SIZE VERIFICATION AND DESIGN ANALYSIS OF PULLEY SHAFT AT LONEA MINING PLANT

IOSIF DUMITRESCU[1], VILHELM ITU[2], MIHAI CARMELO RIDZI[3]

Abstract: Mining industry is still the only supplier of mineral resources, both metals, coal and other useful mineral substances. In order to secure the continuity of the extraction process, winding installations, as main link in the transportation flow of mined out mass, should function in optimum and safe conditions. The paper refers to size verification and design analysis of pulley shaft in the winding installation with skip at Lonea Mining Plant.

Key words: pulley shaft; size verification; design analysis

1. INTRODUCTION

The utilization of coal for energy purposes is still in an essential position in world economy, in spite of the facilities provided by energy based on petroleum and natural gas or nuclear or hydro energetic plants.

In order to secure the continuity of the extraction process, it is important for the winding installations, as main link in the transportation flow of mined out mass, to function in optimum and safe conditions. Therefore it is required to permanently monitor the behavior of these installations in view of improving the technical economical indicators of reliability and exploitation.

Variation of demands is due both to cinematic and dynamic parameters and geometric ones. Cinematic parameters are in their turn influenced by extraction depth and distance between levels, with repercussions on maximum velocity and acceleration and retardation periods.

The winding installation that goes with the skip shaft at Lonea Mining Plant is intended to extract the underground mineral substance, between level -247,35 and the skip discharge level +649,5 m, an 896,85 m route. The extraction vessels are skip-cage

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type of 21620 kg weight for a useful extraction vessel capacity in the range of 7500 and 8000 kg. The two extraction cables, Φ46,5 mm diameters, and 8,049 kg/m specific weight, are winded over the pairs of upper and lower winding pulleys, Fig. 1, Φ 5000 mm diameter and on the drive roll of the Φ5000 mm diameter winding engine. The pulley weight is 12109 kg, in the tower, 51 m high, the axis of the upper pulleys, ans 44 m, the axis of the lower pulleys, as to the level of the shaft ramp. The two balancing cables have a 135x20 mm cross section and a 9,062 kg/m specific weight.

Fig. 1. Extraction pulley platforms

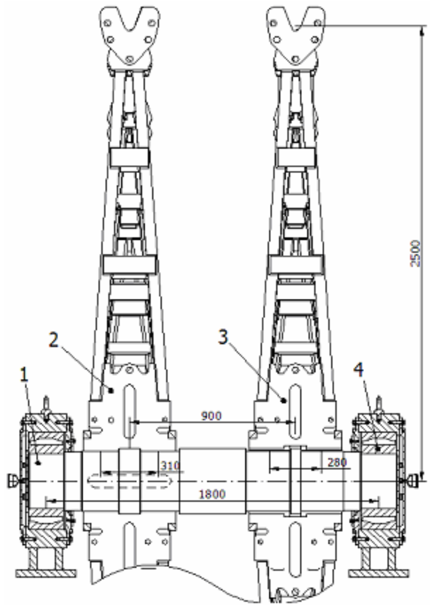


Fig. 2. The pulley shaft

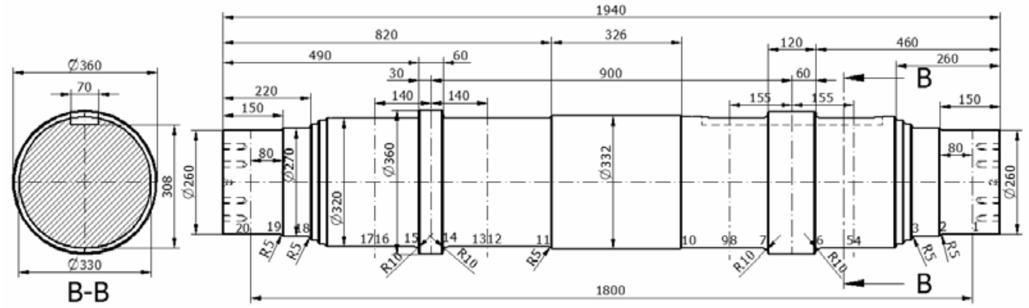
2. SIZE VERIFICATION OF PULLEY SHAFT

The charges on the elements of the multi-cable winding installation can be permanent and temporary. Permanent charges are those due to the weight of the basic elements of the system with extraction vessels without load (extraction cables, cable connecting devices, tension balancing devices in cables, extraction vessel, balancing cables connecting devices, balancing cables).

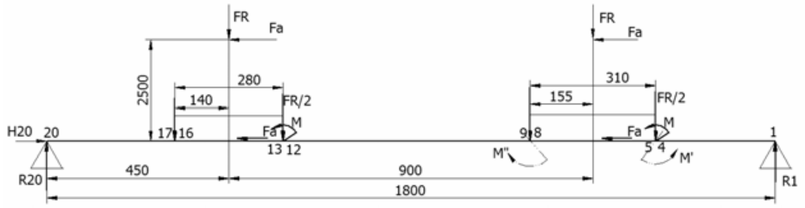
Temporary charges are work charges(load of the extraction vessel, dynamic starting and stopping forces), random and emergency charges acting temporarily on the winding installation, during the functioning of the installation, of the tests and other revision and repair operation of the winding installation.

The highest charges are the emergency ones that occur when the extraction vessel is blocked, which moves upwards the shaft. All the elements of the winding installation are sized to safety coefficients higher than 8, at material transportation, as well as permanent charges.

Fig. 2 shows the pulley shaft, cross sectioning the separation plane of the semi pulleys, where: 1 – shaft; 2 – fixed pulley; 3 – mobile pulley; 4 – pulley shaft support bearings. The fixed pulley is positioned on the shaft through a shoulder and a parallel wedge, and the mobile pulley through a shoulder and two sliding bearings. Semi pulleys are assembled through cantering wedges, fastening screws and fastening rings. The mobile pulley has the role of reducing tensions in the cable and wears of the groove for the cable, due to different lengthening of the two cables when winding and unwinding on and from the drive roll of the winding engine.



a)



b)

Fig. 3. Shaft design size and mathematical load model

The design shape and size of the shaft are given in Fig. 3.a and the mathematical model of loading the shaft in Fig. 3.b. Each pulley is considered to rest on two planes of the shaft, with a force concentrated on the middle of the planes. Based on the mathematical model in Fig. 3.b, a shaft size verification programme for three work situation of the fixed pulley was devised.

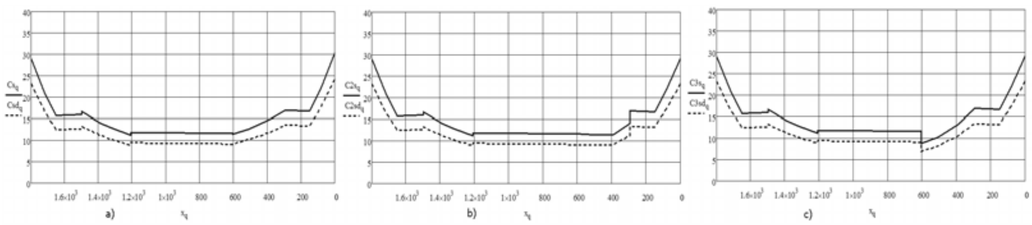


Fig. 4. Variation model of the safety coefficient to the resistance to break and flow limit

Fig. 4 shows the variations of the (σ_r = 980 MPa) safety coefficient compared to the break resistance of the shaft steel, 40Cr10, and the (σ_c = 780 MPa) flow limit in the 20 points on the shaft, for the three situations: I – when the fixed pulley rests on both planes (Fig. 4.a); II – when the fixed pulley rests only on the plane at the end of the shaft (Fig. 4.b); III – when the fixed pulley rests only on the plane at the middle of the shaft (Fig. 4.c).

Even with these values of the safety coefficient, at the beginning of the year 2007, the shaft broke down at point 6, shown in Fig. 5. It is noticed that the break was initiated in the area of the wedge groove and was produced in time due to fatigue.
In the area of the fixed pulley, tension concentrators, due to diameter leap (Φ330 to Φ360) of a 2,5 mm radius and wedge groove, overlap. For the three possible cases of mounting the pulley on the shaft, with the help of Gh. Buzdugan's formula, safety coefficients to fatigue shown in Table 1 were determined.

$$C_\sigma = \frac{1}{\sqrt{\left(\frac{\beta k_{\sigma 1} \cdot \beta k_{\sigma 2}}{\varepsilon_\sigma \cdot \gamma}\right)^2 \cdot \left(\frac{\sigma_a}{\sigma_{01}}\right)^2 + \left(\frac{\sigma_m}{\sigma_c}\right)^2}}, \tag{1}$$

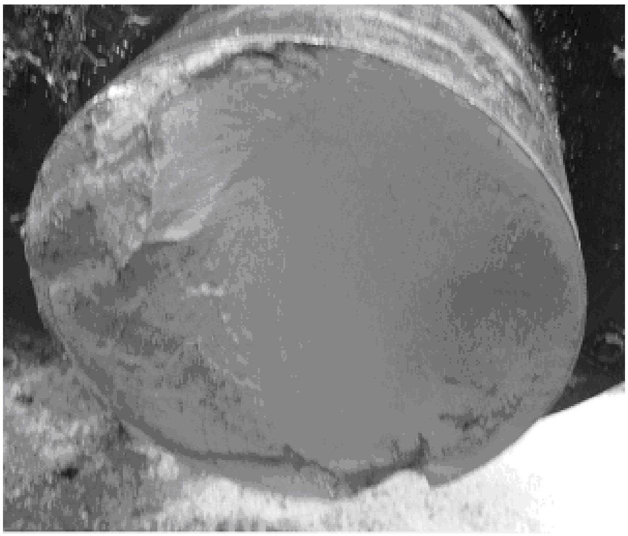


Fig. 5. Shaft break

Table 1. **Safety coefficients to fatigue**

Pulley mounting	**Point on the shaft**	
	6	7
Case I	1,37	1,18
Case II	1,061	1,066
Case III	1,22	0,95

3. DESIGN ANALYSIS OF PULLEY SHAFT

Starting from the design solution of the pulley shaft at Lonea Mining Plant shown in Fig 2, the results of size verifications and breaking of the shaft in the area of the fixed pulley threshold, a design and technological analysis of the shaft was necessary.

In the execution of the two parts of the support plane of the pulley, two level adjustment of the tool should be made, these leading to size deviations of the two parts, even when shape and position deviations didn't exist.

These size deviations lead to fixing the pulley on only one side, its boring being made by only one pass, which brings an additional bending moment to the shaft, reducing the safety coefficient to fatigue even more, (less than 0,95).

The situation shown is confirmed by the use of a copper foil on one of the sides, secured with a bracelet against rejection.

Considering the above, the following design solution was proposed for the shaft, shown in Fig. 6, where 1 – mobile pulley ring; 2 – shaft; 3 –wedge; 4 – fixed pulley ring.

The proposed shaft has symmetrical head pins and one central plane, allowing its easy and precise processing. The mobile pulley's ring is tightened to the shaft and the fixed pulley ring, positioned on the shaft by the two wedges, is mounted loosely.

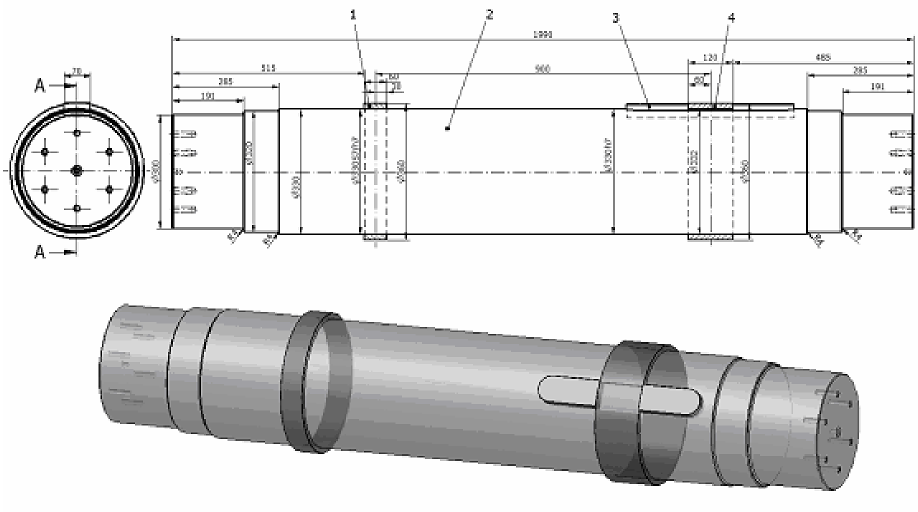


Fig. 6. Modified pulley shaft at Lonea Mining Plant

With the help of Cosmos Design Star software, an analysis with finite elements for the two design solutions was made, and the results are shown in Fig. 7. Case II was analyzed, when the fixed pulley is fixed only on the outer plane, it is noticed that the tension equivalent to the existing shaft is three times higher, due to the geometric shape and of the tension concentrators.

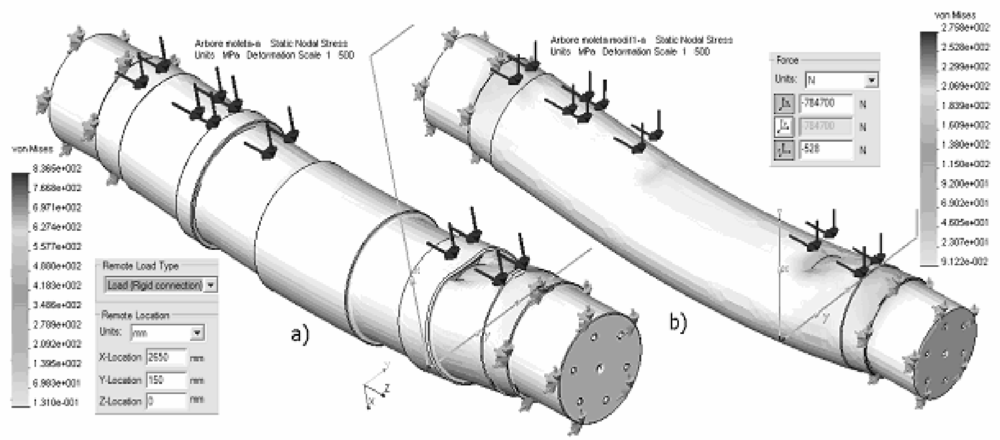


Fig. 7. Analysis with finite elements of the two shafts, existing and proposed

4. CONCLUSSIONS

The design solution proposed shows the following advantages:

- increase of the safety coefficient to fatigue to higher values, due to reducing tension concentrators in the area of the fixed pulley, only the wedge groove;
- economy of forged material of 262,6 kg (from 370 to 340 diameter) of over 500 EURO;
- improvement of degree of use of material, increase from 79,7% to 89,7%;
- improvement of technological conditions of processing;
- improvement of conditions of assembling of fixed pulley.

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