Methodology of coal losses calculation at open pit mining for complex geological conditions - review

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At present, industry documents and methods of coal losses regulation take into account only mining in simple conditions: the coal seam has a constant incidence angle and thickness. However, there is no method of coal losses regulation in difficult conditions, in particular in mining coal seams in tectonically disturbed zones. For deposits having hard conditions of stratification, the creation of this technique is a very urgent task. This article proves the necessity for the creation of this document. Some results of calculating the coal losses at mining by backhoes in disjunctive dislocations areas are also given in this article. Technological schemes of coal seams mining in the areas of dislocations are proposed.

Key words: *hard-structural coal deposits, the loss of coal, open pit mining, backhoes, coal producing, environment, technology*

Introduction

To calculate the loss in the preparation of the project, it is difficult to produce a comprehensive assessment of geological conditions. Therefore, it is necessary to develop specific recommendations or algorithm to easily assess the impact on the loss of certain tectonic disturbances and their degree of importance. Losses in mining zones of tectonic disturbances associated with different factors and take different values. Thus, for example, the displacement amplitude at disjunctive violations is significantly affected by losses. Considering the fact that during the surface mining development open pits have been deepening (Lokhanov et al., 1967; Hrehova, Cehlar et al., 2012; Hummel, 2012; Kuznetsov et al., 1997; Mattis et al., 2012; Molotilov et al., 2009; Oparin et al., 2012; Prokopenko, 2014; Scott et al., 2010; Zhironkin et al., 2016) and deal with complicated geological and hydro-geological conditions (Tyulenev, Zhironkin et al., 2016), the methodological problem of coal losses minimization come in force.

A wide range of papers (Bereznyak et al., 1970; Cheskidov et al., 2014; Demirel, 2011; Nazarov, 2011; Tanaino and Cheskidov, 1999; Vukotic et al., 2013; Tyulenev, Gvozdkova et al., 2016) is devoted to using draglines for overburden removing and coal extracting work; however, draglines' technological parameters do not allow using them for coal beds' roof stripping with minimal losses.

On the other hand, the technical characteristics of backhoes (Tyulenev et al., 2016; Prakash et al., 2013; Matushenko, 1975) allow negligible quantity in the contouring of the coal seam, since these losses are small and are formed by a rough surface formation.

If we consider the loss of the roof and soil of the coal seam, then they will also be produced for the following reasons: the rough surface of overburden rock and coal seam contact and low sensitivity of rock contact (Che and Yang, 2010; Demirel and Frimpong, 2009). When stripping the seam's roof due to the contact's surface irregularities and coal stripping technology imperfections in some areas may remain overburden interbeds (rock pieces), which were later taken out with coal and polluted. A special feature of the hydraulic excavator is the maximum force at any height digging, so the driver does not feel rock contact and may undercut the coal seam.

Similar problems arise when stripping the soil of the seam. Nevertheless, the loss layer's height is much less than with using a rope shovels. The experience of a full-scale study of mining operations on Kuzbass open pits in the areas of disjunctive dislocations occurs multiple "crushing", "bending" of the seam, which leads to an intense admixture of rocks in the coal.

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Some theoretical statements of coal losses calculation using backhoes were given by Kuzbass scholars (Tyulenev, Zhironkin & Garina, 2016).

Used methods

In any case, the development of the classification is very difficult to evaluate all geological conditions, accounting the effect of which would make possible to reduce this process to a typical calculation. Therefore, we assume that the general criterion for assessing the level of losses of coal will be the total length of the contact rock and coal within a stope (panel). This is due to the fact that the main source of losses in the development of complicated coal seams by hydraulic excavators is a rock and coal contact, because other sources of waste in comparison with the work of shovels, in particular, non-digging triangles, will be excluded. However, even in this case, it seems to us very difficult to unify the development environment as bedding options, such as synclinal folds, can vary considerably. For example, it can change the incidence angle of the fold's wings, the width of its joint, the structure (simple or complex seam), etc. In this regard, we attempt to determine the loss of coal under difficult conditions, only relying on the change of basic parameters.

For example, consider the area of the "Volkovsky" seam, complicated by disjunctive dislocation, in a quarry field of "Kedrovsky" open pit mine on the exploration line XIVb (Fig. 1).

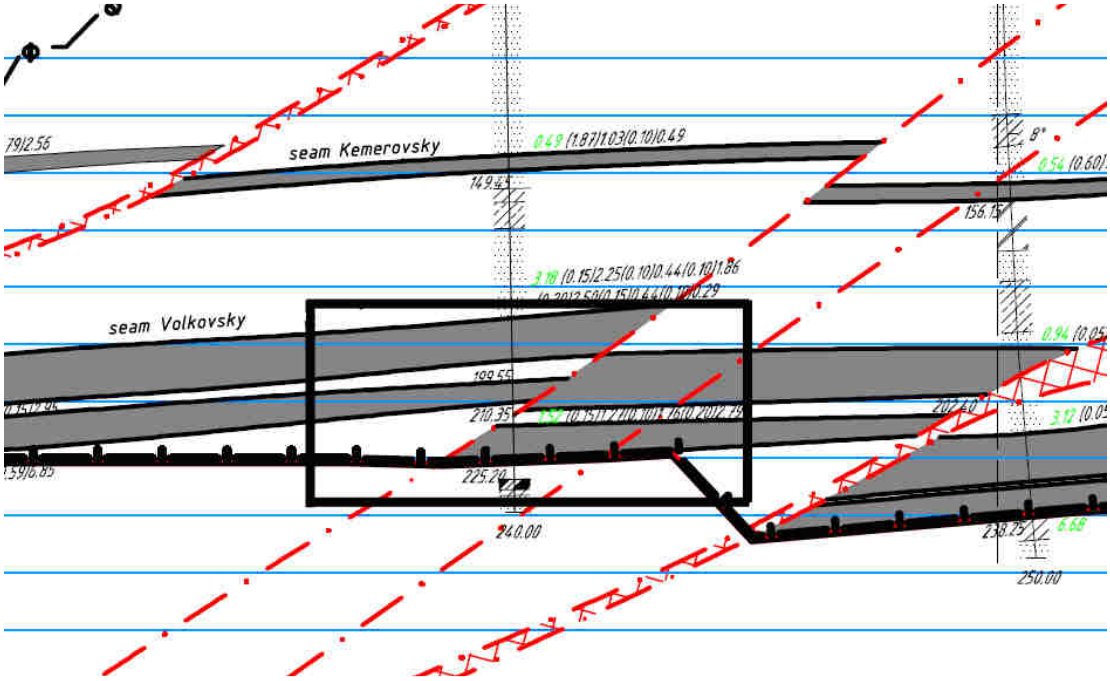

Fig. 1. Typical geological section of faulted seam.

Technological schemes of the stages of mining are shown in Fig. 2-6. This area is a rock-and-coal zone. The main equipment for the mining is a backhoe.

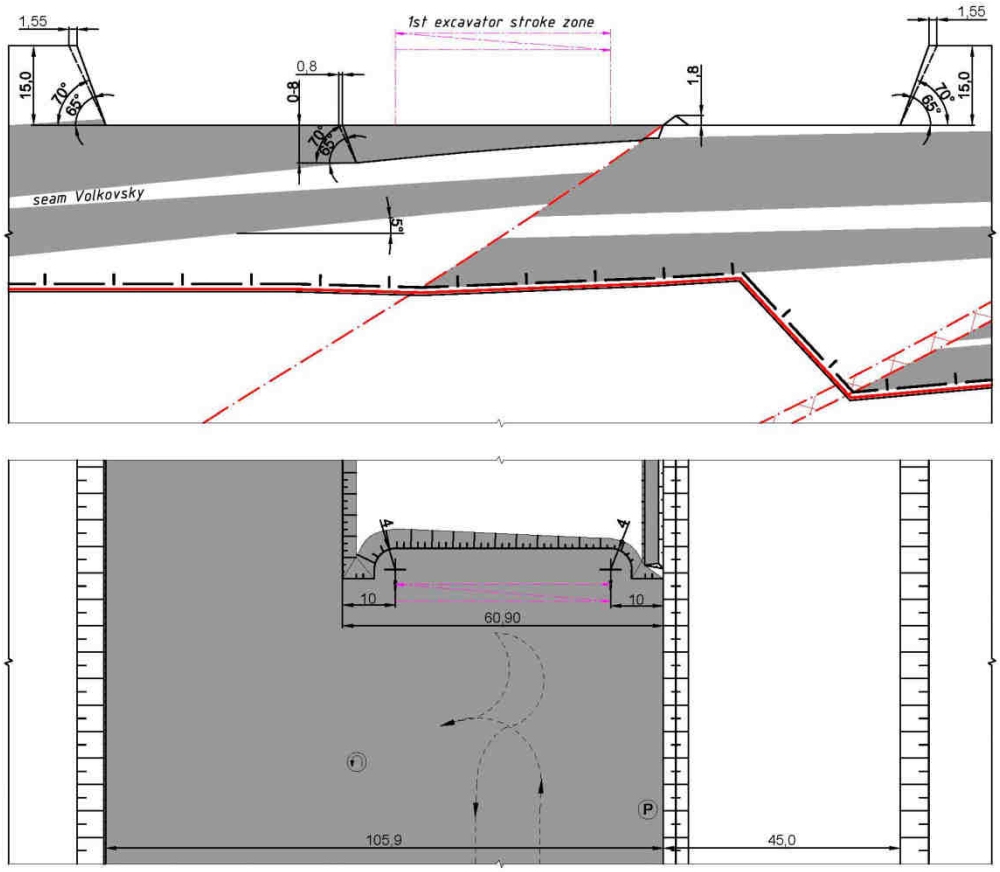

Fig. 2. Working out the upper level of the faulted coal seam.

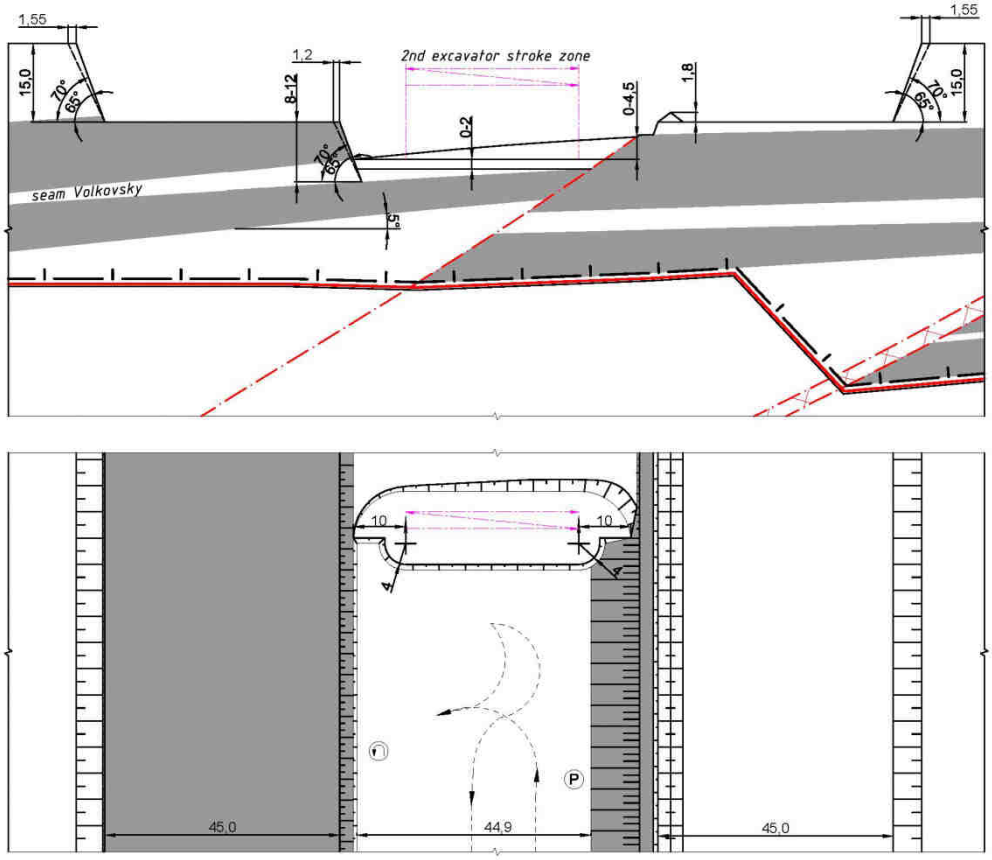

Fig. 3. Working out the 1st (upper) layer of inter-burden.

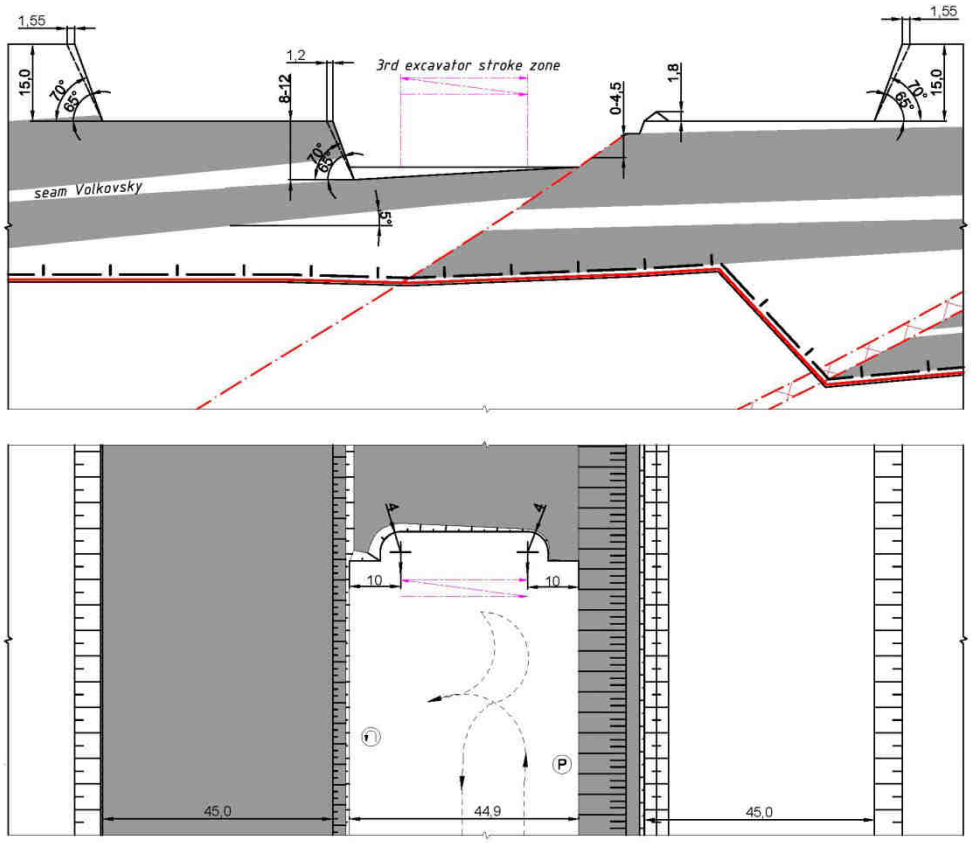

Fig. 4. Working out the 2nd (lower) layer of inter-burden.

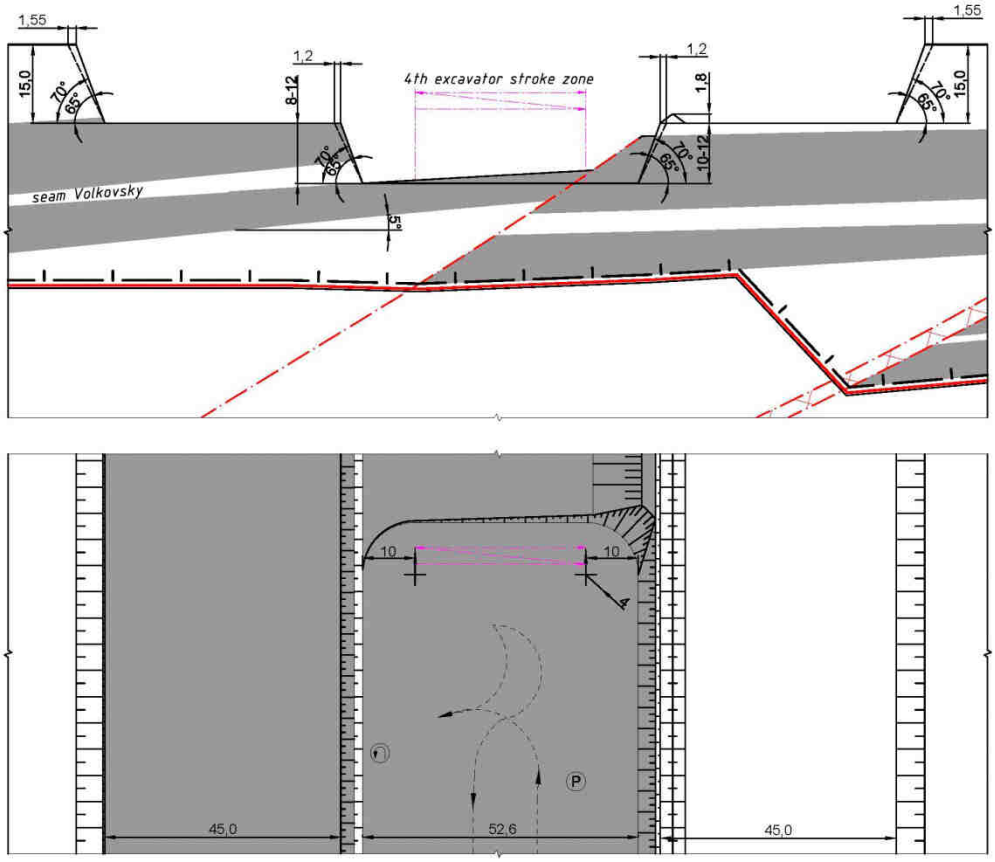

Fig. 5. Working out the bench floor's upper layer of the coal seam.

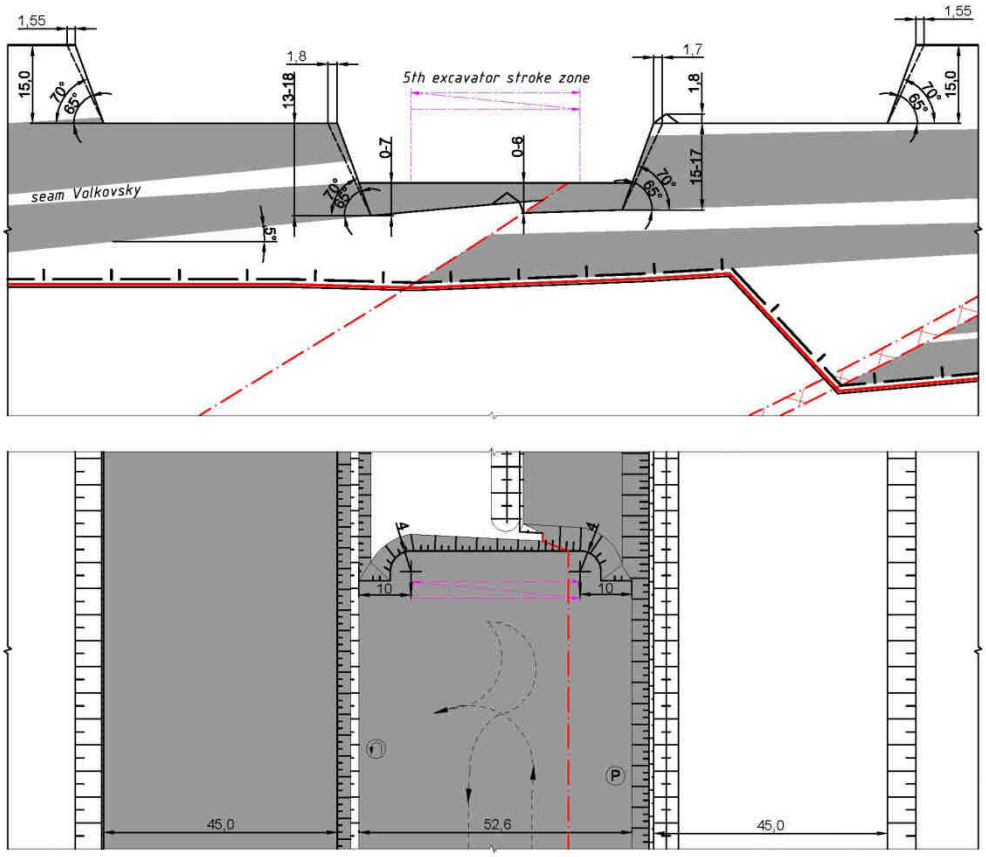

Fig. 6. Working out the bench floor's lower layer of the coal seam.

Results and discussion

It is logical to assume that the definition of the area (and volume) of coal for subsequent calculations will be reduced only to the current conditions in a particular area. Change of all seam parameters can give an unlimited number of calculation options, so for varying parameter has been accepted a seam thickness, because in real conditions this area is just characterised by unevenness of the seam's thickness. Working out of the panel carried up by layers height to 5 m.

Graphical interpretation of the results is shown in Fig. 7.

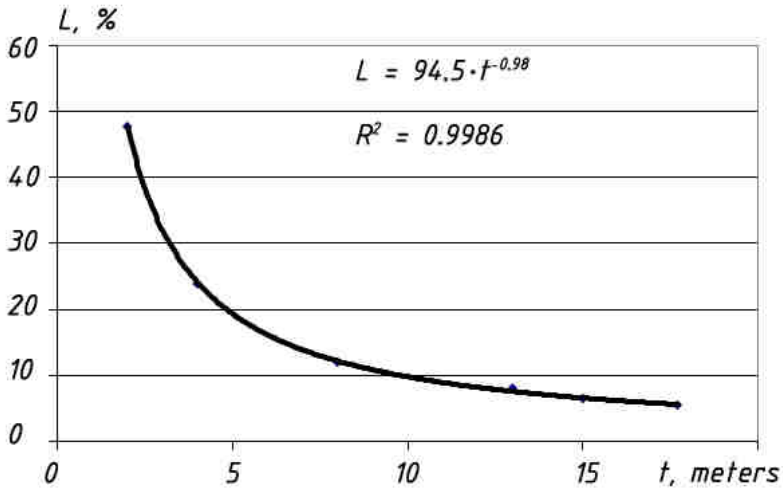

Fig. 7. The dependence of the coal losses from the seam thickness.

Conclusion

The analysis of the Fig. 7 allows us to conclude the following:

1. When seam thickness in areas of faulting is less than 6-7 m, then a sharp jump in the level of losses occurs, reaching up to 50% at the seam thickness of 2 m. Consequently, the priority in the preparation of quarries design should be given to technology of coal seams' mining in zones of faults.
2. The main factor affecting the level of losses in the fault coal seam is the length of the rock-and-coal contact within worked of the panel (stope); other factors include type of disturbance (plicative, disjunctive) and its parameters, as well as the parameters of the coal seam (thickness) and the type of equipment used.
3. Coal losses have inverse power dependence of the seam thickness in the area of disjunctive faulting; the R^2 correlation coefficient is more than 0.99, indicating the high accuracy of the results.
4. It is necessary to develop a unified methodology for calculating losses of coal under a challenging environment at the various types of equipment, followed by its implementation as an industry document.

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