COMPARATIVE STUDY OF MECHANICAL ROCK CUTTING

IOSIF KOVACS[1], MARIN SILVIU NAN[2], IOSIF ANDRAŞ[3], OVIDIU-BOGDAN TOMUŞ[4], ANDREI ANDRAŞ[5]

Abstract: the paper deals with the results of laboratory experimental researches, performed in the past years, in view to establish the parameters characterizing the behavior at cutting of different mineral substances (coal, salt) and surrounding rocks (marl, clay, sandstone) and the laws governing their interdependence in respect to increase the working effectiveness of rock cutting equipment such as shearer loaders and roadheaders.

Keywords: rock, experimental, cutting, shearer loaders, laboratory

1. GENERAL CONSIDERATION

An important and very complex issue in mining industry is the rock cutting mechanization, in general, and the cutting using shearer loaders (SL) and roadheaders (RH) in particular, for underground mining. The experience gained worldwide and in Romania also, confirms, that in the foreseeable future the longwall technology and the drives development in soft rock such type of rock cutting machines will be used. The up to date experience shows that regardless their technological level, these machines must be compliant with the working conditions, the appropriate selection and operation represents the main reserve in improving their operational performance.

The paper presents the results of theoretical, laboratory and field researches regarding the behavior at mechanical cutting of coal, salt and other different rocks from the main mining basins of Romania, as well as the essential correlations necessary to the knowledge of the working regime of the SL and RH taking in mind the

---

[1] *Ph.D., Prof., University of Petrosani*
[2] *Ph.D., Prof., University of Petrosani*
[3] *Ph.D., Prof., University of Petrosani*
[4] *Ph.D., Assist. Prof., University of Petrosani, tobogdan2002@yahoo.com*
[5] *Ph.D., Assist. Prof., University of Petrosani, andrei.andras@gmail.com*

improvement of their performances.

In this situation it is necessary to study the interaction machine-massif in general and specific conditions, in order to derive the general laws of correlation between parameters and the specific application for a given machine in given conditions.

2. PERFORMING EXPERIMENTAL RESEARCH

The experimental research may be performed in lab conditions on samples collected from the ore-body or directly, in situ on field. The lab essays have the advantage of a high accuracy and possibility to establish many parameters. In situ assays have the advantage of being close to real conditions, but due to the difficult conditions in underground environment, the accuracy and number of parameters measured is limited. A rational way, as resulted from the literature, is to verify in situ main results of lab assays, and correct them accordingly.

The laboratory assays required an appropriate testing rig. The most accessible is to be used a shaper or planer machine tool with technical feature appropriate for the purpose. In figure 1 a shaper based test rig is presented and the main components can be observed.
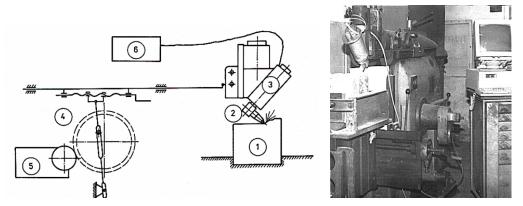

Fig. 1. Shaper type laboratory rig:
1 - rock sample; 2 - test bit; 3 - dynamometer; 4 - slider-crank mechanism; 5 - actuator block

The lab tests require also a correct collection and conservation of samples. So, the samples were collected in cubic shape using removing tools which avoid creation of supplementary stresses during collecting, were covered with paraffin wax to avoid weathering in contact with the air and after their transport in lab were cased in gypsum and wood boxes. The assays were performed short time after collection.

In figure 2, such coal samples are presented, covered with paraffin wax layer of 1-2 mm, introduced in wooden boxes and reinforced with gypsum.

The prismatic bits used on the testing rig have a special construction, their longitudinal axis being inclined with 40 degrees relative to the cutting direction. Some

of the geometric parameters of these bits are with fixed values, others are variable ones, function of the results aimed to be obtained. In figure 3 an example of layout of the test bit is presented, with α and β changing parameters, respectively from α to α ' and β to β'.

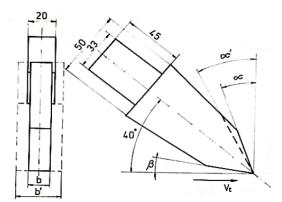**Fig. 2.** Preparation of samples for testing on rig

Fig. 3. Layout of test bits; realization of the test bit kit

In order to measure the cutting forces, a dynamometer has been devised, as in figure 4. The transducer element consist in an cantilevered beam with strain gauges, which are located in such a manner that they can measure the strain produced by the bending moments due to F_x, F_y and F_z.

The electrical measuring block is formed by a system of strain gauge bridges which allows to be measured the three components of the cutting force, and a recording-display system with DAQ card and a PC. (see fig. 5).

By performing the experimental assays, we have had in mind the determination of the cutting forces, of the specific cutting resistance, the breakout angle of the chips resulted, their dependence on depth of cut, on characteristic angles of the cutting tool, on the width of the cutting edge. During each assay, the components of the cutting force were measured. An example of recorded diagram resulted from one cut measure is presented in fig. 6.
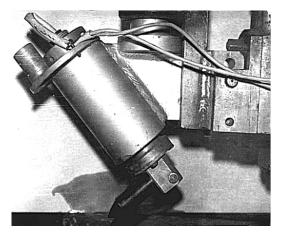
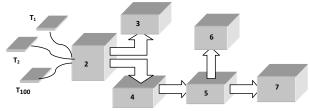**Fig. 4.** Layout and materialization of the dynamometer

Fig. 5. The measuring- recording block:
T_i – strain gauges; 2 - bridge & amplifier; 3 - oscilloscope;
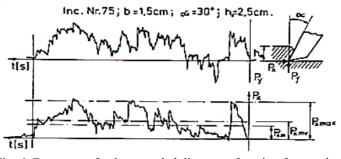4 - DAQ card; 5 - PC computer; 6 - Monitor; 7 - plotter

Fig. 6. Fragment of a the recorded diagram of cutting force value

3. RESULTS OBTAINED

After performing the experimental assays, and data processing, a series of dependences between different parameters has been derived, regarding different coal deposits in Romania as a function of cutting depth, rake angle, cutting edge width a.s.o.

Among the most important characteristics, we can mention: specific cutting resistance, cutting force, penetration force, lateral force, breakout angle and specific

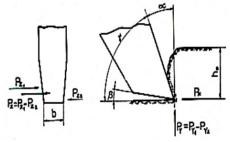energy consumption, as it can be seen in figure 7.

Fig. 7. Main parameters of the bit and cut

Taking into account the relation $F_x=A\ h_o$ (A being the specific cutting resistance and h_o being the depth of cut), which is in unanimity accepted by the literature, it results that the tangential force F_x has a linear dependence on the depth of cut h_o, and A is a constant in rapport with h_o having a well determined value for a given type of coal. Contrarily as it can be seen from the empirical data, the specific cutting resistance A is highly dependent on values of the rake angle α of the cutting instrument. As an example, in figure 8, these dependences are shown.
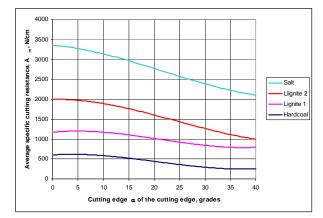

Fig. 8. Dependence of average cutting resistance A_m on raking angle α

As we can see, for the studied range for α between 0° and 40° all the curves are decreasing ones, having an inflexion point at a certain value of α

The breakout angle of removed chips is important to estimate the volume of rock detached and it has been calculated measuring the volume of the chips footprint and using the appropriate geometric relation, approximating the chip with a trapezoidal prism. In figure 9, the variation of the breakout angle Ψ in respect to the depth of cut h_o is presented, for different types of coal, and we can notice that it varies between $50^o...70^o$ for coal and $30^o... 60^o$ for salt.
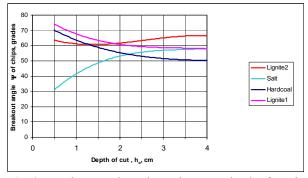
Fig. 9. Breakout angle Ψ dependence on depth of cut h_o

In order to illustrate the differences among different coal, rock and salt types, in figure 10 the specific energy E_s variation in respect with ho is presented.
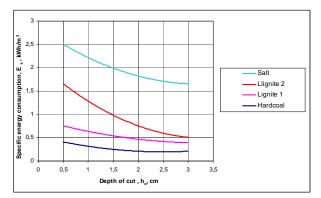

Fig. 10. The variation of specific energy consumption in respect with the depth of cut

4. CONCLUSION

The comparative analysis of experimental data obtained on a large number of coal and salt samples shows that the cutting parameters varies in large limits, so for each rock and each cutting machine it is necessary to know the interdependences between the rock properties and tool parameters.

REFERENCES

[1]. **Andraş, I., Nan, M. S., Kovacs, I.,** *Study on the Random Phenomena occurring in the process of Lignite and Overburden Rocks Extraction with Bucket Wheel Excavators*, 40 th Mining Equipment International Conference, 27-28 sept. 2007, Balatongyörök, Hungary.
[2]. **Kovacs, I., Iliaş, N., Nan, M. S.,** *Regimul de lucru al combinelor miniere*, Editura Universitas, Petroşani 2000.
[3]. **Nan, M. S.,** *Parametrii procesului de excavare la excavatoarele cu rotor*, Editura Universitas, Petroşani 2007.