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V. N. ZAKHAROV[1], *Director, Corresponding Member of the Russian Academy of Sciences*
V. Yu. LINNIK[2], *Professor of Chair, Doctor of Economic Sciences, vy_linnik@guu.ru*
Yu. N. LINNIK[2], *Professor of Chair, Doctor of Engineering Sciences*
E. A. AVERIN[3], *Engineer-Designer, Candidate of Engineering Sciences,*

[1] *Institute of Integrated Mineral Development – IPKON, Russian Academy of Sciences, Moscow, Russia*
[2] *Federal state educational institution of the higher-education "State University of Management, Moscow, Russia*
[3] *Skuratovskiy opytno-ehksperimental'nyy zavod LLC, Tula, Russia*

LOADING OF COAL MINING MACHINE TOOLS AFTER CHANGE IN SPATIAL ORIENTATION OF PICKS

The parameters of the cutters and their spatial orientation relative to the end of the blade of the screw Executive body have a significant impact on the power and energy performance of coal-mining combines. In the designs of the Executive bodies of combines, both domestic and foreign, equipped with tangential cutters cutting edge of the latter is located above the surface of the blade end. With such a spatial orientation of the cutter for certain values of the flow velocities, which are maximum permissible for the particular design of the harvester, the clearance between the end of the blade and the bottom becomes commensurate with the broken chunks of coal, and they are getting there begin to crush. The crushing process is accompanied by the consumption of additional energy. At the same time, the energy intensity of cutting increases and the grade of coal deteriorates. In this regard, studies were carried out to identify the extent to which the spatial orientation of the cutter affects the power and energy parameters of the cutting process. The studies were conducted with tangential prismatic (not rotary) cutters and compared with the results of cutting with radial cutters. In experiments with tangential cutters, the angle of inclination relative to the cutting plane and the angle of rotation relative to the cutting speed vector were changed. It was found that at cutting radial blades for cutting forces and feed is optimum for small values of angle of inclination of the cutter 8–12°, and the lateral component of the load on the cutter from the unloaded array with increasing angle of inclination decreases, and the opposite — increasing. When cutting with tangential cutters, there is also a minimum of effort in the area of the turning angle of about 12°, which corresponds to the angle of inclination of the cutter 6 degrees. In this case, there is a complete balancing of lateral loads to the right and left of the cutter at a relatively low absolute level. Due to the reduction of coal overdrawing, the energy consumption of cutting has decreased and the yield of large coal (+40 mm) has increased significantly.

Key words: *cutter, executive body, coal face, spatial orientation, cutting forces, energy intensity, coal grade.*
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Introduction

The energy strategy of coal industry development in Russia requires tailoring the determination of coal mining equipment parameters in transition to highly productive technologies of longwall mining. For the first turn, the requirements concern with cutting tools of coal mining machines. Drum picks directly contacts coal and rock mass. The joint and, specifically, dynamic loads formed as a result generally lead to unpredictable failure of cutting tool. Conformity of the drum parameters with specific mining conditions governs the whole longwall productivity for the drum as an initial ling in the technological chain of coal mining determines efficiency of cutter–loaders.

The influence of change in the spatial orientation of cutting pick in the cutting efficiency, as well as on the force and energy performance of coal mining machines is understudied. The research works of the Russian scientists give recommendations on turning tangential rotary pick in order to intensify their rotation [1–3]. Some procedures on determination of loads on picks are presented in [4–7]. The foreign approaches concerning this question are described in [8–16].

Main part

Shearer loaders most widely used in underground mining have their cutter picks oriented relative to the blades of the drum so that the cutting edge is above the face. Given such orientation, the rock–blade face distance l_3 reduces as the shearer loader feed grows (**Fig. 1**).

At certain maximum allowable feeds of a specific shearer loader design, the value of l_3 becomes commensurable with cut coal fragments. As a consequence, the latter are over-crushed in-between the blade face and rock mass. Crushing consumes extra energy. Energy input of cutting increases while quality of coal sizing worsens.

For the sequential circuit of cutting by the most domestic drum, it is typical that cuttings have pronounced asymmetry section. Thus, it is necessary to fin optimal parameters for space orientation of cutter picks. To this end, benchmark tests of load on radial and tangential picks were

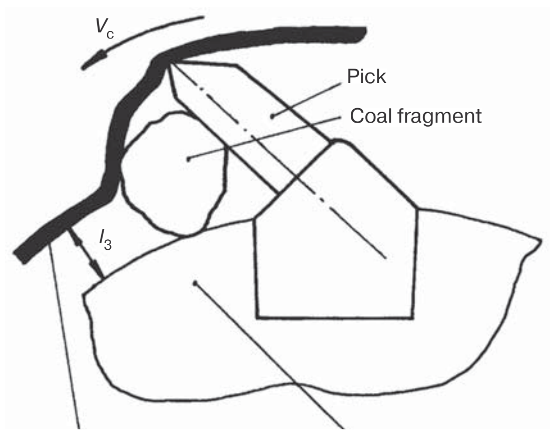

Fig. 1. Cutting and over-crushing of coal

Table 1. Loads on pick in case of its different orientation

Installation angle, deg β_t	β_i	$\overline{Z}$, kN	$\overline{Y}$, kN	$K_r = \overline{y}/\overline{Z}$	$\overline{X}_r$, kN	$\overline{X}_l$, kN	$K_{s.l.} = \frac{\overline{X}_п - \overline{X}_л}{\overline{Z}}$
Radial pick							
0	-30	3.67	4.67	1.27	4.42	0	1,2
0	-22	3.02	2.58	0.85	1.96	0	0.65
0	-15	3.03	2.37	0.76	1.91	0	0.63
0	-10	2.88	1.90	0.66	1.37	0	0.48
0	-7	2.60	1.63	0.63	1.10	0	0.42
0	-5	2.68	1.74	0.65	1.08	0	0.40
0	-3	2.64	1.53	0.58	1.06	0	0.40
0	0	2.68	1.63	0.69	0.85	0	0.36
0	4	2.50	1.62	0.65	0.92	0	0.37
0	8	2.35	1.57	0.67	0.72	0	0.30
0	12	2.30	1.49	0.65	0.63	0.32	0.23
0	16	2.82	1.76	0.62	0.70	0.11	0.23
0	20	2.88	1.93	0.67	0.42	0.17	0.10
0	29	2.91	2.26	0.78	0.22	0.32	0.04
Tangential pick							
0	0	2.19	1.44	0.66	0.59	0	0.28
4	1	2.02	1.28	0.63	0.53	0	0.26
8	3	2.12	1.14	0.54	0.44	0.07	0.18
12	6	1.77	1.06	0.60	0.35	0.12	0.13
16	11	1.92	1.18	0.61	0.41	0.26	0.08
30	24	3.34	1.66	0.50	0.03	0.88	-0.25

Table 2. Coal size in cutting by pick IT-125S

Coal size grades, mm	Coal yield (%) at pick turn angle, deg				
	0	4	8	12	16
+40	15.7	24,6	27.0	28.0	31.0
20–40	21.6	20.1	22.4	17.9	18.4
6–20	31.8	29.4	26.8	27.7	26.4
–6	30.9	25.9	23.8	26.4	24.2

carried out. The test procedures were as follows. Cutting of a coal-and-cement block was performed on a surface-planing machine, at the cuttings 2 cm thick and 5 cm wide. Amplified signals from load gage were sent to computer for interpretation and printing conversationally and synchronously with the tests.

The pick orientation in the cutting tests is shown in **Fig. 2**.

In case of a radial pick, its incline β_i to the cutting plane was only varied from –30 to +30° (positive values—incline toward the subsequent pick—as a rule, toward to loading end of the drum). In cutting with a tangential pick with the chisel-type edge, in order to avoid interaction of side face with rocks, each value of the incline β_l should be fitted with a certain angle of turn β_t relative to cutting velocity vector V_c. For this reason, in the tests, the inclined tangential pick was turned by the pre-calculated angle β_t. The cut length was always not less than 2 m. In average, 5 cuts were made.

The experimental results are compiled in **Table 1**.

Fig. 3 gives plots of average cutting force, feed, side load, coefficient K_l and incline angle β_i for radial picks.

Conclusion

The analysis of the obtained data yield some conclusions listed below.

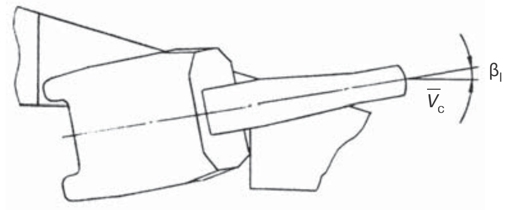

Fig. 2. Orientation pick relative to the drum blade face

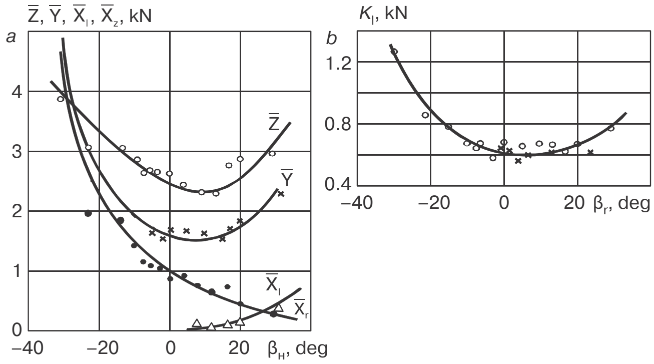

Fig. 3. Cutting force $\overline{Z}$, feed $\overline{Y}$, side load $\overline{X}_r$, $\overline{X}_l$ (*a*) and coefficient K_l (*b*) versus radial pick incline in the cutting plane

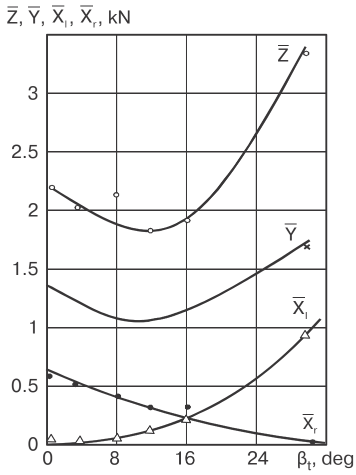

Fig. 4. Cutting force, feed, side load and turn angle β_t of tangential pick relative to the cutting velocity vector

1. The cutting force and feed are optimal at the incline β_i = 8–12°.

2. The side load on the pick on the side of unloaded rock mass lowers along a hyperbola with an increase in β_i while it grows on the opposite side starting from +5°. When the angle β_i is negative from 0° to –22°, the ratio is 0.4–0.65 and grows to 1.2 at β_i = –30°. In the range of optimal values, the ratio $K_{s.l.}$ reduces to 0.6–0.7.

3. In the range of the optimal β_l, the ratio of the average cutting force and feed as well as their maximum values Z_{max} and Y_{max}, respectively, are lower by 15–22% than beyond the optimum.

The variation coefficients ν_z, ν_y and ν_x decrease as the average loads grow.

Figure 4 shows the curves of average cutting force, feed, side load, coefficient K_l and incline angle β_t for tangential prismatic pick.

As in the previous case, the forces have a pronounced minimum at $\beta_t \approx 12°$ which corresponds to the incline $\beta_i \approx 6°$.

It is important that in the optimum zone, the side loads from the right and left are in total balance at the comparatively low absolute level.

Cutting mode was stabilized. The found optimum of loading conforms with the minimum energy input and, as follows from Table 2, with an essential increase in the yield of coarse coal (+40 mm).

The obtained results should be used in designing new shearer drums for graded coal production.

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