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ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ HALYK CHARITY FOUNDATION

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится

работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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IMPROVING THE DESIGN OF A CENTRIFUGAL GROUND PUMP IN ENRICHMENT PRODUCTION

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Abstract. Hydrotransport equipment of mining and processing plants has a low operational reliability, insufficient working resource due to intensive hydroabrasive wear of working surfaces of pipelines and pumping equipment, drawbacks in the design of some nodes of groundwater pumps and their operation. Significant hydroabrasive wear of the main element of the ground pump design, the impeller, causes additional disturbing dynamic forces, which leads to increased vibration of the unit and, consequently, to its premature failure. Until now, insufficient attention has been paid to the influence of water abrasion of the impeller on the service life of their units and their service life. The paper analyzes the manifestation of cavitation wear of parts of

the flowing part of groundwater pumps, outlines measures to reduce cavitation by favorable conditions of fluid intake into the pump and reducing the vacuum suction height. A number of measures of technological and constructive decision, decrease of harmful influence of cavitation are also offered. Materials for manufacturing parts of the centrifugal soil pump with high performance and high service life have been selected and analyzed. These alloys showed high corrosion resistance due to their high chromium content. The ways of improvement of the centrifugal soil pump parts design, allowing to increase the resource of their work, to create an automated system of diagnosing the condition of the construction as a whole are outlined. On the basis of the analysis of wear of parts of a centrifugal soil pump the improved designs of an armored disk with a replaceable disc and a composite impeller with improved indicators of wear resistance and maintainability are developed, allowing to increase their service life, to reduce the cost of spare parts and to reduce the repair period. The influence of wear and tear of centrifugal soil pump parts on its operating parameters has been determined; the dependence of pump head and pumping capacity on the volume of pumped hydro-abrasive mixture has been established.

Keywords: soil pump, impeller, armor disc, hydroabrasive wear, throttling, measuring bench

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Аннотация. Тау-кен байыту комбинаттарының гидротранспорттық жабдықтарының пайдалану сенімділігі төмен, құбырлар мен сорғы жабдықтарының жұмыс беттерінің қарқынды гидроабр тозуына, топырақ сорғыларының кейбір тораптары конструкцияларының кемшіліктеріне және оларды пайдалануға байланысты жұмыс ресурсы жеткіліксіз. Топырақ сорғысының негізгі құрылымдық элементінің — жұмыс дөңгелегінің су ағынының айтарлықтай тозуы қосымша бұзылатын Динамикалық күштерді тудырады, бұл қондырғының дірілінің жоғарылауына, демек, оның мерзімінен бұрын істен шығуына әкеледі. Топырақ сорғыларының жұмыс дөңгелегінің су ағынының тозуының олардың қондырғыларының қызмет ету мерзіміне және олардың ресурсына әсер ету мәселелеріне осы уақытқа дейін жеткіліксіз көңіл бөлінді. Жұмыста топырақ сорғыларының ағын бөлігінің бөлшектерінің кавитациялық тозуының көрінісіне талдау жасалды, сорғыға сұйықтықтың қолайлы түсу жағдайлары есебінен кавитацияны төмендету және сорудың вакуумметриялық биіктігін төмендету шаралары белгіленді. Сондай-ақ, технологиялық және сындарлы шешімдердің бірқатар шаралары, кавитацияның зиянды әсерін азайту ұсынылды. Жоғары пайдалану қасиеттеріне ие, жұмыс ресурсы жоғары орталықтан тепкіш топырақ сорғысының бөлшектерін жасау үшін материалдар таңдалды және талданды. Бұл қорытпалар құрамында хромның көп болуына байланысты коррозияға төзімділігі жоғары болды. Орталықтан тепкіш топырақ сорғысының бөлшектерінің дизайнын жетілдіру жолдары олардың жұмыс ресурсын арттыруға, тұтастай алғанда құрылымның жай-күйін диагностикалаудың автоматтандырылған жүйесін құруға мүмкіндік береді. Орталықтан тепкіш топырақ сорғысының ағын бөлігінің бөлшектерінің тозуын талдау негізінде ауыстырылатын дискісі бар құрама бронедисктің және тозуға төзімділік пен жөндеуге жарамдылық көрсеткіштері жақсартылған Құрама жұмыс дөңгелегінің жетілдірілген конструкциялары әзірленді, бұл олардың қызмет ету мерзімін ұзартуға, қосалқы бөлшектерді сатып алу шығындарын азайтуға, жөндеу кезеңін азайтуға мүмкіндік береді. Орталықтан тепкіш топырақ сорғысының бөлшектерінің тозуының оның жұмыс параметрлеріне әсері анықталды, сорғының қысымы мен түсуінің айдалатын гидроабразим қоспасының көлеміне тәуелділігі анықталды.

Түйін сөздер: топырақ сорғысы, жұмыс дөңгелегі, бронедиск, су ағынының тозуы, дроссель, өлшеу стенді

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СОВЕРШЕНСТВОВАНИЕ КОНСТРУКЦИИ ЦЕНТРОБЕЖНОГО ГРУНТОВОГО НАСОСА В ОБОГАТИТЕЛЬНОМ ПРОИЗВОДСТВЕ

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Аннотация. Гидротранспортное оборудование горно-обогатительных комбинатов имеет низкую эксплуатационную надежность, недостаточный рабочий ресурс из-за интенсивного гидроабразивного износа рабочих поверхностей трубопроводов и насосного оборудования, недостатков конструкций некоторых узлов грунтовых насосов и их эксплуатации. Значительный гидроабразивный износ основного элемента конструкции грунтового насоса — рабочего колеса, вызывает дополнительные возмущающие динамические силы, что приводит к повышенной вибрации агрегата и, следовательно, к преждевременному выходу его из строя. Вопросам влияния гидроабразивного износа рабочего колеса грунтовых насосов на срок службы их установок и их ресурс, до настоящего времени, уделялось недостаточное внимание. В работе выполнен анализ проявления кавитационного износа деталей проточной части грунтовых насосов, намечены меры снижения кавитации за счет благоприятных условий поступления жидкости в насос и снижения вакуумметрической высоты всасывания. Предложен также ряд мероприятий технологического и конструктивного решения, снижения вредного влияние кавитации. Выбраны и проанализированы материалы для изготовления деталей центробежного грунтового насоса, обладающие высокими

эксплуатационными качествами, имеющие высокий ресурс работы. Эти сплавы показали высокую коррозионную стойкость из-за высокого содержания в них хрома. Намечены пути совершенствования конструкции деталей центробежного грунтового насоса, позволяющие повысить ресурс их работы, создать автоматизированную систему диагностирования состояния конструкции в целом. На основе анализа износа деталей проточной части центробежного грунтового насоса, разработаны усовершенствованные конструкции сборного бронедиска со сменным диском, и составного рабочего колеса с улучшенными показателями износостойкости и ремонтопригодности, позволяющие повысить срок их службы, сократить затраты на приобретение запчастей, уменьшить ремонтный период. Определено влияние износа деталей центробежного грунтового насоса на его рабочие параметры, установлена зависимость напора и подачи насоса от объема перекаченной гидроаброзимной смеси.

Ключевые слова: грунтовый насос, рабочее колесо, бронедиск, гидроабразивный износ, дросселирование, измерительный стенд

Introduction

A large amount of ore materials are mined and processed in Kazakhstan in order to extract valuable metals from them. In the process of rock processing, the latter, in accordance with the technological process, are transported by centrifugal ground pumps. Thousands of soil pumps are used in the production process, and their service life is very short, so the research of centrifugal soil pump in order to increase its service life is an urgent problem for mining and construction industry.

Soil pumps are massive units for transporting crushed ore in a water environment. The resulting water-abrasive medium is highly destructive, so that ground pumps have a low service life due to intensive wear of the working parts (Povetkin et al., 2020; Povetkin et al., 2018; Zavertkin, 2009).

Service life of pump parts - armoured disc, impeller, does not exceed 20 days of operation, after which it is necessary to stop the pump and carry out repair work to replace worn parts, which requires a significant loss of working time of the main equipment of the processing plant and a large volume of spare parts (Povetkin et al., 2020).

The analysis of the problem of groundwater pumps operation has shown that groundwater pumps at the enterprises of mining and processing production do not meet the requirements for reliability and energy consumption. The main disadvantage of groundwater pumps is low service life of pump flow parts due to the impact of water on abrasion and cavitation wear (Seitkhanov et al., 2019).

Consequently, the study of mechanical and cavitation wear of impeller parts, development of a new design of a ground pump with a high service life is an urgent task.

The paper analyzes a number of foreign, Russian and Kazakh sources (Aleksandrov et al., 2016; Spence et al., 2009), constructive and technological solutions in creating efficient groundwater pumps, consisting in the following:

- presence of an elastic band in the flow channel, which can be oscillated;
- grooves on the impeller blades arranged in a specific order;

- the use of a protective coating of high hardness material;
- formation of localised turbulent flows, displacement of laminar flows from the periphery to the flow axis;
- reduction of vibrations due to intermediate supports;
- a method of reducing hydrodynamic friction due to the effect of an alternating electromagnetic field on the boundary layer of a liquid or gas;
- application of a screw with two inlets;
- impeller design - solid cast iron;
- modification of the inner pipe design - longitudinal ribs with cylindrical segments fixed on them to reduce aerodynamic friction resistance and boundary layer thickness;
- presence of thrust and wear-resistant rings, in order to retain the liquid film between them, as a consequence - reduction of wear during the rotation of the impeller.

However, these measures have not solved the problem of increasing the service life of soil pumps.

All this allows us to assert that it is expedient to carry out researches on improvement of impeller and armor plate design, as the most basic loaded pump parts (Yao et al., 2018).

The papers (Alexandrov et al., 2018; Shen et al., 2018) present extensive studies of waterjet wear in industrial and laboratory settings, combining theoretical analyses of the wear process with laboratory studies and pilot tests.

The theoretical and experimental studies conducted by the authors (Li et al., 2017) are also of great interest to further investigate the waterjet wear process.

When working with hydraulic mixtures with large solid inclusions, the most intensive wear is exposed to the inlet sections of the blades, with the practical absence of wear in the remaining sections of the impeller and seals. Wear of blade inlet elements affects the deterioration of suction capacity and head reduction.

Evaluation of hydroabrasive wear of ground pump parts, allows to outline essential ways of its decrease, due to change of pump design and creation of automated system of wear rate evaluation, i.e. permanent diagnostics.

One of the significant phenomena affecting the wear of parts of groundwater pumps is cavitation. With cavitation, there is a drop in delivery, head, efficiency and power, erosion of the material of the walls of the wheel, casing, metal corrosion in the cavitation zone. Given in the cited literature (Seitkhanov et al., 2019; Aleksandrov et al., 2016; Spence et al., 2009; Yao et al., 2018; Aleksandrov et al., 2018; Shen et al., 2018; Li et al., 2017), the methods of reducing the wear of working parts of pump units have not led to a radical solution of the issue of increasing the operating life.

Thus, all the above types of wear, lead to the destruction of the working elements of the pump, deterioration of operating characteristics. Consequently, improvement of the design of parts of the pump itself, providing increase of wear resistance and regulation of the operating mode of the pump unit, are actual.

The aim of the research is to justify the process of hydroabrasive wear of soil pumps, to outline the ways of its reduction.

To achieve the goal the following tasks were set:

- to analyze the problems of operation of soil pumps;
- to work out the constructive actions for increasing the life time of the soil pump and its parts;
- to carry out experimental tests of groundwater pumps.

Materials and basic methods

Pump impellers wear due to the contact of solid particles moving in the liquid with the walls of the pump's flow channels. The particles are separated by size in the impeller.

The water-abrasive wear process of pumps is a consequence of the combined effect of all types of destruction: abrasive, cavitation, erosion and corrosion at mining and processing enterprises most often replaced impellers, armored disks and pump casings (scrolls).

The catastrophic size of hydro-abrasive destruction of pump impellers indicates the great destructive capacity of the water flow containing abrasive particles (Gulich, 2010; Smirnov et al., 2019).

Figure 1 shows fragments of a new and worn pump impeller.

а) *б*)

Fig. 1 - Impeller of the soil pump 8Gr-8
a - new impeller; *b* - worn impeller

Abrasive wear of ground pump parts is determined by the formula [14]

$$\Delta_a = \Delta\rho \frac{\pi d^3}{12g} \rho_T v_T^2 n_{ch} \sin\alpha, \quad (1)$$

where Δp - coefficient taking into account the strength of the wear part material and abrasive properties of solid particles;

π - 3,14; d - average diameter of solid particles, mm;

v_T - velocity of solid, m/s;

p_r-density of solid, t/m^3;

g - acceleration of free fall, m/s^2;

α-angle of attack, degrees;

n_{ch} - number of particles colliding with the wear surface per unit time.

The main characteristics of slurry flows characterize their physical and mechanical qualities and sustainable flow conditions in the pump. The main physical and mechanical properties of hydraulic mixtures include: solid content (volumetric S or mass S_1); specific gravity γ [kN/m^3]; pseudo-viscosity μ [N· s/m^2] (for dispersed or finely dispersed mixtures) (Olimstad et al., 2018).

According to the predominant content of solid particles of a particular size class, the following main types of slurries can be distinguished:

- colloidal (atypical) - with the size of solid particles up to 1 micron;
- structural (hydrosols) with the particle size of 1-50 microns;
- fine-dispersed - coarseness of particles 50-150 microns, obtained during sedimentation, crushing;
- coarse disperse: particle size from 100 microns to 2 millimeters, obtained during sedimentation, crushing;
- heterogeneous coarse disperse - coarseness of particles over 1.5-2 mm;
- polydisperse - particles of different size, obtained in the processes of sedimentation, dispersion, grinding or crushing.

At enrichment plants of ferrous and non-ferrous metallurgy, mixtures with predominant content of particle classes characteristic of fine and coarse-dispersed systems are most often encountered (Grigoriev et al., 2017).

The innumerable collisions of flow-borne solid particles with the surface of the workpiece, even if they cause only elastic deformations of the material, also eventually lead to surface failure due to metal fatigue phenomena. In this case, the liquid medium has a destructive effect, thus accelerating the fatigue failure process (Grigoriev et al., 2017; Yao et al., 2011).

V.K. Suprun established that after processing about 100 thousand m^3 of fluid mixture by a pump, its head and supply decreased by 50% on average, while the specific power consumption per 1 m^3 of transported abrasive material increased more than 2 times (Figures 2, 3, 4) (Zhang et al., 2015).

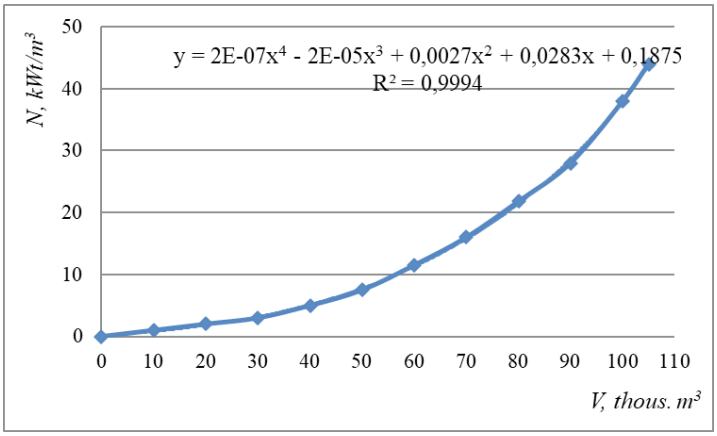


Fig. 2 - Energy consumption as a function of the volume of abrasive material to be processed

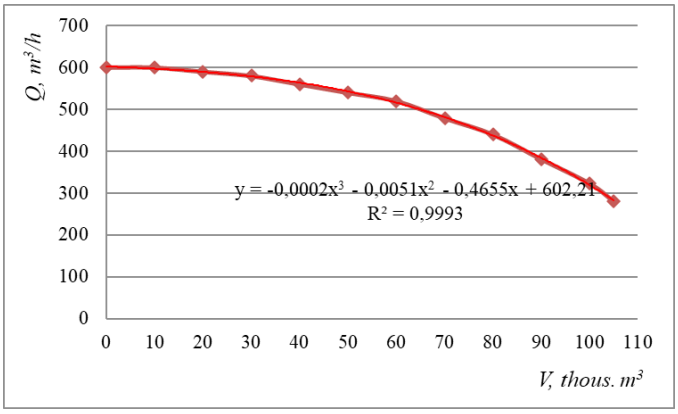


Fig. 3 - Pump flow rate as a function of the volume of abrasive material to be processed

As the volume V of the processed abrasive material increases and, consequently, the wear of working parts of the soil pump, the head *H*, the flow rate *Q* sharply decreases. Analysis of the above dependencies shows that the duration of the inter-repair period of the dirt pump should be determined by loss of mass, due to wear. But also by the reduction of the main indicators of the pump operation (*H, Q*) (Fig. 4) (Wu et al., 2017).

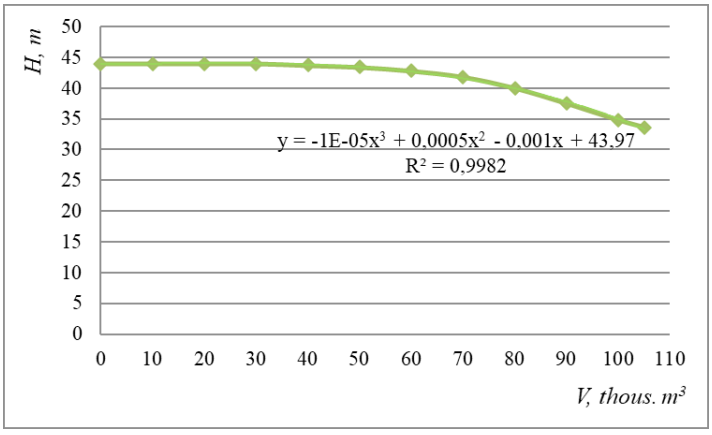


Fig. 4 - Dependence of the pump head value on the volume of abrasive material processed

As a conclusion of simulation of the process of pump units operation using multifactorial experiments and Excel computer programs for planning and processing of experimental data, regression equations were obtained to determine:

- specific power consumption from the volume of abrasive material processed, y = 2E-07x4 - 2E-05x3 + 0,0027x2 + 0,0283x + 0,1875, R^2 = 0,9994;

- the pump flow rate from the volume of abrasive material processed, y = -0,0002x3 - 0,0051x2 - 0,4655x + 602,21, R^2 = 0,9993;

- the value of the pump head from the volume of abrasive material processed, y = -1E-05x3 + 0,0005x2 - 0,001x + 43,97, R^2 = 0,9982.

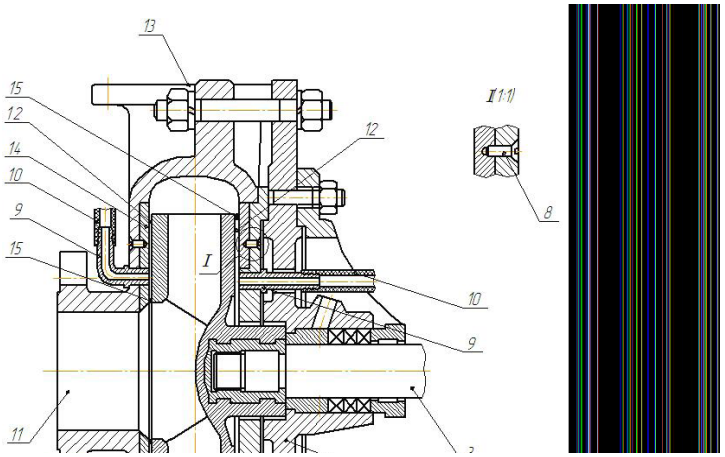
Abrasion wear of the impeller and other details of the ground pump is the main cause of reduction of service life of the pump and the whole hydraulic transportation system. At development of hydroabrasive wear of working surfaces of the impeller the change of vibration spectrum on the main support units of the pump unit is noted. Exceeding the permissible vibrations of the pump casing are transmitted to the bearing units, which perceive significant alternating dynamic loads, leading to their destruction.

If the actual flow Q_A and head H_A of the pump unit, determined at the operating point A, do not meet the specified conditions, the operating mode of the unit changes:

1) By throttling with the help of a regulating device. When it is partsially closed, the hydraulic transmission losses in the pipeline increase by the value of h_{oth}. The required head of the pumping unit increases (Fig. 5, a):

$$H'_{tubes} = H_F + K_c Q^2 + h_{oth} = H_F + K'_c Q^2, \quad (2)$$

where k^1_c is the resistance coefficient of the network with additional throttling. The operating point will move to point B. The pump flow will be reduced.



а *б*

Fig. 5 - Changing the operating point position
a - by throttling; *b* - by change of speed

The method is simple in performance, but is accompanied by power losses:

$$N_{loss} = \rho g h_{oth} \frac{Q_B}{\eta_B}, \quad (3)$$

2) By passing a part of the liquid (Q_{per}) from the discharge line to the suction line (or to the tank) through the bypass line.

3) Variation of the characteristics of the pump itself, e.g. changing the speed of its shaft (figure 5, b); Velocity control can be realized by means of a direct current motor, an internal combustion engine or turbines.

4) The motor pump itself is characterized by the rotation of the impeller, i.e. the decreasing diameter at the outlet ($D^{1}_{2} < D_{2}$). The geometrical similarity of the wheels is broken, the recalculation formulas are semi-empirical:

$$\frac{Q}{Q'} = \left(\frac{D_2}{D_2'}\right)^x ; \frac{H}{H'} = \left(\frac{D_2}{D_2'}\right)^g ; \frac{N}{N'} = \left(\frac{D_2}{D_2'}\right)^z \quad (4)$$

where *Q', H', N'* — parameters of the pump after sharpening.

In consideration not to induce an unreasonable reduction in efficiency, the amount of rotation should not exceed 7...20% of the diameter of a conventional wheel. More turning (up to 20 %) is allowed at $n_s = 60$; less at $n_s = 350$.

Results on development of design character to increase a resource of the soil pump and its parts

In order to increase the service life of groundwater pumps it is suggested, depending on the pump design, to make the impellers composite (Povetkin et al., 2021).

Figure 6 shows the impeller of the centrifugal soil pump - longitudinal section and its top view.

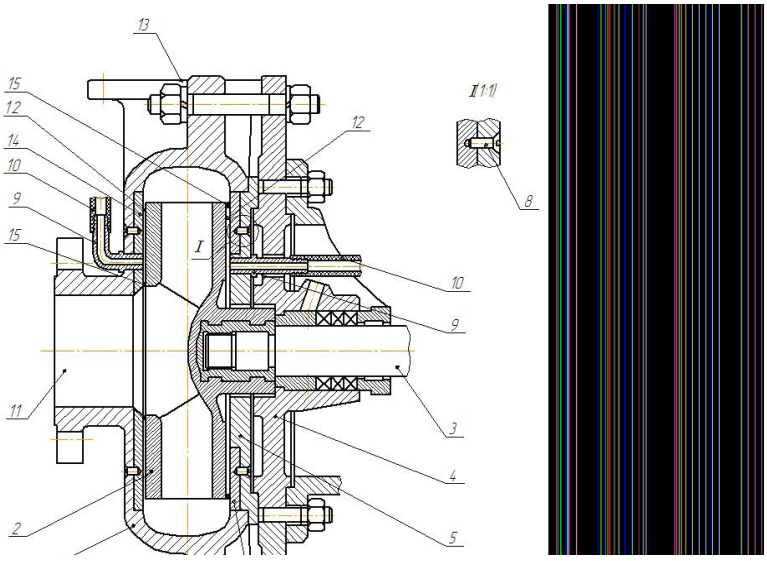


Fig. 6 - Centrifugal pump impeller

Figure 6 shows the impeller of the ground pump, consisting of a driving disk 1 with blades 2, made in one with a driving disk, driven disk 3, fixed on blades 2 by means of coupling screws 4, spring washers 5, dowel pins 6. The blades 2 of the impeller have a working surface, made on the brachystone 7 and the back side 8, made in a logarithmic spiral.

To increase the wear resistance of the ground pump impeller as a whole, on the working and back surfaces of the blades, wear-resistant coatings are cladded, with

the slave disc 3 removed (disassembled). After gas-thermal treatment the impeller is assembled with the slave disk 3 by means of pins 6 and coupling screws 4 with spring washer 5 in the holes drilled beforehand in it and in the blades. Wear-resistant coatings 8 on working and back sides of blades, obtained by gas-thermal method, are alloyed from alloying elements of steels with iron, based on standard alloy PG-Zh40 with inclusion of chrome boride CrB_2 in the charge to increase the strength of the cladding layer.

Optimal composition of chromium boride CrB_2 ligature introduced into the composition of a new cladding alloy PG-Zh40, it was found that to obtain the hardness of the clad metal equal to 450–600 HB, it is necessary to introduce it into the composition of coating within 10 %, of the total mass, %.

The angle α of blade entrance from the working side 7 is 35–450, the angle β of exit from this side is 12–170, and the angle γ of blade installation from the rear side 8 is made constant along the blade length and equal to 20–250, and the blade profile from the working side 7 is made along the brachistochrone, and from the rear side 8 - along the logarithmic spiral. Angles α, β and γ were determined as a result of tests, which showed that at these angles the minimum wear is observed when pumping abrasive medium.

Profiled, in accordance with the specified angles, the blade is characterized by an increased radial directionality of the flowing interblade channels at the inlet and reduced at the outlet. When the angle α is increased above 35^0, the inlet section is in the path of solid particles flow, which causes inevitable collision of particles with the blade in the low velocity region. Decrease of the angle β below 17^0 promotes free, without repeated collisions with the blade, passage of solid particles through the inter-blade channel, after their rebound from the blade at the inlet section.

Brachistochronous shape of the working surface 7 of the blade ensures smooth mating of the inlet and outlet parts of the blade with the specified entry and exit angles. The blade of the working surface 7 made by the brachistochrone shape, otherwise we can say that it is a curve of “fast descent” (Amel’kin, 1987).

Therefore, manufacturing of the wing impeller from composite material allows machining of internal curvilinear working surfaces. And also to cover them before assembly with a special surface coating protecting them from corrosion, cavitation and hydroabrasion, which is difficult to realize in a closed wheel. Restoring the protective coating and replacing worn parts will reduce the cost of purchasing spare part for the pump and extend the life of the pump until major overhaul.

Figure 7 shows an upgraded soil pump containing a casing, a composite impeller and an armor disc located in it, and a gap flushing system with clean water, which goes directly into the gap between the armor disc and the impeller. The armored disc is ½ the diameter with a replaceable disc of wear-resistant material on its working surface (Povetkin et al., 2021).

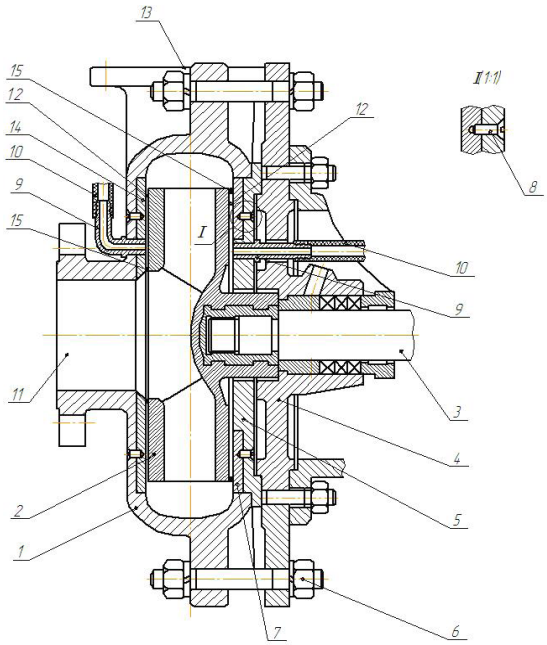


Fig. 7 - Working section of the soil pump with increased wear resistance:
1 - pump body, 2 - impeller, 3 - shaft, 4 - bearing cup, 5 - armoured disc, 6 - pump mount,
7 - replaceable disc, 8 - replaceable disc mount, 9 - supply fitting, 10 - flexible hose,
11 - suction chamber, 12 - slotted cavity, 13 - outlet pipe of volute, 14 - changeable armoured disc,
15 – gland

For constructive-technological improvement of the ground pump and its parts complex researches of wear resistance and repairability have been conducted.

As a result of studies of the laboratory model of the pump it was established that, mainly, the destruction of the impeller is associated with the wear of blades, leading to a change in their configuration, as well as possible reduction in their configuration.

The basic requirement and dependability is the service life of the oil pump. The main part of the spare parts is impellers - up to 50 %, on the armored disks 25 %, on branches and other parts 25 %.

In order to significantly reduce the wear of conveying devices of hydro-abrasive mixtures it is proposed to apply fundamentally new approaches:

- to create a vibration impact on the conveying device;
- to create a vibrating effect directly on the transported mixture..

Discussion of research results

The results achieved in the study of groundwater pumps are based on real solution methods that are both theoretical and experimental in nature.

Design solutions are made at the level of inventions issued by the RSE “National Institute of Intellectual Property” of the Ministry of Justice of the Republic of Kazakhstan (Povetkin et al., 2021).

The limitations inherent in this study are the high percentage of transported

hydroabrasive media, limiting the service life of pump units, which is the subject of further research.

The development of 3D-technology for manufacturing of the main parts of centrifugal ground pumps: spokes, impeller, armor plate, casing, with pre-established requirements of high wear resistance can become promising directions of further research. It is also necessary to conduct research on the physical effects of elastic, wave action on the transported material and the pumping unit.

The solution of technological and constructive problems on increase of a resource of work of the centrifugal soil pump, development of new designs of soil pumps, with the raised term of operation, will allow to raise productivity of manufacture, to reduce the interrepair cycles and quantity of spare parts.

Conclusion

The analysis of hydroabrasive wear and cavitation erosion processes of working parts of soil pumps, the causes of their occurrence, the nature of wear and ways of their prevention, both by changing the modes of their work and by design solutions, is performed.

On the ground of the analysis of the wear of the parts of the main flowing part of the centrifugal pump the improved designs of composite armored disk with replaceable disk and composite rotor with improved indicators of wear resistance and maintainability are developed, which allow to increase their service life, reduce the costs of spare parts acquisition to reduce the repair period. The influence of wear parts of the centrifugal oil pump on its operating parameters has been determined, the dependence of the pump head and flow rate on the volume of pumped water-jet mixture has been established.

The effect of slurry properties and stream parameters on centrifugal pump wear has been established, and analytical and experimental dependences of wear of pump working parts - armor plate and impeller on slurry density and particle size of solid particles have been found. The basic trends of service life extension of wear parts, selection of high-strength steel and wear-resistant coatings, as well as improvement of pump design and evaluation of influence of physical fields of impact on the conveyed material and pump unit are determined.

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