INCREASING THE SAFETY AND EFFICIENCY OF TECHNICAL RESOURCES IN THE MINING INDUSTRY

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ABSTRACT
Mining industry has heavy operating conditions and increased hazard, therefore equipment to monitor mining engineering should be stable to mechanical effect and environmental influence. Creation of monitoring system will ensure safety of people and improve technical resources of mining equipment. The tasks relevant to accuracy of monitoring must be resolved, since the accuracy is very important in analysis of impact impulses and vibration, which provide for diagnostics of bearings, appears in the problems with reduction gears, unbalances, misalignments in mining engineering. Algorithmic correlation technique must be applied to achieve maximum quality of the signal and definite spectrum for further analysis. Safety of people also depends on the steel mining ropes. Possibilities of using synthetic ropes instead of steel ones must be investigating. The task of determination of elasticity characteristics of high-capacity synthetic mining ropes is actual.

Keywords: Mining industry, the accuracy of monitoring in analysis of impact impulses, bearing failure checks, Correlative fractal dimensionality

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1. FUNDAMENTAL ANALYSIS FOR THE INCREASING THE SAFETY AND EFFICIENCY OF TECHNICAL RESOURCES IN THE MINING INDUSTRY

Because of arising of more complicated technologies and large fleet of industrial equipment in mining industry there is a demand for a task of safety increase and technical resources efficiency to assure workability and maximum recoupment of investments. Maintenance expenses in mining industry are often higher than in other branches. In consequence of equipment often failures causing large production losses and high repair costs, a gradual review of approaching to maintenance is going on in the branch. Complex relief and heavy-duty operating conditions are distinctive features of mining industry. The equipment is faced such factors as high loads, special properties of the rocks, intensive oscillations of rotation velocity and considerable overloads. Monitoring of the equipment condition plays more and more increasing importance to forecast the failures because of the equipment dimensions and delivery time of spare parts. In addition, monitoring of the condition is connecting with safety issues and resources saving.

Any mining equipment has got rolling bearings the condition of which influences on the problems with reduction gears, unbalance and misalignment. Safety of people and technical resources efficiency depend on the condition of mining ropes.

Especially important to compile database of responses of equipment failures. The use of vibration parameters (vibration displacement, vibration speed and vibration acceleration) is difficult at small and very high shaft speeds, when there are no shock loads or if the frequency of vibration is too high. Effective use in the analysis of vibration intensity of changes in vibration acceleration and its derivatives. The order of the derivative can be any real number. If the frequency of vibration is not constant, fractional derivatives are used. The intensity of the change in vibration acceleration is estimating using the frequency spectrum of the vibration power [1]. When processing signals that inform about the level of vibration and balance, sometimes an expert-statistical method is applied [2].

To collect diagnostic information, one can use a vibrating stand with the PT 500.04 PC Based Evaluation Software (see Fig.1) for recognition of equipment node state [3]. When processing experimental data, you can use the graphical interface of the System Identification Toolbox. All the above methods of bearing failure checks are based on the analysis of data recorded with a time interval equal to $\Delta\tau$=1s. If the shaft rotates at a frequency of n=200 rpm, then the shaft will make a 3.(3) turns in the time interval $\Delta\tau$=1s. At some point in time, the recording equipment does not detect the shock load. If the expected frequency of vibration at a given speed is 11.9 Hz, then the duration of one rotation of the shaft (300 ms) is 3.57 times the vibration signal time. At this sampling frequency of vibration signals, it is difficult to diagnose faults in bearings.

For more accurate registration of impact loads at low shaft speedsa program was created that allows recording the impact load every millisecond.

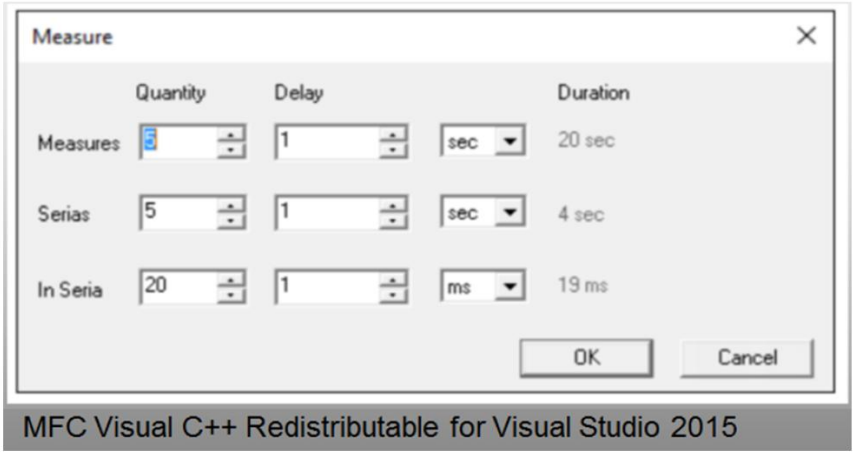

Figure 1. PT 500.04 PC Based Evaluation Software

The bearing was considered as a resonant system, in which its own frequencies were calculated [4,5]. This paper compares the methods of checking the state of rolling bearings for high-frequency vibration. The power of high-frequency bearing vibration was monitoring; analysis of the form of high-frequency vibration excited by short shock pulses; spectral analysis of fluctuations in the power of high-frequency vibration was made too. The relative error in determining the characteristic frequencies of the arising defects at the rotational speeds of the shaft from 200 rpm to 1500 rpm did not exceed 10%.

Monitoring of the condition of any opencast engineering is important for increasing of efficiency of technical resources in mining industry. The condition monitoring technology and fault diagnosis technology of mechanical equipment played an important role in the modern engineering. Rolling bearing is the most common component of mechanical equipment, which sustains and transfers the load. Therefore, fault diagnosis of rolling bearings has Great significance [6].

For these purposes a big role-play sufficiency of multifractal analysis theory application, that is efficient approach for description of the signals of complicated and irregular shapes. Just such signals are information carriers about failures of the machine elements [7-9, 12-18].

High-capacity synthetic ropes for mining winders will be subjected to monitoring and dynamic computation [10,11]. A great attention is paid on the mechanics of anisotropic materials in the modern technology. Elements with structural or artificial anisotropy are used in the design of the ropes. The task of determination of elasticity characteristics of high-capacity synthetic mining ropes is very actual. Classical tasks of theory of elasticity have been always set for simple types of anisotropy. Properties of elasticity for many anisotropy materials have not been determined experimentally. That fact impedes introduction of theoretical developments into the practice of computation. Mining ropes are subjected to complicated stressed states, therefore for their investigations it is necessary to apply the theory of stressed-strained state of curvilinear anisotropic bodies known as a rod with helical anisotropy.

As it is know, two computation models in the calculations of spiral-anisotropic structures (ropes) have got development at present: rod model, continuous model. The theory of flexible strands is often used in power calculation of a rope [11], where rope is considered as a brand without structural features. Besides, a huge spread in the values of elasticity characteristics of the ropes is observed. Discrete model, as well as approximate one, does not give a real picture of distribution of the stresses along the cross-section of the rope.

The task is to apply alternative direction in the mechanics of the ropes based on a continuum approach that is principally differs from discrete model and from the flexible strand, to the practical tasks. Continuous model represents a rope as a solid anisotropic cylinder with anisotropy corresponding to the rope design. It will be necessary to estimate the accuracy of the computation model in relation to the packing density of the wires in the package, considering that cross-section of a single wire does not effect on the accuracy.

2. RESEARCH HYPOTHESIS

Search for effective methods of the rotor type of quarry engineering state monitoring in the breakdown and pre-crash periods is actual. Especially it is important formining-haulage systems. In the given research a system of quarry engineering state monitoring using SPM tools with measurement technique HD will be designed. That equipment is table to mechanical impact and environmental influence. Evaluation of the monitoring accuracy will take into account the degree of equipment stability to external mechanical impacts. Contact less sensors will be fixed on the equipment with the help of which we can get the biggest diagnostic worth.

In misalignment (see Fig. 2) a trajectory of the rotor moving in the bearing is more complicated than ellipse. In some kinds of mechanical loosening (see Fig. 3) an orbit can get a view of chaotic movement, i.e. can greatly differ from ellipse one. Modern mathematical tool will be applied to evaluate degree of vibration suppression.

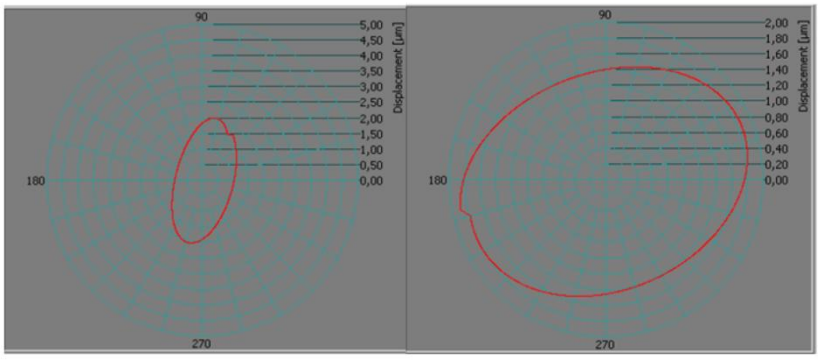

Figure 2. Misalignment.

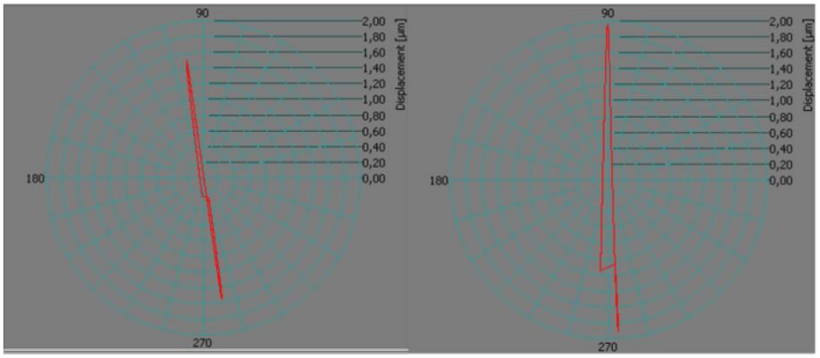

Figure. 3 Loosening.

From the control design perspective, when can develop novel controllers that can provide precise positioning while achieve vibration isolation at the same time. Analyzed studies on the better choices from these controllers will be proposed regarding their performances, cost and energy consumption. In this research the system will be tested with different control algorithms and programed.

We demonstrate the possibilities offered by this differential algebra method to enhance the information from noisy vibration signal. We show that it is possible to use the (standard) Operational Calculus methods to estimate the derivatives of fractional order of very noisy and fast signals (see Fig. 4 and 5). The created system of monitoring of the quarry engineering state will allow to control the condition of steel ropes.

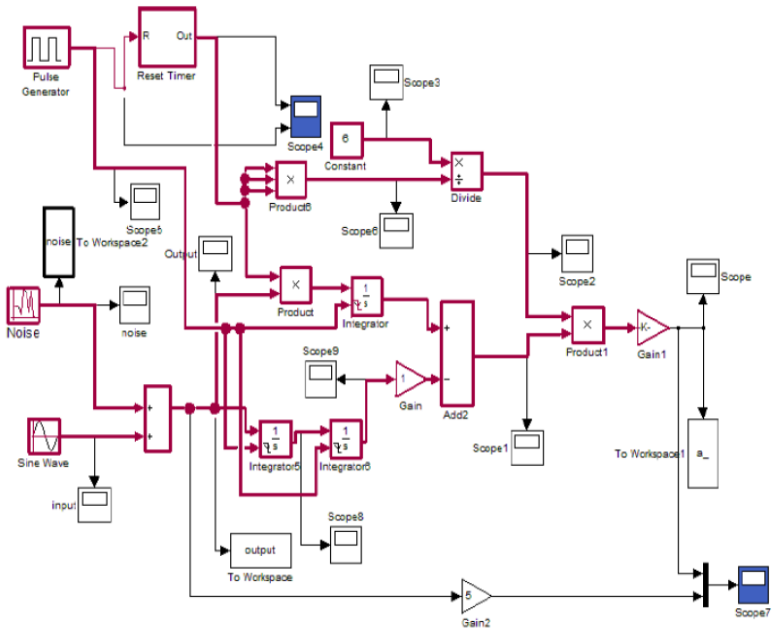

Figure 4. Example of control algorithm.

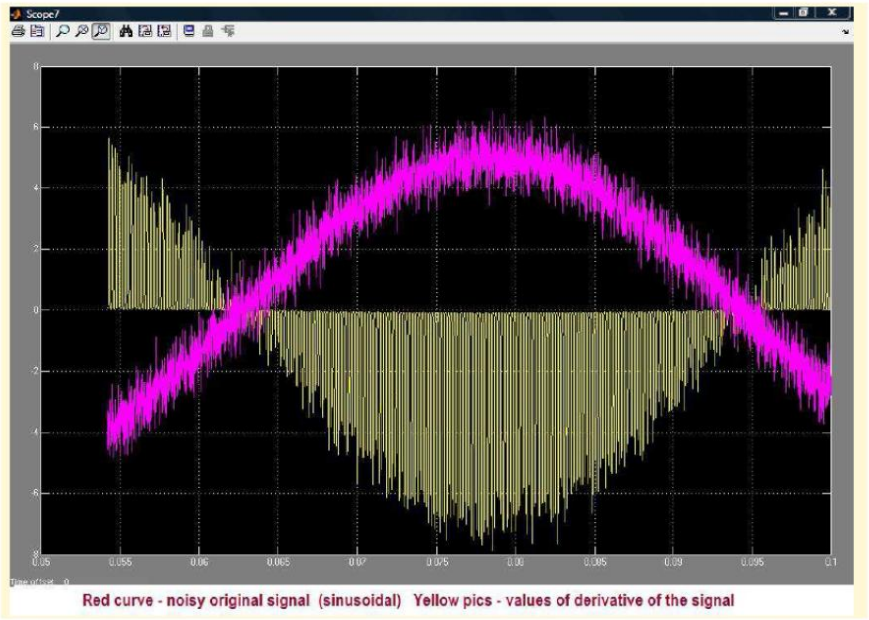

Figure 5. Signal 100 rad/sec and its derivative.

PROBLEM STATEMENT IN THE MONITORING CONDITION OF THE STEEL ROPES. The most wide spread way of an estimation of a tension is connected with the use of a matrix of a system rigidity. We present short survey of the given technique. A rope is considered a solid spiral-anisotropy medium. Such approach has the purpose to determine collective mechanical characteristics: aggregate modules in twisting, tensioning, bending. All these characteristics depend on the design and they should be determined experimentally each time for each design. This theory is based on the law of plane sections, which in this case is true in relation to the ropes, since in considerable tensioning loads because of longitudinal forces in the wires and squeezing of the binding elements with each other, they do not displace relatively the neighboring ones, as well as in bending of such construction considerable friction forces also make this hypothesis acceptable.

The arrangement of binding elements is defined by means of mathematical model and an operating field of numbers. In such each nodal point in which binding element is absent, in the field of numbers it is marked as 0. In a point in which binding element occurs, the number distinct from 0 is established.

A nodal point being under stressed state is given a number 1, 2 or 3 (see Fig. 6). Such field of numbers can be changed depending on a design of a rope. The gained magnitude of a measure function allows defining a spectrum of dimensions of a quantity of a multifractal which assesses a character of a state of stress of an object.

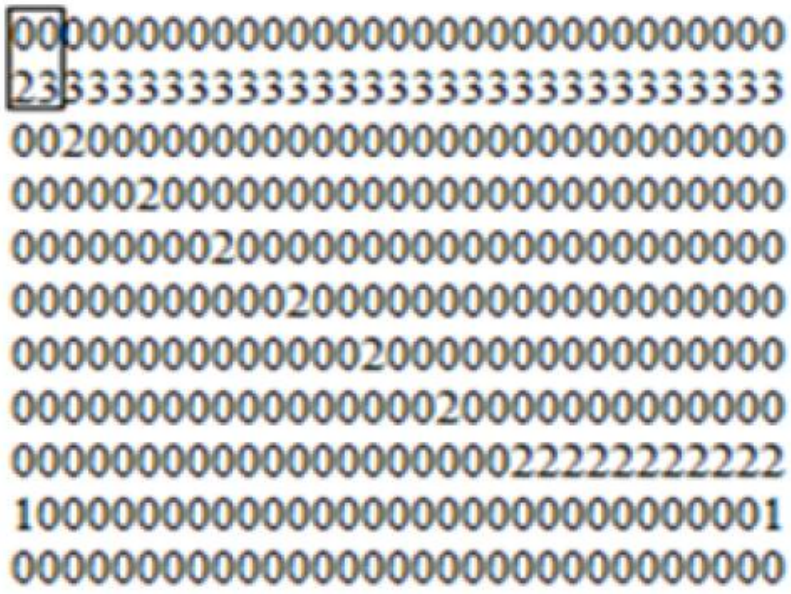

Figure 6. Matrix of numbers

3. CONCLUSION

It is expected that the use of synthetic fiber ropes instead of steel ropes will be proved theoretically and experimentally. It is expected that equation of motion (dynamics) of mining ropes will be solved theoretically and validity of solution proved experimentally.

The properties of materials that suits best for manufacturing of synthetic fiber ropes, will be researched. Synthetic fiber ropes must withstand to all possible variations of loads occurring in real working conditions and especially of dynamic loads.

It is expected that during the research, the effective methods of monitoring systems on mining equipment will be developed. This is a very important aspect in emergency and pre-emergency periods of exploitation of mining equipment. It is expected that high-performance monitoring system of mining equipment will be developed. The monitoring system of mining equipment will be experimentally testing in real working conditions with points of measurements placed on different mining equipment. It is expected that increase of safety level of mining equipment and increase of efficiency of use of technical resources in overall will be achieved.

Safety and efficiency increase is still the most important problem in mining industry. Even a new equipment does not correspond to the calculated useful life under complicated mine and open-cast conditions. The equipment often breaks down and spare parts have to be waited for a long time.

REFERENCES

[1] Lahdelma S., Juuso E. (2007) Advanced signal processing and fault diagnosis for conditionmoni toring. Insight, 5 (49), 719–725.

[2] Barashkova T., Pascault D. (2012) Estimation of Complex Derivatives Using Differential Algebra. Application for Fault Diagnosis. – 17th International Conference on Mathematical Modelling and Analysis.

[3] Malcolm J. Crocker (2007) Handbook of Noise and Vibration Control, John Wiley & Sons,Inc., Canada.

[4. Shock and Vibration Handbook, edited by CYRIL M.Harris, 3d ed., Mc Craw-Hill, BookCompany, New York, 1993.

[5] Fasano A., Marmi S., (2002) Analytical Mechanics, Oxford University Press.

[6] Yu Yuan et al., (2015) Study on Fault Diagnosis of Rolling Bearing Based on Time+Frequency Generalized Dimension, Hindawi Publishing Corporation Shock and Vibration.

[7] Макаренко Н. Г., Князева И. С. (2009) Мультифрактальный анализ цифровыхизображений. Изв. Вузов "ПНД", т.17, №5.

[8] Barashkova T. (2016) Application of the concept of fractal for the stress assessment of thecondition of an object. –International Journal of Independent Research Studies, 8-13.

[9] Shtofel O., Rabkina M. (2016) The use of a multifractal analysis for property evaluation ofcon structional steels. – UNIVERSUM: Технические науки,10(31).

[10] Yujin Li et al., (2015) Stress Analysis and Lifetime Extension of Hoist Rope. Society forMining, Metallurgy and Exploration.

[11] Мусалимов В.М. (2009) Механикадеформируемогокабеля.

[12] Alper, G. et al., (2015) Synchronization and control of chaos in supply chain managa ment.Computers and Industrial Engineering: 1-9. Computers & Industrial Engineering, 86, 107-115

[13] Aryassov, G. et al., (2011) Development of the improved method of grids. In: Annals ofDAAAM for 2011 & Proceedings of the 22nd International DAAAM Symposium Intelligent Manufacturing & Automation: Power of Knowledge and Creativity": 22 nd International DAAAM Symposium, University of Vienna, Vienna, Astria, 23-26th November 2011. (Eds.)B.Katalinic. Vienna, Austria: DAAAM International Vienna, 0565 – 0566.

[14] Aryassov, G. et al., (2010) Generalization of the method of finite differences. Proceedingsof the 21st DAAAM Worl Symposium, 0547-0548.

[15] Li-Chin, W., Sian-Kun L., (2009). A multi-agent based agile manufacturing planning andcontrol system. Computers and Industrial Engineering, 57, 620-640.

[16] Moonsoo, S. et al., (2008) Self-evolution framework of manufacturing systems based onfractal organization. Computers and Industrial Engineering, 56, 1029 1039.

[17] Ussanee, P., Voratas K., (2003) Detecting patterns in process data with fractal dimension.Computers and Industrial Engineering, 45, 653-667.

[18] Allinson, N.M., Lawson, M., (1990) Accurate Texture Characterisation Using Fractal Techniques, IEE Colloquium on: "The Applicationof Fractal Techniques in ImageProcessing".