DESIGN OF WIDE CABLE BINDING DEVICES FOR BALANCING EXTRACTION VESSELS

BOGDAN-ZENO COZMA[1]

Abstract: The wide cable tie devices for balancing connect the extraction vessel and the wide cable for compensating the masses transported vertically. The paper presents the constructive-functional solutions of the wide cable tie devices for balancing DLCLE-118, DLCLE-129 and DLCLE-135. They have the same constructive form, the difference being the dimensions of the component elements, which are subjected to different loads depending on the characteristics of the wide compensation cable. Based on the 3D modeling of the wide cable tie devices, a strength check was performed according to the classical method and using finite element analysis.

Key Words: cable tie device, 3D modeling

1. INTRODUCTION

The wide cable tie devices for balancing connect the extraction vessel and the wide cable to compensate for the masses transported vertically.

The constructive and functional characteristics of the wide cable tie devices for balancing are presented in table 1. [2]

Table 1 **Constructive-functional characteristics of wide cable tie devices for balancing**

Nr. crt.	Feature name	UM	Feature value		
			DLCLE-118	**DLCLE-129**	**DLCLE-135**
1.	Maximum static load	tone/kN	2/20	3,5/35	5,5/55
2.	Wide cable section	mm	106×15,5 118×17	124×18 129×19	135×20
3.	Cable specific mass	kg/m	5,447/6,726	7,558/8,128	8,865
4.	Cable fixing method	-	with loop and eccentric heart		
5.	Bolt diameter	mm	60	70	70
6.	Thickness of the sloop attachment plate	mm	40	48	40

[1] *Assoc. Prof. Ph.D. Habil. Eng., University of Petroșani, bogdancozma@upet.ro*

7.	Number of wide cable clamps		buc	6	6	6
8.	Distance between clamps		mm	120	120	120
9.	Overall dimensions	Length (height)	mm	1327	1577	1706
		Width	mm	380	460	500
		Thickness	mm	238	250	258
10.	Mass		kg	190	248	290

2. CONSTRUCTION AND OPERATION OF DEVICES

The main constructive-functional parts of the wide cable tie devices for balancing DLCLE-118, DLCLE-129 and DLCLE-135 are presented in figures 1 and 2. The three types of wide cable tie devices for balancing have the same constructive form, the difference consisting in the dimensions of the component elements, which are subjected to different loads depending on the characteristics of the wide compensation cable.

According to Figure 1, such a device consists of a row of resistance elements that connect the bottom of the extraction vessel and the eccentric core, whose functional width is determined by the width of the wide cable, and a row of clamps for fixing the cable end wrapped on the core. [3]

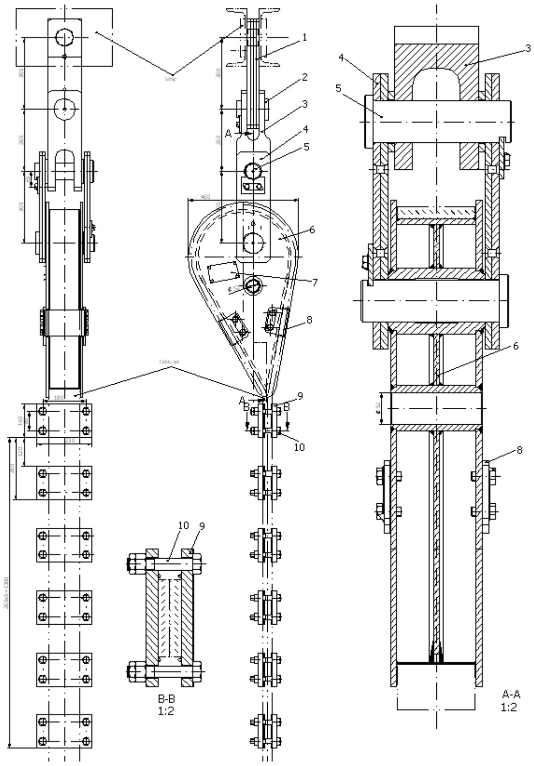

Fig. 1. Wide cable tie for balancing DLCLE 118, 129, 135 [1, 7]

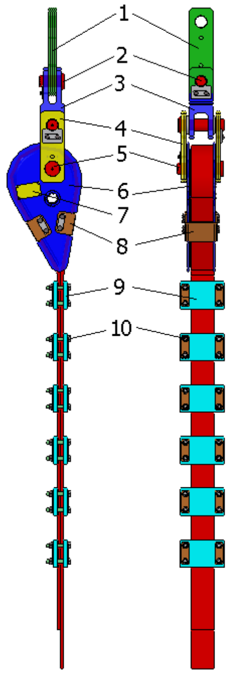

Fig. 2. Wide cable tie for balancing DLCLE 118 [1]

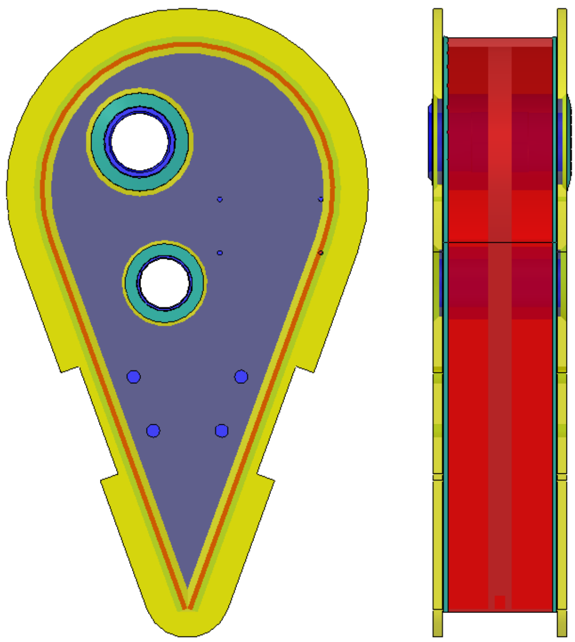

Fig. 3. Eccentric heart [1]

The device assembly is fixed to the extraction vessel by means of the plate 1, which is a resistance structure formed by four steel plates riveted together and machined to nominal dimensions. The connection to the eccentric core 6 is made by means of a fork 3 and two plates 4, composed of two steel plates riveted together, and the connection between the three elements is made by bolts 2 and 5, made of alloyed steel and heat treated.

The eccentric core is a welded metal construction, figure 3, having a central plate that gives the shape and position of the two bushings, and the winding plate and the outer plates create the channel on which the end of the wide cable is wound for compensation. The core has, in addition to the bolt bushing 5, a hole used to support the device in order to mount the cable. The core is fixed with a label 7, for identifying the device, and two clamps 8, with the role of fixing the wide cable in the metal core channel.

The free end of the cable is passed over a distance of approximately 1500 mm above the cable entering the core, the two branches being clamped in six double clamps 9, each having four tightening bolts 10, with nuts and locknuts.

The material of the parts of particular importance, namely the extraction vessel clamping plate plates, all connecting bolts, the connecting fork, the intermediate plate plates, the lower and upper eccentric core plate, must be non-destructively defectoscopically controlled, before cutting the materials, and must correspond to the prescriptions specified in the technical documentation.

When making the scuttle attachment plate, figure 4, the intermediate plate and the lower and upper plates of the eccentric core, the following conditions must be observed:

- hot straightening of the sheets from which the aforementioned subassemblies are made is not allowed;
- cutting the piece from the sheet will be done on the contour by chipping or by thermal cutting, in which case a processing allowance of at least 10 mm is left, which will be removed by chipping;
- cutting the piece is done so that the rolling direction of the sheet coincides with the stress direction of the piece, along its length.
- when making subassemblies made of plates, the outer and inner plates are clamped in a package and the holes for the rivets are made, after which they are fixed by riveting, following which the other holes are processed. After assembling the plate package by riveting, the end of the rivet is processed so that it does not exceed the surface of the outer plate.

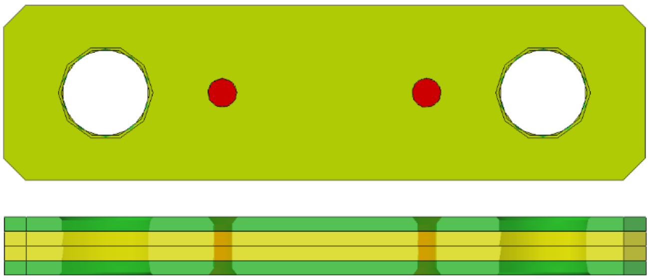

Fig. 4. Skip attachment clip [7]

For the execution of the connecting bolts and forks, forging of the material is not allowed, only its mechanical processing is allowed.

Before installation at the place of use, all the component parts of the device are checked. Component elements that show defects or damage, which could negatively influence the operation of the device, will not be allowed.

The extraction vessel to which the balancing device is coupled is placed on cleats or on a safety bridge.

At the top, the device is coupled to the extraction vessel by means of bolts, and at the bottom, the wide cable is mounted by winding it on the eccentric core and fixing it with clamps.

Daily inspection of the devices is done by careful examination with the naked eye and by knocking, aiming to determine whether the component parts show cracks or deformations.

3. DIMENSIONAL VERIFICATION OF DEVICES

Starting from the mathematical equilibrium model of the cable and the metal core, presented in figure 5, and from the non-slip condition of the cable end locked between the clamps and the cable, the relationship for determining the clamping force of the clamps results,

$$N_1 = \frac{G \cdot e^{-\mu \cdot \theta}}{\mu_1 \cdot \left(1 + e^{-\mu \cdot \theta}\right)}, \text{ N},$$

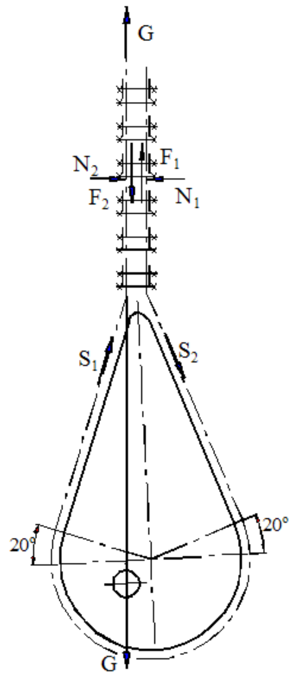

Fig. 5. Mathematical model of cable fastening forces [1]

in which: G is the maximum weight of the balancing cable, G = 20000 N; μ – coefficient of friction between cable and metal core, μ = 0,1; θ – the angle of winding the cable on the metal core, θ = 220°; μ_1 - coefficient of friction between cables, μ_1=0,1.

For a dynamic coefficient of the extraction plant 1,6 … 2 and a safety factor greater than 10, results in a number of 21 of screws M20 executed from OLC35q with yield strength of 370 MPa. Due to the use of four-screw clamps, six clamps are required to securely secure the cable end.

The clevis and yoke were tested for tensile and shear stresses in the bolt area and for contact pressure between the surfaces of their bores and the bolts.

The bolts were tested under combined bending and shear stress, resulting in a safety factor greater than 10 using one of the improved alloy steels. 42MoCr11, 31MoCr11, 31MnCrSi11 or 25MnCrSi11.

Figure 6 presents the finite element numerical analysis of the DLCLE118 device, with the loading mode in Figure 3a, with the fixing of the bolt bore to the schip and the application of a force equal to the maximum weight of the cable, 20000 N, to the surface of the metal core. It can be seen from Figure 3b that the maximum stress on the bolts occurs in the separation zone between the flange and the metal core bushing due to shear stress. This is highlighted by details A and B, where equivalent stresses of 69.306 MPa and 79.468 MPa occur, confirming the need to use alloyed steels for improvement.

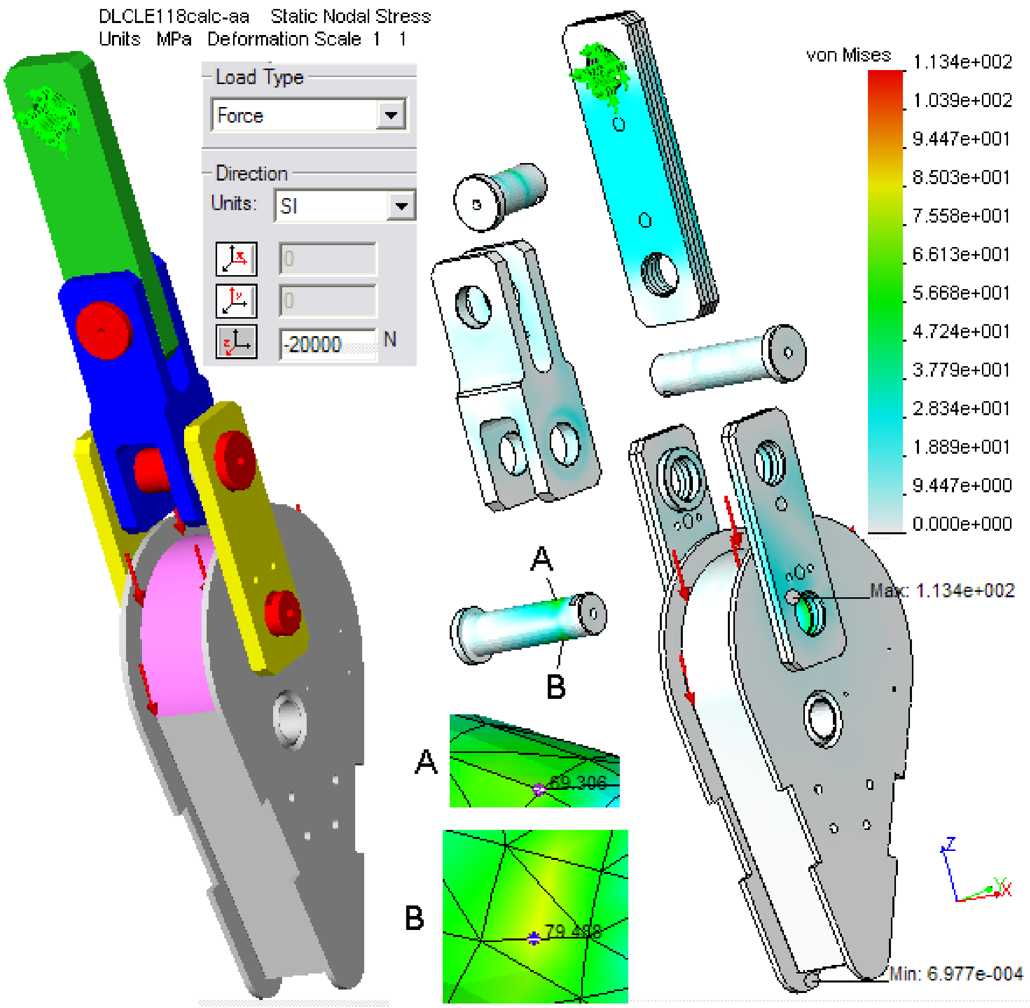

Fig. 6. Finite element numerical analysis of the device DLCLE 118 [7]

4. CONCLUSIONS

When preparing the execution documentation for the wide cable tie devices for balancing under contract no. 193/ASL/2006, concluded with C.N.H. Petroşani, the following technical and economic aspects were taken into account:

- simplifying the constructive solutions from a technological point of view (making the eccentric core and the clamps in welded construction compared to their cast construction);

- standardizing, as much as possible, the constructive solutions for the wide cable tie devices that equip the multi-cable extraction installations in the Jiu Valley. This was particularly difficult since it was necessary to maintain interchangeability with the current constructions;

- using constructive solutions that have been verified in practice for similar devices;
- maintaining the current safety coefficient and in some cases increasing it;
- reducing the cost price by reducing the labor required to make them.

REFERENCES

[1]. Cozma, B.Z., Dumitrescu, I., Popescu, F.D., *Concepţia şi proiectarea asistată de calculator a utilajului minier*, Universitas publishing, Petroşani, 2019.

[2]. Cozma, B.Z., *Bazele proiectării tehnologice asistate de calculator*, Editura Universitas, 2016, Petroşani.

[3]. Dumitrescu Iosif, Cozma Bogdan-Zeno, Itu Răzvan-Bogdan, *Safety mechanisms for mining extraction vessels*, 16th International Multidisciplinary Scientific GeoConference: SGEM, pages: 759-766, Sofia, 2016.

[4]. Cozma, B.Z., *Bazele proiectării tehnologice asistate de calculator*, Editura Universitas, 2016, Petroşani.

[5]. Bogdan-Zeno Cozma, Vilhelm Itu, *Trolley for Skip Maneuvring in Lupeni Mining Plant,* 14th International Multidisciplinary Scientific GeoConference: SGEM, pages: 729-736, Sofia, 2014.

[6]. Iosif Dumitrescu, Bogdan-Zeno Cozma, Itu Vilhelm, *Study the mining winches using the CAD/CAE software,* 16th International Multidisciplinary Scientific GeoConference SGEM, pages: 833-840, Sofia, 2016.

[7]. Dumitrescu Iosif, Cozma Bogdan-Zeno, Urdea Gheorghe Bogdan, *Modernization of EsRc–1400 excavator buckets with the help of CAD/CAE software,* 17th International Multidisciplinary Scientific GeoConference: SGEM, pages: 555-561, Sofia, 2017.

[8]. Bogdan-Zeno Cozma, Gheorghe Bogdan Urdea, *The study of the detachable bits for rotating drillings,* Mining Revue / Revista Minelor, 2009, Vol 15, Issue 7, p23, ISSN 1220-2053

[9]. Bogdan-Zeno COZMA, Gheorghe Bogdan URDEA, Iosif DUMITRESCU, Vilhelm ITU, *Stand for the rotative boring of soft rocks*, SCIENTIFIC BULLETIN, University of Petroşani, 2009.

[10]. Popescu, F.D.; Radu, S.M.; Andras, A.; Brinas, I.; Marita, M.-O.; Radu, M.A.; Brinas, C.L. *Stability Assessment of the Dam of a Tailings Pond Using Computer Modeling—Case Study: Coroiești, Romania.* Applied Sciences 2024, 14: 268.

[11]. Popescu, F.D., Radu, S.M., Kotwica, K., Andraş, A., Kertesz, I. *Simulation of the Time Response of the ERc 1400-30/7 Bucket Wheel Excavator's Boom during the Excavation Process.* Sustainability. 2019; 11(16):4357. DOI: 10.3390/su11164357.

[12]. Andraş, A., Brînaş, I., Radu, S.M., Popescu, F.D., Popescu, V., Budilică, D.I. *Investigation of the Thermal Behaviour for the Disc-Pad Assembly of a Mine Hoist Brake Using COMSOL Multiphysics.* Acta Tech. Napoc.-Ser. Appl. Math. Mech. Eng. 64, 227234, 2021.

[13]. Tomus, O.B., Andraş, A., Andraş, I. *Study of the dependence between the cutting direction relative to stratification and the digging characteristics of lignite in Oltenia coal basin (Romania),* 17th International Multidisciplinary Scientific GeoConference. ISSN 1314-2704, 17(13), 825-830, (2017). DOI: 10.5593/sgem2017/13/S03.104.

[14]. Dumitrescu, Iosif, Cozma, Bogdan-Zeno, Ridzi, Mihai-Carmelo, Itu, Vilhelm, *Study of Restoring Resistence Structure of Motor Wheel of the MK 2, 1x4 Winding Machine With Skip in Lonea Mine*, International Multidisciplinary Scientific GeoConference: SGEM, Vol.1, Iss.3, 2015, pages 611-618.

[15]. **Popescu, F.D. Radu, S.M.** *Vertical Hoist Systems: New Trends Optimizations*. LAP Lambert Academic Publishing, 2013.

[16]. **Popescu, F.D.** *Instalații de Transport pe Vertical,* Editura Focus: Petroșani, Romania, 2010.

[17]. **Popescu, F.** *Controls ways of the transportation capacity variation for the canvas conveyer.* WSEAS Trans. Syst. Control. 3, 393–402, 2008.

[18]. **Popescu, F.D., Radu, S.M., Andras, A., Brinas, I.K.** *A grafo-numeric method of determination of the operation power of the rotor of EsRc-1400 bucket wheel excavator using computer simulation in SolidWorks.* MATEC Web Conf. 290, 04007, 2019.

[19]. **Mitran, I., Popescu, F.D., Nan, M.S., Soba, S.S.** *Possibilities for Increasing the Use of Machineries Using Computer Assisted Statistical Methods*, WSEAS Transactions on Mathematics, Issue 2, Volume 8, February 2009.

[20]. **Nan MS, Kovacs J., Popescu FD.** *Balance control by weighing and tensiometric measurements of bucket wheel excavators,* "WSEAS Transactions On Systems And Control" 2008, 11, 3: 927–936.

[21]. **Kovacs., I.; Andras, I.; Nan, M.S.; Popescu, F.D.** *Theoretical and experimental research regarding the determination of non-homogenons materials mechanical cutting characteristics.* In Proceedings of the 8th Conference on Simulation, Modelling and Optimization (SMO), Santander, Cantabria, Spain, 23–25 September 2008; pp. 232–235.