The Establishment of the Hydraulic Structure Optimal Size in the Conditions of Underground Kimberlite Mines

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Abstract. The article is devoted to the establishment of the hydraulic structures optimal size in underground kimberlite mines. According to the results of parametric tests, the authors obtained a mathematical formula that allows with a high degree of accuracy to calculate the optimal dimensions of the clarifying tanks and water tanks in terms of settling mine water for the needs of the underground kimberlite mines of the Russian Federation.

1. Introduction
A characteristic feature of the sectional pumps used in the systems of the main, district and auxiliary drainage of underground kimberlite mines of the Russian Federation is the low durability of their units and parts (Table 1).

Table 1. Information about the mean time between failures of sectional pumps for drainage units of underground kimberlite mines in the Russian Federation.

| The location of the pumping equipment | Mean time between failures of pumping equipment (h) |
|--------------------------------------|-----------------------------------------------|
| Drainage units of the “Mir” underground kimberlite mine | ≈ 500 |
| Drainage units of the “Udachny” underground kimberlite mine | ≈ 300 |
| Drainage units of the underground “Internacionalny” kimberlite mine | ≈ 700 |

Practice shows that the occurrence of frequent failures of various pumping equipment, including sectional pumps, is explained by the influence on them during the operation of a number of destabilizing factors of different kind [1-20].

These negative factors include a high concentration in pumped out mine waters of solid particles, close contact with which leads to premature failure of parts of the flow part of the pumping equipment existing at underground kimberlite mines due to their active hydroabrasive wear (Fig. 1) [1, 2, 3].
Figure 1. Consequences of a short contact of the disk of hydraulic balancing unit of a sectional pump JSH-200 of the company “Mackley Pumps” with polluted mine water.

Surveys of workers responsible for the mine drainage of the underground kimberlite mines of the Russian Federation indicate that the main reason for the high pollution of pumped mine water is their low efficiency of settling in existing clarifying tanks and water collectors. One of the obvious reasons for the low efficiency of settling of mine water in these underground hydraulic structures is their insufficiently chosen dimensions.

2. Methods and materials
As a toolkit for establishing the optimal size of the clarifying tanks and water collectors of drainage installations of underground kimberlite mines of the Russian Federation, methods of mathematical statistics were used.

3. Results and discussion
The studies conducted by the authors indicate that in the conditions of the underground kimberlite mines of the Russian Federation, the weighted average frequency of cleaning the water tanks T of various drainage installations from sludge strongly correlates with the weighted average level of filling; working depth h (Fig. 2).

Figure 2. Experimental dependence \( T = f(h) \) and its approximation by a linear trend.
Since the frequency of cleaning underground hydraulic structures from sludge and the effectiveness of settling mine water in them are interrelated processes, it can be openly said that the effectiveness of settling mine water increases when the working depth of the brightening tank or sump decreases.

Based on the foregoing, we conclude that when calculating the optimal dimensions of the lightening tanks and catchment basins, it is necessary first of all to focus on their working depth.

As is known, the following mathematical formula is used for calculating the working volume \( V \) of the brightening tanks and catchment basins [3]:

\[
V = Qt
\]  
(1)

where \( Q \) – water inflow; \( t \) – time of deposition of solid particles.

Through studies of the physical properties of mine water taken from the lightening tanks of the main drainage plant at the Udachny underground kimberlite mine, a linear regression equation was derived that allows calculating the deposition time \( t \) of most of the solid particles depending on the working depth \( h \) of the underground hydraulic structure with a high degree of accuracy (Fig. 3) [3].

![Figure 3](image-url)  
**Figure 3.** Experimental dependence \( t = f (h) \) and its approximation by a linear trend.

The derived linear regression equation is universal in terms of use, since the physical characteristics of mine water, pumped out from various underground kimberlite mines in the Russian Federation (particle size distribution of solid particles), affect the sedimentation rate of solid particles.

After combining expression (1) and the linear regression equation (see Fig. 2) together, the authors obtained a mathematical formula that allows calculating optimal sizes of clarifying reservoirs and water tanks with a high degree of confidence in terms of settling mine waters for the needs of underground kimberlite mines of the Russian Federation.

\[
V = Q \left( \frac{H}{0.2363} - 0.1147 \right)
\]  
(2)

4. **Conclusion**

According to the results of the research conducted by the authors, one of the possible ways to reduce the rate of hydroabrasive wear of parts and units of sectional pumps used in the drainage units of the underground kimberlite mines of the Russian Federation was proposed and sufficiently substantiated.

5. **References**

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