INDICATORS OF CORROSION RESISTANCE OF EQUIPMENT IN VARIOUS AGGRESSIVE ENVIRONMENTS

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ABSTRACT

The aggressiveness of the coolant composition is caused by various carbon dioxide - based components, such as CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}, OH^-, H^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, as well as a soluble oxygen molecule and slightly soluble hydrogen sulphide. Such a composition of the coolant, taking into account the indicated ions that are in a dissolved state, it can be said with confidence, is capable of forming and depositing a corrosive composition in the form of scale on the inner surface of pipelines that prevents the free passage of the coolant. Due to the occurrence of electrochemical processes, OH^-, Mg^{2+}, Ca^{2+}, Fe^{2+} products formed near the metal surface of the pipeline are capable of forming and depositing a significant amount of corrosive carbonate sediment on the inner surface of the pipe, causing significant corrosion of the steel surface of the pipeline. Carbonate sediment significantly complicates the passage of the coolant through pipes in heat supply systems.

Keywords: corrosion rate, carbon dioxide compositions, corrosion indicators, carbonate scale deposits.

INTRODUCTION

The areas of anodic and cathodic reactions on the surface of any metal structure are spatially separated, but for the proceeding of corrosion process, the flow of electrons in the metal from the anode to the cathode is necessary. In this case, the material effect of corrosion destruction of the metal structure is manifested in the anode area, i.e. on the inner surface of a metal pipe, due to the operation of a galvanic cell, on the electrodes of which redox processes occur [1-3].

Upon contact with water (coolant), the inner surface of pipelines, radiators at elevated temperatures undergoes corrosion with the possible formation of scale-corrosion deposits (SCD) on the surface, preventing the coolant from passing to the consumer and at the same time increasing energy costs for additional heating [4,5].

In order to protect metal equipment in heat supply systems, it is necessary to understand the depth of damage to the metal surface due to corrosion, which is significantly manifested with some aggressiveness of the coolant. General and local corrosion of the metal surface of the pipeline at different pH values increases or decreases with time, which is significantly affected by the composition of the coolant [6-8].

MATERIALS AND METHODS

Testing the corrosion resistance of steel samples taken from the pipe was carried out in solutions of acids: hydrochloric, sulfuric, oxalic, citric, sulfamic. Steel samples cleaned, degreased, washed, dried and weighed were placed in glasses with solutions of a certain acid composition for 1,3,6 days. After the specified time, the samples were removed from the acid solution, washed, dried, and weighed again.

The mass indices of the corrosion rate (g/m^2·h) were calculated based on the difference in the obtained masses after acid testing of the sample surface.

1. Mass index of the corrosion rate of a steel pipe sample in hydrochloric acid.

$$K_{mass} = \frac{0.0865}{0.2178 \cdot 24} = 0.016$$

$$K_{mass} = \frac{0.2939}{0.2178 \cdot 72} = 0.019$$

$$K_{mass} = \frac{0.6783}{0.2178 \cdot 144} = 0.022$$

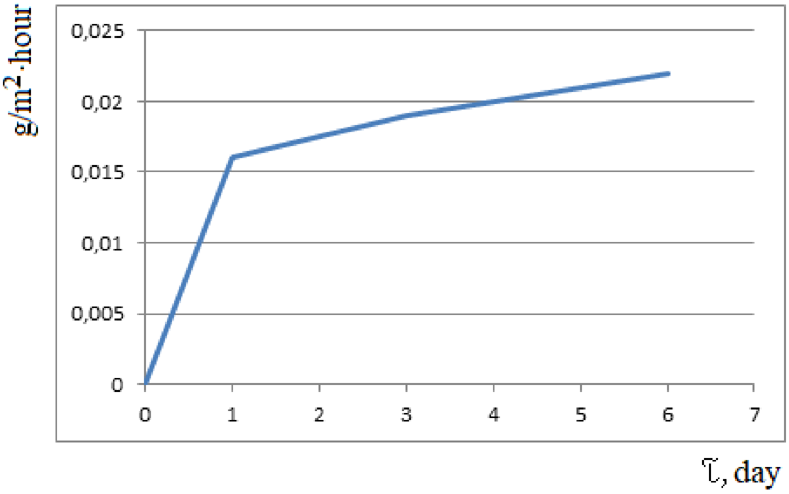

Fig. 1. Corrosion rate of sample in hydrochloric acid

Calculation of the corrosion rate of a steel pipe sample in sulphuric acid

$$K_{mass} = \frac{0.2979}{0.1848 \cdot 24} = 0.06$$

$$K_{mass} = \frac{1.2976}{0.1848 \cdot 72} = 0.09$$

$$K_{mass} = \frac{2.7039}{0.1848 \cdot 144} = 0.1$$

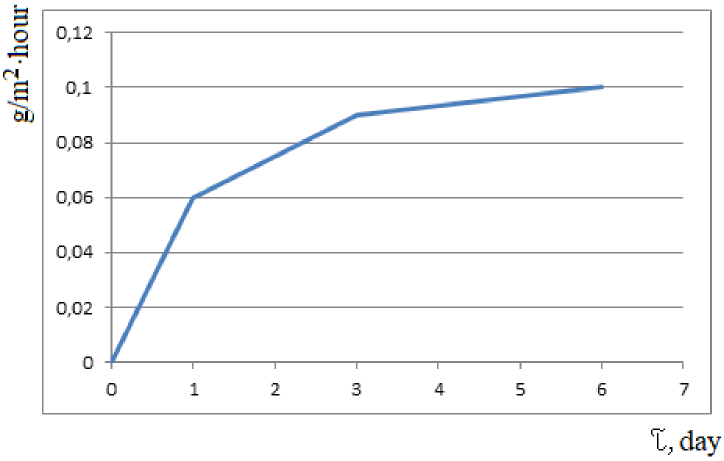

Fig. 2. Corrosion rate of sample in sulphuric acid

Calculation of the corrosion rate of a steel pipe sample in oxalic acid

$$K_{mass} = \frac{0.0035}{0.188 \cdot 24} = 0.0008$$

$$K_{mass} = \frac{0.023}{0.188 \cdot 72} = 0.0017$$

$$K_{mass} = \frac{0.1503}{0.188 \cdot 144} = 0.0056$$

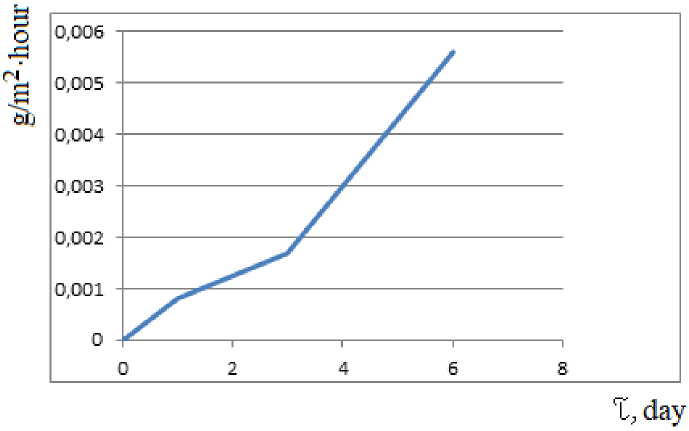

Fig. 3. Corrosion rate of sample in oxalic acid

Calculation of the corrosion rate of a steel pipe sample in citric acid

$$K_{mass} = \frac{0.0504}{0.228 \cdot 24} = 0.009$$

$$K_{mass} = \frac{0.0677}{0.228 \cdot 72} = 0.004$$

$$K_{mass} = \frac{0.122}{0.228 \cdot 144} = 0.003$$

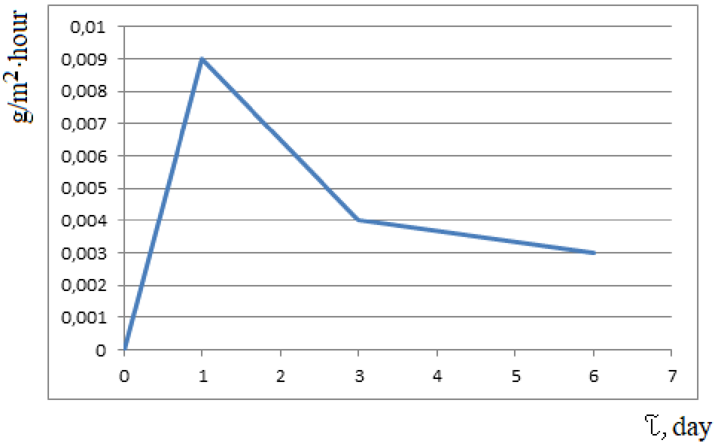

Fig. 4. Corrosion rate of sample in citric acid

Calculation of the corrosion rate of a steel sample in sulfamic acid

$$K_{mass} = \frac{0.0002}{0.222 \cdot 24} = 0.00004$$

$$K_{mass} = \frac{0.0006}{0.222 \cdot 72} = 0.00005$$

$$K_{mass} = \frac{0.003}{0.222 \cdot 144} = 0.00009$$

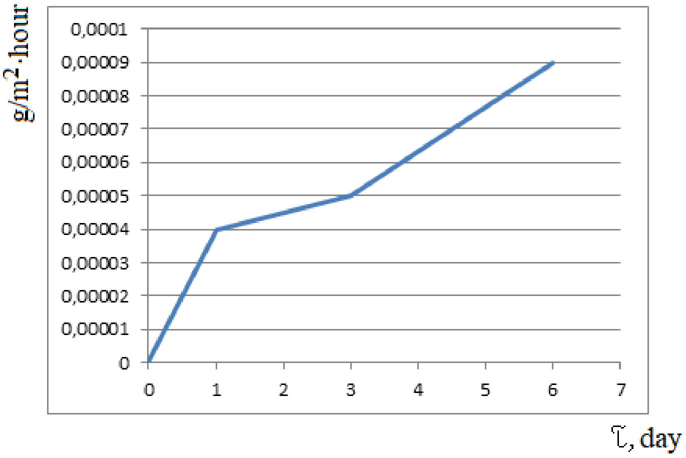

Fig. 5. Corrosion rate of the sample in sulfamic acid

The analysis of the obtained and calculated data is presented graphically. From the above data, it can be seen that sulfuric and hydrochloric acids possess the greatest aggressiveness, and sulfamic acid possesses the least.

It is also important to know some other corrosion indicators, calculated through the mass corrosion index.

The current corrosion index was calculated according to the formula:

$$I_{corrosion} = K_{mass}\frac{n}{A}26.8\cdot 10^{-4}$$

where K_{mass} is the mass index of corrosion, g/m2·hour; n is the number of electrons; A is the molar mass of an iron atom, g/mol; 26.8 – Faraday constant, A·hour·mol^{-1}, and showed the following values of the current corrosion index:

$$I_{corrosion} = K_{mass}\frac{0.042\cdot 2\cdot 26.8\cdot 10^{-4}}{56} = 3.8\cdot 10^{-6}$$

which indicates a slight influence of a mildly aggressive medium on the metal surface.

The depth corrosion index of the steel sample (mm/year) was also calculated using the value of the mass index according to the formula

$$\Pi_{depth} = \frac{K_{mass}\cdot 8.76}{d}$$

where K_{mass} is the mass corrosion index of the steel sample; d is the density of iron 7.86, g/cm^3; 8.76 is the calculation factor from the number of hours per year 8760 divided by 1000.

The following values:

$$\Pi_{depth} = \frac{0.042\cdot 8.76}{7.86} = 0.046 \text{ mm/year}$$

Analysis of metal losses from corrosion from the pipe surface in mm/year on samples activated with acid during different days shows that metal losses of samples, activated for six days, compared with metal losses of a sample, activated for one day, are approximately two times less (2.57/1.4=2).

REFERENCES

1 Lipovskikh V.M., Kashinsky V.I., Reformatskaya I.I. Zavisimost' korrozionnoy stoykosti teploprovodov iz uglerodistoy stali ot vodnogo rezhima teplosetey [Dependence of the corrosion resistance of carbon steel heat pipelines on the water regime of heating systems] // Zashchita metallov - Metal protection, 1999, No. 6, pp.653-655.

2 Zaichik L.I. Opredeleniye skorosti korrozii metallov v usloviyakh vneshne diffuzionnogo rezhima [Determination of the corrosion rate of metals under external diffusion conditions] // Teploenergetika - Thermal power engineering, 1995, no. 7, pp.12-15.

3 Balaban-Irmenin Yu.V., Litovskikh V.M., Rubashov A.M. Zashchita ot vnutrenney korrozii truboprovodov vodyanykh teplovykh setey [Protection against internal corrosion of pipelines of water heating networks]. Moscow: News of heat supply, 2008. 450 p.
4 Akolzin A.P., Zhukov A.P. Kislorodnaya korroziya oborudovaniya khimicheskikh proizvodstv [Oxygen corrosion of chemical production equipment]. Moscow, Khimiya, 1985. 239 p.
5 Glazyrin A.I., Glazyrin A.A., Orumbayev R.K. Korroziya i konservatsiya teploenergeticheskogo oborudovaniya [Corrosion and conservation of thermal power equipment]. Pavlodar: ECO, 2011. 728 p.
6 Ilyin D., Zhilin V. Osobennosti sushchestvuyushchikh metodov bor'by s solevymi otlozheniyami i korroziyey [Features of existing methods of dealing with salt deposits and corrosion // Novosti teplosnabzheniya - Heat supply news, 2010 no. 2, pp.3-7.
7 Balaban-Irmenin Yu.V., Fokina N.G., Petrova S.Yu. Zashchita vnutrenney korrozii truboprovodov vodyanykh teplovykh setey [Protection of internal corrosion of pipelines of water heating networks]. Materialy III nauchno-prakticheskoy konferentsii «Sovremennyye metody podgotovki i zashchity oborudovaniya ot korrozii i nakipeobrazovaniya» [Proceedings of the 3rd scientific and practical conference "Modern methods of preparation and protection of equipment from corrosion and scale formation"]. Moscow, 2009, pp. 12-20.
8 Glazyrin A.I., Glazyrin S.A., Glazyrin A.A. Nekotoryye problemy ekspluatatsii teplovykh setey i vnutrennikh sistem otopleniya zhilykh pomeshcheniy [Some problems of operation of heat networks and internal heating systems of residential premises]. Sbornik materialov 1 Mezhdunarodnoy nauchno-prakticheskoy konferentsii «Nauchnoye obespecheniye zhilishchno-kommunal'nogo khozyaystva» [Collection of materials of the 1st International scientific and practical conference "Scientific support of housing and communal services"]. Astana, 2012, pp. 57-60.