

SUMMARY

for the dissertation of Myrzabekova Dinara Myrzabekkyzy on "The foundation of parameters and the development the design of hinged units of technological machines working in underground mines" for the Doctor of Philosophy (PhD) degree on the specialty 6D071200 – Mechanical engineering.

Relevance of the research topic. The movement of minerals by machines in underground mines is an integral part of the production and technological process in the mining industry. This is related to the need for loading, unloading and transportation of extracted minerals from the place of its excavation from the massif to the place of its transshipment to the conveyor by using mining Load-Haul-Dump (LHD) machines. Aggressive environmental conditions and heavy load conditions caused intensive wear of the hinge assembly (HA) of the articulated frame of these machines. Restoring the operability of the articulated frame hinges requires suspending the operation of machines, which entails a loss of working time and a decrease of the work productivity at the mine. In addition, the process of repairing nodes in underground conditions is quite time-consuming and expensive.

Thus, the research aimed at ensuring the operability and controllability of the HA is relevant and practically significant.

The paramount idea of this scientific research is analyzing the performance of the HA, assess their reliability, as well as developing technical solutions to ensure higher operability and controllability of the HA.

In this case, the research tasks were set. They include the analysis of the HA wear, the assessment of their reliability, the identification of the causes of wear, the research of the process of destruction of the HA, experimental confirmation of the dominant factor of the HA destruction, the development of technical solutions in the HA design aimed at ensuring its operability and controllability during operation.

Thus, at present, the most relevant aspects are the issues of the HA operability ensuring in the LHD according to the criteria of reducing operating costs and improving the efficiency of underground mining processes. This is achieved by the development and implementation of an HA improved design including improved operating features with using more effective technical solutions.

The object of research is the HA for bracing of the hydraulic cylinder rod of the pivoting articulated LHD machine (using the example of the Caterpillar R1300G underground loader, Sandvik EJC417 underground dump truck).

The subject of research is methods of the HA operability ensuring of bracing of the hydraulic cylinder rod.

The purpose of the dissertation work is to increase the efficiency of LHD machines on the basis of the HA efficiency ensuring.

To achieve the research purpose, it is necessary to solve the following tasks:

- to study the condition of the research issue, to perform a literary and patent analysis;
- to develop a mathematical model and a design scheme of the HA and to investigate the strength of its parts by the finite element method;
- to perform experimental research of the operability and reliability of the HA during its operation;
- to develop a physical model of the HA operation and confirm the hypothesis of HA self-dismantling under vibrational influence experimentally;
- to develop an device improved design for the protection and controllability of HA LHD machines;
- perform a technical and economic assessment of the research results effectiveness.

The research methodology is based on proven methods of theoretical analysis, field and virtual experimental studies.

The level of the research topic elaboration. The number of previously performed research works by various scientists allowed us to identify the prerequisites for the implementation of this dissertation research and obtain new scientific results. The analysis of the HA failures causes regarding the hydraulic cylinder rod bracing of the LHD machine turning mechanism with a articulated frame is carried out. The complex entity of the HA wear has been established, such as a violation of lubrication modes due to a decrease and contamination of the lubricant in the HA, plastic deformation (crumpling) of the working surface in the upper eyelet and the appearance of local wear (ovalization) of the socket of the upper eyelet. The vibrational nature of the axial movement of the hinge pin in the upper eyelet, leading to self-dismantling of HA, is revealed. To improve the efficiency of the HA, an improved design of the device has been developed, which prevents contamination of the lubricant of the HA, as well as ensuring its controllability, which makes it possible to increase the efficiency of LHD machines. At the same time, the monitoring sensor installed in the proposed device allows you to quickly identify the technical condition of the HA for carrying out preventive technical actions to prevent self-dismantling of the HA. The transmission of sensor information about the technical condition of the HA is provided by using wireless Wi-Fi technologies and integration into the general system of planned preventive technical impacts of the Maintenance 4.0 level.

Scientific novelty of the work:

- a mathematical model of vibration displacement in tribo-couplings of the HA of the hydraulic cylinder rod bracing regarding the turning mechanism in the LHD machine with a articulated frame, based on the dependencies of the mechanical interaction of the contacting bodies;
- methods of maintaining the operability of the HA in operation;
- a device for protecting and monitoring the condition of the HA of an articulated vehicle, which prevents contamination of the lubricant and allows to

identify quickly the technical condition of the HA for carrying out preventive technical actions to prevent self-dismantling of the hinge.

Theoretical significance. Mathematical models of deformation (local crumpling) and wear (ovalization) of the working surface of the "pin-bushing" pair of the HA, as well as the vibrational movement of the HA finger, have been developed, allowing to simulate the process of the HA self-dismantling.

Practical significance. A device for protection and control of the technical condition of a HA for carrying out preventive technical actions at enterprises operating LHD machines with an articulated frame has been proposed and patented.

Provisions submitted for protection:

- a mathematical model of vibration displacement in tribo-couplings of the HA of fastening the hydraulic cylinder rod of the turning mechanism of the LHD machine with an articulated frame, based on the dependencies of the mechanical interaction of the contacting bodies;

- experimental equipment for vibration tests of a HA;

- results of modeling the wear process of the friction pair "pin-bushing" in Solid Works;

- a device for protecting and monitoring the condition of the HA of an articulated vehicle, which prevents contamination of the lubricant and allows to identify quickly the technical condition of the HA for preventive technical actions to prevent of the HA self-dismantling.

Implementation of the work results. The results of the dissertation research have been accepted for implementation in Kazakhstan mining company LLP.

Approbation of the work. The main results of the work were reported at international scientific conferences and discussed at scientific seminars.

According to the subject of the dissertation research, 5 works have been published in scientific publications, including 2 articles in a journal indexed in the Scopus database.

Structure and scope of work. The dissertation consists of an introduction, four chapters, and a conclusion. The total volume is 88 pages and includes 43 figures, 8 tables, and 3 appendix.