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METHODS OF CORROSION PROTECTION OF EQUIPMENT AND PIPELINES IN THE OIL AND GAS INDUSTRY

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Abstract. In the oil and gas industry, corrosion of equipment and pipelines poses a serious threat to the safety, reliability and durability of infrastructure. Various methods have been developed to protect against corrosion, which are key to ensuring the stable operation of technical systems. This article examines the main methods of corrosion prevention, including cathodic protection, the use of protective coatings, the use of corrosion inhibitors and regular maintenance. The advantages, limitations and optimal conditions of application of each method are discussed, as well as recommendations for choosing the most effective corrosion protection strategies in the oil and gas industry are offered.

The paper considers the main types of corrosion, their causes and consequences. Then various protection strategies are highlighted, including cathodic and anodic protection methods, the use of protective coatings, the use of corrosion inhibitors, as well as technical methods for monitoring and monitoring the condition of equipment.

The advantages and limitations of each of these methods, their effectiveness, implementation and maintenance costs are analyzed. There is also an emphasis on innovative technologies and the latest developments in the field of corrosion protection, which may have the potential to improve the durability and reliability of oil and gas equipment.

The study highlights the importance of using a combination of different protection methods, as well as the need for continuous improvement of technologies to minimize corrosion processes in the oil and gas industry.

Key words: factors, corrosion, equipment, aggressive components, protection methods, protective coatings, pipelines, condition monitoring.

The issue of protection of oil and gas equipment of the Republic of Kazakhstan from corrosion is currently one of the most urgent in the oil and gas industry.

The problem of metal corrosion has arisen since time immemorial, that is, in the process of manufacturing metal weapons by man, and then various equipment.

The importance of the problem of metal corrosion has increased in the age of scientific and technological progress, the increase in metal and profits used for the manufacture of technical means, as well as the development of new technologies, increased revenues from oil and gas products and refining, drilling and transportation of oil.

The development of oil fields occurs as a result of the use of underground devices and in aggressive power environments, where hydrogen sulfide, carbon dioxide, organic acids, layered waters with dissolved mineral salt, which lead to the corrosion process. In addition to aggressive components that cause corrosion of devices, they are affected by high temperatures and pressures, which accelerate the corrosion process. Underground metal structures are very expensive, in principle, their service life is determined by the corrosion cost.

The term "corrosion" should not be used if the oxidation of metals is necessary to undergo a certain technological process. For example, it is impossible to talk about corrosion of a soluble anode in an electrolytic bath, since the anode must be oxidized by passing its ions into the solution in order for the electrolysis process to take place. The aluminothermic process cannot be said about aluminum corrosion in the past. But in all such conditions that have passed with metal, the physico-chemical nature of the changes is the same: the metal is oxidized. Therefore, the term "corrosion" is widely used in major scientific papers, as well as in technical literature[1].

Materials and methods of research. Depending on the nature of the interaction of the metal with the medium, corrosion is distinguished by the mechanism of 2 main types: chemical and electrochemical corrosion.

Chemical corrosion occurs according to the laws of the chemical reaction of metal with the surrounding gaseous or liquid medium. In addition, corrosion products are formed over the entire surface of the metal in contact with an aggressive environment. Together with their chemical mechanism, the following types of corrosion processes occur: corrosion in gas and non-electrolytes.

Gas corrosion is the best destruction of metal at high temperatures and the complete loss of a liquid film on the surface of metal products as a result of metal oxidation with oxygen or other gas (for example, corrosion of gas turbines at compressor stations, pipes of boiler installations, exhaust manifolds of internal combustion engines.

Corrosion of fishing equipment-underground corrosion is often caused by the life of microorganisms found in the earth's crust and soil. Currently, much attention is being paid to biocorrosion. It secretes anaerobic bacteria in the absence of oxygen and aerobic bacteria whose vital activity stops in the presence of oxygen. The greatest danger is posed by anaerobic sulfate-reducing bacteria, which are widespread in nature, develop in silty, soil and swampy places, mud, sewage, oil wells, soil, cement, places where anaerobic conditions exist. The most suitable environment for the development of these bacteria is the earth with a pH = 5-9 (optimally 6-7.5) at a temperature of 20-25℃ [2]. Bacteria reduce sulfates contained in the earth to sulfide ions by releasing oxygen using hydrogen produced during the cathode process.

$$MgSO_4 + 4H+ = Mg(OH)_2 + H_2S + O_2 \qquad [1]$$

The released oxygen is consumed for the passage of cathodic depolarization. Hydrogen sulfide reduces the current strength of hydrogen in acidic and slightly acidic regions, facilitating the cathode process under these conditions. Sulfide ions are accelerated by the anodic corrosion process of steel. Under the action of sulfate-reducing bacteria, hydrogen sulfide is formed, which binds to iron and gives sulfurous iron *FeS*. Some researchers report that the rate of corrosion damage to iron can increase by 20 times due to exposure to these bacteria.

There is also a small risk of aerobic bacteria for underground metal structures. Aerobic sulfur bacteria play an important role in the process of metal destruction, which, according to the following equation, oxidize hydrogen sulfide to sulfur, and then to sulfuric acid:

$$2H_2S + O2 = 2H_2O + S_2 \qquad [2]$$

$$S_2 + 2H_2O + 3O_2 = 2H_2SO_4 \qquad [3]$$

The resulting acid intensively destroys metal underground structures.

The corrosion process starts from the metal surface and penetrates into the material. As a result, the mineral changes: chemical processes occur on its surface, forming depressions (spots, fistulas, wounds) filled with corrosion products, mainly Fe_2O_3. Table 1 shows the classification according to the nature of corrosion damage to the metal.

Table 1. The nature of corrosion disorders.

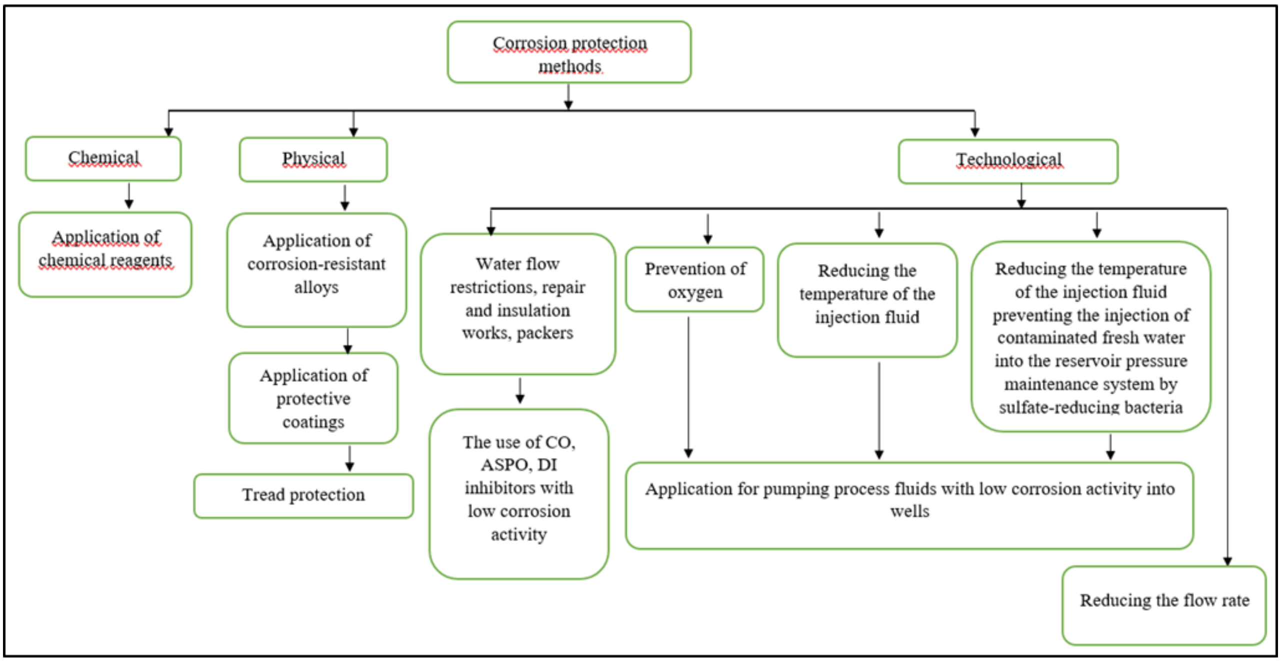

Table 1 discusses the classification of corrosion damage to metal. In modern science, there are several classifications based on the mechanism of chemical corrosion, redox reactions underlie most corrosion processes. The decomposing metal is a reducing agent, an oxidizer. At temperatures above 300 °C, iron is oxidized with oxygen, and hydrogen sulfide is slightly lower at 260 °C and above. In a wet state, the activation energy is slightly lower than in a humid climate, when there are no water molecules, and the mechanism of the entire reaction changes.

The main methods of corrosion control of oilfield equipment used today by domestic and foreign companies can be divided into three groups: chemical, physical and technological.

Technological methods of corrosion protection can be called the correction of corrosion factors in the well, including limiting water flow, preventing oxygen intake, reducing fluid flow and temperature, etc.

The concept of corrosion refers to the chemical and mechanical destruction of metal surfaces under the influence of the environment.

The increased corrosive aggressiveness of water extracted with oil is also a serious problem. It will be necessary to distinguish between external and internal corrosion caused by atmospheric phenomena, groundwater or aggressive environment carried inside the main pipelines.

Corrosion is a slow process that can take several years, gradually destroying the equipment. Protecting oilfield pipes from corrosion is an important task for the industry's core industry.

Purpose of the work

The main purpose of corrosion inhibitors is to reduce the aggressiveness of gas and electrolytic media, as well as to prevent active contact of the metal surface with the environment. The inhibitor must have good solubility in a corrosive environment and high adsorption capacity on the metal surface.

The main way to protect professional equipment from corrosion is braking. Corrosion inhibitors are not difficult to use and are very effective, since waste and semi-finished products of the synthesis of a number of organic additives can be used in the preparation of inhibitors.

The main reason for the corrosive destruction of the inner surface of metals is the presence of water, salts and aggressive gases in a tasmanized or stored environment. After obtaining oil and gas (mechanical impurities, salts, hydrocarbons, carbon dioxide, etc.), a large number of the listed components remain in them. Gases and salts dissolved in water form an electrolyte that causes corrosion of metal equipment used in the transportation of oil and gas.

Table 2. Types of inhibitors.

Types of corrosion inhibitors (by mechanism of action)					
Barrier-type inhibitors			Neutralizers	The Destroyer	Other
Anodic, cathodic, mixed	Oxidizing agents	Surface Film Conversion	Increases the pH environment	Removes aggressive components from the environment	Suppresses the function of sulfate-reducing bacteria
Forms films with physical adsorption	The oxide forms a film that moves the corrosion potential into the passive zone	Forms insoluble films on the metal surface			
Acetylene alcohol, sulfur-containing substances	Nitrites, chromates, etc.	Phosphates, silicates, ferrocyanides	Soda, borax, etc	Dioxane and others	Biocides

Table 2 shows that corrosion on the inner surface of metal equipment can be stopped or slowed down by the double action of various chemicals (neutralizers, inhibitors) on the transported or stored medium. Currently, neutralizers are often not used, and inhibitors are used only if accurate data on the type of corrosion and the conditions of the corrosion process are known. A number of approaches to the introduction of inhibitors into all installations have been improved. They ensure that the inhibitors get into the most difficult areas of the installation.

Results and discussions

The solution to the problem of improving the technology of preparing Alba Cenomanian waters to maintain reservoir pressure is based on practical experience in using oilfield equipment at the Alibekmola field. Based on the analysis of the processes occurring in the layers and measures aimed at combating corrosion complications, recommendations have been developed for the protection of equipment and reservoir pressure systems at the Alibekmola deposit.

During the development of oil fields, flooding forms a complex multicomponent system: pumped water - pumped water - buried water - oil formation rocks with dissolved gas. Apparently, of all the processes occurring in this complex system, the processes of mixing pumped waters with groundwater (reservoir and buried) have the greatest influence on the composition of water, as well as the interaction of pumped waters with reservoir rocks and petroleum hydrocarbons are of practical importance [6].

Research methods

The main sources of formation of mechanical impurities in the system are the increase in reservoir pressure of the Alibekmol deposit:

1.corrosion processes.

2. microbiological infection.

3. the presence of oxygen.

4. The presence of divalent iron in water.

The solution to the problem of improving the technology of preparing Cenomanian landscape waters to maintain reservoir pressure, including the composition of mechanical impurities up to 15 mg/l, lies in the field of eliminating the causes contributing to their formation [2].

Anti-corrosion measures. Examples of hull density violations in cemented zones are significantly less than in cemented zones, which means that the cement ring protects the metal well from corrosion damage. Therefore, from the very beginning of well construction, it is recommended to cement qualitatively, increasing the level of cement mortar to the mouth. The inner surface of lifting pipes and pipelines of oil wells is protected by anti-corrosion coatings resistant to aggressive environments with a temperature of 50-80 °C. In some cases, in the absence of internal insulated pipes, protection is provided by corrosion inhibitors. With the help of mobile installations, the inhibitor is periodically fed into oil wells (into the pipe space between the housing and the lifting pipe). For this purpose, a sealing device (cuff) with a small (3-7 mm) hole for the inhibitor outlet is provided between the body and the pipe (in the shoe). The volume of the inhibitor supplied to the well is a reserve for 10-15 days. The required amount of inhibitor for processing the entire surface of the protected equipment, including the inner surface of the production column, the outer and inner surface of the lifting pipes, the surface of the rods, the inner surface of the switching line, is calculated by the formula:

$$P = qS \qquad [4]$$

where q is the rate of consumption of the inhibitor per 1 m^2 of surface, kg/m^2; S is the total surface area of the protected equipment, m^2.

Conclusion

- The development of new fields, the construction of various facilities using large volumes of metal structures lead to new tasks for the anti-corrosion protection of oil and gas equipment.

Up to 90% of construction in the oil and gas industry -mining and processing - is based on ferrous metal structures. These are internal structures for equipment, residential and auxiliary infrastructure facilities, pipeline systems – almost the entire industry. Where there is iron, there is also a problem of corrosion. Given that most of the oil and gas fields are located in the continental part of the northern economic region, the operating conditions are extraordinary, and issues of anti-corrosion protection are becoming a priority.

The corrosion monitoring system for oil and gas equipment and pipelines should be a set of technical, methodological, software tools, as well as organizational measures. It should be a means of information support in the planning and implementation of measures to prevent the occurrence of emergency situations used in corrosive environments of pipelines and oilfield equipment.

To achieve the goal, the following main tasks were set:

- analysis of modern methods of protecting field pipes from corrosion processes;
- determination of the mechanisms of corrosion processes occurring in professional pipelines;
- construction of a mathematical model of the influence of physico-chemical parameters on the aggressiveness of the pumped medium ;
- determination of the effect of a corrosion inhibitor on the corrosion rate of oilfield pipes.

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МЕТОДЫ АНТИКОРРОЗИОННОЙ ЗАЩИТЫ ОБОРУДОВАНИЯ И ТРУБОПРОВОДОВ В НЕФТЕГАЗОВОЙ ПРОМЫШЛЕННОСТИ

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Аннотация. В нефтегазовой отрасли коррозия оборудования и трубопроводов представляет серьезную угрозу безопасности, надежности и долговечности инфраструктуры. Разработаны различные методы защиты от коррозии, которые являются ключевыми для обеспечения стабильной работы технических систем. В данной статье рассматриваются основные методы предотвращения коррозии, включая катодную защиту, использование защитных покрытий, использование ингибиторов коррозии и регулярное техническое обслуживание. Обсуждаются преимущества, ограничения и оптимальные условия применения каждого метода, а также предлагаются рекомендации по выбору наиболее эффективных стратегий защиты от коррозии в нефтегазовой отрасли.

В статье рассматриваются основные виды коррозии, их причины и последствия. Затем выделяются различные стратегии защиты, включая методы катодной и анодной защиты, использование защитных покрытий, использование ингибиторов коррозии, а также технические методы мониторинга и слежения за состоянием оборудования.

Анализируются преимущества и ограничения каждого из этих методов, их эффективность, затраты на внедрение и техническое обслуживание. Также особое внимание уделяется инновационным технологиям и новейшим разработкам в области защиты от коррозии, которые могут потенциально повысить долговечность и надежность нефтегазового оборудования.

В исследовании подчеркивается важность использования комбинации различных методов защиты, а также необходимость постоянного совершенствования технологий для минимизации коррозионных процессов в нефтегазовой отрасли.

Ключевые слова: факторы, коррозия, оборудование, агрессивные компоненты, методы защиты, защитные покрытия, трубопроводы, мониторинг состояния.

МҰНАЙ-ГАЗ ӨНЕРКӘСІБІНДЕГІ ЖАБДЫҚТАР МЕН ҚҰБЫРЛАРДЫ КОРРОЗИЯҒА ҚАРСЫ ҚОРҒАУ ӘДІСТЕРІ

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Андатпа. Мұнай-газ саласында жабдықтар мен құбырлардың коррозиясы инфрақұрылымның қауіпсіздігіне, сенімділігіне және беріктігіне елеулі қауіп төндіреді. Техникалық жүйелердің тұрақты жұмысын қамтамасыз етудің кілті болып табылатын коррозиядан қорғаудың әртүрлі әдістері әзірленді. Бұл мақалада коррозияның алдын алудың негізгі әдістері, соның ішінде катодты Қорғаныс, Қорғаныс жабындарын пайдалану, коррозия ингибиторларын пайдалану және тұрақты техникалық қызмет көрсету қарастырылады. Әр әдісті қолданудың артықшылықтары, шектеулері және оңтайлы шарттары талқыланады, сондай-ақ мұнай-газ саласындағы коррозиядан қорғаудың ең тиімді стратегияларын таңдау бойынша ұсыныстар ұсынылады.

Мақалада коррозияның негізгі түрлері, олардың себептері мен салдары қарастырылады. Содан кейін әртүрлі қорғаныс стратегиялары, соның ішінде катодты және анодты қорғау әдістері, қорғаныс жабындарын пайдалану, коррозия ингибиторларын пайдалану және жабдықтың күйін бақылау мен бақылаудың техникалық әдістері ерекшеленеді.

Осы әдістердің әрқайсысының артықшылықтары мен шектеулері, олардың тиімділігі, енгізу және техникалық қызмет көрсету шығындары талданады. Сондай-ақ, мұнай-газ жабдықтарының беріктігі мен сенімділігін арттыруы мүмкін коррозиядан қорғау саласындағы инновациялық технологиялар мен жаңа әзірлемелерге ерекше назар аударылады.

Зерттеу әртүрлі қорғаныс әдістерінің комбинациясын пайдаланудың маңыздылығын, сондай-ақ мұнай-газ саласындағы коррозиялық процестерді азайту үшін технологияларды үнемі жетілдіру қажеттілігін көрсетеді.

Түйін сөздер: факторлар, коррозия, жабдық, агрессивті компоненттер, қорғаныс әдістері, қорғаныс жабындары, құбырлар, жағдайды бақылау.