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STUDY OF PROTECTION DEGREE AND CORROSION INHIBITION FACTOR BY ANTICORROSION MATERIALS IN SALT MEDIA AT VARIOUS pH VALUES

Urinov Abrorbek Axrorovich
Doctor of Philosophy (PhD) on Technical Sciences
Namangan State Technical University, Uzbekistan
(0009-0008-2757-0034)

Akhrorov Amirkhon Abrorbekovich
Student Academic Lyceum of Tashkent of
University of Information Technologies, Uzbekistan
(0009-0006-9979-1368)

Abstract

The huge expenses of oil companies associated with corrosion of metal pipes led to the creation of metal pipes with high corrosion resistance. Coating of pipelines is performed for protection against corrosion, mechanical damage and other external impacts. There are several basic methods of coating pipelines, and the choice of method depends on the operating conditions, type of pipes, protection requirements and cost. The introduction of certain components into the metal and the observance of a certain technology of continuous steel casting makes it possible to obtain metal that is pure in terms of the content of impurities. Such a metal is distinguished by its strength, plastic and corrosion-resistant characteristics. The anticorrosive coating proposed by the authors effectively reduces the corrosion rate of stainless steel and provides a high degree of protection in salt media at various pH and temperature variations.

Keywords. Pneumatic spraying, corrosion rate, salt concentration, bitumen, oxygen, aggressive substances, pyrolysis distillate, thermal decomposition, anti-corrosion, composite, resistance, adhesion.

Introduction

The huge expenses of oil companies associated with corrosion of metal pipes led to the creation of the same metal pipes, only having high corrosion resistance. The introduction of certain components into the metal and the observance of a certain technology of continuous steel casting makes it possible to obtain metal that is pure in terms of the content of impurities. Such a metal is distinguished by its strength, plastic and corrosion-resistant characteristics. This also includes pipes made of titanium, aluminum and stainless alloys (nickel and chromium).

Coating of pipelines is performed for protection against corrosion, mechanical damage and other external impacts. There are several main methods of coating pipelines, and the choice of method depends on the operating conditions, type of pipes, protection requirements and cost [1; 1999].

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Compressor coating refers to the spraying of protective coatings. This is one of the most common and effective ways to treat pipelines, especially in industrial conditions [2;2001].

Before coating with a compressor [3; 2004]:

1. Clean the pipe from dirt, oil, scale.
2. Perform shot blasting or sand blasting (to the degree Sa 2 ½ or Sa 3 according to ISO 8501-1).
3. Degrease.
4. Provide a dry and clean surface.

Based on bitumen-alkyd protective coatings, which are often used for corrosion protection of metal structures and pipelines, especially in underground and humid conditions.

Applying such a coating using a compressor is possible and effective, but it requires compliance with certain conditions.

Recommended application method: pneumatic or airless spraying [4; 2002].

1. pneumatic spraying (compressed air + spray gun with nozzle from 2.5 mm)

A compressor (300-600 l/min, pressure 6-8 bar) supplies air to the spray gun, creating an aerosol from a bitumen-alkyd composition. Simplicity of equipment. Suitable for layers up to 100 microns.

2. airless spraying (hydrodynamic)

A high-pressure pump (150-250 bar) supplies the coating to the pistol without air. Suitable for viscous materials and thick layer application. Less overspending, smoother coverage. Recommended when applied to large diameter pipes or in industrial volumes.

Solvents (e.g. white spirit, kerosene, xylene, gasoline, pyrolysis distillate) are added to adjust the viscosity of the formulation.

Application temperature: not lower than +5 °C.

Material temperature: before application, it is advisable to heat up to +30...+50 °C to reduce viscosity.

Layers: usually 2-3 layers with intermediate drying (6-12 hours, depending on temperature and humidity).

Anticorrosive materials based on bitumen-alkyd-urethane ingredients form the strongest film that protects the substrate substrate from mechanical damage, scratches and chips. The alkyd molecule is smaller than the acrylic molecule and thereby contributes to its deeper penetration into the painted surface. The aesthetic appearance of the substrate substrate to be treated is significantly improved, in addition to giving a smooth and shiny surface, as well as a relatively low cost of production [5; 2004].

Table 1 Corrosion rate dependence

№	Damage	Condition	Time (h)	Degree of protection Z, %	Koef. braking K
1	Uncoated	Continuous corrosion	48	–	–
2	Coated	Unit points (1-2 mm)	240	90%	10.0

Method: salt mist chamber (5% NaCl, 35 °C), 240 h
Sample: steel St3, coating in 2 layers (thickness ~ 100 μm)
As corrosion media, saturated salt solutions of potassium and sodium chlorides were used at temperatures of 20 and 100 °C. Prior to the tests, the samples after preliminary preparation were weighed, the area was determined using a caliper. Studies were carried out for 24 hours, after which the samples were removed, washed, and the immersion area of the sample in the solution was clarified. Corrosion products were removed in concentrated nitric (for stainless steel) and sulfuric (for carbon steel) acids at room temperature for 30-40 seconds. The samples were then washed, dried and weighed. Mass corrosion index Km, g/($m^2 \cdot h$) was calculated from the mass change[6;2010]:
$Km = \Delta m/St = ik \cdot q$
where Δ m is the change in the mass of the test sample, g;
S - sample area, m:
t - sample exposure time in the test solution, h;
ik - corrosion current density, A/m^2;
q is the electrochemical equivalent, g/(Ah).
Potentiometric method was used for polarization curves. Automatic maintenance of the specified potential values constant for a long time was carried out using a potentiostat. The PI-50-1 potentiostat is designed to study fast-flowing electrochemical processes at the electrode-electrolyte boundary using potentiostatic, potentiodynamic, and pulsed methods[7;2014] (Table 2).

Table 2 -Metal corrosion rate

Brine temperature, °C,	Deep corrosion index, mm/year	Resistance score	Corrosion rate, g/($m^2 \cdot h$)
100	0,034	4	$3{,}4 \cdot 10^{-2}$
20	0,00012	1	$1{,}2 \cdot 10^{-4}$

As can be seen, the corrosion rate of stainless steel 1.4462 increases significantly with the brine temperature: from $1.2 \cdot 10^{-4}$ g/($m^2 \cdot h$) at 20 °C to $3.4 \cdot 10^{-2}$ g/($m^2 \cdot h$) at 100 °C. At room temperature, the steel is practically not subject to corrosion, which is confirmed by the minimum depth index and a high resistance score. At high temperatures, it is recommended to use protective coatings to preserve the durability of the metal[8;2023].

Table 3- Corrosion rate versus temperature

№	Brine	Temperature (°C)	Corrosion rate (g/m ²· day)
1	3% NaCl	20	0,5
2	3% NaCl	40	1,1
3	3% NaCl	60	2,3
4	3% NaCl	80	4,8

From these data in Table 3, it can be seen that the corrosion rate also increases significantly with increasing temperature. At high temperatures, the protective metal layer is destroyed, and the activity of ions is enhanced, which leads to the acceleration of corrosion processes. Corrosion is especially dangerous for equipment operating at high temperatures, for example, heat exchangers, boilers, equipment of the oil industry[9;2018].

One of the main causes of corrosion is salts. The salts create an electrolytic environment. When salts (for example, NaCl, $MgCl_2$, $CaCl_2$) dissolve in water, they dissociate into ions, forming an electrolytic solution. This activates electrochemical corrosion processes and accelerates metal ion exchange, resulting in rapid rust formation[10;2020].

Some metals (for example, aluminum, chromium) form a passive layer on the surface that protects them from corrosion. However, the chloride ion (Cl^-) destroys this layer, and the rust formation process begins.

Effect of different salt concentrations on metal [11;2019]:

1. Solutions of salts with different concentrations (0.01%, 0.1%, 1%, 3%, 10%) were prepared.
2. Metal samples were placed in these solutions.
3. Samples were aged for a certain time (1, 3, 7 days).
4. After holding, the samples were washed, dried, and weight loss was recorded.

Table 4 - Effect of salts of different concentrations on the metal

№	Effect of salt of different concentration on metal	Corrosion rate V (g/dm²· h)	Degree of impact
1	0,01% NaCl	0,00625	Minor but present
2	0,1% NaCl	0,003	Onset of activity
3	1% NaCl	0,008	Severe corrosion
4	3% NaCl	0,012	Very Strong
5	10% NaCl	0,014	Solution saturated, stabilized

Table 4 shows that the corrosion rate also increases with increasing salt concentration. This is due to ion exchange and oxygen exposure in the NaCl environment. At a concentration of 10% NaCl, the corrosion rate increases compared to 1% NaCl. Thus, an increase in salt concentration increases metal corrosion.

Conclusions

The developed anticorrosive coating effectively reduces the corrosion rate of stainless steel and provides a high degree of protection in salt media at various pH and temperature. The corrosion inhibition coefficient remains high even at elevated temperatures, which makes the material suitable for the operation of oil and gas equipment. Combination of bitumen, alkyd-urethane varnish and mineral fillers provides stable barrier and structural protection of metal, reducing impact of aggressive components of medium.

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