About possibility of immediate evaluation of technical condition of mining equipment using signal value of acoustic emission friction

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Abstract. An experiment was conducted to confirm the reliability of the evaluation of the technical condition of transmission elements during operation in terms of the magnitude and nature of the acoustic emission signal, while completing the negative effect of the artificial environment on the durability of the transmission elements. Thus, the results of the experiment are presented where the acoustic emission signal in the friction pair was changed depending on the pressure value in the contacting pair and the angular velocity value. The possibility of obtaining an estimate of the technical state of the transmission elements during its operation in terms of acoustic and emission characteristics has been experimentally confirmed.

1. Introduction
Currently the development of the mining economic sector is impossible to imagine without application and usage of quarry and mining machines with high reliability and power. However, the severe and extreme conditions of mining machines exploitation lead to their low working time, to the significant downtime periods for this equipment, labour intensity increase and high repair costs.

The matter for mining machines reliability is rather acute because its lifetime for open-air works compared with that of the machines is much lower. Such machinery failures in quarry conditions have drastic consequences with high probability [1,4,9].

An additional effective diagnostics of machines transmissions is suggested to be included into the technology of mining machinery technical maintenance and repair (TMR). Such diagnostics is typical for the strategy of TMR based on the actual condition [2,3], and it should help to use optimally the mining machinery potential together with its reliability increase. Such maintenance is based on obligatory application of the newest control and adjusting means and methods that allow finding out the main part of different equipment defects. The maintenance is to use a complex approach to solve the engineering and technical matters with the aim to keep the machines in workable condition. The effective tool for such diagnostics is the estimation of the signal value in the acoustic emission range and character caused by an interaction character of machine transmission working elements.

2. Non-destructive testing
Non-destructive testing is a wide group of analysis techniques used in science and industry to evaluate the properties of a material, component or system without causing damage. The terms “nondestructive examination”, “nondestructive inspection”, and “nondestructive evaluation” are also commonly used to describe this technology. Non-destructive testing does not permanently alter the article being
inspected, it is a highly-valuable technique that can save both money and time in product evaluation, troubleshooting, and research.

Non-destructive testing is one part of the function of quality control and is complementary to other long established methods. By definition non-destructive testing is the testing of materials for surface or internal flaws or metallurgical condition without interfering in any way with the integrity of the material or its suitability for service.

It is possible to decrease the risks of emergency failures by damages and defects early discovery and to plan rationally the means and forces by carrying out the technical maintenance [5,4,10,12] when providing the data analysis about the signal character and value of acoustic emission friction. The analysis is made according to estimation results of the machinery technical condition.

To provide the transmissions work of normal mining machinery in hard ambient conditions of its exploitation, the lubrication is to guarantee separation of contacting surfaces, to prevent galling and sticking, to decrease wear intensiveness. Besides from the above listed requirements, the lubrication is to have stable viscosity, low solidification temperature, good anticorrosion properties [3,6,7,11].

To estimate oils lubricating capability, it is necessary to check the real friction couple contact condition. The signal of acoustic emission friction does not depend on temperature and contacting pair materials, on tested lubricant properties and on the contacting square of the parts.

3. Result and Discussion
The experiments with usage of the device ARP-11 (Bearing life analyzer) produced by METKATOM Ltd are held. In the experiments a relative index $D$ is measured that is proportional to the value of acoustic emission appearing in the friction couple “counterbody – plate” and to the index of friction in the couple [2,8,10].

Figure 1 shows the changing in the signal value of acoustic emission friction described by the index $D$ for a sequence row of angular speeds by constant pressures in a contacting pair.

![Figure 1](image)

**Figure 1.** Value dynamics of index $D$ depending on speed in the contacting pair with the lubricant “Industrial oil I-20”.

The figure shows a stable existing trend of acoustic emission signal increasing together with the angular speed increase. Herewith the higher the pressure in the contacting pair, the more intensive the increase in index $D$. It bears evidence about degradation of the contacting pair friction conditions, pressing lubrication out of the contact area and transfer from volumetric friction to dry friction.

Figure 2 demonstrates the character of acoustic emission value change described by index $D$ for a sequence of pressure values in a contacting pair by constant angular speeds.

Similar to the angular speed parameter influence, the trend reveals that the acoustic emission signal value corresponding to the friction factor should change depending on pressure in the contacting pair. Transfer to the dry friction condition by high speeds happens already according to low pressure values,
that is, low speeds in the contacting pair in the normal conditions are kept even by significant forces [3,5,9].

Figure 2. Value dynamics of index $D$ depending on pressure in the contacting pair with the lubricant “Industrial oil I-20”.

Taking into consideration the discovered trends, based on laboratory experiments it becomes possible to find out the limit friction areas with the value lower than 4 MPa. This area is a limit parameter for a particular lubrication type “Industrial oil I-20”. During the experiment it has been found out that for the condition estimation, for example, of a mechanical transmission represented by a 2-stage gearbox, it is not obligatory to mount sensors on each of the components. To estimate integrally the condition of all transmission elements and to discover those that cause most of the problems, it is enough to determine the distinctive points on the gearbox case body. Such method provides the possibility to simplify significantly the monitoring system to follow the technical condition of a technically complicated object in terms of maintenance strategy on base of actual condition. More than that, the ARP-11 device allows composing a database about the equipment condition, and it provides the possibility to fix degradation processes in dynamics [2,11].

4. Conclusion
The important rule aimed to provide the exploitation reliability of transmission elements in mining and quarry machines consists in high-quality regular maintenance and repair. The most informative parameters to estimate the condition of a mining machine transmission are the value and type of the acoustic emission signal [3,13]. A particular usage of this information widens possibilities of the existing non-destructive inspection methods and results in emergency failures prevention, the rational forces and media distribution by technical maintenance and repair. It is experimentally confirmed that changes in the acoustic emission value reflect the friction processes in a contacting pair, and according to this value the type of friction can be estimated. As a result of the research, we have confirmed the possibility to evaluate the working surfaces condition of the interacting transmission elements, to control the surface wear, to estimate the workability of the entire assembly or a separate kinematic pair without disassembling the gearbox. Hereby the adequacy of the received information seems to be enough to make a particular decision [2,5].

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