Research and Optimization of the Conditions of the Melting and CastingProcess of Bearing Alloys Intended for Sliding Layers of Bearing Shells

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ABSTRACT: The main aim of the work was to study the influence of variable melting and casting process conditions on the microstructure and hardness of a commercial tin-based alloy with the addition of copper and antimony. The research was aimed at checking the possibility of controlling the share and morphology of brittle Sb-Sn-based phases in the microstructure by using a variable heat removal rate during the solidification process. The research included chemical and metallographic analyzes of the produced castings, along with the analysis of the present phases and hardness measurements.

Keywords: Melting and casting; Bearing alloy; Babbit; Microstructure

1 Introduction

The motivation to undertake this research topic was the increased interest in the production of bearing shells by domestic enterprises due to the difficult geopolitical situation, which influenced the availability and disruption of supply chains of these products from the Eastern market, which was previously leading in this segment [1]. The future introduction of an innovative technology for the production and regeneration of bearings based on Wire Arc Additive Manufacturing (WAAM) 3D printing will significantly improve the current situation and will also improve the quality of the layer applied to the bearing, reduce the consumption of expensive bearing material, reduce removal machining and improve the process yield. The introduction of 3D printing technology, in turn, first requires the development of a technology for producing wires from SnSbCu bearing alloys. In turn, to produce wires, it is necessary to prepare a feedstock in the form of cast material.

In addition to the melting and casting process parameters, the chemical composition has a key influence on the formation of hard reinforcing phases and the final properties of the SnSb11Cu6 bearing alloy. The main alloy additions in the form of Sb and Cu added to the Sn matrix increase the strength and bearing properties while reducing ductility. The ductility of bearing alloys depends strictly on the amount of antimony and copper added to the chemical composition. Increasing the copper content at a constant antimony content causes a drastic decrease in elongation and ductility, which is an undesirable effect from the point of view of plastic working [2,3]. The standard chemical composition of the SnSb11Cu6 alloy (Ł83) developed so far is aimed at ensuring appropriate casting properties enabling the production of sliding layers with the required level of mechanical and sliding properties in the casting process of bearings.

As part of the work, conducted research aimed at optimizing the melting and casting process of the commercial SnSb11Cu6 alloy in terms of developing conditions enabling the elimination of the negative impact of brittle phases on the susceptibility to plastic working (by changing the morphology and reducing the size of brittle phases), while maintaining the appropriate bearing properties of the alloy, defining the possibility of its application on the sliding layers of bearing shells. Changing the crystallization conditions of the alloy by using appropriate casting conditions resulted in a reduction in the size of the brittle phases.

2 Experimental procedure

Melting and casting tests were conducted using a crucible furnace. The temperature of the castingmold and liquid metal was recorded using a multi-channel recorder connected to a computer with LabMini software. Chemical composition analyzes were performed using anoptical spark emission spectrometer SPECTROMAXx LMX09. Hardness measurements using the Brinell method were performed using a universal Wolpert hardness tester (HBW2.2/15.625/180). Metallographic observations of the specimens were carried out using a Keyence VHX-7000 digital microscope. The specimens were observed in both polished and etched states. Additionally, to identify phases and inclusions, examination of sections of the produced castings was carried out using a Zeiss EVO MA10 scanning electron microscope, and energy dispersive analysis (EDS) was used to determine the chemical composition in micro-areas using a Bruker Xflash® 5010 EDS spectrometer.

3 Result and discussion

The paper presents the results of tests on casting the alloy into a casting mold made of B555 bronze. Incase of variant 1, the material was cast into a cold mold, while in the case of variant 2, before casting the ingot mold was heated to a temperature of 400℃. The casting temperature was 490℃.

The results of the analysis of the chemical composition (average value) of the produced castings are presented in Table 1. The chemical composition was within the range specified in the PN 82/H 87111 standard [4] for the Ł83 alloy (SnSb11Cu6).

Table 1.Chemical composition of the produced castings, %

Sn	Sb	Cu	As	Cd	Ni
82,7	10,74	6,47	<0,0025	0,0014	0,0019
Co	**Pb**	**Zn**	**Al**	**Fe**	**Bi**
0,00042	0,0504	0,00022	<0,00010	0,0481	0,0114

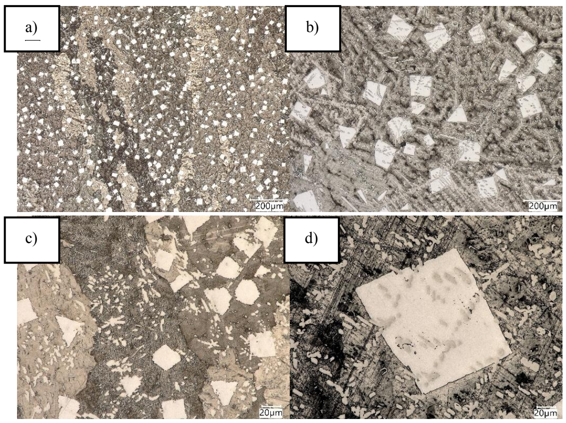


Fig.1 Microstructure of the produced castings depending on the process conditions: a) c) variant 1, b) d) variant 2

No internal casting defects were observed for the tested samples. In the case of faster heat removal, which took place in the case of variant 1, a significant reduction in the size of the SbSn phase precipitates is visible (Fig. 1. a,c). The average size of these precipitates is approximately 468 μm^2, while for variant 2 these precipitates are approximately 18926 μm^2.

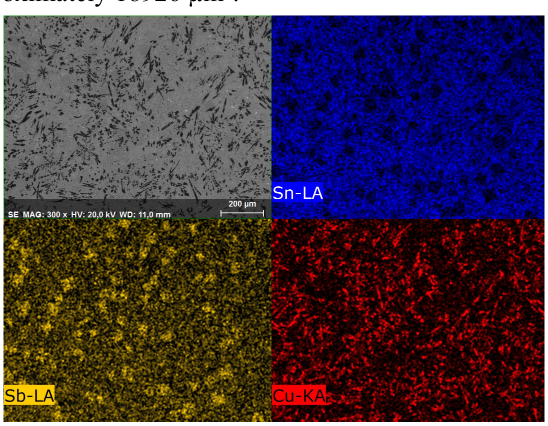
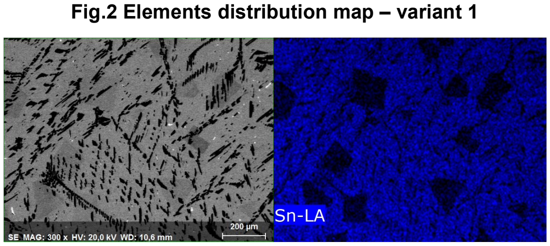


Fig.2 Elements distribution map – variant 1



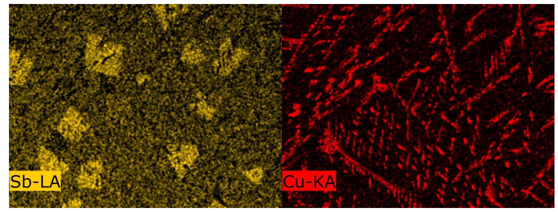


Fig.3 Elements distribution map – variant 2

The microstructure of the produced castings consists of rhomboid precipitates with a stoichiometry corresponding to the SnSb phase and numerous needle-shaped precipitates in the case of variant 2 and much finer precipitates in the case of variant 1 with a stoichiometry corresponding to the Cu_6Sn_5 phase distributed against the background of a tin-rich matrix.

The structure of tin-based bearing alloys therefore includes hard antimony-rich crystals and a network of copper-rich acicular crystals. Hard crystals are dispersed in the soft matrix, thus increasing the hardness of the alloy. The average hardness of the cast material does not differ between the cooling variants - in the case of variant 1 it is - 25.2 HBW, while for variant 2 - 24.7 HBW, so the difference in the obtained hardness values is within the measurement error. The results of the distribution of hardness measurements show relatively good homogeneity across the cross-section of the tested samples.

4 Conclusion

The use of a variable heat removal rate during the solidification process of the SnSb11Cu6 alloy changed the share and morphology of brittle Sb-Sn-based phases in the microstructure. The fragmentation of the precipitates and their even distribution in the matrix did not result in an increase in Brinell hardness.

It is possible to control the morphology and size of the SnSb and Cu_6Sn_5 phase precipitatesby appropriately selecting the parameters of the melting and casting process.

Acknowledgments

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