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Vibroacoustic evaluation of the rolling bearings' technical condition

Abstract

In the article authors presents results of study, which have on aim qualification of technical state of rolling bearings with vibroacoustics methods. Examined bearings were mounted in rollers of belt conveyor working in coalmine. Research was conducted after certain time of rollers' operation. For analysis were used vibrations signals, recorded in laboratory, on special test stand. The basis of evaluations was changes in signals caused by damages and wear of bearings.

Keywords: Rolling bearings, vibroacoustic diagnostics, measurements of vibrations.

1. Introduction

Belt conveyors are the largest group of devices designed to continuous transport. The largest application, about 80% length all routs, falls on mining, in which conveyors provides to moving winning. From remaining important branches of industry in which belt conveyors find large application are metallurgy, heat and power generating plants and the power stations.

Belt conveyors have simple construction, in which can be specified: going and reversible barrels, barrels they stretch the belt, and belt leading rollers. In dependence from length of conveyor, the kind of transported material etc., number of rollers can differ significantly, and cost of their exchange can make up the different part in value of whole conveyor [2, 4, 8]. In construction of rollers are used rolling bearings, which work in very different conditions, depending on location of roller installation in conveyor.

Having on attention that from number of rollers are depended the losses of energy on rolling motion of the belt on jacket of roller, also the friction of belt with the jacket of rollers, as well overcome turn resistances of rollers, the aim of presented investigations was verification of the possibility of rollers diagnostics with use vibroacoustics methods. Only bearings in good technical state guarantee possibility of reduction of conveyor work costs.

Presented in article results of investigation come from researches which were led on laboratory test stand. Various tests are only the basis for the created database symptoms of the technical condition of bearings mounted in rollers. The measurements of jacket's vibrations of rollers installed on laboratory stand were conducted. Next, registered vibration signals were processed with use different methods of analysis. The comparison of results obtained for all of tested rollers allow qualifying usability of wear rollers to further operation.

2. Research object

The object in presented research was rolling bearings mounted in rollers of belt conveyor. The conveyor named Gwarek 1200 is working in coalmine KWK Mysłowice–Wesoła and transporting winning to output shaft on level 665 m. The length of conveyor carries out 140 m. For driving of belt conveyor are used two electric engines. Entire power of engines amounts to 180 kW. The maximum efficiency of conveyor is 1200 t/h. Upper rollers in presented belt conveyor was spaced every 1.5 m, while bottom rollers every 3 m. With attention on number of rollers, assurance of proper their technical state can contribute to lower consumption of necessary energy to drive of belt conveyor [1, 5, 7].

In examined rollers were applied bearings 6305 ETN9 / C4, produced by SKF with poliamid basket strengthened with glass fibre [6, 12]. Rollers characterize the C4 class of seal in bearings as well as the labyrinth seal U4Exp 62/65 with cover 2LU4. The construction of belt roller is shown in Fig. 1.

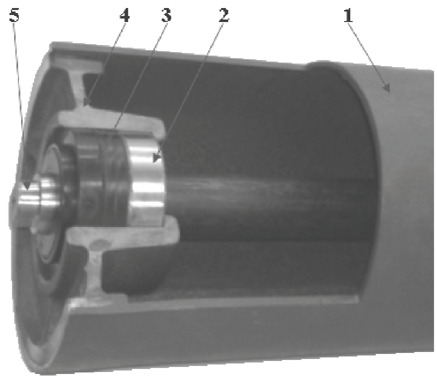

Fig. 1. The construction of belt roller: 1 – jacket, 2 – bearing, 3 – labyrinth seal, 4 – cast iron hub, 5 – axle [9, 10]

During studies were used thirty rollers - 10 rollers $\phi 133\times 670$ and 20 roller $\phi 133\times 465$. All rollers, with the exception of one roller, were disassembled from belt conveyor working in mine and have clearly visible symptoms of wear. One roller was delivered to laboratory in new condition. Selected rollers are presented in Fig. 2.

Fig. 2. First part of examined rollers

3. Procedure of testing

The aim of the study was to obtain information about the influence of technical state of rolling bearings on jacket vibration of the belt roller. Technical condition of bearings directly affects to the resistance of rollers rotation.

In laboratory, condition of bearings may be assessed in many ways. For example evaluation of sounds generated during operation of the bearing is possible. The methods which use traditional or electronic stethoscopes are subjective and not always allowing for the proper diagnosis, because the sense of hearing and the ability of its perception, tends to get used to the processes that occur gradually.

In presented research was used method of evaluation of bearings' technical state, in which are used analyses of vibroacoustic signals. That eliminates subjective character of studies. On test stand was conducted measurements of jacket vibrations.

Vibration measurements of rollers' jackets were carried out with use acceleration transducers PCB. During the study was made simultaneous measurements of linear accelerations of jacket on the hub of bearing (Fig. 3). During measurements jacket was attached in a manner preventing its rotation, while the drive is adjusted to the axle direct from motor rotating at a speed ~650 rpm.

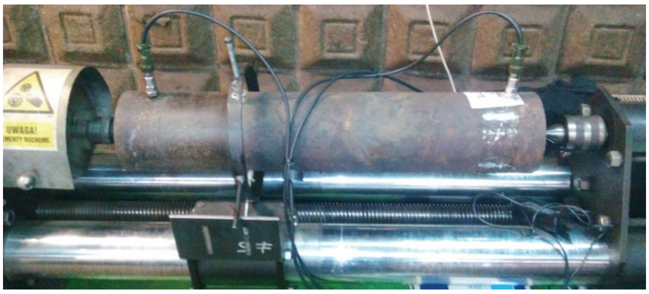

Fig. 3. Examined roller mounted on test stand

The signals were recorded with use 8–channel data acquisition card EC VibDAQ. As a result of signal processing, taking into account radial cylindricity deviation of jacket, was made filtration of recorded vibration signals. In result was received the time courses of vibrations caused by the work of the bearings.

Vibration acceleration sensors (standard ICP) allow registration of vibrations with frequencies up to 10 kHz. The signals are sampled at a frequency of 31.25 kHz, which allowed in accordance with the Nyquist criterion for the registration of whole range of vibration acceleration measured by sensors.

Like in preliminary research, described in [9, 10], changes in the vibration signals caused by operational wear of bearings mounted in roller were determined by a number of simple amplitude measurements derived from time courses. Some of the measures used in the study are listed below as formulas 1-5. The selection of the measures was based on the basis of literature sources and the practical experience of authors [9, 10]:

- mean square value:

$$\Psi^2 = \lim_{T\to\infty} \frac{1}{T}\int_0^T x^2(t)\,\mathrm{d}t \tag{1}$$

where: T – time of averaging, s

- RMS value:

$$x_{RMS} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\,\mathrm{d}t} \tag{2}$$

- standard deviation:

$$\sigma = \sqrt{\frac{1}{T}\int_0^T \left[x(t) - \bar{x}\right]^2 \mathrm{d}t} \tag{3}$$

- variance:

$$\upsilon = \lim_{T\to\infty} \frac{1}{T}\int_0^T \left[x(t) - \bar{x}\right]^2 \mathrm{d}t \tag{4}$$

- peak to peak value:

$$x_{P-P} = \left|\max_{0<t\le T}(x(t)) - \min_{0<t\le T}(x(t))\right| \tag{5}$$

In analyses were also determined values of dimensionless discriminants:

- crest factor

$$C = \frac{x_{P-P}}{x_{RMS}} \tag{6}$$

- waveform factor:

$$K = \frac{x_{RMS}}{\frac{1}{T}\int_0^T |x(t)|\,\mathrm{d}t} \tag{7}$$

- clearance factor:

$$L = \frac{x_{P-P}}{\left(\frac{1}{T}\int_0^T \sqrt{|x(t)|}\,\mathrm{d}t\right)^2} \tag{8}$$

- impulsivity factor:

$$I = \frac{x_{P-P}}{\frac{1}{T}\int_0^T |x(t)|\,\mathrm{d}t} \tag{9}$$

Sample time course of vibrations of roller's jacket was presented in Fig. 4.

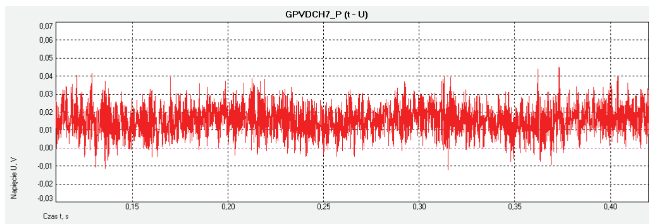

Fig. 4. Time course of vibrations of roller's jacket

4. Selected results of research

The basic information on the changes in the vibration signal caused by operational wear delivers RMS value of vibration accelerations. In Fig. 5 and 6 are presented the values of the RMS of vibration accelerations of jacket selected rollers (right side of rollers' jacket). Figure 5 refers to rollers ϕ133×670, whereas Fig. 6 to rollers ϕ133×465.

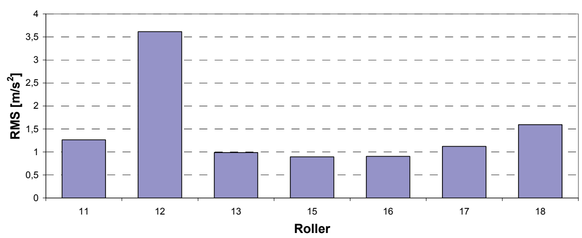

Fig. 5. RMS values of vibrations of selected rollers ϕ133x670

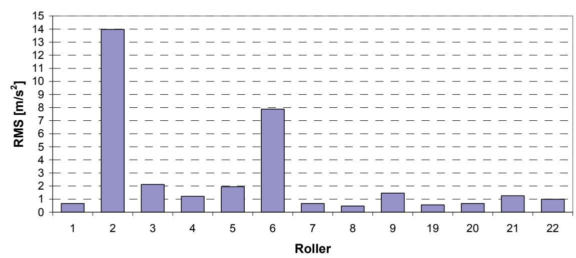

Fig. 6. RMS values of vibrations of selected rollers ϕ133x465

The high RMS values were obtained for three rollers: with number 12 (roller ϕ133×670), 2 and 6 (rollers ϕ133τ465). The values were several times greater in comparison to values obtained for the other rollers. That may result due, inter alia, from different place of roller installation on the conveyor.

The comparison of not-averaged voltage time courses of vibrations obtained during studies on roller number 2 and on new roller is presented in Fig. 7.

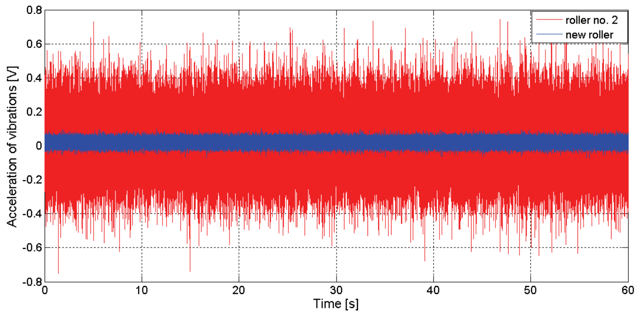

Fig. 7. Voltage time courses of vibrations obtained for roller number 2 and for a new roller

5. Conclusions

With attention on scale of applications of belt conveyors, it applies the high importance to reliability their construction [11]. Guidelines of evaluation technical state of rollers can prevent the exchange of rollers whose condition allows further operation, as well be a basis for a possible an exchange of worn rollers, which, according to the current evaluation criteria for such an exchange is not yet eligible [3].

The study shows that the operational wear of rollers affects on the level of the generated vibrations. It is visible in simple amplitude measures and in results (not presented in article) of time-frequency analyses.

Additional laboratory tests carried out on rollers has shown that, despite the significant differences seen in the vibration signal caused by the occurrence of wear, most of them still have a low static and dynamic resistance to rotation. Only rollers with numbers 2, 6 and 12 were classified as unfit for further use.

6. References

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