Device for maintaining the nominal operating modes of the section pump of a mine district drainage system in conditions of intensive silting of water reservoirs

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Abstract. This paper presents in detail a device that allows you to maintain the nominal operating modes of centrifugal section pumps in real time. The practical implementation of this device will reduce the risk of failure of a centrifugal section pump mounted on a mine district drainage plant by constantly maintaining the nominal pressure in its suction pipe, which reduces the risk of the rotor critical axial shift.

1. Introduction
Drainage is an integral technological process in the extraction of various mineral raw materials, including diamond-containing. Its role in mines and underground mines may increase markedly over time, so a decrease in mining operations is usually accompanied by the growth of the rock mass water cut.

Practice shows that a high concentration of mechanical impurities that are a part of mine water usually leads not only to intensive hydroabrasive wear of section pump parts mounted in drainage systems of Russian underground mines, but also to premature silting of water reservoirs, especially with regard to district drainage. As can be seen (table 1), the silting of the water reservoirs of the local drainage system can be several times more intense than the silting of the water reservoirs of the auxiliary drainage systems [1-6].

Table 1. Weighted average frequency of drainage cleaning of underground kimberlite mines in the Russian Federation.

| Name of the drainage system                      | Frequency, days |
|-------------------------------------------------|-----------------|
| UTS-650 district drainage system, “Udachny”     | 30              |
| underground kimberlite mine                      |                 |
| UTS-310 district drainage system, “Mir”          | 21              |
| underground kimberlite mine                      |                 |
| VNS-210 auxiliary drainage system, “Mir”         | 150             |
| underground kimberlite mine                      |                 |
Abundant silting of the water reservoir can lead to a significant pressure drop in the suction pipe of the section pump, which in the future, due to the design features of the latter, can contribute to its transition to emergency operation, which should be understood as the operation of the pump during a rotor critical shift [1, 5].

Even the short operation of a section pump with a rotor critical shift of the can lead to catastrophic destruction of its basic parts (figure 1).

Figure 1. Unacceptable destruction of the impeller of a section pump.

Thus, it is clear that the fight against the effects of silting of mine drainage water reservoirs is an urgent scientific and practical task, since its solution will increase the operational reliability of section pumps, which are the most common type of centrifugal pumps in underground mining of mineral deposits, in particular kimberlite ores.

Of course, a number of well-known methods are currently used to limit the operation of section pumps of the district drainage of kimberlite mines in emergency conditions. Usually, to limit the operation of section pumps of a mine drainage system in emergency conditions, their suction pipelines are equipped with winches, with the help of which the depth of the pipeline is lowered into the silting water reservoir (figure 2) [3].

Figure 2. Section pump of the ZNS 180-200 model, pump station UNS-380, kimberlite mine Mir, “ALROSA” company.
Practice shows that the main drawback of this technical solution is the fact that the regulation of the depth of the lowering of the pipeline is carried out manually by the workers of the mechanical energy sector, i.e., not in real time. In other words, in case of emergency, the operational control of the depth of the pipeline lowering is not always possible, for example, in the case of shift change.

The authors have developed a technical device that allows you to maintain the nominal operating modes of section pumps in real time to solve this problem [7].

A patent of the Russian Federation for utility model No. 136600 “Automated control system for the pumping complex” was obtained for the construction of this technical solution.

2. Materials and methods
The basic laws of hydromechanics and automatic regulation of the operating parameters of machines and mechanisms were used as tools for developing a device that allows maintaining the nominal operating conditions of section pumps of district mine drainage systems under conditions of intensive siltation of water reservoirs.

3. The results of the study and their analysis
The design of the developed technical solution is shown in detail in figure 3. The central link in the technical solution is a programmable logic controller - hereinafter referred to as the PLC (position 8), which stores the program that provides the logic of the automated system. The PLC basic module from the input device - pressure sensor (item 6) installed on the discharge pipe (position 18) receives signals that are interpreted and converted into the required format and transmitted to the central processor (CP) of the controller, which due to certain written commands allows you to control the output devices - three solenoid valves (positions 3-5).

The necessary set of commands is written and edited using a personal computer, after which they are written into the controller itself.

Figure 3. Automated control system for pumping equipment: 1 - pump; 2 - balancing valve; 3, 4, 5 - electromagnetic valves; 6 - pressure sensor; 7 - portable compressor installation; 8 - PLC; 9 - stock; 10 - a piston; 11 - a nut; 12, 13 - washers; 14 - spring; 15, 16, 17 - rubber products; 18 - discharge pipe.
As a pressure sensor, a two-contact signaling manometer is used, operating on the principle of short circuit—short circuit. The signaling manometer ensures that a group of contacts is triggered for the lower and upper adjusted limits, in case of an arrow moving beyond a threshold value.

As the lower limit we use the value of pressure deviating from the nominal by −5%, and as the upper limit we use the value of pressure deviating from the nominal by +5%.

When the nominal pressure decreases by more than 5%, a short circuit of electrical circuit occurs, the final result of which is the opening of two solenoid valves (positions 3, 4).

When these valves are opened, compressed air from the portable compressor unit (position 7) enters the working cavity of the balancing valve integrated in the discharge pipe of the section pump — a throttling device (position 2), which leads to the progressive movement of the piston (position 10).

The tightness of the balancing valve is ensured by three rubber products (positions 15–17).

When the current pressure is stabilized to a lower threshold value, the solenoid valves are closed.

If the nominal pressure rises by more than 5%, only the electromagnetic valve (position 5) opens, which is responsible for the release of compressed air from the working cavity, which will ensure the reverse movement of the stock (position 9) with the piston by straightening the shock spring (position 14).

When the current pressure is stabilized to the upper threshold value, the electromagnetic valve is closed.

Continuous maintenance of the nominal pressure at the outlet, and, accordingly, at the inlet to the section pump within −5% ... + 5% of the nominal value, will entail a reduction in the risk of its emergency operation.

4. Conclusion

The paper has presented in detail the technical device, which makes it possible to maintain the nominal operating modes of section pumps in real time. Its practical implementation will reduce the risk of failure of the section pump of the mine section drainage system by constantly maintaining the nominal pressure in its suction pipe, which reduces the risk of the rotor critical axial shift.

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