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## Decorative Finishing Metal Artwork

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**Annotation:** The article deals with topical issues of the use of decorative finishes and restoration of sculptures made of copper and bronze alloys with a brief summary of it.

**Key words:** copper, bronze, electrolyte, alloy, electrochemistry, brushing, polishing, oxide, casting.

Decorative finishing of metal art products, sculpture and some details of architecture is carried out by tinting in a given color by applying appropriate reagents to the metal and forming oxide or sulfide films on it, obtained by a chemical or electrochemical method. A combined decorative finish of metal is also used by applying metal films to it, followed by their tinting. Artificially applied decorative films imitate naturally formed oxides on copper and bronze. They not only decorate the metal, but in many cases protect it from corrosion.

Decorative finishing of sculpture and art products is carried out only by chemical or electrochemical methods. Oxide films of different colors are obtained due to the formation of chemical compounds of the painted metal or as a result of the electrochemical effect of the electrolyte on the treated surface.

Electrochemical coloring of metal makes it possible to obtain a rich range of various tones and halftones.

Copper is easily oxidized and colored by chemical and electrochemical methods, while the oxide film can take on a wide variety of colors.

Copper films deposited on products from a sulfuric acid or cyanide bath behave differently when stained. The best results are obtained when staining copper applied to a cyanide electrolyte product. Copper alloys containing alloying metals are more difficult to paint than pure copper. So, for example, bronzes with a high content of tin, which protect copper from oxidation, are more difficult to color.

Preparing the sculpture before chemical and electrochemical finishing is a mandatory operation, on which the success of toning largely depends. The most difficult and responsible in the decorative finishing of sculptures and artistic metal products is the chemical action of appropriate reagents on the metal surface, which determines the production of the desired colors and chiaroscuro.

The quality of decorative finishing depends on the correct choice of the whole complex of mechanical, chemical and electrochemical treatments of a given sculpture or art product. In each case, one of the most important tasks is to obtain the appropriate color and light and shade solution for plastic forms, as well as to protect the metal from corrosion.

The shiny surface of a metal product, which has a high reflection coefficient, is of exceptional importance in decorative finishing. The state of the metal surface is determined by two factors: its purity and physical properties, which depend on the structure of the metal and the quality of the surface treatment. Clean is considered a flat and smooth surface. A shiny surface, which has a high reflectivity and retains the color and brilliance of the metal, is of particular importance for jewelry, in particular for products with precious stones.

The finished product - whether it is jewelry, sculptural casting, chased relief or dishes that have a utilitarian purpose - is necessarily subjected to decorative finishing at the final stage. It not only improves the appearance of the item, but also protects it from corrosion. A well-finished product is a pleasure to hold in your hands. It is hygienic, as all kinds of contaminants are easily removed from it. For many centuries, craftsmen have invented more and more new ways of finishing metal. They learned how to grind and polish the surface of metal products, give it a rough texture if necessary, and paint it. There are many recipes for applying the thinnest protective films in a wide variety of colors.

Let us consider two methods of polishing metals: mechanical polishing with wheels and manual polishing pads and electrolytic polishing, which is now increasingly used in the art industry, where the best finish is achieved by this method.

To remove the roughness formed in the process of galvanic metal deposition, the products are brushed with rotating brass brushes made of thin wire. Brushing is carried out with abundant wetting of a rotating brass brush, from which the friction of the brushing brush against the surface of the product foams. The resulting foam easily separates and carries away the sludge. However, after brushing, traces of wire work remain on the metal, they are especially noticeable on soft metals such as gold, silver or platinum. Therefore, after brushing, the product is polished to give it a mirror finish. When processing various art products coated with precious metals, polishing is carried out manually or on mechanical machines.

Electrolytic polishing can be applied not only to non-ferrous metals, but also to stainless steel of various grades. This method of polishing steel is now widely used. Especially often it is used for architectural details made of sheet material. Electrolytic polishing of some grades of stainless steel can be done directly in sulfuric acid, but this requires a significant current density, which is difficult to carry out under production conditions. Therefore, in practice, polishing of various types of stainless steel is carried out in a mixture of phosphoric and sulfuric acids, to which chromic anhydride is usually added. Almost all works of art made of metal - from monumental sculpture to jewelry - undergo a decorative and anti-corrosion finish by sulfiding, oxidation or electroplating. The quality of decorative finishing depends on the correct choice of the whole complex of mechanical, chemical and electrochemical treatments of a given sculpture or art product. In each case, one of the most important tasks is the appropriate color and light and shade solutions for plastic forms, as well as the protection of metal from corrosion. The protection of metals from corrosion and the finishing of artistic metal products, like many other related areas of industry, are associated with electrochemistry, the history of which has come a long way. Discoveries in this area followed one after another. Some of the stages of electrochemistry described were the basis for the further development of this science.

Today, the environment affects sculptures and artistic metal products. In the city, the air is clogged with industrial gases, mostly acidic - sulfur dioxide and hydrogen sulfide. They primarily affect copper and copper alloys. Sulfur dioxide in the presence of water and air oxygen is easily oxidized to sulfuric acid. Copper acts as a catalyst for this process. The aggressiveness of these reagents is therefore most active during the period of precipitation, including substances that pollute the air, including particulate matter. Solid particles consist of chlorides, carbonates of sodium, calcium, magnesium, potassium and others, as well as coal and sand; settling, they adsorb moisture and gases from the air and create microgalvanic vapors on the metal surface.

The color of the decorative finish of an outdoor sculpture usually undergoes changes. It darkens due to the formation of copper sulfides and oxides, becomes black and is perceived as a silhouette, this applies not only to copper, but also to bronze sculpture, which also darkens in the atmosphere of industrial cities. In addition, spots or greens may appear on the surface of the sculpture due to the formation of basic copper salts, which protrude mainly on the horizontal planes of the sculpture. Such defects, violating the color integrity of the sculpture, crush and distort its plastic forms.

The main requirements for the decorative finishing of sculptures and various artistic metal products are as follows:

1. strength of color texture (so that under the influence of atmospheric and mechanical factors the original finish is not disturbed);
2. corrosive operating conditions (weather resistance);
3. light fastness finish;
4. long-term immutability of the finish;
5. sanitary and hygienic conditions (non-toxicity of coatings).

The possibility of these defects should be taken into account in the process of decorative finishing of the sculpture, they must be eliminated by timely prevention and restoration. One must also remember about corrosion factors that can affect the stability and preservation of decorative finishes and the state of the surface of the metal from which the sculpture is made.

The protection of metals from corrosion and the finishing of artistic metal products, like many other related areas of industry, are associated with domestic electrochemistry, the history of which has come a long way.

Knowledge of the history of decorative metal finishing in architecture, arts and crafts and the technology used is absolutely necessary for restoration work, which occupies a significant place among other types of decorative finishes. So, in the overwhelming majority of cases, restorers have to repeat the old technology and apply old methods of work. Some of the stages in the history of electrochemistry described by us formed the basis for the further development of this science.

Before applying a decorative finish to a sculpture or an artistic metal product by means of a chemical or electrochemical method, its surface is preliminarily prepared. The quality of the preparation largely determines the effect of the decorative finish.

The surface of sculptures and art products, regardless of the appearance of the metal, is processed and cleaned by mechanical, chemical or electrochemical methods.

When an unprepared surface is oxidized, an oxide film, as a rule, does not form on it, and if metal build-up occurs, it will peel off. Even the smallest amount of fats and oxides is enough to prevent the formation and strong adhesion of the oxide film to the metal. It often happens that the poor quality of the applied decorative coating is detected much later, since the peeling process may not occur immediately.

Brushing is also performed as a final treatment of metal after it has been electroplated. It gives the product shine, and when hard brushes are used, it gives it a haze, and the processing of the oxide layer by brushing is used to obtain chiaroscuro on the relief of artistic products.

In addition, there is the technique of matting sculptures and art products - one of the auxiliary processes of decorative metal finishing. Many artistic metal products - from jewelry to monumental sculpture - do not completely separate under shine, since the shiny surface of artistic products and especially sculptures breaks the chiaroscuro and, in this regard, makes the sculptural forms flat.

Therefore, in some artistic products, shine is given only to certain areas of the surface. The main areas are usually matte or oxidized in dark colors, depending on the appearance of the product, the nature of the metal, the type of plating or oxide film, and the texture of the product.

Matted surfaces of art products can be divided into three groups:

- frosted grain.
- matte finish.
- line matting.

Matting can be achieved by mechanical or chemical treatment of the metal surface. Mechanical methods include metal sandblasting and brushing with steel or brass brushes. To chemical methods - etching of metals in various acids.

For matting products and sculptures made of bronze, copper, aluminum and cast iron, as well as for galvanic coatings and oxide films, sandblasting of the surface of products with quartz sand is most widely used. Sand is sprayed from the nozzle. In this case, a certain pressure and a certain angle of inclination of the jet are observed. Depending on the type of sand and the size of its grains, different surface textures can be obtained.

Before matting, the surface of the treated metal is degreased, otherwise the metal surface is difficult to process and after matting it retains greasy spots.

Sand matting with pre-treatment of the background of bas-reliefs, various medallions and other products coated with a layer of galvanized silver, gold or oxide film, gives a training halo around the contour with soft transitions into relief.

Products made of copper, brass, silver are matted with steel brushes. The filling of the matt surface is carried out on conventional polishing machines with round scattered rotating steel brushes. Wire bundles of brushes are mounted in movable rings. When matting, the product is pressed against the brush and moved in a circular motion in a horizontal plane. Gradually, the entire surface is covered with an even layer of matte grain.

Chemical matting of products made of copper and copper alloys is carried out with acids. That gives a velvety and matte finish to the surface of the product, while emphasizing the texture of this metal. To obtain a textured surface, the technique of metal graining is used when matting by chemical means. The product is polished, degreased and slightly heated after drying. The product prepared in this way is placed in a chamber in which asphalt, ground to powder, is pre-sprayed through a fine sieve. The product is covered with asphalt dust, which sticks to a warm metal surface. After the metal has cooled, etching is carried out in a matting solution. After washing and drying the product, asphalt pollen is removed from its surface by washing the metal in a solvent. The surface of the metal treated in this way is covered with a grain, which is a shiny dot.

Protective and decorative films formed on the surface of a bronze culture in the open air are conditionally divided into three types: the first type of films includes green and blue patinas, consisting of sulfides, chlorides, nitrates, carbonates. To the second type - consisting of nitrous oxide and copper oxide. To the third type - sulfide films, consisting of copper sulfides or inclusions, usually found on the surface of the patina, which are sulfides of other metals. Research and observations have established the expediency of creating a green and blue patina during the restoration of old monuments, on which a stable natural patina has formed over many years. Created for the protective and decorative finish of a newly installed sculpture located in atmospheric air that does not contain an increased amount of aggressive reagents.

When erecting monuments under conditions of an increased amount of aggressive reagents, patinating compounds should be used that form patinas consisting of basic sulfate or basic copper nitrate. When installing a sculpture in seaside cities where chlorine compounds are present in the air, it is not recommended to use patination compounds based on chloride compounds, since over time, films consisting of chloride and basic copper carbonate will gradually chemically change under the influence of sulfur dioxide.

With chemical patination, the first layer of mortar must be very thin and even. The formation of drops and bubbles, which easily appear when applying the liquid, should be avoided. For patina, a low concentration solution should be used, as they give a stronger patina than concentrated solutions. This is especially important when applying a thick patina. The solution is heated to 30-400 C, especially in winter. Strong heating of patinating solutions should be avoided, as the patina turns brown and even black.

A layer of this color can be applied as a primer before applying a second layer of patina. With a two-layer patination method, the most durable coating is obtained. The primer, translucent through the top layer of the coating, gives the patina a more natural color. A similar translucency of a dark or brown undercoat is commonly seen in natural patinas.

To obtain a sublayer, it is recommended to treat the surface with a 20% solution of copper nitrate, after which the surface acquires a dark color. The sculpture should be strongly heated over a brazier with coal, coke, etc.

A study by specialists has shown that the following salts are most suitable for creating an "antique patina" on bronze, brass and copper: ammonium chloride, copper nitrate, copper acetic salt, acetic acid and ammonia.

It is best to use copper nitrate with the addition of alcohol, an ammonia solution with nitric acid, copper or acetic acid, as well as ammonium chloride and carbon dioxide.

With such processing of sculpture and art products, the beauty of these works of art can be extended for a long time. Particularly interesting are the decorative effects of toning that occur at sunrise, when the sculpture becomes pink-red, at sunset, when it becomes crimson, and also in cloudy weather, giving the sculpture a dark blue color.

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