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TESTING RIG FOR EXPERIMENTAL STUDY OF THE MECHANICAL ROCK CUTTING

This paper presents some problems as for the characteristics experimental determination when mechanically cutting coals and rocks. The booth for cutting heterogeneous material, dedicated to the determination of specific resistances when cutting the lignite and sterile rocks is consisted of an hydraulic shaper model 7310 D, a strain dynamometer used for the measurement of the stress in the dipper tooth, the standard dipper tooth, the sample of lignite or rock, the installation for remaking and registering experimental data, and the electrical power plant and central office, both needed for electrical supplying and commanding the booth. The booth provides the existence of cutting forces with values between 5000... 28000 N, cutting rate from 0,05m/s up to 0, 8 m/s and a 1000mm forward motion. Also the set of standard dipper teeth allows a variation of the front rake angle between 10 and 50° and simulation of the dipper tooth abrasive wear. The working table allows using a test sample having the maximum size of 600×500×400 mm.

INTRODUCTION

One issue in bettering efficiency in the mechanization of coal and sterile rocks extraction from the uncover is bettering work parameters of the bucket-wheel excavator, considering the technical endowment glory-holes of lignite from Romania.

Thus, establishing mechanic cutting rocks through chip removal characteristics, such as dipper teeth of the bucket-wheel excavator cut them in practice, represents an essential issue and underlies the concrete knowledge of rock dislocation.

Laws of interdependence among the geometrical and technological parameters of the dipper teeth, dislocated chips parameters and the cut-off conditions parameters that can be established qualitatively and quantitatively for each rock fractionally must be the result of the dates obtained through experimental attempts.

DESIGN FOR PROPER BOOTH

When performing experimental attempts for dislocating coal and mineral rocks using the bucket-wheel excavator which have dipper teeth as the cutting element, it is necessary to conceive and manufacture an experimental attempts booth that contains a suitable shaper, a strain dynamometer which allows measurement of forces that operates upon the dipper teeth and a measurement, processing and recording installation equipped with an electronic computer and the necessary peripheral equipment.

The booth for the inhomogeneous material cutting, designed for experimental attempts in sight of establishing specific cutting resistance of lignite and sterile rocks is shown in figure 1.

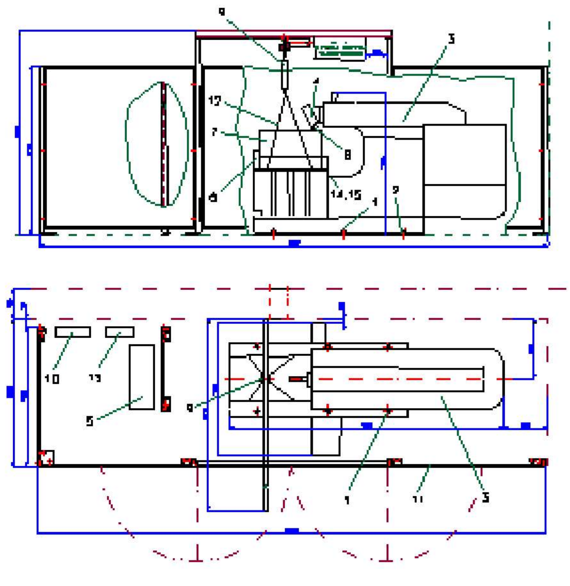

Fig. 1 – The booth for the material inhomogeneous cutting

In this figure we noted:

1 – stone bolts; *2* – rubber carpet; *3* – shaper model 7310 D; *4* – strain dynamometer; *5* – Data processing and recording device; *6* – sample screwing on the work table device; *7* - sample of lignite or sterile rocks fixed in the sample box; *8* – standard dipper tooth for attempts (set made up of six standard teeth: 5 dipper teeth with the variable rake angle ranging between 10-50° and a dipper tooth which simulates wear); *9* - crane for lifting samples on the working table; *10* - electrical power plant and central office; *11* – protection screen ; *12* – iron cable for samples handling; *13* - shelf for material keeping.

As figure 1 shows the booth for the experimental attempts is made up of a hydraulic shaper *3* upon which the dynamometer *4* is mounted, the standard dipper teeth *8* that help in cutting the lignite and sterile rock proof samples, packed in the proof boxes *7*. Handling sample boxes, in order to fix them on the work table of hydraulic machine through the device *6*, is done using a monorail system with the manual crane *9*. As for the protection of the operator and experimental data recording and processing device, the screen 11 was designed.

The hydraulic shaper is fixed on the foundation by the screws *1*, as it is laid on the rubber carpet *2*, which provides systems “machine-teeth-sample” elasticity. The hydraulic shaper offers the possibility of mounting the standard dipper teeth *8* by means of strain dynamometer 4 used as a bounded strain gauge for the measurement of on-tooth forces.

The strain dynamometer is part of the data measurement, recording and processing device. The hydraulic shaper allows achievement of cutting forces ranging between 5000 and 28000 N, and also of adjustable cutting speeds ranging between 0,05 m/s and 0,8 m/s, having a maximum forward motion of 1000mm.

DESIGN DEVICES FOR THE FIXATION SAMPLES ON BOOTH

The device designed for the sample fixation on the booth is shown in figure 2.

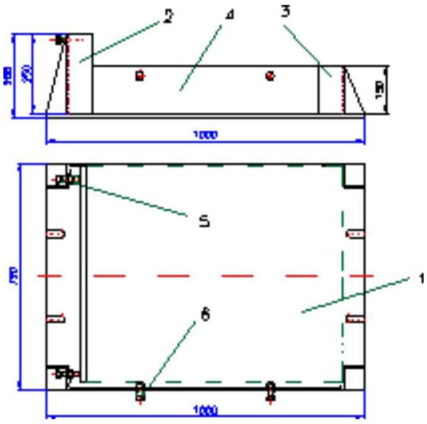

Fig. 2 – The device designed for the fixation samples on the booth

When designing the fixation samples on the booth device, we had in view the fulfil of the following conditions:

- the device can be well fixed on the attempt work table;
- the device has the overall dimensions according to work table and proof box dimensions
- the strong fixation of the proof sample together with it's packing on the device is to be granted;
- the rigidity of the system "work table – proof box", during tests should also be granted;
- the device is to have a simple and attempt solicitations resisting.

In respect of these conditions we designed the device presented in the figure above, which consists of the foot plate *1*, pillars *2* and *3*, the wall *4* and the frontal and lateral attachment screws *5* and *6*.

The base plate *1* composed of iron plate (OL 37) with thickness of 10 mm, is equipped with 4 bezels needed for the fixation of the devices, with screws, on the work table. The pillars *2* are made of equal angle iron, 80×80×10 mm. They are 250 mm high and are endowed with the screws *5* (M16) for the longitudinal fixation of the sample pack.

In order to provide proper fixations and good rigidities for the system, the screws *5* are mounted in 3 couples of holes located 80 mm away from each other. Between the sample box and screws is also located an iron plate 10mm thick upon which the compression is executed. This plate provides the rigidity of the "device of fixation – box for sample" system, during experimental attempts. The device is equipped with a set of 4 iron plate of this type, having the different heights, which replace each other during the experiment.

The pillars *3* are also made up of the same equal angle iron, 80×80×10 mm, and have the height of 150 mm that allows the ram of shaper's penetration down to depths close to sample's base.

The wall *4* located on the same side as the human operator, is also equipped with the screws *6* (M16) so as to transversal lock the sample. When compressing the sample box with the transversal clamping bolts some plate shall interpose between the wooden wall of box and the heads of the screws to prevent its penetration.

In order to increase bending resistances of pillars *2* and 3, when welding on the iron plate *1*, we will strengthen them with gussets made of iron plate 10 mm thick.

DESIGN OF THE STANDARD DIPPER TEETH

Standard dipper teeth used-up in tests are due to carry out the following conditions: they must have a similar geometry to that of the dipper teeth that equip the dipper real cutting process; they must have the size to allow their fixation on dynamometer and, by default, test machine; they must provide a rigid fixation during testing periods; they must be made up of wear resistant material to keep the geometry during attempts.

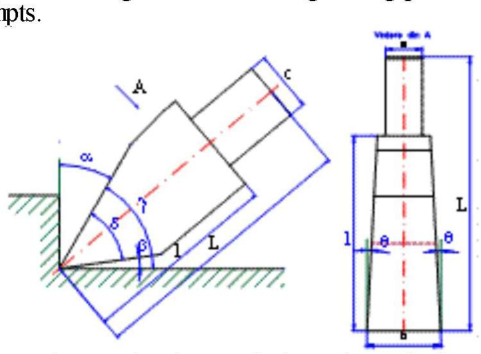

Fig. 3 – Sketch general of a teeth standard

The general sketch of the standard dipper tooth used in attempts is presented in figure 3. In this figure: L represents the total length of the tooth; l - length of the active part of the tooth; b - the width of the cutting edge of the tooth; a, c - the fixation in dynamometer tail transversal section sizes; α - the angle rake; β - the bottom rake; γ - the cutting angle; δ - the angle of keenness; θ - the lateral angle.

The sizes L, l, a, b and c are constant in the whole set of standard teeth. The size of these values come out from the mounting in dynamometer conditions, from the sizes of fitting on the booth, from the experience accumulated with cutting as well as from other examples existing in the world. Thus, we adopted the values L = 150 mm, l = 106,5 mm, a = 20 mm, b = 40 mm and c = 33 mm.

The angle rake α is variable in order to contains all types of used teeth, choosing the values 10°, 20°, 30°, 40° and 50°. The bottom rake β is dependent on dislocated material's elasticity and it has the values ranging between 5…15°. We choose the constant value of 8°. The cutting angle γ is complementary to the back rake angle and has the values of 80°, 70°, 60°, 50° and 40°. The angle of keenness comes out from the values previously defined, because it complies with the relation δ=90-α-β (degrees), and has the values 72°, 62°, 52°, 42° and 32°.

The lateral angle θ was picked to have the value of 3°, considering that he eliminates the lateral frictions between teeth and material. This is the solution adopted by the manufacturers with renown in domain.

THE DESIGN OF THE MEASUREMENT DEVICE SCHEME AND THE CHOICE OF NECESSARY APPARATUS

In figure 4 is shown the schema of measurement, recording and processing device scheme for the experimental sizes (forces F_x, F_y, and F_z) which result in from the cutting process.

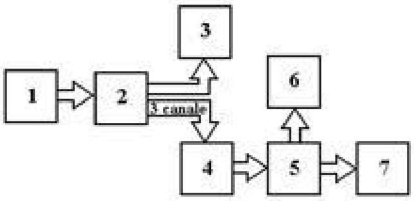

Fig. 4 – Schema of the measurement and recording device

In figure 4 we used the following notations: *1*-strain dynamometer; *2*- amplifier; *3*-osciloscope; *4*-analogue-digital plate; *5*-calculator; *6*-monitor; *7*- printer.

Electric signals produced the resistive transducer, pursuant to the unit deformations that appeared in tensometric bar (which is a constitutive part of the strain dynamometer), are took over and amplified by the amplifier in the shape of an analogical signal which is then converted into a digital signal by a converting plate and recorded by the computer as a data file. This data file may be processed with of numerical analysis programs, and the results are printed by a printer.

Choose the necessary apparatus.

For the measurement, we use a tensometric device N2300, Romanian manufactured.

The tensometer N2300 is used for the measurement of diverse mechanic sizes such as: deformation and unit efforts, forces, couples, pressures etc. The transducers we use may be of resistive or inductive nature, and they are made of half deck resistance or complete deck resistance.

The results of static measurement are read on prompter. For dynamic measurements an exterior recording instrument can be connected. The measurements may be done in 12 points, providing their individual equilibration and the successive commutation of the amplifier. Reading output measurers can be done on an instrument analogical display instrument (N2321, N2322) or through numerical display (N2323).

Technical characteristics

- the number measurement points: 12;
- the measurement range: 0±100000 μm/m (0±50000 μV/V for K=2 and the power-supply of the deck 4 V_{ef}) in 10 scales;
- output: 10V_{ef} 20mA;
- the linearity: 0,03 %;
- power-supply of the deck: 1, 2, 4, 8 V_{ef};
- useful transducers(in half deck resistance or complete deck resistance): R=50±1000 Ω; L=2±25 mH;
- the equilibration in 11 steps;
- the possibility of a utilization of unique compensation transducer for 12 active transducers.

The measurement amplifier with carrier frequency N2314

The amplifier of measurement with carrier frequency N2314 is the part of the "Modular system of tensometric apparatus N2300". The apparatus can ply with sensitive tensoresistive and inductive elements constitute in half deck resistance or complete deck resistance, to which it delivers power-supply, and whose variations generated by the size of mechanical input quantity, converts them in output voltage.

With proper transducers, having sensitive element of the forenamed types, the apparatus can be used for the measurement of diverse sizes such as: mechanic deformation, forces, couples and pressures. Along with other systems N2300 modules, the amplifier N2314 can constitute specialized measure ensembles.

His functional characteristics and the metrological parameter turn the N2314 amplifier into a large usability apparatus in diverse measurement and check devices and in industry.

The output signal of the N2314 amplifier can be introduced into one of the processed modules (N2331, N2334). The extension of the usability considering the transducers and incoming circuit can be achieved by using the N2315 bridge preamplifier and N2336 modulator adapter, and the extension of the calibration possibility is done using the N2338 module. The apparatus can also be comprised in the many measurement point with manual and automatic commutation and measurement devices.

The functional description of the N2314 amplifier

The N2314 is a carrier and demodulation amplifier that supplies deck of transducers (5kHz, AC.) and outcomes the unbalance of the deck using the direct indications method. The functional description comes out from block diagram shown in figure 4.

The internal sinusoidal generator of 5 kHz (15-20), symmetrically supplies the bridge of floating transducers given the earth mass (without point of table). The deck can be connected with 4, 5 or 6 lines. The last two cases provide the appreciable decrease of errors brought about by cable even in the case of great distances measurements. This effect is obtained through the self-governing of generator's amplitude, so that to maintain constant supply voltage of the deck. The tuning of the oscillator is accomplished using control threads of the cable.

The calibration of the apparatus can be accomplished using the internal two polarities signals (±10000 μm/m) or from the N2338 external drawer, or from another calibration device, (for instance the DIT-5K or UL 2001 laboratory inductive dividers). The N2314 module has no supply switch. The supply is done through connecting-up in the system 220V/50Hz of the display and supply modules(N2321, N2323) or through the connecting-up to the external power supply, which is accomplished by connection at terminals + 24, 0, -24 from the back panel of the N2321 power supply mounted in same box with N2314.

Connecting-up the transducer

The resistive transducers between 25 and 1000 Ω or inductive transducers between 5 and 25 MHz can connect to the apparatus. Before attaching the bridge, it is necessary to verify the isolations of transducers against the piece on which they are attached and their continuity.

In connecting the transducers CETYY 3×2 (18×0.10) cable is used

CONCLUSIONS

The booth for the inhomogeneous material cutting designated to the determination of cutting unit resistance when cutting lignite and sterile rocks is formed of the 7310 D hydraulic shaper, a strain dynamometer used for the measurement of stress in dipper teeth, the standard dipper tooth, a lignite or rock sample, the processing and recording experimental data device and the electrical power plant and central office.

The ram of shaper is hydraulic manipulated, that allows easy adjustment of forces and cutting velocity. The maximum pressure in the hydraulic circuit 6.3 MPa. The flow of the hydraulic pump is maximum 100 l/min and minimum 50 l/min.

The booth provides a cutting force ranging between 5000…28000 N, cutting velocity ranging between 0,05 and 0,8 m/s and a forward motion of 1000 mm. The set of standard teeth allows a variation of the angle rake from 10 and 50° and the simulation of the tooth wear. The work table permits the use of a sample having the maximum sizes of 600×500×400 mm.

The proof sample can be fixed on the booth's work table through a bolting device that permits the longitudinal and transversal clamping of the box.

The shaper and the processing and recording experimental data device are surrounded by a metallic screen in order to protect the device and the operator. The overall size of the booth along with protective screen is 6886×3010×2640 mm.

Conclusively the designed booth permits the determination of the cutting characteristics when cutting the lignite and sterile rocks, as well as the establishing of laws that relate these characteristic to the parameters of the used teeth and dislocated slivers.

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