STUDY THE ADAPTATION OF A 45 KW MINING WINCH FOR LIFTING THE MINING EQUIPMENT AT E.M. LUPENI

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Abstract: Mining winches can be used for horizontal traction, on railways, and on inclined planes. They can be with one or two drums and with friction washer. Winches for inclined planes with powers greater than 40 ... 50 kW have a construction similar to that of extraction machines, with a safety brake, a position indicator of the towed load and other signaling and automation elements.

Keywords: Advance mechanism, coal, CAD software

1. INTRODUCTION

Mining winches can be used for horizontal traction, on railways, and on inclined planes. They can be with one or two drums and with friction washer. Winches for inclined planes with powers greater than 40 ... 50 kW have a construction similar to that of extraction machines, with a safety brake, a position indicator of the towed load and other signaling and automation elements. They can be driven with worm-gear reducers or cylindrical reducers. In the case of cylindrical reducers, electrohydraulic cylindrical brakes are required on the input shaft, similar to the electric hoists on overhead bridges.

Three years ago, a 75 kW winch used to handle skips with a maximum mass of 30 tons was destroyed, which fell into the shaft at a height of more than 200 m and caused the drum to be torn off and the reducer to be destroyed, figure 1. In the case presented, there were no human casualties, only material damage and the coal extraction flow was blocked, interrupting the mine's production process.

The ratchet mechanism or shoe brake in mining winches is mounted on the sides of the drum, with the role of preventing the lifted load from falling in the event of a failure of the mechanical transmission of the winch. [6]

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Fig. 1. Mining winch destruction mode [6]

The paper presents the method of adapting a 45 kW inclined plane winch existing at E.M. Lupeni in order to replace the 75 kW winch destroyed following a wrong maneuver. The adaptation consists of solving problems regarding the mechanical transmission, fixing to the foundation, strengthening the drum bearings and improving the control system of the ratchet safety mechanism. [1,3]

2. NEW WINCH MECHANICAL TRANSMISSION

The lack of technical documentation for the 45 kW winch required its identification and verification of its mechanical transmission. The kinematic diagram of the winch is shown in Figure 2, where the following were noted: 1 – 45 kW electric motor, n = 1450 rpm; 2 – elastic coupling with bolts; 3 – FC 315 circular brake with electrohydraulic lifter; 4 – four-speed cylindrical reducer; 5 – coupling with bolts; 6 –

spherical joint; 7 – winch drum; 8 – ratchet wheel; 9 – ratchet; 10 – counterweight; 11– winch support frame. The reducer bearings are radial with double row barrel rollers.

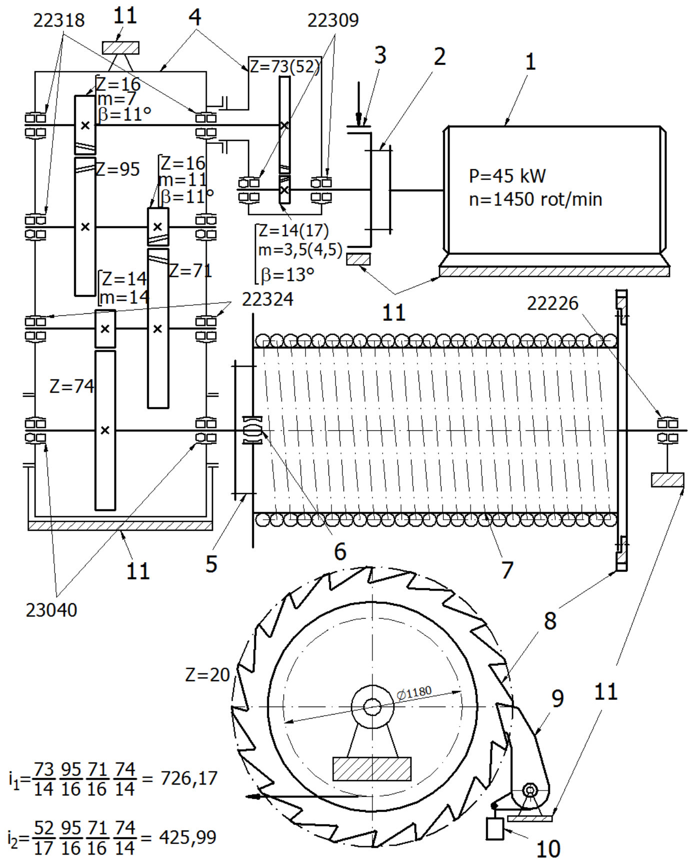

Fig. 2. Kinematic diagram of the 45 kW winch [1, 6]

The transmission of motion is done from the electric motor to the drum through an elastic coupling with bolts, a four-stage cylindrical reducer, with a transmission ratio of 726.17 and a rigid coupling with bolts. As safety elements on the kinematic chain there is a circular brake FC 315 with electrohydraulic lifter, item 3, having as a brake washer the half-coupling mounted on the input shaft of the reducer, item 2, and the ratchet mechanism, items 8 and 9, mounted on the left end of the drum, with the drum locking when pulled. Due to the ratchet mechanism and the construction of the cable attachment on the drum, it results that the cable is wound on the drum only on the right from the bearing to the reducer.

Upon examination, it was found that instead of the input shaft cover in the three-stage cylindrical reducer, which has a transmission ratio of 139.26, a cylindrical gear with a transmission ratio of 5.21 was installed, figure 3. It had two broken teeth on the pinion, which required the manufacture of a new gear. [3]

Fig. 3. First cylindrical stage additionally mounted at the input of the large gearbox [6]

Based on the kinematic diagram of the reducer, figure 2, and with the help of MathCAD software, a calculation brief was made based on STAS 12223-84 and 12268-84 for its four gears. Due to the more than fivefold increase in the torque transmitted by the gears of the large reducer, their verification was carried out in a range of nominal drive power from 22 kW to 45 kW. The material of the gears and the heat treatment applied to them, which resulted from the measurement of the hardness of the teeth, are as follows: stage I is made of case-hardening steel (56 – 62 HRC); stages II and III have the pinion heat-treated, improved to 45 HRC, and the gears to a hardness of 200 HB; stage IV has both the pinion and the gear to a hardness of 200 HB. [3]

The results obtained from the calculation brief for the 4th gear of the reducer, the safety factors for contact pressure fatigue SH and bending fatigue at the tooth root SF, respectively the traction force Ftr for the first and second layers of turns on the drum are presented in Figure 4. From figure 4a it results that the tractive force at 45 kW is over 310 kN, sufficient for the skip handling, but the contact fatigue coefficient has the admissible value only for a drive power of 26 kW. At a drive power of 26 kW the tractive force is 190 kN, which is insufficient for the 275 kN skip handling.

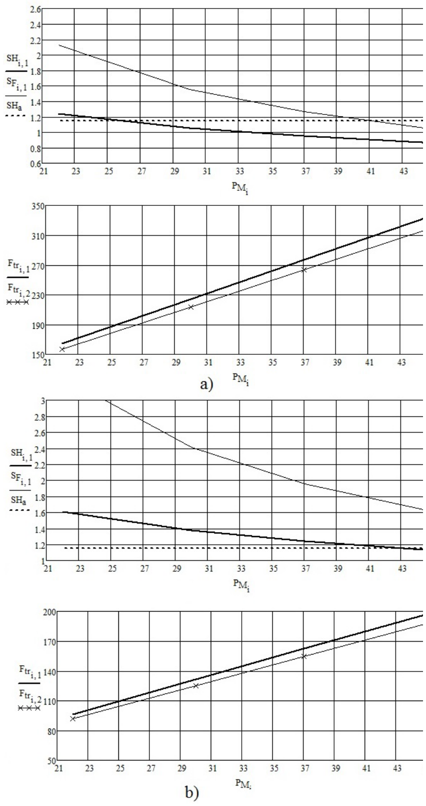

Fig. 4. Variation mode of safety coefficients in 4th gear and traction force

To solve these problems of the winch transmission, the transmission ratio of the first stage was reduced from 5.21 to 3.06, and the transmission ratio of the reducer was reduced from 726.17 to 425.99, under the conditions of the execution of a new gear. Figure 4b shows the variation mode of the safety coefficients for the 4th gear and the tractive force for the reducer with a transmission ratio of 425.99. The SH contact fatigue safety factor for a power of 45 kW is close to the permissible value, and the pulling force is over 185 kN.

This reduction in the transmission ratio increases the speed at the winch drum from 1.99 rpm to 3.4 rpm, resulting in a pulling force of 187.8 kN at a pulling speed of 13.2 m/min for a cable diameter on the drum of 1240 mm, layer two. By using a simple hoist (pulley) in the shaft tower section, the pulling force is doubled, reaching 338 kN for a hoist efficiency of 0.9, and the pulling speed is reduced to 6.6 m/min.

Due to the use at long intervals, 2 years, it is recommended that the gear reducer be lubricated with molybdenum disulfide and graphite gear grease, due to the large amount of TIN 300 oil required, over 170 l, and its degradation over time.

The construction of the winch with a single safety mechanism with a ratchet, in the direction of lifting the load, makes it difficult to handle without a good correlation of the controls of the electric motor, the circular brake FC315 and the ratchet mechanism. For this reason, it is recommended to control the ratchet with the foot through a lever system. [4]

According to the specialized literature, for a cable winding drum diameter of 1140 mm, a cable with a maximum diameter of 30 mm can be used.

3. CONSTRUCTIVE ADAPTATION OF THE NEW WINCH

To position the winch on the foundation, the foundation and frame of the old 75 kW winch were used, which was checked after the winch was pulled off this foundation. Due to the deformations produced in the old foundation frame, made of U24, in the area of the fixing bolts of the old winch, in addition to the M30x100 bolts used to attach the frame of the new winch, clamps were also used to fix the two frames made of 16 mm sheet metal and assembled by welding. Two rows of clamps were placed to fix the front crossbars of the frames, where the stress is maximum.

Figure 5 shows the constructive solution for positioning the winch on the foundation and the constructive changes that must be made, where the following have been noted: 1 – foundation frame of the old winch; 2 – new winch; 3 – frame fixing brackets I; 4 - frame fixing brackets II; 5 - lateral frame fixing brackets; 6 – ratchet control mechanism; 7 – additional bracket.

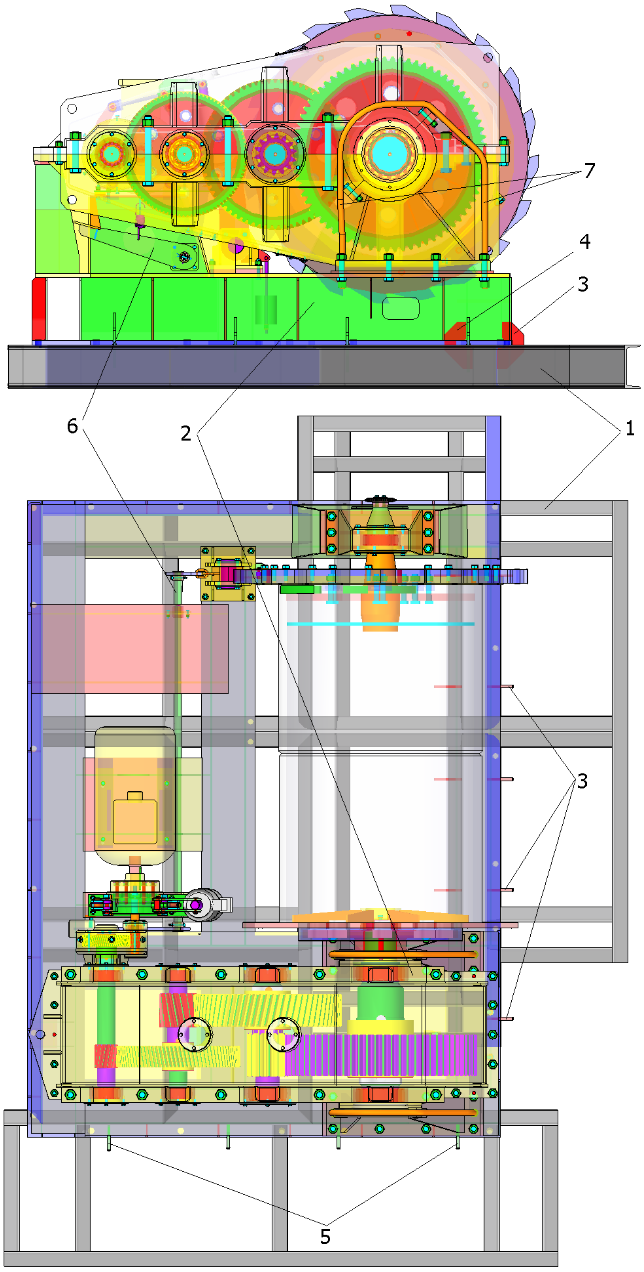

Fig. 5. Construction of the winch positioning on the foundation [1, 4, 5]

In order to verify the constructive solutions for adapting the winch to the new skip handling installation, a calculation brief was made starting from the calculation model of the winch drum in figure 6a. The forces Fr and Ft given by the traction force in the cable move along the drum over a length of 1710 mm, x=180…1890 mm, l=2140 mm, depending on the winding or unwinding of the cable, achieving different loading of the drum bearings. [3]

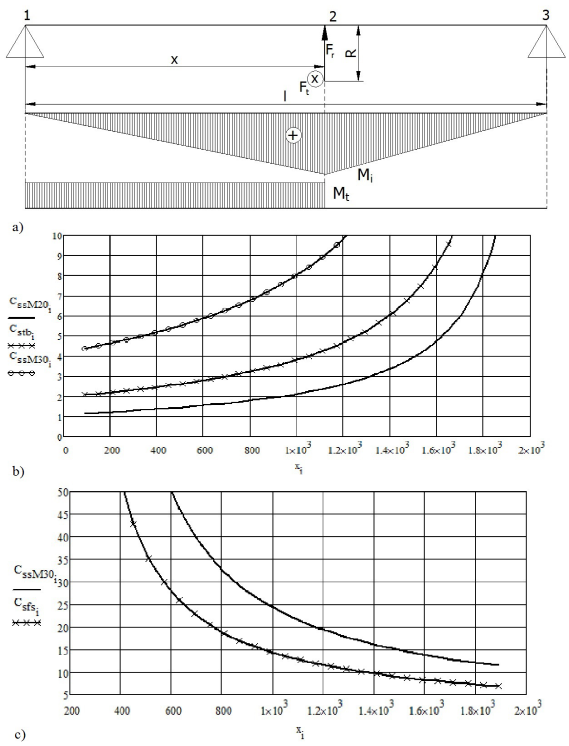

Fig. 6. Winch drum calculation model with verification of drum bearing supports

Figure 6b shows the variation of the crushing safety coefficients for the M20x110 screw, C_{ss}M20, for fixing the closing clamps of the reducer support, in which the drum rests on support 1. It is observed that this coefficient has the value of 1.15 when the cable is near support 1, which is small. To strengthen this support, a round steel clamp of 30 mm, which additionally fixes the old clamp, reference 7 figure 5. The new clamp alone ensures a tensile safety factor C_{stb} = 2.07 for a steel with a yield strength of 400 N/mm2 or a bolt from group 5.8. The safety factor for the M30x130, C_{ss}M30 bolts, for fixing the reducer support to the winch frame has values greater than 4 for group 5.8.

Figure 6c shows the variation of the safety coefficients of M30x130 bolts in crushing, C_{ss}M30, and of the weld seam in shear, Csfs, for an allowable shear stress of 150 N/mm2, for an OL 37 steel. These coefficients have minimum values, greater than 5, when the cable approaches support 3. [3]

Next, the method of fixing the new winch to the frame of the old one was checked based on the calculation model in figure 7a, where the following were noted: 1 – frame of the old U24 winch; 2 – new winch; 3 – fixing brackets.

The reactions in the bearings of the reducer output shaft and the drum were summed in the two components F_{hl} and F_{vl}, and only the weight of the winch frame G_{rt} = 29.7 kN at a = 1245.67 mm was taken into account, because the weight of the reducer and the drum are found in the calculation of the reactions in the bearings.

For the five frame fixing clamps, made of OL 37 steel with a yield strength of 210 N/mm2, the safety coefficients for clamp tension C_{sib}, for weld shear C_{sfs} and for M30x100 bolts for crushing C_{ss}M30 with values greater than 4.4 resulted.

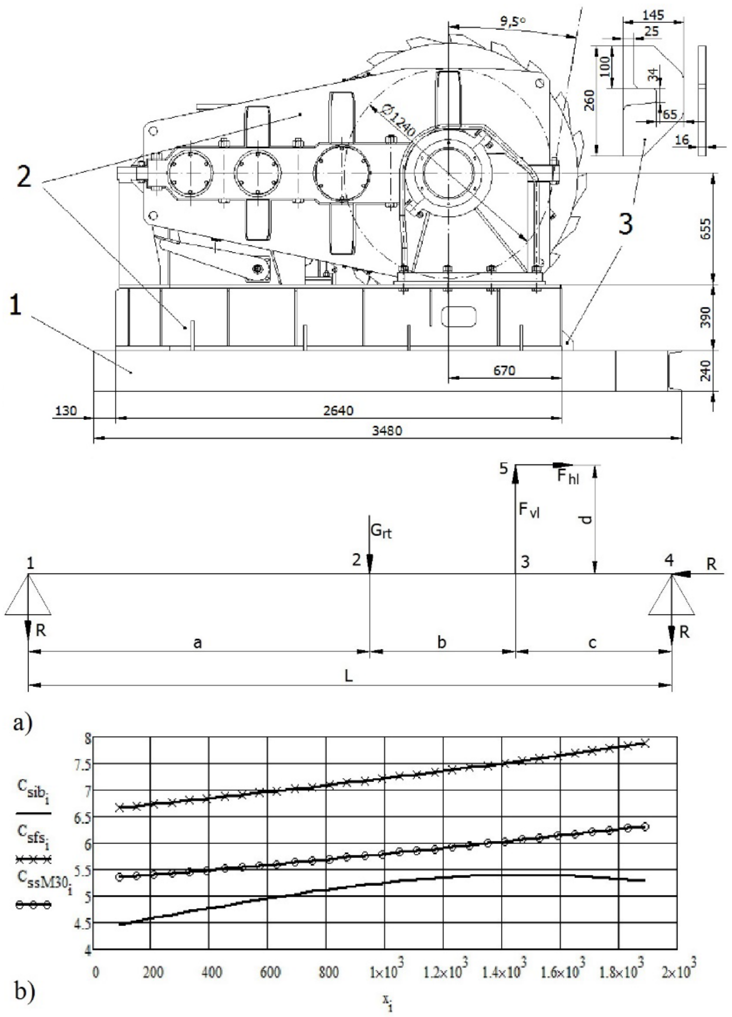

Fig. 7. Calculation model of fixing the new winch to the old frame and its verification [6]

The constructive solution of the ratchet control mechanism is presented in figure 8, where the following were noted: 1 – ratchet control arm; 2 – self-locking bolt; 3 – 11/2 pipe; 4 – 5x45 cotter pin; 5 – Φ44xΦ60x3 washer; 6 – bearing; 7 – M12x30 screw; 8 – M12 nut; 9 – Grower washer N12; 10 – foot control arm; 11 – tension spring 12 – ratchet handle link.

To position the ratchet control mechanism, Φ61 mm through holes are made in the electric motor and brake support walls for the pipe to pass through and Φ13 mm holes for fixing the bearings. Also, a support for holding the tension spring and a stop for the gusset next to the pedal are welded onto the FC 315 brake support to keep the spring pre-tensioned, respectively to press the ratchet onto the ratchet wheel.

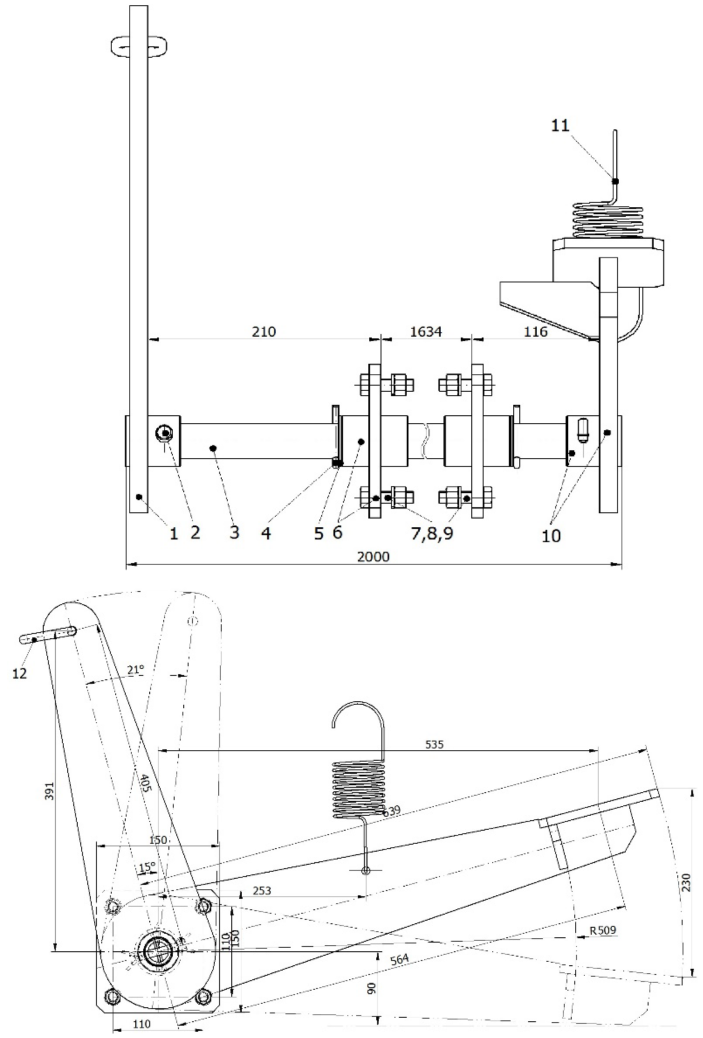

Fig. 8. The constructive solution of the ratchet control mechanism [6]

4. CONCLUSIONS

In the conditions of the economic crisis, of reduced investment funds, the problem of adapting existing equipment arises. Adapting the existing winch for the construction of a skip handling installation at Well no. 2 E.M. Lupeni led to savings of over 60,000 Euros. Because the execution of the first gear of the reducer at S.C. NEPTUN Câmpina cost 640 Euros, 27.5 Euros/kg, and the weight of the reducer is 4000 kg.

Studying the realization of the adaptation of the winch to the new operating conditions in advantageous technical and economic conditions led to the application of the following constructive solutions:

- changing the transmission ratio of the reducer from 726.17 to 425.99 to increase the safety coefficients of the gear teeth in the reducer;
- using clamps to fix the frame of the new winch to the foundation frame of the old winch;
- making an additional bracket to strengthen the attachment of the reducer to its frame;
- installing a foot-operated ratchet control mechanism that ensures the winch is locked under high load, so that the human operator can control the start and stop of the electric drive motor.

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