PAPER • OPEN ACCESS

Belt conveyors: principles of building control and diagnostics systems

To cite this article: V E Dzhundibayev *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1047** 012041

View the article online for updates and enhancements.

Belt conveyors: principles of building control and diagnostics systems

V E Dzhundibayev[1,3], A V Kochetkov[2] and A B Bobeev[1]

[1] L. N. Gumilyov Eurasian national University, Nur-Sultan, Republic of Kazakhstan
[2] Perm National Research Polytechnic University, Perm, Russia

[3] E-mail: dzhundibayev_v@mail.ru

Abstract. Diagnostics allows you to get information about the technical condition of the main components of the belt conveyor, the results of which the control system adapts to changing conditions. Diagnostics is carried out by technical means of diagnostics and assessment of transport and operational condition. The main provisions of the conceptual plan and functional properties of advanced diagnostic systems are developed. The requirements for software and hardware and data bank for diagnostics of the state of belt conveyors are defined.

1. Introduction

The problem of increasing the reliability of technical and operational indicators of belt conveyors is seen through the expansion of the range of parameter measurement by the control system, modernization of technical diagnostic tools and automation of the diagnostic process.

Diagnostics of belt conveyors serves as the basis of the automated belt conveyor state management system, including planning, distribution and use of funds allocated for the maintenance, repair and reconstruction of the conveyor, and organization of work. The task of diagnostics as an integral part of the work on assessing the state of belt conveyors is to maintain information and automation tools, including the current collection and analysis of information about parameters, characteristics, operating conditions, the presence of defects and the causes of their occurrence, which is necessary for evaluating and predicting the state of belt conveyors. The purpose of diagnostics and assessment of the condition of conveyors is to obtain complete, objective and reliable information about their transport and operational condition, their operating conditions, as well as the degree of compliance of actual consumer properties, their parameters and characteristics with the requirements of parametric reliability.

2. Methods

Search was conducted of technical solutions and analysis of advanced domestic and foreign experience in technology and systems diagnostics, studied the normative and technical base and refined requirements for the accuracy of the measurements of the main parameters, describes the goals, tasks and structure of the bank's historical data and current condition monitoring of belt conveyors.

3. Overview of solutions

Automated technical means for diagnostics and assessment of transport and operational condition of belt conveyors are a necessary tool for achieving this goal [1, 2]. Currently, a wide range of diagnostic equipment is produced in the CIS countries and abroad, covering the entire range of tasks for diagnostics

of various technical objects. However, the measurement efficiency of many parameters of belt conveyors is still low, and it is not possible to measure several parameters simultaneously. The nomenclature of measurements requires expansion, as well as unification of measuring equipment and software.

Analysis of domestic and foreign technical means of diagnostics of conveyor belts shows that they cover the entire range of tasks of diagnostics and condition assessment and form the basis for creating complex and specialized diagnostic systems. Different countries use their own methods and systems for inspection, certification and inventory of conveyor belts, the general requirements for which are the speed of obtaining information, objectivity, high reliability and accuracy of measurement data, and automation of the measurement process.

Currently produced automation tools mostly meet the specified accuracy criteria. To improve the accuracy of measurements, it is also necessary to develop optimal algorithms for processing signals from sensors, in terms of minimizing measurement errors. For example, a statistical approach that is widely used in measurement technology should be used, including maximum likelihood methods, hypothesis testing, adaptive methods for estimating unknown parameters against the background of interferences, and so on.

Modern equipment for primary data collection, element base and signal processing technologies provide the creation of measurement systems and devices for effective assessment and control of transport and operational qualities of belt conveyors. The choice of a specific element base will depend on the state of the market for electronic components at the time of development of schematic circuits.

The central part of the diagnostic system is a computer complex that includes a control unit and a computer that collects information, manages measurements, processes measurement results, and diagnoses functional nodes. Data processing – filtering, estimation of signal parameters, and measurement optimization - can be performed using microcontrollers, digital signal processors, and programmable logic integrated circuits that provide fast solutions to almost all production tasks of the automated conveyor belt diagnostics system. The computer is used for visual monitoring of measurements, calibration of measurement systems, post-processing of information, generating reports and statements.

Currently, effective information service is achieved by creating electronic libraries - systems implementing a unified approach to the production, storage and organization of a variety of information for the purpose of searching, analyzing and accessing it using global computer networks. Use of the latest technologies in the field of creating software applications to maintain the modes of entering and searching the required information with the provision of data in formats defined by regulatory documents and consumer requests. It can be achieved by using macros of the new generation computer software, as well as the data structuring language, in relation to the outputting of output forms.

The tasks of improving the data bank for belt conveyor diagnostics (DBBCD) include determining the range of tasks that are necessary for making management decisions in a company, a production line based on a belt conveyor or a separately operated belt conveyor. Improving the DBBCD software taking into account the customer's comments, changing the database structure and user interface with the addition of supplementary information for each storage unit. Updating the accumulated information and adding information on new storage units during the entire period of work on condition assessment, taking into account the requirements and operating procedures of the company.

The DBBCD integration should be done as part of the quality management system of the company.

It is necessary to constantly operate and improve the DBBCD in terms of maintaining and improving the user interface and constantly updating existing and incoming information.

Also, it is necessary to ensure that the information and tools stored in the data bank correspond to the information capabilities of modern diagnostic, inventory and certification systems in software and hardware aspects (for example, for the possibility of automated data entry in real time, direct data display, correct data description).

It is advisable to use video systems to determine the parameters of the transported material, the state of its loading and unloading places, and the presence of conveyors operating in the service area. The

development of intelligent image recognition and processing algorithms will effectively solve this problem. The video technological complex includes a video (photo) camera, a video input device, and video image processing programs. The complex performs automatic video recording with digital processing and recording of information about the conveyor belt, forming a video data bank, measuring the linear geometric dimensions of objects and defects from the video image.

4. Results

As a result of the research, the principles of construction, functional and technical and operational requirements for monitoring and diagnostics systems were developed and proposed for discussion [3].

Based on the established goals and objectives the main requirements to the diagnostic system for belt conveyors, comprising a unified normative-methodological base for the survey, a system of transport performance indicators, the use of metrologically certified technical diagnostics, ensuring a high level of normative-methodical base and technical diagnostics can be formulated [4,5].

The main directions for solving the problem of conveyor diagnostics are as follows: ensuring the functional stability of the design of the control and diagnostics system of an automated belt conveyor, implementing the aggregate-modular principle of designing measuring instruments, installing measuring instruments in information zones, switching from measurement methods to methods of relative assessment of the dominant factor or parameter, adaptability, good observability and controllability.

Based on the works [6,7], the research results developed the main provisions of the conceptual plan, to which promising diagnostic systems for belt conveyors should correspond [1]:

- the use of a computer and modern digital devices for controlling and processing measuring signals;
- adaptability and weak dependence on the influence of disturbing factors and parameters of different nature;
- modular construction principle that provides standard interfaces for the exchange of measurement data;
- use of efficient technologies processing measurement signals to improve the accuracy and reliability of measurements;
- integration of measurement channels;
- autonomous power supply system;
- diagnostics and self-diagnostics of measurement modules;
- calibration of measurement systems during preparation and during measurement.

It is established that the software must provide adaptability and extensibility of the measuring complex, the ability to simultaneously measure several parameters and configure any settings necessary for the user, including executable and other codes of microcontrollers, digital processors, programmable logic integrated circuits, universal processor (computer), libraries, interfaces, and the operating environment. At the same time, the unification of hardware and software interfaces, the modular construction principle, and the object-component architecture should be provided.

Experience shows that the development of new measuring equipment from the zero cycle is very problematic, and one of the options for successful implementation of this task is to study the world's best practices.

The following functional properties of belt conveyor diagnostics systems are defined:

- measurement management (collection and analysis of measurement data obtained from sensors of functional units and systems, the ability to optimally control measurements and configure them depending on the operator's requirements);
- maximum automation of the measurement process;
- processing (filtering) of measurement data in order to extract useful information;

- ability to diagnose and self-diagnose functional nodes;
- integration of measurement channels;
- processing of measurement results and their presentation in the form prescribed by regulations (reports, statements, etc.);
- possibility of calibration and self-calibration of measurement modules.
- Requirements for software and hardware:
- modularity and the ability to build software and hardware;
- reliable operation in conditions of vibration, a wide range of operating temperatures (-10+70°C), dust, high humidity (up to 80%), high level of electromagnetic interference;
- the possibility of effective repair in a work environment;
- self-diagnosis of measurement modules;
- ability to quickly change the control program;
- low power consumption;
- nonvolatile storage of identification and calibration data.

One of the main directions is the development of applications based on the information of created automated data bank diagnosing the state of a belt conveyor DBBCD containing detailed information on diagnosis, inventory and certification of belt conveyors and tools of diagnosing, controlling and automating them with comprehensive data analysis and subsequent development of engineering solutions.

Currently, there is no general methodological approach to creating DBBCD, a regulatory framework, and a unified structure of attribute and geo-data. The structure of the data bank on the state of a specific belt conveyor as an extended transport system is proposed, taking into account analogues used in the road sector for diagnostics and inventory of highways [8].

It is necessary to solve the following main tasks:

- clarification of the structure of the automated data bank and the list of software systems used to manage the state of belt conveyors;
- determination of ways, methods and means of optimizing the information system for monitoring and technical diagnostics of the state of belt conveyors based on the introduction of modern automated technologies for collecting, storing, processing, visualizing and analyzing information, which will increase the efficiency of the use of funds.

Based on [9,10], the regulatory requirements for the accuracy of measuring the parameters of the belt conveyor are determined this way:

- the distance along the axis is 0.1 %
- geometric characteristics $\pm$ 5°/°°
- roughness $\pm$ 0.1 mm
- coefficient of adhesion $\pm$ 0.02
- slack between roller supports $\pm$ 0.2 mm

5. Conclusion

The introduction of an automated system for monitoring and technical diagnostics, the widespread use of the obtained results will reduce the time and increase the reliability, order and objectivity of work, significantly improve the quality and validity of management decisions.

References

[1] Dzhundibayev V E, Kochetkov A V, Kasymbek Zh N and Bobeev A B 2008 Functional stability of automated belt conveyors *Bulletin of science of the Kazakh agrotechnical University named after S. Seifulin* **2(49)** 429-33

[2] Dzhienkulov S A, Dzhundibayev V E and Alibek B A 2012 *Functional stability and technical diagnostics of belt conveyors* (Almaty, Kazakhstan: Eltanin)

[3] Dzhundibayev V E and Akhmetova S D 2008 Principles of building control and diagnostics systems for automated belt conveyors *Bulletin of KazNTU named after K. I. Satpayev* **1(64)** 60-4

[4] Kosilova A G and Sukhov M F 1972 *Technology of production of lifting and transport machines* (Moscow, USSR: Mechanical Engineering)

[5] Chernyavsky E A, Nedosekin D D and Alekseev V V 1989 *Measuring and computing tools for automation of production processes* (Leningrad, Russia: Energoatomizdat)

[6] Nahapetyan E G 1990 *Control and diagnostics of technological equipment* (Moscow, Russia: Science)

[7] 1981 *SS 25044-81 Technical diagnostics. Diagnostics of cars, tractors, agricultural machines construction and road vehicles. Fundamentals* (Moscow, USSR)

[8] Dzhundibayev V E 2007 Automated data bank for diagnostics of the state of the transporting machine *Bulletin of KazATK* **5(48)** 102-5

[9] Dyachkov V K and Smirnova N A 1980 *Basic requirements for the design of general-purpose belt conveyors RTM.24.093.04-80* (Moscow, Russia: Ministry of heavy and transport engineering)

[10] Shakhmeister L G and Dmitriev V G 1987 *Theory and calculation of belt conveyors* **2** (Moscow, Russia: Machine industry)