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Research into robotic automation of drilling equipment by the Institute of Mining, UB RAS

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Abstract. The article discusses the issues connected with the development of instrumentation for the express-determination of strength characteristics of rocks during blasthole drilling in open pit mines. The trial results of the instrumentation are reported in terms of the drilling rate–energy content interrelation determined in the analyses of experimental drilling block data and by the digital model of rock distribution in depth versus drilling complexity index.

The main modern trends in improvement of open pit mining processes for the period to 2025–30 include partial robotic automation and remote control. Regarding drilling of blastholes, the improvements can be achieved by solving a key problem connected with automation of drilling control, based on express-analysis of physical properties of rocks.

The Institute of Mining, UB RAS, is engaged in R&D on design of the instrumentation for the express-information on strength characteristics of rocks [1].

The instrumentation is based on the theory that the torque generated by the drill rig rotator motor is proportional in value to the strength and resistance of rocks to be overcome by the rotator gear. On this basis, the rock strength criterion can be the value of the rotator motor torque and the power consumed by removal of drill cuttings from hole.

Thus, keeping the data on rock mass strength current is based on the knowledge of power spent by the drill rig motors in drilling.

Designed jointly by the Institute of Mining and Avtomatika Science and Production Association), a dedicated set of instrumentation is placed on an operator's board. During drilling, special sensors record electrical parameters of drill rig motors. Electrical signals of the sensors are converted into a digital model of rock mass areas having different strength characteristics.

The instrumentation set has been trialed in blasthole drilling by drill rig SBSH-250MNA-32 in open pit mines of Uralasbest. As a result, the instrumentation has offered a huge data base on energy content of drilling in rocks of different petrographic composition.

In particular, according to the analysis of data on drilling block 1, energy consumed per 1 m-long drilling is 3–4 kW·h, energy consumed by removal of drill cuttings from the hole is to 0.5 kW·h and auxiliary operations consume round 1 kW·h of energy. The fluctuations in the energy content are governed by the external influence, including faulting and facial nonuniformity. At the same time, the data interpretation shows that the block compose of rocks having the same average strength (category VII–XII with drilling energy content to 2 kW·h/m) has a pocket composed of stronger rocks (diorite, drilling energy content higher than 2 kW·h/m). The presence of this pocket has been proved after blasting when the pocket appears undamaged (Figure 1).

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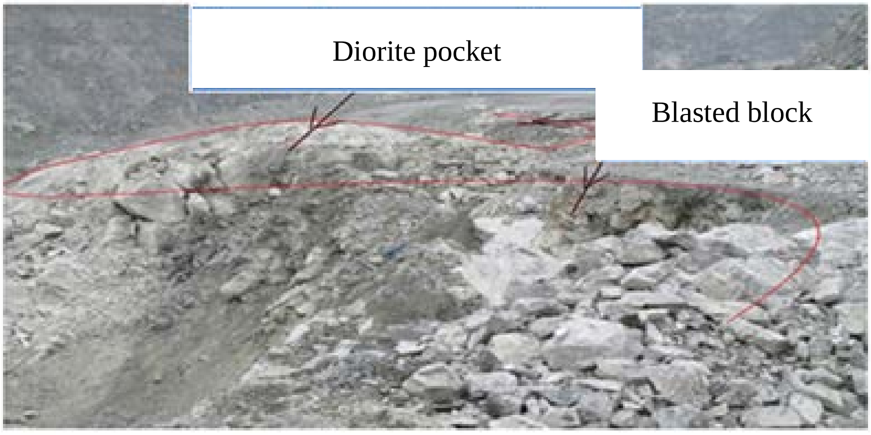

Figure 1. Block 1 after blasting with an unshattered diorite pocket.

Furthermore, the trial results allow finding comparatively tight correlation between the drilling energy content *e* and the drilling rate *v* for rock of different strength (Figure 2). The correlation can be approximated as:

$$v = 15.6e^{0.255}.$$

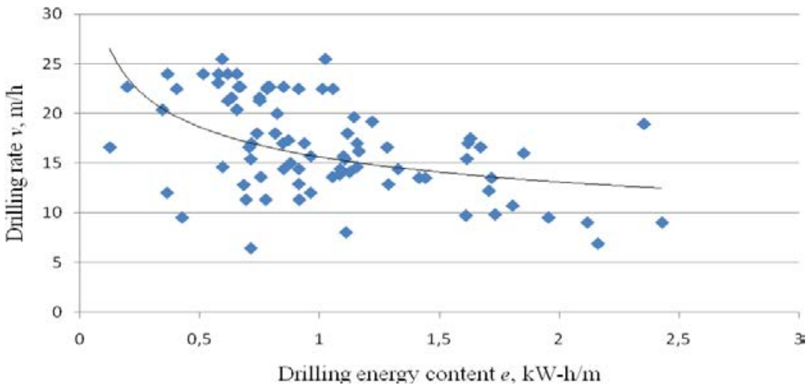

Figure 2. Drilling energy content–drilling rate curve.

It is seen in Figure 2 that the energy content of drilling lowers with the higher drilling rate. Thus, this is where the practical significance of the found correlation lies: in drilling different petrographic varieties using the same drill bit, it is possible to cut-down energy consumption by 1.5–2.0 times through the change of the drilling rate.

By expressing rock strength in terms of a drilling complexity index Π_6, based on the data on energy consumption, it is possible to visualize distribution of strength characteristics in rock mass by constructing a plane model (Figure 3).

With such model and based on the data on power consumed by the drill rig motors, a rock mass can be zoned by categories of drillability and blastability, which means that it is possible to adjust drilling mode and blasting design for each separate hole.

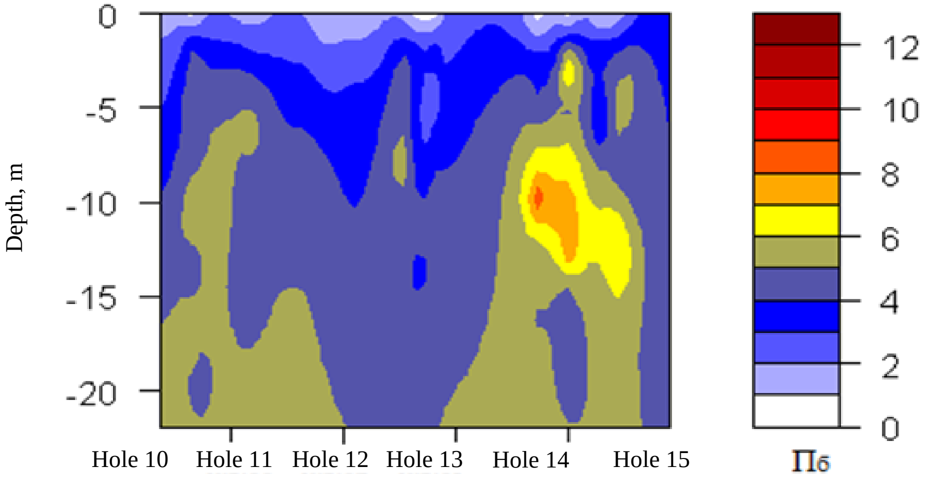

Figure 3. Model of rock strength distribution per depth by the drilling complexity index Π_6 by Rzhevsky.

Conclusions

1. Availability of promptly refined and adjusted data on strength characteristics of rocks allows applying energy saving modes of drilling, efficient size drilling equipment and optimized drilling pattern.

2. The designed software/hardware for the on-line determination of varying strength characteristics in rocks allows optimization of blast designs as early as the project stage, improvement of fragmentation quality and cutting down the drilling and blasting cost 1.2–1.3 times.

Acknowledgments

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References

[1] Regotunov AS and Antonov VA 2015 Regressive modeling of experimental crystalline rocks break-down by rock burst *Problemy nedropolzovaniya* No 2 pp 3745 (in Russian)