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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

DEVELOPMENT OF INNOVATIVE METHODS TO INCREASE OF THE LIFETIME OF EQUIPMENT AND PIPELINES IN WELL-COLLECTOR SYSTEMS

Specialty: 3354.01 - Construction and operation of oil and gas pipelines, bases and storage facilities

Field of science: Technical science

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MAIN CHARACTERISTIC OF THE WORK

Relevance and degree of development of the topic

The rapid development of the oil and gas industry in modern conditions requires the creation of new, improvement of existing equipment and technologies, increasing the lifetime of equipment and pipelines of systems for collecting and transporting oil from a well. The main disadvantage of underground and surface downhole equipment, most of which is made of steel and its various brends, including corrugated pipes, sucker rods, tubing, collection and transportation lines, despite of their mechanical strength, rigidity and low cost, is susceptibility to influence of corrosion, premature failure due to precipitation of salt, paraffin and asphalt-resin compounds. Equipment and transport pipelines used in oil recovery systems from wells are subject to corrosion during operation of the initial period to the last period of oil and gas field development, depending on the aggressiveness of the product, operating method of the wells, the environment and conditions.

The thesis presents the results of the introduction of innovative methods in the field of corrosion protection to increase the lifetime of equipment and pipelines in oil collection systems from wells - with a higher scientific and technical level, i.e. research, technological processes, materials used and organizational work in comparison with previous years, corresponding to the new requirements for consumer quality. A new multifunctional heat-resistant complex-acting bactericidal type corrosion inhibitor was studied using local raw materials, and a technology for its injection into a well was developed. The inhibitor creates a “protective curtain” on the metal surface that prevents corrosion by preventing the interaction of aggressive corrosive components with the metal. Since only the inner surface of pipes can be protected from corrosion by corrosion inhibitors, another area of research is the development of a technology for insulating the outer surface of pipes using coatings of corrosion-resistant, shock-resistant and wear-resistant glass-basalt plastic composite materials in the restoration and construction of tanks and other metal containers. Recently, extensive research has been carried out in the field of oil production to replace metal equipment and pipes with one-piece plastic materials. For this purpose, a technology has been developed for manufacturing protective pipelines, tubing and pumping rods from a solid basalt-fiberglass composite material for use in wells with increased corrosiveness. The use of these technologies leads to an increase in the lifetime of equipment and transport pipelines in oil product collection systems, as well as to a sharp decrease in the number of underground and surface repairs, and an increase in the duration of the overhaul period. As a result, the cost of oil and gas is decreased, and the overall cost of production is significantly reduced.

Goals and objectives of the study

The aim of the study is to develop innovative methods in the field of protecting equipment and transport pipelines in oilfield gathering systems from corrosion in order to increase their lifetime. The object of the research is the equipment and transport pipelines operated in the collector systems of wells. The main objectives of the study are to solve the following complex issues:

- analysis, research and study of operating conditions and condition of equipment and transport pipelines in well-collector systems based on laboratory studies, field tests and practical observations;
- factors affecting the service life and capacity of wellhead equipment and transport pipelines in certain periods of oil and gas field development and when using various well operation methods;
- composition, physico-chemical properties and characteristics of the main components in oil and gas products that cause corrosion of equipment and pipelines;
- Causes of corrosion of metal equipment and pipes in the oil-gas-water system;
- short information about the conducted studies, technologies, methods and techniques in the field of corrosion protection of equipment for well-collector systems and transport pipelines and their critical assessment;
- determination of the dependence of corrosion of equipment and transport pipelines in well-collector systems on the main influencing factors, by the method of group accounting of arguments;

- development of a multifunctional, bactericidal and heat-resistant corrosion inhibitor with a complex effect based on naphthenates;
- technology for isolating the outer surface of metal pipes with corrosion-resistant, impact-resistant and wear-resistant basalt-plastic and fiberglass composite materials;
- use of basalt and fiberglass materials for corrosion protection of tanks and other capasities;
- technology for the production of corrosion-resistant, impact-resistant and wear-resistant one-piece basalt-plastic pump rods that replace metal rods in oil wells operated by rod pumps in highly aggressive environments, especially with aggressive gases H_2S, CO_2 and O_2 in products;
- the use of corrosion-resistant protective pipelines and tubing made of pure basalt-plastic materials without deposits of salt, paraffin and asphalt-resinous compounds in oil collector and transport pipelines;
- analysis of some operational advantages and cost-effectiveness of pure plastic pipes and rods in highly corrosive conditions compared to metal pipes and rods;
- calculation of economic efficiency obtained by applying innovative methods by increasing the lifetime of equipment and transport pipelines in well-collector systems.

Research methods

The solution of theoretical problems was carried out in relation to existing types of corrosion, and methods for their research, analysis was carried out, experiments and tests were carried out in laboratory and field conditions, mechanical strength, impact resistance, corrosion resistance and tear resistance of samples made of plastic were tested in the factory.

The main provisions for defense:
- application of the method of group accounting of arguments when determining the impact of not individual factors affecting the corrosion of equipment and transport pipelines of well-collector systems, but their combination;
- development of a complex, multifunctional, bactericidal and heat-resistant corrosion inhibitor based on naphthenates;

- development of technology for insulating steel protective belts, pumping and compressor and transport pipelines, oil and other tanks with lining made of basalt-plastic and fiberglass materials;
- production of protective belts, tubing and pumping rods from pure basalt-plastic and fiberglass materials.

Scientific novelty of research:

- for the first time, the method of group consideration of arguments was applied in the study of factors causing corrosion of wells-collector systems and transport pipelines;
- on the basis of naphthenic compounds from local raw materials, a new complex multifunctional and heat-resistant bactericidal corrosion inhibitor has been developed;
- a protection technology was developed for isolating the outer surface of protective belts, tubing and transport pipes lined with corrosion-resistant, shock-resistant and wear-resistant basalt-plastic and fiberglass materials;
- Basalt-plastic material was used for the first time to protect oil and other tanks from corrosion;
- protective belts, tubing pipes and pumping rods of pure basalt-plastic and fiberglass material were made, which not subject to corrosion and without of the precipitation of salts, paraffins and asphalt-resinous compounds, and a production technology in the plant was developed.

Theoretical and practical significance of research

The method of group consideration of arguments is used in the study of not individual factors that cause corrosion of wells-collector equipment and transport pipelines, but their combined effect. By the classical method, during the determination of a specific influencing factor, the remaining factors were taken as constant. The proposed method can be used to determine of the complex effect of corrosion factors. A new corrosion inhibitor based on naphthenic compounds, synthesized from local refined products has been developed and applied in oil wells-collector systems. This inhibitor of complex action. The application in the oil fields of Azerbaijan is the most effective from an economic point of view. The cost of a new developed inhibitor is 3-4 times cheaper than imported corrosion inhibitors of the same action. Taking into account the field conditions, the field tests of the technology for isolating the outer surface of steel pipes used in protective belts, pump-compressor and other collector-transport pipelines with coatings made of shock-resistant and mechanically resistant basalt-plastic materials were developed and carried out. The insulation material is produced from local raw materials. The economic efficiency of this material compared to other coatings based on bitumen and lacquer paints is high.

Wells-collector steel equipment and transport pipelines operating in extremely aggressive environments often fail due to corrosion. In order to solve this problem, a technology has been developed for the production of protective belts, tubing, pump rods from basalt-plastic and fiberglass materials that are not subject to corrosion, without deposition of salts, paraffins and asphalt-resin compounds on the surface, and a production technology in the factory has been developed. These pipes and rods, weighing 3.5-4.0 times lighter than steel, have been tested under field conditions.

Approbation and implementation of the results

The results of the dissertation were discussed at the following conferences: "Macromolecular Chemistry, Organic Synthesis and Composite Materials" conference dedicated to the 50th anniversary of ANAS, Institute of Polymer Materials, Sumgayit, 2016. International conference and forum "Problems of non-use" St. Petersburg, 2017; International conference dedicated to the 100th anniversary of academician B.Zeynalov at ANAS, “Petrochemical synthesis, catalysis in complex systems”, Baku, 2017. Proceedings of The V International scientific and technical conference “Geology and Hydrocarbon potential of the Balkan-Blask Sea region ”Varna, Bulgaria, 2017. Conference dedicated to the 110th anniversary of academician M.Nagiyev at the Institute of Catalysis and Inorganic Chemistry of ANAS, Baku, 2018. International Scientific-Practical Conference“ Modern Information, Measurement and Control Systems Problems and Perspectives, “July 1-2, Baku, 2019. 7th International Conference on Control and Optimization with Industrial Applications. 26-28 August 2020, Baku.

The results of the dissertation work were tested at the OGPU named after N.Narumanov and an application act was obtained. The act on the application of measures is attached to the dissertation.

The main results of the dissertation were published in 19 works submitted at the end of the abstract. 11 of them are articles, 8 are theses and conference materials.

The results of the dissertation work have been tested in the OGPD named after N. Narimanov, an implementation act has been received.

Scope and structure of work

The dissertation contains 175 pages and consists of 3 chapters, including 33 figures, 24 tables, conclusions and suggestions, as well as a bibliography of 150 titles. The dissertation contains 249047 characters.

The introduction contains the relevance of the topic, the purpose of the work, scientific novelty, implementation, the significance of research, the provisions submitted for defense and the level of approbation of the dissertation.

The first chapter is devoted to a review of the literature. The analysis, research and study of the state and operating conditions of the equipment in well-collector systems and transport pipelines in oil and gas fields, of the impact on corrosion of various periods of field development and various methods of oil production, of an oil and gas environment were conducted, physical and chemical properties and characteristics of aggressive components of the produced products are presented, causing corrosion, the causes of corrosion of wells-collector equipment and transport pipelines were investigated. A comparative and critical assessment of existing technologies, methods and techniques, studied and applied in the field of corrosion protection in oil production, was carried out: Factors affecting the lifetime of equipment and pipelines in certain periods of oil and gas field development were studied; The physical and chemical properties of metal parts and pipes that corrode the main parts and their characteristics in the produced oil and gas products are given; The main causes leading to corrosion of equipment and pipes in the oil and gas environment are investigated; a critical assessment of the technologies, methods and techniques used to date for corrosion protection of equipment of well-collector systems and pipelines was carried out, a short review was presented.

The first chapter is devoted to the literature review: The operational condition and condition of the equipment of well-collection systems and transport pipelines in oil and gas fields were analyzed, researched and analyzed; Factors affecting the service life of equipment and pipelines during separate development periods of oil and gas fields have been investigated; Physical and chemical properties of the main components that corrode metal equipment and pipes and their main characteristics are given in the produced oil and gas products; The main causes of corrosion of equipment and pipes in the oil and gas environment have been investigated; Brief information was provided on the technologies, methods and techniques that have been studied and found in the field of corrosion protection of well and equipment systems and pipelines, and their critical evaluation was conducted.

In the second chapter, a study of the object was carried out and methods were developed, including new innovative, effective scientific and technical methods for protecting equipment and transport pipelines of well-collector systems from corrosion in order to increase their service life, i.e. new methods of protecting them from corrosion in comparison with existing technologies, methods for their implementation have been developed. The concept of "innovation" is broader than the concept of "new technology". Corrosion protection innovation is a perfect technological process as the end product of the process of updating research and applied technologies in the field of corrosion. The main factor of competitiveness is innovation. As mentioned in the section on determining the dependence of the operability of equipment and transport pipelines of well-collector systems on mechanical, physical and chemical factors, so far the influence of various factors, such as steel corrosion rate, formation water salinity, surface tension, fluid flow rate, lifetime, exposure to corrosive gases, temperature, pressure, surface erosion, etc. on corrosion intensity was studied separately, while the combined effect of these factors was not studied. A new mathematical-statistical method for studying the cumulative impact of influencing factors is proposed.

A complex multifunctional, bactericidal and heat-resistant corrosion inhibitor based on naphthenates has been developed. Naphthenates are a group of organic compounds consisting of salts and esters of naphthenic acid. Despite the use of some of them - technical soap, emulsifiers, disinfectants, desiccants, reagents, lubricant additives (additives), as anti-corrosion agents and anti-rot agents (for wood materials), their use as a corrosion inhibitor studied few. It has also studied as a heat-resistant reagent to facilitate the transport of the viscous oil. These compounds have also been studied as heat-resistant reagents that facilitate the transport of base oils. Some physicochemical parameters of the inhibitor are given in the table below (Table 1).

Table 1

Some physicochemical parameters of the inhibitor

Indicator names	Indicator
Color	From dark brown to yellow
Good	Weakly specific
Density, at 20° C, q/sm^3	0,8500-0,9010
Kinematic viscosity, at 20° C, $mkm^2 \cdot san$	25-28
VZ – 4 in viscometer , at 20° C, san	35-40
Acid number (KOH), q	28-42
Freezing point , °C	(-8)–(-10)
Ignition temperature , °C	107
Alovlanma temperaturu, °C	220
The presence of a solution,	good
In water	very weak

The inhibitor is based on local raw materials. Its corrosion protection is based on the mechanism of reducing the impact of corrosive aggressive components on the metal surface, creating a high "adhesion" on the surface of the metal pipe and a thin "protective curtain". Inhibitors are designed to protect the inner surface of the protection pipe in oil and gas wells, the inner and outer surface of the pump compressor pipes, the inner surface of the discharge lines, collectors, other in-line pipes, as well as the outer surface of the pump rods (Figure 1).

Corrosion and corrosion-erosion processes occurring in equipment and transport pipelines of a well-collector system are multifactorial. This problem is solved by the classical method by changing one parameter while keeping the other parameters constant. However, this approach to the issue takes a long time, since, for each factor, a specific set of experiments is required.

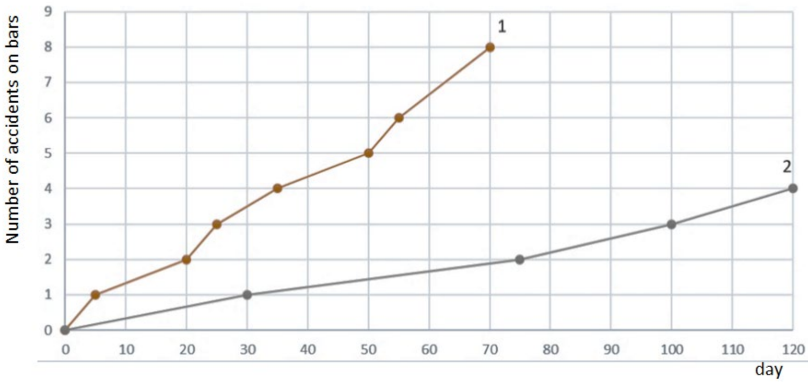

Figure 1. Curves showing the time change of accidents in the rod set in sharply corroded wells 1 - without inhibitors, 2 - after the application of inhibitors.

For the first time in the dissertation, the technology of insulation of the outer surface of steel pipes with basalt-plastic and glass-plastic materials, which are not subject to corrosion, resistant to impact, corrosion and abrasion, was developed. The insulation material used is bitumen, varnish, polyethylene, etc. In addition to being resistant to corrosion compared to insulation materials, it is also resistant to shock, abrasion, friction and other mechanical and physicochemical effects. The insulation process can be carried out both in the factory and in the mine. Insulation of steel pipes in the factory is carried out on special machines. In mining conditions, the lining is first made in the form of a pipe at the factory and brought to the ore pipe rolling shop and put on the outer surface of steel pipes with a special device (Figure 2, 3).

Figure 2. General view of steel pipes insulated with composite plastic cladding on the outer surface

The figure shows that the number of accidents in the rods in wells without the use of inhibitors operating under conditions of acute corrosion is much higher than in wells with inhibitors.

Before the start of insulation technology, the outer surface of steel pipes should be free from various impurities, rust, temporarily painted paint residues, etc. cleaned and transferred to the insulation bench. This technology can also be used to repair old pipes. The insulation coating is 1.5-2.0 mm thick. If the insulated steel pipes are intended for threaded joints, the insulation shall extend to the threaded part of the pipe. A special carbon lubricant is used to protect the threads from corrosion. The remaining surface is insulated, except for the location of bolts in the flange joint. When welding, 4-5 cm long uninsulated surface is kept at the ends of the pipes. This technology can also be used to repair old pipes. The insulation coating is 1.5-2.0 mm thick.

Figure 3. Tubular coatings designed to insulate the outer surface of steel pipes

If the insulated steel pipes are intended for threaded joints, the insulation shall extend to the threaded part of the pipe. A special carbon lubricant is used to protect the threads from corrosion. The remaining surface is insulated, except for the location of bolts in the flange joint. When welding, 4-5 cm long uninsulated surface is kept at the ends of the pipes. After welding, it is cooled and covered with a cloth made of insulating material. Basaltplastic and fiberglass materials were studied for corrosion protection of external and internal surfaces of newly constructed and existing reservoirs, tanks and other capacities, especially the bottom parts and the ceiling covering in contact with steam. Figure 4 shows the curves showing the effect of the mineral content of the formation water (S) on the corrosion rate (K) of the bottom of the reservoirs holding the commodity, (1) technology (2) and crude oil (3). As can be seen from the figure, the maximum value of the bottom of the 3-purpose tanks was obtained in the amount of 20 g / l of mineral. The least corrosive are crude oil storage tanks. Insulation with plastic materials increases the service life of these tanks by 2-3 times.

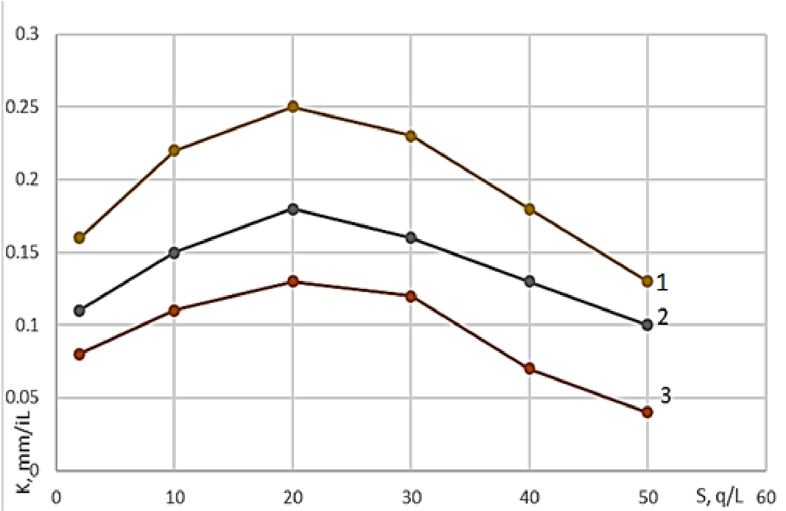

Figure 4. Curves showing the effect of mineral water (S) of formation water on the corrosion rate (K) of the bottom of tanks holding commercial (1), technological (2) and crude oil (3)

In the dissertation the technology of production of pure basalt-plastic and glass-plastic pipes and rods capable of replacing steel pipes in well-assembly systems and transport pipelines in acute corrosive environment and can be used together with them, mechanical, physical and chemical properties were studied. Laboratory studies were conducted in produced waters containing hydrogen sulfide, carbon and oxygen gases. The study found that these materials are resistant to the most severe environments that affect the rate of corrosion in oil fields. Pipes and rods made of pure composite plastic have the following advantages over steel pipes and rods: they do not corrode and weigh up to 4 times lighter; As the surface is smooth and slippery, salt, paraffin, asphalt-resin compounds and mechanical mixtures do not settle on the surface.

The wall thickness of the pipe to be made is proportional to the number of wraps, and the diameter of the pipe is controlled by a special template. On the other hand, depending on the area of application of the pipe, the density of the fibers, the number of windings and the amount of resin are regulated, taking into account the mechanical, physical and chemical stresses falling on it. During the wrapping process, a bracelet is placed on one end of the tube and a threaded nipple is placed on the other end. The plastic pipe is dried after being removed from the metal filling. The drying process consists of 7 steps and is carried out in special ovens for 24 hours. Starting from the first stage, the temperature is in the range of 60 ± 5, 80 ± 5, 90 ± 5, 100 ± 5, 110 ± 5, 120 ± 5 and 150 ± 5 ºC. Upon completion of the drying process, the pipes are inspected for mechanical, physical and chemical stresses, including hydraulic shock, torsion, external and internal pressure, temperature difference, tension, compression and design parameters. The threads of plastic pipes are opened on lathes. In order to increase the strength of the threads in plastic pipes, the thread steps are opened wide, unlike metal in this case the strength of the groove is 2-3 times higher.

Depending on the field of application, the pipes are made of 6 to 10 m in length and the wall is of any thickness. Some physical properties of composite basalt-glass plastic material compared with carbon and stainless steels, as well as aluminum metal are given in Table 2.

Composite plastics belong to the class of thermosetting polymers, which do not soften when heated. Figure 5 shows the temperature dependence of the strength of 50 mm diameter composite plastic pipes. As can be seen from the figure, composite plastics do not lose their strength at temperatures up to +100 C. Figure 6 compares the operating costs of 1 km long 120x8 mm plastic pipes of the same size, not protected from corrosion, for 20 years. The initial cost was $ 75,000 for plastic pipes and $ 50,000 for steel pipes. Although the initial cost of the plastics was high, no cost was incurred in the pipeline during the subsequent operation. So, while the total cost of steel pipes for 20 years is 250-275 thousand US dollars, in plastic pipes this figure is at the level of 75 thousand US dollars.

İn figure 7 compares the cost of operating a 100 m long 75x8 mm composite plastic pipeline with the same length of 89 x 4 mm, one of which is insulated with varnish and the other with an inhibitor given.

Table 2
Composite basalt - glass plastic material with some metals comparable key physical indicators

Indicators	Metals			Composite
	Carbon steel	Stainless steel	Aluminum	Plastic
Density, kq/m^3	7900	7900	2800	1900
Coefficient of linear expansion, × 10^6, 1ºC	12	17	19	20
Tensile strength, Kqc/cm^2	4600	5900	3400	6900
Thermal conductivity, kkal (ms ºC)	42	36	172	0,3-0,4
Elasticity modulus, ×10^{-6} kqs	2,1	2,0	0,8	0,28-0,3
Special strength,kN	5,8	2,4	12	40

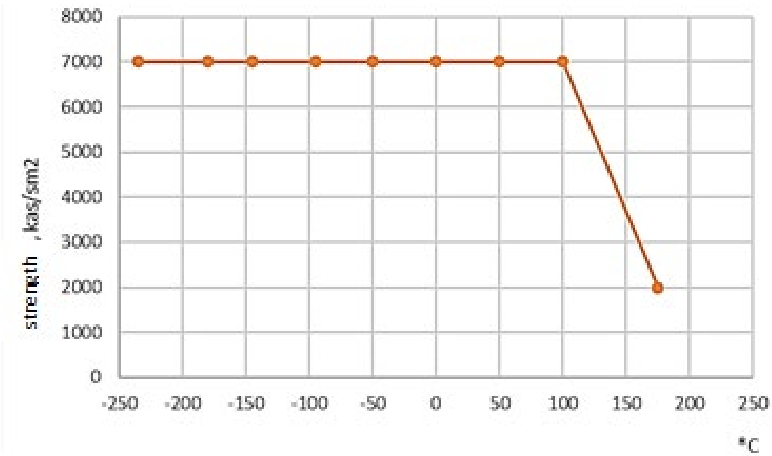

Figure 5. Temperature dependence of the strength of plastic pipes (50 mm)

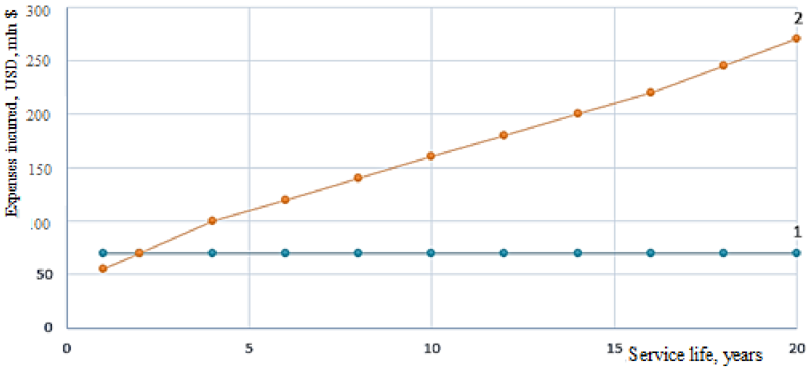

Figure 6. Comparison of the relationship between the service life of plastic pipes and steel pipes and the costs incurred
1 - plastic pipes, 2 - steel pipes.

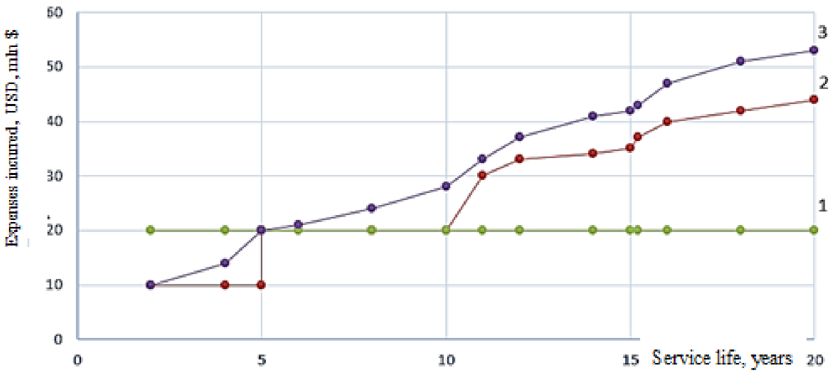

Figure 7. Comparison of the relationship between the cost of a plastic pipeline and a steel pipeline and the service life
1 - 75x8 mm plastic pipeline, 2 - 89x4 mm steel pipe insulated with varnish on the outer surface, 3 - 89x4 mm inner surface inhibitor shielded steel pipe.

As can be seen from the figure, the initial cost of the composite pipeline (including the cost of the pipes) was 20,000 AZN and 10,000 AZN for each of the steel pipelines. 40,000 AZN was spent on an insulated steel pipeline and 50,000 AZN on an insulated steel pipeline.

Figure 8 gives an overview of plastic pipes and grooved flange methods for their connection. The destructive internal hydraulic pressure resistance of plastic pipes was tested at the factory. Under conditions of severe corrosion, wells containing aggressive hydrogen sulfide in their products often break in the rod belt, which is the main part of the rod depth pumping unit. The technology of making the body of the bar set, which can be released to a depth of 2000 m, from plastic material has been developed.

Figure 8. General view of plastic pipes

In the second chapter, the research object and methods of the dissertation are developed: innovative methods of corrosion protection to increase the service life of equipment of well-assembly systems and transport pipelines; a statistical method has been proposed to determine the dependence of the capacity of well-assembly systems equipment and transport pipelines on mechanical, physical and chemical factors; developed a complex, multifunctional, thermally resistant, bactericidal type corrosion inhibitor based on naphthenates; the technology of insulation of the surface of metal pipes with linings made of corrosion-resistant, shock-resistant and corrosion-resistant basalt-plastic and fiberglass materials has been developed; the possibility of using basaltplastic and fiberglass materials in the construction and repair of tanks and other capacities was investigated; Technologies for the manufacture of protective belts, pump compressors and transport pipes, as well as pump rods from pure basalt-plastic and fiberglass materials in the highly corrosive oilfield environment have been developed and their application together with metal pipes and rods has been analyzed.

The third chapter is devoted to the application of the developed innovative methods in oil and gas fields and the identification of economic efficiency: a technology has been developed for pumping a new corrosion inhibitor based on naphthenic compounds into oil and gas wells and transport pipelines; the installation of metal protective belts, tubing and transport pipes with insulation of the outer surface with basalt-plastic and fiberglass coatings are presented; a technology has been developed for the use of protective belts, tubing and transport pipes made of pure basalt and fiberglass, as well as pumping rods in highly corrosive oil and gas fields and their joint installation with metal pipes and rods; the economic efficiency and calculation of the results of the application of the studied, developed and applied innovative methods of corrosion protection to increase the service life of equipment of wells-collector systems and transport pipelines in oil production are given.

The purpose of the study of a new corrosion inhibitor in the dissertation work is, first of all, the development of a new multifunctional, heat-resistant complex inhibitor, bactericidal type (significantly reduces the deposition of salts, paraffins and asphalt-resin compounds on the metal surface) using local raw materials, which is significantly cheaper than manufactured inhibitors (selling price foreign inhibitors is in the range of 4000-5000 US dollars), introducing an innovative method, by performing discrete continuous way, by manufacturing in a workshop conditions, which are the simple and easy technological process.

For the continuous use of the created inhibitor, a new method for implementing the technology of continuous simultaneous injection of the inhibitor into several wells and transport pipelines has been developed. In the proposed method, the inhibitor enters the dosing station from a 10-ton tank in a single line and is distributed from there to the wells through several pipelines (0.5 inches). The technological process is carried out in accordance with the parameters of each well. The essence of the innovative method is to achieve high economic efficiency as a result of the preparation of a developed high-quality corrosion inhibitor in a short time using a simple technology and its application at low cost.

Another innovative method in the dissertation is the insulation of the outer surface of steel pipes with plastic coatings to protect against corrosion. Corrosion inhibitors protect only the inner surface of pipes, but are not ineffective in cases of mechanical stress, including impacts, wear, scraping, etc. It is concluded that the innovative method of increasing the service life of pipes due to the technology of insulation and the use of new plastic coatings for protection against impacts, wear and scraping in oil fields is promising, in comparison with varnishes - paint, bitumen, etc., used so far for insulation of the outer surface of the pipes. Before injection of the inhibitor into oil and gas wells, and into the pipelines of the collector system, were studied of the technical condition of the equipment, the performance indicators such as the chemical composition of the oil-gas-water system and aggressive environment, deposits of the salt and paraffin, the amount of asphalt-resinous compounds and mechanical impurities, and the accumulation of corrosion products in the annular space, the course of the observed physical and chemical processes, etc . If the condition of the equipment surface is satisfactory (no deep pittings, detachments, corrosion products, salt deposits, paraffin deposits, hydration formation, etc.), the inhibitor can be applied without cleaning. Upon detection of equipment defects, salt deposits, paraffin, etc. the inhibitor should be injected after they have been removed. Inhibitors are pumped continuously and intermittently into fontaine (oil and gas), gas-lift and depth pumping oil wells - into collector systems, as well as transport pipelines. To calculate the economic efficiency of injection of a corrosion inhibitor into oil well-collector systems and pipelines, the following formula is used:

$$¡ = (x_1 - x_2) \cdot A \tag{1}$$

Here x_1 and x_2 are the costs for 1 well or 1 km of pipeline without inhibitors and after the use of an inhibitor, respectively manat/well or manat/pipe; A - the number of wells in which an inhibitor is used or the length of the pipeline; Formula (1) can be written as follows:

$$¡ = [(S_1 + E_n K_1) - (S_2 + E_n K_2)] \tag{2}$$

where S_1 and S_2 are the costs of operating the equipment of the well-collector system and the transport pipeline without inhibitor and after injection of the inhibitor, respectively, manat/well. or pipeline; K_1 and K_2 - capital costs for downhole equipment or pipeline without inhibitors and after their application; E_n - normative coefficient of efficiency of capital investments. Annual costs for the operation of equipment for well-collector systems and main pipelines without an inhibitor are expressed by the following formula:

$$S_1 = Z_1 + Z_2 + Z_3 \tag{3}$$

where Z_1 - costs incurred on tubing (pumping pipes), rods and other equipment and pipes of well-collector systems, manat/well collector equipment in connection with the supply to the oil and gas department within 1 year with third-party departments; Z_2 - annual costs associated with corrosion of well-collector systems and pipelines, manat/well.collect. system; Z_3 - annual losses in oil production due to downtime of wells due to equipment repair due to corrosion, manat/well.collective equipment. The annual costs for the operation of well-collector systems and transport pipelines after the use of inhibitors are expressed by the following formula:

$$S_2 = Z_1^1 + Z_2^1 + Z_3^1 + Z_4^1 \tag{4}$$

where Z_1^1, Z_2^1 and Z_3^1 - are the costs after the application of the inhibitor (as in Z_1, Z_2^1 and Z_3^1, respectively); Z_4^1 - costs for the well-collector system and pipelines after the application of a corrosion inhibitor, manat/well.collector system. The cost of equipment of the well-collection systems and pipelines before the implementation of inhibitors is expressed by the following formula:

$$K_1 = B_1 + B_2 - B_4 - B_5 \tag{5}$$

where B1 is the cost of replacing of the equipment damaged by corrosion in well-collector systems with a new one in the current year (including transportation and preparation before delivery to the oil and gas production department), manat/well.collect. equipment; B2 - residual value as a result of the delivery of equipment and pipes of wells-collector systems damaged by corrosion in the current year; B4 - residual value of equipment and pipes corroded in the current year, but suitable for use in other wells-collector systems; B5 - income from the sale of WCS and pipes for metal, manat/well-collect.equipment. Capital costs for well equipment and pipelines obtained after the use of an inhibitor are expressed by the following formula:

$$K_2 = B_1^1 + B_2^1 + B_3^1 - B_4^1 - B_5^1$$

where B_1^1, B_2^1, B_4^1 and B_5^1 - costs after the application of a corrosion inhibitor (as for B_1, B_2, B_4 and B_5, respectively), manat/well.collect.equipment, pipes; B31 - costs for the development and technology of application of corrosion inhibitors, manat/well.collect. equipment, pipes. Calculations show that the economic effect from the use of an inhibitor in one well is expected to be 10,000 manats per year. The annual economic efficiency of the use of plastic pipes and rods in wells-collector equipment and in transport pipelines consists of saving all production resources. Economic efficiency is determined by comparing the present value of the base and delivered new equipment, in this case, new equipment refers to the plastic pipes and the rods. The above costs are calculated as the sum of the cost and normative income:

$$Z = C + E_n K \quad (6)$$

where Z - is the reduced cost per unit of production, manat; C - unit cost of production, manat; K - special capital investments in production funds, manat; E_n - is the normative coefficient of efficiency of capital investments (0.15). When calculating economic efficiency, the new and basic options should be comparable in terms of: the volume of output; product quality indicators; natural conditions for the use of technology; the level of oil and gas losses; environmental impact, etc. The economic effect obtained from the use of new equipment, which allows saving production resources in the production of a particular product, is calculated by the following formula:

$$E = (Z_1 - Z_2) \times A_2 \quad (7)$$

where E - annual economic efficiency, manat; Z_1 and Z_2 are the reduced costs per unit of output (work) produced (performed) by the basic and new equipment, respectively, manat. Then the calculation of economic efficiency is carried out according to the following formula:

$$E = [(C_1 + E_n K_1) - (C_2 + E_n K_2) \times A_2 \quad (8)$$

where C_1 and C_2 - the cost of a unit of production by options, manat; K_1 and K_2 - special capital investments by options, manat; A_2 - the volume of products (work) produced by new equipment, in physical terms. The use of plastic pipes and pump rods in oil production is associated with: replacement of the well-collector system - of the pipes of the protective belt, tubing, pump rods, land transport pipelines, injection pipelines, collector pipes in conditions of severe corrosion; comparing was carried out relativley the metal pipes and rods. The third chapter is devoted to the application of the developed innovative methods in oil and gas fields and the identification of economic efficiency: a technology of injection of the new corrosion inhibitor based on naphthenic compounds into oil and gas wells and transport pipelines has been developed; a installation method of the metal protective belt, tubing and transport pipes with external insulation from basalt-plastic and fiberglass coatings is presented; A using technology for the use of protective belts, tubing and transport pipes made of pure basalt and fiberglass, as well as sucker rods in highly corrosive oil and gas fields, and their installation together with metal pipes and rods has been developed. The economic efficiency and calculation results from the application of the studied, developed and applied innovative methods of corrosion protection in oil production to increase the lifetime of equipment of well-collector systems and transport pipelines are presented.

CONCLUSIONS

1. Data are presented and critical studies of the operating conditions of well-collector systems and transport pipelines in oil and gas fields, various methods of oil production in different periods of field development, physical and chemical properties of the main components in products that cause corrosion, developed and used at present time in this area of technology methods and methods.

2. For the first time, the method of group accounting of the argument was applied to determine the dependence of the performance of wells-collector systems and transport pipelines on mechanical, physical and chemical factors.

3. A new multifunctional, complex, bactericidal and heat-resistant corrosion inhibitor based on local raw materials has been proposed.

4. For the first time, a new technology of basalt and fiberglass insulation has been developed to protect the outer surface of metal belts, pumps, compressor pipes, and transport pipelines from corrosion.

5. During the construction and repair of external and internal surfaces of tanks and other containers, a new method of insulation by composite basalt-plastic and fiberglass material was developed for the first time.

6. A technology for the production of clean basalt-plastic and fiberglass protective belts, pumps, compressors, collector pipes and pump rods in well-collector systems has been developed and tested.

7. The calculation of the economic efficiency of the developed new technologies was carried out and an act was obtained on their application in the OGPD named after N. Narimanov.

Main content of dissertation reflected in the following works:

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Personal contribution of the applicant:

[8, 12, 14, 16, 17, 18] - works were performed freely,
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