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INHIBITOR PROTECTION BY PIPELINE IN OIL WELLS

Abstract: The oil industry is the largest consumer of corrosion inhibitors. It uses vast quantities of these materials in production and ends with the use of petroleum products by the consumer. Corrosion inhibitors are widely used due to the corrosive nature of liquids, most commonly water and gases. In the application of corrosion inhibitors in the petroleum industry, a number of specific corrosion problems can be identified. Many of them arise during oil production.

Keywords: inhibitors, corrosion, oil-gas wells, protection, water-oil factor, electrochemical destruction.

The literature on the use of corrosion inhibitors in oil production is extensive, but the advent of high molecular organic corrosion inhibitors has revolutionized the oil industry. It turned out that wells abandoned after the short-term operation due to pumping equipment failure now made sense to use until the water-oil factor in the fluid being pumped made them uneconomical [1].

The widespread use of organic inhibitors has had a noticeable impact on overall oil production and the industry.

Neutral wells include: flowing oil wells, pumping oil gas wells, and gas condensate wells. For neutral spouting wells, possible types of corrosion are electrochemical and galvanic corrosion, stress corrosion, electrolytic corrosion, and erosion corrosion.

In the case of pumping wells, oxygen corrosion is also added. Consider the factors that cause corrosion in each case.

Electrochemical corrosion depends on the composition of liquid and gas. First, it concerns water composition as an oil-water system's most corrosive active phase.

The amount of water, its composition, the nature and amount of dissolved gases, pressure, and temperature all change and have a decisive influence on the intensity of corrosion.

The water that comes with the oil is a salt brine with 1–10% NaCl content. It may also contain calcium, magnesium, barium, sulfates, and other water components. The pH of this brine is affected by the presence of acetic acid, carbon dioxide, and dissolved gases, and the brine is usually slightly acidic. Because of pressure differences in the wells, gases are released from the brine, so its pH at the wellhead is higher than at the bottom. Measuring the pH at the wellhead does not indicate the degree of corrosion at depth. Initially, there is little water in the well and corrosion is negligible. The water content increases as the well is operated, and the system becomes more corrosive. Carbon dioxide is the leading cause of corrosion in neutral wells [2; 3].

The presence of carbon dioxide accelerates the formation of complex parts of scale and deep holes with sharp edges.

Aliphatic acids such as formic and acetic acids may be present in the solution. Although these acids are relatively aggressive, they have little effect on corrosion because of their low concentrations compared to the attention of carbon dioxide and salts in the brine. At low carbon dioxide pressures, wells are highly corrosive due to high concentrations of fatty acids (converted to acetic acid) [4].

The temperature of the fluid in the well varies widely and depends on the depth of the well. Fluctuations from ambient temperature up to 120 °C are considered normal for all wells. The temperature significantly affects corrosion because the dissolution rate increases significantly with temperature. Another factor is the wetting ability of the oil. The degree to which metal is wetted by water varies, and the protective film of oil is destroyed at some critical value for each well of the water-oil factor.

These considerations mainly refer to electrochemical destruction because it is the leading cause of corrosion and is characteristic of all types of wells. Galvanic and stress corrosion is related to the nature of the metals being destroyed. Galvanic corrosion in a borehole does not only occur when two dissimilar metals are present. It can be caused by cracks in the rolling scale and the relationship between the corrosion products and the metal.

Electrolytic corrosion occurs under the influence of external superimposed current and manifests in the external destruction of casing and flowlines.

They are subject to the same type of corrosion damage as fountain corrosion. In addition, oxygen corrosion can also occur in them.

When operating with open interstitial space and a low fluid level, oxygen enters the well and causes corrosion that is difficult to protect against with conventional inhibitors.

Gas-operated wells are more susceptible to corrosion than pumped wells due to high temperatures and low and low pH values at the bottom of the well. The presence of water exacerbates corrosion. The design of gas pressure wells makes it challenging to use inhibitors below the interstitial space and gas valves. In gas-condensate wells, the volume of workovers and tank failures is increasing. The danger posed to operating personnel exacerbates the importance of the problem. A gas-condensate well releases condensate from saturated steam when the temperature and pressure drop. Corrosion in gas-condensate wells occurs as deep pitting caused by acidic gases dissolved in water droplets condensing on pipe changes. Below, the condensation zones of pipes can be untouched by corrosion because there is no water phase. In addition to electrochemical corrosion, ring corrosion, and erosion-corrosion occur in gas condensate wells [5].

Ring corrosion occurs below and above the dislocated pipe ends and appears as a ring inside the pipe. The erosion process occurs mainly near the restrictor, where flow rates and turbulence are higher than usual. Carbon dioxide is the leading corrosive agent.

Oil wells are referred to as acid wells. Corrosion in wells that emit hydrogen sulfide is a severe problem – even a tiny corrosion rate increases as the life of the sound increases. Often through-corrosion and the buildup of corrosion products in the pump will require replacement. Depending on what, the well produces oil or gas, then sour wells oil or gas, then sour wells are divided into oil and gas wells.

The following processes can occur in oil wells: electrochemical corrosion; sulfide stress corrosion cracking; erosion corrosion; hydrogen embrittlement and bubble formation; microbiological corrosion; condensation in the inter pipe space; galvanic corrosion; electrolytic corrosion [6].

Inhibitor protection is the most effective and technologically simple technology of pipeline integrity assurance that supplements activities on reconstruction and replacement of pipelines.

Inhibitors are easy to use with existing water injection technology.

Currently, most oil and gas fields are at the late stage of development when the production rate is decreasing, and the water cut is increasing dramatically.

Such fields are characterized by significant complications in oil production, collection, and treatment associated with the formation of persistent oil emulsions, inorganic salts, mechanical impurities, and corrosive destruction of equipment and oil pipelines. Increasing the corrosive activity of water produced together with oil is a serious problem at this stage. This is where inhibitor protection technology is needed.

Implementing inhibition programs requires several times less money than replacing pipelines.

Corrosion inhibitors are molecules of organic matter that attach to the surface of a steel pipe.

Corrosion inhibitors are designed to reduce the aggressiveness of gas and electrolytic media and prevent active contact between the metal surface and the environment.

This is achieved by introducing an inhibitor into the corrosive environment, resulting in the solvation activity of its ions, atoms, and molecules decreasing sharply. In addition, their ability to assimilate electrons leaving the surface of the metal during its polarization also decreases.

A mono- or polyatomic adsorption film is formed on the metal, which significantly limits the contact area of the surface with the corrosive medium and serves as a reliable barrier that prevents the course of self-dissolution processes.

The inhibitor must have good solubility in the corrosive medium and high adsorption capacity both on the juvenile metal surface and on the films of different natures formed on it.

Adding an inhibitor at the inlet to the pipeline makes it possible to protect it along the entire length over a distance of up to several 100 km.

According to the mechanism of action, inhibitors are divided into adsorption and passivation inhibitors. Passivation inhibitors cause the formation of a protective film on the metal surface and promote the transition of metal to the passive state.

Passivators are most widely used to combat corrosion in neutral or close-to-neutral environments, where corrosion occurs primarily with oxygen depolarization.

The mechanism of action of such inhibitors varies and is determined mainly by their chemical composition and structure.

Several types of passivation inhibitors exist, for example, inorganic substances with oxidizing properties (nitrites, molybdates, chromates). The latter is capable of creating protective oxide films on the surface of the corroding metal [7]. In this case, as a rule, there is a potential shift towards positive values to the value corresponding to the release of oxygen from water molecules or hydroxyl ions.

The formed oxygen atoms are chemisorbed on the metal, which blocks the most active centers of the metal surface and creates an additional potential jump that slows the dissolution of the metal.

The chemisorption layer that emerges is similar in composition to the surface oxide. A large group consists of passivation that forms insoluble compounds with ions of corroding metal.

The salt residue, formed in this case, if it is dense enough and well adheres to the metal surface, protects it from contact with the corrosive medium. Such inhibitors include polyphosphates, silicates, and carbonates of alkali metals.

A separate group is composed of organic compounds, which are not oxidizing agents but contribute to the adsorption of dissolved oxygen, which leads to passivation.

These include sodium benzoate and sodium salt of cinnamic acid for neutral media.

In water, the inhibiting effect of benzoate on iron corrosion is not observed. Particles of adsorption inhibitors (depending on the structure of the inhibitor and the composition of the medium, they may be in the form of cations, anions, and neutral molecules), interacting electrostatically or chemically with the metal surface (physical adsorption or chemisorption, respectively) are fixed on it, which leads to inhibition of the corrosion process [8].

Consequently, the effectiveness of the inhibiting action of most organic compounds is determined by their adsorption capacity in contact with the metal surface. As a rule, this ability is large enough due to the presence of atoms or functional groups in the molecules, providing active adsorption interaction of the inhibitor with the metal.

Such active groups can be nitrogen, sulfur, oxygen, and phosphorus groups that are adsorbed on the metal due to donor-acceptor and hydrogen bonds. The most widespread are inhibitors based on nitrogen-containing compounds.

The protective effect shows aliphatic amines and their salts, amino alcohols, amino acids, azomethines, anilines, hydrazides, imides, acrylonitriles, imines, nitrogen-containing 5-membered (benzimidazoles, imidazolines, benzotriazoles, etc.) and 6-membered (pyridines, quinolines, piperidines, etc.) heterocycles.

Compounds containing sulfur atoms in the molecule are of great interest. These include thiols, polysulfides, thiosemicarbazides, sulfides, sulfoxides, sulfonates, benzamides, thiocarbamates, thioureas, the sulfonic acids, thiophenes, sulfur-containing triazoles and tetrazoles, thiocyanates, mercaptans, sulfur-containing aldehydes, keto sulfides, thioesters, etc.

Of the phosphorus-containing compounds, thiophosphates, pyrophosphates, phosphoramides, phosphonic acids, phosphonates, dialkyl, and diaryl phosphates are used as corrosion inhibitors.

Oxygen has the lowest protective properties in the series of heteroatoms: oxygen, nitrogen, sulfur, and selenium, but oxygen-containing compounds can be used to create highly effective inhibitor compositions.

Pyranes, pyrene, dioxanes, phenols, cyclic and linear esters, allyl alcohol esters, benzaldehydes and benzoic acids, alcohols, furans, dioxolanes, acetals, etc., have found application.

In recent years in the development of corrosion inhibitors, there has been a tendency to use raw materials containing transition metals, complexes based on them, and complex-forming compounds that interact with transition metals present in the electrolyte or on the protected surface [9].

It is proved that based on such compounds and complexes, using catalyst production wastes and spent catalysts as raw materials, it is possible to create highly effective environmentally friendly inhibitors of corrosion of carbon steels in aqueous media.

Compounds and complexes based on organopolymolybdates, aromatic and aliphatic amines, hydrazides of some organic acids, and triazoles, including Zn, Ni, Al, Co, and their salts, are among the most studied ones.

Chemisorption of complexes on a steel surface occurs due to the interaction of the complex anion, which is formed during the dissociation of the complex in aqueous media, with the electrons of unfinished d-orbitals of iron.

Unfortunately, the reagents used do not always provide a sufficiently high protective effect.

This may be due to the solubility (dispersibility) of inhibitor in formation fluids, the low degree of its compatibility with formation waters, and improper selection of reagent for specific conditions.

Usually, in practice, this problem is solved by increasing the reagent dosage, which only sometimes gives the desired effect.

Consequently, it is necessary to create new inhibitor compositions which could provide a high protective effect in a wide range of application conditions or to improve the quality of existing compositions.

Thus, to solve the complex problems associated with the corrosion destruction of equipment and pipelines, it is necessary to create new inhibitor compositions or use physical methods of exposure to corrosive environments, or combined chemical and physical processes.

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