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Development of the technological process of electrolytic bronzing

Abstract

Relevance of the research.

Electroplating with alloys is common in various industries, especially in instrumentation and mechanical engineering. Such coatings are formed by co-deposition of several metals, due to which they combine a number of new positive properties.

Bronzes are two- or multi-component copper alloys in which zinc or nickel are not the main alloying elements. In electroplating, coatings based on tin bronzes are mainly used. Such coatings are obtained by co-electrochemical deposition of copper and tin, while the color and physico-chemical properties depend on the percentage of copper and tin in the coating.

Electroplated bronze coatings can have a number of positive qualities characteristic of cast tin bronzes, such as ductility, wear resistance, corrosion resistance, solderability, decorative appearance, and others. Electrochemically deposited bronzes are used both as decorative and functional coatings, for example, in electronics and in the manufacture of bearings.

The most popular for practical use are bronze coatings with a tin content of 6 to 14%. A higher tin content in the alloy is undesirable, since the alloy structure becomes multiphase, which leads to a sharp decrease in toughness and plasticity. And the lower content of tin, in turn, does not allow to significantly change the physical and mechanical properties of alloy coatings relative to copper coatings.

To date, in industry, to obtain electrolytic bronze coatings, cyanide electrolytes are mainly used, which have good technological characteristics, but contain highly toxic substances. A large number of cyanide-free electrolytes have been developed to replace toxic cyanide solutions. However, there are a number of reasons preventing their wide industrial application, among which are the low stability of solutions during operation and a narrow range of current density, which

provides the required composition of the alloy.

Of interest is the development of alkaline electrolytes based on organophosphates, which are effective chelating agents and have been found to form stable complexes with many metal ions. Due to their chelating properties, they can be an effective replacement for cyanide complexes.

The degree of development of the research.

Studies of electrolytes based on phosphonic acids for bronze deposition were considered in foreign works by the following authors: U. Manz, S. Berger, K. Bronder, B. Weyhmüller and G. Wirth. These works show the fundamental possibility of obtaining bronze coatings from this type of electrolytes, but there is no information about the properties of deposited coatings and the possibility of industrial use of phosphonic bronzing electrolytes.

In addition, the electrolytes presented in these works have a complex composition (due to the presence of several groups of complexing substances (pyrophosphates, methanesulfonates, phosphonates)), which greatly complicates the correction of the electrolyte. In addition to the complex composition, the presence of pyrophosphates in the electrolyte significantly reduces its stability at high operating temperatures.

The research objective is to development of a technological process for the electrodeposition of bronze from an electrolyte based on phosphonic acids, which allows deposition directly on the surface of carbon steel.

The research tasks:

1. Evaluation of the stability constants of complexes formed in an alkaline solution of a ligand with copper and tin ions

2. Study of the process of alloy discharge from the studied solutions

3. Establishing the reason for the absence of contact precipitation of copper from the studied solutions on a steel surface

4. Development of solutions that allow the process of electrodeposition of bronze coatings

5. Determination of the operating parameters of the electrodeposition

process to obtain coatings with a given composition

6. Determination of microhardness, adhesive strength of the resulting coatings and their comparison with metallurgical bronze

7. Determination of the stability of the solution and the conditions for its adjustment

Scientific novelty of the research.

It has been established that during the electrodeposition of bronze from a nitrilotrimethylphosphonic (NTMP) electrolyte, a nanoscale film is formed on the surface of steel and the deposited alloy, which prevents the contact precipitation of copper on carbon steel. It is shown that the formed film changes the discharge kinetics of copper and tin ions in such a way that the process of incorporation of copper into the alloy depolarizes to a much lesser extent than the process of incorporation of tin. It was revealed that the resulting nanoscale film includes monovalent copper compounds.

Practical significance of the research.

A stable alkaline cyanide-free electrolyte has been developed that makes it possible to deposit bronze coatings of a uniform composition with a tin content of 8–14% in the range of current densities of 1–5 A/dm^2. The deposition of bronze coatings from the developed electrolyte can be carried out directly on carbon steel.

Provisions for defense:

1. Evaluation of the conditional stability constants of complexes formed in NTMP solutions in an alkaline medium with copper (II) and tin (IV) ions and their effect on the convergence of electrode potentials in the absence and presence of polarization

2. Influence of nanoscale films formed on the cathode surface in alkaline solutions of NTMP on the process of bronze electrodeposition

3. Results of studies of the physical and mechanical properties of bronze coatings deposited from alkaline electrolytes based on NTMP

4. Results of studies on the stability of an alkaline electrolyte for bronze deposition based on NTMP and the possibility of its correction