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EFFICIENCY OF HIGH-MODULUS LIQUID GLASS FOR REMOVAL OF CORROSIVE-SCALE DEPOSIT IN PIPES OF HEAT SUPPLY SYSTEMS

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ABSTRACT

Energy saving is an important direction of economic and social development of the Republic of Kazakhstan. Modernization of energy saving programs requires new innovative approaches for their implementation. One of the important directions in the uninterrupted operation of heat supply systems is to ensure the free passage of the coolant (water) through the system. Statistics show that during the operation of heat supply systems, the formation of corrosion-scale deposits on the inner surface of pipelines, radiators, boilers is detected, which impedes the passage of the coolant and increases the energy consumption for heating it.

The advanced achievements of domestic and foreign experience in reducing energy costs for heating objects in thermal systems allow us to correctly approach the solution of the problem and clearly formulate the purpose of the study. -6490LV with systems of energy dispersive microanalysis INSAEnergu and structural analysis HKL - Basic with a useful magnification of 300,000, as well as the selection of an inhibitor composition - high-modulus sodium silicate, which prevents the corrosion process on the metal surface of pipelines by creating a protective film against the accumulation of corrosion-scale deposits.

Keywords: heat supply systems, corrosion-scale deposits, high-modulus glass

INTRODUCTION

The chemical composition of corrosion-scale deposits on the inner surface of pipelines in heat supply systems accumulates from the coolant and has a different composition. It can be classified as: silicate, iron-manganese, alkaline earth, etc. But each of the compositions consists of almost all 80% of carbonates and silicates, to a lesser extent of sulfates and phosphates of alkali metals. Corrosive-scale deposits are formed in the form of solid, dense deposits in pipes of heating networks [1-3].

The presence of phosphates and silicates in water initially contributes to the deposition of loose, crumbling scales, which subsequently turns into layered solid corrosion accumulations. A change in the hydrodynamic and thermal regime in heat supply systems causes a washout of sludge from the pipe walls, which includes complex carbonates and partially phosphates. The sludge is captured by the coolant and actively participates in the processes of scale formation, contributing to the formation of denser layers of deposits on the inner surface of the pipe, radiator, boiler, which impede the passage of the coolant through the system [4].

The free passage of the coolant through the system is facilitated by the process of removing scale deposits. To select effective chemical solutions, the authors studied the composition of corrosion scale deposits [5].

In recent years, much attention has been paid to the silicate treatment of the coolant using sodium silicate with different modulus values $[Na_2O]/[SiO_2]$. ratio. Under the conditions of operation of heating systems, the effectiveness of silicate treatment was established, which helps to slow down the oxygen and carbon dioxide corrosion of steel pipes [6, 7].

MATERIALS AND METHODS

To establish the effectiveness of the sodium silicate module, to create an effective protective film on the surface of pipelines, we conducted studies of all three modules of sodium silicate. For this purpose, weighted steel samples prepared for testing, with S = 0,02 cm^2, were immersed in a sodium silicate solution with module 1 (two tubes), with module 2 (two tubes), with module 3 (two tubes) for a day. Then during the day in the circulation mode, water was passed through the tubes treated with sodium silicate with a circulation rate of 0,5 m/s at room temperature. After this time, the tubes were weighed again, and the corrosion rate (g/m^2 h) was calculated from the mass of iron that had left the tube surface.

Table 1 shows the mass of iron, the calculated corrosion rate data and the calculated corrosion loss data for the year (mm/year).

Table 1 - Indicators of corrosion rate and corrosion losses on samples of steel inhibited by sodium silicate

Inhibitor, module index	Inhibitor concentration, mg/l	Mass of iron left from the sample, g	Corrosion rate, g/m^2 hour	Corrosionlosses, mm/year
Na_2SiO_3 m = 1	3000	0.049	0.102	1.11
Na_2SiO_3 m = 2	3000	0.041	0.085	0.93
Na_2SiO_3 m = 3	3000	0.029	0.060	0.65

Modul 1
$$Ksk = \frac{0.049}{0.02 \cdot 24} = 0.102$$

Modul 2
$$Ksk = \frac{0.041}{0.02 \cdot 24} = 0.085$$

Modul 3
$$Ksk = \frac{0.029}{0.02 \cdot 24} = 0.060$$

To calculate the weight loss of iron for the year, we use the data for the day and for the year, then: for module 1, the mass loss will be 0.102x24x356=871 g/year, and taking into account that 100 microns per year from a mass of 780 g (d=7.86 g/cm^3) of iron [24.25], then in mm it will be 871: 780 = 1.11 mm/year;

for module 2, the mass loss will be 0.085x24x356=726.2 g/year, and given that 100 μm per year is taken from the mass of 780g of iron, then in mm it will be 726.2:780 = 0.93 mm/year;

for module 3, the mass loss will be 0.060x24x356 = 512.6 g/year, and considering that 100 microns per year is spent from a mass of 780 g of iron, then in mm it will be 512.6:780 = 0.65 mm/year. The graphical dependence of the corrosion rate on the inhibitor modulus on a steel surface is shown in Fig. 1.

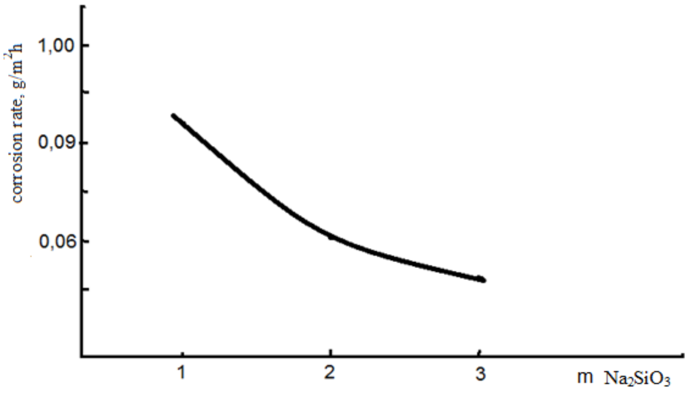


Fig. 1. Dependence of the corrosion rate of a steel sample on the inhibitor modulus

To create conditions for the appearance of an effective protective film on the inner surface of pipelines in heat supply systems, the authors used a well-known technique - surface activation [8]. Based on experience, we carried out the process of activating the steel surface before processing with sodium silicate.

The prepared samples were activated with acid solutions: sulfamic (two tubes), citric (two tubes), oxalic (two tubes), hydrochloric (two tubes) for 12 hours in circulation mode, washed with water, weighed and immersed in a sodium silicate solution with modulus m= 3 per day. After a predetermined time, water was passed through the steel tubes treated with the inhibitor during the day in the circulation mode at a circulation rate of 0.5 m/s at room temperature.

Table 2 shows the mass of iron, calculated corrosion rates and corrosion losses per year (mm/year).

Table 2 - Indicators of corrosion rate and corrosion losses on samples of steel activated by acids and inhibited by sodium silicate

Inhibitor, module index	Inhibitor concentration, mg/l	Mass of iron left from the sample, g	Corrosion rate, g/m^2 hour	Corrosion losses, mm/year	Inhibitor, module index
Na_2SiO_3 m = 3	15-hydrochloric	3000	0.0240	0.051	0.55
Na_2SiO_3 m = 3	15-citric	3000	0.0201	0.042	0.47
Na_2SiO_3 m = 3	15-oxalic	3000	0.008	0.017	0.186
Na_2SiO_3 m = 3	15-sulfamic	3000	0.004	0.010	0.109

Based on the obtained and calculated data, a graphical dependence of the corrosion rate on the surface activator of the steel tube - acid was built. As you can see from the figure, the greatest activation effect is achieved by sulfamic acid.

The composition of scale deposits in the pipes of heat supply systems taken from the object of the city of Shymkent, YKU named after M. Auezov, where the average carbonate hardness of water in mg-eq / l is 3.7 mg / eq-l, respectively.

We determined the composition of corrosion-scale deposits using a JSM-6490LV scanning electron microscope with INSAEnergu energy-dispersive microanalysis and HKL-Basic structural analysis systems with a useful magnification of 300,000 in combination with a VarianProStar high-performance liquid chromatography.

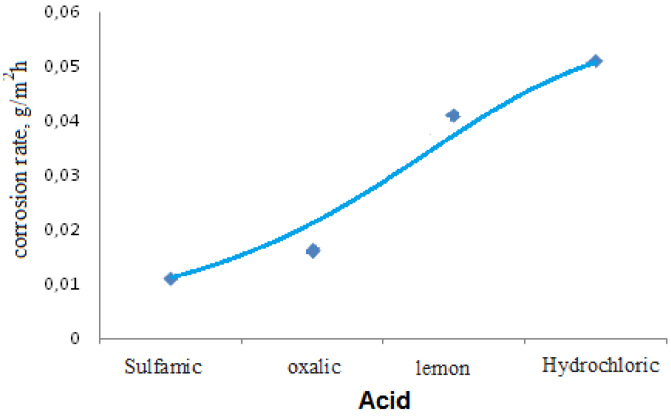
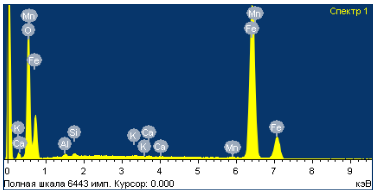


Fig. 2. Dependence of the corrosion rate of a steel sample on the composition of the activator solution (acid).

The capabilities of the microscope make it possible to determine the content of all elements in the analyzed samples in weight percent, as well as to see the structure of the analyzed samples.

Fig. 3 and 4 show the compositions of the components in scale deposits taken from the inner surface of metal pipes. Fig. 3 shows samples of corrosion-scale deposits not activated by acids, but treated with an inhibitor. Fig. 4 shows samples of corrosion-scale deposits activated by acids and treated with an inhibitor.

Element	Weight, %
O	24.00
Al	0.56
Si	0.94
K	0.15
Ca	0.13
Mn	0.43
Fe	73.78



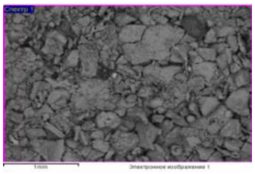


Fig. 3. Quantitative composition of the components-elements and the structure of corrosion-scale deposits removed from the surface of a metal pipe in Shymkent city

Element	Weight,%
O	24.07
Al	0.43
Si	0.41
K	0.17
Ca	0.18
Mn	0.43
Fe	74.31

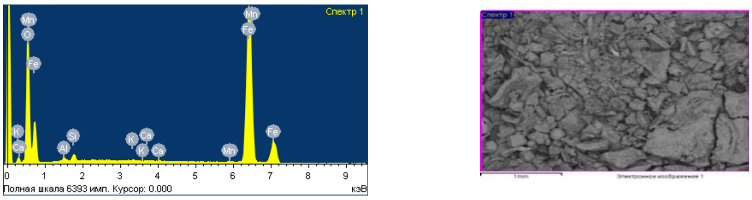


Fig. 4. Quantitative composition of the components-elements and the structure of corrosion-scale deposits removed from the surface of a metal pipe in Shymkent city.

To study the effect of acid as a solvent for corrosion-scale deposits from the inner surface of the tubes, the tubes were placed in acid solutions with a concentration of 15 wt.%, left for five days at room temperature. After a predetermined time, the composition of the acids was analyzed for the content of these components.

Table 3 shows the indicators of the solubility of the elements of corrosion-scale deposits

Table 3 - Indicators of the solubility of the elements of scale-corrosion deposits in acid solutions

Acid	Elements in the composition of scale deposits before their dissolution in acid	Elements in the composition of scale deposits after their dissolution in acid
Sulfamic acid	Al, Si, K, Ca, Mn, Fe	traces of iron
Hydrochloric acid	Al, Si, K, Ca, Mn, Fe	traces of iron and manganese
Oxalic acid	Al, Si, K, Ca, Mn, Fe	traces of silicon, iron, manganese
Lemon acid	Al, Si, K, Ca, Mn, Fe	traces of iron, aluminum, silicon, manganese

As you can see, sulfamic acid dissolves elements more completely, while traces of almost all components are found in solutions of other acids. Analyzing the results obtained, based on experimental data, conclusions can be drawn.

CONCLUSION

1. Arguments are given about the possibility of the formation of corrosion-scale deposits in the pipes of heat supply systems, depending on the composition of the coolant
2. The role of the inhibitor module in reducing the corrosion rate on steel specimens and creating an effective protective film is shown.
3. A positive effect of the activator on the rate of dissolution of corrosion-scale deposits in pipes of heat supply systems has been established.

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