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Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
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GEAR PUMP QUALITY IMPROVING BY CHANGING THE DESIGN AND SIZE OF THE SUPPORT BUSHINGS

Abstract. Productive and uninterrupted operation of the chemical, oil, geological exploration and other sectors of the national economy of the Republic of Kazakhstan directly depend on the quality of work of units and assemblies of technological equipment, in particular, from hydraulic drives and hydraulic machines. The development of the chemical technology of oil and gas cannot be carried out without the improvement and automation of technological equipment, mechanisms and assemblies, which are accompanied by continuous improvement of their design and the degree of use of hydraulic devices in them. The main units of each volumetric hydraulic transmission used in the chemical technology of oil and gas are hydraulic pumps, gear pumps (GP). An extended study was conducted to determine the main causes of premature failures of gear pumps associated with breakage and wear of parts. The results of the survey showed thatwear and breakage of parts occur in the initial stage of operation of the gear pumps. The reason for this may be the imperfection of the pump design, poor quality assembly and machining of parts. The authors propose a "biaxial connection" based on the theory, which will change the design, technology of mechanical processing and assembly of parts and assemblies of gear pumps. The use of a biaxial connection in the gear pump design led to a change in the design of the support bushings and the system for setting their dimensions. It is established that partial restriction of relative movements of individual parts of the gear pump leads to an increase in quality indicators. The research was carried out within the framework of the grant №AP09562459.

Key words: Gear pump, support bushing, sliding element, biaxial connection, landing, wear.

Introduction. Gear pumps of the gear pump type are intended for pumping mineral oil in hydraulic systems of tractors, loaders, agricultural, municipal, road construction machines and other equipment. To determine the main causes of premature failures of gear pumps associated with breakage and wearof parts, an extended study was conducted. The works devoted to the study of deterioration and breakdowns of gear pump parts were studied, as well as the state of the issue in the conditions of production of machine-building enterprises was analyzed. Analysis of references and patent sources has shown that a lot of work is devoted to the problem of improving the quality of performance of the gear pump. Let's take a closer look at some of them.

Issues of improving the quality of manufacturing, repair and restoration of gear pump parts are considered in the works [1,2,3,4,5,6]. In [1, p.5], a technology for restoring aluminum bushings of gear pumps with diffusion metallization is proposed. In [2, p. 12; 3, p. 53] it is achieved by improving the quality of production of serrated gearing due to the formation of ceramic and polymer coatings. And in [3, p. 23] the method of correction of serrated gearing was used for this purpose. Some technologies for repairing gear pumps are considered in [4, p. 21; 5, p. 46]. Technological processes for restoring pumps of the gear pump-32 type are described in [7]. However, the use of these technologies for manufacturing gear pumps in modern production is not possible, due to the renewal of the fleet of technological equipment. In [8], a method for controlling the quality of assembly of gear pump parts was developed, as a result of which the problem of stabilizing the side gap in the gear engagement was solved. Work [9] is aimed at developing a technological process for restoring and strengthening the sliding bearings of oil pumps gear pump -50 U, made of aluminum alloy AK9M2

GOST 1583-93. The author proposed a method for strengthening and restoring the sliding bearings of gear pumps gear pump-50 U CVD-method of metallorganic compounds. The results of the study on improving the durability of gear pumps by restoring and strengthening worn surfaces of parts by electric spark treatment (for example, the gear pump-50 U) are presented in [10]. The author uses a method of electric spark processing when restoring worn parts of the pump. The paper reveals the regularities of the formation of gaps and wearing of the working surfaces of friction pairs, as well as the calculation of the components and closing links of the technological and dynamic dimensional chains of the pump. Works are devoted to the development of a new technology for repairing pumps of the gear pump-K type by restoring and strengthening deteriorated parts using the combined method [11,12,13,14]. They proved that the methods of electric spark processing (ESP) - electric spark surfacing and hardening and cold gas dynamic deposition (CGDD) of powders can be applied to restore the size of deteriorated parts of circular gear pumps. The mathematical model between internal leakage, volumetric efficiency and clearances in mates, as well as the mathematical model of the relationship between the modes of ESP and hardness of the metal plating layerareproposed.

In [15], the causes of failure and wear of gear pump elements used in the aviation industry are investigated. It is noted that the main reason for the growth of volumetric leaks of the working fluid in the cavities of the gear pump and the drop in its volumetric efficiency may be wear of the working profiles of the teeth and surfaces of the gear pump bearings. In practice, when the volumetric efficiency is reduced to 0.65, gear pumps are considered inoperable. The main defects of parts of the gear pump [16]: wear of cylindrical surfaces of housing wells; wear of bronze bushings on the ends and inner diameter. Figure 1 shows photos of gear pumps parts that are subject to wear.

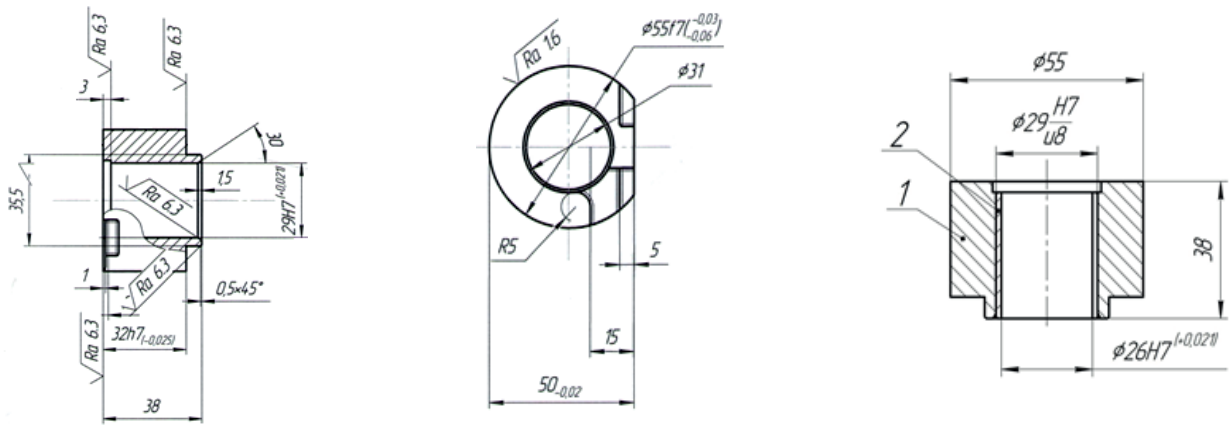
a) b) c) d)

a, b-wear of the housing opening; c-wear of the outer surface of the bushing; d-wear of the tooth height of the gear wheel.

Fig. 1-Photos of gear pump parts that are subject to wear.

The results of the analysis showed that wear and breakage of parts occur in the initial stage of operation of the gear pump. The reason for this may be the imperfection of the pump design, poor quality of assembly and machining of parts. Basically, all these works are devoted to solving production and technological problems in a narrow direction, i.e. ensuring the specified resource of gear pumps, manufacturing and restoring worn parts, general issues of repair, restoration, maintenance regulations, testing and improving the quality of assembly, etc. Taking into account the results of the analysis, we came to the conclusion that there is a problem in the quality of manufacturing gear pump products. The authors developed a connection called “biaxial”, which leads to the creation of a new pump design with high performance [17,18,19,20]. In this regard, the paper [21] proposes a “biaxial connection” based on the theory, which will change the design, technology of mechanical processing and assembly of parts and assemblies of gear pumps. The essence of the “biaxial connection” is that the surface of the shaft or the hole of the bushing is made in the form of the intersection of two cylindrical surfaces with different diameters and parallel axes offset by some eccentricity. Theoretical studies show a number of advantages of the new compound over traditional compounds. This connection is particularly relevant when used in shaft-gear connection designs (hydraulic machines, in particular gear pumps).

Materials and methods. The use of a biaxial connection in the gear pump design led to a change in the design of the support bushings and the system for setting their dimensions. Figure 2 shows drawings of bushings bearing gear pump-50 type gears.



a) *b)*

a - bushing; b –bushing assembly with a bushing-sliding bearing

Fig. 2-Drawings of bushings bearing gear wheels of gear pump-50

The supporting bushing shown in figure 3, shows the bushing with the traditional formulation of the dimensions. For example, the flat on the bushing (figure 3) of the gear pump-50 is located at a distance of $22{,}5^{-0{,}02}$мм. This size setting can be considered correct from the point of view of the manufacturability of the design for its manufacture. Figure 3 shows two drawings of the support bushing in the end section of the gear pump-50. In the drawing, figure 3a is a traditional sizing scheme. Figure 3b shows the new dimension of the support bushing that is being offered.

a) *b)*

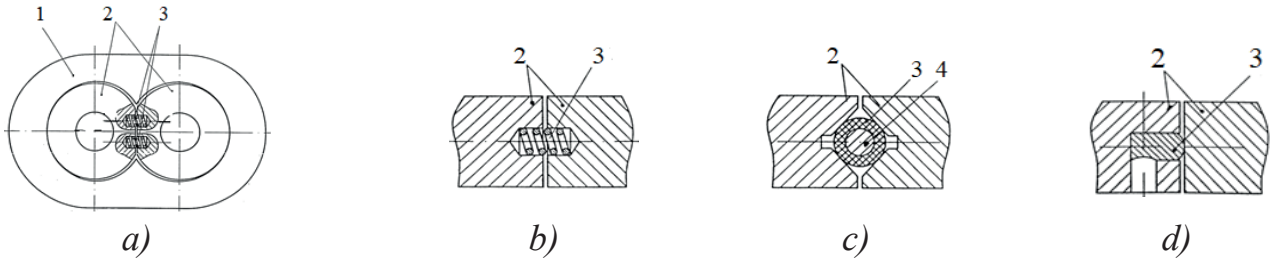
a - the traditional scheme of setting of the dimensions; b - thenew proposed dimensioning of the support bushing

Fig. 3-Drawings of the support bushing in the end section of the gear pump-50

Analyzing the position of the support bushings in the pump housing of the gear pump, it can be seen that the movement of the support bushings along the axis of the center distance is limited to two bars located at a distance of $22{,}5^{-0{,}02}$ ммand the cylindrical surface of the flat $\emptyset 55f7^{-0{,}03}_{-0{,}06}$. The distance between the contact surfaces along the center distance line in figure 4a will be equal to the sum of the dimensions $22{,}5^{-0{,}02}$ and $0{,}5 \times 55^{-0{,}03}_{-0{,}06}$ mm. In the design of the support bushings, replacing the specified amount of distances with one sizeis suggested. This size will be the size of $50g6^{-0{,}009}_{-0{,}025}$ mm.The accuracy quality and the selected fit are traditionally used in the mass production of components and mechanisms that are subject to increased requirements, such as gear pumps [22,23,24].

Results. A distinctive feature of the gear pump type pumps is that inside the pump housing, four support bushings and two shaft gears do not have fixed positions relative to the pump housing. All the mentioned parts are mounted relative to each other with a guaranteed clearance. That is, the pinion shaft mounted on the support bushings is assembled in the pump housing with guaranteed clearances. During the operation of the gear pump, contact interaction forces occur between the parts, which lead to relative movements of all parts inside the pump body within the gaps in the connections. It is practically very difficult to foresee the magnitude and direction of relative movements inside the gear pump. The influence of relative displacements

can be determined indirectly by such indicators as pump noise, pump body heating temperature, wear of mating parts, etc. exceeding the permissible values for each of the indicators is not desirable. Based on the clearances and deviations in the dimensions of the contacting surfaces of the pump housing, support bushings, and pinion shafts, the maximum value of relative displacements in the direction of the center distance and in the direction perpendicular to themcanbecalculated. This solution will only allow judging the numerical values of relative offsets. It will be difficult to judge quality indicators. One of the tasks of improving quality indicators was to partially limit the relative movements of individual parts. This solution was the proposal to install sliding elements between the support bushings that would push the support bushings to the direct contact of the cylindrical surface of the support bushing and the surface of the cylindrical hole in the pump housing. Figure 4 shows the connection of the support bushings to the expansion elements in the holes of the pump housing.



a - the position of the bushings in the gear pump housing; b,c - options for expansion joints; d-expansion joint with a solid element made of soft material; 1-pump housing; 2-support bushings; 3-expansion elements; 4-core.

Fig. 4-Connecting the support bushings to the expansion elements in the holes of the pump housing.

Discussion. Figure 4*a* shows the positions of the bushings in the gear pump housing. Figures 4 *b,c* and *d* show options for expansion joints. Thus, figure 4*b* shows the release elements in the form of springs. In figure 4*b*, the release element is a body with a rigid core located between V-shaped depressions. Figure 4*d* shows a solid-body compression element made of a soft material that selects the available gap between the support bushings due to deformation through the hole in the end part of the support bushing. According to the design of the patent [25], a prototype of support bushings and expansion elements was made. Figure 5 shows the manufactured prototypes of support bushings and expansion elements.

a - support bushings; b-support bushings with expansion elements

Fig. 5-Prototypes of support bushings and expansion elements

The conducted studies have shown that the installation of sliding elements between the support bushings pushes the support bushings to the direct contact of the cylindrical surface of the support bushing and the surface of the cylindrical hole in the pump housing. This provides a partial restriction of the relative movements of individual parts of the gear pump, which leads to an increase in quality indicators.

Conclusions. It is established that, as follows from the design of the gear pumps, the gap between the bushings leads to the formation of a reverse flow of the injected oil and, consequently, to a decrease in the performance of the gear pumps.

It was found that partial restriction of relative movements of individual parts of the gear pump leads to an increase in quality indicators. This is achieved by installing sliding elements between the support bushings, which push the support bushings to the direct contact of the cylindrical surface of the support bushing and the surface of the cylindrical hole in the pump housing. The research on the gear pump design (under patent No. 27941) showed that the diameters of the support bushingof the shaft gear cannot be the same size and the same fit. If the outer diameters of the support bushing and the pinion shaft are the same, the pinion shaft rotation may be jammed.

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ТІРЕКТІ ТӨЛКЕЛЕРДІҢ ҚҰРЫЛЫМЫН ЖӘНЕ ӨЛШЕМДЕРІН ҚОЮДЫ ӨЗГЕРТУ АРҚЫЛЫ ТІСТЕГЕРІШТІ СОРҒЫНЫҢ САПАЛЫҚ КӨРСЕТКІШТЕРІН АРТТЫРУ

Аннотация. Қазақстан Республикасының химия, мұнай, геологиялық барлау және басқа да халық шаруашылығы салаларының өндірістік және үздіксіз жұмысы технологиялық жабдықтың тораптары мен агрегаттарының, атап айтқанда, гидрожетектер мен гидромашиналардың жұмыс сапасына тікелей байланысты. Мұнай мен газдың химиялық технологиясын дамытуды технологиялық жабдықтарды, механизмдер мен агрегаттарды жетілдірусіз және автоматтандырусыз жүзеге асыру мүмкін емес, бұл олардың конструкциясы мен гидравликалық құрылғыларды пайдалану дәрежесін үздіксіз жетілдірумен қатар жүреді.

Жоғарыда аталған салаларда гидравликалық сорғылардың басқа түрлерімен қатар тісті сорғылар (ТС) кеңінен қолданылады. Тістегерішті сорғылардың бөлшектерінің бұзылуы мен тозуына байланысты уақытынан бұрын істен шығуының негізгі себептерін анықтау үшін біз кеңейтілген зерттеу жүргіздік. Тістегерішті сорғының тозуы мен бұзылуын зерттеуге арналған жұмыстар зерделенді және машинажасау кәсіпорындарының өндірісінде туындайтын мәселенің жағдайына талдау жасалды. Талдау нәтижелері бөлшектердің тозуы мен бұзылуының ТС-ны пайдаланудың бастапқы кезеңінде орын алатынын көрсетті. Оның себебі сорғы құрылымының жетілдірілмеуі, бөлшектердің тиімсіз орналастырылуы мен механикалық өңдеуінің сапасыздығы болуы мүмкін. Жүргізілген талдау нәтижелерін ескере келіп, біз тістегерішті құралды сапалы шығаруда проблемалар бар деген қорытындыға келдік. Авторлар тарапынан «екіөсті» деп аталатын жаңа қосылыс түрі жасалған, осы қосылысты қолдану арқылы жоғары өнімділікке ие болған тістегергіш сорғының жаңа құрылымы жобаланды. Екі өсті қосылысты қолдану тірек төлкелерінің құрылымының өзгеруіне және олардың өлшемдерін қою жүйесінің өзгеруіне алып келді.

Патент №27941 құрылымына сәйкес тірек төлкелері мен ажырату элементтерінің тәжірибелік үлгісі әзірленді. Жүргізілген зерттеулер тірек төлкелерінің арасында орнатылған ажырату элементтерінің тірек төлкелерін тірек төлкелерінің цилиндрлі қабаты мен сорғы корпусының цилиндрлі саңылауының қабаты тікелей байланысқа түскенше ажыратып тұратынын көрсетті. Осы арқылы сапа көрсеткіштерін арттыруға жол ашатын ТС-ның жекелеген бөлшектерінің қозғалысқа түсуін ішінара шектеуді қамтамасыз етеді.

Түйінді сөздер: тістегергішті сорғы, тіректі төлке, керуші элемент, екіөсті қосылыс, орнатпа, тозу.

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УДК 621. 664

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ПОВЫШЕНИЕ КАЧЕСТВЕННЫХ ПОКАЗАТЕЛЕЙ НАСОСА ШЕСТЕРЕННОГО ЗА СЧЕТ ИЗМЕНЕНИЯ КОНСТРУКЦИИ И ПРОСТАНОВКИ РАЗМЕРОВ ОПОРНЫХ ВТУЛОК

Аннотация. Производительная и бесперебойная работа химической, нефтяной, геологоразведочной и других отраслей народного хозяйства Республики Казахстан напрямую зависят от качества работы узлов и агрегатов технологического оборудования, в частности от гидроприводов и гидромашин. Развитие химической технологии нефти и газа невозможно осуществить без совершенствования и автоматизация технологического оборудования, механизмов и агрегатов, которые сопровождаются непрерывным усовершенствованием их конструкции и степени использования в них гидравлических устройств. В вышеуказанных отраслях наряду с другими типами гидравлических насосов широко применяются шестеренные насосы (НШ). Для определения основных причин преждевременных отказов насосов шестеренных, связанных с поломкой и износом деталей, нами было проведено расширенное исследование. Были изучены работы, посвященные исследованию износа и поломок деталей насосов шестеренных, а также проанализировано состояние вопроса в условиях производства. Результаты анализа показали, что износ и поломка деталей происходит и на начальном этапе эксплуатации НШ. Причиной этому может быть несовершенство конструкции насоса, некачественная сборка и механическая обработка деталей. Учитывая результаты проведенного анализа, мы пришли к выводу о существовании проблемы качества изготовления изделий шестеренного насоса. Авторами разработано соединение, называемое «двухосным», которое приводит к созданию новой конструкции насоса с высокой производительностью. Применение двухосного соединения в конструкции НШ привело к изменению конструкции опорных втулок и системы простановки их размеров. Согласно конструкции по патенту №27941 был изготовлен опытный образец опорных втулок и разжимных элементов. Выполненные исследования показали, что установление между опорными втулками раздвижных элементов раздвигает опорные втулки до непосредственного контакта цилиндрической поверхности опорной втулки и поверхностью цилиндрического отверстия в корпусе насоса. За счет этого обеспечивается частичное ограничение относительных перемещений отдельно взятых деталей НШ, которые приводят к повышению качественных показателей.

Ключевые слова: насос шестеренный, опорная втулка, раздвижной элемент, двухосное соединение, посадка, износ.

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