ARCHIVES of FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 13
Special Issue
1/2013
147–152

29/1

Mediaeval Casts of the Eastern Reliquary Crosses

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Received 15.03.2013; accepted in revised form 08.05.2013

An abstract

Non-destructive testing methods are widely applied for metal artefacts research. The analyses presented here are part of research and conservation program encompassing metal artefacts discovered during archaeological excavations in the years 2010 – 2011 in the area of Czermno. Among metal artefacts of archaeological origin there is an important group of objects connected with cult. Reliquary crosses called encolpions can be distinguished here; worn both by priests and by lay people in Central and Eastern Europe. They present an interesting group for historical and iconographic research, as well as for the analyses of the materials and the techniques applied. The type of cast encolpions were examined, found in the area of the old dwelling complex connected with fortified settlement of Czermno (the old Grody Czerwieńskie). These objects are initially dated to the 12th century. These metal artefacts are researched, by application of the non-destructive testing methods, at the Faculty of Foundry Engineering of the AGH University of Science and Technology in Kraków in cooperation with Maria Curie-Skłodowska University in Lublin, the Polish Academy of Sciences and the Rzeszów University. The research helped to enlarge the scientific scope of knowledge on Mediaeval materials and manufacturing techniques, while the conservation efforts gave back the proper artistic value to the artefacts from Czermno and allowed for the appropriate exhibition.

Keywords: Non-destructive testing methods, Artistic casting, Metal artefacts conservation, Copper alloys, Bronze

1.Introduction

The role and rank of the historical artefacts and objects manufactured artistically demand the application of modern research techniques. At present, intensive development of the testing methods leads to the development of a new conservation approach, based, among others, on the research coming from the field of materials science. There is a mutual influence and development of sciences supporting research and historical artefacts conservation [1-4]. Cross-disciplinary teams carry out work concerning the choice of the most suitable research methods for metal historical materials, resulting in the most complete picture of the old metal production technology [5-8].

Among metal artefacts an important role is played by objects connected with cult, crosses included here. A significant group of historical pieces of this kind is in the possession of the National Museum in Krakow and the National Museum in Warsaw [9]. New finds of cast encolpions come from archaeological excavations in Czermno, carried out in the years 2010-2011 [10-14].

Early Christian reliquary crosses, due to their function, had distinguished character. Encolpions, protecting sacred relics, had to have a form worthy of what they were containing. Wearing them was not only a way of proclamation of faith, but also protection from evil. Probably they were commemorating important moments in a Christian's life (baptism, pilgrimage, attaining priesthood, etc.) Because of their function and variety they are a good material for historical and iconographic research, as well as the analysis of the manufacturing techniques and the materials used. Some researchers allow the possibility that these crosses were manufactured in the area of present day Poland, which, in the early Mediaeval period, temporarily belonged to Ruthenia. Based on the concentration of the finds, especially the repeated types of encolpions as well as their character, the area of Gródek at the Bug should be taken into account, as well as Czermno (Lublin area), Przemyśl, Trepcza (Subcarpathian region), and possibly Drohiczyn (podlaskie voivodship). Molds for casting beads, used for suspending encolpions,were found at Gródek at the Bug and Trepcza near Sanok [9].

2.Research and Conservation

The results presented in this paper concern the cast encolpions found during archaeological excavation of the old fortified settlement complex in Czermno at the Huczwa river (Tomaszów Lubelski township), most often identified with Czerwień known from the chronicles, and the territory of so called Grody Czerwieńskie (Picture 1). The archaeological research was conducted by the Institute of Archaeology of Maria Curie-Skłodowska University in Lublin, the typological and stylistic analysis are conducted in cooperation with the Institute of Archaeology and Ethnology of the Polish Academy of Sciences, the Krakow's branch and the Institute of Archaeology of the Rzeszów University. The work was guided by Marcin Piotrowski, MSc, and Marcin Wołoszyn, PhD. The metallurgic research was conducted by the team from the Faculty of Foundry Engineering of the AGH University of Science and technology in Kraków. The conservation was done by E.M.Nosek, PhD.

Picture 1.Exploration of a dig at the foot of the fortified area. (photo by A. Kokowski)

Numerous early Mediaeval reliquary crosses have been investigated for a long time by archaeologists, historians and historians of art, yet these investigations have not included, usually or in more detail, the technological aspects. Specialist metallurgical research of the reliquary crosses from Czermno can throw more light on the technical aspect of their manufacturing process [15]. The research of the historic material has been conducted applying non-destructive techniques in the Laboratory for metal, alloys and archaeological artefacts research at the Faculty of Foundry Engineering of AGH. The methods used were mainly light microscopy, X-ray fluorescence spectroscopy (XRF), as well as scanning electron microscopy and energy dispersive spectroscopy (SEM-EDS) in the micro-areas.

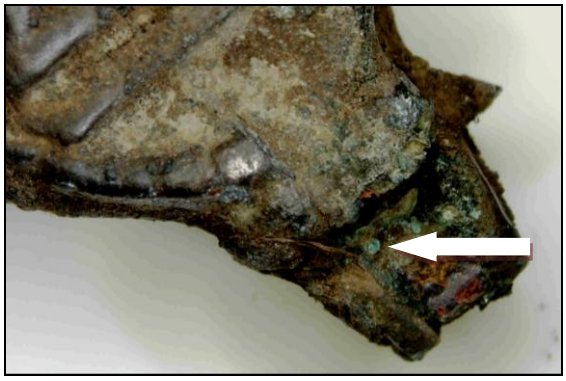
2.1. Conservation

Part of the research program of the Czermno artefacts is their conservation. An initial survey of the Mediaeval crosses condition was conducted using macro-and microscopic analyses as well as X-ray tests. A series of initial research of chemical composition was carried out, which facilitated the choice of the proper ways of conservation. The condition of the metal finds indicated a considerable pollution of the outside layers, the presence of thick layers of corrosion products and local mechanical damages. (Picture 2) After initial removing of the dirt the corrosion layers were seen, as a green build-up of considerable thickness and black traces, identified as layers of oxides and other products of corrosion. Fragments of original patina were seen, silver-gold in colour, worn off at places. In some places the original material was missing, which resulted both from the technological process itself (misruns) and from mechanical damage which coming from usage (Picture 3-4). The general condition of the casting can be described as good, although the contamination, to a significant degree, deformed the artistic impression of the artefact.

Picture 2. A cast reliquiary cross from Czermno, the condition before the conservation, 2011. (photo by P. Jurecki)

During the conservation process the build-up was removed from the encolpion's surface, including corrosion products; great care was taken to preserve the original cladding.

Picture 3. The imperfections of the casting, mechanical damages, corrosion products and dirt seen in the lower section of the cross, condition during the conservation 2011 r., (photo by. P. Jurecki)



Picture 4. The imperfections of the casting, mechanical damages, corrosion products and dirt seen in the lower section of the cross, condition during the conservation 2011 r., (photo by. P. Jurecki)

The most efficient method turned out to be very delicate removing of the successive layers under a microscope or a magnifying glass. The last step of the conservation was covering the cleaned and stabilized, with respect to the corrosive processes, surface of the encolpion with protective layers (1% solution of benzotrizole in alcohol). Multiple polishing, coupled with applying layers of hydrophobic wax brought back the proper colouring and the shine of the original cladding. A preservative conservation was carried out, exposing aesthetical and artistic values of the historical piece. The conservation was accompanied by laboratory tests of the surface and chemical composition, carried out at successive stages of conservation work.

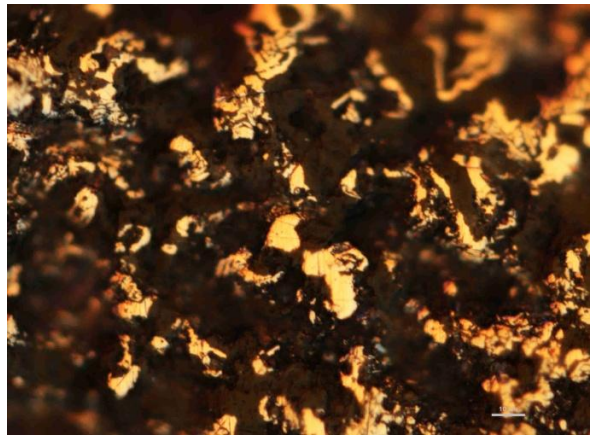
2.2. Metal science analyses

Laboratory analyses were based on surface observation, as well as chemical content analysis in macro- and micro-areas. Based on the results (Figure 5, Table 1) it can be concluded, that the material examined points to the content of tin bronze with varied admixture of arsenic, lead and antimony. The changing content of antimony, tin and lead results form the fact, that the surface layer of the cast varies in thickness. Micro-structure of the material and content analysis in micro-areas are compared in figures 6 and 7, and in table 2. The micro-structure tested on the area of polished surface shows non-uniformly directed crystallites, which proves the presence of original casting structure of tin bronze (Picture 7). The results show, that, against the background of the dendritic structure of the solid solution crystallites, there appear areas of surface covered by low-melting coating (Picture 7). This coating is also visible in the macro-photographs and profilographs recorded on the encolpion's surface (Pictures 8-9), as well as confirmed by chemical content analyses (Table 3).

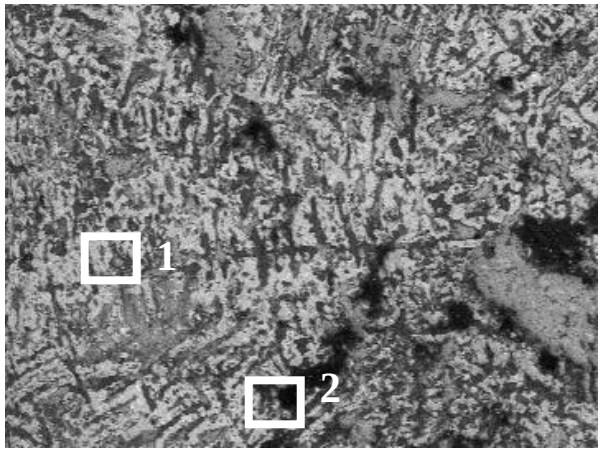
Picture 5. Macro-area of microscopic and chemical content examination, during the conservation, 2011.

Table 1.
Chemical content of reliquary cross. The average results based on XRF method analysis (wt%).

Chemical content (wt.%)				
Cu	Sn	Sb	Pb	As
75,1	10,6	7,9	1,4	4,2



Picture 6. The micro-structure of the surface of the cast examined



Picture 7. The picture from a scanning microscope of the surface of the cast examined.

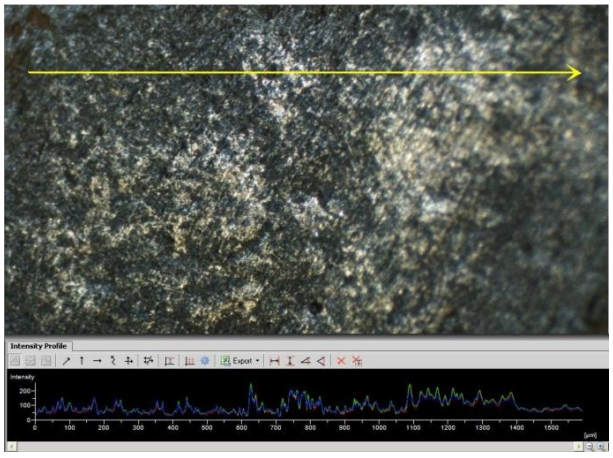
Table 2.
Chemical content of the reliquary cross alloy. The average tests results based on the SEM-EDS method analysis in the micro-areas (wt%).

Micro-area	Chemical content (wt.%)			
	Cu	Sn	Sb	Pb
1	**89,1**	5,4	1,2	0,0
2	**64,3**	4,6	3,2	21,2

Picture. 8. Macroscopic picture, a visible area of missing cladding, during the conservation process.

Table 3.
Chemical content of the cladding and alloy of the reliquary cross in the areas marked as 1 and 2. The average tests results based on the SEM-EDS method analysis in the micro-areas (wt%).

Area	Chemical content (wt.%)				
	Cu	Sn	Sb	Pb	As
1	**79,7**	7,7	6,5	1,4	3,1
2	**90,0**	4,2	3,4	0,5	0,5



Picture 9. Macroscopic picture with a profilograph of the surface of the cast, a missing area of cladding visible, during the conservation process.

Within the hinge there is a distinct, differently coloured area with a heightened copper content - above 98%, (Table 4, Picture 10). The research of the macro-areas of of the joining sections showed the presence of an alloy with a high tin content. Tin is also the matrix complementing missing material in the lower part of the cast, which can be seen from the inside part of the encolpion (Picture 11, Table 5). At other points the content of tin is lower in this tin bronze ally.

Picture 10.Macroscopic picture, a missing part of cladding is visible, during the conservation process.

Table 4.
Chemical content of the element inserted where the fastening of the reliquary cross should be. The average tests results based on the SEM-EDS method analysis in the micro-areas (wt%).

Area	Chemical content (wt.%)				
	Cu	Sn	Sb	Pb	As
1	**98,4**	0,1	0,3	0,3	0,2

Picture 11. Macroscopic picture, soldering visible inside the encolpion; during the conservation process.

Table 5.Chemical content inside the casting fault area of the reliquary cross. Average research data based on SEM-EDS (wt%).

Area	Chemical content (wt.%)				
	Cu	**Sn**	Sb	Pb	As
1	20,0	**76,0**	0,4	1,9	0,2

As part of the complementary analysis there were X-ray tests and computer tomography tests performed, based on which the presence of sacred relics inside the encolpions was confirmed. Further research with the help of a scanning microscope allowed for specifying the kind of relic. This research took place in cooperation with Foundry Research Institute in Krakow, The Faculty of Materials Science and Ceramics and the Faculty of Metals Engineering and Industrial Computer Science of AGH.

Picture 12. Opening the encolpion during the conservation process.

3. The results description

The examined crosses belong to hollowed, openable encolpions. They were made using casting technique, the parts are connected with a hinge with bolts, with a bead used for hanging. They were cast from bronze, but the content of the alloy shows considerable variation in the artefacts examined. The decorative aspects of the object was enhanced by the finishing layer which added shine and noble colouring (Pictures 13-14) .

Picture 13. Encolpion after the conservation.

Picture 14. Encolpion after the conservation

4. Conclusions

Modern advanced tools and techniques as well as adapting research methods of engineering sciences to the conservation demands allow proper and complex survey and protection of historical artefacts.

Old Russian encolpions were examined earlier both by historians and art historians, however, those researches did not encompass their technological aspects. Even without attempting here to solve the problem where the manufacturing workshops

were located, it is worth to pay attention to the manufacturing technology of the specific types of the crosses.

As the result of conservation work the valuable bas-relief of the encolpion was fully restored by precise, successive removing of the corrosion built-up layers under a microscope or a magnifying glass. Systematic polishing, coupled with applying wax layers, heightened the decorative aspect of the artefact and revealed the application of the cladding , giving shine and a noble colouring. Metal science analyses were conducted within a joined, research and conservation program.

The research has yielded valuable suggestions as to the choice of proper conservation techniques, which allowed us to reveal the surface of these artefacts. It should be stressed, that all the research was made using non-destructive methods, which did not damage the historical structure of the artefact.

The research showed that the encolpion was made by casting from tin bronze. The crosses examined belong to the hollowed, openable type. The two parts were cast in thin alloy and then joined by a riveted hinge. Bronze casts are characterised by non-uniform internal chemical composition as well as varied composition in specific areas of the area tested. This results form the technique of covering the cast's surface with a cladding of special decorative and anti-corrosive value, which make the cross examined (inventory number 508-136) a distinguished item among similar reliquary crosses cast in bronze.

Specialist analysis are conducted also for the better understanding of destruction processes of archaeological metal artefacts. These processes are treated as the starting point for the proper conservation efforts. Metallurgic analysis is the key element for preparing the artefacts for conservation, the choice of proper protective means and in some cases preparing the reconstruction of the objects. This research also has a great informative value, due to specifying the materials used, manufacturing technology and decorative techniques.

The research carried out helped to increase our knowledge on Mediaeval materials and manufacturing techniques. The conservation efforts brought to these historical artefacts from Czermno their proper artistic value and allowed them to be properly exhibited.

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