Theoretical Features of Rope Shovels and Hydraulic Backhoes Using at Open Pit Mines

Andrew Strelnikov[1,*], *Sergey* Markov[2] , *Ludger* Rattmann[3], and *Dieter* Weber[4]

[1]CJSC Stroyservice, 650055 Kemerovo, 121 Kuznetsky Avenue, Russian Federation
[2]T.F. Gorbachev Kuzbass State Technical University, Surveying and Geology Department, 650000 Kemerovo, 28 Vesennya st., Russian Federation
[3]Technische Hochschule Georg Agricola (THGA), Bochum, Germany
[4]Czech Technical University in Prague, 166 36 Zikova 1903/4, Praha, Czech Republic

Abstract. Open coal mining companies in Kuzbass (Western Siberia, Russia) constantly face challenges to increase the economic efficiency of mining operations, reduce coal losses and increase profitability. One of the ways to increase the efficiency of open pit mining is to improve the technology for the development of coal-bearing zones of quarry fields on complex structured inclined and steep deposits. At present, the projects for promising deposits have been completed, and a number of operating open pits conduct the development of coal-bearing zones along their entire width by horizontal layers. The excavating and loading equipment for overburden and mining operations in these zones is diverse: quarry rope shovels, hydraulic backhoes or their joint work. When they work together in the coal-bearing zone, the rope shovels extracts the interbeds, and the hydraulic backhoes extract the coal seams. However, such technical solutions are not sufficiently substantiated. The fact is that rope shovels and hydraulic backhoes have their advantages and disadvantages in operating.

1 Introduction

When deciding on the choice of equipment, it is necessary to take into account the factor of constructive and technological features of rope shovels and hydraulic backhoes because many projects pay not enough attention to the maximum use of excavators' working parameters. Consequently these features are especially important in the conditions of excavating equipment operation in the coal-bearing zone.

2 Materials and Methods

The following research methods are used in the work: analysis of mining operations on surface mines; analysis and synthesis of scientific research and technological development results; statistical method for processing the results of observations [1].

* Corresponding author: a.strelnikov@stroyservice.ru

The study of the international experience of open pit mining operations conducting, with attraction of foreign producers, investors, companies' owners, led to the massive introduction of hydraulic backhoes into the open mining operations of Kuzbass [2]. The reason of the hydraulic backhoes preference, as it seems to us, was a natural desire to modernize existing technologies, to bring them to the global practice.

But at the same time, a careful analysis of mining and geological conditions in which the purchased excavator was supposed to operate, was often not carried out. This led to frequent breakdowns of hydraulic backhoes, technological downtimes, etc. [3]

It should be noted that the mining and geological conditions of the Kuznetsk Coal Basin (Kuzbass) are among the most complex in the world. The coal seams have various thicknesses and dip angles, numerous plicative and disjunctive dislocations, high watering, etc. In the world practice, there are almost no such conditions for open pit coal mining anywhere [4-6], Figure 1.

To some extent, such complexity of coal deposits development by quarrying is compensated by a wide branded composition of extracted coal, including the most expensive brands.

3 Results and Discussion

Detailed qualitative analysis of rope shovels and hydraulic backhoes special features is given in Table 1.

Table 1. Qualitative analysis of technological possibilities and constructive features of rope shovels and hydraulic backhoes.

Hydraulic backhoes		**Rope shovels**	
Advantages	**Shortages**	**Advantages**	**Shortages**
1. Excavator's weight			
Constructers tend to weight decreasing to improve maneuverability	Low weight and less endurance decrease durability in the hard working conditions	Durable and substantial construction provides long time of working in the hard conditions	Heavy metal construction
2. Mobility and independence			
Small in size and light in weight, with a self-propelled diesel engine, quickly move	–	–	Heavy machines powered by electric cables have low mobility
3. Digging force			
High digging forces are created at the bottom of the face	High digging forces are created at the top of the face	High digging forces are constant along the face	–
4. Use of caterpillars to increase bucket filling			
–	Limited boom stroke requires a caterpillar to be regularly used to perform an efficient digging cycle	The excavator can perform a large number of digging cycles before moving	–

5. The order of layers' development	
It is able to remove rocks from the top to the bottom and from the bottom upwards, enabling the selective excavation of rocks and coal	It removes rock layers only from the bottom up, which makes it difficult to selectively develop rocks and coal in the face
6. Excavator dimensions	
Can work in close faces, characteristic of the coal-bearing zone	The dimensions of the face are large, providing high-performance in the coal-less zone
7. Life period	
Excavators are designed with the tendency to "recycling and replacement" with new higher capital investments. Service life is 7-8 years.	The excavator is easily upgraded. Has a service life of 2-3 times more than hydraulic.

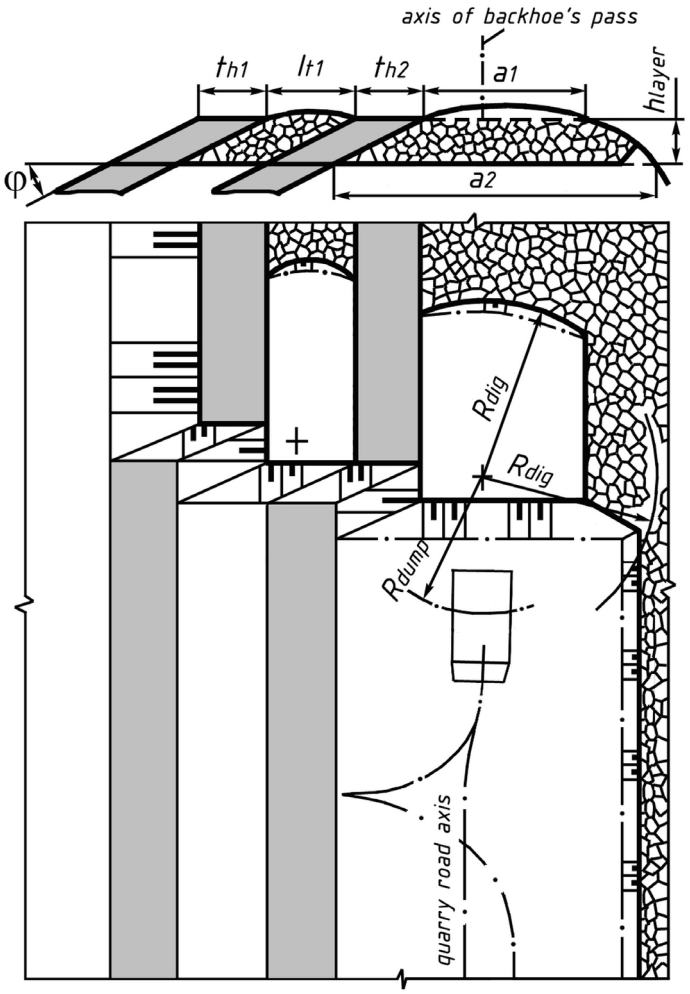

Fig. 1. Technological scheme of hydraulic backhoe use in the coal-bearing zone.

Thus, the priority application of hydraulic excavators has been established. Lightweight, mobile, independent of power supply lines, they have the possibility of selective upward

and downwars digging, hydraulic backhoes are more suitable for the coal seams excavating in the coal-bearing zones. The rope shovel, steadily operating at low temperatures, heavy, with a sturdy construction, provides durability of work, stable and high-performance working on blasted overburden rock in a coal-less zones and on the thick interbeds in a coal-bearing zone.

Hydraulic backhoes, due to their short life and high capital investment, should work in a gentle mode and carry out strictly specific types of work in, if possible, minimum volumes. These types of work are associated with the excavation of the coal seams. All stripping operations in large volumes should be carried out with rope shovels [7].

Analysis of the technology for of coal-bearing zones development in the quarry fields with inclined and steep deposits showed that at present they are being developed layer by layer with two or three steps. This is the unity of the technological solution of the design organizations.

At the same time, there is a wide range of decisions on the use of excavating equipment, despite the certain similarity of mining and geological conditions. For the development of rock interbeds and coal seams, design organizations have adopted the following options for axcavating and loading equipment for coal-bearing zones development [8-9]:

- rope shovels for excavation of interbeds and coal seams;
- rope shovels and hydraulic shovels for excavation of interbeds and coal seams;
- rope shovels for interbeds excavation and hydraulic backhoes for excavation of coal seams;
- hydraulic backhoes and shovels for excavating interbeds and coal seams.

With the accumulated experience of using rope shovels and hydraulic shovels, hydraulic backhoes, the advantages and disadvantages of these machines are clearly revealed:

- rope shovels, with a sturdy construction, ensure the durability of the work, work stably and highly efficiently on the blasted hard rock at low operating costs;
- hydraulic backhoes – light, mobile, have the possibility of selective excavation of the coal in the face, which provides a lower level of coal losses than for interbeds. The also have a limited working life poor maintainability, associated mainly with hydraulic systems.

4 Conclusion

Thus, according to the types of excavators listed in this article, a field of rational application by types of work has been defined. The various adopted design solutions suggest that, firstly, the areas of application of rope and hydraulic shovels and hydraulic backhoes are not always taken into account. Secondly, due to the obvious availability of rational areas, there are no scientific recommendations on the optimal ratio of the volumes of rock mass performed by rope shovels and hydraulic backhoes.

Further, for hydraulic backhoes, there is no system and principles for the formation of structures for conducting mining operations in conditions of close or dispersed bedding of coal seams in the strata.

This circumstance complicates the choice of a rational technological scheme for certain type of equipment.

Therefore, for further development in this direction, two major scientific tasks can be distinguished:

- to establish the types of work and the structure of technological schemes for hydraulic backhoes;
- to establish a rational value of the volume of rock mass, excavated by hydraulic backhoes when working out the coal-bearing zones.

References

1. N. Demirel, O. Gölbası, Minerals, **6:2**, 51 (2016)
2. T. Gvozdkova, S. Markov, N. Demirel, S. Anyona, E3S Web of Conferences **21**, 01024 (2017)
3. B.L. Gerike, Soviet Mining Science **27(2)**, 114-118 (1991)
4. V. Selyukov, Journal of Mining Science, 51:5, 879-887 (2015)
5. M. Tyulenev, O. Litvin, M. Cehlár, S. Zhironkin, M. Gasanov, Acta Montanistica Slovaca, **22:3**, 296-302 (2017)
6. O. Litvin, M. Tyulenev, S. Zhironkin, S. Prokopenko, Acta Montanistica Slovaca, **22:2**, 146-152 (2017)
7. M. Tyulenev, S. Zhironkin, E. Tyuleneva, A. Abay, S. Anyona, M. Hellmer, Coal International, **265:3**, 30-34 (2017)
8. V. L. Martyanov, Journal of Mining and Geotechnical Engineering, **1**, 35-41 (2018) DOI: 10.26730/2618-7434-2018-1-35-41
9. A. V. Katsubin, E. V. Makridin, Journal of Mining and Geotechnical Engineering, **1**, 81-88 (2018) DOI: 10.26730/2618-7434-2018-1-81-88