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THE EFFECTIVENESS OF THE USE OF NANOTECHNOLOGY IN INCREASING THE RESOURCE OF OILFIELD EQUIPMENT

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ABSTRACT

The current stage of development of science and technology is characterized by the level of application of nanotechnology. The scope of application of this technology in industry is increasing every day. For the first time in Azerbaijan, nanotechnology has been applied in the oil sector and has had a serious impact on the level of oil and gas production. The republic has adopted three Nanoneft programs covering 2010-2015, 2016-2020 and 2021-2025. These programs have become a great incentive for the development of this field of science. Currently, nanotechnologies are successfully applied in such areas as oil production, well drilling, petrochemistry, ecology, geology, and petroleum engineering. The article considers the possibility of using nanotechnology in the designs of oil and gas field equipment in order to increase their reliability and durability.

KEYWORDS

Equipment for oil and gas fields; Nanotechnology; Reliability

1. Introduction

Despite the fact that petroleum science has a rather long history, the use of nanomaterials and nanotechnologies in this sector of the Azerbaijani industry dates back to the 80s of the twentieth century. At the same time, the rapid development of this direction is associated with the beginning of the XXI century, covering such industries as mechanical engineering, defense industry, information sphere, radio electronics, energy, transport, biotechnology, medicine, etc.

Nanotechnology is a new direction about the creation of modified technologies based on the use of components with particle sizes less than 100 nm (10-9 meters), having a fundamentally new quality.

Currently, more than 30 countries of the world have adopted national programs for the development of nanotechnology in a wide range of industries of oil and gas extraction and processing, their conservation and transportation. For the first time in Azerbaijan, nanotechnology was applied in the oil sector, covering such areas as «Nano-mining», «Nanoburring», «Nanoneftekhim» and «Econanoneft».

Three Nanoneft programs covering 2010-2015, 2016-2020 and 2021-2025 have become a great incentive for the development of this area of science.

Currently, with the use of NT, good results have been achieved in the fight against salt formation and sand jams, as well as with deposits of paraffin and various resins [1].

When using nanosolutions in the drilling process, an increase in penetration was achieved, since the use of nanosystems contributes to a sharp decrease in the coefficient of friction in the «clay shell-drilling tool» contact. In parallel with this, their synergistic effect was established, in particular, an increase in the corrosion resistance and wear resistance of the chisels.

It is known that [2, 3] heavy waterlogging of sediments and low permeability of formations complicate the extraction process. This requires the development and application of new innovative technologies, including nanotechnology.

In the works discussed above, the following issues were mainly studied: the impact of nanosystems on the productivity of production processes, combating waterlogging of wells, reducing energy costs for pumping, lifting and preparing oil; utilization of low pressure and associated petroleum gas, environmental problems, etc. were touched upon. At the same time, the issues of increasing the durability of oilfield equipment due to the use of NT were considered to a lesser extent [4].

In this part, it is possible to note developments on the practical application of nanotechnology in the field of creating structural materials that increase strength, operational and special properties due to the nanocrystalline structure [5-7].

2. Statement of research objectives

Based on the above, the purpose of this work is the tactical and strategic possibilities of using nanotechnology in oilfield equipment.

Since 2015, nanotechnology has found applications in such sectors as geology and oilfield equipment. Therefore, the use of nanotechnology in the structures of oilfield equipment, in order to increase their reliability and durability is relevant (fig.1).

The purpose of this work is to study the possibility of using nanotechnology in the structures of oilfield equipment, in order to increase their reliability and durability.

By analyzing the main causes of failures of OGFE parts and assemblies, it was found that they can be combined as corrosion, wear and deformation. In parallel, it was found that steels, polymers and compositions based on them, as

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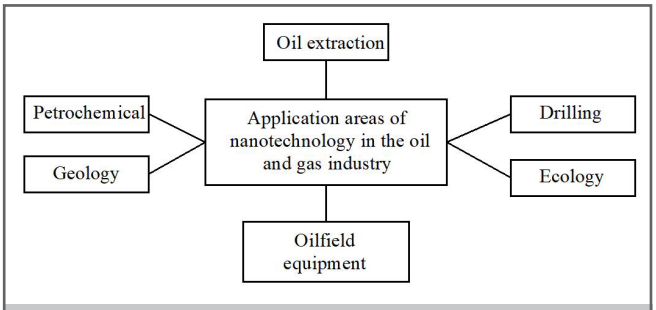

Fig.1. The main directions of nanotechnology application in the Azerbaijan oil sector

well as rubber of various brands are used as materials for their manufacture.

Table 1 shows the rate of application of polymer materials in the structures of oilfield equipment.

As can be seen from the analysis of table, when the use of plastic materials applied in parts and nodes of the ODE significantly decreased compared to 1970, the number of them began to increase in dynamics in the following years.

Depending on the operating conditions and constructive characteristics of the oil drilling equipment, various requirements are imposed on the plastic materials applied here. The requirements of machine parts made of metal are classified in 4 groups depending on their functional purpose: connecting, sealing, parts used in power and friction units. As a result of our research, it has been established that the requirements in parts made of polymeric materials can be grouped according to the following indicators:

- by designation: threaded parts, transmission nodes (rotation, displacement, etc.);
- according to geometric characteristics;
- according to its constructive structure: monolithic and hybrid parts, fittings and parts included in the plug assembly.
- polymer-based coating materials.

Taking into account the above, polymeric materials used in the structures of the OGFE can be included in the following requirements: high mechanical strength, dimensional accuracy, wear resistance and resistance to external aggressive environment. In addition, it should be borne in mind that in the country's conditions, oil and field equipment is affected by a wide range of atmospheric changes, and it is very important to take into account these factors. The fact that the operating conditions are below and above the norm leads to the rapid disintegration of the materials used in the structures of the OGFE or to a change in their properties. Also, due to air pollution, intensive wear of rubbing surfaces of parts can occur, for example, in Absheron Peninsula, there are frequent winds accompanied by storm, as a result of which large amounts of dust and sand are emitted into the air. It has been established that the climatic conditions in yistism are very complex, sometimes the atmospheric temperature varies within the limits from -20 to + 48 °C.

Depending on the seasonal changes, the average annual relative humidity in the country is 70-72 %, in winter it rises to 81-88 %, and in summer it falls to 50-55 %.

Based on the above, a group of details of oilfield equipment for the use of polymer materials with nanonized surfaces were selected for further research

Figure 2 shows the operating conditions and functional purposes of oil and gas field equipment, the main materials for the manufacture of their parts and assemblies, as well as a list of parts where nanotechnology can be used.

It is known [8] that modern oil and gas field equipment (OGFE) is operated in specific and difficult conditions. During operation, many parts and interfaces experience significant cyclic and variable loads, the influence of abrasive and aggressive media. These have a strong effect on the bearing capacity of OGFE. One of the innovative approaches to eliminate these shortcomings is the use of nanotechnology.

As a result of field observations of OGFE's work, we have selected a number of parts and assemblies for the near future as research objects, in the manufacture of which it is advisable and initially nanotechnology will be used. The list of such components and parts includes fittings for fountain fittings, couplings and a plunger pair of rod borehole pumps, the working body of electric pump units, sealing cuffs, including oil seals and sealing rings of oilfield pumps, etc. The design of some are shown in figure 3.

As can be seen from the analysis of figure 3, these details are applied mainly to protect the grooved surfaces from damage, which are not subject to force and overloads, as well as to protect them from damage. The requirements for obtaining accuracy is out as a key factor in their preparation. However, in some cases, it is required to solve complex requirements for the preparation of precision abrasive wear resistance (filter pumps), as well as parts subject to friction wear (working rod of electric submersible Nano).

Hybrid (metal+polymerized composite) parts used in the structures of equipment from oil were reflected (fig. 4).

Nanotechnology has been successfully applied in the structures of ceramic parts, in particular in the manufacture of fountain fittings [9-11]. In 2019, 386 units of nanostructured fittings of various diameters (3-16 mm) were tested in various oil-producing divisions of Azneft PU, including OPD «28 May» (121 wells), OPD «Neft Dashlari» (152 wells), OPD «Absheronneft» (101 wells) and «Bibi-Eybatneft» (12 wells).

Thanks to the use of nanotechnology, the efficiency of fittings used to regulate the pressure in fountain fittings has been dramatically increased. With the use of nanotechnology, the breakage of sectional connections of electric submersible pumps was practically eliminated,

Table

Information about polymeric materials applied in oilfield equipment

Indicators	By years						
	1970	1995	2000	2005	2010	2015	2020
Number of parts made of polymer material, PCs	300	52	75	78	90	91	98
Thermoplasts, ton	258.3	46.6	65.5	67.2	81.5	85.8	86.6
Reactoplasts, ton	85.2	16.8	22.1	34.1	45.9	57.6	66.2
Coating materials, ton	2123.5	1224.3	1625.8	1764.3	1805.5	1866.4	1902.2

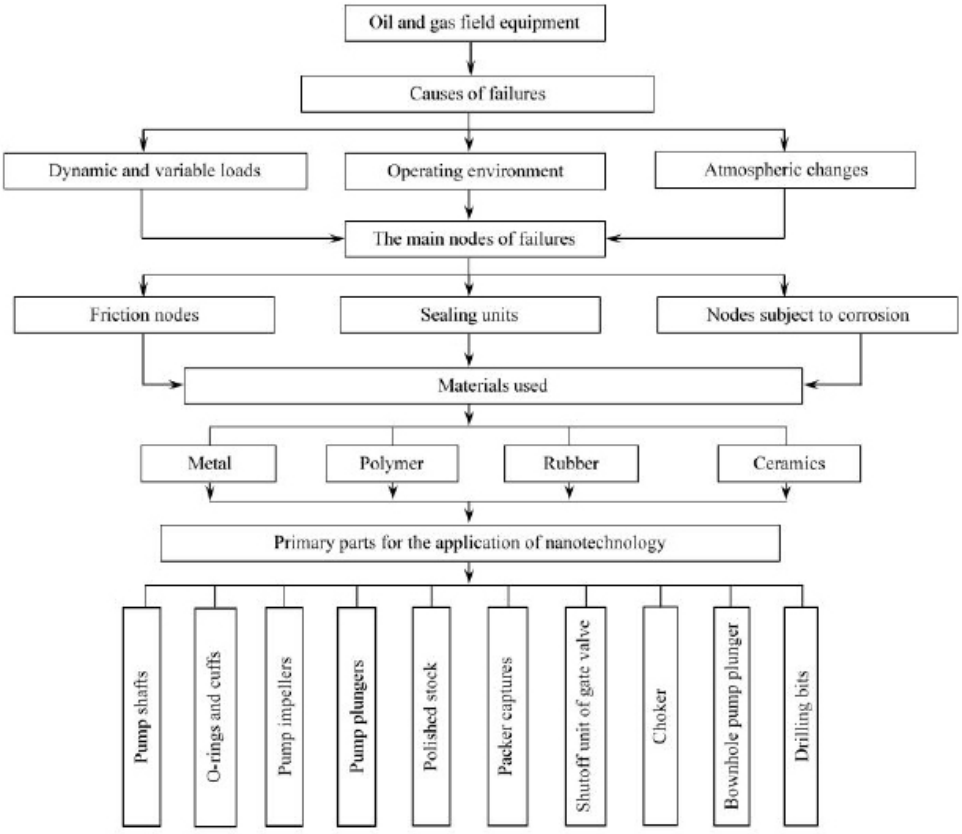

Fig.2. Operating conditions of oil and gas field equipment and a list of parts recommended to be manufactured using nanotechnology

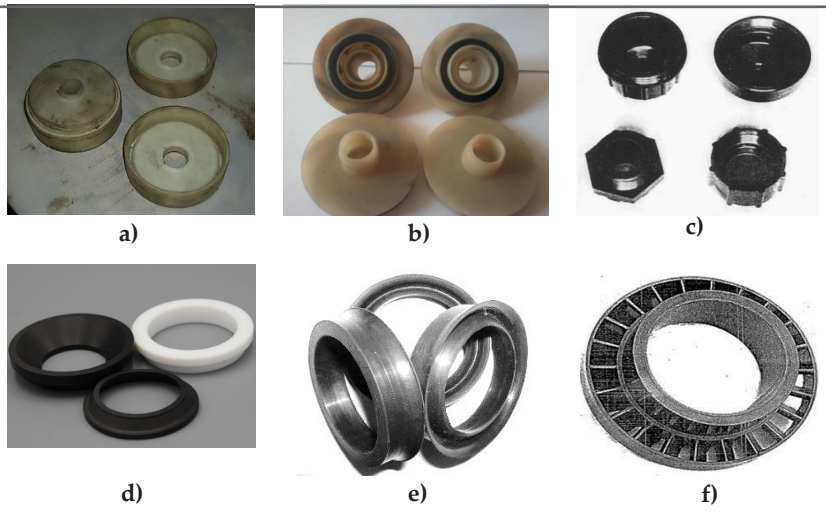

Fig. 3. Parts and knots of oil equipment made of plastic and polymer based composition materials. a),b) working step of submersible pump; c) threaded caps made of thermoreactive materials; d) sealing cuffs; e) drilling pump polymer - based composites; f) rotor of truboburus from prestoz

and for the period 2017-2020, no accidents were observed due to «flights» of pump sections.

As a result of field observations of the operation of 100 electric centrifugal pumps (ECP), it was found that the average operating time to failure due to mechanochemical damage to the studs of flange connections is 70-150 days.

With the use of nanocoating, the breakage of the sectional connections of the ECN was actually eliminated, and in 2018-2020, emergency situations due to «flights» of pump sections were not observed.

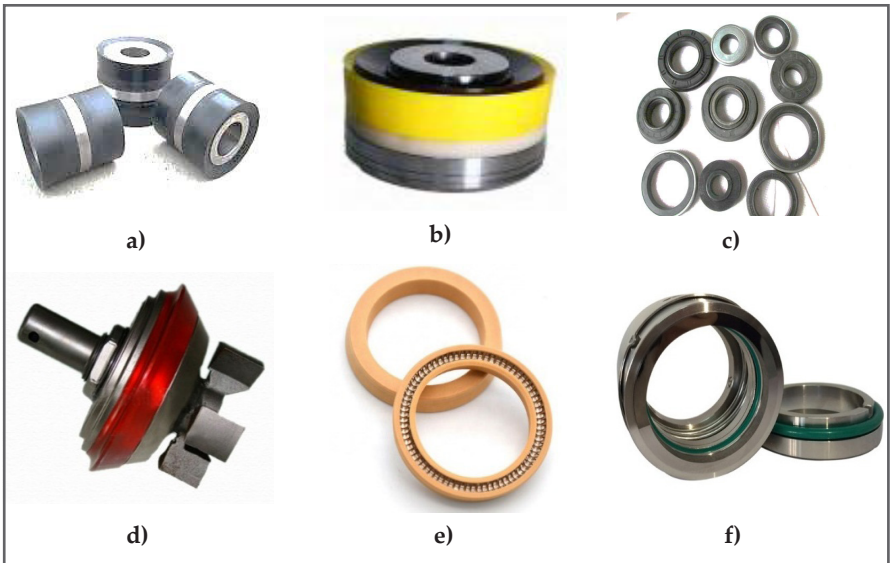

Fig. 4. Hybrid (composite based on metal+polymer) parts used in oil-bearing equipment: a), b) piston of oil-bearing pumps; c) metal + polymer seals; d) valve of oil-bearing pump; e) spring elastamer rings used in water pumps

Conclusion

Thus, the following conclusions can be drawn:

- the use of nanotechnology has broad prospects for improving the efficiency of oil and gas complex equipment, while further development of the theory and practice of using nanotechnology in oil and gas field equipment is important.
- fillers are the most important element of the structure of polymer nanocomposite materials.
- the properties of composites are largely determined, among other parameters, also by the area of the interface and the intensity of intermolecular interactions between the matrix and filler materials. The transition to nanoscale fillers while optimizing the parameters of their synthesis allows not only to reduce their specific consumption, but also to obtain materials with higher performance characteristics.
- among the specific areas of application of nanotechnology to improve the efficiency of development, it is indicated: an increase in oil recovery (by 40-60%); a reduction in the water content of the extracted oil and environmental improvement of the entire complex.

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Эффективность использования нанотехнологий в конструкциях нефтепромыслового оборудования

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Реферат

Современный этап развития науки и техники характеризуется уровнем применения нанотехнологий. Сфера применения этой технологии в промышленности увеличивается с каждым днем. Впервые в Азербайджане нанотехнологии были применены в нефтяном секторе и оказали серьезное влияние на уровень добычи нефти и газа. В республике приняты три программы «Нанонефть» на 2010–2015, 2016–2020 и 2021–2025 годы. Эти программы стали большим стимулом для развития этой области науки. В настоящее время нанотехнологии успешно применяются в таких областях, как нефтедобыча, бурение скважин, нефтехимия, экология, геология, нефтегазовое дело. В статье рассмотрена возможность использования нанотехнологий в конструкциях нефтегазопромыслового оборудования с целью повышения их надежности и долговечности.

Ключевые слова: оборудование для нефтегазовых месторождений; нанотехнология; надежность.

Neftmədən avadanlıqlarının konstruksiyasında nanotexnologiyaların tətbiqinin səmərəliliyi

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Xülasə

Elm və texnikanın müasir inkişaf mərhələsi nanotexnologiyaların tətbiqi səviyyəsi ilə səciyyələnir. Sənayedə bu texnologiyanın əhatə dairəsi günü-gündən artır. Azərbaycanda ilk dəfə olaraq nanotexnologiyalar neft sektorunda tətbiq edilmiş və neft və qaz hasilatının səviyyəsinə ciddi təsir göstərmişdir. Respublikada 2010-2015, 2016-2020 və 2021-2025-ci illər üçün üç Nano-neft proqramı qəbul edilmişdir. Bu proqramlar bu elm sahəsinin inkişafı üçün böyük stimul oldu. Hazırda nanotexnologiyalar neft hasilatı, quyuların qazılması, neft kimyası, ekologiya, geologiya, neft-qaz biznesi kimi sahələrdə uğurla tətbiq olunur. Məqalədə neft və qaz avadanlıqlarının etibarlılığını və davamlılığını artırmaq üçün onların layihələrində nanotexnologiyalardan istifadə imkanları nəzərdən keçirilir.

Açar sözlər: neft və qaz yataqları üçün avadanlıq; nanotexnologiya; etibarlılıq.