ANALYSIS OF COMPENSATING CABLE CONNECTING DEVICES FOR WINDING INSTALLATION VESSELS

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Abstract: Winding installations have the role of transporting, between underground and surface, useful minerals, materials, equipment, and people, with extraction vessels. Cable connecting devices connect winding installation cables to extraction vessels. Depending on their design, connecting cables can be: with loop and core, self-tightening with wedged core on one or both sides; with hinged jaw; with cone-shaped friction wedges; with wedges and bridles.

The paper presents an analysis of flat metal cable connecting devices.

Keywords: compensating cable connecting device;

Introduction

Fixing cables to extraction vessels is done by means of connecting devices and harnesses. Both connecting devices and harnesses should be safe in use and resistant to fatigue, lightweight and small, they should protect cables and should be easy to maintain. Cable connecting devices are subject to significant static and dynamic load. Besides, additional strain might occur in the form of transversal, longitudinal or torsion oscillations, due to defective mounting.

Connecting devices are classified according to design and depending on the cable used. Thus, for compensating cable connecting devices one can find flat compensating connecting cables (Fig. 1), round compensating connecting cables (Fig. 2), round, vortex type compensating cable connecting devices (Fig. 3).
Table 1. The constructive-functional characteristics of flat cable devices for equilibrium.

<table>
<thead>
<tr>
<th>No</th>
<th>Characteristic</th>
<th>UM</th>
<th>Value of characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UM</td>
<td>DLCLE-118</td>
</tr>
<tr>
<td>1</td>
<td>Maximum static load</td>
<td>tone/k N</td>
<td>2/20</td>
</tr>
<tr>
<td>2</td>
<td>Flat cable section</td>
<td>mm</td>
<td>106×15,5</td>
</tr>
<tr>
<td>3</td>
<td>Specific cable mass</td>
<td>kg/m</td>
<td>5,447/6,726</td>
</tr>
<tr>
<td>4</td>
<td>Cable fixing</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bolt diameter</td>
<td>mm</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>Cover plate width for attaching to the skip</td>
<td>mm</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Number of fixing clamps of flat cable</td>
<td>pc</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Space btw. clamps</td>
<td>mm</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Length (height)</td>
<td>mm</td>
<td>1327</td>
</tr>
<tr>
<td>9</td>
<td>Width</td>
<td>mm</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>mm</td>
<td>238</td>
</tr>
<tr>
<td>10</td>
<td>Weight</td>
<td>kg</td>
<td>190</td>
</tr>
</tbody>
</table>

**Device construction and functioning**

Main constructional-functional parts of flat cable connection

The main constructional-functional parts of flat cable connecting devices for equilibrium DLCLE-118, DLCLE-129 and DLCLE-135 are shown in Fig. 4 and 5.

The three typo-dimensions of flat cable connecting devices have the same constructive shape, the difference lying in the dimensions of the component elements, which are subject to different trials depending on the characteristics of the compensation cable.

According to Fig. 1, such a device is made up of a series of elements of resistance making the connection between the bottom of the extraction vessel and the eccentric core, its functional width being determined by the width of the flat cable and a series of clamps for fixing the end of the cable wound around the core.

The whole of the device is fixed to the extraction vessel by means of cover plate 1, which is a structure of resistance made up of four steel plates riveted between them and processed by cutting to nominal size. The connection to the eccentric core 6 is done by means of a fork 3 and two cover plates 4, made up od two steel plated riveted between them, and the connection between the three elements being made by bolts 2 and 5, made of allied steel and thermally treated.
The eccentric core is a welded metal structure, Fig. 6, with a central plate giving the shape and position of the two sleeves, and the winding plate and the exterior plates make up the canal around which the end of the flat cable is wound for compensation. The core, besides the bolt 5 sleeve also has a hole used to support the device in view of mounting the cable. The label 7 is fixed tot the core, to identify the device and the two flanges 8, having the role of fixing the flat cable to the canal of the metal core.
The loose end of the cable is passed along 1500 mm over the cable entering the core, the two branches being seized in six double clamps 9, each having four tightening screws 10, with nuts and counter-nuts.

From the mathematical cable equilibrium and metal core model shown in Fig. 8, and from the nonslip condition of cable end blocked between clamps and cable, the clamps tightening force is \( N_f \).

The material of the important parts, the plates of the cover plate seizing the extraction vessel, all the connection bolts, the connection fork, the plates of the intermediary cover plate, the lower and the upper plate of the eccentric core respectively, should be monitored for defects, non-destructively, before the material flow, and should meet the prescriptions specified in the technical documentation.

In the execution of the skip that seizes the cover plate, Fig. 7, of the intermediary cover plate and the lower and upper plates of the eccentric core, the following conditions should be met:

- heat straightening of the sheets of which the before mentioned subassemblies are made, is not allowed;

- the piece will be cut out from the sheet along the outline by chipping or thermal
cutting, in which case a processing addition of minimum 10 mm is left, which will be removed by chipping;

- the piece will be cut out so that the direction of lamination of the sheet would coincide with the strain direction of the piece, along it.

In the execution of the subassemblies made up of plates, the exterior and interior plates are gripped in a package and the boring for riveting is done, after which they are riveted together, and the other boring operations will be done. After assembling the plate packages by riveting, the end of the rivet is processed, so that the outside of the of the plate surface would not be extended in the exterior.

In order to execute the connecting bolts and forks, the forging of the material is not allowed, only its mechanical processing.

Before its installation at the place of use, all the component pieces of the device are verified.

The component elements showing defects or damages, which might adversely influence the functioning of the device will not be allowed.

The extraction vessel to which the equilibrium device is attached is found on pegs of a safety bridge.

At the upper part, the device is mounted by means of bolts to the extraction vessel, and at the lower part the flat cable is mounted by winding around the eccentric core and fixing by clamps.

The daily verification of the devices is done by careful visual examination and tapping, watching whether the component parts show fissures or deformations.

**Size verification of devices.**

Starting from the mathematical equilibrium model of the cable and metal core, shown in Fig. 9, and the non-slip condition of the end of the cable blocked between clamps and cable, the relations of determination of clamps tightening force is given below:

\[
N_1 = \frac{G \cdot e^{\mu \theta}}{\mu_1 \cdot (1 + e^{\mu \theta})} \cdot [N]
\]

where: \(G\) is the maximum weight of the equilibrium cable, \(G = 20000 \text{ N}\); \(\mu\) – friction coefficient between the cable and the metal core, \(\mu = 0,1\); \(\theta\) – winding angle of the cable on the metal core, \(\theta = 220^\circ\); \(\mu_1\) – friction coefficient between cables, \(\mu_1=0,1\).

For a dynamic coefficient of the winding installation of 1,6 ... 2 and a safety coefficient higher than 10, a number of twenty one M20 screw result executed in OLC 35q, with a flow limit of 370 MPa. Due to the use of clamps with four tightening screws, six clamps for safe fixing of the end of the cable are required.

The cover plates and fork have been tried for tear and shear in the bolt area and for contact pressure between their boring surfaces and bolts.
Bolts have been tried for strains at bending and shear, for a safety coefficient higher than 10, the use of one 42MoCr11, 31MoCr11, 31MnCrSi11 or 25MnCrSi11 alloyed steels of improvement resulting.

Fig. 10 shows the numerical analysis with finite elements of the device DLCLE 118, in Fig. 10,a showing the way of loading, fixing with of the boring of the bolt of attachment to the skip, and application to the surface of the metal heart of a force equal to the maximum weight of the cable, 20000 N. Fig. 10,b shows that the maximum strain of the bolts occurs in the area of separation between the cover plate and the sleeve of the metal heart due to the shear strain, this is highlighted by the detail A and B, where tensions equivalent to 69,306 MPa and 79.468 MPa come up, confirming the necessity of using alloyed steels of improvement.

Conclusions

In drawing up the documentation of execution for connecting devices of flat cables for equilibrium in contract No. 193/ASL/2006, concluded with CNH Petrosani, the following technical economic aspects had been in view:

- simplification of constructive solutions from technological point of view (eccentric core and clamps in welded construction compared to their cast construction);
- equalization, as far as possible, of constructive solutions for flat cable connecting device, which equips multi-cable winding installations in the Jiu Valley. This was particularly difficult, since it was necessary to maintain the interchangeability with the present constructions;

- use of constructive solutions that had been verified in practice for similar devices;

- maintaining the present safety coefficient, and in some cases, its increase;

- decrease of costs by reducing manoeuvre.

References

