DIAGNOSIS OF THE WINDING MACHINE IN THE OLD SHAFT WITH SKIP IN LONEA MINING PLANT

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Abstract: To study the operation of the winding machine in the Old Shaft with Skip in Lonea Mining Plant, the dynamic analysis of the driving wheel (Koepe wheel) was performed, by resistive electric tensometry methods, acceleration measurements, and vibromechanical analysis on the bearings of Koepe driving wheels, on functioning cycles and vibromechanical analysis of the reduction gear. The paper presents aspects regarding vibromechanical measurements and resistive electric tensometry methods in the winding machine..

Keywords: compensating cable connecting device;

Introduction

Underground extraction of coal and rock in Lonea Mining Plant is done by the winding installation of the Old Shaft with Skip made up of the winding machine in the tower as well, provided with two skips, 8 ton each. Any malfunction in the functioning of the winding machine with the Old Shaft with Skip, can lead to important losses in production, and to endangering the safety of the seam and of the workers. Along the years, fissures occurred in the wheel of the winding wheel, fissures present both on the hub, and on its spokes, which evolved in time in size and number. Similarly, at the level of the rotation reduction gear, damage occurred in time at the teeth of the toothed wheel, which are continuous, not cyclic, but which permanently evolved. Therefore, it was necessary to analyze the causes leading to the phenomena described in the above, also in view of establishing practical solutions to stop in due time the above mentioned phenomena.

Prezentation of the winding machine

The winding machine itself is in the tower of the winding installation (Fig. a), with the Old Shaft with Skip,(the axis of the machine is at the level of the shaft +46,5 m) and it is destined to transport the useful mineral substance, the sterile and materials between two levels (loading station underground at level -320m, and dumping above ground level +21, 5 m). The part winding the cable is a multicable driving wheel. The type of the winding machine is MK 2,1 x 4(Fig. 2). The winding machine has asynchronous actuation. The winding installation is dynamically balanced(the balancing cable being heavier than the winding cable). The machine is actuated by two asynchronous motors(Fig. 3), with Pn = 2 x 500kW, with wound rotor, supplied at 6 kV. The transmission ratio of the 2TD-14 type reduction gear (fig. 4) is 6, the weight of the reduction gear without oil is 16060 kg, the oil volume in the reduction is 600 l. The size is 4000 mm length, 2300 mm width, 1790 mm height. Maximum number of rotations 750 rpm, maximum momentum on the main shaft 20 Nm, rotation direction reversible, number of steps 2. To reduce the shocks of the main reduction gear by 2 steps, 2 entries and 1 outlet, support springs were mounted. The helical springs on which the reduction gear of the winding machine is mounted have been sized for the maximum load produced when the transportation vessel is blocked on the shaft.

***Fig.1**. Winding installation ,, Old shaft with skip”*

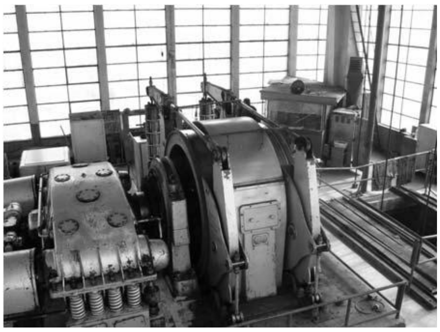

***Fig.2.** MK 2,1 x 4 type winding machine*

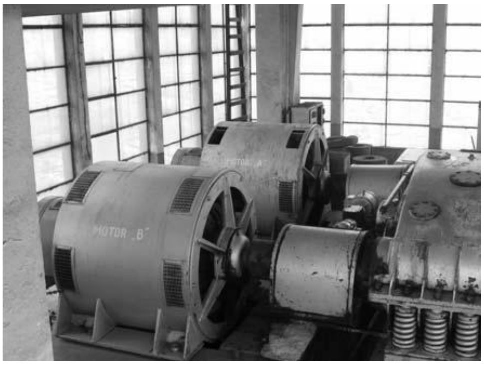

***Fig. 3.** Actuation of the winding*

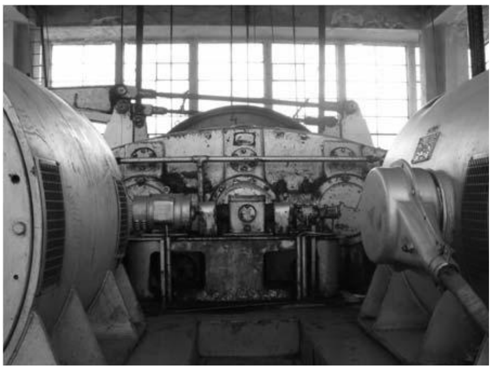

***Fig. 4.** Reduction of the winding machine*

The extreme loads of the reduction gear on spring are determined function of the magnitude of the extreme momentum of the reduction gear that occurs at the moment of blocking the transportation vessel along the shaft. At a major increase of the extreme momentum, one of the supports of the reduction gear moves down at the lowest point (to the support buffer), and the other moves upwards until the relaxation limit of the cylindrical helical spring. In this situation, the rotation momentum of the reduction gear is taken over by the helical spring that is compressed and the main shaft of the winding machine. At the modification of the rotation direction of the electrical driving motors, the loads change their values. To damp down the oscillations produced in the reduction gear by the momentum provoked by the electric motors, the reduction gear is provided with a buffer made up of a piston placed in a cylinder with oil inside. The rod of the piston is rigidly fixed to the brim of the reduction gear along the axis of the spring batteries (Fig. 5). The scheme of the. hydraulic buffer is shown in Fig. 6. Between the reduction gear and the main shaft there is a rigid coupling with bolts.

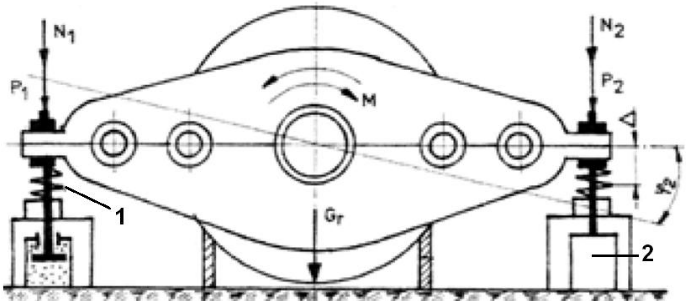

Fig. 5. *Battery of springs (1) and piston (2)*

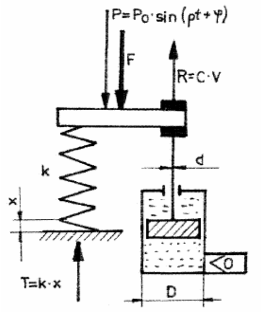

Fig. 6. *Buffer*

Vibration and resistive electric tensometry measurements of the machine

To determine the defects, vibration measurements have been done. The vibromechanical measurements have been have been performed with– 4371 type acceleration meters, made by Bruel & Kjaer, Denmark, - ICP, accelerometer Model 103.02-9 made by VibraSens France, Electronic vibrometer N2104 made by ICE Bucureşti, data acquisition has been made by SPIDER 30 and as acquisition soft CATMAN has been used, made by Hottinger Baldwin Messtechnic Germany, Fig. 7.

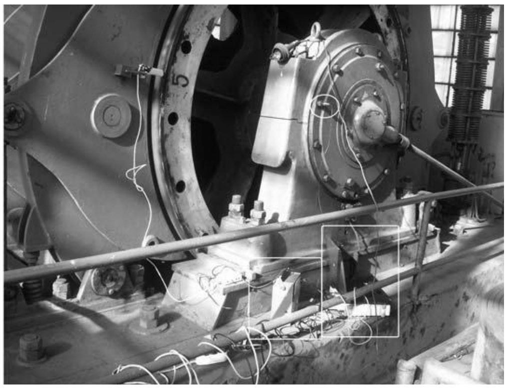

Fig. 7. *Apparatus for vibrations*

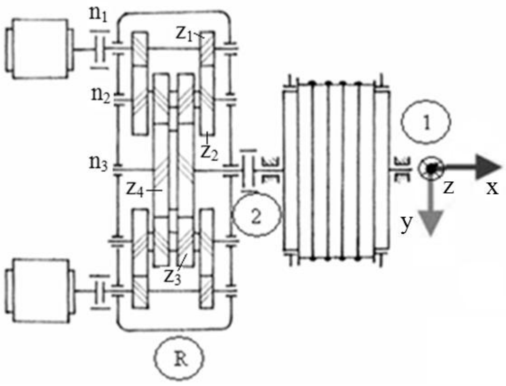

Fig. 8. *Kinematic scheme and measurement points*

The investigation points are presented in Fig. 8, where the free bearing has been given number 1, the bearing next to the reduction gear has been given number 2, and the reduction gear noted R. In all the three points of measurements, measurements were performed in 3 directions, X(axial with the shaft of the driving wheel), Y(radial with the shaft of the driving wheel, horizontally), Z(radial with the shaft of the driving wheel, vertically). To determine the frequencies generated by the reduction gear, the formula in [3], page 354 were used. The kinematic scheme of the reduction gear is presented is shown in Fig. 8. Where z_1=61 teeth, z_2=113 teeth, z_3= 41 teeth, z_4=134 teeth. The inlet rotation in the reduction gear is 500 rpm. The reduction system(m), the spring package(k) and buffers(c) make a system of vibrations with a degree of liberty, Fig. 9.

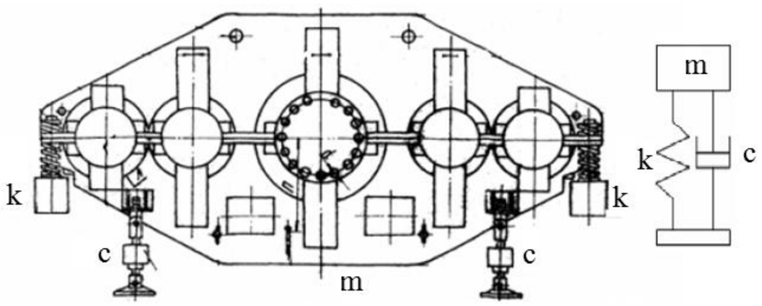

Fig. 9. *Reduction system (m), package of springs (k) and buffers (c)*

Frequencies generated by the gearing of the reduction gear at 500 rpm motor rotation are shown in Table 1.

Table 1. *Frequencies generated by the gearing of the reduction gear at 500 rpm motor rotation*

Position		Rotation n_i rpm	Freq. Hz
Motor inlet		500	8,3
Step I	Z_1 = 61 teeth	500	508
	Z_2 = 113 teeth	270	508
Step I	Z_3 = 71 teeth	270	184,5
	Z_4 = 134 teeth	83	184,5
Motor outlet		83	1,38

Buffers play the role of reducing vibration levels close to resonance frequencies. For the given system, the analytical determination of this frequency is cumbersome. Experimental determination is much simpler. The accelerometer is placed on the reduction gear in position R vertically.

The reduction gear is taken out of equilibrium, and it is let to vibrate freely.

The acceleration level is recorded function of time.

Fig. 10 shows acceleration measurements on the reduction gear verticallyat an impulse type excitation. The amplitude of the acceleration is in the range of -2 … 1,686 g.

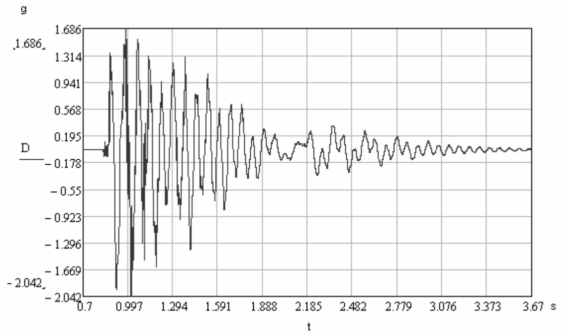

Fig. 10. *Accelerations on the reduction gear at an impulse type excitation*

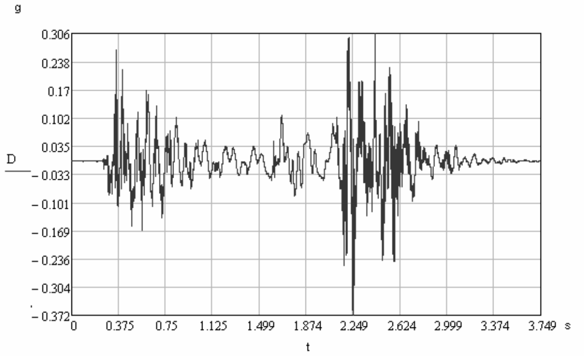

Fig. 11. *Accelerations on reduction gear vertically at an impulse type excitation*

The peak to peak acceleration amplitude is 3,72 g. The time elapsed between two maximums is 0,083 s. The own determined frequency is 12 Hz.

Fig. 11 shows acceleration measurements on the reduction gear horizontally, perpendicular to the motor, at an impulse type excitation. The acceleration amplitude is in the range of -0,372 … 0,306 g. The peak to peak acceleration amplitude is 0,678 g. The time elapsed between two maximums is 0,083 s. The own determined frequency is 12 Hz.

Fig.12 shows measurements on the reduction gear horizontally axially with motors at an impulse type excitation. Acceleration amplitude is in the range of -0,9864 … 1.0424 g. Peak to peak acceleration amplitude is 2,029 g. The time elapsed between two maximums is 0,084 s. The own determined frequency is 12 Hz.

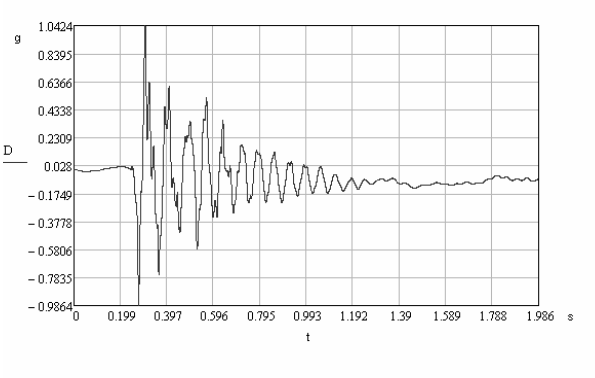

Fig. 12. *Accelerations on the reduction gear horizontally axially with motors at an impulse type excitation.*

As a result of the measurements performed, the values obtained have been synthesized as it follows: peak to peak speed and ASR measured on the winding machine are shown in Table 2, the peak to peak movement values and ASR measured on the reduction gear are presented in Table 2.

Table 2. Peak to peak speed values and RMA (average square root) measure on the winding machine

Measurement point	Peak to peak mm/s	ASR mm/s	Mark Table 4
1x	25,0	14,0	4
1y	13,0	6,6	3
1z	3,9	2,0	2
2x	80	42	4
2y	35	20	4
2z	7	3,5	2
Rx	34	18	4
Ry	18	9,6	3
Rz	74	37	4

Tense-metric measurement were made with SPIDER 30 type apparatus, 1-LY11-6/120 type electrical resistant transducers, , and as data acquisition soft CATMAN utilitary has been used, made by Hottinger Baldwin Messtechnic Germania, fig. 12.

Table 3. *Peak to peak movement values and ASR measured on the reduction gear*

Measurement point	Peak to peak mm	ASR mm
Rx	1,3	0,7
Ry	0,9	0,5
Rz	2,5	1,3

Table 4. *Vibration level according to VDI 2056, Group G heavy duty machines higher than300 kW*

V_{ASR} mm/s	Mark	Obs.
2,28 ... 1,8	Bun	1
1,8 ... 4,5	Acceptable	2
4,5 ... 11	Still acceptable	3
11 ... 46	Inacceptable	4

Fig. 12. *Apparatus for vibrations tensometry measurements*

Fig. 13. *Transducer welded by the two halfhubs*

In order to see the movement value along axial direction of the two half-hubs at the fissure occurred in the welding, a tense-metric transducer has been developed. The transducer is made up of a 10x10 mm and 410 mm long rod on which 2 electrical resistant transducers have been placed.

The transducer has been welded by the two half-hubs fig. 13.

By coupling the transducers to the tense-metric bridge, a series of measurement have been done, in the case in which the transducer was at maximum and minimum vertical position (12. and 6 o'clock).

The values measured in µm/m are shown in Fig. 14. The recording shows a 0,1 mm movements.

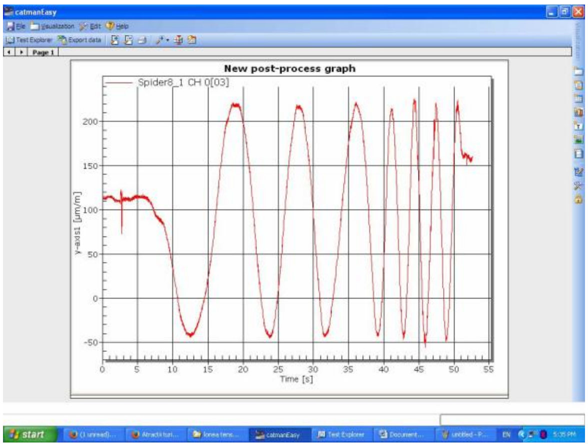

Fig. 14. *Movement value between half-hubs*

Conclusions

As a result of tensometric and vibration measurements, a series of conclusions can be drawn:

Space between welding fissures between the two semi-hubs is 0,1 mm, which is confirmed from the calculations with finite elements. The reduction gear system’s own frequency, elastic elements of buffer is 12 Hz.

Maximum frequency generated by the reduction gear’s gearing are are1,38 Hz, 8,3 Hz, 148,5 Hz, 508 Hz. These frequencies are for a rotation of 500 rpm of the driving motor. All frequencies increase from zero to maximum value, along with the increase of the motor rotation. Thus, frequencies generated by step I and II pass through resonance frequency of the reduction gear. The buffer plays the role of reducing to minimum the amplitudes around 12 Hz frequency. The 8,3 Hz frequency, the nominal rotation frequency is close enough to the 12 Hz frequency. The treaties of mechanical vibrations recommend for the working frequency to differ from the resonance frequency by ±20 %. In fact we have a percentage of - 44,5%.But this does not mean that there is no need for buffer.

According to the level of vibrations according to VDI 2056, Group G > 300 kW on rigid foundations, the vibration level of the entire machine is over the admitted limit.

According to ASR (average square root) in Table 2 it is seen that the higher vibration level, 37 mm/s is that of the reduction gear vertically. High vibration levels are met axially, intermediary bearing, 42 mm/s, with attenuation next to the free bearing, 14 mm/s attenuation due to the mass of the driving wheel. On the reduction gear an 18 mm/s vibration level is found. In the two bearings, radial vibrations are lower than axial ones, approximately twice.

The buffers of the winding machine have great clearance in the articulations due to bolt holes becoming oval, which might have been conditioned by sleeving the bolt boring.

Dumping shocks of the reduction gear when starting and stopping, due to buffer deficiencies, are transmitted to the teeth of the reduction gearing leading to its damage. To improve the functioning of the winding machine it is recommended in the first place to change the two defect buffers or repair them an consolidate the driving wheel to reduce elastic deformation of its shaft, in order to improve the functioning of the reduction gear.

For comparison, vibration measurements have been performed on an identical winding machine in Livezeni Mining Plant.

The vibration level of the winding machine in Livezeni Mining Plant, horizontally in the free bearing is 8,33 times smaller and on the reduction gear vertically 2,3 times smaller.

Similarly, comparatively the level of movement between the two reduction gears, the one of Livezeni Mining Plant is 6,1 times smaller.

Comparing the acceleration measurements on the reduction gear vertically at an impulse type excitation, it is noticed that in the case of the reduction gear in Livezeni Mining Plant, the movement is evenly slowed down, while the one from Lonea Mining Plant has a series of irregularities. These occur due to the deficient functioning of the buffers.

Because of the buffers the gearing inside the reduction gear was destroyed. Thus high level vibrations occur, vibrations and shocks that can lead to damage of the system and fissuring of the driving wheel.

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