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A REVIEW STUDY ON CORROSION &ITS PREVENTION IN THE OILFIELD EQUIPMENT

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ABSTRACT

Corrosion is a critical failure in the petroleum sector that must be considered in the design of oilfield equipment in order to not only reduce economic losses but also to keep the resources safe and secure. As a result, different experimental and numerical investigations were conducted in order to better understand the processes and rules of corrosion types that occur in the oil and gas production areas, as well as the variables that influence these kinds. The present study aims to examine the many kinds of corrosion that have occurred in oilfield and flow line equipment, as well as how they may be avoided. The impact of a variety of difficult working environments, such as the presence of high levels of corrosive gases like carbon dioxide (CO2) and hydrogen sulfide (H2S), is also taken into account. In addition, several kinds of corrosion protection techniques, such as inorganic inhibitors (e.g., anodic and cathodic protection methods), organic inhibitors (e.g., film forming or coating), and environmental conditions (e.g., scavengers and biocides), are extensively discussed.

KEYWORDS: *Corrosion Inhibitors, Sweet Corrosion, Sour Corrosion, Oxidation Corrosion.*

1. INTRODUCTION

Metal corrosion in oil and gas well production systems is a significant issue and a hazardous mode of failure since corrosion may result in not only financial losses but also difficulties with resource protection and safety. Understanding the causes of corrosion in oil and gas systems at all stages, from downhole to surface equipment and processing facilities, is critical for making a reasonable corrosion prevention design that will assist oil and gas field exploration and development. To grasp this idea, you must first comprehend the working conditions of oilfield production systems, as well as the variables that influence corrosion. As a result, certain oil and gas wells have poor operating conditions due to the presence of corrosive elements including carbon dioxide (CO2), hydrogen sulfide (H2S), and chloride anions, which accelerate corrosion. In addition, most oil and gas wells include co-produced water injected during water flooding, condensate water with high concentrations of chloride ions and acetic acid, as well as oxygen introduced during well building and down entire operations such as acidizing(1–4).

As a result, water is constantly present in oil and gas reserves, and corrosion is a possibility. In addition to the aforementioned variables, there are a number of additional that have a significant impact on the severity of corrosion in oil and gas production systems. The pH value, fluid dynamics, temperature, pressure, and gas-to-oil ratio are all measured in situ. Other significant factors influencing corrosion prevention design include material selection and structure, galvanic coupling, stray currents, and microorganisms. Numerous review articles have summarized previous published experimental and numerical studies on the most common types of corrosion occurrences in petroleum industry systems, as well as their mechanisms, including electrochemical corrosion, chemical corrosion, environment-assisted fracture, stress corrosion, and flow- and phase change induced corrosion. According to the literature, stress corrosion cracking causes general and localized corrosion in tanks, casings, and tubing, as well as internal corrosion or corrosion/erosion in the wellhead assembly, operational pipes, and other equipment (SCC). It was also observed that galvanic corrosion occurs seldom in wells with corrosion-resistant tubing string(5–8).

In the oil and gas sector, corrosion inhibitors (CIs) and catholic or anodic protections may potentially be employed to prevent corrosion or reduce its pace. Several types of corrosion inhibitors can only prevent corrosion for a limited amount of time, and the majority of them can't fully stop it. The operation variables that influence the corrosion protection and corrosion inhibition selection criteria were also addressed. However, there is currently no overview research that explains the behavior of corrosion in the oil and gas sector, including its kinds and processes, in connection to production environmental conditions and how they may be avoided(8,9). The goal of this study is to determine the impact of oil environmental variables (such as flow, pressure, temperature, oil phase, and water phase) on the rate of corrosion in oil and gas equipment. The effect of anionic species (e.g., chlorides, sulfides, sulfates, carbonates, and bicarbonates) and cationic species (e.g., ferrous, ferric, magnesium, strontium, calcium, and barium) in the generated water content on the kind of corrosion is addressed. In addition, the impact of additional oil components such as carbon dioxide (CO2), hydrogen sulfide (H2S), oxygen (O2), particulates and microorganisms, pH, organic acids, and mercury on corrosion start and mechanism is discussed(10–12)(13).

1.1. Types of corrosion in the oil and gas equipment:

In general, all facilities utilized in oil and gas production systems have the potential to fail due to corrosion. Internal and exterior corrosion are the two kinds of corrosion that often occur in oil and gas well production systems. Internal corrosion occurs in the tubing, casing, wellhead assembly, field equipment, and operational pipeline's interior walls. External corrosion occurs when the casing's exterior wall and cement sheath come into contact with corrosive generated water or produced oil containing high levels of CO2, H2S, and elemental sulfur, as well as high-salinity formation water. The deposition of elemental sulfur and hydrate, as well as the development of scale, may obstruct the flow channel, resulting in complex downhole operations and erratic output. When studying and analyzing corrosion in oil wells, it is necessary to comprehend working environmental conditions, corrosive media or gases in produced fluid and their concentrations, the material chosen and its structure, and so on in order to determine the severity of corrosion and the interaction among them.

1.1.1. Oxygen (O2) related corrosion:

One of the main chemical types responsible for corrosion in oil production equipment is oxygen. Corrosion is caused by O2 in a variety of ways, including dissolved oxygen corrosion, water injection tubing, and surface treatments. Corrosion in the surface processing is common during oil treatment because most of it is done at ambient pressure, allowing oxygen to enter more easily via leaky seals, vents, and other openings. Furthermore, the chemical agent is responsible for most of the oil's exterior deterioration. Corrosion inhibitors on water injection pipe corrosion under static and dynamic conditions. The dissolved O2, Ca2+, and other inorganic salts in generated water were shown to be the primary cause of pipe corrosion(9,14,15).

1.2. Sweet Corrosion:

Carbon dioxide (CO2), often known as sweet corrosion, is the main cause of corrosion in oil and gas production equipment. It is made of carbon steel and, when mixed with water, tends to produce acidic solutions (corrodible substrate). The corrodants include H+, which comes from carbonic acid (H2CO3) and CO2 dissolving in the brine. CO2gas may be present in the reservoir as a natural component or it can be added during activities such as CO2 injection into the reservoir via improved recovery procedures. CO2 would not be corrosive if it were a dry gas.

1.2.1. Types of sweet corrosion

Sweet corrosion affects oil and gas equipment in a variety of ways, including localized and general corrosion. Localized corrosion usually results in simple metal dissolution followed by pitting, which is caused by the collapse of the protective passive layer on the metal surface. Pitting causes different patterns of corrosion, such as "mesa-type" corrosion, which occurs in low to medium flow regimes and is caused by the metallurgical processing employed in the tubing, grooves, and channels. In stationary to moderate flow conditions, tapered and smooth side pitting corrosion develops. When welding is not followed by full-length normalizing of the tube after processing, ring worm corrosion develops, and "raindrop attack" occurs when gas condenses in wells or water condenses on metal.

1.2.2.Sour Corrosion:

Hydrogen sulfide (H2S) is a poisonous and corrosive gas that is responsible for H2S-related corrosion (sour corrosion). The following are some of the factors that influence sour corrosion:

- The H2S corrosion rate is controlled by a number of interdependent factors rather similar to these of the CO2 related corrosion are:
- The rate of H2S corrosion is governed by a variety of interconnected variables that are similar to those that govern CO2 corrosion.
- Temperature: General and pitting corrosion rates are typically acceptable at lower temperatures owing to the existence of a protective FeS layer, while at higher temperatures, such as 110oC, the FeS film is not protective and will be porous..
- Steel composition and microstructure: Because steel composition can affect passive film stability and phase distribution (e.g., Chromium in stainless steel), minor alloying elements can cause local changes in passive film forming element (e.g., Carbon in stainless steel causing sensitization), and impurity elements can segregate to grain boundaries and causticity, this has a direct impact on corrosion rate.
- The impact of sulfate reducing bacteria (SRB) on the corrosion of Q235carbon steel in the crevice under simulated gypsum coating in soil-extract solutions was studied using electrochemical impedance spectroscopy (EIS) (SES). The corrosion rate in the SES with SRB is reduced during the stationary phase of SRB, but increased during the death phase, according to the findings. The biofilm has a significant impact on the reactive process of the metal/solution interface, as shown by the comparison of polarization (Rp) and charge transfer resistances (Rt). SRB is present in the pits on the steel's surface.

1.2.3. Types of sour corrosion:

Other kinds of cracking caused H2S related corrosions include: sulfide stress cracking (SSC), step wise cracking (SWC) (or Hydrogen-Induced cracking (HIC) or hydrogen pressure induced cracking (HPIC)), and stress oriented hydrogen induced cracking (SOC) (SOHIC). The presence of atomic hydrogen in solid solution in bulk causes sulfide stress cracking (SSC), which reduces ductility and deformability. Tensile tension may very readily result in fractures that run perpendicular to the stress direction. In sensitive steels exposed to aqueous environments containing hydrogen sulphides, stepwise cracking (SWC) or hydrogen-induced cracking (HIC) develops. H2 accumulation at trap sites (e.g., voids associated with inclusions) causes local fractures and blisters, which develop stresses around the substrate and neighbors, eventually creating a connected array and causing equipment failure. The combination between tensile tension and hydrogen generated blisters and cracks causes stress oriented hydrogen induced cracking (SOHIC). Crack arrays resembling ladders develop, running roughly perpendicular to the stress direction(16–18).

1.2.4. Corrosion inhabitation:

Methods based on environmental modification (e.g., adjusting the pH, dehumidification of the air, and the addition of inhibitors), methods based on metal modification (e.g., adding alloying elements, and heat treatments), and methods based on protective coatings can all be used to delay corrosion in the oil and gas industry (e.g., coating by a reaction product either chemical or electrochemical treatment of metal surface, organic coating such as paints, resins, inorganic coating, and metal coating).

1.2.4.1.Importance of Corrosion inhabitation:

Corrosion inhibitors are important in many settings because they regulate the corrosion process. However, there are certain exceptions, such as equipment exposed to turbulent flow, systems running beyond the inhibitor's stability limitations, and equipment subjected to high velocity above 4 m/s. In order to enhance the effectiveness of inhibition, many variables must be addressed, including frequent cleaning of pipelines using the pigging process, reducing fluid stagnation due to well shut down, and regularly evaluating the efficiency by analyzing the inhibitor concentration(17–20).

1.2.4.2.Classification of corrosion inhabitation:

Anodic, cathodic, and mixed corrosion inhibitors are the three major types of liquid-phase corrosion inhibitors. Corrosion inhibitors are chosen based on their solubility or dispensability in the fluids that need to be prevented from corroding. To achieve the appropriate selection of corrosion inhibitors, the following factors must be addressed:

- The extent to which uniform and localized corrosion is suppressed
- Inhibitor performance as a function of temperature and concentration.
- How long does the efficacy have to last?
- Determining if additional metals connected to the primary system have a bimetallic connection.
- Recognizing the current state of the system to be safeguarded.
- Heat transfer properties as a result of the inhibitor.
- Pollution and toxicity issues
- Competitive in terms of cost and technology with other inhibitors under consideration.
- Corrosion inhibitors can be classified according to their mechanism and composition as follows:
- Organic or inorganic.
- Anodic or cathodic.

1.3. Mixed Corrosion inhibitors:

It's impossible to say if it's anodic or cathodic. The degree to which mixed inhibitors adsorb and blanket the metal surface determines their efficacy. The structure of the inhibitor, the surface charge, and the kind of electrolyte all influence metal adsorption. Amines, triazoles, and allylthiourea are examples of mixed organic inhibitors including nitrogen and/or sulfur. Physical adsorption, chemisorption, and film generation are all ways that mixed inhibitors protect the metal. Electrostatic interaction between the inhibitor and the metal surface causes physical adsorption. Physical adsorption of negatively charged (anionic) inhibitors is enhanced when the metal surface is positively charged. Chemisorption (or chemically adsorption) is the most efficient combined inhibitor, although it takes longer than physical adsorption to work. Between the inhibitor molecules and the metal surface, chemisorption includes charge sharing or charge transfer. The film production process is only successful when the films are adherent, non-soluble, and restrict solution access to the metal. If the thickness of a thick film, such as an air generated layer on a steel surface, reaches a critical threshold, it may lose adhesion owing to mechanical damage. Protective coatings are often referred to as ohmic inhibitors because they raise the circuits resistance, preventing corrosion or conducting (self-healing films).

2. DISCUSSION

Corrosion is a critical failure in the petroleum business that must be considered in the design of oilfield equipment, not only to reduce economic losses but also to keep the resources safe and secure. As a result, different experimental and numerical investigations were conducted in order to better understand the processes and rules of corrosion types that occur in the oil and gas production areas, as well as the variables that influence these kinds. The present study aims to examine the many kinds of corrosion that have occurred in oilfield and flow line equipment, as well as how they may be avoided. The impact of various hard working environments characterized by high levels of corrosive gases (e.g., carbon dioxide (CO2) and hydrogen sulfide (H2S)) is also taken into account(21–23). Corrosion inhibitors (CIs) and catholic or anodic protections may potentially be employed to prevent or reduce the rate of corrosion in the oil and gas sector. Several types of corrosion inhibitors can only prevent corrosion for a limited amount of time, and the majority of them can't fully stop it. The operation variables that influence the corrosion protection and corrosion inhibition selection criteria were also addressed. However, there is currently no overview research that explains the behavior of corrosion in the oil and gas sector, including its kinds and processes, in connection to production environmental conditions and how they may be avoided.

3. CONCLUSION

Corrosion failure is a leading cause of structural degradation in oil and gas structures and pipelines, resulting in structural collapse, leakage, product loss, pollution, and even death. This article aims to provide a comprehensive overview of the main kinds of corrosion that occur in oil and gas systems, as well as the best methods to prevent corrosion. The review focuses mostly on sweet and sour corrosion, as well as the variables that influence their rates. Pitting corrosion, along with general and localized corrosion, is the most dangerous kind of corrosion in petroleum equipment. CO2corrosion pits are often hemispherical deep pits with localized corrosive along the steep edges. Several kinds of cathodic, anodic, and mixed inhibitors might delay the development of localized corrosion for a short amount of time, but most of them couldn't fully prevent it. Sulfate, iron, and CO2-reducing bacteria, sulfur, iron, and manganese-oxidizing bacteria, as well as microorganisms that produce organic acids or mucilage, are responsible for the majority of buried pipeline, bio corrosion, and cable failures, but sulfate reducing bacteria (SRB) are responsible for over 75% of the corrosion in productive oil.

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