynchronous mode of operation of the drive synchronous motor of an ore grinding mill in the event of a loss of synchronism or during asynchronous start-up. The obtained dependences make it possible, for different drive motors and moments of resistance, to study the change in voltage at the motor terminals and, thereby, to determine the permissible limit of its change, which does not allow emergency operation of the engine.

IV. METHODOLOGY

According to [18], at the initial moment of starting the mill, when dry contact takes place, the static coefficient of sliding friction of the steel trunnion on the babbitt of the bearing housing is f_0 = 0.210, and at steady state operation, the dynamic coefficient of friction is f = 0.013 - 0.024.

The total moment of friction in bearings is determined by the formula

$$M_{mp} = f(N_1 + N_2)R_c, \tag{1}$$

where N_1, N_2 - loads perceived by bearings; R_c is the radius of the drum journals.

It can be seen from the formula that a decrease in the loads taken by the bearings leads to a decrease in the friction torque also by 1.2 - 1.1 times. In addition, the starting conditions are facilitated, since the initial value of the friction moment decreases, equal to

$$M_{mp_0} = f_0(N_1 + N_2)R_c. \tag{2}$$

To assess the energy consumption for friction in bearings, we note that the power expended on friction is equal to $P_{mp} = M_{mp}\omega_б$, where $\omega_б$ is the angular speed of rotation of the drum.

The influence of the dynamic parameters of a drum mill can be considered most fully on the basis of an adequate mathematical model, where transients in a synchronous motor are described by the complete Park - Gorev equations [8]

$$\left.\begin{aligned}
U_{id} &= i_{id}\cdot R_s + p\Psi_{sd} - \omega\cdot\Psi_{sq};\\
U_{iq} &= i_{iq}\cdot R_s + p\Psi_{sq} + \omega\cdot\Psi_{sd};\\
U_f &= i_f\cdot R_f + p\Psi_f;\\
0 &= i_{rd}^{(1)}\cdot R_{rd}^{(1)} + p\Psi_{rd}^{(1)};\\
0 &= i_{rd}^{(2)}\cdot R_{rd}^{(2)} + p\Psi_{rd}^{(2)};\\
0 &= i_{rq}^{(1)}\cdot R_{rq}^{(1)} + p\Psi_{rq}^{(1)};\\
0 &= i_{rq}^{(2)}\cdot R_{rq}^{(2)} + p\Psi_{rq}^{(2)}.
\end{aligned}\right\} \tag{3}$$

Here $i_{sd}, i_{rd}^{(1)}, i_{rd}^{(2)}, \Psi_{sd}, \Psi_{rd}^{(1)}, \Psi_{rd}^{(2)}, i_{sq}, i_{rq}^{(1)}, i_{rq}^{(2)}, \Psi_{sq}, \Psi_{rq}^{(1)}, \Psi_{rq}^{(2)}$ are the components of the current vectors and flux linkages of the stator and rotor contours, respectively, along the d and q axes; i_f, Ψ_f - current and flux linkage in the

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excitation winding; $R_s, R_f, R_{rd}^{(1)}, R_{rd}^{(2)}, R_{rq}^{(1)}, R_{rq}^{(2)}$ - active resistance of the phase of the stator winding, field winding, as well as the resistance of the rotor circuits, respectively, along the d and q axes; ω - rotor speed.

The equivalent circuit of a synchronous motor in the d and q axes is shown in Fig. 1.

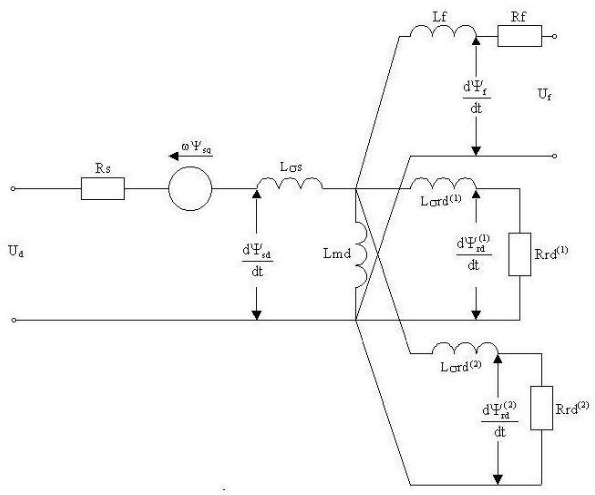

Fig. 1. Equivalent circuit of a synchronous motor

Figure 2 shows the calculated dependences of the angular speed and torque in the drive shaft when starting a synchronous motor of a rubber-lined mill, which show that the use of a rubber lining made it possible to reduce the start-up time by 1.4 times.

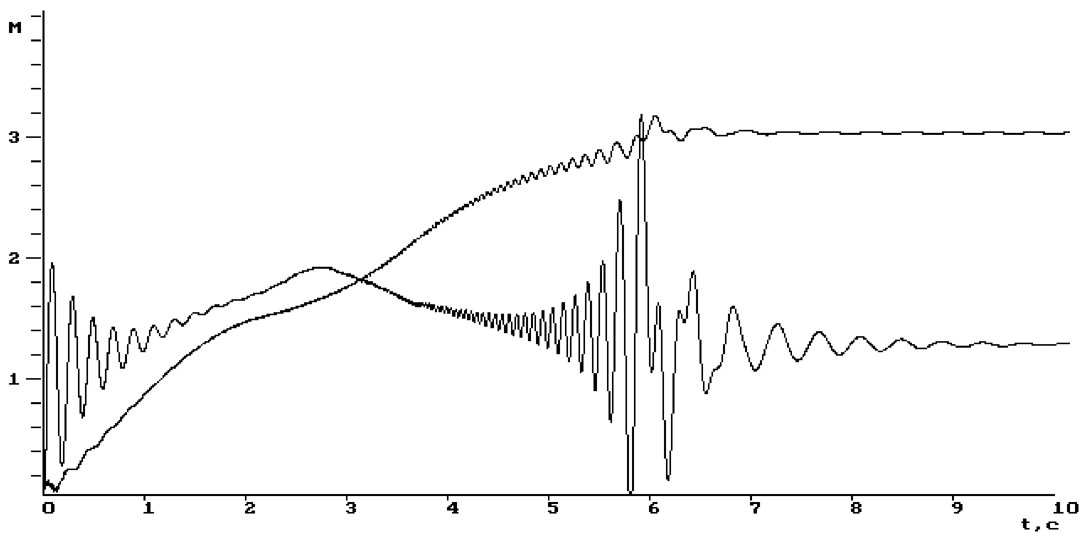

Fig. 2. Dynamics of the drive of the mill at start-up

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V.CONCLUSION AND FUTURE WORK

The literary review and analysis of the current state of the technology of the grinding stage carried out in the framework of this work showed that direct start-up of the mill engine presents certain difficulties, especially in conditions of limited power supply networks. The use of rubber lining facilitates starting conditions. It has been determined that the use of a rubber lining can reduce the start-up time by 1.4 times and reduce the power consumption for the start-up mode by up to 1.2 times.

REFERENCES

[1] Abramovich B.N., Ustinov D.A., Plotnikov I.G., and Turysheva A.V. "Investigation of starting modes of synchronous drives of oil and gas companies" Notes of the Mining Institute, vol. 196, 2012, pp. 218-221.
[2] Baghdasaryan M. An Algorithm for Preventing the Irregular Operation Modes of the Drive Synchronous Motor Providing the Ore Grinding // Open Science Index, Electrical and Computer Engineering Vol:14, No:6, 2020 waset.org/Publication/10011282.
[3] Nøland J.K., Nuzzo S., Tessarolo A., Fernando E. Excitation System Technologies for Wound-Field Synchronous Machines: Survey of Solutions and Evolving Trends // IEEE Access (Volume: 7) P.: 109699 – 109718. Date of Publication: 06 August 2019 . Electronic ISSN: 2169-3536.
[4] Semenov A. S., Semenova M. N., Fedorov O.V. The Results of the Implementation of the System for Monitoring the Quality of Electricity in Mining Enterprises // 2019 1st International Conference on Control Systems, Mathematical Modelling, Automation and Energy Efficiency (SUMMA). 20-22 Nov. 2019. Lipetsk, Russia.
[5]Tasheva Kh.T. Features of start-up regimes of milling installations of the mining and metallurgical industry // Scientific and practical research. No. 7-2 (30), 2020. P . 8-10.
[6]Mnoyan T.N. To research heating of the winding of the synchronous motor of the ore-grinding mill, arising in the asynchronous mode // Bulletin of The National Polytechnical University of Armenia. Electrical Engineering, Energy. 2017. P. 49-55.
[7]Baghdasaryan M.K., Mnoyan T.N., Alaverdyan S.S. Study of the asynchronous operation mode of the drive synchronous motor of the ore-grinding mill at voltage deviations in the network // Bulletin of The National Polytechnical University of Armenia. Electrical engineering, energy. Issue: No 2 (2016) Pages: 28-34.
[8] Herrera M., Pérez-Hernández M., Kumar A., Izquierdo J. Multi-Agent Systems and Complex Networks: Review and Applications in Systems Engineering // Special Issue "Control and Optimization of Multi-Agent Systems and Complex Networks for Systems Engineering", 8 March 2020.
[9] Kovach K.P., Rat I. Transient processes in alternating current machines. M.-L. Gosenergoizdat, 1963 .—744 p.

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