Analysis of the defect diagnostics methods and scanning for instructive parameters of the belt conveyor gear

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Abstract
The substantiation of the use of information systems for the rational management of the belt conveyor for transport rocks by the criterion of the technical condition of its equipment is considered.
Key words: DIAGNOSTIC SYSTEM, ELECTROMECHANICAL SYSTEM, TECHNICAL CONDITION, DIAGNOSTIC SIGNS, DIAGNOSTIC MODELS

The problem and its connection with science and practical tasks

Belt conveyors are part of the most efficient continuous transportation system because of its productivity, construction and service

simplicity, exploitation spending and working reliability. Application of special events may increase efficiency of its work, in particular, improve its reliability indicators, such as: readiness coefficient and coefficient of technical use. Reduction of recovering time is needed to improve overall readiness coefficient and exclusion of time for extraordinary maintenance is needed to improve coefficient of technical use. All these objectives may be reached using reliable and highly efficient instruments of technical state diagnosis and gear work-resource forecast.

Analysis of research and publications

Diagnosis of the general and special purpose mechanisms was engaged by several authors [1, 2, 3, 5, 6, 7], who developed general provisions and principles of technical diagnostics. Technical state determination process for each mechanism have its own specificity in case of great length (conveyor), presence of the complex nodes and mechanisms, connected with each other by flexible traction body. So permanent diagnostic control of the technical state of these elements and forecast of the residual resource with keeping in mind the degree of theirs effect on general resource is very important thing.

Development of the functional diagnostic schemes and research connected with finding informative parameters [1, 8, 9, 16, 17, 19, 20, 21] shown, that any complex mechanism, which consists of a number of smaller mechanisms and nodes, must be investigated in the context of separate node, in other words, reliable results may be achieved only if each node of the mechanism is investigated separately.

Statement of problem

Well known, that existing diagnostic methods of the technical state and prediction of conveyor's efficiency are inefficient. More of them require stopping the mechanism in order to inspect it, also partial disassembly is needed. In this case necessity to investigate belt conveyor as a diagnosis object is appeared and with it there is a necessity to develop progressive and technically implemented ways and devices and use them as a base in process of forming principles of automated diagnosis and forecast system. New possibilities in work and exploitation process of diagnosis and forecast system are appearing when using the belt conveyor, which equipped with adjustable gear and automatic control system of transportation modes.

Representation of the materials and results

In [6, 19] considered gear, which in its turn consist of next nodes: electric motor, countershaft with bearing assembly, wire joints, reduction gear and drive roll. Failure of each of this nodes leads to failure of entire gear. That is why diagnosis of the gear, as the most complex electromechanical system, authors offer to implement using separated nodes, where resource of single element actually determines resource of entire gear, because according to computational scheme of reliability, they connected successively.

Main node of the gear – electric motor is an electromechanical system, which consist of numerous elements that interact with each other. Changes in state of one element may cause changes in state of other elements. However, development of the accurate and reliable methods of the electric motor technical state diagnosis require determination of the interconnection between separate nodes and structural parameters and diagnostic signs, in other words – determine the cause-effect relationships of the process of forming of diagnostic signs.

In [6] there shown graph of the cause-effect relationships of the process of forming diagnostic signs squirrel-cage motor. Structurally graph consists of several levels, which match to the separate elements of the object, structural parameters, defects and informative parameters. Also there shown interconnection between parts of the graph, because modern powerful systems are equipped with wound-rotor motor. This graph ignores a number of elements (collector, brush gear) and features of this type of engine (three-phase rotor winding, rotor shape, etc.). So this graph doesn't give the possibility for full establishment of interconnection of diagnostic signs, which are connected with rotor defects, rotor winding and brush gear.

Author of the work [6] offers to use temperature techniques for diagnosis of the electric motor state. We showed, that the state of rotor winding isolation may be determined by the adiabatic (without interaction with surrounding environment) heating time of the winding, which may change with changes in thermophysical parameters of the isolation, cracks caused by temperature. If adiabatic heating time becomes greater than the previous results and winding heating velocity stay constant, the conclusion is that the winding is damaged. Heightened heating of the winding also may be caused by faults in refrigerating system. If adiabatic heating time becomes greater than the previous results and winding heating velocity decreases, the conclusion is that both the winding and refrigerating system is damaged. If adiabatic heating time decreases and

winding heating velocity is rising, the conclusion is that there is interwinding fault (shorting). Shortage of this diagnosis method is that the faults are determined too late and there is why forecast of the residual resource can't be achieved ahead of schedule. Besides, this method uses integrated sensors to manipulate the temperature and generally, this path leads to reduction of control reliability, because process of replacement of sensor that was corrupted requires disassembling an entire gear.

Widely known technical state diagnostics method of the engine powered transmission [7] founded on use of the vibration parameters. In the random point of the transmission that is chosen, vibration signal is determined. Then get its band amplitude-frequency spectrum and emit a signal in the form of spectral round. At the same time the current value of the drive motor, which corresponds to idling and nominal load, is setting up. Measure the motor current. With the value, less than value of the idle load current and equal to the value of the nominal load current the diagnostic feature is determined. For this math expectation of the round is determined and difference of the math expectation of the rounds values less than or greater than the math expectation of the separated signal of the round spectrum. Next the received values of the diagnostic parameter are compared. If its value with the value of the idle load current less than current that less or equal to nominal load, but greater than the value of the idle load current, the transmission fault is fixed. The disadvantage of the described method is the need for additional measuring motor current in two drive modes, and the inability to locate and determine the type and extent of the defect and degree of its progress in the transmission, so, method cannot be used to forecast the technical state.

The reduction gear faults are frequent event and permanent diagnosis is required. The work [8] provides the analysis of reduction gear diagnostics methods used in mining industry. Primary methods are found on the analysis of the solids in the reduction gear oil and on the temperature and vibration analysis in different points of the reduction gear. The simplest method of diagnosis of the reduction gear working condition is to determine the level of solids in oil. This method allows getting a clear trend of the solid growth process that prior to the fault of the reduction gear. The main disadvantage of the described method is the greater severities, connected with automation process of collecting and processing data and inability to identify specific type of defect.

Analysis of the temperature diagnosis method showed that along with the simplicity of processing diagnostic information, this method cannot diagnose defects that arise and allows fixing the fault directly before the crash.

As noted in [11] reduction gear diagnostic method based on the analysis of its hull vibration allows revealing its defects on the stage of their origin and predict faults beforehand. Using this method, defects are localized and identified with high accuracy. However, to achieve high sensitivity and accuracy of diagnosis there is a necessity to use complex and expensive equipment, often do not adapted to mining industry conditions.

Now the new perspective diagnostic method of the technical state of the toothed reduction gear and rolling-contact bearing in the process of their exploitation is developed by American firm Stewart Huges Co. Ltd. [12]. This diagnostic method of defects, which in origin, of contacting surfaces of the teeth of gears in complex toothed reduction gears is based on sharing synchronous accumulation operation, low-frequency filtering operation, amplitude demodulation operation, statistic calculations and clipping of the round and calculation the autocorrelation function operation. The disadvantage of this method is its sensitivity to changes in load and rotational speed of the drive motor, which greatly reduces its efficiency. In electric motors the bearing nodes are the elements with the lowest relatively to others resource [4] and often subjected to damage. Fault of the bearing node causes the fault of entire motor. Diagnosis of bearing nodes of the motors or reduction gears can be made using parameters such as: vibration, temperature, lubrication condition [15]. The most efficient method is based on analysis of vibration of the bearing node [4].

In [4, 15, 16] there considered many statistical researches of high-frequency vibration of the bearing nodes. These researches have shown that one of the sensory defects on all types of diagnostic features is changing the parameters of the distribution of the probability density value of vibration signal and, in particular, the higher distribution points. Analysis of models of different signals contained in the work [4] shows, that higher distribution points may change with the

advent of the harmonic components in the high-frequency part of the spectrum during process of random components modulation, which in their turn are associated with the appearance of the rolling surface defects.

But disadvantage of this method is the complexity of hardware, capable to compute higher distribution points and lack of information about the type of bearing defect makes it impossible to use this method to meet the challenges of the forecast.

In [2, 4, 15] there shown that if bearing has wear defects, such as cracks on the rolling surface, in the high-frequency vibration except stationary components there is also a transient components, which appearing with shock interactions of the damaged rolling surfaces. Isolation of these components at frequencies over 20 kHz and the measurement of their passage allows to determine the type and depth of the wear defects. Diagnostic instruments developed based on this principle and consider additional growth of high-frequency vibration with the appearance of defects are widely used now. Their advantages are manifested in the fact that value of shock impulses practically depends only on defect, rotation velocity of the bearing separator and mass of the rolling elements; this fact allows to configure easily the device for the needs of each machine.

This method, however, has some major disadvantages, which limit its usage in solving problems of diagnostics and forecasting of technical state. This method does not allow to determine type of defect if there are couple of them and also does not allow to detect defects of the bearing node assembly, which affects its resource and a number of wear defects, which does not accompanied by the appearance of pits and cracks on the rolling surfaces.

In [2, 4, 15, 16] there considered method of spectral analysis of the round of high-frequency components of the vibration signal, which is created by shock pulses in rolling bearings. This method allows to increase the probability of determination of the type of bearing wear defects. For more efficient allocation of high-frequency components on the background of random vibration created by friction, it is proposed to raise the measured vibration frequency up to 500 kHz, where the random vibration weakly manifested. Despite more efficient solution to the problem of identifying the type of defect, this method has several disadvantages and limited possibilities. Increased frequency of the measured vibration due to high losses during dissemination, requires embedding of their measurement sensors into body of bearing shield and does not ensure equal sensitivity of detection of identical defects on different rolling surfaces.

There is a way of diagnosing of rolling bearings [2, 15, 16], based on statistical analysis of its vibration. Performed an evaluation of the statistics moment of fourth degree - excess - in four vibration frequency ranges of the bearing: 3Hz – 5kHz; 5 – 10kHz; 10 – 15kHz; 15 – 20kHz. In the absence of defect excess is zero in all frequency ranges (amplitude distribution law by Gauss). Initial damage causes changes mainly in the low frequency ranges and more developed damage to the greatest extent affects the high frequencies, returning excess back to the original value at low frequencies. This fact provides a possibility to do a quantitative assessment of the degree of bearing's damage, so this method can be used in forecast purposes. The main advantage of this method is that it is not sensitive to changes in speed and load of the damaged bearing. The disadvantage of this method is the inability to identify the type of defect, significantly reduces the accuracy of forecast of the node resource in diagnosis process.

Conclusions

Analysis of the presented treatises shows that it is necessary to create and modernize diagnostic models, which combine existing methods for determination of the technical condition of major components and the entire conveyor. In famous models the nodes are separated on elements, determined main defects, in a few cases structural and diagnostic parameters are determined too, also there offered methods, which determine one or another defect. During development of these models, occurred some difficulties with determining changes in characteristic diagnostic features that clearly respond to the expression of a particular type of defect.

Possibility to control machine transportation modes, namely, reduce velocity of the belt, change the tension and traction distribution between drums, provide soft start of the loaded conveyor [10, 11, 19, 23] allow to change load on conveyors mechanism, increase the service life of the belt, rollers, drums, increase time between repairs, additionally, increases readiness coefficient to 0.01 – 0.013 and utilization coefficient to 0.015 + 0.02. [24]

Native and international experience shows that one of the most important means to improve the quality, reliability and economic efficiency of

mechanical equipment is the use of technical state diagnostics and forecasting systems [19]. Thus, development of the automated system for diagnostic and forecasting of technical state of conveyor mechanisms and coordination of its work with an automatic transportation control system, is an urgent task.

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