Cairo University

Faculty of Archaeology

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Treatment and Conservation of Ecclesiastical Bronze Bells, With Application on a Selected Object"

A thesis submitted in fulfillment of the requirements for the Master degree

In Restoration of Antiquities

By

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Summary

The study is divided into six chapters as follows:

Chapter one: general introduction to the Master Thesis.

Chapter two: literature review focusing on the history of the use of bronze bells, their shapes and using, the bell ringing, the method of ringing bronze bells, alloys used in the manufacture of bells. In addition, the deterioration of bells, internal and external factors, as well as the traditional and non-traditional methods to repair bell cracks.

Chapter three: Discusses the experimental set up of, which includes inspections and analyses of bell (the object of study).An experimental study was done to introduce replica/coupon materials to simulate the actual bell materials. In addition to parametric study to determine the conditions of the experimental tests to evaluate the materials used in the treatment of the bell crack.

Chapter four: the results and discussion of the experimental study. Samples were prepared for microstructural, as well as mechanical testing. Besides, filler materials were prepared as foils, powder, separately or mix. In order to obtain the coalescence of the bell base metals, solid state processing and semi-solid state processing are achieved at low temperatures (200^{o}C to 540^{o}C). A combination of proximity and activity is achieved utilizing parametric study. Microstructure characterization and mechanical characterization are also established via optical microscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX) and shear testing. The study concluded that mix of Pb:Sn 4:6 at 300^{o} C at 45 minutes is the most ideal to repair the bell's crack.

Chapter five: represents Scientific Case Study of cracked bell manufacturing by Casting Technique, from Abanoub church in Samanood- Gharbia. Moreover, includes historical and artistic documentation using both photography and Auto CAD. Also applying study for the conservation and restoration of a historical bronze bell. Mechanical cleaning was performed to remove corrosion, cement, paints and different corrosion products obliterating the surface. Then Paraloid B-72 with 3% in acetone had been applied on the bell' surface, and keep the preservation of the bell

Chapter six: conclusion of the thesis. This research study ends with a general discussion, results and recommendations for the use of non- traditional methods for repairing the cracks of archaeological bronze artifacts

Key words

Bells

Tin bronze

Corrosion

Fatigue

Vibrations

Restoration

Low melting phase

Localize bonding

Interface/interphase

Self-healing

Abstract

The ancient Egyptians knew the bells manufacturing, bronze bells were known from the 23rd dynasty. In China, the first small bronze bells were manufactured in 2000 BC, large bells were spread out in many European countries thereafter. The bronze bell alloy is about 21% to 24% tin. Many other elements are added to improve the properties of the alloy including sulfur, phosphorus, zinc, lead, and others. However, Bronze bells suffer from different failure mechanisms leading to cracks with limited possibility of remedy. The traditional treatment methods for cracked bells affects harmfully the base metal, inscriptions, or the functionality of the bell. Therefore, there is a need to explore a new non-traditional methodology for bell crack restoration.

This thesis represents scientific case study of a cracked bell manufactured by a casting technique. The bell is located in Abanoub church, in Samanood city- Gharbia, Egypt. This research submitted a detailed study for the bronze bell's history, usages, and tunes. The research also covered a study of bell's parts, forms, and manufacturing, in addition to studying the aspects of deterioration in bronze bells. Experimental studies were conducted to introduce replica/coupon materials to simulate the actual bell materials. Samples were prepared for microstructural, and mechanical tests. Besides, filler materials were prepared as foils or powder, either separated or mixed. In order to obtain the coalescence of the bell base metals, solid state processing and semisolid state processing are achieved at low temperatures (200^{o}C to 540^{o}C). A combination of proximity and activity is achieved utilizing parametric study. Microstructure characterization and mechanical characterization are also established via optical microscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX) and shear testing. The study concluded that the mix of Pb: Sn 4:6 at 300^{o} C at 45 minutes are the ideal parameters to repair the bell's crack.

Dedication

This dissertation is dedicated to my parents, my brothers, my sisters, my husband, my children, and my friends for their continuous support and help. And, to anyone who tries to make a difference.

Acknowledgment

First of all, I would like to express my deep thanks to Allah, who made us as we are, different, so we complement each other; the only One who grants me the ability and perseverance to finish this MSc and hopefully help someone with it.

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