Shape determinants of electrochemical restoration in historical metal objects

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Abstract:

The electrochemical restoration process is one of the restoration processes, in addition to electrodeposition used to form or weld corroded or missing metal parts in historical metal objects with a thickness of layers that may reach several millimeters at a low cost and high quality. Also, the electrochemical restoration process is the ideal process for fabricating parts in some historical models in places that are difficult to reach by other traditional methods, such as fine nozzles, deep crevices, and so on.

However, practical applications of electrochemically restoring metal objects gave the proof that many objects with complex shapes are difficult to restore. Here, the role of the research is the answer on many inquiries related to the determinants of the shape of the product and related to the basics of the electrochemical restoration process.

Therefore, there is an urgent need to set many determinants that must be available in the form of the product to be restored by the electrochemical method. If these determinants are available in the form of the product, they will facilitate the restoration process to successfully perform the operation and obtain the desired results.

And by doing several experiments, it has been proven that one of the most important limitations is the absence of deep gaps in the parts that will be electrically restored, as well as avoiding overlapping surfaces with sharp or right angles in the places that must be repaired...etc. It has been found that the absence of attention to verify the presence of these limitations in the product

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form will negatively affect the results of the restoration process, although their presence in the product has a clear positive effect in the electrochemical restoration of metal objects.

Research problem:

- The need to put clear formal parameters to guide those who perform electrochemical restoration to realize the importance of the shape characteristics of the product to be restored and to facilitate the restoration process.

Research Purpose:

1.The knowledge of the most important defects and advantages of traditional restoration processes.
2.The recognition of the electrochemical restoration process, how it works? The solutions used and their nature, and the most important minerals that can be restored in historical objects.
3.Determination of the formal parameters based on which we define if the product is suitable for electrochemical restoration or not.

Research Hypotheses:

- For the shape of the product in the electrochemical restoration process will lead to:

a) Facilitating the electrochemical restoration process for those in charge of the operation.
b) Obtaining more positive results for the electrochemical restoration process.
c) Specifications are better than traditional restoration processes.

Research Methodology:

The research follows the descriptive analytical method.

Keywords:

Electrochemical restoration, Electrodeposition, Polymers, Shape determinants

Introduction

The field of metal products restoration is exposed to many different problems and difficulties by forming and finishing the surfaces of some parts of the product, which negatively affects it and leads to a clear deficiency in the shape and surface of the product.
The electrical restoration process is one of the most important processes used in forming and adding metals and alloys to the metal product to improve the aesthetic and appearance properties and to increase the service life of the parts that are being restored for it.
The restoration process has several methods, including restoration with synthetic materials (polymers), restoration with plaster materials, and recently electrochemical restoration, each of which has its importance in restoring products of various raw materials.
Electrochemical restoration is one of the methods used in building and shaping defects and deformations in the shape and surface of products of different metals, but this role is hampered by some difficulties related to the shape of the product. Therefore, the researcher was interested in setting determinants in the shape of the product to be restored to guide those who perform the operation to overcome these difficulties and problems in the electrochemical restoration of

products. Also, these many formal determinants are influential in the success of the electrochemical restoration process to achieve its appearance and aesthetic goals for the product if the repairer is committed to verifying its presence in the shape of the product.

1- The importance of restoration of the metal product:

Over the past forty years, the field of restoration has evolved from a simple craft to an integral part of archaeology. The term "restoration" has attracted the attention of many European researchers in the field of antiquities restoration in the modern era.

The importance of restoring historical metal products is due to:

a. Restore the metal trace as much as possible to its original condition. [5]

b. Exposing the aesthetic, artistic and historical values of this mineral trace.

c. Disclosure of technical information that depends on the existence of the historical product.

d. Protection of antiquities in accordance with what was established by law and recommended by international conventions for the protection of antiquities, such as the 1966 Venice Charter, which considered the restoration process as a highly specialized operation. [8]

2- The most important traditional restoration of historical metal products

The principles of restoration depend on clarity, i.e., clarifying the restorations that took place so that we can see them clearly and distinguish between what is original and what is added in our time, and whether the materials restored with it are original or new, the principle is that the distinction should be easy. Therefore, restoration works that result in erasing, removing, or obliterating the material and moral characteristics of the historical metal product should not be carried out. The principle of durability, the materials with which they are restored should be tough, not easily brittle, and not affecting the physicochemical factors greatly. Without excessive restoration, there are several forms of restoration, the most important of which is collecting scattered samples and re-installing them by welding or gluing using synthetic resins to restore their original shape.

2-1- Restoration of historical metal products using synthetic materials (polymers).

Polymers (adhesives) are used to bind or stick metal parts together and these materials are like organic or inorganic materials. These adhesives consist of two compounds, the first of which contains mainly resin and the other contains hardener, after which the curing process begins [1]. Polymers are used in the process of strengthening and consolidation to give the structural strength to the historical metal product, which faces the risk of disintegration, as microcracks spread in the metal trace, so it must be strengthened, and two basic conditions are considered in the completion.

- Homogeneity (the supplement material should be homogeneous with the trace material).
- Differentiation (which is that the areas of completion are distinct in color and texture, and the differentiation varies according to the age of the antiquity, type of the trace material, shape, size, and color of the patina). [15]

- **Disadvantages of using polymers in the restoration of a historical metal product**

1- Using restoration materials in an uncontrolled way can lead to additional damage to the metal product.

2- It requires very high skill and high accuracy in the assembly process so that there are no errors when using these labels because it freezes quickly, which hinders the assembly operations afterwards.

3- Restoration materials (polymers) can spread around the surface surrounding the missing part to be completed and at first, they are invisible, but over time its color changes and becomes distorted for the aesthetic appearance.

4- The use of fillers may lead to different surface levels and irregularities, which were painted to mimic the original surface, which led to the obscuration of important details from the decorations of the original metal product. [6]

5- For the application of the adhesives, it is required to remove the splinters, i.e., the minute residues on the surface, as well as a good cleaning of the fat.

6- Synthetic materials (polymers) are subject to decomposition by environmental factors, such as: heat and light, and oxygen gas is the main factor, especially in the presence of light and ultraviolet rays, which are the most dangerous types of radiation on materials manufactured from industrial plastics. Oxidation of plastics breaks down long particles and forms small, oxidized particles, which results in discoloration and loss of tensile strength between particles, which consequently leads to brittleness. [16]

2-2 Restoration of historical metal products by welding

Parts of historical metal product can be assembled by soldering, which is sufficient to return the product to its original form. The metal used for soldering must have a melting point less than the metal of the historical metal product. There are two types:

The first type: Hard solder, which melts at a temperature of 600° C. It is preferred because it is highly bonded to metal parts.

The second type: Soft solder, usually consisting of lead and tin.

- **Disadvantages of using soldering technology in the restoration of the metal product.**

The use of heat and heating, in addition to the use of welding alloys also in assembling the historical metal product and completed parts, is completely unacceptable, especially with metal traces. It has been recognized that heating and welding of antique can represent the following risks:

1- The melting points of existing compounds that are completely different from the object of the antique may cause a risk of melting one of them.

2- Heating can erase engraving and previous work of decoration even a simple welding process can lead to the growth of unwanted grains.

3- The missing areas of the metal products are the result of complete corrosion of the metal in these areas and therefore it is not possible to weld new strong metal to this corroded part.

4- The heat used in welding leads to a change in the internal composition of the metal in the places of welding and thus these areas lose their metallographic features that indicate the method of manufacturing the antique, which loses the validity period of the metallographic study after that.

5- Some damage may result from the use of auxiliary materials for welding fluxes in soft welding, as some of them result in rust-causing materials such as chloride residues.[3]

6- Occurrence of oxidation or darkening of the parts surrounding the welding area, and the historical metal product has less resistance to stresses and agitation after welding. [7]

7- Welding results in the occurrence of minute cracks of the historical metal product because of the process of expansion (resulting from the heat of the welding material) and contraction after cooling the historical metal product. [20]

Since many old and traditional methods of restoration, many of them cause damage to artifacts, the duty of the maintenance and restoration official is to preserve the artifacts using the best means and methods that can be employed for this purpose.

3- Electrochemical restoration process:

Electrochemical processes are often used as a manufacturing process by addition and as an alternative to traditional restoration processes that may take a lot of time and consume effort and money and do not lead to the desired results in the shape and surface of the historical product. The electrochemical restoration process is one of these processes, for which we define several definitions, including:

- It is the process of restoring products by immersion in electrolytes.
- It is an electrochemical process used to restore the historical metal product by adding metals or alloys to the sites of deformation and defects in the shape of the product. [22]
- It is the addition of a tight metal to a part of the shape or surface of the product using chemicals (solution) and the application of electric current. [19]
- It is the electrolytic and metallic addition to a part of the surface or shape of the product in a strong ionic solution with a direct current.
- It is the process of passing electric current through the metal product in a solution to add a thin or thick metal layer to the surface and shape of the metal product, resulting in a precise restoration in specific locations for this product. [17]

3-1- The most important features of the electrochemical restoration process:

3-1-1- The ease of conducting the operation with few components and a simple economic cost.

3-1-2- High corrosion resistance of the surface of the product being restored in this way. [18]

3-1-3- Maintaining the product and its raw materials for a long time.

3-1-4-This process is used in restoration when high quality is needed.

3-2- The main disadvantages of the electrochemical restoration process:

3-2-1-Partial corrosion of some process equipment.

3-2-2- Restoration of products with specific areas, meaning that it is difficult to restore large products in this way.

3-2-3- Consumption of a great deal of energy.

3-2-4- The need for auxiliary electrodes for complex shapes.

4- The shape of the product and its relationship to the electrochemical restoration process.

- The electrochemical restoration process aims to add metals or their alloys to specific locations in the shape or surface of the historical metal product to reduce the gaps and modify the imbalance resulting from various environmental factors that affected the product with corrosion and damage in some of its parts. [22].
- Whatever the purpose of the process (improving appearance, corrosion resistance, etc.), the electrochemical restoration process is of clear importance and is an important part of the restoration process that must be planned with care and attention as in other traditional processes.

- With an understanding of the dynamics of the electrochemical restoration process, product restorers can obtain outstanding results in restoring their products. [18]
- The basic rules of electrochemical restoration assume the importance of certain limitations on the size and shape of products and any program to improve the quality of electrochemical metal product restoration should start with the selection of an appropriate form of the process.
- The determinants of the shape of the product for electrochemical restoration center around three determinants that will benefit the restoration technicians, and these determinants are:

A- The surfaces and locations to be electrochemically restored must have the ability to be wetted in all solutions and to be washed with water in all steps of the process.

B- The weight of the material added to the surface or shape of the product must be proportional to the density of the current passing through this part of the surface.

C- The products must have the ability to conduct electric current without any negative effects. [21]

4-1- Regular thickness of the formation (restoration) in the damaged places of the product:

The most important factor to determine the quality of the surface of the restored product is the uniformity of the thickness of the forming in addition to the surfaces of the products and the basic laws of electrochemistry may affect the prevention of this complete uniformity in the thickness of the forming layer in the places of damage in the metal product (cathode) of any shape or size, because the parts of the product near the anode become thicker than those far from it, as well as sharp edges and protruding parts from the surface, it tends to take a more portion of the electric current, which leads to the thickness of clearer and larger layers in these places than the places of restoration in the product.

One of the primary goals of the restorers is to reduce the degrees of variation in the thickness of the forming layer (restoration) and at the same time the uneconomical loss of energy due to insignificant areas to be avoided.

Those who restore products must take into consideration that the three-dimensional products have areas where the current density is low, known as “Low Current Density Areas”, in which the thickness of the sedimentation layer is much less than other areas known as “High Current Density Areas”, and the effective role here is how to control these differences between the different areas in the product. [11]

5- Formal determinants affecting electrochemical restoration:

The placement of shape determinants available in the product for electrochemical restoration depends on the possibility of distributing the electric current adequately to all parts and places to be restored from the shape and surface of the product.

From the above we know that the electric current passing through the surface of the product during the electrochemical restoration process is concentrated in certain parts of the surface without other parts, and then the characteristics of these parts where the current is concentrated and the others at which the current is weakened must be determined to guide technicians to overcome such problems.

In fact, those in charge of the electrochemical restoration process often complain about the shapes of complex products because of their many hollow areas and others that are clearly

prominent, which results in thick layers on the surface of the product and others that are thin, and this occurs in all parts of the surface of the product, and this is often not wanted.

Therefore, the researchers were interested in setting the formal determinants associated with the shape of the product and affecting the success of the electrochemical restoration process, the most important of which were the following:

5-1- Avoid that the places to be restored in the product being concave and it is preferable that they be flat because the convex or prominent areas in which the sedimentation layers are clearly organized.

5-2- Avoid sharp edges in the product so that the electric current is not concentrated there, and if necessary, it must be rotated.

5-3- Avoiding the presence of prominent peaks and low bottoms on the surface of the product, because the current is concentrated at the prominent peaks without the low bottoms, which leads to a clear contrast in the sedimentation uniformity of the single surface, and then this must be avoided, or the heights of the prominent peaks should be reduced. [10]

5-4- The radii of the overlapping angles and corners should be as large as possible.

5-5- Reducing the depth of deep gaps whenever possible by making the largest depth in the cavity not more than 50% of the diameter of the gap.

5-6- Avoid sharp and right angles between different surfaces and take into consideration that the angles are obtuse by a degree of not less than 110°.

5-7- Reducing the number of impermeable holes and limiting their depth to 50% of their diameter, and avoiding holes with diameters less than 0.55 cm.

6- The most important search results:

1.Each method of restoration has its advantages and disadvantages, but the advantages of electrochemical restoration are more positive, and disadvantages are less negative.

2.There are many difficulties that may encounter those in charge of the electrochemical restoration process due to some complexity in designing the shape of the product.

3.Failure to verify some determinants in the product form may lead to lower quality and costlier results.

4.The most important determinants that must be ascertained in the form of the product for the uniformity of the restoration layer by sedimentation:

a) Avoid sharp and right angles between overlapping surfaces in the product and turn them into obtuse angles of 110 degrees.

b) Avoid sharp edges and must be rotated to give good results.

c) Reducing the depth of the gaps whenever possible, so that the depth of the cavity does not exceed 50% of the diameter of the gap.

d) Reducing the number of impermeable holes (jamming) and limiting its depth to 50% of its diameter, and avoiding holes with diameters less than 5.5 mm.

e) Product restoration technicians can reduce energy cost and improve quality by emphasizing and adopting these determinants while avoiding the complex forms of electrochemical restoration.

7- Recommendations

1) More research should be done on the problems caused by incorrect restoration of metal products.

2) Attention should be paid to advanced research in the field of electrochemical restoration.

3) Interest in training more technicians for the restoration of metal products in the field of electrochemical restoration.

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