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Hard inclusions in fixture brasses

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Abstract: This article shows some of the results obtained in the studies on relations between chemical composition and the hard inclusions occurrence in fixture brass structure. Authors indicate the most active elements in creating such phases and present some interactions between the alloy components.

Keywords: Fixture brass, Hard inclusions, Intermetallic phases

1. INTRODUCTION

Fixture brasses are the second group of copper alloys in the regard to copper usage. Mainly it is used for home and industrial fixture elements, lock parts, keys and other elements which production and exploitation requires high machinability, corrosion resistance, castability and good technological properties. Primary alloy which represents the fixture brasses group is the leaded brass CuZn39Pb2.

When in production of this alloy a scrap containing some particular elements is used the technological properties of the prepared alloy decrease significantly. Deterioration concerns mainly the machinability, corrosion resistance and the preparation of the surface for coating application (fixture elements, keys, etc.). All this is caused by new microstructure component – hard inclusions. These are mainly the intermetallic phases with hardness significantly higher than the alloy matrix, consisting of such elements like: Fe, Al, and Si but also Mn, Cr, Ni, and P [1, 2, 3]. Some of them are introduced to the process as technological additions, others are introduced with the scrap.

Many publications describe the chemical identification of the hard inclusions and its other properties [1 – 4]. In presented studies authors tried to find relations between the chemical composition of the alloy and quantity and type of the occurring hard inclusions.

2. STUDIES

Own studies and literature data helped to create a elements group of which the hard inclusions are consisted. Taking into account double equilibrium systems of these elements the most active elements were indicated. Special activity table was prepared showing type and quantity of intermetallic phases created by particular elements. To the studies four elements were selected: Fe, Si, Al and P.

Special active experiment was prepared, in which the variable was the content of listed above elements. The experiment allowed to study the influence of many additions on structure and properties of the alloy and simultaneously to investigate interactions between the additions. Full experiment enclosed 14 casts with variable chemical composition, in which quantity of the additions did not exceed the level specified in PN.

Alloy was prepared with pure components (Cu, Zn) and preliminary alloys (CuFe, CuSi, CuAl, CuP) in inductive furnace in accordance to foundry practice for copper alloys. Thermo physical conditions for all casts remained constant. Alloy was poured into a metal mould heated to 300^{o}C temperature. Fixture brasses are used mainly for permanent mould casting and thus such method was used.

From every cast a sample was taken for analysis, which enclosed chemical composition determination, qualitative and quantitative microstructure analysis. Analyses results were then used for statistical examination.

3. RESULTS

3.1. Microstructure

In figure 1 a microstructure for fixture brass containing numerous hard inclusions is showed. The matrix consists of two phases $\alpha + \beta'$, what is typical for this group of alloys.

Occurrence of hard inclusions was found in every carried cast. Alloy matrix has changed through the casts from two – phase $\alpha + \beta'$ into one – phase matrix β'. Main cause for this change is variable content of silicon and aluminum which move the β' phase region to lower content of zinc. This is in agreement with coefficient proposed by Guillet [5]. Introduction of phosphorus to the alloy changes the morphology of the inclusions.

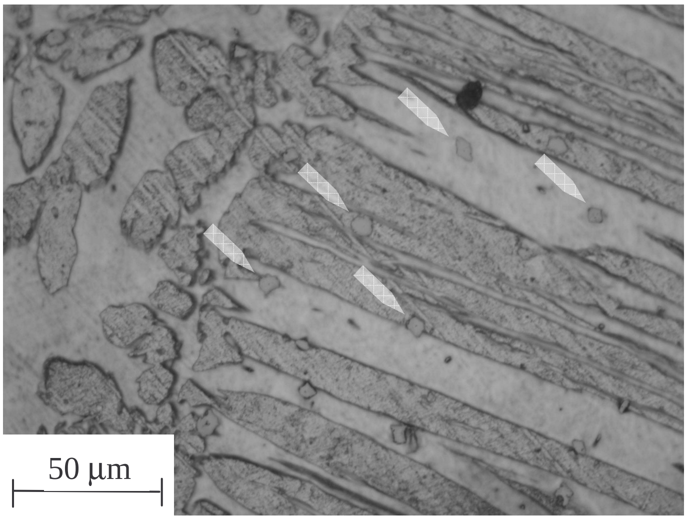

Figure 1. Brass microstructure containing numerous hard inclusions (pointed by arrows); on the light β' background the darker α phase and the hard inclusions, HNO_3 etched

3.2. Roentgenographic analysis

To find the chemical composition of occurred inclusions the roentgenographic analysis was conducted. It revealed that inclusions consist of intermetallic phases Fe_xSi_y and CuZnγ. Some of the results are shown in figures 2 and 3.

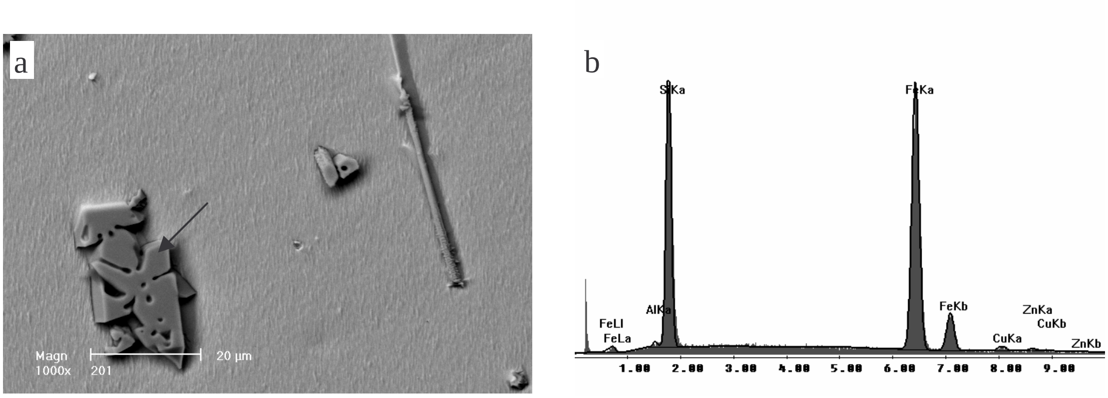

Figure 2. Roentgenographic analysis of hard inclusions; a) measuring field, b) point analysis of the inclusion pointed by arrow (% mas. content: 71.15 Fe, 25.35 Si, 1.72 Cu, 1.17 Zn, 0.60 Al)

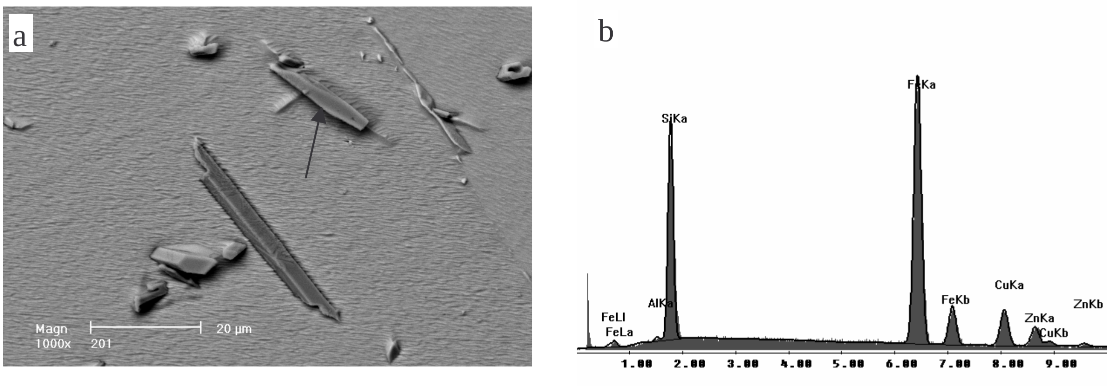

Figure 3. Roentgenographic analysis of hard inclusions; a) measuring field, b) point analysis of the inclusion pointed by arrow (% mas. content: 59.61 Fe, 18.22 Si, 11.54 Cu, 10.23 Zn, 0.40 Al)

Introduction of phosphorus to the alloy caused occurrence of another intermetalic phase with different morphology – more developed surface. Roentgenographic analysis revealed that this was a intermetallic phase AlP containing additionally oxides of aluminum, phosphorus and silicon. All these components create together conglomerates with very developed surfaces. Occurrence of such phases is also observed in alloys containing these elements (for example Al – P, Al – Si – P) [11].

4. SUMMARY

Presented studies enabled finding the relations between chemical composition and the quantity of observed hard inclusions. It must be pointed that, although all additions were introduced in permissible quantities the hard inclusions content excided significantly the permissible level. In all casts the hard inclusions were observed. Statistical analysis showed that the most active elements are phosphorus and iron. Quantity of the intermetallic phases showed almost linear relation to the phosphorus content – this was in agreement to predictions made on basis of activity table prepared before the experiment.

Developed set of elements interaction coefficients in complex alloy (CuZn based) will allow creation of chemical composition ensuring proper technological properties (like castability and machinability) and structure (permissible inclusion content). these studies are now conducted in doctor's thesis of one of the authors. Detailed description of obtained relations will be published in another publication of the authors.

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