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The impact of hydro-wear parts of pumps for operational efficiency of the pumping station.

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Abstract. During the work considered questions of the occurrence of cavitation in hydro abrasive flows, which can lead to a rather complex phenomenon that is difficult to understand the essence of this process. Today, the wear of the working bodies of centrifugal and axial pumps, depending on the mode of their operation has not been learned much, and there has been developed a technique for selecting operating modes, taking into account the wear of their parts. Also, the results of complex laboratory and field studies on the intensity of wear of the flow elements of centrifugal and axial pumps are presented. It has been established that the alternating, pulsating load leads to an increase in the force of interaction of the hydro abrasive flow with the camera surface and increases its wear by 10 %, and also reduces the capacity of the pumping unit to 9%.

1.Introduction

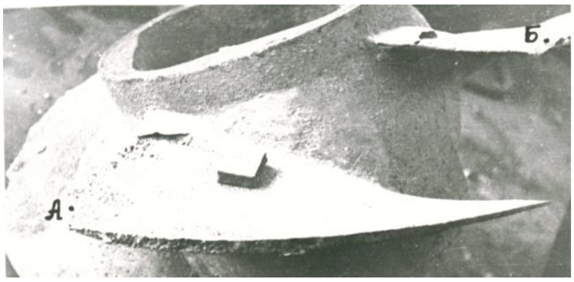
The operational experience of centrifugal and axial pumps has shown that their overhaul life does not exceed one irrigation season. One of the main reasons for the decrease in the operational parameters of centrifugal pumps is the intensive wear of the blades and the sealing gaps of the impeller in a waterjet environment. As the operating practice shows, to date, the wear of the working bodies of centrifugal and axial pumps, depends on the mode of their operation, has not been studied much, and a methodology for choosing the operating modes taking into account the wear of their parts has not been developed. Therefore, the identification of the causes of wear during various modes of operation of pumping units is the main purpose of this work.

Research methodology. Laboratory studies were carried out to identify the causes of wear of parts of centrifugal and axial pumps.

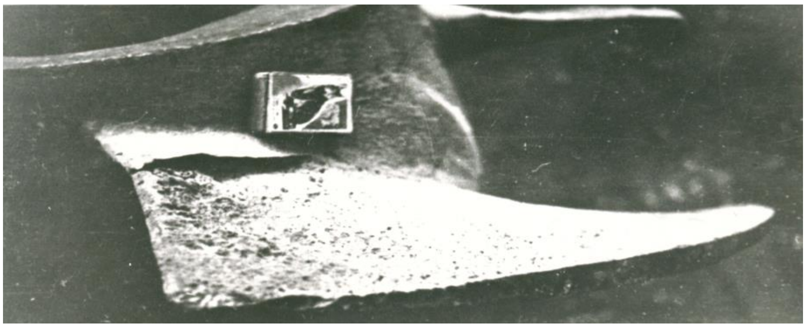
2.Main part.

Before starting work on the experimental pumps, the initial thickness measurements of the inlet and outlet edges of the blades and impeller disks were measured at pre-determined points. The thickness of the blades was measured using a specially made indicator plug at five points along six sections. The diameters of the sealing ring and the impeller disk were measured in four places, along two mutually perpendicular diameters of the circle. The micrometer results of the working parts of the pumps showed that the impeller blades wear out unevenly both in size and in shape [1, 2, 3].As can be seen from fig. 1, and after 2680 hours of operation of the pump in the inlet, the wear thickness of the impeller blades is negligible, i.e. 0.3-0.5 mm. In the output part, the wear of the blades in thickness increased to 2.6-2.86 mm, which can be explained by the increase in the kinetic energy of solid particles and their local concentration on the working surface of the blade due to an increase in the centrifugal and Coriolis forces along the radius of the impeller. In the zone of exit edges on the working surfaces of the blades, more pronounced deepened rows of furrows up to 1.5 mm deep were observed, which result from the shearing properties of solid abrasive particles in water.

a)



b)



v)

Figure.1 General view of the wear of the impellers of axial pumps.

Legend: a - wear of the end edge of the pump blades OP10-185 after 7781 hours of operation; b and c - wear of the back surface and end face of the 30PrV-60 pump blades after 5486 hours of operation.

On the back surfaces of the blades, no noticeable signs of wear were observed. In the impellers of the PS pumps Turakurgan-1 and Turakurgan-2, the inlet edges of the blades took a sawtooth shape with deep smoothed damage over the entire width. This is explained by the fact that sometimes, in rainy weather, larger solid particles of bottom sediments, which occurred for this station (Fig. 2, a and 2, b), enter the supply pipelines [4, 5].

The inner surfaces of the impeller disks also wore unevenly both in radius and in channel width. The greatest wear of the inner surface of the disks occurred near the working surfaces of the blades at the exit (2.17 mm). In a spiral discharge device, the maximum hydro abrasive wear was observed at the interface with the diffuser, i.e. in the area of the "tongue", as well as on its walls along the entire length, which had scaly forms. An increase in the surface roughness of the outlet device due to wear leads to a decrease in the pump head due to an increase in the hydraulic resistance of its flow part. Protective sleeves were exposed to significant wear at the locations of the seals. Although the wear of the protective sleeves affects the characteristics of the pump to a lesser extent, it contributes to a large loss of metal mass and their replacement with new ones [6, 7]. A more significant impact on the performance of centrifugal pumps is the gap between the O-ring and the outer rim of the impeller disk.

As a result of wear, the surfaces of the impeller sealing wheels take an uneven wavy appearance with a scaly shape. The greatest wear of the working surface of the O-ring occurs at the place of rotation of the flow in its end part, which has a trench shape in radius.

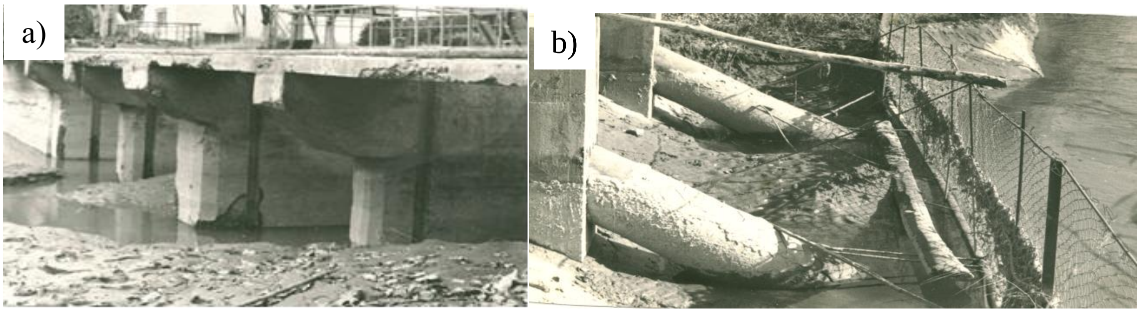


Figure 2. Deposition of sediment in the water intake chambers of the National Assembly "Turakurgan-1" (a) and the advance chamber of the National Assembly "Turakurgan-2" (b).

Apparently, when the flow enters the slot, the jet is compressed, which leads to an increase in the local velocity and a decrease in pressure to a critical value. This leads to the formation of cavitation cavities in the gap, and increased wear intensity in the end part of the surface of the sealing ring. Besides, a vortex-like flow movement arises from the rotation of the disk, which is an additional source of wear intensification.

In fig. Figures 3a and 3b show the dynamics of increasing the sealing gaps of the impellers of centrifugal pumps of the D6300-80 and 200D-90 brands.

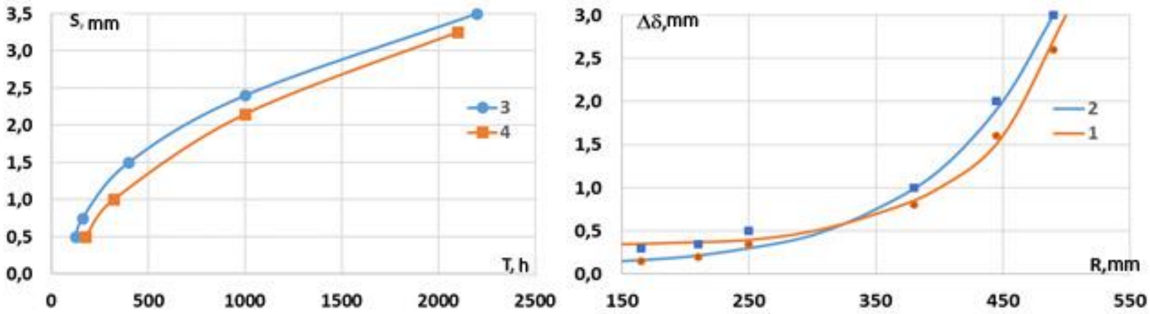


Figure 3. Dependency charts

Figure 3 represents graphs of the dependence of (a) the thickness of the wear of the blades on the radius of the impeller and b) the size of the sealing gap on the duration of operation centrifugal pumps.

Legend: 1-3 - for the pump D6300-80 PS "Dustlik"; 2 - for the pump D6300-80 PS "Mustakillik-1"; 4 –for the pump 200D-90 PS "Khozhabosmon".

The most intensive increase in the gap from the effect of cavitation-abrasive slit flow occurs in the initial periods of operation. The maximum gap after 2000 hours of operation of the pump is 3.1 ... 3.3 mm [8, 9].

To find out the reasons for the decrease in water supply of the pump D6300-80, tests were carried out of unit No. 3 of the PS "Dustlik". As a result, it was found that the change in pressure during the irrigation season was insignificant, i.e. by 3.5-4.2 m. The pump water supply, calculated by the average flow rate in the pipeline and measured using a pitot tube, was 1.5 m3 / s at the beginning of operation, and decreased to 1.42 m3 / s at the end of the irrigation season, i.e. at 80 l / s. This is a consequence of an increase in the sealing gaps of the impeller, which is confirmed by calculations carried out according to the method described in [10, 11, 12].

3.Research and discussion results.

Observations revealed that on the impeller blades of an axial pump of the OP10-185 brand, cavitation-abrasive wear occurs mainly in four places: on the working surface, on the back surface, on the end edge and in the area between the end edge and the inlet. The wear of the end part of the impeller on OP10-185 pump of the Kuyumazar PS made of X18N9TL stainless steel (Fig. 1a) due to crevice cavitation and sediment exposure is characterized by the presence of a wavy surface. The surface of the end face of the pump blade 30PrV-60 of the Dangarinsk PS (Fig. 1, c), made of ordinary steel 25, has punctures, small ulcers with indentations [13, 14, 15].

The impeller blades of the same type of pumps 30PrV-60 of the Dangarinsk PS have a different nature and wear zones depending on operating conditions.The inlet portion of the blade adjacent to the end edge (zones A and B in Fig. 1, b) suffered the most wear on the first pump, which does not occur for the second pump. Moreover, on the back surface of the blade of the second pump, which has a more loose, spongy structure than the first, cavitation destruction predominates. By comparing the operating seasons of each of these units, it was found that the first one worked longer in the spring-summer periods, when the level and turbidity of the water in the river were greatest, and the second when the water level and turbidity of the water source were reduced.This means that the first pump was subjected to more hydroabrasive wear, and for the second, cavitation destruction is predominant.

In axial pumps, the surfaces of the impeller chamber also suffered the greatest wear. In fig. Figure 4a shows graphs characterizing the increase in the gap between the end face of the blade and the impeller chamber of the pumps OP11-193 of the Kuyumazarsky PS and OP5-110 of the Alatsky Pumping station (Bukhara region), depending on the duration of operation .The gap intensifies most intensively from cavitation-abrasive action of a weighted target stream in the initial periods of operation. With an increase in the gap, the leading role is played by the pump heads: for the OP11-193 pump with a pressure of H = 17 m, the gap increases more intensively than for the OP5-110 pump with H = 8.5 m.Using the data in Fig. 4a, by calculations it can be obtained that the increase in the gap due to wear depends on the pressure of the pumps to the degree of 1.5-1.2. By increasing the clearance S, the volumetric efficiency and the pump flow are reduced. As calculations showed, over the year of operation, the feed of the OP5-110 pump decreases by 0.35 m3 / s, and that of the OP11-193 pump - by 1.1 m3 / s (Fig. 4, b).

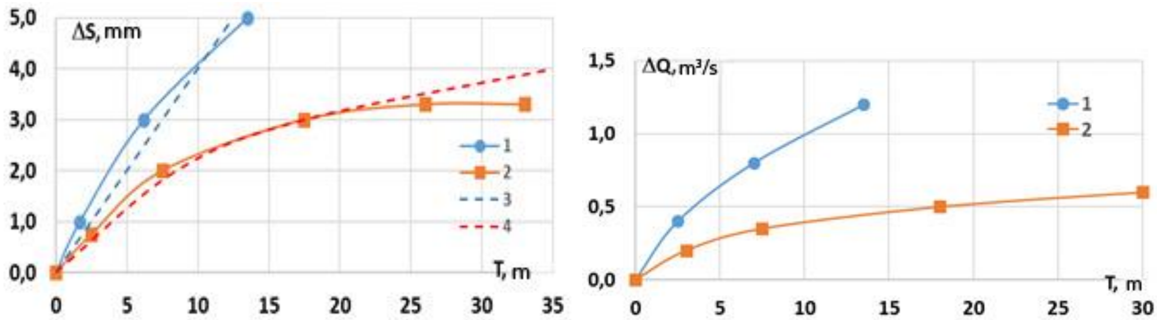


Figure. 4. The dynamics of the increase in the gap (a) and the amount of leakage between the impeller and the chamber wall of the axial pumps (b).

Legend: 1 - for the unit No. 5 of the PS "Kuyumazar", 2 - for the unit No. 1 of the PS "Alat", 3-4 - according to the calculated data.

The nature of the destruction along the height of the pump chamber OP5-110 of the Alat PS shows the difference in the forces acting on the chamber walls (Fig. 5, a, b).The first zone is characterized by the presence of large deep shells and voids penetrating deep into the metal. This section is affected by the largest pulsating alternating load.In the second zone the surface is spongy. In the upper zone of the chamber, a variable pulsating load of relatively smaller magnitude acts and point ulcers appear on the surface of the chamber, which penetrate relatively deep into the metal [16].

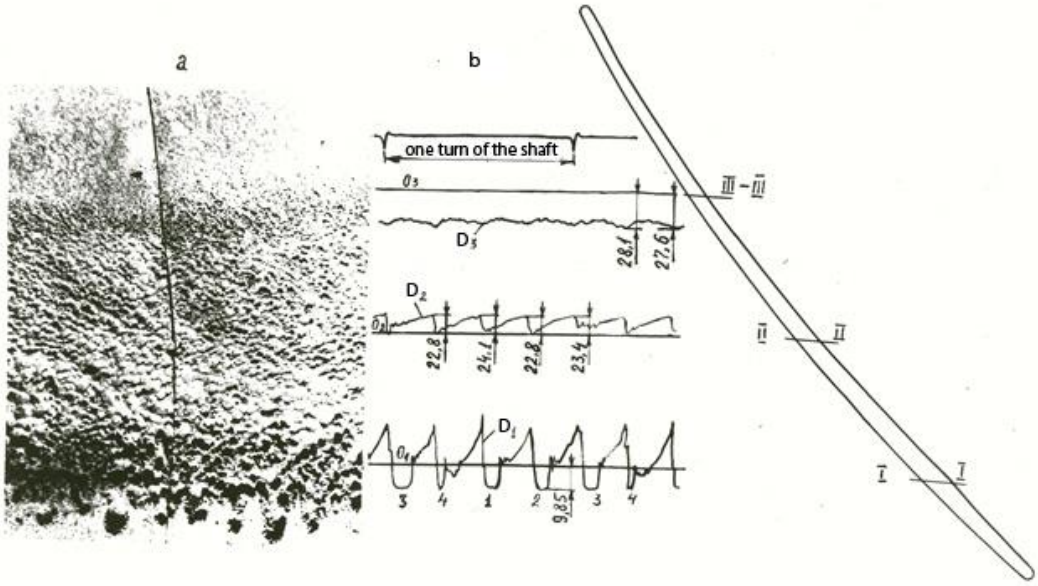


Figure. 5. The nature of the destruction of the wall of the chamber of the axial pump OP5-110

The fixed vanes of the straightening apparatuses of almost all pumps undergo cavitation-abrasive wear in the inlet part of the outer part adjacent to the rim, where flow separation and vortex formation occurs (Fig. 6).The fracture zone usually has a width of 50 to 200 mm, the erosion depth varies up to through holes, which, for example, for the OP10-185 pump, occurred after 6100 hours of operation.

Figure. 6. Damage to the straightening apparatus of the pump OP10-185 PS Kuyumazar after 6100 hours of operation.

The nature and dynamics of wear of the working parts of the PG-35MA axial pump were studied by observing the operation of two pumping units installed in the shirkat farm of the Dangarinsky district of the Ferghana region. In the Fig. 7 illustrated the curves of changes in the wear thickness of the axial pump blades along the length and width after 1800 hours of operation. [17, 18]. A change in the wear thickness of the impeller blades along its width shows that with an increase in the radius of the wheel, the wear intensity increases (Fig. 7, b). The dependences obtained for the input and output edges, as well as for the middle part of the blade show that in all sections the pattern of wear has a curvilinear increasing character. Moreover, the largest amount of wear corresponds to the output, and the smallest input edge of the blade [19, 20].

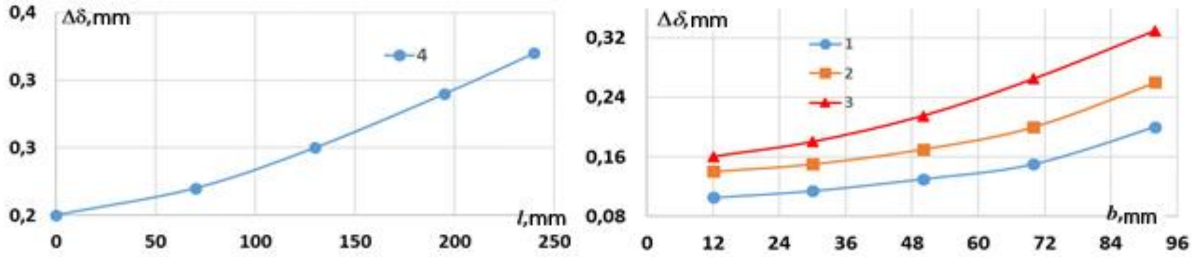


Figure 7. Graphs of changes in the wear thickness of the impeller blades of the axial pump along its length (a) and width (b).

Legend: 1 - for the input edge, 2 - for the output edge, 3 - for the middle part of the blade, 4 - for the peripheral part of the blade.

If you do not take into account the gravity of a solid particle, which is relatively small in comparison with other forces, then a particle located in the inter-blade channel of the impeller of an axial pump is mainly affected by: hydrodynamic force in the direction of the axis, centrifugal force in the radius direction, the opposite direction of wheel rotation is the Coriolis force.According to the resultant of these three forces, the magnitude of the force and the angles of interaction of solid particles with the surfaces of the blade and the impeller chamber are determined.Based on the above considerations, it can be argued that the number of particles hitting the surface of the parts (with the surface and end edge of the blade, the wall of the chamber) increases from entrance to exit along the length of the inter-blade channel.

In fig. 8 shows the dynamics of increasing the gap between the chamber and the impeller blades of the axial pump for 1800 hours of operation.The graphs of wear increase at the beginning of operation are curvilinear in nature, and then change according to a straightforward law.Apparently, this is a consequence of the fact that at the beginning of the irrigation season the pumped water has the highest sediment concentration.

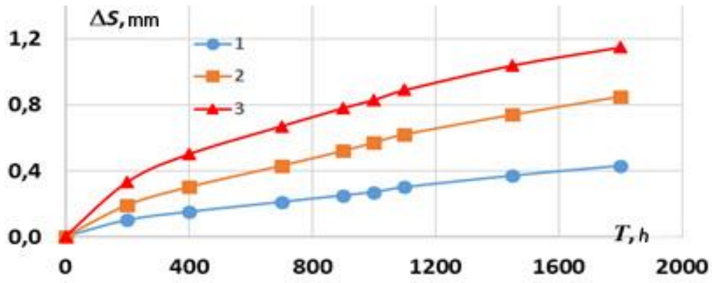


Figure 8. The increase in the end gap of the impeller from the duration of the operation of the PG-35MA

axial pump: 1 — increase in the gap, 2 and 3 — respectively, the thickness of the wear of the chamber and the end edge of the blade.

4. Findings.

The structure of cavitation-abrasive wear of the end part of the blade indicates that for stainless steel having the highest resistance to cavitation, abrasive particles play a predominant role, and for ordinary steel, cavitation failure is ahead of hydroa brasive.

The intensity of the increase in wear characterized by the angle of inclination of the line to the abscissa axis increases with increasing blade length. This phenomenon is explained by an increase in the local concentration of sediments due to the Coriolis force and the kinetic energy of solid particles on the blade surface along its length, or when the hydroa brasive flow moves along the length of the impeller blade, the kinetic energy and Coriolis force acting on solid particles also increase peripheral speed, and accordingly centrifugal force along the radius of the impeller, and the particles are separated along the width of the blade.

A more intensive wear of the chamber is noted than the end part of the blades of the impeller of the axial pump, although the flow rate of the hydro abrasive flow relative to the chamber will be significantly lower than relative to the end part of the blade. This is due to the fact that an alternating pulsating load acts on the surface of the chamber due to the difference in the differential pressure on the surfaces of the blades. The frequency of change and the magnitude of the alternating pulsating load depend on the number of blades and pressure created by the impeller of the pump, i.e. alternating pulsating load leads to an increase in the force of interaction of the hydro abrasive flow with the surface of the chamber and increases its wear by 1.1 times, and also reduces the productivity of the pump unit to 9%.

References

[1] Mamajonov M. Uralov B. Hydroabrasive wear of the elements of the flow-through part of centrifugal and axial pumps. *Science-tech. Fergana*. 2003. No. **3**. Pp. 30-35
[2] Bogachev I.N. and others. Hydroabrasive resistance of chrome-manganese steels. *Power engineering*. 1987. - No **7**. Pp.75-79
[3] Glovatsky O. Uralov B. Ergashev R. Reliability assessment and measures for resources-saving on water lifting engine systems in the republic of Uzbekistan. Perspectives of innovations. *Economics and Business International Gross-Industry Research Journal,* Volume **4**, 2010, Pp. 118-120.
[4] Abduramanov A.A. Hydraulics of hydrocyclones and hydrocyclone pump installations. Monograph. Parts 1 and 2. Almaty: Gylym, 1993. Pp. 353
[5] Abduramanov A.A., Abirov A.A., Abduramanov E.A. Jet pumps. Hydrocyclone pumping units. Pumping stations. Analytical review. Taraz, 2003. Pp. 32
[6] Kos'min V. G., Pacera S. T., Protsiv V. V. Analysis of the reasons for the lack of wear resistance of pump parts for waterjet mixes. 2015. No. **1**. Pp. 83-89.

[7] Mamajonov M., Uralov B., Tursunov H. Change in the water supply of pumps. *Journal Agriculture of Uzbekistan*. 2005. No. **1**. Pp. 28-29
[8] Mamajonov M. Definition of water supply of centrifugal and axial pumps used for irrigation of crops. *Bulletin of agrarian science of Uzbekistan*. 2003. № **1**. p. 94-97.
[9] Mamajonov M. Uralov B.R. Analysis of the working conditions of pumping stations for agricultural purposes. *Reporter of agrarian science of Uzbekistan*. 2004. № **1**. p.77-80.
[10] Volkov P.M. Modeling of dusty streams and practical application. *The theory of similarity and modeling*. - M.: issue AH1989. Pp.75-82
[11] Kim V.A., Kabulov I.N. Experience of operation of centrifugal pumps D4-125-0 at the pump station "Kokayty" Land reclamation and water management. 1991. No. **5**. Pp. 37-39
[12] Mamajonov M., Sudakov V.P. Cavitation-abrasive wear of parts of the flow-through part of axial pumps at meliorative pumping stations. Design, construction and operation of hydraulic structures and pumping stations in the conditions of Uzbekistan: TIIAME. Tashkent. 1984. No. **135**. Pp. 95-100
[13] Volodin A. Ju., Nazarov V. P., Bocherikova Ja. V. Influence of the geometric dimensions of non-contact seals on the efficiency of centrifugal pumps. - 2014. - V. **1**. - No. **18**. Pp. 257-261.
[14] Wagner H. Boitrag zur Abflusberechnung offoner Gerinne. Wissensehaftliche Zeitschrift der Technischen Univernitat Dresden. 1972, Heft 3, Pp. 641-648.
[15] Troitskiy V.P., Uralov B.R. Influence of the shape of the free-flow cylindrical channel and roughness on the pressure loss. *Protection of the environment from pollution by industrial emissions from pulp and paper industry, Interuniversity collection of scientific papers, issue*. 9, Leningrad. 1981. Pp. 142-147
[16] Vasil'ev A. A., Igoshin D. N., Gorin L. N. Influence of cavitation abrasive wear on screw pumps. *Young Scientist*. 2015. No. **22**. Pp. 135-137
[17] Vasil'ev A. A., Igoshin D. N., Shisharina A. N. Reducing the effect of cavitation on the wear of pump parts. 2016. No. **1**. Pp. 28-29.
[18] Gafurov S. A., Rodionov, L. V., Kryuchkov, A. N., Shakhmatov, E. V. Reducing the dynamic loading of the combined pump unit *Pumps. Turbines. Systems* - 2012. No. **2**. p 26
[19] Zhang M., Wang H., Tsukamoto H. Numerical analysis of unsteady hydrodynamic forces on a diffuser pump impeller due to rotor-stator interaction //*ASME 2002 Joint US-European Fluids Engineering Division Conference. – American Society of Mechanical Engineers*, 2002. Pp. 751-760.
[20] Jakimov S. B. i dr. On the effect of the fractional composition of abrasive particles in the produced fluid on the types of wear of parts of electrical centrifugal pumps *Territory «NEFTEGAZ»*. 2018. No. **11**. Pp. 32-38.