Investigation of stiffness of drilling flight of roller-bit drilling mill RBDM-250

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Abstract
The problem of rise of increased dynamic loads on mechanical and electromechanical equipment of roller-bit drilling mills of RBDM-250 type, used during open-pit mining of ore deposits, is considered. It is found that the reason is elastic vibrations of drilling flight. For this purpose investigations of

influence on drilling flight both single crippling load and together with dynamic centrifugal force, arising in consequence of bend of rotating flight, are conducted. Test methodologies for bending stiffness for both cases are stated, corresponding calculation formulas and results are given. The results are also presented in the form of dependence curves of total load and crippling load on the length of drilling force. Curve analysis allows to maintain that for the borehole with the length not more than 24 m, elastic vibrations of the flight are not connected with the loss of bending stability of the last.
Key words: ROLLER-BIT DRILLING MILL OF BLAST BOREHOLES RBDM-250, BENDING STABILITY OF DRILLING FLIGHT OF THE MILL

Exploitation of mills of roller-bit drilling is characterized by increased vibrational loads on their equipment, the reason for which are elastic vibrations of drilling flight [1]. Some authors connect this fact with the loss of bending stability of drilling flight [1, 2]. To check these statements, we conducted investigations of drilling flight of the mill RBDM-250 for stability both under the action of single crippling load and under its action together with dynamic centrifugal force at Kryvyi Rih National University.

In the first case we found ultimate loads of compession P_{ult} for calculation of compression bars for stability according to Euler formula [3]:

$$P_{ult}=\frac{\pi^2 E J_{sec}}{(\mu l)^2} \quad (1)$$

Where E - plastic modulus of bar material , Pa; J_{sec} – bar second area moment, m^4; l – bar length, m; μ – index considering grip conditions of drilling flight (fig.1).

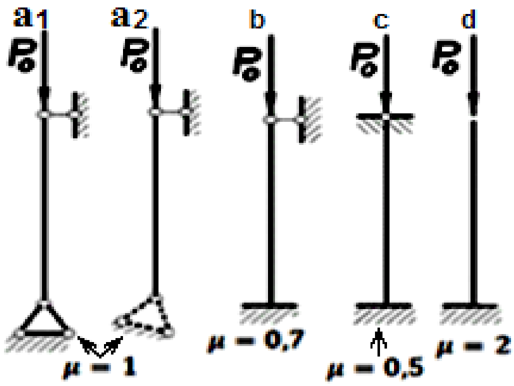

Figure 1. Values of coefficients of gripping of drilling flight ends:

a_1, a_2 – flight top with vertical displacement of the butt end, lower end is swinging joint with obstruction; b – top end, the same as a_1, a_2, lower end – anchorage; c- top end is swinging joint with obstruction, lower end is the same as b; d – top end is free , lower end is anchorage.

Table 1 gives calculation parameters of critical values of crippling load. Obtained data shows that not only for heavy thickwalled drill steels with the diameter from 200 to 215 mm (in Krivbass with the help of such drill steels there drilled boreholes with the depth up to 24 m in the rocks of different hardness and with maximum axial force P_o on the drilling flight up to 250 kN), but also for more light-weight ones with the diameter 180 mm (not lower P_o does not exceed 250 kN) there is no problem of stability loss, because $P_o<P_{ult.}$

Taking into account dynamic centrifugal force arising during rotation of drilling flight with bent axle, its bent increases [4], which leads to increase of equivalent critical force P_Σ, which in its turn may be calculated according to the following formula:

$$P_\Sigma = P_o + 0{,}076\,\frac{q\omega^2 l^2}{g} \quad (2)$$

where the second summand is dynamic component of the loss of drilling flight stability; q – rotating mass (proper mass intensity), kg; g= 9.81 m/s^2 – gravitational acceleration; ω – rotational speed of drilling flight, rad/s; l– length of drilling flight, m. Changing the values of parameters q,ω and l, it is possible to set regularities of change of equivalent critical force P_Σ.

Equation (2) was solved in a graphical manner with the help of Mathcad. The results of calculations for heavy drill steels Ø 219(215)×51.5mm in the form of dependence graphs of total load and crippling load on the length of drilling flight are presented in the fig. 2. We may see that the point *1* of cross of the cur-

Table 1. Calculation values of critical crippling load P_{ult}

No	Demensions of drilling steels ($Ø_{out} \times S_{walls}$), mm	P_{ult}, kN Index, considering the anchorage of drilling flight $\mu = 1$ Length of drilling flight l, m		
		8	16	24
1	215×51,5	7811.236	1952.810	867.916
2	203×50	6257.325	1564.330	695.261
3	203×38	5674.882	1418.719	630.542
4	203×28	4858.778	1214.690	539.862
5	203×22	4179.305	1044.820	464.370
6	200×50	5919.404	1479.847	657.709
7	200×36	5254.709	1313.679	583.857
8	200×25	4316.232	1079.059	479.581
9	180×35	3564.862	891.217	396.099
10	180×25	3015.542	753.887	335.064
11	180×16.5	2299.931	574.980	255.552

ve P_{ult} with P_{Σ}≈310 nN characterizes the regime of loss of bend stability of drilling flight with the length l=25 m. This will happen when advancing the fourth 8-meter drilling steel, but in Krivbass there not used flights of such length (32 m). There is no loss of bend stability when length is l=24 m (point 2).

Obtained data allows to maintain that in conditions of flight drilling, consisting not more than 3 8-meter drilling steels, vibration of borer RBDM-250, the reason of which are elastic vibrations of the flight, are not connected with the loss of bend stability of the last.

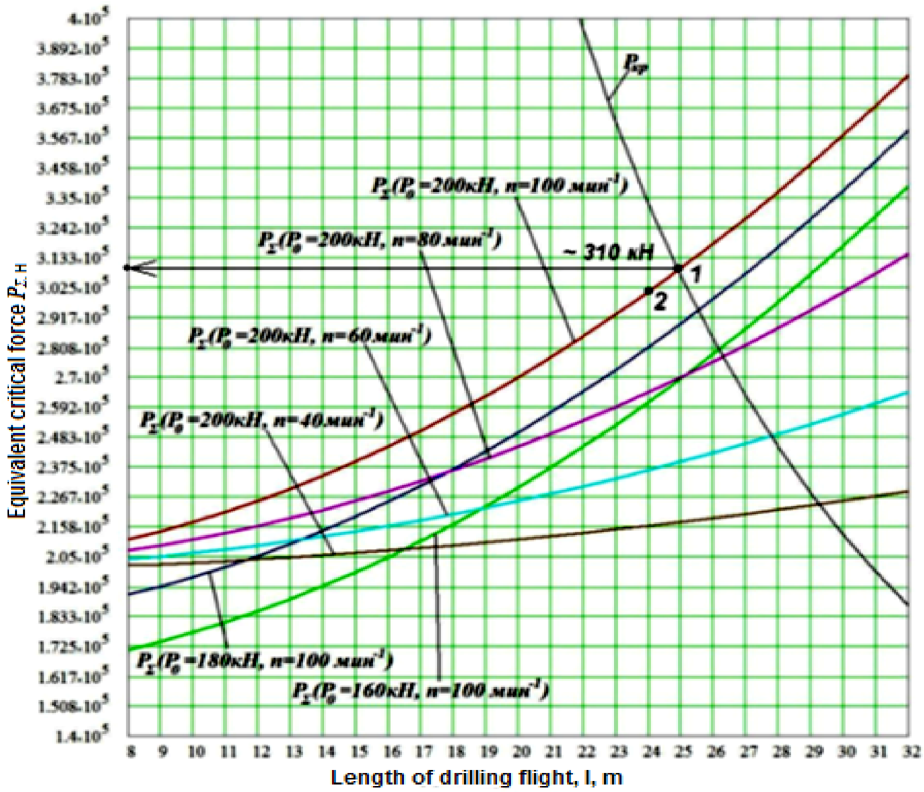

Figure 2. To the determination of critical lengths of drilling flights consisting of heavy drilling steels Ø 219(215)×51.5 mm, taking into account combined action of axial force and centrifugal force as the consequence of bend axis of the flight.

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UDC 622.27

The research of strain-stress state of magnetite quartzite deposit massif in the condition of mine “Gigant-Gliboka” of central iron ore enrichment works (CGOK)

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