

Modern Methods of Coating Zinc and Chromate Shells on the Surface of Structural Materials

Khojiev Sh.T.¹, Saidova M.S.¹, O'rinboyev M.J.¹

¹Tashkent State Technical University, Tashkent, Uzbekistan

E-mail: hojiyevshohruh@yandex.ru

Abstract— Most metals are corroded by air, water, acids, alkalis, and salts. This phenomenon is called corrosion. The word corrosion comes from the Latin word "corrodere" meaning decay. Corrosion is of two types in terms of its physicochemical nature: chemical and electrochemical corrosion. The type of corrosion that occurs in metals depends on the environment in which the metal is formed. Chemical corrosion occurs when metals are exposed to dry gases (oxygen, sulfite anhydride, hydrogen sulfide, halogens, carbon dioxide, etc.) and non-electrolyte liquids. This is especially common at high temperatures, so this decay is also called gas corrosion of metals. Gas corrosion is particularly damaging to metallurgy. Iron and steel products are coated with aluminum to protect them from gas corrosion. At a time when the production of modern construction materials is developing, the task of coating them with galvanic coatings in order to increase their hardness, resistance to hot and cold conditions and their chemical stability, and to create a decorative appearance has become one of the priorities.

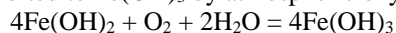
Keywords— corrosion, oxidation, reduction, chromatization, protective shell.

1. INTRODUCTION

Chemical corrosion is also caused by corrosion caused by liquid fuels. The main components of liquid fuels do not corrode metals, but corrosion occurs as a result of exposure of metals to sulfur, hydrogen sulfide and organic sulfur in petroleum and lubricating oils. This effect is observed only in the absence of water. In water, it undergoes electrochemical corrosion [1-5].

Corrosion caused by electrolytes is called electrochemical corrosion. Many metals are mainly corroded by electrochemical corrosion. Electrochemical corrosion is caused by the formation of small galvanic cells in the metal. Reasons for the formation of galvanic cells:

1) many metals contain other metals in addition;
2) the metal is always surrounded by water, air humidity and electrolytes. For example, in wet weather, copper may touch iron. This creates a galvanic cell (iron acts as an anode, copper acts as a cathode). Iron is oxidized: $\text{Fe} - 2e^- = \text{Fe}^{2+}$ and Fe^{2+} ions combine with OH^- ions to form $\text{Fe}(\text{OH})_2$. $\text{Fe}(\text{OH})_2$ is converted to $\text{Fe}(\text{OH})_3$ by atmospheric oxygen and moisture:



As a result, the iron corrodes. If there are plenty of hydrogen ions, the electrons from the iron will return the hydrogen ions without returning the oxygen in the air: $2\text{H}^+ + 2e^- = \text{H}_2$

When iron touches tin, corrosion occurs more slowly than when iron touches copper. If iron touches zinc, it will not rust, because iron is more of an original metal than zinc. In the presence of electrolytes in the galvanic element formed by zinc and iron, zinc acts as an anode, iron - as a cathode.

Protection of metals from corrosion. Several precautions are taken to protect metals from corrosion:

- a) coating the metal surface with other metals;
- b) coating the metal surface with non-metallic substances;
- d) various additives to metals;
- e) coating the metal surface with chemical compounds.

Coating the metal surface with other metals. One method of coating a metal surface with other metals is anode coating. The standard electrode potential of the metal used for this purpose should be less negative than that of the metal to be protected from corrosion along with the activity of the metal. For example, zinc plating of iron (anode plating) is of great benefit, because the iron object does not decompose until all the zinc covering its surface is finished. When iron is coated with tin, a cathode coating is obtained because the coating metal is more original than the coated metal. If any part of the cathode coating moves, the protective metal, the iron, will corrode very quickly [6-10].

Coating of metal surfaces with non-metallic substances. Coating, enameling, etc. of metals with varnish, paint, rubber, lubricating oils (solid, technical Vaseline) protects metals from corrosion.

Add various additives to metals. Adding 0.2-0.5% copper to ordinary steel can increase the corrosion resistance of steel by 1.5-2 times. Stainless steel contains up to 12% chromium, which is a passive state that gives the steel strength. When nickel and molybdenum are added to steel, its corrosion resistance increases. These steels are called alloy steels.

Coating the metal surface with chemical compounds. By performing special chemical experiments, the metal surface can be coated with a coating of corrosion-resistant compounds. Such curtains are called oxide, phosphate, chromatic, etc. curtains. The

process of forming a corrosion-resistant oxide film on a metal surface is called oxidation. There are three ways to oxidize a metal piece:

- 1) the surface of a metal product is oxidized with organic matter at high temperatures (darkened, greened, etc.);
- 2) the metal product (such as MnO_2 ; NaNO_3 ; $\text{K}_2\text{Cr}_2\text{O}_7$) is heated to the boiling point of the liquid with a concentrated alkaline solution in the presence of oxidizing agents;
- 3) A metal object is electrolyzed by placing it in an electrode solution at the anode pole, a process called anodizing.

Corrosion activators and inhibitors. The rate of corrosion is greatly affected by the concentration of ions in the solution, ie H^+ and OH^- ions, ie the pH of the solution. As the concentration of H^+ ions increases, corrosion increases, and an increase in the concentration of OH^- ions reduces the corrosion of iron. However, the corrosion of metals whose hydroxides have amphoteric properties (Zn, Al, Pb) accelerates with increasing concentration of OH^- ions. Corrosion accelerators are called corrosion activators. These include fluorides, chlorides, sulfates, nitrates, and the like. Substances that reduce the corrosion of metals when added to a corrosive medium are called corrosion inhibitors. For example, amines, urea, aldehydes, sulfides, chromates, phosphates, nitrites, silicates, etc. are corrosion inhibitors [11-15].

2. MATERIALS AND METHODS

Electrochemical and chemical coatings are applied to protect metals from corrosion, to give them a decorative appearance and special properties on their surface (increasing electrical conductivity, increasing friction resistance, antifriction properties, welding).

In industry, zinc plating of items and equipment used in normal atmospheric conditions is more common. In many engineering industries, in order to protect parts from corrosion, especially hardware (fasteners - screws, nuts and washers) are definitely inspired. In gasoline and sulfur environments, however, spirit protects metal products better than cadmium and lead. The fact that almost all machine-building and electrical engineering plants now have galvanizing shops is a clear proof of our opinion [16-20].

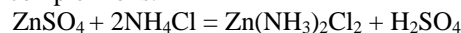
The surface of the detail is prepared before coating the metal. To do this, it is necessary to be free from irregularities, oxide and oil layers, various surface defects.

When cleaning the surface of the product, the oxide shells on the metal surface are removed, various irregularities are smoothed. The following processes are carried out when polishing the surface of a metal product:

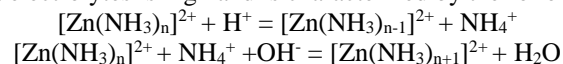
- a) the metal part was removed and the surface parts were cleaned of irregularities using egov and fine sand paper;
- b) the oils on the metal surface were cleaned with a 0.2-0.7% solution of household soap with water prepared in a container at a temperature of 40-50 °C;
- c) oxide shells formed under the influence of the environment and various other factors are removed using chemical reagents alkalis, acetone or trechlorethylene;
- c) the irregularities remaining on the metal surface after rotational effects are electrochemically smoothed:

To do this, zinc sulfate 80-100g / l, ammonium chloride 160-200g / l, dextrin-based electrolyte are prepared and loaded into an acid-resistant galvanic bath. In the electrochemical method, the product is connected to the bath in the form of an anode, and the process of electrochemical decomposition is carried out, in which the metal surface is much smoother than other methods. An alternating current is connected to the electric circuit and the device is held for 10 min depending on the unevenness. The product participates in the process as a soluble anode. In this case, the surface should come out in a mirror-like gloss. The cleaned surface will be ready to form a galvanic coating.

Then the basic zinc coating application procedure is performed. For this purpose ammonia galvanizing electrolytes are used, in which zinc is present in the form of simple or complex ions.



The buffering property of ammonia electrolytes is high and is characterized by the following equilibrium equations:



In ammonia electrolytes, organic compounds such as urotropin, thiourea, gelatin, glue, dextrin are added to form a uniform and light-colored coating. In the laboratory, the following electrolytes were used:

Zinc sulfate. 80-100g / l
 Ammonium chloride. . . . 160-200g / l
 Temperature. 20-40 °C
 Current density. 0.1-0.3kA / m²
 Current output 96%
 The duration of the coating process is 20-40min.

The stationary potential of the spirit at $E_{\text{H}^+} = 1\text{mol} / \text{l}$ is approximately -0.772 V. The stationary potential of iron is -0.44 V, and because it is more electrically positive than zinc, in aggressive (corrosive) environments, zinc decomposes before iron and

electrochemically protects iron (because zinc-iron serves as a zinc anode in galvanic pairs, as well as in tread protection of underground pipes) zinc metal is used).

3. RESULTS AND DISCUSSION

According to its electrochemical properties, zinc is a metal that emits low voltage at the cathode and has a high alternating current. Therefore, large-particle coatings are formed from simple alloys of this metal. The extreme strength of hydrogen in this metal ensures that the current efficiency in the cathode coating process is also high in acidic solutions.

Thus, when we compare the separation potentials of spirit and hydrogen at a current density of 300 A / m², we see that the spirit is released before hydrogen is formed. In a solution of 1 mol / l ZnSO₄ and 1 mol / l H₂SO₄:

$$E_{H^+/H_2} = 0 + 0,058 \lg 1 - 1,057 = -1,057 \text{ V (25}^\circ\text{C)}$$

$$E_{Zn/Zn^{2+}} = -0,76 + 0,029 \lg 1 - 0,01 = -0,77 \text{ V (25}^\circ\text{C)}$$

The higher the current density, the higher the hydrogen intensity and the higher the current output of the spirit. The polarity diagrams of spirit and hydrogen shown in Figure 1 below show that the stationary potential of spirit in its acid salts solution, its equilibrium potential having a positive value greater than Ep(Zn) = -0.8 V, because not only in the formation of potential Zn → Zn²⁺ + 2e reaction (Zn²⁺ + 2e → Zn is not taken into account because the reverse reaction rate is small) 2H⁺ + 2e → H₂ reaction is also involved (H₂ → 2H⁺ + 2e is not taken into account because the reverse reaction rate is small).

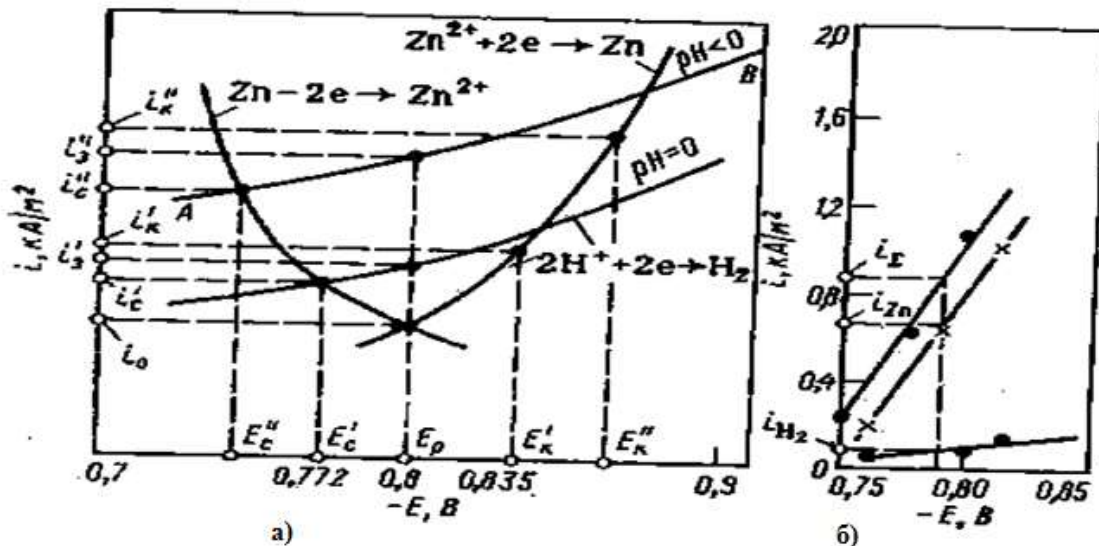


Fig.1. The relationship between zinc ion and solution potential

From Ep(Zn) = -0.8 B, conditions are created at the cathode where the spirit can be separated. Cathodic protection of the spirit is achieved when the current density is ia', if the current density is increased again, the ionization rate of the spirit is greatly reduced and the spirit begins to separate with hydrogen. The higher the current density, the greater the current efficiency at the spirit output.

Polarization curves of zinc and hydrogen in acidic solutions; a) is a schematic diagram of a partial curve. b) is the real partial curve.

Figure a shows the output curve of hydrogen at the cathode from a more acidic solution, ie, when the amount of H⁺ cations is greater, through the line A - V. In determining the kinetic parameters, it can be seen from the graph that EcZn shifts towards positive values (Ec'') and the rate of spontaneous melting of the soul increases to ic''. In order to achieve cathode protection, a certain high current density (ia'') is required, which means that the spirit begins to emit only at certain high current densities.

Higher current densities than those of sour alloys will be required to achieve high output current yields in spirit extraction.

The distribution of electrical energy expended on spirit and hydrogen can only be determined by comparing their sum and partial polarity curves (Fig. b).

When the potential is -0.788V (see Figure b):

$$B_{T_{Zn}} = 100 \cdot i_{Zn} / i_{\Sigma} = 100 \cdot 0.065 / 0.072 = 90\%$$

$$B_{T_{H_2}} = 100 \cdot i_{H_2} / i_{\Sigma} = 100 \cdot 0.0072 / 0.072 = 10\%$$

An anode made of pure zinc (the surface of which should be equal to the surface of the cathode) is placed in the galvanizing vessel parallel to the cathode and connected to the positive pole of the current source by a wire.

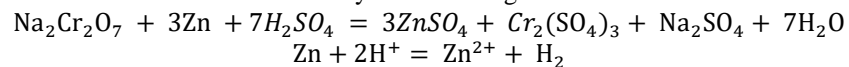
The vessel was filled with electrolyte to the extent that it did not bury the electrodes, and an electric current was connected to the resulting system. The coating thickness was 6 μm.

Table 1. Sample surface cleaning results

№	Types of processing	Initial mass of the sample, mg	Sample mass after cleaning, mg	Surface condition
1	Mechanical and chemical processing	1100	1054	There are irregularities, the color is dull
2	Electrochemical treatment	1054	1022	The plain color is dull
3	Coating formation	1022	1034	Smooth, shiny

At high humidity, zinc coatings corrode very quickly, including its exterior. appearance worsens. In order to increase the chemical stability of the electrochemical coating created on steel products in various aggressive conditions and to give a quality appearance, coating of new galvanized products with chromate coating is carried out.

The essence of the chromatisation process is the partial dissolution (oxidation) of zinc metal in a chromatic acid medium and the reduction of hexavalent chromium to trivalent chromium by the following reaction:



and chromium sulfate containing trivalent chromium undergoes hydrolysis to form a chromate shell that corresponds to the following formulas, which are very stable under natural conditions: $\text{Cr}_2\text{O}_3 \cdot \text{CrO}_3 \cdot \text{H}_2\text{O}$

The resulting chromatic shell is composed of yellow and blue compounds and looks like a multi-colored rainbow (Figure 2).



Fig.2. Appearance of chromatic samples in different ways

The composition of a common solution for chromatisation of coatings from cyanide electrolyte is as follows:

- Sodium bichromate. 200g / l;
- Sulfuric acid (1.84). 10mg / l;
- Temperature. 15-20 °C;
- Processing time is 20-30 seconds.

The items are thoroughly washed and dried at a temperature of up to 60 °C.

It is advisable to use a solution of the following composition to chromate the zinc coating obtained from the acid electrolyte:

- Chromium anhydride CrO_3 150 g / l;
- Sulfuric acid (1.84). 20mg / l;
- Nitric acid (1.4). 20mg / l;
- Temperature. 15-20 °C;
- Processing time 20-60 seconds.

A chromatizing solution of the above composition is prepared in a 250 ml volumetric flask and stored in the dark in an airtight container. Before chromatization, the sample is weighed on an analytical balance. Pour 100 ml of the chromatizing solution into the bath. An experimentally galvanized sample plate is inserted into it for 5-10 seconds to carry out the chromatization process. The metal plate is thoroughly washed in calm water. The product is dried in a drying oven at temperatures up to 60 °C. The thickness of the dry coatings was 1.5 µm. The sample was weighed on an analytical balance and the results were recorded in the table 2.

Table 2. Sample surface chromatization results

№	Types of processing	Initial mass of the sample, mg	Mass after chromatization, mg	Surface condition
1	Electrochemical leaching	1034	1054	Smooth, shiny
2	Creating a chromate shell	1054	1075	Smooth, shiny

4. CONCLUSION

The series of stresses of metals is of practical importance. For example, a series of metal stresses are used to protect submarine - metal parts of ships from corrosion. To do this, a metal to the left, such as a magnesium ingot, is connected to the underwater part of the ship in a series of voltages, as a result of which magnesium corrodes and the underwater part of the ship is preserved. The same method is used to protect buried pipes from corrosion. This method is called electrochemical shielding, and a metal that is far to the left of the shielded metal in a series of voltages, such as a magnesium ingot, is called a tread.

5. REFERENCES

- [1] М.А. Беленкий, А.Ф. Иванов – Электроосаждения металлургических покрытий. Справочник. Москва Металлургия 1985 й.
- [2] А.М. Ямольский – Электроосаждение благородных и редких металлов. “Машиностроение”, 1977 й.
- [3] Патент. Виноградов С.С.(RU), Кудрявцев В.Н.(RU), Ярлыков М.М.(RU), Шахамайер Стив(US), Способ электрохимического нанесения хромовых покрытий на металлы и сплавы.
- [4] Винокуров Е. Г., Кудрявцев В. Н., Шахамайер С. Р., Кузнецов В. В., Азарко О. Е. Электролит для осаждения хромовых покрытий на металлы и сплавы (патент РФ № 2146309).
- [5] Khojiev Sh., Fayzieva D., Mirsaotov S., Narkulova E. New The Main Trends in the Integrated Processing of Waste from Mining and Metallurgical Industries // International Journal of Engineering and Information Systems, 5(4), 2021. P. 182-188.
- [6] Khojiev Sh., Berdiyarov B., Gulomov I., Mamatov M. The Current State and Development of the Integrated Use of Technogenic Waste // International Journal of Engineering and Information Systems, 5(4), 2021. P. 189-194.
- [7] Khojiev Sh.T., Berdiyarov B.T., Alamova G.X., Abjalova H.T. Application of Energy-Saving Technology in The Smelting of Copper Sulfide Concentrates in Autogenous Processes // International Journal of Academic and Applied Research, 5(3), 2021. P. 30-33.
- [8] Yusupkhodzhaev A.A., Khozhiev Sh.T., Akramov U.A. Use of non-traditional reducing agents to expand the resource base of OJSC Uzmetkombinat // Chernye Metally, Volume 2021, Issue 4. P. 4 – 8.
- [9] Toshpo‘latov D.D., Hojiyev Sh.T. Rux ferritini metallotermik tiklanish jarayonining imkoniyatlarini o‘rganish // “Fan va texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika ilmiy-amaliy anjumani to‘plami, Toshkent, 21-23 aprel, 2022 y. C. 256-258.
- [10] Toshpo‘latov D.D., Hojiyev Sh.T. Xalkopiritni ozon yordamida kislotali muhitda oksidlanish jarayonining termodinamikasini o‘rganish // “Fan va texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika ilmiy-amaliy anjumani to‘plami, Toshkent, 21-23 aprel, 2022 y. C. 258-259.
- [11] Toshpo‘latov D.D., Hojiyev Sh.T. Molibden dioksidini kislotali oksidlashning termodinamik tahlili // “Fan va texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika ilmiy-amaliy anjumani to‘plami, Toshkent, 21-23 aprel, 2022 y. C. 260-261.
- [12] Karimova M.Sh., Hojiyev Sh.T. Konvertor changlarini gravitatsion usulda qayta ishlash // “Fan va texnika taraqqiyotida intellektual yoshlarning o‘rni” nomli Respublika ilmiy-amaliy anjumani to‘plami, Toshkent, 21-23 aprel, 2022 y. C. 307-309.

- [13] Berdiyarov B.T., Khojiev Sh.T., Matkarimov S.T., Munosibov Sh. (2021) Study of the thermodynamic properties absorption sulfur storage gas of zinc and copper industry // Technical science and innovation, Vol. 2021, Iss.4. P. 293-301.
- [14] Khojiev Sh.T., Rakhmataliev Sh.A., Tulaganov M.I., Umirkhulov H.A. Modern technologies of tungsten production // Образование и наука в XXI веке, 2022, 25(3). С. 1210-1219.
- [15] Khojiev Sh.T., Rakhmataliev Sh.A., Tulaganov M.I., Rakhmonaliyev M.M. Modern technologies of zinc production // Моя профессиональная карьера, 2022, 35(8). С. 266-275.
- [16] Хожиев Ш.Т., Бердияров Б.Т., Мухаметджанова Ш.А., Нематиллаев А.И. Некоторые термодинамические аспекты карботермических реакций в системе Fe-Cu-O-C // O'zbekiston kimyo jurnali. – Toshkent, 2021, – №6. – С. 3 – 13.
- [17] Toshpo'latov D.D., Hojiyev Sh.T. Oksidlangan mis birikmalarini etil spirti bilan tiklab mis olishning termodinamik tahlili // Texnika yulduzlari, 2021, №4. P. 13 – 18.
- [18] Berdiyarov B.T., Khojiev Sh.T. Thermodynamic analysis of reduction of oxidized copper compounds in a slag phase // Kompozitsion materiallar, 2021, №4. P. 39 – 43.
- [19] Третьяков Ю.Д. Твердофазные реакции. – М.: Химия, 1978. 360 с.
- [20] Khojiev S.T., Nuraliev O.U., Berdiyarov B.T., Matkarimov S.T., Akramov O'.A. Some thermodynamic aspects of the reduction of magnetite in the presence of carbon // Universum: технические науки: электрон. научн. журн., Часть 3, 3(84), 2021. P. 60-64.