STUDY ON THE MECHANICAL PROPERTIES OF THE ROCK SALT

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Abstract: *A problem of high importance and great complexity in the extractive industry is the cutting operation of rocks, especially the cutting of rock salt. The acquired experience acknowledges that in present and also in the near future the technology used in the excavation of rock salt is and it will be a mechanized one.*

Key words: *rock salt, hardness, strength, friability*

Brinell and Meyer hardness

The Brinell hardness is computed using the relation:

$$HB = \frac{F}{\frac{\pi D_0}{2}\left(D_0 - \sqrt{D_0^2 - d_u^2}\right)}, \quad (1)$$

in which:

F = 187.5 daN, printing force;

D_0 = 10 mm, diameter of the testing ball;

d_u - the size of the printed trace;

As a result of testings where determined the average values of the printed trace:

- for the forces applied parallel with the strata

d_u = 3.61 mm, HB = 17.2 daN / mm^2

- for the forces applied perpendicular on the strata

d_u = 4.39 mm, HB = 11.73 daN / mm^2

The Meyer hardness is computed using the relation:

$$HM = \frac{F}{\frac{\pi d_u^2}{4}}, \quad (2)$$

For the same measurement conditions the obtained values are

- on surfaces parallel with the strata

$$HM \approx 18.30 \text{ daN / mm}^2$$

- on surfaces perpendicular on the strata

$$HM \approx 12.36 \text{ daN / mm}^2$$

At the same time, there have been determined the average values of penetration h of the penetration device, the values of the remanent strain h_0, and of the elasticity coefficient ε:

- for the forces applied parallel with the strata

$$h = 0.63 \text{ mm}; h_0 = 0.35 \text{ mm}; \varepsilon = 0.445;$$

- for the forces applied perpendicular on the strata

$$h = 0.81 \text{ mm}; h_0 = 0.51 \text{ mm}; \varepsilon = 0.380;$$

Strength To Crushing

Strength to crushing has been determined with the help of a plane penetrating device that accomplishes a simultaneous loading and a more uniform one throughout the whole testing surface.

It was used a cylindrical penetrating device, having a diameter of 12.1 mm, with a printing force having values between 187.5 daN and 2000 daN. There have been measured for every test both the penetration depth h and the remanent strains h_0.

The strength to crushing was computed as a ratio between the applied printing force and the diameter of the cylindrical penetrating device.

We consider that the average value of strength to crushing obtained this way is the nearest possible to the values of strength to crushing measured on the plane bevels of the boring blade in contact with the rock salt (see Table 1).

Table 1. The results of the testing to crushing

No.	Strength to crushing σ_s, daN / mm^2	Penetration depth h, daN / mm^2	Remanent strains h_0, daN / mm^2	Elasticity coefficient ε
1	1.63	33.66	8.20	0.756
2	2.17	46.33	12.47	0.734
3	4.35	87.87	37.92	0.568
4	8.70	133.62	76.62	0.425
5	13.05	169.50	112.25	0.338
6	17.40	200.87	162.12	0.192

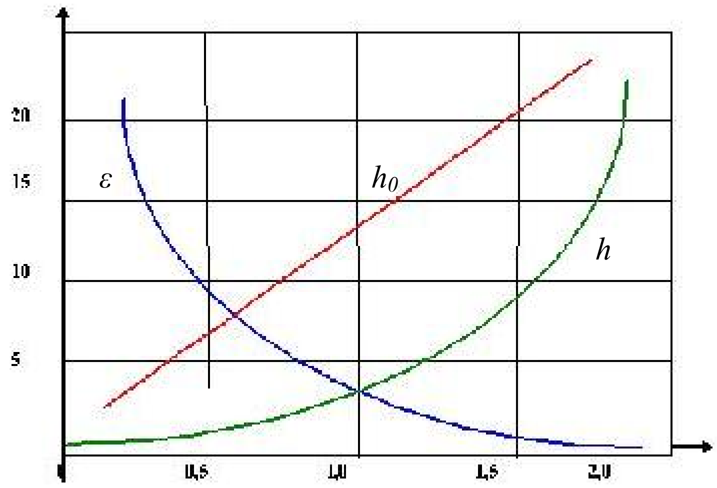


Figure 1. Diagrams σ_s , σ_s (h_0), $\sigma_s = h$(b) and ε_t

In the Figure 1 are presented the curves of h, h_0, ε for different values of σ_s. Knowing that h_0 and ε are functions of σ_s, for a given value of σ_s one can determine the corresponding h_0 and ε. Also knowing S and n one can determine V_p, necessary for the calculus of the rotation momentum, digging power and other elements necessary in the process of boring.

Experimental tests upon the salt rock samples taken from Ocna Dej show that the function:

$$h_0 = h_0\,(\sigma_s) \text{ or } \sigma_s = \sigma_s\,(h_0)$$

can be represented as a line described by the following equation:

$$\sigma = 0.65 + 10.7\,(h_0) \qquad (3)$$

where h_0 is measured in mm and σ_s is measured in daN / mm^2.

The dynamic friction coefficient μ between the rock salt and steel has been determined by using the known bar oscillating method, bar that is rubbed against two cylinders that rotate with the same number of rotations in the opposite way, as it can be noticed from the Figure 2.

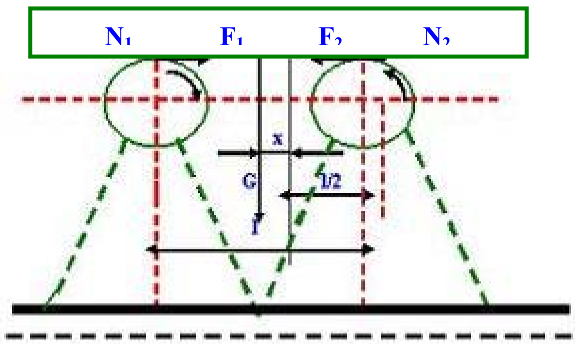


Figure 2. Main sketch of the friction coefficient test appliance

It has been measured practically the period of oscillation of the two salt blocks joined under the shape of a bar on the testing platform.

The computation formula for the friction coefficient in the case of this experiment is the following:

$$\mu = \frac{2\pi^2 I}{gT^2} \tag{4}$$

where

I = 24 cm represents the distance between the axes of the two cylinders that are rotating in the opposite way,

g = 9,81 m/s^2 gravity acceleration,

T = the oscillation period of the bar (sec)

The average of a lot of measurements has lead to the following value for the oscillation period T = 0.875 s and for the friction coefficient μ = 0.56.

Strain resistance

Strain resistance of rock salt was measured on cylindrical test rods having $d = h = 55$ mm, that were stressed to astriction on cross-cut. In this case the specific resistance to stretching is computed using the following formula:

$$\sigma_i = \frac{2P}{\pi \cdot d \cdot h} \tag{5}$$

because the breaking up is made along the diameter that is superimposed on the strut of the loading forces. This is the particular case of the rock salt.

The friability coefficient of the rock salt

The determination of the specific cutting effort was based upon the cutting tests, acquiring the curve:

$$\sigma_t = \sigma_t(t) \tag{6}$$

the values of the specific cutting strength A_0 being determined by extrapolation of the diagram from the figure 1.1, because in this particular case we have much smaller cutting depths. The values of the strength A_0 were used for a blade beam b = 1.5 cm, because this value in on-coming to the dimensions of a cutting edge of the drill chuck. Also, the values of the strength A_0 were used for a rake angle of 0^o and 10^o, because normally the rake angle for the cutting edges of the drill chuck is chosen to be 0^o, but it is formed an artificial angle.

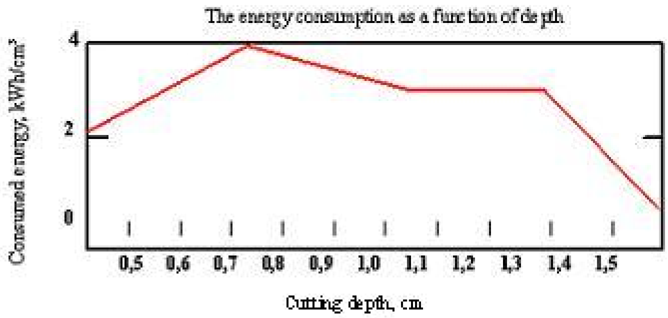
The expression of σ_t has the shape of a line, for a rake angle of 0^o:

$$\sigma_t = 1.36 + 0.107h \tag{7}$$

and for a rake angle of 10^o:

$$\sigma_t = 1.28 + 0.056h \qquad (8)$$

Figure 3. The diagram of the energy consumption function of the cutting depth



Computing the ratio between the σ_t and σ_s, who's values were obtained from the curve $\sigma_s = \sigma_s(h)$, one had determined the curves that represent the values of the friability coefficient, function of σ_s by means of h.

$$K = K(\tau_s) \qquad (9)$$

These curves are represented for the rake angle $\alpha = 0^o$ and 10^o, for the rock salt from Ocna Dej, in the Figure 4. One can see that $K \to \infty$, and the influence of rake angle decreases by the augmentation of σ_s.

Note that in the case of the rotating drilling the artificial rake angle, because the construction manner of the drill chuck and of the usual drilling speeds, doesn't exceed 10^o, such that the value of K can be easily be collated between the two curves.

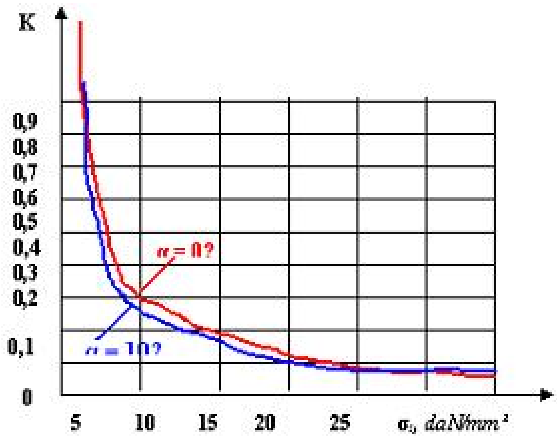


Figure 4. The friability coefficient of the rock salt function of the pinching strength

Compression strength

The compression tests were made on control cylinders having $d = h = 55$ mm, on the Russian made machine P – 50. Beside the measurement of the limit forces also was recorded the characteristic curve shown in the Figure 4., and was measured the breaking strain.

By compression with parting planes was obtained:

$$\sigma_c = 1.630 \text{ daN/mm}^2 \quad ; \quad \sigma_c = 8.75 \%$$

and by compression perpendicular on the planes was obtained:

$$\sigma_c = 1.955 \text{ daN/mm}^2 \quad ; \quad \sigma_c = 9.45 \%$$

The characteristic curve was recorded for a compression test piece parallel with bedding in layers. The shape of the curve is not influenced by the direction of the bedding in layers beside the compression, changing the orientation of the layers influences only the boundary parameters of the curve, without affecting the rate of the curve.

Conclusions

The choice or the design of some machines capable of work in the current conditions, implies a good knowledge of the chemical and physical characteristics, and also of the cutting techniques of the rock salt. These informations can become very useful in practice only if are known the interactions between them and also the laws of dependency between the parameters of the cutting tools and devices. These understanding implies theoretical research, laboratory and real life tests.

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