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Investigation of Suitable Inhibitors to Reduce Corrosion of Used Metals in Refinery Industries

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Abstract

The corrosion has caused various economic problems in the chemical and petrochemical industries over the years. To prevent the rate of corrosion, as well as to maintain various devices, a series of materials are used as inhibitors. If these materials are used, the lifespan of tools and devices will be increased and economic costs will be reduced. In this study, a new inhibitor that can be used instead of hydrazine was used. This inhibitor is called Levoxin-15 and can be used to prevent corrosion caused by oxygen in steam tanks. The laboratory results showed that by keeping the concentration of Levoxin-15 at a constant value of 15 mg/l in steam tanks, no signs of corrosion were observed during 2 years of operation. The obtained results show with increasing the concentration of hydrochloric acid to about 3500 mg/l the relative corrosion rate increases almost, linearly. This increase will be such that at a concentration of 3500 mg/l of hydrochloric acid the corrosion rate will be about 300 times. In addition, the results illustrate that with increasing the concentration of hydrazine from about 20 to 30 mg/l and also the concentration of levoxin-15 from about 78 g/m^3 to about 88 g/m^3, the operating time increases significantly. Also, results state that with increasing acidity from about 11 to 15, the relative corrosion rate will increase almost as a quadratic function to about 178 times.

Keywords

Hydrazine, Levoxin-15, Cavity Corrosion, Oxygen Depletion, X-ray, Steel Alloy

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1. Introduction

The corrosion has caused various economic problems in the chemical and petrochemical industries over the years [1-3]. To prevent the rate of corrosion, as well as to maintain various devices, a series of materials are used as inhibitors. If these materials are used, the lifespan of tools and devices will be increased and economic costs will be reduced [4-7].

1.1. Description of Corrosion

The corrosion is defined as the destruction or decay of a material by reaction with its environment. Some insist that this definition should be limited to metals, but often a corrosion engineer must consider both metals and non-metals to solve a problem [8-11]. For example, the destruction of paint and rubber by sunlight or chemicals, the corrosion of the wall of a steel furnace, and the corrosion of one solid metal by the melt of another metal are called corrosion. The corrosion can occur quickly or slowly. Railroad tracks usually rust slowly. But, the calling speed is not fast enough to affect their performance over many years. Delhi's famous ferric pillar was built in India about 2000 years ago and is still well on its first day. It is 23 feet high and 2 feet in diameter [12-15]. The corrosion of metals can be considered as the opposite of extractive metallurgy. In mining metallurgy, the main purpose is to obtain metal from ore and refine or alloy it for various uses. Most ores contain ferric oxides, and the rusting of steel by water and oxygen leads to the formation of hydrated ferric oxide. Although most metals

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form oxides when eaten, the word rust is used only for ferric and steel [16-19].

1.2. Types of Corrosion

The corrosion can be classified in different ways [20-23]. The basis used in this manuscript is the appearance and shape of the metal [24-27]. In this way, the type of corrosion can be determined simply by observing the corroded metal [28-33]. In most cases, the naked eye is sufficient to detect the type of corrosion [34-41]. But, sometimes magnification (such as a magnifying glass or microscopes with low magnification) will be useful, or valuable information to solve a corrosion problem is often obtained by carefully studying corroded test specimens or equipment or components that have been destroyed [42-49]. It is necessary to study the eaten samples, especially before cleaning them. Among the types of corrosion, 8 unique types can be found. But, all of them are more or less similar [50-54]. These 8 types are: (1) uniform or uniform corrosion, (2) bimetallic corrosion, (3) groove corrosion, (4) cavitation corrosion, (5) inter-granular corrosion, (6) selective separation, (7) abrasion corrosion, (8) stress corrosion. This classification is optional and may not be 100% complete [54-59]. But, it covers almost all types of corrosion problems and damage. The above order does not indicate the importance of these types [60-63]. The price and corrosion resistance are the most important factors, although appearance is often the most important issue in architectural applications, and productivity, which indicates the ease of forming welding and other mechanical operations, should also be considered [64]. It is important and should be considered even when choosing corrosion resistance [65]. In some highly corrosion resistant materials such as gold, platinum and some super alloys, the presence of these materials is often the determining factor [66]. In some cases, the delivery time for ordering parts of very special metals and alloys is so long that their use may be neglected, and the engineering aspects of corrosion resistance should not be overlooked. Platinum or glass is possible [67]. However, in most cases, the use of these materials is not practical. The corrosion resistance or chemical resistance depends on various factors and its study requires information in several scientific fields [68]. The thermodynamics and electrochemistry are very important for understanding and controlling corrosion. Thermodynamic studies and calculations indicate the direction of a reaction. In the case of corrosion, thermodynamic calculations can determine the theoretical possibility or impossibility of corrosion [69]. The electrochemistry of the field and the kinetics of the electrodes will be discussed in detail. Often metallurgical factors have a great influence on corrosion resistance. There are many cases in which the control of the metallurgical structure of alloys can be used to reduce corrosion. The physical chemistry and its various fields are very useful in studying the mechanisms of corrosion reactions, surface conditions and some of the main properties of metals [70 and 71].

In this study, a new inhibitor that can be used instead of hydrazine was used. This inhibitor is called Levoxin-15 and can be used to prevent corrosion caused by oxygen in steam tanks.

2. Materials and Methods

2.1. Description of Corrosion Process

Various parameters play a role in the occurrence of corrosion problems. These parameters include the amount of dissolved oxygen, the solubility of the gas, which causes corrosion in various industries. Figure 1 shows the relationship between these factors.

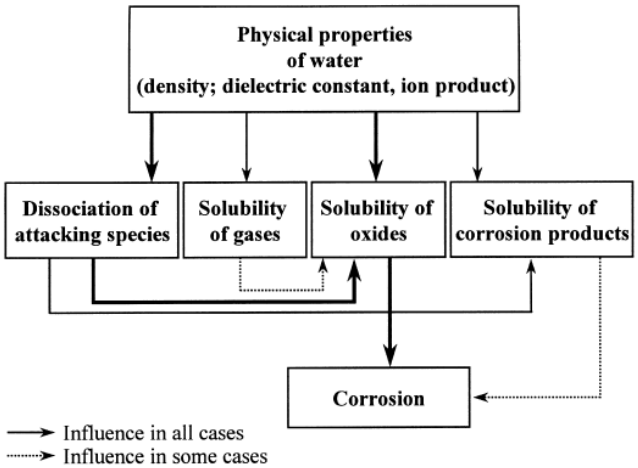

Figure 1. Relationship between corrosion factors and factors determining the amount of corrosion at high temperatures.

In modern boiler systems, the majority of oxygen is removed mechanically. Some contaminants are also removed chemically. As can be seen in the Figure 1, according to the physical properties of water, its effect on the rate of corrosion can be seen. This chart states that the amount of corrosion that occurs on the metal surface will also vary depending on the solubility of the gases dissolved in the water (especially oxygen). Mechanical removal of oxygen can be done by vacuuming the gases in the tank. Exhaust gases reduce the amount of oxygen to less than 0.5 mg/l to 1 mg/l. Also, by using heater heaters, the oxygen concentration can be reduced to 0.005 mg/l to 0.01 mg/l. It is worth noting that even this small amount of oxygen is corrosive due to the pressure and operating temperature of the boilers. By removing the factors and compounds that need oxygen, the same amount of low oxygen can be eliminated. To do this, hydrazine and sulfide are widely used in various industries. But these materials also have drawbacks and shortcomings. However, sodium sulphite is widely used as a pollutant in various industries. But not recommended for systems with operating pressures above 1000 pounds per square inch. The sodium sulphite also increases the amount of dissolved solids in the system, which leads to high fluid conductivity inside the tank. Hydrazine, by combining and reacting with oxygen to produce water and hydrogen gas, can effectively remove residual oxygen in the system. Unfortunately, it has been repeatedly reported that hydrazine is a highly toxic substance. But it is highly tempting to treat water in systems that are generally free of contaminants. However, for systems operating under local operating conditions, boilers are effective in preventing corrosive agents and delaying corrosion.

2.2. Laboratory Equipment

It is a metal box that is located in the pipeline and is in contact with water and oxygen. This box measures the average corrosion rate. Its material is proportional to the material of the steam tank pipeline and its dimensions are proportional to the diameter of the pipeline. This device measures the amount of corrosion in millimeters per year, mills per year and inches per year according to the following equation. This device is shown in Figure 2.

Average corrosion rate = weight of the sample box measured at the beginning of the work multiplied by the specific gravity at the time of contact at the contact surface (1)

Contact level = sum of 6 levels minus twice the area of the circle (2)

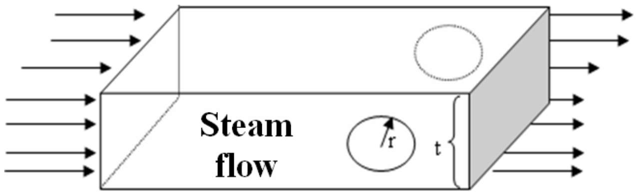

Figure 2. Schematic of the corrosion rate measuring box.

As shown in the corrosion measuring device in Figure 2, this device is located in the flow path of the passing fluid (which in this study contains water and oxygen) and is eaten based on the coupons used in it and its weight decreases. Because the initial weight of the coupon was measured by a scale. It can be re-weighed over time. The difference between the two weights (at the beginning and at the end of the operation) will indicate the rate of corrosion in the defined time period. The Equations (1) and (2) are used to calculate and estimate the corrosion rate.

3. Results and Discussion

The steam tank pipes are typically made of carbon steel or low-alloy steel. The experiments have shown that the rate of ferric corrosion at 310°C is directly related to the acidity of the water. Laboratory results also indicate that the maximum protection of the metal tubes of steam tanks occurs when the acidity is between 11 and 12. In soda with high concentrations and acids with more than 12, the amount of ferric corrosion is greatly increased and the ferric oxide film, Fe_3O_4 is dissolved and converted to Na_2FeO_2. The reaction is performed as follows.

$$Fe + 2NaOH \rightarrow Na_2FeO_2 + H_2 \tag{3}$$

As shown in Reaction 3, the Ferric combines with sodium to form sodium ferrite with the chemical formula Na_2FeO_2. As mentioned above, at pH above 12 and high concentrations of soda, ferric corrosion takes a sharp upward rate and the Fe_3O_4 film is converted to sodium ferrite with the chemical formula Na_2FeO_2. The corrosion effect of soda (sodium carbonate) at high pressures of steam tanks is greater than low pressures. Local corrosion often occurs in steam tanks, and if the acidity level is controlled in the range of 9 to 9.5, it will strongly prevent total corrosion. It also occurs at low acidity levels and is generally visible is in the Figure 3. When the tanks are in standby mode, it is recommended to use Levoxin-15 as a protection against moisture corrosion. In this case, the Fe_3O_4 magnetic film is protected from corrosion and eventually the corrosion is delayed. The amount of levoxin-15 required for injection depends on several factors. For example, the standby period of the tank, water quality, stability of the magnetic layer. The quality of hydrazine and levoxin-15 varies somewhat based on the standby time of the steam tanks and is in the acidic range of 10 to 10.5. Figures 3, 4 and 5 illustrate this point.

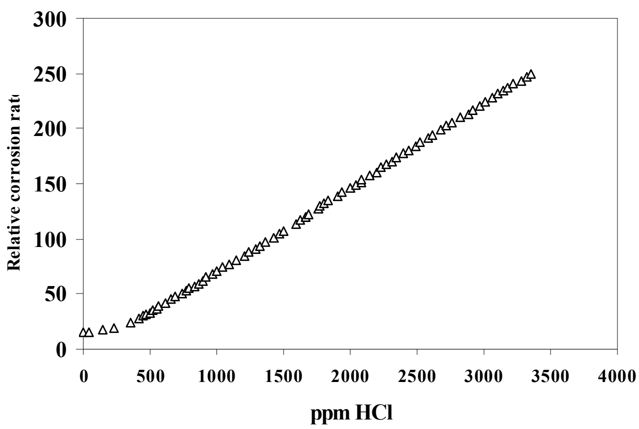

Figure 3. Investigation of relative corrosion in terms of hydrochloric acid concentration.

As shown in Figure 3, with increasing the concentration of hydrochloric acid to about 3500 mg/l the relative corrosion rate increases almost, linearly. This increase will be such that at a concentration of 3500 mg/l of hydrochloric acid the corrosion rate will be about 300 times.

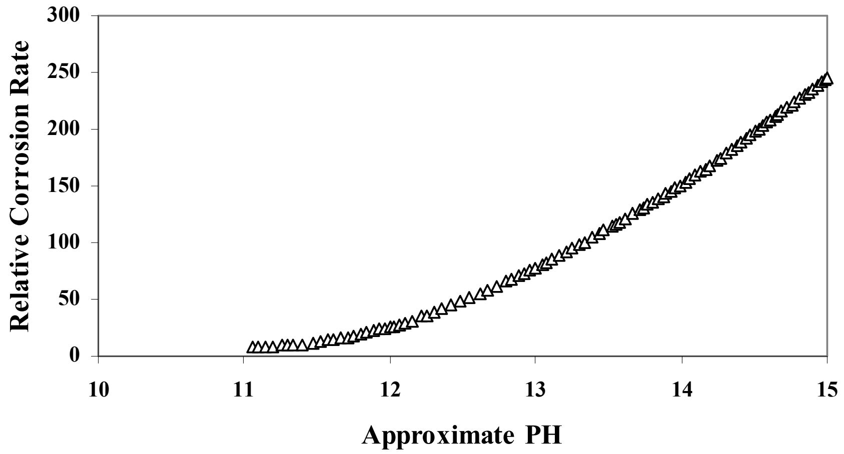

Figure 4. Investigation of corrosion rate in terms of flow acidity.

As shown in Figure 4, with increasing acidity from about 11 to 15, the relative corrosion rate will increase almost as a quadratic function to about 178 times.

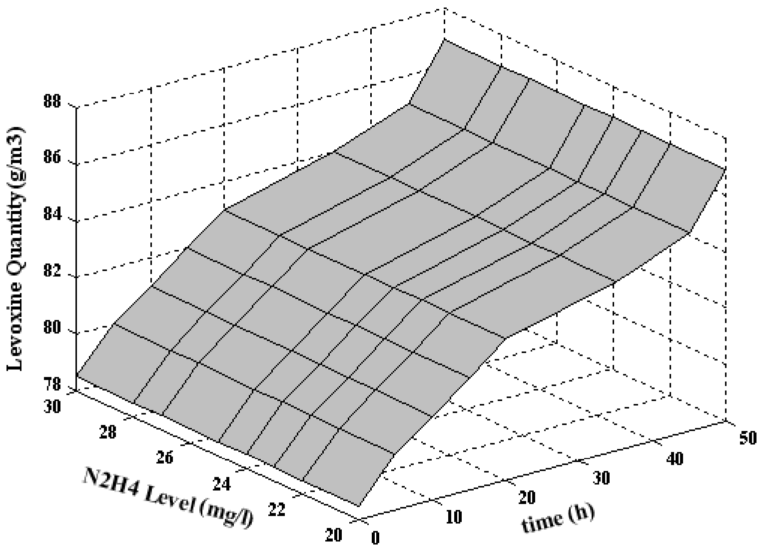

Figure 5. Investigation of the relationship between operating time, hydrazine and leucine (low concentration range).

As shown in the Figure 5, with increasing the concentration of hydrazine from about 20 to 30 mg/l and also the concentration of levoxin-15 from about 78 g/m^3 to about 88 g/m^3, the operating time increases significantly. In other words, laboratory results indicate that the concentration of hydrazine and levoxin-15 will have a positive effect on the operating time of the used system. This effect can be explained by the removal of oxygen ions by the nitrogen compounds hydrazine and levoxin-15. As can be seen in this diagram, its increasing slope is somewhat towards the vertical axis (effect of levoxin-15) and as a result, it can be said that the effect of levoxin-15 is somewhat greater than the effect of hydrazine in removing oxygen from corrosion.

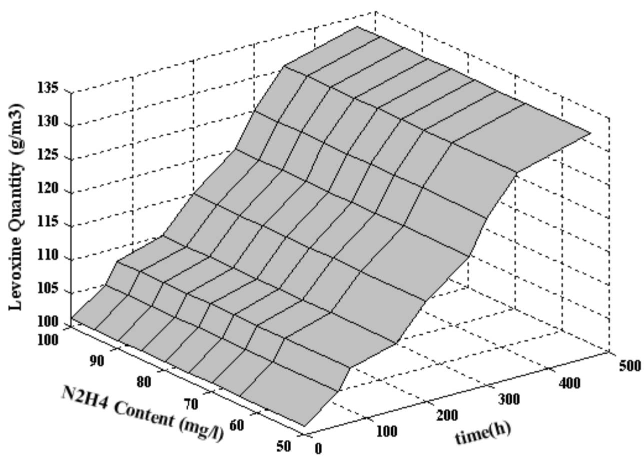

Figure 6. Investigation of the relationship between operating time, hydrazine and leucine (average concentration range).

The Figure 6 also shows the effect of increasing the concentration of hydrazine from about 50 mg/l to 100 mg/l. Also, the concentration of levoxin-15 in this experiment has increased from about 100 to 135 grams per cubic meter and has increased the operating time of steam tanks to about 480 hours. In other words, by increasing the concentration of hydrazine and levoxin-15, the life of steam tank tubes can be increased and the process can be more economically justifiable. This diagram also shows that the functional effect of levoxin-15 is somewhat better than that of hydrazine.

4. Conclusion

Oxygen often removes the protective magnetic layer of Fe_3O_4, thus exacerbating pore corrosion. The precipitate also causes local heating of the pipeline and a large amount of oxygen to attack other parts of the process, including steam tanks. X-ray images were taken from inside the steam tank tubes. Hydrazine acts as a very strong anti-scaling that makes the environment alkaline and acts as an excellent inhibitor to prevent corrosion. This substance is a common compound that is used in all petrochemical industries. It is also used to delay corrosion. However, this substance is dangerous and toxic and causes dangers to humans, animals and the environment. According to the laboratory results, local corrosion in the tubes of steam tanks as well as general corrosion is delayed by keeping the acidity of water constant between 9 and 9.5. Based on laboratory results, it has been observed that levoxin-15 eliminates the corrosion process by reducing the amount of oxygen in the environment and minimizing the electrochemical reduction of oxygen in the cathode areas on the metal surface. Levoxin-15 acts as an inhibitor of operating steam tanks by setting the acidity between 11 and 12 and stops corrosion. This material also causes the acidity of standby tanks to be between 10 and 10.5, and in this case, stops corrosion for this group of steam tanks. Also, the compounds derived from this substance (Levoxin-15) are not corrosive and increase the life of the equipment and reduce maintenance costs. Also, during 2 years of using this substance (Levoxin-15) as well as its derivatives, no adverse effects on humans and animals have been reported so far.

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