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INFLUENCE OF ALUMINIUM IONS ON CORROSION OF GALVANIZED STEEL USED IN HEATING SYSTEMS

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ABSTRACT

This work presents the results obtained during the study of influence of aluminum ions, added to natural waters on corrosion behavior of carbon and galvanized steels, used in the equipment for heating installations. The aluminum ions have been obtained by dissolving of aluminum metal anodes.

The corrosion rates and potentials of galvanized steel in water with total salt content of about 0.2 g/l in the presence of 0.6 mg/l Al^{3+}-ions have been measured. Although, the last ones are a comparatively good inhibitor of iron corrosion in the same medium, it has been established that they do not affect considerably the corrosion of galvanized steel.

It has been also shown that in the presence of Al^{3+}-ions, the zinc coating retains its protective effect up to temperature about 70°C.

Keywords: corrosion, galvanized steel, heating installation

INTRODUCTION

The corrosion problems concerning heating installations are mainly connected with the destruction of the heat lines and heaters (steel radiators). For their protection under these conditions, inhibitors for water systems are often used, which should meet strictly both the efficiency and non-toxic requirements. The inhibiting activity of aluminum ions with respect to the corrosion of carbon steel in water and salt solutions, as a basic constructional material in these installations [1-4] has been studied in our country for the last 20 years. There have been developed, mixed in a certain proportion of components, aluminum-thiocarbamide inhibitors [1] in which aluminium ions have been introduced in the medium in the form of aluminum sulphates, while the addition of thiocarbamide increases the composition efficiency.

It is known that the corrosion resistance of zinc in neutral water medium is due to forming a film on its surface from secondary corrosive products whose protective properties depend on the temperature and composition of the medium [6].

The suggestion [5] for applying inhibitor protection of carbon steels with Al^{3+}- ions, obtained by anodic dissolution of metal aluminium called also for a

study of corrosion behaviour of galvanized steels, used in production of hot-water supply installations.

EXPERIMENTAL

The corrosion behaviour of hot galvanized low carbon steel was studied in natural water extracted from a surface source with a total salt content of 0.2 g/l. The required concentration of Al^{3+}- ions in the medium was reached by electrolysis in which anodes of technical aluminum and cathodes of graphite were used at the following parameters: operating voltage 24 V, anode current density in the interval 15-25 A/m^2 and process duration – 60 min/24 hours.

The tests were carried out in a stationary electrolyte at temperatures 25, 35, 55 and 70^{0}C$\pm$1.0 ^{o}C as their selection was according to the initial conditions, accepted at designing different types of heaters for hot-water supply.

Gravimetric method BDS ISO 8407 was used for determining corrosion rate of galvanized steel samples in natural water. The corrosion potentials were measured by potentiostate EG&PAR- model 273A.

RESULTS AND DISCUSSION

Fig. 1 presents the corrosion rates of galvanized steel determined by the Gravimetric method at different temperatures of natural water without and in the presence of 0.6 mg/l Al^{3+} ions (determined as maximum allowable). It can be seen from the figure that the corrosion rate increases by increasing the temperature both in the lack and in the presence of aluminum ions in water without any essential difference. The increase in corrosion rate was particularly observable over 50-55 ^{o}C and at 70 ^{o}C it was nearly 10 times higher than at obtained at 25 ^{o}C.

Visual observations of the exposed in natural water samples showed that voluminous products were formed on the surface – locally on spots in white and light grey color which represent the typical corrosion damage of zinc - the so called “white rust”.

Under the condition of the experiments, the water was not stirred and in the lack of CO_2 a resistant

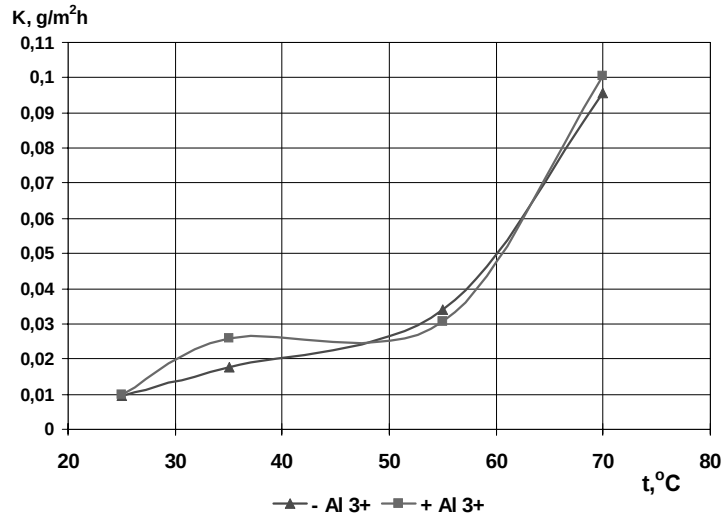

Fig. 1. Corrosion rate dependence K of galvanized steel in natural water on temperature

protective layer was not formed which except oxides to contain as well as zinc carbonates. It was also established that in the presence of Al^{3+}- ions the corrosion products were removed from the samples surface more difficult (with better adhesion) than those formed in the absence of Al^{3+}- ions.

The alteration of the corrosion potential of galvanized steel in natural water without and in the presence of Al^{3+} – ions by temperature is shown in Fig.2. It is obvious that with the increase of temperature in the lack of Al^{3+} – ions, the corrosion potential as expected, is displaced to positive direction, which leads to a decrease in the protective action of zinc coating with regard to the steel. And vice versa, in the presence of aluminum ions in the medium and other equal conditions, the corrosion potential over 35^{o}C becomes more negative (e.g. with about 100 mV at 70^{o}C). The potential displacement would lead to the decrease in corrosion rate of the galvanized steel under these conditions, which was not practically observed. The most probable reason is that at that concentration of aluminum ions, a significant inhibitor effect was not achieved in the medium - for instance, by forming a thick screening layer on the zinc surface.

The comparison of corrosion potentials of low carbon and galvanized steel in natural water containing aluminum ions is of great interest for practice (Fig.3). It

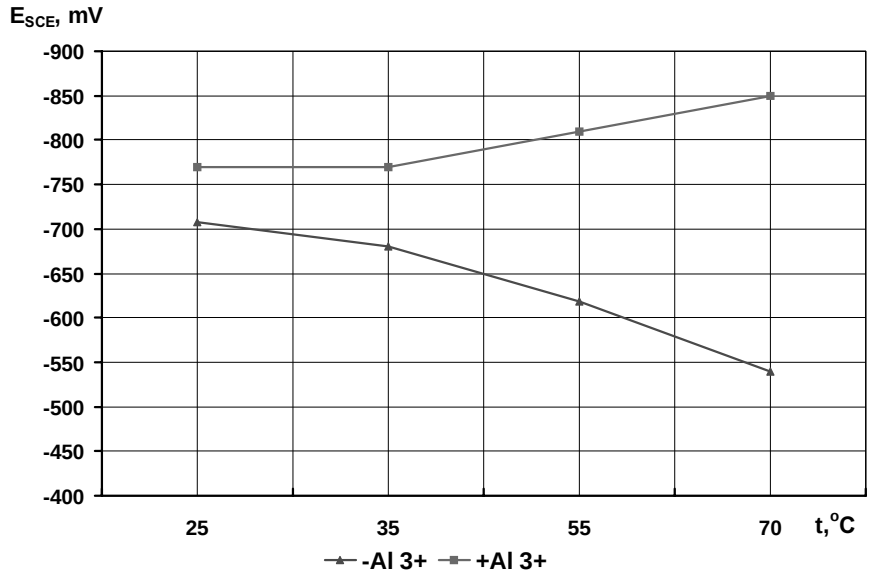

Fig. 2. The dependence of the corrosion potential E of galvanized steel in natural water, on temperature.

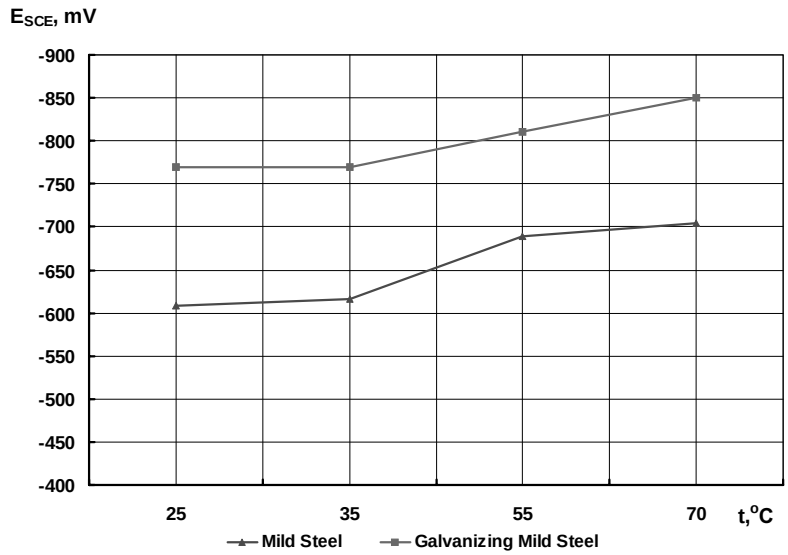

Fig. 3. The dependence of the corrosion potential E of galvanized and carbon steels in the presence of 0,6 mg/l Al^{3+}- ions, on temperature.

follows from the figure that the corrosion potential of galvanized steel remains about 150m/V more negative than that of carbon steel for which was proved that this quantity of aluminum ions in the medium manifests good inhibiting effect [5]. It also follows from the results that the presence of aluminum ions in allowable concentrations without any effect on the corrosion rate of galvanized steel could protect the equipment of heating installations and heat supply systems made of carbon steel.

CONCLUSIONS

• It has been proved that the presence of aluminum ions (0.6 mg/l does not affect essentially the corrosion rate of galvanized carbon steel in natural water;

• The presence of aluminum ions in the medium leads to displacing the corrosion potential of galvanized steel in negative direction with increase of temperature without changing its corrosion rate;

• The addition of aluminum ions to natural water as inhibitor will not have any effect on the corrosion of the part of hot water supply equipment made of galvanized steel.

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