UDC 622.233.6

A.S. GROMADSKYI, Doctor of Science (Engineering), Professor, Kryvyi Rih National University, Ukraine
V.A. GROMADSKYI, PhD (Engineering), Associate Professor, Kryvyi Rih National University, Ukraine
Vik.A. GROMADSKYI, PhD (Engineering), Associate Professor, Kryvyi Rih National University, Ukraine

ENERGY SAVING IN MINING BY USING RATIONAL OPERATING REGIME OF ROLLER-BIT DRILLING MILLS

At the mining enterprises of Ukraine one of the most common methods of drilling mechanization is using a roller-bit drilling mills. As it is known that operation of roller-bit drilling mills is followed by the equipment increased vibration, which affects negatively its longevity, increases energy consumption and deterioration of working conditions of the operating personnel [1, 2].

During the research of vibration of the drilling rig and increasing energy costs amplitude of oscillations of the drill rods was simulated. Oscillation of the drill rods 16 m in length (Ø215×51.5 mm) was simulated in the Solidworks environment using the FFEPlus application.

Calculations showed that at a resonant frequency of the first mode (in round figures, 1.885 Hz on axes x and y) rotations of a drilling flight with number of turns n=113 min^{-1}, vibration amplitude a_1 had to reach 171 mm in the center of a drilling flight. However, due to restriction of vibrations resonant amplitude by bore hole walls, the rod of drilling flight starts scraping on the bore hole wall by the external surface in the vibratory-percussion mode, and not only on the first mode, but also on the second one with a frequency of 7.5 Hz and amplitude of 21.7 mm that also exceeds the available gap S=14.75 mm between a bore hole wall and rod. Such mode causes extreme dynamic loads on the rig equipment and as a result of increased energy consumption.

The evaluation actual of energy consumption when drilling is conducted on the RBDM-250MNA-32 rig (Ore Mining and Pro-

cessing Industrial Complex "Ukr-mekhanobr", Kryvyi Rih) in three modes: subresonance, at drilling flight resonance when bore hole gumming. The feeding pressure, drilling flight rotation number, values of voltage and rotator flow were fixed from the display in the operator cab. From the evaluation, it is seen that in the resonance mode, the energy consumption increased from 23.3 to 31.2 kW, i.e. by 34% in comparison with the subresonance mode. In order to reduce the vibration of the drilling rig, the bore hole was gummed (it is filled with a dense abrasive slurry). In this case, energy consumption increased from 31.2 to 35.5 kW, which is by 18% more in comparison with the resonance mode.

The investigation of drilling rate and energy consumption at various drilling regimes was conducted also in the conditions of Ingulets GOK on the RBDM-250A mill No 87 (drilling by two heavy rods of Ø215×51.5 mm in the rock with a strength of 16-18 according to M. M. Protodyakonov scale with drilling flight feeding pressure of 220 kN). Previously, considering wear and actual rods sizes, modeling of natural vibrations and amplitude of resonant vibrations was carried out, therefore the following numbers of rotations are determined: *a*) - subresonance mode n_{subr}=100 min^{-1}; *b* - resonance mode - loss of vibration resistance n_{res}=115 min^{-1}; *c* - superresonance - nominal detuning from the resonance mode n_{super}=130 min^{-1}.

At drilling rate determination, depending on the drilling modes, this parameter was registered after the second rod adding in order to avoid the errors because of the bottom hole top layer, which is partially destroyed after the previous blast. Drilling time along the length of the second bar of 8m was determined, and then, the drilling rate and specific energy consumption were calculated. Dependences of drilling speed and power consumption on operating mode of RBDM-250A mill are 38,4 kw in 100 min^{-1}, 46,3 kw in 115 min^{-1} and 43,6 kw in 130 min^{-1}. From these dependences, it is seen that the energy consumption increases in the resonance mode by 20.5%, and the drilling rate decreases by 4% in comparison with the usual drilling mode.

The energy consumption decreases by 7% in comparison with the resonance mode on a frequency of detuning by increase in rotations number. Thus, the drilling rate increases by 15.5%. Specific energy consumption and drilling rates of the rig are 2.4 kW·h/l·m. of bore hole for Subresonance mode, 3,0 kW·h/l·m of bore hole for Resonance mode and 2,4 kW·h/l·m. of bore hole for Superresonance mode. It is seen that specific energy depending on the drilling modes.

Specific energy consumption increases considerably (by 25%) in the resonant mode (from 2.4 to 3 kW·h/l·m of bore hole). Specific energy consumption in the superresonance drilling mode is reduced to the value of the superresonance mode. However, the superresonance drilling mode is more rational in comparison with subresonance one. In this mode, the drilling rate increases by 11% in comparison with subresonance mode.

To summarize one of the way to reduce energy costs for drilling blastholes is using rational operating regime of roller-bit drilling mills. The drilling modes by heavy rods of the flight length of L_f =16 m with number of turns n=125-130 min^{-1} at standard axial feeding pressure of drilling flight P_0=200-220 kN provide the minimum specific energy consumption of 2.4 kW·h/l·m of bore hole, maximum drilling rate v_d=18 m/h and the absence of vibration rigidity loss of drilling flight, extreme loads on the equipment and operator workplace.

References

1. **Marasonov Yu.P.** (1972) Elastic vibrations of a drilling flight when deviating hole making with roller-cone bit. Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal. ("Journal of higher educational institutions. Mining journal"). Moscow, № 2, p.p. 132-140

2. **Saroyan A.E.**(1979) Buril'nye kolonny v glubokom burenii. [Drill columns in the deep-drilling]. Moscow, Nedra,