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STUDY OF THE PROTECTIVE EFFECT OF NAOH ON THE CORROSION RESISTANCE OF CARBON STEEL AND GRAY CAST IRON IN THE OIL AND GAS INDUSTRY

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Abstract

The article presents the results of a study of the protective effect of NAOH on the corrosion resistance of carbon steel and gray cast iron. Modern methods of corrosion research and their results applied in aqueous media of the main inhibitors of atmospheric corrosion, film inhibitors, in the presence of aggressive mixtures of hydrogen sulfide and concentrated acids are presented.

Keywords: corrosion inhibitors, secondary amine salts, quaternary ammonium compounds, corrosion rate

Introduction

One of the most important factors influencing metal corrosion is the pH of the solution: the possibility of using a particular metal in practice is often determined by those pH limits within which the metal is satisfactorily resistant (Hammood, S. Ali, lieth Mahdi Haider, 2012). As a rule, the pH of circulating water is maintained within 6...8 (Kumar Chiranjib, Gupta, 2003).

Caustic soda enters the circulating system of barometric condensers from evaporators, which can change the pH of the circulating water within a wide range. To maintain the required pH values, it is neu-

tralized with hydrochloric acid, which leads to an increase in the chloride content in the circulating water and an increase in its corrosiveness. The rate of iron corrosion at alkaline pH values slows down (Lunarska, E. 1996). However, do these data relate to non-mineralized solutions, or did the studies use a universal buffer mixture containing an inhibitory component such as to maintain pH P_4^{3-} . Therefore, it is of interest to study the protective effect of sodium hydroxide on the structural materials of the circulating system of barometric capacitors when operating on mineralized water.

There was an assumption about using a reagent for protection against corrosion, which is actually a waste product and spontaneously enters the circulating water, instead of scarce and often toxic corrosion inhibitors. An additional criterion in favor of this premise was the fact that sodium hydroxide has a bactericidal effect (Espinoza, Vázquez, Figueroa, I.A., Sánchez, D. Molina, Rodríguez-Gómez, F.J., Angeles Beltrán, D. 2021). It was possible to use the same reagent for both corrosion protection and biofouling suppression.

Naturally, the increase in pH associated with the addition of NaOH can lead to increased scale deposition. However, in a circulating system of barometric condensers, when operating on water of high salinity, barometric condensate is sufficient to replenish the system, i.e. water that does not contain hardness salts.

Other circulating cycles at modern chlorine plants are fed not with river water, but with highly purified water, containing up to 2 g/l NaCl and having a total hardness of up to 1.5...2 mg-eq/l. Thus, in production conditions, replenishing the system with water containing a minimum amount of hardness salts

will avoid the problem of scale deposits even at alkaline pH values of the circulating water.

The assumption of using NaOH to suppress corrosion in circulation cycles required laboratory testing in order to determine specific pH values, NaCl concentration and temperature at which the corrosion rate of equipment in the recycling water supply system would correspond to acceptable values (up to 0.1 g/m³h) (Espinoza Vázquez, Figueroa I. A., Sánchez D. Molina, Rodríguez-Gómez F.J., Angeles Beltrán D. 2021). The studies were carried out using gravimetric and electrochemical methods.

The results of the influence of pH on the corrosion rate of carbon steel and gray cast iron in circulating water with a mineralization of 0.02 mol/l NaCl are given in table 1. Test duration is 1560 hours, temperature – 22 °C.

As you can see, with an increase in the pH of the solution to 13, the corrosion rate of metals decreases significantly, especially in the waterline zone (by 5...8 times). Obviously, this is due to the formation of insoluble protective films at alkaline pH values, which directly inhibit the electrochemical anodic stage of dissolution.

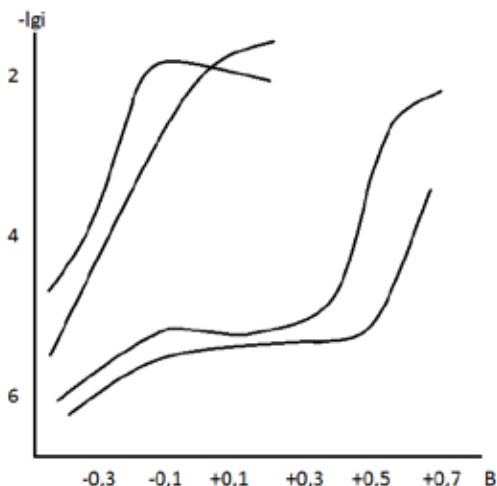
Table 1. Effect of pH on the corrosion rate of carbon steel and gray cast iron in circulating water with a concentration of 0.02 mol/l NaCl

Material	pH	Test site	Corrosion rate, g/m ² h	Nature of corrosion
Steel St.3	8	In the volume of electrolyte	0.0278	Spots
	10		0.0160	Spots
	11		0.0101	Spots
	13		0.0088	Spots
	8	In the waterline area	0.1045	Uneven
	10		0.0657	Uneven
	11		0.0560	Uneven
	13		0.0170	Spots
Cast iron SCh 18–36	8	In the volume of electrolyte	0.0425	Spots
	10		0.0248	Spots
	11		0.0177	Spots
	13		0.0128	Spots
	8	In the waterline area	0.1545	Uneven
	10		0.1133	Uneven
	11		0.0960	Spots
	13		0.0225	Spots

The observed dependencies are complemented by electrochemical studies on gray

cast iron (Fig. 1). Similar curves were obtained for carbon steel.

Figure 1. Effect of pH on the anodic polarization curves of gray cast iron in circulating water with a concentration of 0.02 mol/l NaCl. pH of mineralized water: 1–7.0; 2–10.0; 3–11.5; 4–12.5



The main characteristics of anodic processes on cast iron depending on pH in circulating water containing 0.02 mol/l NaCl are summarized in table 2.

Table 2. Influence of pH on the main electrochemical characteristics of anodic processes on cast iron

pH	Stationary potential, V	Pitting potential, V	Passive state area, V
7.0	-0.44	-0.44	Absent
8.5	-0.40	-0.40	Absent
9.0	-0.40	-0.40	Absent
10.0	-0.45	-0.35	0.1
11.5	-0.35	0.78	0.9
12.5	-0.14	0.83	1.1

Analysis of the table 2 shows that the effective influence of pH on the characteristics of anodic processes under the conditions under study occurs at $\text{pH} \geq 11.5$. At these pH values, the stationary potential of the metal improves, which indicates inhibition of the anodic process itself. At $\text{pH} \geq 11.5$, the pitting potential shifts significantly to the positive side: the healing process pitting occurs

faster than their formation. This increases the region of the passive state on the anodic polarization curve, and at pH 12.5 this region is equal to 1.2 V.

Thus, by changing the pH of the solution to the alkaline region, it is possible to effectively slow down the rate of corrosion of ferrous metals in circulating water, especially in the waterline area.

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