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STUDY OF CONSTRUCTIVE IMPROVEMENT OF CABLE WINDING DRUMS FOR THE LIFTING MECHANISM OF THE BUCKET HOLDER WHEEL OF EsRc-1400 EXCVATOR

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ABSTRACT: The paper presents solutions for two constructive-functional variants for traction cable winding drum of the lifting mechanism of the EsRc-1400 excavator bucket wheel boom,

KEY WORDS: Excavator, lifting mechanism, cable winding drum

1. INTRODUCTION

Coal extraction in quarries has only started at the beginning of the 20th century, it developed rapidly, along with the improvement of the adequate excavators and transportation systems, thus beginning with the year 1950, 48% of the useful mineral substances are extracted from quarries worldwide, in 1970 this percentage increases to 75%. In our days, 90% of the brown coal and lignite production is extracted in quarries.

Nowadays, extensive coal extraction machines are used rather intensively, leading to production increase not only by investments, but especially by increasing the utilization indices of installations and machines.

Currently, two types of lifting - lowering mechanisms of bucket wheel excavator booms are used worldwide:

- hydraulic lifting - lowering mechanisms with linear heavy duty hydraulic motors;
- lifting – lowering mechanisms with mechanic winches, pulleys and cables;

The winch, pulley and cable mechanism is the most frequently used.

Fig. 1 shows an overall view of the EsRC-1400 excavator where the lifting mechanism is seen and the related lifting mechanism and metal structure.

Figure 1. Overall view of EsRc-1400 bucket wheel excavator

The lifting mechanism of the bucket holding boom is on the counterweight box at the end of the balancing boom and allows lifting or lowering the boom, vertically, according to the exploitation needs.

The upper platform of the excavator is situated above the base shaft and can rotate against it by the support and rotation bearing, of Ø 8650 mm, having a toothed crown. The toothed crown and the lower rolling track of the bearing are locked with the base shaft, and the upper rolling track is locked to the rotating platform. The platform rotation with all its upper construction resting on it is done with the help of the rotating mechanism.

The rotating mechanism is protected by the safety coupling that stops the drive in case of overload. In the middle of the platform the connecting bridge bearing between the

excavator itself and the loading carriage is situated.
On the rotating platform the four pillars of the tower are seated. The balancing boom is fixed to the tower, and on its opposite part the bucket wheel boom is hinged, by means of two axes.
The pillar sustaining the guiding block rollers of the cable of the lifting boom of the bucket wheel is also hinged to the tower.
At the end of the balancing boom the the tiltable cabin for the ballast is also found. On the ballast box the boom lifting mechanism is also mounted. On the upper part (bracing) of the balancing boom the rolling track for the 10 ton crane is situated, used for mounting and repair.
The end of the hinged pillar at the roller block is linked to the ballast box by means of two anchoring cables. The rotating platform takes over compression loads from the upper construction, but also momentums from its rotating movements.

2. CONSTRUCTION AND FUNCTIONING OF THE LIFTING MECHANISM

Fig. 2 shows the lifting mechanism, where: 1 –275 kW/1000 rot/min electric motor; 2- 300 elastic coupling with Φ 710 brake washer; 3 – 710/300 brake with shoes, counterweight and electric-hydraulic lifter, 600 daNm; 4 – cylindrical reduction gear 2H-M-1060-0; 5 – brake protection; 6 – brake washer; 7 – claw clutch, maximum momentum 72 000 N·m; 8- bearing Φ 200, var. I; 9 – pinion Z=19, m=22; 10 - bearing Φ 200, var. II; 11 – toothed wheel Z=172, m=22; 12 – cable drum; 13 – shaft (ballast box construction); 14 – exterior transmission shield.
The winch is driven by an electric motor that transmits movement to a reduction gear.
The reduction gear has two transmission speeds, with cylindrical toothed wheels and greasing by bubbling. The pinion shaft from speed I extends outwards with both ends.
At one of the ends the elastic coupling is mounted with the brake washer Ø710, making connection to the electric motor, and at the other end a brake washer of the same diameter Ø710 is mounted, and on it the two brakes with two shoes and counterweights are mounted.
Further, the movement from the reduction gear is transmitted by the toothed coupling to the pinion axis, which engages with the cylindrical toothed wheel, made up of with the division diameter of 3784 mm.
This wheel is joined by flanges on the metal construction of the drum, drum which is seated by means of an axis on the radial bearings with sleeves, with the cable seating diameter of 1600 mm.
Resting the bucket wheel on the ground is dangerous, due to the fact that the weight center of the entire unit of the excavator is moved.
In order to ensure an adequate functioning, safety devices are mounted on the lifting-lowering mechanism of the boom (centrifugal switch, rotation arrester, hydraulic compression dynamometer).
The drum on which the traction cable is wound, Fig. 3, is a welded metal construction, to which the toothed wheel and the cable ends are fixed by means of assembling parts.
In Fig. 3: 1 – drum shaft Φ 200; 2 – drum metal construction; 3 – toothed wheel z=172, m = 22; 4 – shaft blocking plate; 5 – fixing plate; 6 – wear plate; 7 – axle box; 8 – cable fixing strap.
Fig. 3 shows the toothed wheel made up of two pieces, mounted on the support welded to the metal construction of the drum, as well as the method of fixing the cable ends to the metal construction and the way of blocking the drum shaft.

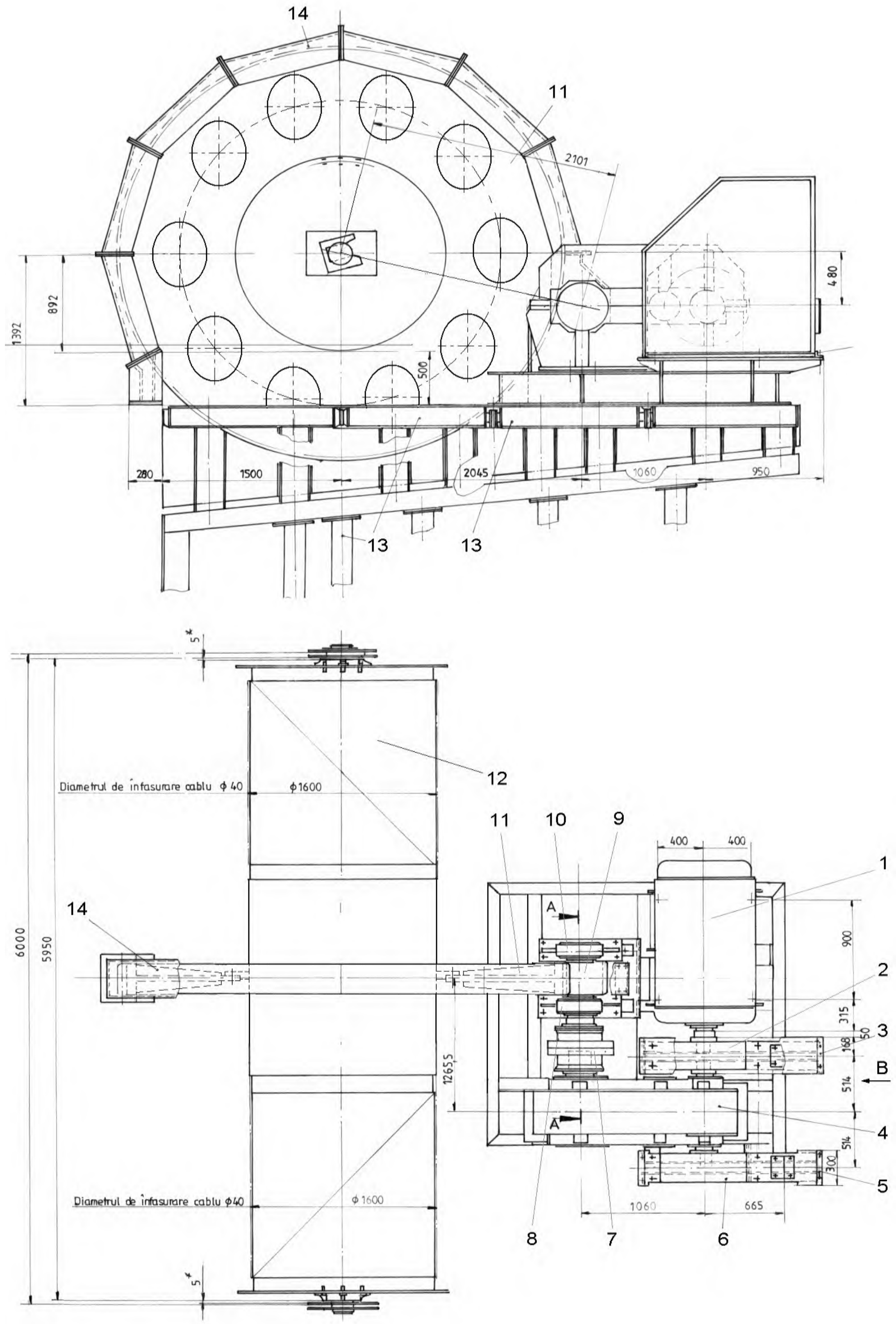

Figure 2. Overall view of EsRc-1400 excavator

3. DIMENSIONING AND VERIFICATION OF CABLE WINDING DRUM

Fig. 4 shows the model of calculating the cable winding drum of the lifting mechanism of the excavator, with the cable forces horizontally situated F_{ch} and in vertical plane F_{cv} and the forces of the cylindrical gear F_{ah} and F_{av}. For the cable forces their variable position was taken in the range of d_{38} = 144 … 1816 mm with the pitch of the drum groove of 44 mm. The forces in the cylindrical gear have been determined function of F_t tangent force and F_r radial force of the gear, the positioning angle of the engagement line relative to the horizontal plane, respectively.

The forces of the cylindrical gear have been determined function of the tangent and radial force of the gear, and the positioning angle of relative to the horizontal plane, respectively.

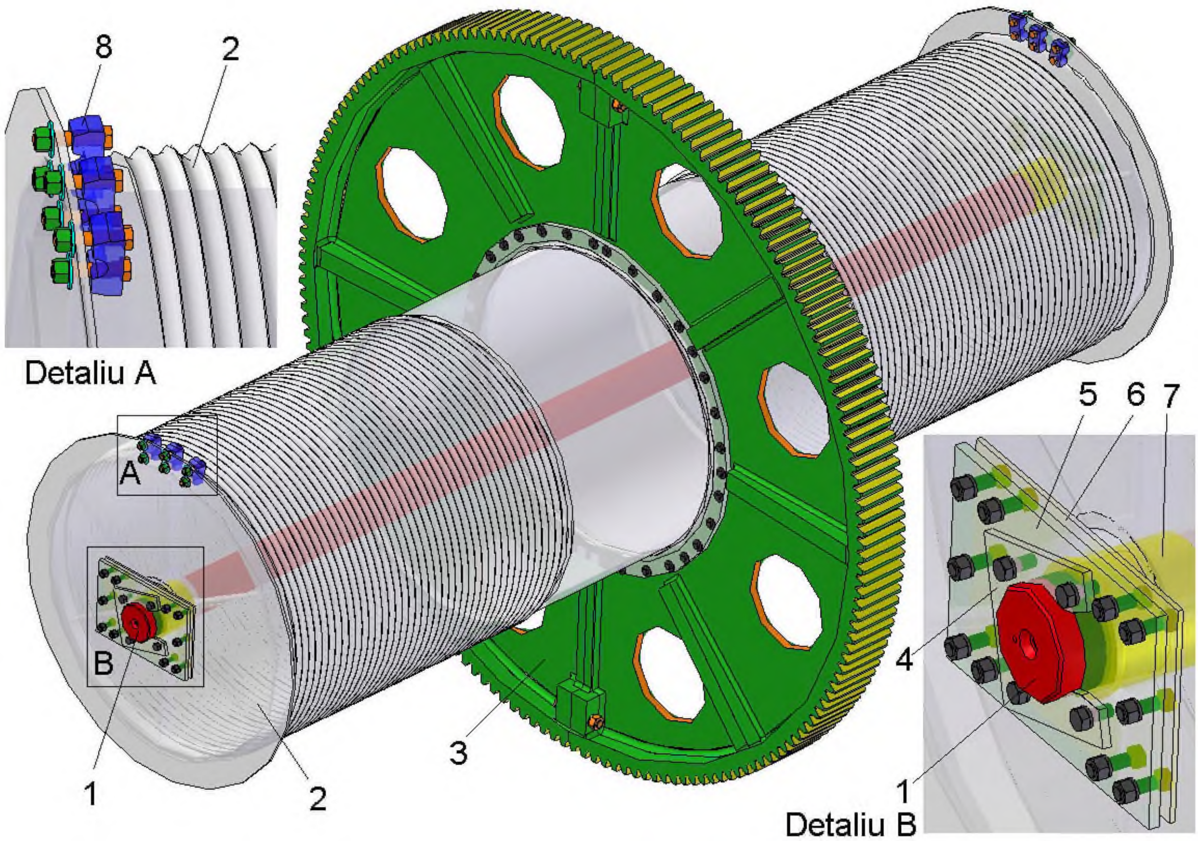

Figure 3. Cable winding drum

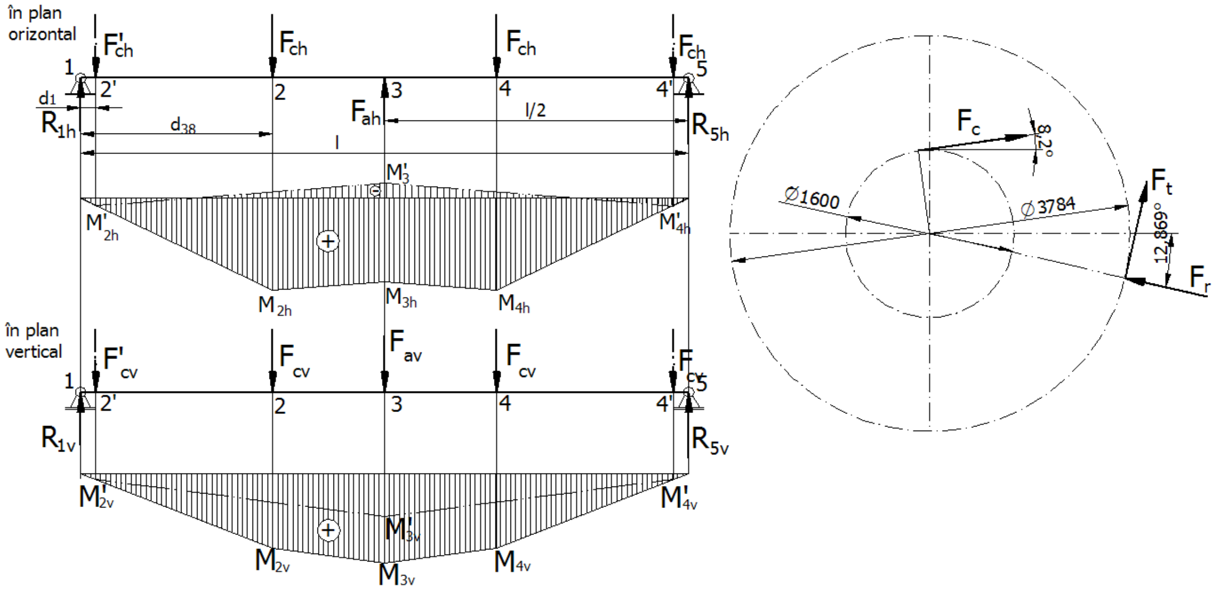

Figure 4. Calculation model of the cable winding drum

With the help of the cable winding drum calculation model the reactions in the drum bearings have been determined, horizontal and vertical bending momentums, and the equivalent strains in the cable winding areas and in the central area of the drum have been determined.

The bending strain values shown in Fig. 5 are smaller than the admitted strain for the steel's alternant symmetrical stress OT400 σ_a = 55 N/mm^2.

Similarly, the influence of the axial and radial wear influence of the cable winding grooves on their elongation, shown in Fig. 6 for 1 groove Δl_1, and for 10 grooves Δl_{10} have been observed.

Fig. 6 shows that the cable elongation significantly increases radial wear, having an influence of approximately 100 times higher than the axial wear.

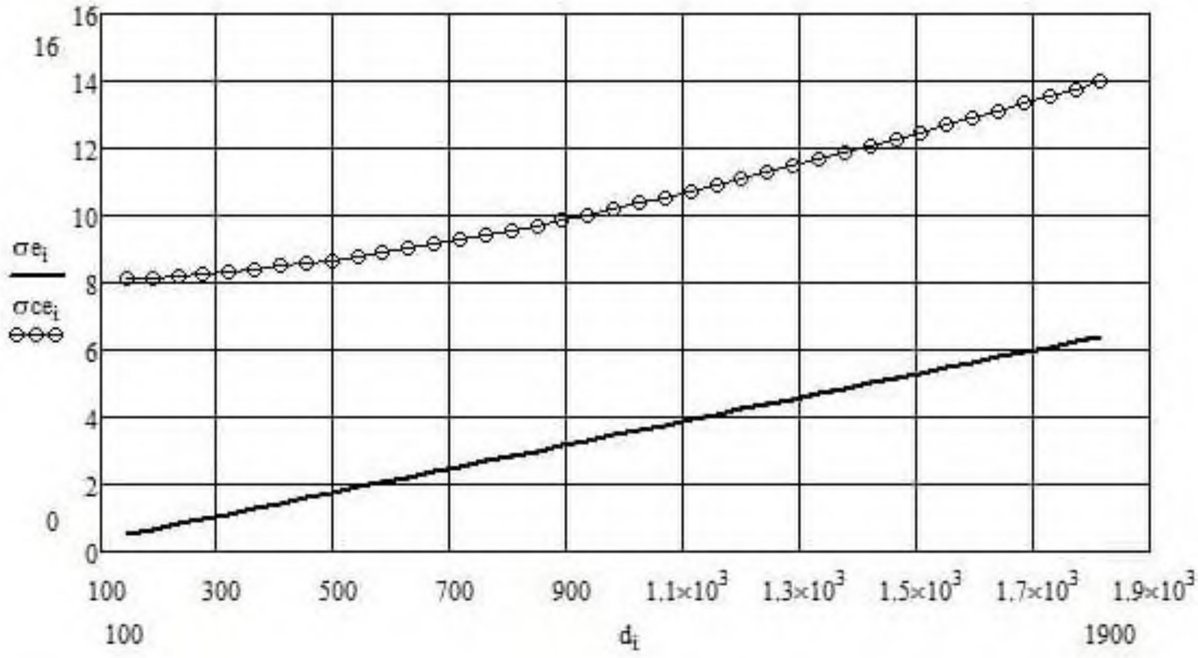

Figure 5. Bending strain variation function of the cable position

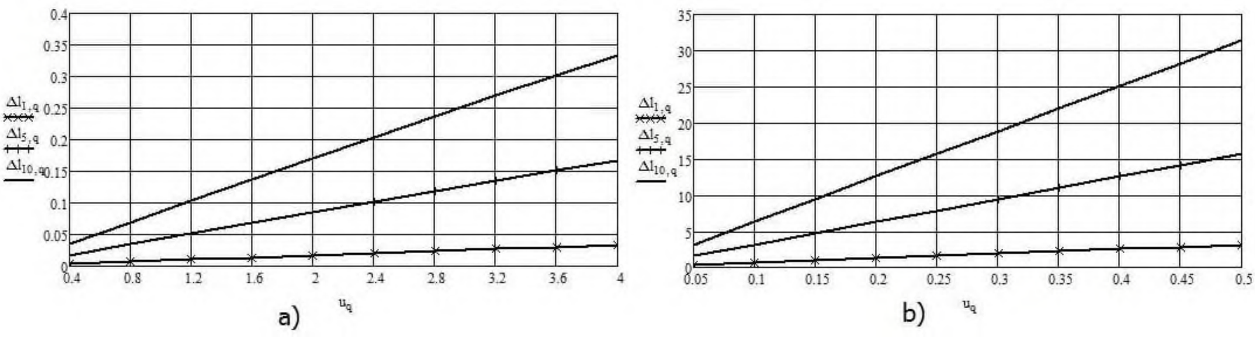

Figure 6. Influence of axia and radial wear of the drum grooves on the cable elongation

4. IMPROVEMENT SOLUTIONS OF THE CABLE WINDING DRUM CONSTRUCTION

Starting from the defects occurring in time at the lifting-lowering mechanism of the excavator boom, corroborated with the experience acquired in its exploitation, two constructive – functional drum variants have been designed for the winding of the traction cable, which will be below called variant I and variant II.

Cable winding drum – variant I

Fig. 7 shows the overall solution of the traction cable winding drum, variant I, the component elements of this sub-unit being mentioned, from which modernization performed can be seen, compared to the classic variant presented in Chapter I.

The new drum is made up of: 1 – drum shaft Ø 200; 2 – drum metal construction; 3 – brake disks; 4 – toothed wheel z=172, m=22; 5 – cable fixing strap; 6 – observation hole; 7 – rubber packing; 8 – fixing plate; 9 – shaft blocking plate; 10 – wear plate; 11 – bearing sleeve..

Thus, the following modifications can be pointed out, being constructive improvements in the meantime regarding the lifting system as a whole:

1. On the metal construction of the drum, on one side and the other of the toothed wheel z=172, m=22, reference 4, two brake disks are fixed, reference 3, by means of screws, detail C. These disks contact the wear surface of the hydraulic brake wrenches, the drum being thus directly stopped, the strain on the cylindrical gear being thus eliminated during the braking process.

2. On the metal construction of the drum, Fig. 7, at the extremities of the winding areas, towards the drum center, two additional rings are welded, used to link the cable end, detail B. The change of the cable connection from one side to the other is necessary, because in the opposite area of the connection, where the cable is wound and unwound from the drum during the lifting-lowering process, due to the great efforts in the cable, a significant wear occurs in the guiding groves of the cable. By changing the connections, the unworn area becomes the active winding - unwinding area, leading to the doubling of the drum's life span.

3. the toothed wheel z=172, m=22 from the exterior cylindrical gear has been redesigned, it became welded, of one piece, with advantages regarding the execution precision, mounting and functioning conditions.

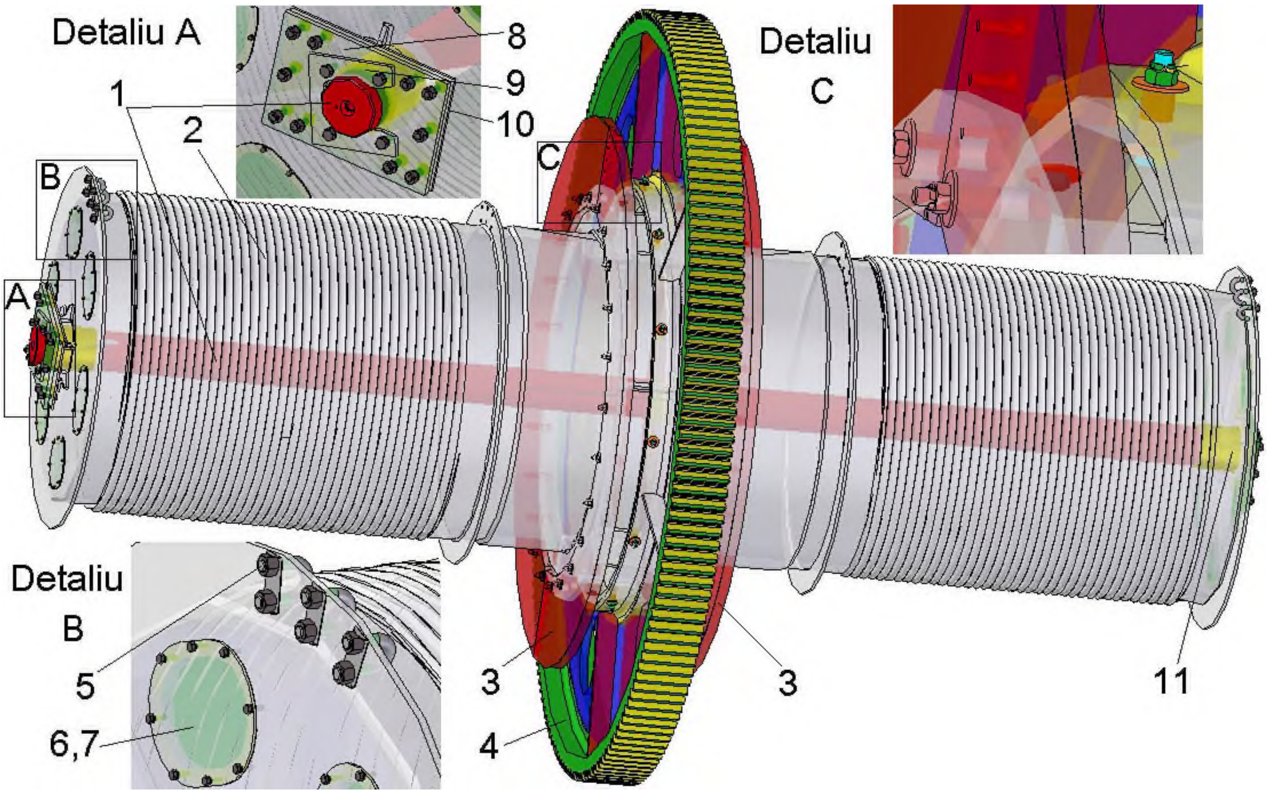

Figure 7. Overall solution for the drum for cable winding – variant I

Cable winding drum – variant II

Fig. 8 presents the overall solution for the drum for traction cable winding variant II, variant which is 95% redesigned.

Maning of the references in Fig. 8: 1 – drum shaft Ø 200; 2 – drum metal construction; 3 – observation hole; 4 – rubber packing; 5 – demountable support for the brake disk; 6 – brake disk; 7 – toothed wheel z=172, m=22; 8 – cable fixing strap; 9 – bearing sleeve; 10 – shaft blocking plate; 11 – fixing plate; 12 – wear plate.

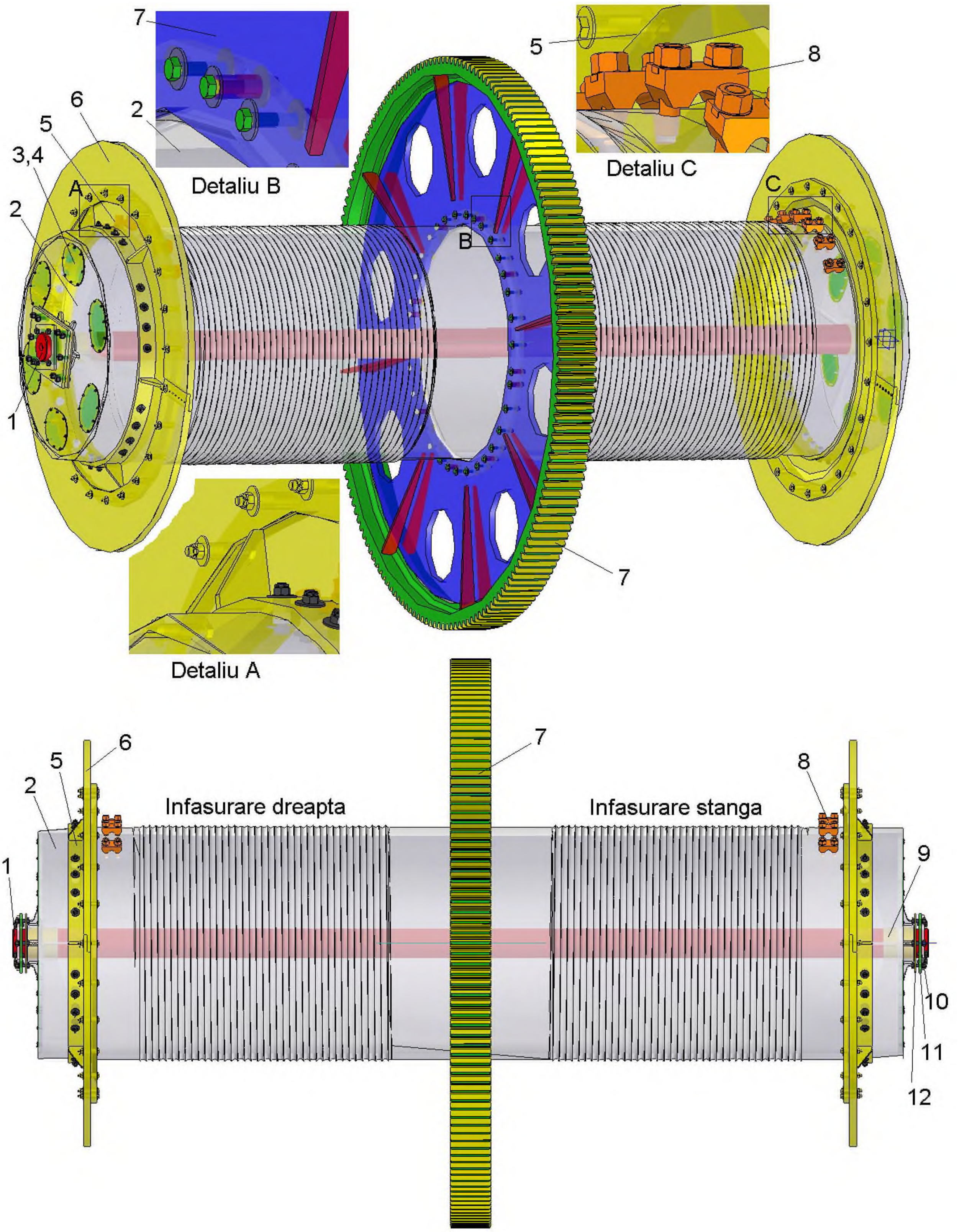

Figure 8. Overall solution for the drum with brake disks – variant II

6. CONCLUSION

Two constructive variants are presented for the cable winding drum, for which the disks of the brake mechanism are directly mounted on the drum, behind the exterior cylindrical gear.

The first variant implies mounting the brake disks, and thus of the brake mechanism, next to the longitudinal centre of the cable winding drum.

The point in which the traction cable is connected to the resistance construction of the drum is reconsidered, the cable fixing strap is redesigned, in view of increasing safety in functioning of the mechanism, the cylindrical toothed wheel of the open cylindrical mechanism is redesigned.

The second drum variant, conceived in order to fit in the whole lifting-lowering mechanism of the excavator, is a new, simple concept, with constructive and functional advantages, where the brake disks are positioned towards the drum extremities. Its great advantage is that the wear elements are easily demountable, which significantly simplifies maintenance.

REFERENCES

[1] Cozma, B.Z., Bazele proiectării tehnologice asistate de calculator, Editura UNIVERSITAS, Petroşani. 2016

[2] Dumitrescu, I., Florea, V.A. – Desen tehnic industrial, utilizând soft-uri CAD, Editura Universitas, Petroşani, 2018.

[3] Jula, D., Urdea Gh.B., - Toleranţe, ajustaje şi starea suprafeţei. Teorie şi aplicaţii, Editura Universitas, Petroşani, 2017.

[4] Radu, D., Rezistenţa materialelor, curs şi aplicaţii, Editura UNIVERSITAS, Petroşani, 2017.

[5] Radu, D., Tigae, I., Ridzi, M.C., Culegere de probleme de rezistenţa materialelor, vol.2, Editura UNIVERSITAS, Petroşani, 2004.

[6] * * * - Documentaţia tehnică a excavatorului EsRc 1400.