COMPARATIVE STUDY OF THE CHARACTERISTICS DURING THE CUTTING PROCESS OF DIFFERENT TYPES OF CLAY AND LIGNITE LOCATED INSIDE THE PERIMETER OF JILT OPEN PIT MINES

Mihăilescu, Sorin
Assoc. Prof. Eng. PhD., Department for Machines, Installations and Transportation Means, University of Petroșani, mihaiilescu@gmail.com

Abstract: This paper shows the progression of the testing operations regarding the cutting of different types of clay and lignite in Jilt open pit mines. Based on the laboratory results and by using an analytical methodology, there have been determined in situ the forces that act upon the teeth of the excavator during real time working conditions. The comparison illustrates, both qualitatively and quantitatively, different types of clay and lignite behavior during mining operations by the excavator teeth.

Key words: rotor excavators, cutting operation, different types of clay, lignite

1. GENERAL ASPECTS

Increasing the operating performances of the rotor excavators in operation at lignite open pit mines shall depend, to a great extent, on the efficiency of the displacement due to mechanical cutting, either of lignite or of the sterile rocks overlaying the lignite beds.

On one hand, the results of the comparative analysis are useful to emphasize the behavior to cutting of clays under study and, on the other hand, these results are useful to improve the constructive and the operating parameters of teeth, buckets, the rotor and of the whole cutting – loading system for the rotor excavators used at Jilt E.M.C. These results can make up a scientific base for the future selection of new equipment for mining of sterile rocks and coal in Jilt coalfield.

2. COMPARATIVE STUDY OF THE CHARACTERISTICS DURING THE CUTTING PROCESS OF DIFFERENT TYPES OF CLAYS AND OF LIGNITE

Based on the parameters established for the cutting of different types of clay and lignite, it is possible to carry out a comparative analysis that should underline the efficient average cutting forces, the dynamic coefficients, specific resistances to cutting, the penetration forces, the tearing angle of cuts from the massif, the specific power consumption during the cutting process.

The comparisons were mad by introducing all the results for the same parameter (established for $\alpha$ angle = 50°) in the same diagram. We have chosen this value of 50° because the researches that have been carried out up to now show the beneficial use of this type teeth compared to other types, both from the point of view of the force and power characteristics and from the point of view of the mechanical resistance of this type of teeth. Moreover, this value of $\alpha$ angle = 50° is also supported by the recommendations that can be found in
literature and by the effective parameters of the teeth made by the companies that produce rotor excavators intended to mine lignite and sterile rocks, i.e. values of $\alpha$ angle between 45° and 55°.

The relation of dependence between the average cutting force $F_{xm}$ and the cutting depth $h_0$ is shown in figure 1. One can see that grey clay displays the highest values and the blue clay displays the lowest values. Between these two limits we have marl clay, green clay, sandy clay and lignite in a decreasing order.

![Fig. 1. The effective average cutting force $F_{xm}$ in relation to the cutting depth $h_0$](image1.png)

The dependence of the dynamic coefficient $k_d$, in relation to the cutting depth $h_0$, shown in figure 2. The cutting depth $h_0$ has a lower influence over the dynamic coefficient $k_d$, for all types of clay. It is obviously that the values of the dynamic coefficient $k_d$ for lignite are much higher compared to the ones for different types of clay.

![Fig. 2. The dynamic coefficient $k_d$, in relation to the cutting depth $h_0$](image2.png)

Figure 3 shows the specific strength to cutting $A = f(h_0)$ for different types of clay and lignite. It can be noticed that the highest values correspond to grey clay and the lowest values for blue clay. All the other clays situate within these limits in a decreasing order: marl clay, green clay and sandy clay, the same as at $F_{xm}$. Figure 4 shows the relation of dependence between the specific strength to cutting $A_1 = f(h_0)$ and different types of clays. The order is the same as for the case of $A$ and $F_{xm}$.

The specific strength to cutting $K_e = f(S_0)$ is shown in figure 5. One can notice that this variation is almost constant against the cross section $S_0$ and can take values between 35 and 75 N/cm². The lignite takes values lower than the other types of clay.

Figure 6 shows the breaking angle of cuts $\psi$ in relation to the cutting depth $h_0$ for different types of clay. In this case one can notice that the cutting depth plays a relatively small influence over the breaking angle, $\psi$. The highest values of $\psi$ shall be for the lignite and the grey clay while the lowest values shall be for compact blue clay; in between them there are
the following types of clay in an increasing order: sandy clay, green clay and marl clay.

**Fig. 3.** The relation of dependence between the specific strength to cutting $A$ and the cutting depth $h_0$

**Fig. 4.** The relation of dependence between the specific strength to cutting $A_1$ and the cutting depth $h_0$

**Fig. 5.** The relation of dependence between the specific strength to cutting $K_e$ and the cross section area $S_0$ of the dislodged cut

Figure 7 shows the specific power consumption $E_s = f(h_0)$ for different types of clay and lignite. One can notice that the cutting depth plays a relatively small influence over the specific power consumption for the case of all types of clays under study, but for lignite that decreasing. For the purpose of dislodging by cutting means, the specific power consumption $E_s$ can take values between 0.15 and 0.2 kWh/m$^3$.

Figure 8 shows the relation of dependence between the average value of the penetration force, $F_{ym}$, against the cutting depth $h_0$. Also, the coefficient $k_y = f(h_0)$ shown in figure 9. It is obviously that the values of the penetration force, $F_{ym}$ and the coefficient $k_y$ for lignite are much higher compared to the ones for different types of clay.
**Comparison among different types of clays and lignite**

![Graph](image)

**Fig. 6.** The relation of dependence between the sloping angle $\psi$ and the cutting depths $h_0$

**Comparison among different types of clays and lignite**

![Graph](image)

**Fig. 7.** The relation of dependence between the specific power for cutting, $E_s$, and the cutting depths $h_0$

**Comparison among different types of clays and lignite**

![Graph](image)

**Fig. 8.** The average effective value of the penetration force $F_{ym}$ against the cutting depth $h_0$

**Comparison among different types of clays and lignite**

![Graph](image)

**Fig. 9.** The coefficient $k_y$ in relation to the cutting depth $h_0$
The lateral force $F_{zm}$ and the coefficient $k_z$ in relation to the cutting depth $h_0$ shown in figures 10 and 11.

![Fig. 10. The lateral force $F_{zm}$ in relation to the cutting depth $h_0$.](image1)

![Fig. 11. The coefficient $k_z$ in relation to the cutting depth $h_0$.](image2)

### 4. CONCLUSIONS

We have established the particular features displayed by the different types of clay and lignite from Jilt open pit mines during the cutting process based on the experimental data that had been processed accordingly. The following items have been determined for each case apart: average cutting forces $F_{xm}$, dynamic coefficient $k_d$, the specific strengths to cutting $A$, $A_1$ and $K_e$, the penetration forces $F_{ym}$, coefficient $k_y$, the lateral forces $F_{zm}$, coefficient $k_z$, the breaking angle of the cuts from the massif $\psi$, the specific power consumption during the cutting process $E_s$. Consequently, there resulted families of curves that illustrate with sufficient accuracy the parameters regarding the cutting process of different types of clay and lignite, both from a qualitative point of view and from a quantitative point of view.

The establishment of these parameters helped to carrying out a comparative analysis that pointed out the cutting forces, the specific strengths to cutting, the penetration forces, the breaking angle of the cut from the massif, the specific power consumption during the cutting of different types of clay and of lignite. On one side, this comparative analysis is very useful to show the behavior of sterile rocks and lignite in Jilt coalfield during the cutting process and on the other side it is helpful to improve the constructive parameters of teeth, buckets and of the whole rotor. The comparison among different types of clay illustrates the following decreasing order: grey clay, marl clay, green clay, sandy clay and compact blue clay. By comparing the different types of clay to lignite located in the same area, it results that the former one displays a higher strength to cutting and specific power consumption than lignite.
REFERENCES

[1]. Mihăilescu, S., Praporgescu, G., Analyzing the operation of the extraction system in the E.M.C. Jilt open casts, Annals of the University of Petroșani, Mechanical Engineering, vol. 8, Petroșani, 2006, ISSN 1454-9166
