ANNOTATION

to the dissertation work prepared for obtaining the academic degree of Doctor of Philosophy (PhD) in the educational program 8D07110 - "Digital engineering of machinery and equipment"

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"Research and development of invariant chamber pneumatic drives of technological machines"

Relevance of the work. A significant number of technological machines with heavy rotor are operated in various industries. In particular, at the enterprises of the mining and metallurgical complex (MMC) - industrial mills and furnaces with large-sized and heavy drums; in heat and power engineering - rotary electric machines and rotary steam power machines, etc. The unfavourable operating modes due to large inertia mass lead to multiple exceeding of ΔΔ. Unfavourable operating modes caused by high inertial mass lead to multiple exceeding of loads on drive devices, which in the end is fraught with significant reduction of service life, frequent failures and, as a consequence, multiple increase of operating costs.

Due to their large inertial mass, the most unfavourable modes of operation are start-up modes, in which there is a multiple excess of loads on the starting devices, which is fraught with a decrease in their life, frequent failures and the need for their repair.

Start-up of equipment with heavy rotor is tried to be carried out with increased precautions: start-up is carried out in strictly regulated time intervals; during this period, parallel start-up of other equipment, welding work, etc. is prohibited due to voltage sag in the network.

To prevent unfavourable start-up modes of heavy rotor equipment in operation, they are often not stopped even when there is no raw material or load, so they run for a long time without loading 'idle' in the mode of waiting for raw material loading or in the mode of waiting or receiving load. Operating costs for electricity alone in this mode of unproductive operation for several years may exceed tens of millions of tenge or become comparable to the cost of a new unit. In addition, intensive wear of the main units continues in these modes, which also leads to a decrease in the resource of their operation.

Application of various types of hydrostorage auxiliary starting devices, frequency-controlled electric drives did not allow to solve this problem to the full extent due to insufficient reliability of hydrostorage systems, complication of their operation in real production conditions. And application of variable frequency drives is effective only in a certain range of operating modes, when the machine rotor has already gained a certain speed of rotation. Their application is limited during start-up modes due to high start-up currents.

The solution to this problem lies in the field of optimisation of starting modes by using simple in design pneumatic starting devices, which allow to create high torques, which will allow to reduce the load on the standard drive and exactly in the starting modes. Preliminary start of the equipment with application of these devices will allow to choose clearances, to exclude shock loads in mechanical gears of the standard drive, to overcome friction of rest in support units of a rotor and thus essentially to reduce starting currents on windings of an electric motor.

This thesis presents the results of development and research of original pneumatic devices with high torque, which designs fit well into the drive layout of heavy rotor machines and will improve the reliability of their standard drives. The same devices can serve as a driving device during repair works on the rotor (for example, for turning during condition inspection and maintenance, replacement of separate units, etc.), which can significantly reduce the time of repair and restoration works.

Preliminary analysis and assessment of technological and economic efficiency of the introduction of start-up and auxiliary devices as an alternative to methods associated with the use of electronics in the regulation of the supply network for electric motors showed that the simplicity

of modernisation of the standard electric drive by retrofitting them with a start-up and auxiliary pneumatic device makes this solution technologically very attractive.

In order to create a reliable methodology of computational modelling of the modes of operation of the start-up and auxiliary device in tandem with the standard drive of the drum mill, the technical solutions to improve energy efficiency and reliability have been verified by conducting computational and experimental studies of the modes of operation of the virtual model and establishing the initial design parameters for the development and creation of a working sample of the start-up and auxiliary drive.

The aim of the work is the development and research of invariant pneumatic drives of technological machines.

Object and subject of research. As an object of the research the PVPU on the basis of bellows cylinders, flat and wedge chamber systems, which are offered for introduction in the structure of standard drives of technolgical machines with heavy rotor, are chosen.

The subject of the research is the optimisation of design parameters and operating modes of the PVPU when working together with the standard electric drive to increase its energy efficiency in start-up modes and reliability.

Objectives of the research. In accordance with the goal set in this work the following tasks are to be solved:

- collection, analysis and generalisation of materials on practical application of pneumatic devices of chamber or balloon types for providing starting impulse for technological machines with heavy rotor;
- justification of the PVPU design for introduction into the regular drives of technological machines of rotor type;
- analysis of the existing methods of calculation and design of PVPU;
- selection and justification of the initial parameters and development of the methodology of calculation modelling of the PVPU operation modes in the system ‘electromechanical drive - heavy rotor’, which allows to establish rational design parameters of its elements to ensure optimal values of starting currents during the start-up and acceleration;
- calculation-experimental research of the operating modes of the virtual model of the PVPU with simulation of the operation as a part of the standard electromechanical drive with the use of computer modelling;
- substantiation and selection of the design of the HTPP elements. Evaluation of its efficiency in bench conditions;
- technical development and manufacturing of operating models of the PVPU and a test bench with a set of instrumentation for testing the PVPU with simulation of real loads;
- bench tests of the PVPU as a part of the standard drive with an assessment of its efficiency and checking the adequacy of the methodology of simulation of real loads;
- Analysis and generalisation of the results of experimental research with specification of parameters of the methodology of computational modelling of the operating modes of the PVPU in the conditions of the bench and development of practical recommendations on designing and manufacturing of industrial designs of PVPU.

Research methods. The methodological basis of the thesis research is analytical and computational-experimental studies based on the fundamental laws of applied mechanics and electrical engineering.

As the basic methods were used: mathematical modelling with application of applied computer programs and comparison of their results with the results of bench experimental researches on full-scale samples of PVPU.

The main scientific provisions put forward for defence. The following provisions are put forward for defence:

1) The ways of increasing energy efficiency and reliability of standard drives of technological machines with heavy rotor can be achieved by applying invariant starting and auxiliary pneumatic devices (PVPU), pre-starting of these devices will allow to select clearances,

exclude shock loads in mechanical transmissions of standard drive, overcome rest friction in rotor support units and thus significantly reduce starting currents on electric motor windings.

2) The methodology of computational modelling of operating modes of the PVPU as a part of the standard drive and the results of complex theoretical and experimental studies to verify its reliability are specified.

3) Practical recommendations for the application of starting and auxiliary devices to improve the energy efficiency of technological machines with heavy rotor.

Scientific novelty of the work:

1) Experimental studies have established that the use of start-up-auxiliary pneumatic devices as part of standard drives in contrast to electromechanical ones allows to reduce start-up currents (up to nominal currents - in steady-state mode) twice and thereby significantly increase their reliability.

2) The original method of estimation of influence of the main drive starting point on the sliding trajectories of the pneumatic chamber system of the starting and auxiliary device, which allows to reduce the starting currents as much as possible, has been developed.

3) The parameters of the pneumatic accumulator (receiver) for retrofitting of the starting and auxiliary device under conditions of low pressure in the shop pneumatic mains or even its absence (mobile start) have been established by the calculation-experimental researches.

Practical significance of the research:

1) Theoretically and experimentally confirmed the practical possibility of increasing the efficiency of application of starting-auxiliary devices for equipping standard (standard) drives of technological machines with heavy rotor.

2) Original experimental stands for estimation of: force and sliding parameters of different variants of systems; torques and parameters of cyclogram of motion of flat and wedge chamber shells are developed and created.

3) Practical recommendations for the design of starting and auxiliary devices for technological machines with heavy rotor are developed.

Information about metrological support of the dissertation. At carrying out of bench experimental researches modern devices and measuring means which have passed metrological certification and preliminary taring with certified devices, confirming reliability of readings, were used.

Approbation of the work. The results of theoretical and experimental research were reported at international scientific-practical conferences (including foreign countries) and seminars of the department.

The results of the conducted researches have shown interest in JSC ‘Almaty Heavy Engineering Plant’ and they can serve as a basis for joint R&D on a contractual basis.

Publications. During the period of work performance 6 scientific articles and reports were published, including: 3 articles - in peer-reviewed publications recommended by CCSON; 1 article - in international scientific journals with quartile Q2 and Q3, included in the Scopus database; 2 reports - at international scientific conferences, including 1 report in a foreign international conference. Also, 2 patents of RK for invention have been received.

Structure and volume of the dissertation. The dissertation consists of an introduction, 4 sections, conclusion, list of used sources and appendices.

The volume of the dissertation is 127 pages of typed text, 4 tables, 94 figures, 62 sources of literature list.