PROMISING PNEUMATIC PUNCHERS FOR BOREHOLE DRILLING

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The state of borehole drilling by downhole pneumatic punchers and their potential use in open and underground mining as well as in exploration for reliable sampling are analyzed. Performance specification is presented for the new-generation pneumatic punchers equipped with a pin tool, effectively operating at a compressed-air pressure of 0.5…0.7 MPa, and with an additional extended exhaust from the power stroke chamber during working cycle.

Drilling method, downhole pneumatic puncher, drilling energy intensity, impact capacity, impact energy

Borehole drilling by downhole pneumatic percussion machines or pneumatic punchers is a progressive method [1]. The downhole pneumatic punchers ensured that up-to-date technologies of ore and other mineral mining have become realizable, especially underground. The Institute of Mining, Siberian Branch, Russian Academy of Sciences, has come to the forefront in the development of air percussion drilling method since its inception [1]. At that time, abroad, rod drilling was in progress due to application of high-strength drill steel unavailable in Russia. However, in the 1960s, the downhole pneumatic punchers have become in use in the foreign practice of blasthole drilling, as mining enterprises needed deeper boreholes of larger diameter. At present, all developed countries in the world produce and employ the machinery discussed.

Speaking of engineering performance standard, technical potentials, and application of the downhole pneumatic punchers, their main functional parameters are the energy and impact frequency. The impact capacity, the other conditions being the same, depends only on working pressure of the energy-carrier (compressed air). But the predominant parameter necessary for the effective operation is the unit impact energy. Its values are designed based on the operational reliability of the machine and tool in order that energy intensity of rock failure is minimal.

Based on the data obtained in long-term testing of prototype and commercially produced domestic and foreign downhole pneumatic punchers, it has been established that energy intensity of drilling depends on the specific energy of impact, type of the tool (edge, pin), system of bottom hole cleaning, and scheme of the bottom loading.

It is seen from Fig. 1 that the energy intensity considerably decreases as the specific energy increases. Consequently, a priority-driven trend for this method development is the design of the high-energy downhole pneumatic punchers with a pin tool.


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The downhole pneumatic punchers, commercially produced in Russia, had been designed in the Institute of Mining, Siberian Branch, Russian Academy of Sciences, in the beginning of the 1980s and were as good as the foreign analogues. They were intended to operate at a compressed-air pressure of 0.5 MPa and with an edge rock-failing tool. When the up-to-date pin tool designed later came in use with the pneumatic punchers in question, it appeared mostly to be low effective, while its advantages over the edge tool have been proved by the world experience. To make a pneumatic puncher equipped with a pin tool operate efficiently, it is required to raise impact energy at least by a factor of 2-3. At the compressed-air pressure of 1.8–2.4 MPa, it is feasible to reach high impact energy with a specified dimension-type of the pneumatic puncher. Besides, the performance parameters of air percussion drilling such as drilling velocity, machine service life, rock-failing tool durability, which increase almost proportionally to the compressed-air pressure rise, may become considerably better. At the air pressure of 0.5 MPa even a double increase in the impact energy is complicated, especially in the existing systems of underground mining in iron-ore deposits.

Drilling equipment (downhole pneumatic puncher PP110 (M48), NKR-100MP) that have been put into operation since the 1970s up to now is applied for drilling a bundle of parallel boreholes for block breaking. This was an advanced technology in mining upper levels. In the current situation, mining is conducted on deeper levels, and the working schemes with ore breaking into compensation chambers and cavities are complicated by higher rock pressure. Intensive deformations take place in the massif, drilled boreholes fail and are lost, which causes extra expenditures of up to 50 % for re-drilling with worse quality of crushing. Moreover, due to short sharpening-to-sharpening durability of a drill tool, up to 50 % of operating time is spent for trips. This decreases shift productivity, whereas industrial authorities press for rising the shift productivity by a factor of 1.5–2 without change in working conditions of the pneumatic puncher and in scheme of block drilling-off. Foreign drilling equipment is unfit for mines where block — level mining systems are applied, since it is inconsistent with the parameters of drilling rooms.

It seems that the way out is to reduce the time of the block drilling-off by means of:
— transfer from the borehole diameter of 110 mm to 130 mm that is maximal permissible value with respect to available technical potential of the up-to-date drill flit (NKR-100MP); the equivalent drilling time is expected to be reduced by nearly 30%.