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OPERATION EXPERIENCE OF CENTRIFUGAL SINGLE-STAGE PUMPS IN «ALROSA» JOINT STOCK COMPANY

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When mining diamond-bearing raw materials and further extracting diamonds from it in the joint-stock company ALROSA, which is a city-forming enterprise in the north-east of the Russian Federation, various pumping equipment is used, in particular, centrifugal single-stage pumps. In the present work, it is noted that the least reliable in terms of absence of failures of centrifugal single-stage pumps used in the joint-stock company ALROSA are the impellers, seals and bearing assemblies. Using linear correlation and regression analysis, it was found that the durability of the seals and bearing assemblies of the investigated pumps largely depends on the durability of their impellers. In the course of research, it was found that unbalancing the pump rotor due to excessive hydroabrasive wear of the impeller also leads to deformation and fracture of the shaft. In general, residual deformations and destructions are characteristic of the shafts of domestic pulp pumps of GrAT, GrT and Gr types. The most loaded sections of shafts of centrifugal single-stage pumps are installed. The most effective from the point of view of application among the pulp (ground, slurry and sand) pumps are pulp pumps of the Finnish company «Metso». When working on highly mineralized water (brines), the «X» type pumps have proven to be the best among centrifugal single-stage pumps.
Key words: ALROSA; centrifugal single-stage pumps; wear; durability; impeller; vibration; shaft.

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Introduction. In the joint-stock company ALROSA, both for the extraction of diamond-containing raw materials and the further extraction of diamonds from it, both centrifugal multistage (sectional) pumps and centrifugal single-stage pumps are used. The latter should be understood as two-way inlet pumps (hereinafter referred to as «D» pumps) and cantilever pumps of various significance – pulp and chemical pumps (hereinafter referred to as «X» pumps).

At the mining and ore-dressing facilities of the joint-stock company ALROSA, centrifugal single-stage pumps (see table) are used to transport various natural liquids, namely: mineral slurries, brines and process water [4, 7].

The investigated single-stage centrifugal pumps of the joint-stock company ALROSA

Model of pumping equipment	Place of pumping equipment operation
Model of pumps KETO-F6131P-A05A, KETO-FAP14/12G-G и 12NDc	Seasonal processing plants JSC «Diamonds Anabara» (SPP)
Model of pumps Gr 600-65	Processing plant number 3, Mirny MCC (PP № 3)
Model of pumps Metso MM-150, Metso MM-200, Metso NM-200 и SPV 365-SP5	Processing plant number 16, Nyurbinskiy MCC (PP № 16)
Model of pumps GrAT 1800-67, 1GrT 1600-50, GR 600-65, GrAT 350-40, GrAT 225-67, Metso NM-100, Metso NM-200, Metso Vasa HD 507-150 и KETO-FAP 50A-C	Concentration plant number 12, Udachninsky MCC (PP № 12)
Model of pumps 12NDc	Workshop of tailing facility, Udachninsky MCC (WTF)
Model of pumps 1D630-90 и 1D500-63	Underground kimberlite mine «Mir»
Model of pumps X200-150-500	Underground kimberlite mine «Udachnyy»

These fluids differ from each other in the concentration of solid particles contained in them, the mechanical properties of solid particles, their salinity, pH and other characteristics. The service life of parts of the flow-through part of pumping equipment, mainly impellers [1-17], largely depends on these characteristics.

Figure 1 shows the weighted average terms of the impellers T of the investigated pumps in the form of a histogram.

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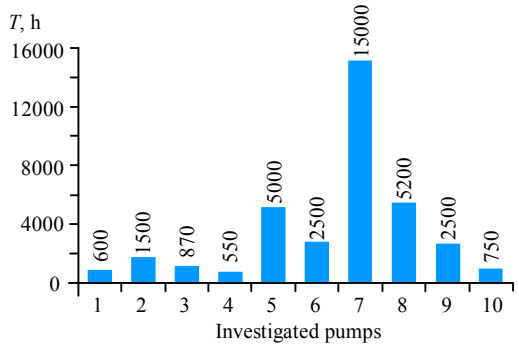

Fig.1. Weighted average service life of the impellers of the investigated pumps

1 – domestic ground pumps, PP № 12; 2 – pumps manufactured by KETO, SOF; 3 – pumps company KETO, OF № 12; 4 – domestic ground pumps, PP № 3; 5 – pumps company Metso, PP № 16; 6 – pumps company Metso, OF № 12; 7 – pumps model 12NDs, TSHH; 8 – pumps of model X200-150-500, underground successful kimberlite mine; 9 – pumps 12NDs, SOF; 10 – pumps of models 1D630-90, 1D500-63, underground kimberlite mine «Mir»

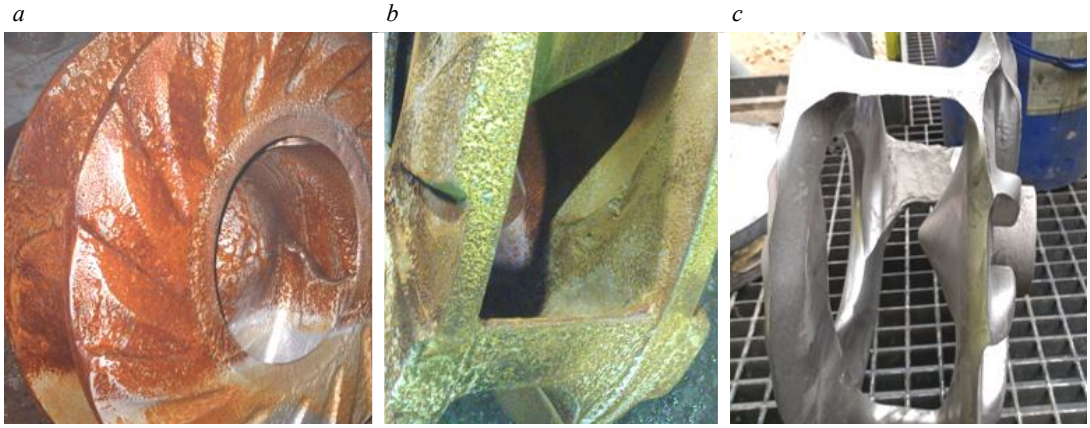

Fig.2. Intensive wear of impellers of pulp pumps: *a* – models Gr 600-65 after 500 hours of operation; *b* – models GrAT 1800-67 after 900 h of operating time; *c* – KETO-F6131P-A05A models after 1150 h of operation

Analysis of the production data showed that the most common cause of the failure of the impellers of the single-stage centrifugal pumps investigated is the intense hydro-abrasive wear of their disks and blades. Among the studied pumps, the most wear-resistant impellers are Finnish pulp pumps manufactured by «Metso» [4].

Figure 2 clearly shows the effects of hydroabrasive wear on the impellers of a number of domestic and foreign pulp pumps.

As you know, hydroabrasive wear of the impeller, in addition to reducing the hydraulic parameters of a centrifugal single-stage pump, also leads to an increase in the vibration of its rotor due to unbalance [3, 8].

Practice shows that the systematic deflections of the rotors of the investigated pumps contribute to the deterioration of the technical condition of their seals (stuffing boxes, end seals and dynamic seals) and bearing assemblies, up to destruction (Fig. 3) [1, 3, 7].

Fig.3. Destruction of the separator bearing pulp pump model GRaT 1800-67

In our case, this is confirmed by the results of statistical processing of production data on failures of the investigated pumps.

Figures 4, *a* and *b* show the experimental dependences of the average weighted service life of the sealing elements t_1, as well as the bearing units t_2, on the weighted average service lives of the impellers T of the investigated pumps and their approximation using a linear trend line.

The coefficients of determination of the derived linear regression equations indicate that there is a noticeable direct relationship

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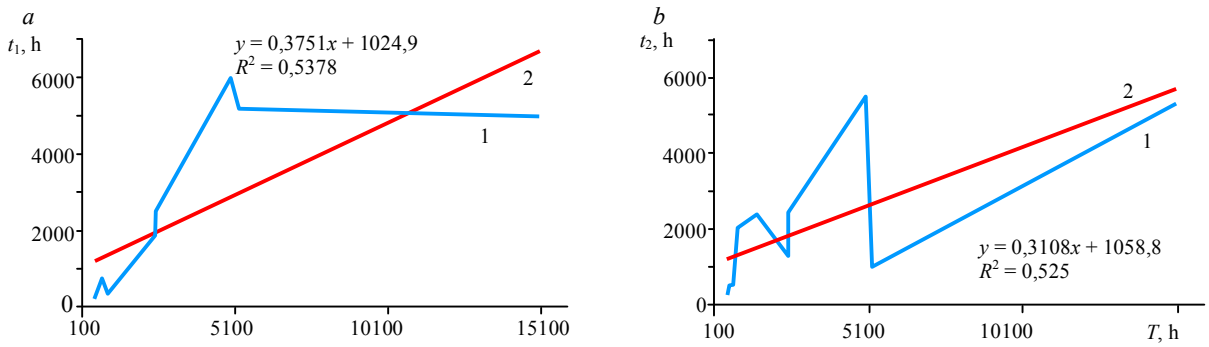

Fig.4. Linear approximation of experimental dependencies: *a* – weighted average service life of impellers and sealing elements of pumps; *b* – weighted average service life of impellers and pump bearing units
1 – experimental dependence; 2 – trend line

between the durability of the parts in question on the Cheddock scale. It should be noted that the obtained single-factor linear regression equations are adequate at a level of reliability $a = 0.1$ (F is significance, in the first case it is 0.016, in the second – 0.018).

The operation of a centrifugal single-stage pump with a worn out impeller over time can lead to deformation or even to fracture (destruction) of the shaft [7, 8, 14].

The results of observations and a survey of the working personnel of the joint-stock company ALROSA indicate that the shaft of a cantilever centrifugal pump basically bends (up to permanent deformation), and less often it collapses in the contact zone of the impeller and the seal mounted on it; in a lesser proportion of cases, in the areas of landing of the seal, as well as in the sleeve-pin half-coupling or pulley (Fig.5, *a*, *b*). In turn, the centrifugal pump shaft of the «D» type tends to bend (up to residual deformation), and less often to collapse in the seats for the impeller and pin-and-half coupling (fig.5, *c*).

Fig.5. Kinks of shafts of centrifugal single-stage pumps:
a, *b* – pulp pumps; *c* – «D»-type pump

The results of calculations of the static strength of the shafts of centrifugal single-stage pumps of cantilever execution and type «D» show that their problem areas are stress concentrators, which explains the propensity of shafts to deform and collapse in these places (Fig.6) [5, 14].

Practice shows that in the joint-stock company ALROSA, in rare cases, the deformed shafts are not replaced and reused (this is caused by a limit of important parts).

Repeated use of deformed shafts often adversely affects the long-term bearing assemblies and seals of the investigated pumps. The least reliable type of seal when the pump is operated with a shaft of this kind is the mechanical seal. The shafts of domestic pulp pumps are more susceptible to permanent deformation and destruction, which is explained by their large shaft overhang.

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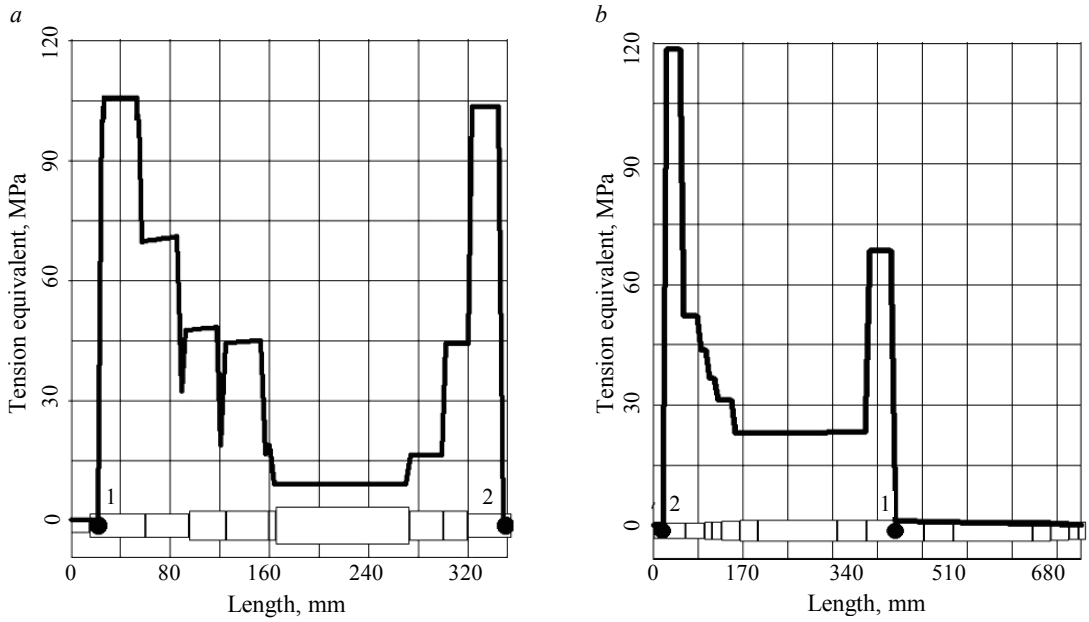

Fig.6. The results of the statistical strength of the shafts of centrifugal pumps: *a* – pump model K8-18; *b* – pump model D200-36
1, 2 – shaft seats under the impeller and the half coupling

At the underground kimberlite mines of the joint-stock company ALROSA, the additional deflections of the shafts of the investigated pumps, besides the wear of the impellers, are also the result of clogging of the suction pipelines of the latter. This is due to the constant quest for headers or the result of their work in idle mode, which in turn is explained by the failure or lack of automation equipment.

According to production data, the use of pumps of type «D» when working on plastics is a highly undesirable solution. Such a chemically active medium, such as brine, especially adversely affects the durability of the impellers and labyrinth rings of «D»-type pumps. When working on such a medium aggressive to metal among the centrifugal single-stage pumps investigated, pumps of the «X»-type proved to be well recommended.

As you know, the efficiency of using machines for various purposes can be assessed through an indicator such as the coefficient of technical use. $K_{t.u}$.

Figure 7 presents the weighted average values of the coefficient of technical use of the investigated pumps. As can be seen from the figure, the most efficient centrifugal single-stage pumps used in the joint-stock company ALROSA are pulp pumps manufactured by Metso and domestic pumps of «D»-type used in the Central Art Museum. The high efficiency of the use of the latter is explained by the sparing characteristics of the natural liquid they pump, the process water. When working on a more aggressive environment (brines), the weighted average values of the coefficient of technical use of pumps of «D»-type are already defined.

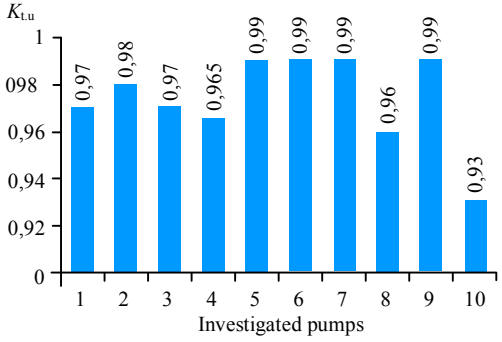

Fig.7. Weighted average of the coefficient of technical use of pumps

1 – domestic ground pumps, PP № 12; 2 – pumps manufactured by KETO, SOF; 3 – pumps company KETO, OF № 12; 4 – domestic ground pumps, PP № 3; 5 – pumps company Metso, PP № 16; 6 – pumps company Metso, OF № 12; 7 – pumps model 12NDs, TSHH; 8 – pumps of model X200-150-500, underground successful kimberlite mine; 9 – pumps 12NDs, SOF; 10 – pumps of models 1D630-90, 1D500-63, underground kimberlite mine «Mir»

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Outputs

1. Using linear correlation and regression analysis, it was proved that the durability of the impellers of the investigated pumps definitely affects the durability of their seals and bearing assemblies.

2. The most effective from the point of view of application among the pulp pumps studied are the pumps of the company «Metso».

3. Pumps of «D»-type are effectively used only in the case when the pumped medium is not so aggressive to the metal.

4. When pumping brines among centrifugal single-stage pumps, pumps of «X»-type have proven themselves well.

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