OPTIMIZING UPPER EXCAVATOR

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Abstract: An essential element when establishing the balance of a bucket wheel excavator is the determination of the barycentre, the best results being thus obtained by weighting after having installed all the components. The lack of correct balance for bucket wheel excavators determines their operation in an inadequate dynamic mode, or in extreme cases, there is the danger of losing stability by tilting over the excavator respectively suffering huge material and human loss. It is compulsory to verify for the correctness of the position and mass value of balance because there might be substantial error sources leading to compromise the operation. One of the most popular methods is that of weighting the entire equipment from the superior platform of the excavator. The weighting process implies the lifting of the excavators in three spots with hydraulic cylinders, the measurement of the forces, as well as the measurement of pressure inside the cylinders and of the stroke of each cylinder. The data measurement and rehashing installation is destined to determine the dimensions that finally define the weighting process of excavators or other operating machineries to which the balancing and control of stability is imposed.

Key words: transport, optimizations, mechanics

1. Generalities

The balance problem of such bearing structures is of utmost importance, because the resultant of all the forces which act on the structure is not allowed to touch or to overpass the perimeter of the bearing surface, consequently leading to the instability of the structure.

The problem is much more difficult because the center of mass of the rotor excavator is higher than the bearing structure as well as the point where all the exterior forces act on the excavator. Figure 1 schematically represents the superior part of a rotor excavator.

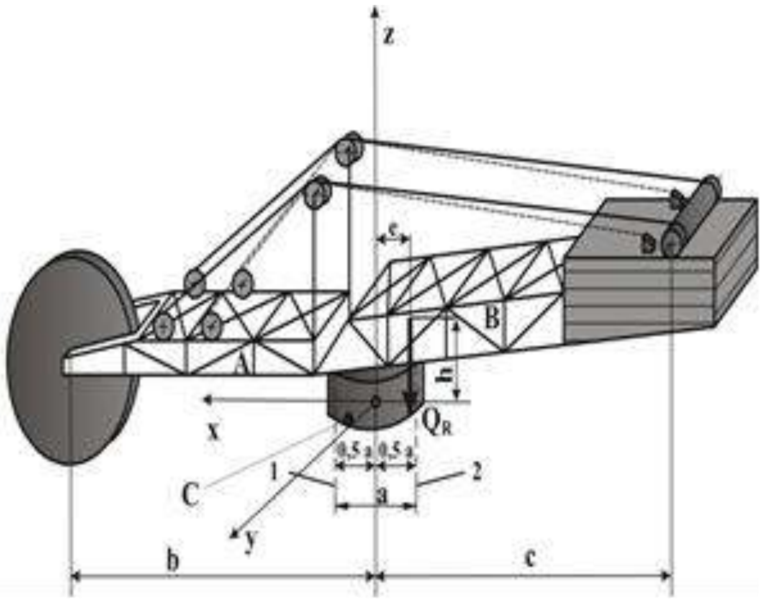

Fig.1 Specific elements of the balance and stability of the superior rotary platform of the rotor excavators

A – rotary arm;
B – counterweight arm;
C – rotary crown of the superior part;
1 and 2 – limits of the bearing perimeter of the superior part.

The limits of the bearing perimeter are represented by the numbers 1 and 2, are situated on a distance of 0,5×a from the axis of revolution of the superior part to the axis z of the reference system.

The distance between the two bearing perimeters "a" is small compared to the rotor "b" and of the counterweight "c".

The center of mass of the superior part's weight QR is shifted by the extension "e" towards the arm, depending on "z", at a height "h" from the perimeter of the bearing surface.

These two measures "e" and "h" are not constant and depend on the height where the rotor is lifted, thus "e" is minimum when the arm of the rotor is in horizontal position and once the arm is lifted it rises, and "h" is minimum when the arm is lowered and rises as the arm of the rotor is lifted.

In horizontal position of the working machine, respectively the rotor excavator, and the resultant pierces the bearing surface to a distance "e" and an axis z. When the machinery is tilted, the point where the resultant pierces the bearing surface is shifted, and according to the direct tilt, the distance to the axis may be greater or smaller than "e".

2. Lifting Installation

The main parameters characteristic of a hydraulic cylinder are: the nominal pressure, p; the diameter of the piston, D; the diameter of the rod, d; and the operating ratio of the sections .

Other parameters involved in the characterization of hydraulic cylinders are: the stroke, c; the pushing forces, respectively the developed traction for pressure p, Fi and Ft; and the flow of used liquid to realize a certain speed, v, marked with Q; the time needed for a stroke, t, the mechanical and volumetric load for the operating pressure, am and TV; the volume of the liquid inside the cavities delimited by the piston, V, considered for a certain stroke; set up length, l, considered between lmin and lmax, lmax = lmin + c; the thickness of the barrel, h; the unitary admitted effort for the material of the barrel, σ; the inertia moments of the barrel, respectively those of the rod, I1, I2.

Other parameters the cylinder needs to meet, as input data, are calculated according to the implied parameters.

The following input data are considered for the use of hydraulic cylinders inside the lifting installation:

- the necessary force for lifting the excavator onto a cylinder, maximum 2010 kN;
- the nominal operating liquid pressure, 25 MPa;
- the maximum liquid pressure, for the cylinder's trial operation, 37,5 MPa;
- the stroke of the cylinder, 160 mm;
- the cylinders are mounted onto the lifting installation by with a simple bear on, no articulations necessary;
- the lifting speed has a decreased value;
- considering the insulating elements manufactured by Hallite, implying the execution of cylinders components.

Hydraulic cylinders are conceived in two different ways:

- Option I, double effect hydraulic cylinder, design number UP-LCM-02/I-2.0, where the opening and the closing are made on both operating sides;
- Option II, simple effect hydraulic cylinder, design number UP-LCM-02/II-2.0, where the opening is made hydraulically and the closing is spring operated.

The following steps are taken for the calculation of hydraulic cylinders with the presented input data:

- imposing the technological forces which need to be developed;
- dimensioning the motors by calculating the parameters D, d, φ and h;
- mechanical rigidity check.

Hydraulic cylinders are used for the lifting installation presented in figures 2 and 3. The lifting installation is composed of the two cylinders, marker 2 or 3, installed between the two beams, inferior 1 and superior 4. The ultrasonic force transducers are installed on the superior part of the cylinders on the mounting brackets 6 or 7. The installation also has an ultrasonic or an inductive position control transducer mounted on the stroke of the hydraulic cylinder.

2. Lifting Installation

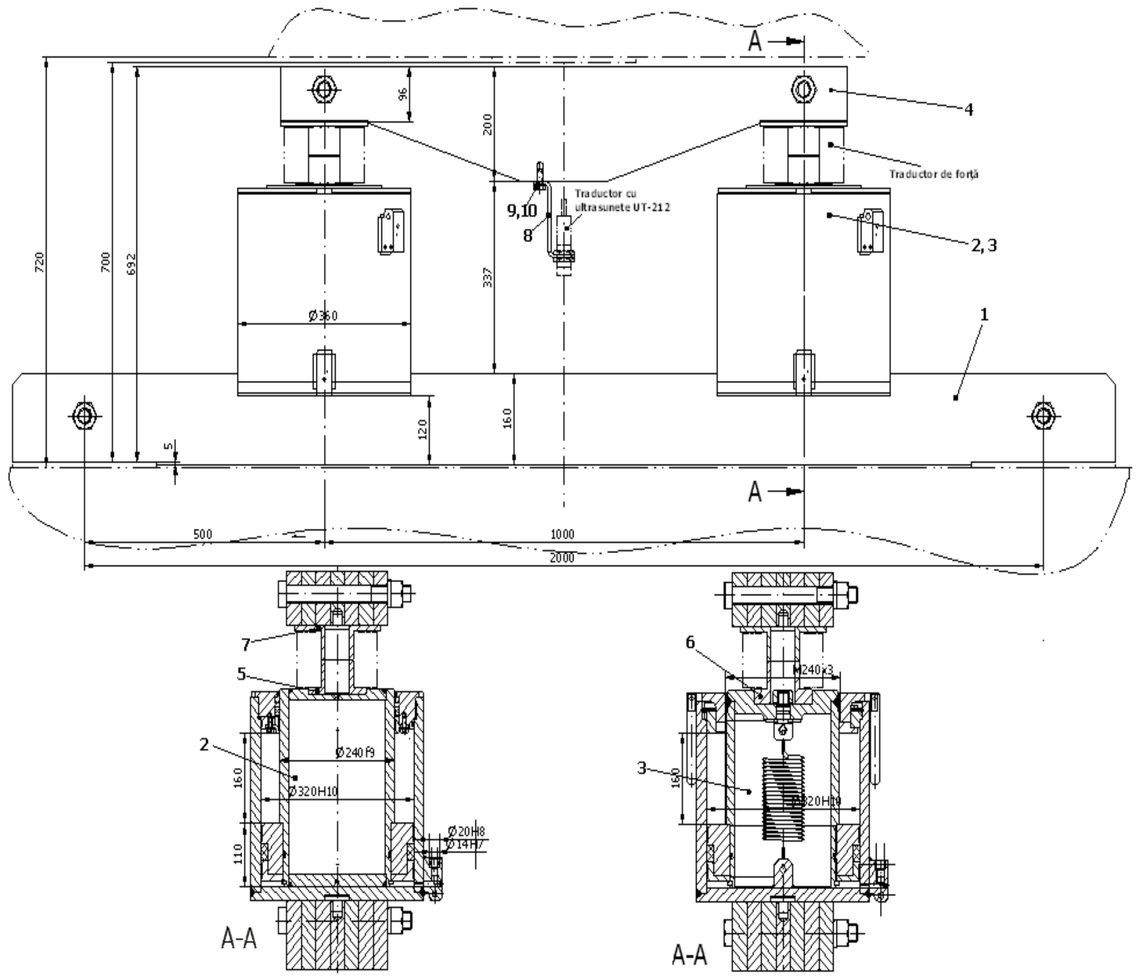

Fig.2 General view of the lifting installation

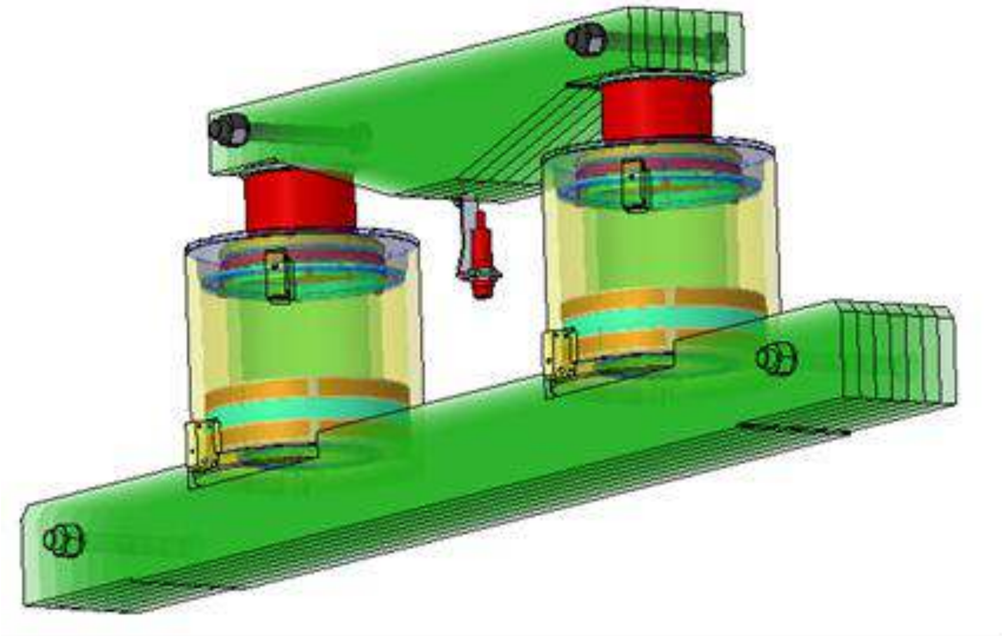

Fig.3 Spatial view of the lifting installation

3. Excavator analogical weighting system

The term analogical refers to the analogical signals sent by the transducers to a computer through an A/D data acquisition card (figure 4).

The tensions provided, by the transducers in each lifting point are accepted by the A/D data acquisition card through connection cables. This type of card is installed on the main board of a numerical computer. In order to be able to monitor the process, a language C software has been developed, which will allow to read, interpret, compare and record all the pieces of information obtained by the I/O card.

Force, pressure and location transducers are used, the construction details of which are presented in the following paragraphs by briefly describing the construction and the operation, the technical characteristics, the conditions of installation, connection, etc.

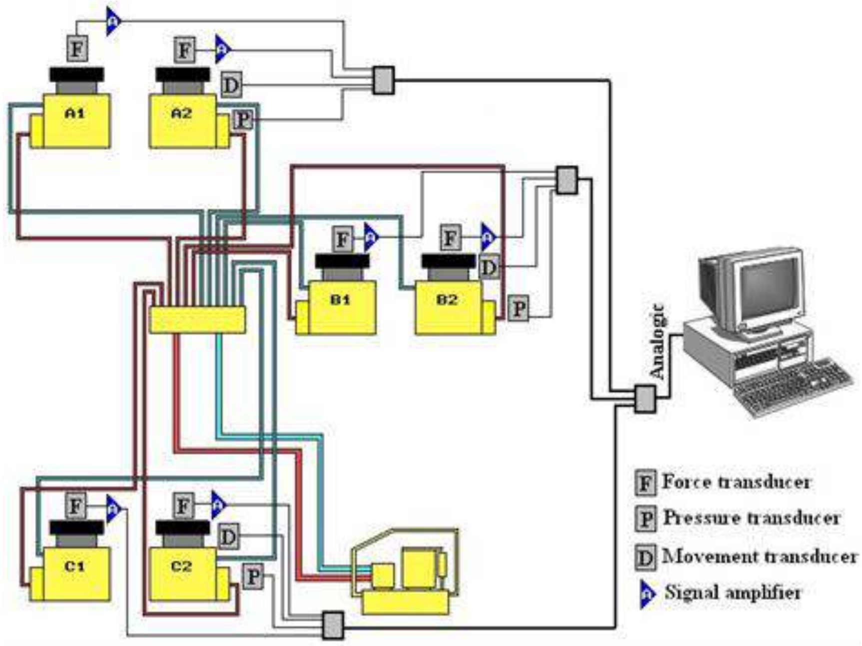

Fig. 4 Transmitter data collection system – analogical signal

3.1 Force transducer

The force transducers are destined to determine the level of the elevation force developed by each hydraulic cylinder. Six C6A force transducers are used (figure 5) manufactured by Hottinger Baldwin Messtechnik GmbH.

Fig.5 The C6A Force Transducer

These measurement devices represent the resistive transducers to determine the compression and extension forces in a static or dynamic regime. Regarding their usage, they don't need excessive maintenance and may be installed in places hard to reach. The electrical signal provided by this type of transmitter may be broadcasted to a certain distance in order to measure, rehash, display and record it.

The operating principle of such a transmitter is based on the proportional variation of the calibrated tensiometric element ohmic resistance, being deformed under such a force. This type of ohmic resistance variation, generates the imbalance of the Wheatstone bridge, thus, supplying the bridge with power, an output signal (tension) proportional to the ohmic resistance variation and consequently proportional to the compression force is determined.

3.2 Pressure transducer

The three P6A pressure transmitters (fig. 6) are, manufactured by Hottinger Baldwin Messtechnik GmbH.

The requirements of the installation impose the selection of a P6A Pressure Transmitter, the P6A-500B-D with connector, with a measurement range of 10 to 500 bar, and which is destined to measure static and dynamic pressures in the range mentioned earlier.

Fig.6 The P6A pressure transducer with connector

3.3 Movement transducer

For the analogical weighting system we will consider a Microsonar UT-212 (figure 7) movement transmitter with ultrasonic.

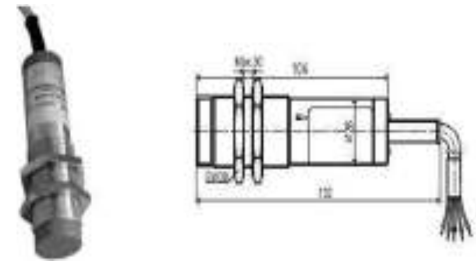

Fig.7 Ultrasound transducer Microsonar UT-212

The experiments were made using transducers Microsonar UT-212, which were installed on a plate surface, which allows to change, the distance in order to set up their transfer characteristic. In Figure 8 it is shown the transducer transfer characteristic MicrosonarUT-212, as well as its transfer equation.

The equation was used in an application, which allows to measure the distance to the target.

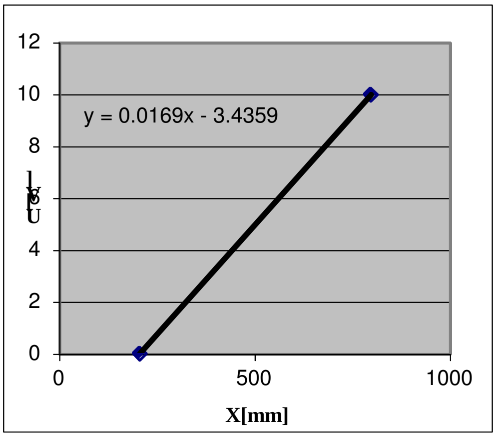

Fig.8 Transducer transfer characteristic

3.4 Signal Amplifiers

If the distance between the resistive transmitters and the measurement amplifier is greater than 3m, in order to ensure the safety and precision of transmitting the signal from the transmitters, signal amplifiers will be used. For resistive transmitters we will use MC3 signal amplifiers, and for the inductive transmitters we will use MC2A signal amplifiers. Both types of amplifiers are manufactured by Baldwin Messtechnik GmbH (figure 9).

Fig.9 Signal Amplifier for resistive and inductive transmitters

Conclusions

In order to elaborate this work several researches have been made both in real conditions in the brown coal basin of Oltenia in general and of Jilt, in particular, as well as in the specialty literature and the conclusion was that the weighing operations, the methodologies to determine the barrycenter, respectively the counterweight size and stability analysis, are made on machineries within mines (bucket wheel excavators, dumping machineries, etc) for a long time with classic means and methods, but which can be brought up to date so that balance and stability and the work condition to improve and so the performance of the equipment and of the whole system in general to improve too.
The study regarding the balance of bucket wheel excavators, applies the classical mechanics theory regarding the balance of some equipments and the conditions that have to be fulfilled so that the equipments should work properly.
The technical and technological aspects of the weighing operations, of the determination of the barrycenter, of defining the area in which this vector should be placed in order o assure the balance and the stability of the equipment, respectively to determine the balance weight and to identify the possibilities to a constant control of the brrycenter (in the area defined by stability) by the excavator driver, on the computer screen placed in his cabin, are synthetically presented.
The researches made in our country and abroad emphasize the importance of a mobile "Weighing and tensiometric measurement laboratory" equipped with all the necessary elements to do such operations in every quarry with a large number of excavators, both in brown coal quarries and to other potential beneficiary (harbour installations, lifting machineries and installations and transport in both civil and industrial constructions, machineries and installations in the oil industry, etc).
The theoretical research and the experiments, the designing work, came up to this concept of "Weighing and tensiometric measurement laboratory" that is a modern an accessible solution to improve the balance and to control the stability of the excavators and other equipments in lignite quarry, in order to improve the exploitation performances, respectively to increase their usage degree. This mobile laboratory offers its services in this field, including determining the tension in the metallic construction for other potential beneficiary.
The work regime of the bucket wheel excavators is influenced by the degree of stability and balance, which is in relation with the intensive and extensive index of usage. A theoretical hypothesis is that the inadequate degree of stability and balance can have a negative effect on the excavator in at least two cases: extra solicit because of the tendency to lack balance through modifying the geometry and respectively, the kinematics of the excavation, due to the oscillations- the balance of the arm, which leads to an overstressing of the mechanic elements and to damages.
Taking into account the costs due to casual weighing works and tensiometric measurements in Jilt mines, and other services provided to third person we can say that in about two-three years the investment will be paid off. The gain is related to the precision and accuracy of the measurements, in one word is related to the credibility of the steps related to the use of such system. All efforts, both human and material, given by the introduction of this concept, will lead to a technical level increase in daily exploitation, influencing the increase use of

technological equipment. A technical-scientific base is created, which will allow an expertise that will lead to determine the span and the ways of increasing it for the existing equipment in the Jilt mines.

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