ANALYSIS OF THE MANIFESTATION OF THE MAIN FAULTS OF MINING MACHINES ON THEIR VIBRATION MODE

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Abstract

In this paper, taking into account ergodicity of random processes in material processing, information about changes in the technical condition of bearings operating in the same conditions is recorded in the device "Topaz", which allows for frequency analysis of the vibration signal. Vibration measurement was carried out according to the block diagram, which includes a sensor (piezoaccelerometer), an analyzer (Topaz device), a computer with a set of programs for vibration monitoring.

Keywords: Bearing, frequency, ejection signal, assembly, gearbox, sensor, computer.

Introduction

In order to determine the technical condition of parts and assemblies of mining equipment by means of vibration measurements, a methodology of data collection and processing was developed, as well as research to identify operational factors affecting the parameters of the vibration signal.

The objectives of the research included:

- establishment of dependence of the vibration signal of rolling bearings on operating conditions;
- Establishment of criteria of technical condition of rolling bearings;
- establishment of mandatory control modes during diagnostics.

Based on the need to obtain a sufficient amount of data on the technical condition of parts and units of mining equipment, the following requirements were imposed on the information: continuity, completeness, reliability, homogeneity.

Data on changes in the technical condition of rolling bearings running in the same conditions, taking into account the ergodic property of random processes during material processing, were recorded on the device "TOPAZ", which allows to carry out frequency analysis of the vibration signal. Vibration measurements were performed according to the block diagram (Fig. 3.8), which includes a sensor (piezoaccelerometer), analyzing device (TOPAZ device), computer with a package of programs for vibration monitoring.

A piezoaccelerometer sensor with a wide frequency range was used to convert mechanical vibrations into digital form. Piezoaccelerometers have the smallest measurement error and have a wide enough frequency range from 5 Hz to 25 thousand Hz. The mass of the sensor is small

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in relation to the mass of the investigated objects and therefore does not affect the vibrational characteristics.

The sensor was attached magnetically. The method provides sufficiently reliable fixing of the sensor. The sensor was installed in the points containing the most complete information about the state of kinematic pairs, i.e. near the bearing seats of the input, intermediate and output shafts of the gearbox.

The errors in determining the technical condition using the proposed diagnostic equipment consisted of the error associated with the physical nature of the vibroacoustic method and hardware error. The errors were estimated by the relative measurement error in percent

$$\Delta r_{отн} = \frac{\Delta r}{r_{cp}} \cdot 100\%,$$

where Δr - total absolute measurement error; r_{cp} - average value of the measured value.

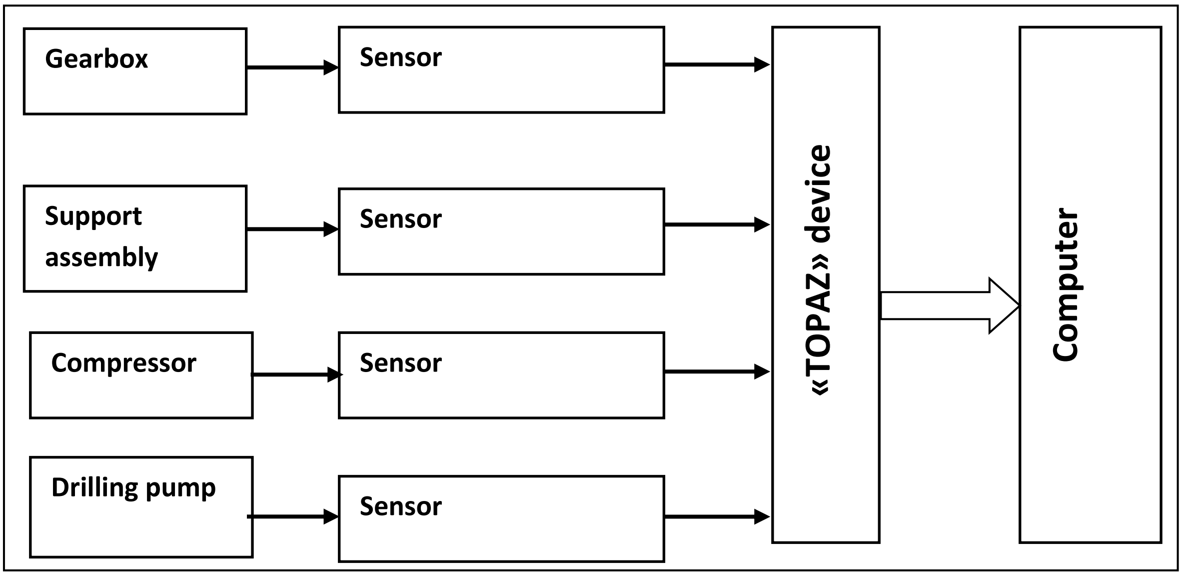

Fig. 3.8. Block diagram of apparatus for analyzing vibration of mining equipment

The total absolute error was determined by the formula

$$\Delta r = \sqrt{(\Delta r_a)^2 + (\Delta r_{\phi})^2},$$

where Δr_a - hardware error; Δr_{ϕ} - the error associated with measurement error and when using the selected diagnostic equipment did not exceed 5%.

The necessary and sufficient number of observations N for changes in the technical condition of drilling equipment was determined by the formula:

$$N = \frac{n \cdot T}{k_1 \cdot k_2 \cdot t},$$

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where n – number of measurements; T – possible operating time before reaching the limit state of the node, hour; k_1 – continuous operation coefficient of the object under study; k_2 – coefficient taking into account the machine operating mode; t – shift duration, hour.

The number of measurements n that need to be recorded when making observations is a function of the required confidence level γ and the accuracy factor δ.

The value of γ is taken equal to $\gamma = 0.9 - 0.95$, and the coefficient δ is determined according to the dependence:

$$\delta = 1/(1+\varsigma),$$

where ς is the acceptable error value, taken as 0.05-0.15.

The mathematical expectation is determined by the formula: $m = \frac{1}{n}\sum_{i=1}^{n} x_i$.

As an estimate of the variance σ^2 we take the value of $\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$.

Standard deviation $\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$.

Determination of limits of ranges of statistically possible and statistically permissible vibration levels: the range of statistically permissible vibration levels of the i-th object depending on the operating time (number of measurements) and accumulated vibration data of serviceable objects, for ni-th measurement is determined by the formula:верхняя граница: $X^{в}_{i,n_i} = \bar{X}_{i,n_i} + K^{в}_{n}\sigma$; lower limit: $X^{н}_{i,n_i} = \bar{X}_{i,n_i} - K^{н}_{n}\sigma$,

where: X_{i,n_i} - average value of the registered vibration parameter obtained by n_i measurements; σ - standard deviation of the registered vibration parameters of serviceable objects; $K^{в}_{n}, K^{н}_{n}$ - tolerance coefficients forming respectively upper X_{i,n_i} and lower $X^{н}_{i,n_i}$ limits according to the specified probabilities of vibration of the diagnosed object beyond their limits, provided that the vibration dispersion is determined by the dispersion σ^2.

When performing vibration monitoring of mining machines, one of the main tasks is to determine the cause of changes in the vibration mode of the machine in order to establish the level of technical condition of the machine.

Table 3.1 summarizes the manifestations of the main specific faults in mechanical and electromechanical elements of mining machines.

Table 3.1

Source of vibration	Basic frequency	Main area	Phase ratio
Imbalance Static Dynamic	 1•r/pm 1•r/pm	 Radial Radial	 In the phase In antiphase
Uncentering Angular Offset Offset + corner	 1; 2•r/pm 1; 2; 3•r/pm 1; 2; 3...r/pm	 Axial Radial Radial and axial	 In antiphase In antiphase In antiphase
Curved shaft	1; 2•r/pm	Axial	In antiphase

Bearing shells Loosenesses Oil swirl	Multiples of revolving 0.43•r/pm	 Radial Radial	
Transmissions Transmission faults Unbalance misalignment Tooth damage	Gear frequency +harmonics 1•rpm 1; 2•rpm Gear frequency + side frequencies	 Radial (cylindrical spur wheels) Radial (cylindrical spur wheels) Radial	
Electrical faults Faults in the stator Crack in rotor body Rotor eccentricity	 2•frequency network 2•Network frequency + network side frequencies 1 - mains frequency + slip-dependent side frequencies	 Radial Radial	

As can be seen from the table, most faults in mechanical or electrical parts are identified by examining the vibration spectrum or current draw. Let's look at some examples in detail.

Manifestation of mechanical attenuation on the components of the vibration spectrum.

The nature of attenuation can be classified into two main groups.

1. Structural weakening:

A) weakening of supports;

B) cracks in the housings;

C) loosening of bearing parts;

D) bearing clearance deviations.

2. Weakening of the rotating elements:

A) impeller parts;

B)fans;

D) bearings;

E) couplings.

In this case, most attenuation is characterized by the presence of a large number of harmonics, the presence of half-harmonics, manifested in some cases subharmonics, random, non-periodic nature of the temporal signal.

Manifestation of defects in gears on the components of the vibration spectrum.

Gearboxes (gearboxes) have a rather complex mechanical system, which significantly complicates the interpretation of their vibration parameter spectra.

Most gear defects are characterized by the manifestation of tooth frequencies or gear frequencies.

Determining the value of the gear frequency is done by multiplying the revolving frequency of the wheel by the number of teeth.

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Manifestation of defects in electric motors on the components of the vibration spectrum.

In addition to mechanical faults in electric motors, electrical faults can also occur, which also affect machine vibration.

The main sources of induction motor rotor vibration are:

1. Damage to the rotor bars, which is manifested by a predominant vibration at operating speed of the shaft with side bands located at an interval equal to the product of the number of poles of the electric motor by its slip.
2. Weakening of the iron or groove as indicated by predominant vibration at the 2nd harmonic of the linear electrical frequency and rotor slot frequency.
3. Rotor and stator air gap eccentricity, as indicated by a peak in the first harmonic with sidebands spaced at an interval equal to the slip frequency.

The main sources of induction motor stator vibration are:

1. Weakening of the stator core sheets, manifested by a peak at the second harmonic of the linear frequency.
2. Open or shorted windings, which manifest themselves by peaks in the second harmonic of the linear frequency, as well as an increase in the amplitude of vibration and temperature rise of the electric motor.
3. Insulation breakdown causing a peak in the second harmonic of the line frequency.
4. Phase misalignment, resulting in a peak at the second harmonic of the linear frequency.

To identify the electrical source of vibration manifestation, the well-known method of vibration analysis is used when the electric machine is coasting after disconnection from the supply network. It should also be taken into account that electrical problems manifest themselves in the radial direction, except in cases of mismatch of the magnetic axes of the electric motor.

Electrical defects in an electric motor can lead in their development to mechanical problems as well, which confirms the need for early detection-The rotor bars on either side of a damaged bar, for example, are forced to carry more current to maintain the speed of the motor. This causes the rotor to have some hot grooves and heats up unevenly. In addition, by causing deformation of the rotor, heating also causes the rotor to lengthen and if the rotor is deprived of free axial movement, this increase in length will cause excessive axial load on the bearing units and when bearing clearances become too small, the bearings overheat and fail.

To identify the electrical defect along with the vibration signal, it is necessary to have the spectrum of current consumed by the motor.

Conclusions

- On the basis of kinematic and dynamic analysis of bearing units operation, characteristic frequencies of vibrations corresponding to certain types of defects of mining equipment bearings were calculated;
- Control and observation of the level of vibration parameters allows to determine the nature of malfunctions in the mechanical systems of mining equipment.

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REFERENCES

1. Змановский В.А. Исследование по акустической диагностике механизмов с подшипниками качения.//Автореферат. дисс. на соискание ученой степени канд. техн. наук. –Новосибирск, 1965 г.
2. Ивович В.А. Переходные матрицы в динамике упругих систем. Справочник. –М.: Машиностроение, 1981, 183 с.
3. Кантович Л. И., Дмитриев В. Н. Статика и динамика буровых шарошечных станков. М., Недра, 1984, 200 с.
4. Эгамбердиев И.П. Исследование интенсивности виброакустического сигнала в опорных узлах горного оборудования // Фан ва технологиялар тараққиёти. –Бухоро, 2019. – №4. – С. 18-21 (05.00.00; №24).
5. Эгамбердиев И.П. Методика расчета динамических характеристик опорных узлов бурового оборудования // Горный вестник Узбекистана. – Навои, 2011. – №4. – С. 68-71 (05.00.00; №7).