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DETERMINATION OF THE EFFICIENCY OF THE IKFA CORROSION INHIBITOR IN THE AGGRESSIVE ENVIRONMENT OF MDEA ABSORBENT ON A SAMPLE OF STEEL 09G2S

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ОПРЕДЕЛЕНИЕ ЭФФЕКТИВНОСТИ ИНГИБИТОРА КОРРОЗИИ ИКФА В АГРЕССИВНОЙ СРЕДЕ АБСОРБЕНТА МДЭА НА ОБРАЗЦЕ СТАЛИ 09Г2С

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ABSTRACT

In the chemical industry, the corrosion process occurring in technological devices is one of the urgent problems. Because corrosion causes great economic damage due to the rapid failure of metal products, equipment, structures and devices. Various methods and corrosion inhibitors are used to reduce this level of damage. This scientific article presents data on the effectiveness of the newly synthesized corrosion inhibitor IKFA.

АННОТАЦИЯ

В химической промышленности процесс коррозии, происходящий в технологических устройствах, является одной из актуальных проблем. Потому что коррозия наносит большой экономический ущерб из-за быстрого выхода из строя металлических изделий, оборудования, конструкций и устройств. Для снижения этого уровня повреждений используются различные методы и ингибиторы коррозии. В данной научной статье представлены данные об эффективности вновь синтезированного ингибитора коррозии ИКФА.

Keywords: MDEA (methyldiethanolamine), corrosion, urotropine, hydrochloric acid, acetone, desiccant, steel, drying cabinet, corrosion inhibitor.

Ключевые слова: МДЭА (метилдиэтаноламин), коррозия, уротропин, соляная кислота, ацетон, эксикатор, сталь, сушильный шкаф, ингибитор коррозии.

Introduction

The damage caused by corrosion of metal products, equipment, structures and devices used in developing industries is unprecedented. For example, in the United States of America, the damage caused by corrosion is about 300 billion dollars per year, which is 6% of the country's national income.

In the Russian Federation, 12% of the total mass of the metal stock is lost every year due to corrosion. This indicator is 30% of the annual metal production.

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In oil and gas processing enterprises, heat exchange devices make up about 50% of the total devices.

30% of the total metal consumption corresponds to heat exchange devices in oil and gas processing enterprises [1].

In addition to such direct damage, there are also many indirect damages. They include the loss of power of metal equipment, damages caused by their forced shutdown due to accidents, as well as expenses for eliminating the consequences of accidents that often lead to environmental disasters.

Corrosion problems are common in shell-and-tube heat exchangers, which are used in gas absorption purification technology in gas processing plants.

These shell-and-tube heat exchangers are made of 09G2C steel alloyed with manganese and silicon.

Aggressive medium consisting of MDEA (methyldiethanolamine) and sulfuric acid enters the shell-and-tube heat exchanger with a temperature of 50°C and leaves the device with a temperature of 80°C. The pressure in the heat exchanger is 1.66 kg s/cm^2 [2].

The proposed IKFA corrosion inhibitor is directly added to MDEA at a mass ratio of 0.05%. This composition blocks the corrosion process that occurs in the heat exchanger during the circulation of natural gas in the process of absorption purification [3].

Below are the results of determining the corrosion rate of 09G2C steel samples and the effectiveness of IKFA corrosion inhibitor based on GOST 9.905-82.

Research methodology

First experiment: Determining the corrosion rate of 09G2C steel samples in the aggressive environment of MDEA without an inhibitor.

To perform the test, the following sequence of operations was performed:

1.Before starting the test, the mass of 3 specially numbered steel samples was determined (Fig. 1 A). The obtained results were recorded in the table. (Table 1)

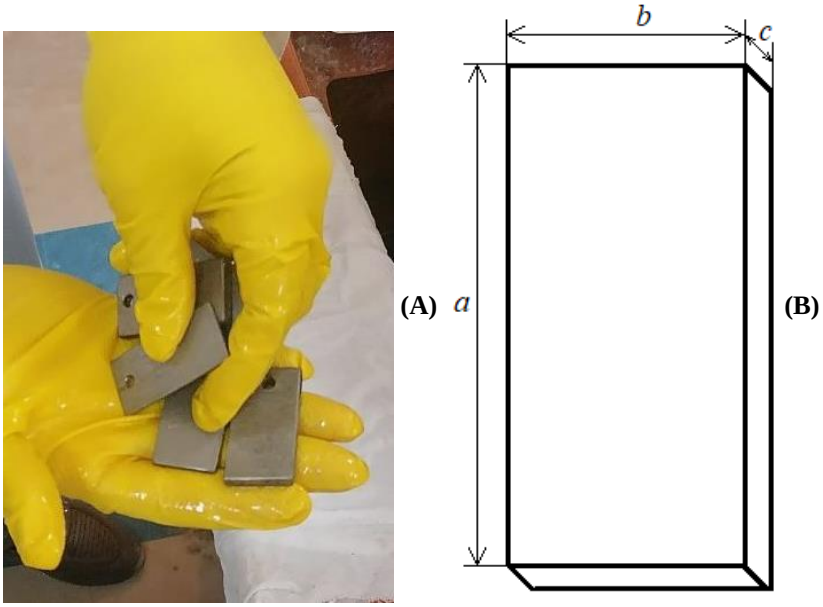


Figure 1. 09G2C steel samples (A) and gauge dimensions (B) Pre-test masses of steel samples

Table 1.

Data

Samples	Masses,m_1 (g)
First sample	58,48
Second sample	67,60
Third sample	75,80

2. The overall dimensions of each sample are determined (Fig. 1 B). The obtained results were recorded in the table. (Table 2)

Table 2.

Dimensions of steel samples

	First sample (mm)	Second sample	Third sample
a	40	41	42
b	18	20	21
c	11	11	11

3. Their surfaces were calculated based on the overall dimensions of the samples (1).

$$2(a\times b + b\times c + a\times c) \quad (1)$$

First sample: 2(40×18+18×11+40×11)=2716mm^2
Second sample: 2(41×20+20×11+41×11)=2982mm^2
Third sample: 2(42×21+21×11+42×11)=3150mm^2

4. The steel samples were polished until there were no sharp edges on the sandpaper.

5. Polished steel samples were kept for 4 minutes in a container containing "cleaning solution" (urotropin 10 g + hydrochloric acid 100 g) (Fig. 2). The temperature of the cleaning solution is 15-25°C [4].

Figure 2. Cleaning solution

6. Steel samples were scraped with a eraser a stream of distilled water.

7. Then the surface of the steel samples was wiped with acetone and wrapped in filter paper.

8. After that, it was placed in a drying cabinet at a temperature of 100°C for 2 hours.

9. It was then kept in a desiccator until it cooled.

10. After that, the steel samples were placed in a 500 ml conical flask with a temperature of 75 °C, 300 ml of MDEA saturated with absorbent, and a reflux condenser (Fig. 3). [5]

11. The time was recorded. The duration of the test was 24 hours.

12. Steel samples were taken after 24 hours and cooled.

13. Then, the mass of each steel sample was determined and the results were recorded in the table. (Table 3)

Table 3.

Masses of steel samples after testing

Samples	Masses,m_2 (g)
First sample	58,414
Second sample	67,53
Third sample	75,73

14. Based on the obtained results, the corrosion rate was calculated (2).

$$Kgrav = \frac{m1-m2}{S\times\tau} \quad (2)$$

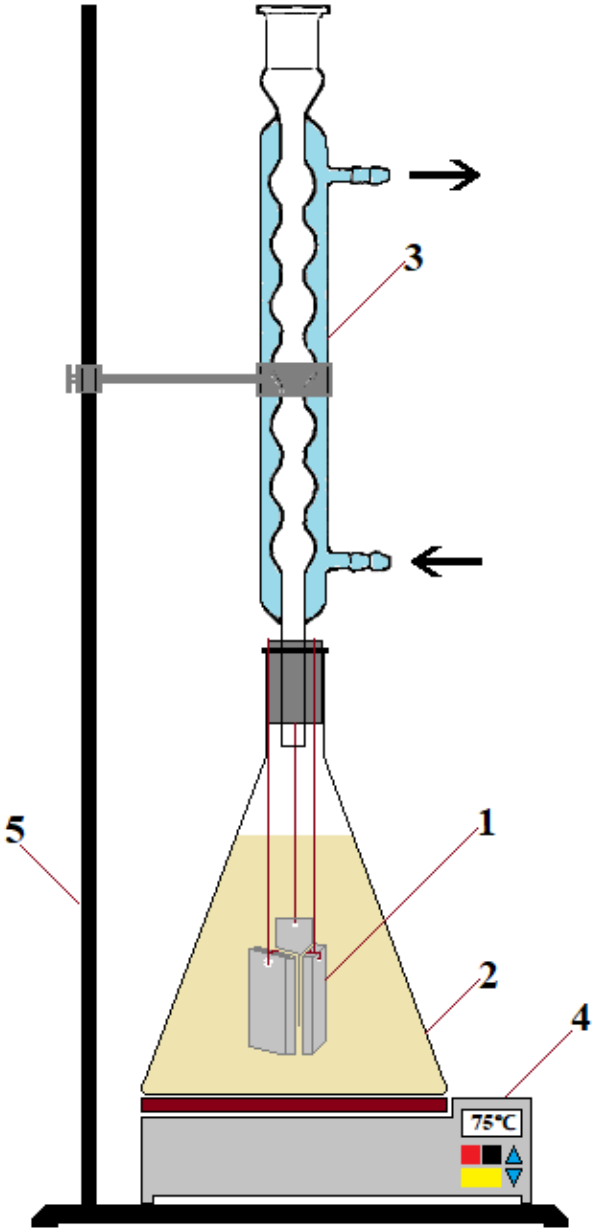
Here: m1 = mass of the steel sample before the test; m2 = mass of the steel sample after the test; S = steel sample surface, cm^2; τ=test time, hours.

First sample: $Kgrav = \frac{58{,}48-58{,}414}{27{,}16\times 24} = 10{,}1*10^{-5}$g/sm^2

Second sample: $Kgrav = \frac{67{,}60-67{,}53}{29{,}82\times 24} = 9{,}781*10^{-5}$g/sm^2

Third sample: $Kgrav = \frac{75{,}80-75{,}73}{31{,}50\times 24} = 9{,}259*10^{-5}$g/sm^2

The average result of three samples was equal to $9{,}7*10^{-5}$ g/sm^2. [6] Therefore, the corrosion rate of 09G2C steel samples in the aggressive environment of MDEA without inhibitor Kgrav=$9{,}7*10^{-5}$ g/sm^2.



1-steel samples; 2-conical flask; 3-return cooler; 4-heater; 5-tripod

Figure-3. Test device

Second experiment: Determination of corrosion rate of 09G2C steel samples in an aggressive environment with IKFA corrosion inhibitor of MDEA.

To carry out the test, the same sequence of work as in the first experiment is performed. The testing process lasted 24 hours.

The pre-test and post-test masses of steel samples were determined in the appropriate order and the results were recorded (Table 4).

Table 4.

Masses of steel samples

Before the test (gr)	**After the test (gr)**
First sample	
m_1=61,02	m_2=61,01
Second sample	
m_1=67,69	m_2=67,68
Third sample	
m_1=70,21	m_2=70,21

The results of determining the dimensions of each sample were recorded in the table below. (Table 5)

Table 5.

Dimensions of steel samples

	First sample (mm)	Second sample (mm)	Third sample (mm)
a	37	40	40
b	19	20	21
c	10	11	10

Their surfaces were calculated based on the overall dimensions of the samples (1).

First sample: $2(37\times19+19\times10+37\times10)=2526mm^2$

Second sample: $2(40\times20+20\times11+40\times11)=2920mm^2$

Third sample: $2(40\times21+21\times10+40\times10)=2900mm^2$

Based on the obtained results, the corrosion rate was calculated (2).

First sample: $Kgrav = \frac{61,02-61,01}{25,26\times24} = 1,65*10^{-5} g/sm^2$

Second sample: $Kgrav = \frac{67,69-67,68}{29,20\times24} = 1,42*10^{-5} g/sm^2$

Third sample: $Kgrav = \frac{70,21-70,21}{29,00\times24} = 0\ g/sm^2$

The average result of three samples was equal to 1.02 g/cm^2. So, the corrosion rate of 09G2C steel samples in an aggressive environment with IKFA corrosion inhibitor of MDEA is Kgrav=1.02 g/cm^2.

Summary

The results of the analysis showed that the corrosion rate of the tested steel samples in the aggressive environment of MDEA without added corrosion inhibitor was equal to 8g/cm^2.

In the second experiment, the corrosion rate of steel samples tested in the aggressive environment of MDEA with IKFA corrosion inhibitor was equal to 1.02g/cm^2 [7].

Therefore, when IKFA corrosion inhibitor was used, the rate of corrosion was dramatically slowed down [8].

We determine the effectiveness of IKFA corrosion inhibitor using the following formula (3):

$$\mathbf{Z = \frac{Vo-Ving}{Vo} \times 100} \qquad \mathbf{(3)}$$

Here: Vo = lost mass of the steel sample tested in an environment without an inhibitor; Ving=mass loss of a steel specimen tested in an inhibitory environment.

The average mass loss of a steel sample tested in an environment without an inhibitor: Vo=0.0566;

The average mass loss of a steel sample tested in an inhibitory environment: Ving=0.0066;

$$Z = \frac{0,0687-0,0066}{0,0687} \times 100=90,4\%$$

Therefore, the effectiveness of IKFA corrosion inhibitor in the aggressive environment of sulphide acid of MDEA was 90.4%.[9]

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