Funeral art and electroplating: history, present and future

Arte funerária e a galvanoplastia: história, presente e futuro

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ABSTRACT
Electroplating is the technique of producing an artifact by electroplating a metal onto a model. This manufacturing method can be applied to produce pieces with complex shapes and a wide variety of dimensions and, mainly in the 19th century, it was used to make funerary art items. This technique is also used to produce replicas of artistic items in order to safeguard them, but also to make them public through these replicas. Although electroplating is a widely used technique, galvanoplastic sculptures present a laborious restoration process due to the difficulty of electroplating only the regions of damaged deposits and the fragile core. In order to identify the main production characteristics and damage present, with a view to a possible restoration stage, the statuary from the Santa Casa de Misericórdia cemetery in Porto Alegre was studied. Samples were taken from the mould and the electrodeposited layer of statues in different states of conservation to be analyzed by metallography. It was possible to observe the structure of the electrodeposits, the width and quantity of layers deposited and the material used to make the model.

Keywords: electroplating, sculpture, funerary art.

RESUMO
Galvanoplastia é a técnica de produzir um artefato através da eletrodeposição de um metal sobre um modelo. Este método de fabricação pode ser aplicado para produzir peças de formas
Complejas, con gran variedad de dimensiones e, mayoritariamente en el siglo XIX, fue utilizado en la confeción de objetos de arte funerario. Utiliza también esta técnica para la producción de réplicas de objetos artísticos a fin de salvaguardarlos, mas aún torná-los públicos através destas réplicas. Embora a galvanoplastia seja uma técnica amplamente utilizada, esculturas galvanoplásticas apresentam um processo de restauração laborioso devido à dificuldade de eletrodeposito apenas nas regiões de depósitos danificados e ao núcleo frágil. A fim de identificar as principais características de produção e danos presentes, visando uma possível etapa de restauração, foi estudada a estatuária do cemitério da Santa Casa de Misericórdia de Porto Alegre. Amostras foram retiradas do molde e da camada eletrodepositada de estátuas com diferentes estados de conservação para serem analisadas por metalografía. Foi possível observar a estrutura dos eletrodepósitos, largura e quantidade de camadas depositadas e o material utilizado na confeción do modelo

**Palavras-chave:** galvanoplastia, escultura, arte funeraria.

1 INTRODUCTION

Cultural objects may, over time, deteriorate naturally. However, in addition to this natural deterioration, there is the contribution of external agents such as pollution and vandalism. But the aging of cultural objects can present quality if the external conditions are favorable and the maintenance periodically. However, with the current tendency to neglect some of these items, often due to the cost of maintenance, these objects can be found at an advanced stage of deterioration.

Cultural objects are all artifacts that have an individual meaning given by man, such as constructions, monuments and sculptures that can be natural or manufactured. These items bring with them an added value derived from their history and representativeness and also by the manufacturing methods applied, which vary according to the culture, technology and purpose of the item. In sculptures, various methods of manufacturing can be identified, such as modeling, casting, welding, and here, electroplating stands out. This is a technique of producing or reproducing an object from a mold whose surface is coated with metals by the electroplating process [1]. At the end of the deposition process, the metallic film can be removed from the mold thus becoming a standalone object, hollow electroplating, or remain on the model, core electroplating [2]. In sculptures with a nucleus the metal layer is usually less thick, a few millimeters, because the nucleus is responsible for the mechanical characteristics and support of the work. Hollow electroplastic, in turn, requires a thicker copper each, since the mechanical characteristics are those of the deposited metal. Due to the different thicknesses of the deposits,
the manufacturing time can vary from hours to days and with this the production in more than one stage of deposition [3,4].

Through metallographic analysis of cross sections of the electrodeposited metal it is possible to define the manufacturing characteristics used [5] as quantity of electroplating steps, thickness of the film and with this the origin of the part, and the format of grain in needle allows to affirm that the parts are produced by electroplating. By the direction of the growth of the crystals can also distinguish whether the sample is from a hollow or core galvanic sculpture. In a nucleus electroplastic, the crystals grow from the interior of the figure towards the surface, while in a hollow electroplastic it is the opposite, the crystals grow from the surface towards the interior and only the last thin layer of finish shows grains in the opposite direction. The statues produced by WMF [6], for example, have three layers of electrodeposited copper:

The first layer aims to cover the entire surface of the model. To check the cover, the part was removed from the bath and with this the growth of the grains was finished. During the time that the part was analyzed outside the acid solution, the surface underwent oxidation, thus forming a visible demarcation line in optical microscopy. At this stage, all imperfection was repaired by brushing and the piece returned to the bath. This first layer has an average thickness of 100 μm.

The second layer of copper was responsible for determining the total thickness of the part. After the electroplating of the second layer, if it was formed by more than one piece, the figure was removed from the bath and the parts welded. After welding, the entire surface was reworked as a whole by brushing and sanding and reinserted into the bath.

Finally, a third layer was electrodeposited to cover possible welds and generated imperfections, also presenting an average thickness of 100 μm.

Figure 1 shows the piece metallography produced by WMF where the 3 described regions can be observed.
Since the beginning of production in the 19th century, electroplating has been used for the creation of items of funerary art, such as angels and grave adornments [7]. However, due to the difficulty of restoring these items and often due to the abandonment of the graves [8], these statues may be unmaintained and in a poor state of preservation.

In Porto Alegre / Brazil, is located the cemetery of Santa Casa de Misericórdia, the oldest in the city, created in 1850, which has a collection of more than 200 sculptures and hundreds of small adornments [9,10]. In these sculptures are found deteriorations of natural aging, but also broken and missing parts due to external agents.

In order to safeguard the art and technology employed for the manufacture of the statuary produced in electroplating that is found in the cemetery of the Santa Casa, the characterization of the state of conservation and the method of manufacture of the statues was carried out.

2 MATERIALS

In order to determine the number of statues present in the cemetery of the Holy House, materials and methods employed in the manufacture and the state of conservation of the statuary was carried out the mapping of the cemetery. Due to the high number of metallic elements and the length of the cemetery (approx. 170 x 350 m), the section of the cemetery with the highest...
density of tombs with statues was studied, this section having its use started in the 20s of the twentieth century. Through the aerial photo of the cemetery, figure 1, it was possible to observe the pattern of location of the deposits and according to the nomenclature used by the administration of the Santa Casa divided the area into "streets" and "avenues" and the deposits being then the "houses".

In figure 2, the total area of the cemetery is represented by the red rectangle. On the right, at the yellow point, is the main entrance and the region with the highest density of ornate deposits is in the area indicated in blue.

Figure 2. View area of the cemetery of the Santa Casa (red rectangle), with demarcation of the studied area (blue rectangle).

The survey of the materials used in the manufacture of the grave items was directed towards the metallic sculptures, thus excluding the analysis of the statues in stone and marble. The chemical analysis was performed using x-ray fluorescence (FRX) to determine the composition of the alloys and the method of manufacture was determined from the metallography of samples taken from the statues. It was also possible to determine the materials and methods employed through the defects found, such as broken and missing parts.

The metallographic analysis was done in order to characterize the microstructure, thus confirming the production methods. The samples were hot-dipped with bakelite, sanded in 200, 400, 600, 800 and 1000 granulated sandpaper and polished with diamond paste. The chemical
attack was carried out with a solution of 50% nitric acid and an attack time of 10 s, and the analysis was carried out with an optical microscope.

A visual analysis of the main damage to the statuary was performed, using the unarmed view. The damage was divided into two main groups: external agents (missing and broken parts) and internal agents (manufacturing and installation defects).

After the separation of the estuary into groups according to material and production method, 2 statues produced by electroplating were selected for removal of samples. These two statues have in common broken or missing parts, so samples could be taken from the regions with previous damage, in order not to perform interventions that could damage the structure or the surface in a significant way.

3 RESULTS AND DISCUSSION

The mapping of the studied area is shown in Figure 2. In this depiction of the area of 30 by 130 m, in gray are the streets and main avenue and the deposits are represented through the rectangles. Due to the high number of ornaments and decorations, only sculptures with one size greater than 1 m were selected. The 52 deposits with sculptures within the scope are filled in black in image 3.

Figure 3. Representation of mapped area of cemetery. In black, deposits with statues larger than 1 m in size.

Through visual analysis, 17 statues produced in stone and 35 in metal were counted. Figure 4 (a) shows an example of a stone figure, while Figure 4 (b) shows a metal sculpture.
FRX analysis of metallic sculptures showed five main similar groups in chemical composition: 99% copper, bronze tin and bronze aluminum, brass (Cu/Zn) and iron (Fe-Si), dispersed according to the graph of Figure 5. The bronze and iron alloys, fragile alloys, are usually fused to form the sculpture and through surface analysis the cooling pores of the metal were observed, figure 6.
In some figures we can observe the signature of the manufacturer company, as is the example of figure 7 (a) where it reads "Atelier of Art and Galvanoplasty Warstate & Ely Noffmann 320" and in the second example, of figure 7 (b), "Warstat & Ely Unicos galvanoplastas Porto Alegre". Both signed statues had a 99% copper composition, thus confirming production through electroplating.
Usually found in figures exposed to the weather, the accumulation of water in sculptures is a failure of usual design. Figures whose design favors this accumulation were observed forming small reservoirs. These were assessed as dry and it was possible to observe several corrosion products in different colors, indicating corrosion of the core, the copper layer and also changes in the original patina. Figure 8 gives an example of a statue, which has 4 copies in the cemetery, where water accumulates.
Several statues arranged over the deposits were fixed with the use of cement, a method quite common for the period they were installed. However, this method is not recommended for installation, because cement, being a hygroscopic material, can raise the humidity inside the statues, thus facilitating corrosive processes, as was confirmed when observing sculptures with broken copper film and with exposure of the internal cement. In these cases, a restoration intervention aimed at the removal of cement and reinstallation with metal supports is necessary, because the deterioration process is irreversible in these cases. Figure 9 shows an example of a region where the metal broke up due to internal pressures exposing the fixative material. From this damaged region was removed small body of proof for metallographic analysis (statue 1).

Figure 9. Detail of the metal film broken with the exposure of the fixing cement.

Another case of poor installation with cement was the one found in the deposit shown in figure 10 (a). It is possible to observe by comparison with Figure 10 (b) that there was burial of the region of the legs of the figure. Due to the difference in aeration, cracks between cement and metal and accumulation of water have been found several points with advanced corrosion processes.
It was also possible to observe missing parts of the statuary as well as adornments of the deposits. Figures 11(a) and (b) represent sculptures with missing parts. Samples of the deposited layer and core for metallographic analysis (statue 2) were removed from the region near the knees of the figure of Jesus in figure 11 (b).
It has been noted that statues with missing parts are mostly electroplated statues. This is possibly due to the action of thieves who seek to steal bronze items (which have high value in the parallel market) wrongly scrape pieces of galvanic plastic statues, since these have lower mechanical resistances compared to bronze ones, but with similar surface features, such as patina in green.

Problems were observed, mainly in galvanic plastic figures, due to welding of the constituent parts of the works. Defoliation of the copper layers in these regions can be observed, possibly due to the fragility of the thin thickness of copper deposited on the weld (usually 100 µm). Figure 12 is an example where the lead core of the statue can be seen due to defoliation in the welding region.

Figure 12. Detail of plating in welding region.

Figure 13, in turn, shows the welding line in the belly region of the image. Still in the initial stage of deterioration, white oxide is observed, possibly from the nucleus.
Figure 13. Detail of the welding line in the region of the belly and ribs.

Figure 14 shows the detail of the first deposit layer of sculpture 1. In this image it is possible to observe the dividing line between the stages of production of the sculpture, the right more amorphous region of the thicker and the left the grains in needle format. It can also be seen from the "V" shape of the grains, that the growth took place from the amorphous layer to the outer surface. The presence of patina corrosion and natural corrosion products can be observed in the surface region through the different colors of the formed products.
Figure 14. Analysis of the cross section of sculpture 1 reveals characteristic of production.

Source: author’s image

Figure 15 provides an analysis of the cross-section of the copper skin of statue 2. As in the analysis of the statue 1 film, one can observe the growth of the grain from the sinus of the sample to the surface.

Figure 15. Analysis of the cross section of sculpture 1 reveals characteristic of production.

Source: author’s image
4 CONCLUSIONS

Like the statues produced in Europe, the statues produced in Porto Alegre / Brazil present similar structure of the electrodeposited copper films. The same pattern of thin films was observed as the first and last layer and thick films between the extremes in order to increase the thickness of the film. The main defects found in the European grave figures were found in the sculptures of the Holy House, such as rupture due to internal pressures and unplating in welding line regions.

The main difference found in the sculptures lies in the making of the model/nucleus. While in Europe the models were usually produced with plaster and rubber materials, the figures here found in the cemetery of the Holy House show layers of lead in their structure.
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