Analysis of winning performance of shearer loader cutter head using modeling

STELA DINESCU, ANDREI ANDRAS
Department of Machine and Installation
University of Petrosani
Str. Universitatii, nr.20, Petrosani, ROMANIA
dinescudinela@yahoo.com, andrei_24@yahoo.com

Abstract: - The paper deals with the modeling of longwall shearer cutterhead interaction with the coal, in order to study the influence of different limiting factors of the haulage speed, and the cutting regime insuring optimal energy consumption. A computer simulation model is used to draw-up the torque vs haulage speed and the haulage force vs haulage speed dependence diagrams, for different strength of coal and different degree of wear of bits.

Key-Words: - cutterhead, shearer loader, bits, haulage speed, haulage force, torque, coal, energy consumption

1 Cutterhead model

The rock cutting process using shearers (fig.1) is characterized by a special complexity, as a results of the variable structure and strength properties of rocks and, on the other hand, due to the varied and large number of design and operational parameters of cutting tools (bits) and of working parts (cutterheads), fig.2.

Fig.1 Shearer loader

Fig.2 Cutterhead

The wear of the cutting bits has also an important influence on the performance of the shearsers, such as the haulage speed and the absorbed power.

Among the different kinds of shearers the double ended one is the most frequently used rock cutting machine because it provides coal cutting as loading of the separated coal on the scraper conveyor at the same time. The main part of any shearer is the drum. From previous investigations it is known that a type of the bits mounted on the drum, their number and their arrangement highly influence on the winning process.

Shearer performance is determined mainly by the haulage speed which influences the production rate. As it was found, the cutting tool haulage speed influences the shearer working parameters, namely the haulage force, F and the torque about drum axis, M. So, in Figure 3 the conceptual model of the shearer-rock interaction is presented, showing the specific interdependencies between the different parameters involved.

Fig.3 The conceptual model of the shearer-rock inter-action.
2 Analysis of winning performance

In the actual study of winning process, a simple method of cutting parameters assessment has been used [2], according to which the haulage force \( F \) and the torque \( M \) on whole cutter head was determined as resultants of the normal and tangential forces acting on the bits. Thus, imposing the forces and their respective torque on the cutting lines, the authors obtained relations (1) and (2):

\[
F = \left( \frac{N A K_n}{2\pi} \right) \Gamma h_{\text{max}} \quad (1)
\]

\[
M = \left( \frac{N A D}{4\pi} \right) \Phi h_{\text{max}} \quad (2)
\]

where:
- \( N \): the total number of bits on the drum;
- \( A \): the specific cutting force;
- \( h_{\text{max}} \): the maximum depth of cut;
- \( D \): the diameter of drum;
- \( \Gamma, \Phi, K_n \): shape coefficients depending on different geometrical parameters as in Figure 4.

A computer application for the simulation of the working regime of three shearers under specified working conditions has been elaborated based on this model. The authors determined the dependence of the haulage speed on the rock properties and shearers’ parameters taking into account the restrictions of its value by permissible haulage force and torque about drum axis.

![Fig. 4 Scheme of the forces acting on the bit number i (normal, Ni and tangent Ti) and on the drum (haulage force F and torque M)](image)

The calculations were accomplished for two sets of physical–mechanical properties of coal, which represent the presence or absence of hard sphenosyderitis veins in the seam structure and for new and worn bits.

For each set of data we consider maximum and average values of properties, which are specific for the Romanian hard coal seams of Jiu Valley. The problem was to establish which parameter is limiting mainly the advance speed, the maximal available haulage force or the maximal available torque. Three shearers specifications where used, namely KS-3M, KWB-3RDU and 2KS-3.

The author observed on that the obtained reduction of haulage speed results from the restriction by the permissible torque and wear of bits. At the same time it can be observed that the obtained performances of shearer are less that they were expected and correspond to technical specifications for specified conditions, they were been chosen for. The past research showed that “the bottleneck” of the shearers is the bit lacing shape on drums.

So, on the basis of conclusions made by accomplished simulation we proposed a new the scheme of arrangement of the bits on drum for three shearers that the author had studied.

In Figures 5-6, the cutting curves torque \( M \) vs haulage speed \( v_a \) and haulage force \( F \) vs haulage speed \( v_a \) for pure coal, for the new bits respectively are represented.

![Fig. 5 Dependence of torque M on haulage speed, \( v_a \), for soft coal and new bits. 1- KS-3M, 2-KWB-3RDU 3- 2KS-3.](image)

![Fig. 6 Dependence of haulage force F on haulage speed, \( v_a \), for soft coal and new bits 1- KS-3M, 2-KWB-3RDU 3- 2KS-3.](image)
In Figures 7 and 8 the same cutting curves for coal with hard veins are represented. The indexes: 1, 2, 3 refers to the three different types of shearer.

In case of hard coal with veins, the limited speed by the allowable torque decrease to 0.25, 0.22 and 0.21, four times. The maximal speed from haulage force limitation became also smaller, i.e. 0.65, 0.65 and 0.7, so the reserve is smaller.

In the case of worn bits, the limiting factors i.e. the torque and haulage force, act quasi equally, both for soft coal and hard coal, the limit values from the two criteria being quit similar.

Regarding the specific energy consumption, the comparison is given in the Table 1.

It can be noticed that from energy consumption point of view the shearer no. 1 is the most convenient, and the coal hardness affect more the energy consumption that the bit wear.
3 Conclusion

The increase of possible haulage speed and the reduction of the influence of the wear of the bits on the haulage speed have been achieved by this research.

Using the elaborated computer application it is possible to estimate the performances of the shearsers in specified working conditions much realistic then through the classical calculation methods.

References: