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Ljubiša Balanović
Dejan Tanikić

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović

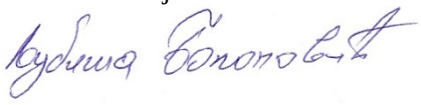

TABLE OF CONTENTS

Plenary Lectures

Invited Lectures

Conference Papers

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MICROSTRUCTURE AND THERMAL PROPERTIES OF LEADED BRASS AFTER QUENCHING

Ivana Marković[1], Dalibor Jović[2], Uroš Stamenković[1], Dragan Manasijević[1], Ljubiša Balanović[1], Milan Gorgievski[1]

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Abstract

Rapid cooling of Cu-Zn alloys from the two-phase (α + β) or single-phase β region can reduce or even prevent the existence of the α phase. In this way, by quenching, the proportion of α and β' crystals changes compared to the initial microstructure obtained by casting, which directly affects the change in the properties of these alloys. The investigation in this paper was conducted to analyse the influence of quenching temperature on the thermal properties of CuZn40Pb2 alloy. After casting the alloy, it was heated at 500 °C, 600 °C, 700 °C, and 800 °C and cooled in ice water, to maintain the high-temperature structure. Microstructure was analysed using optical microscopy. The values of thermal diffusivity, specific heat, and thermal conductivity were determined for the alloy in the cast and quenched states. The sample that was quenched from 800 °C was subjected to continuous annealing during the DSC analysis showing two endothermic reactions characteristic for the melting of a lead phase and disordering of β' phase.

***Keywords**: lead bronze, thermal diffusivity, specific heat, thermal conductivity*

1. INTRODUCTION

Cu-Zn alloys (brasses) have very high electrical and thermal conductivity, good corrosion resistance, and excellent workability. Because of these properties, they are widely used in numerous industries [1-4]. Lead is usually added to brasses to increase their machinability (due to increasing chip breakage), cutting parameters, and tool life (due to decreasing the cutting forces) [1,5,6]. Properties of α + β' brasses depend on phase composition, i. e. contribution of two main phases: α solid solution with face-cantered cubic crystal lattice and β phase which is intermetallic compound CuZn with body-cantered cubic crystal lattice with a disordered structure, that below 454 °C undergo to ordering and transformation into the ordered β' phase. In the structure of duplex leaded brasses, except these two phases, particles of free lead are always presented [7,8]. Lead-free or low-leaded brasses have been studied by numerous researchers [9,10]. However, the cost of these types of brasses is high and their high-temperature strength is lower [11]. Therefore, α + β' brass with a low content of lead (2 wt.% Pb) and traces of Sn, Fe, and Ni was used as starting material, to analyse how changes in the ratio α/β' in the structure influence the thermal properties of these alloys.

2. EXPERIMENTAL

After measuring the calculated amount of pure copper and alloying elements, they were melted in a flame furnace with a silicon carbide pot. The CuZn40Pb2 alloy (in wt.%) was obtained by casting the melt in a sand-clay mould, whereby a cylindrical ingot with a diameter of 20 mm was obtained. The ingot was machined on a "PA-B 30" lathe to a diameter of 12.7 mm and cut into 10 mm high samples, which were subjected to further heat treatment. The cutting was done using the "Mesotom - Struers" cutting device. The samples were solution annealed in the furnace "Vims-elektrik LPŽ-7.5S" at four temperatures: 500 °C, 600 °C, 700 °C, and 800 °C for 1 h. After heating at different temperatures, the samples were quenched. Microstructure was analysed using "Carl Zeiss Jena

EPITYP 2" optical microscope. The following thermal properties of quenched samples were measured: thermal diffusivity, thermal conductivity, and specific heat using the "Discovery Xenon Flash DXF-500" device. Differential scanning calorimeter (DSC) "TA Instruments Q600 SDT" was used to analyse the thermal behaviour of CuZn40Pb2 alloy quenched from 800 °C during heating at a constant rate of 10°C/min.

3. RESULTS AND DISCUSSION

The microstructure of CuZn40Pb2 alloy in cast and quenched states is shown in Fig. 1. The microstructure of cast CuZn40Pb2 alloy is two-phase α + β'. With increasing quenching temperature amount of β' phase gradually increased. Sample quenched from 800 °C shows the presence of only β' phase.

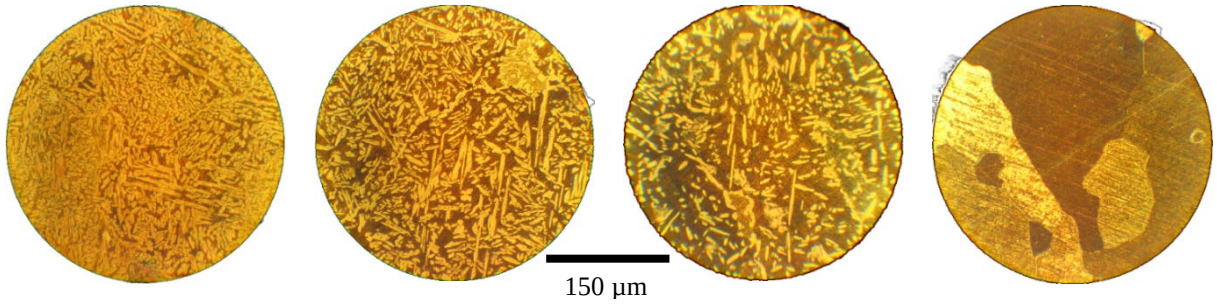

Figure 1 - Microstructure of CuZn40Pb2 alloy after (a) casting; (b) quenching from 600 °C; (c) quenching from 700 °C; (d) quenching from 800 °C

Among the thermal properties, the values of thermal diffusivity, specific heat capacity, and thermal conductivity were measured. The values of thermal properties of CuZn40Pb2 alloy after casting and quenching from different temperatures are shown in Fig 2. Copper has excellent thermal properties (thermal diffusivity 1.16 cm^2/s; specific heat capacity 385 J/kgK; and thermal conductivity 397.48 W/mK [12]). It is noted that cast CuZn40Pb2 alloy has similar values of specific heat capacity (360.8 J/kgK) as copper, but a quarter of the thermal diffusivity (0.335 cm^2/s) and thermal conductivity (105.1 W/mK) of pure copper. From Fig. 2, it can be seen an irregular pattern in the increase and decrease of the thermal properties of CuZn40Pb2 alloy as the quenching temperature increases. Generally, quenching causes an increase in thermal diffusivity values compared to the cast state. Quenching from 500 °C and 600 °C has led to an increase in specific heat capacity, while quenching from higher temperatures decreased it. The thermal conductivity of quenched samples was something smaller compared to the cast state except for the sample quenched from 800 °C whose thermal conductivity is the highest. This sample has a microstructure that consists only of β' phase, unlike the other samples with α + β' microstructure.

The sample quenched from 800 °C was subjected to continuous heating at a constant heating rate of 10 °C/min up to 500 °C on a DSC device to analyse phase changes, and possibly detect the decomposition of the presaturated β' phase. Fig. 3 shows the DSC curve of CuZn40Pb2 alloy quenched from 800 °C. DSC monitors the difference in heat flux to the sample and standard when they are heated [13].

The first slight peak on the DSC curve indicates an endothermic reaction and occurs around 325 °C. This peak designates the melting of a lead phase, which is present in the CuZn40Pb2 alloy in a small amount [14]. The required heat for melting the lead phase is 0.3554 J/g. The second peak on the DSC curve also indicates an endothermic reaction and occurs at around 460 °C. This endothermic peak indicates a phase change according to the phase diagram Cu-Zn-Pb, where the

β' ordered phase becomes the disordered β phase. The required heat for the transition from the ordered β' phase to the disordered β phase is 0.6761 J/g.

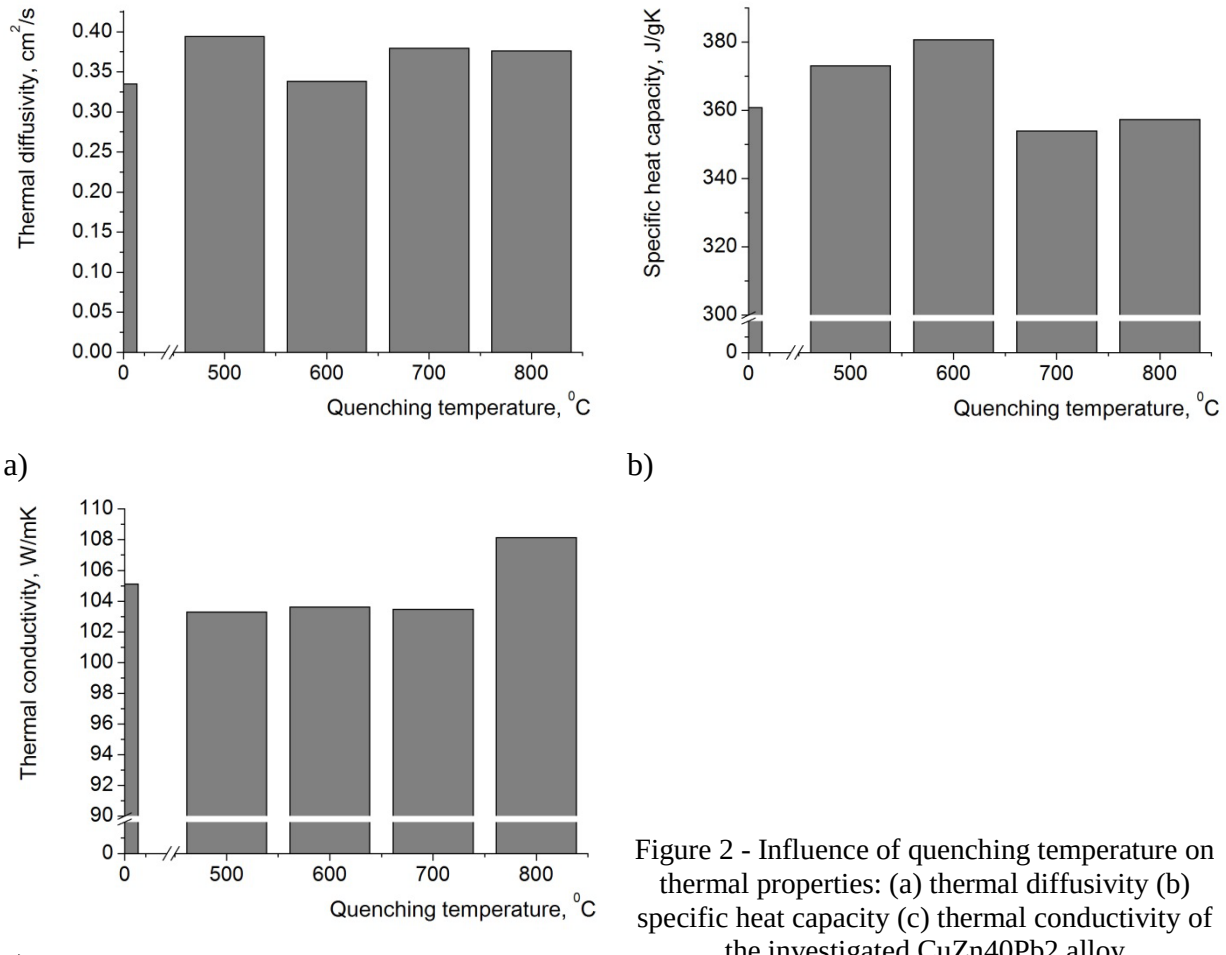

Figure 2 - Influence of quenching temperature on thermal properties: (a) thermal diffusivity (b) specific heat capacity (c) thermal conductivity of the investigated CuZn40Pb2 alloy

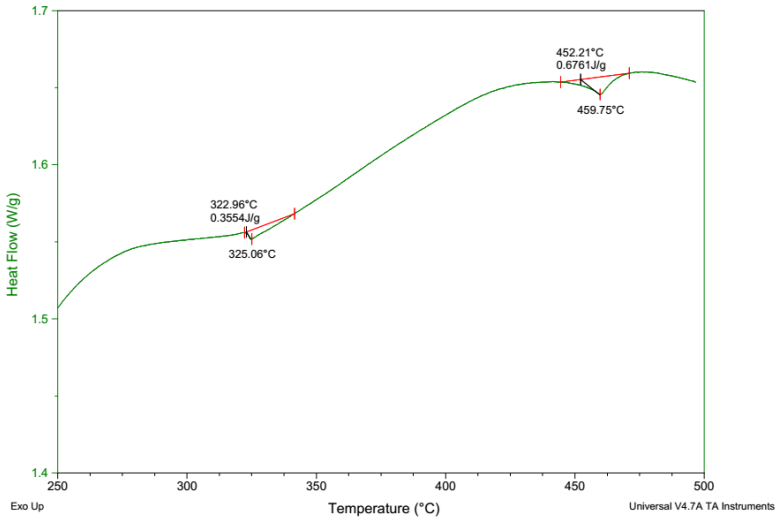

Figure 3 - DSC curve of CuZn40Pb2 alloy quenched from 800 °C

4. CONCLUSION

Based on the performed experiments, the following can be concluded:

- The cast CuZn40Pb2 alloy is two-phased α + β' brass. With an increase in quenching temperature the amount of β' phase gradually increased up to 800 °C where there is only β' phase.

- The cast CuZn40Pb2 alloy has a similar specific heat capacity as copper, but a quarter of the thermal diffusivity and thermal conductivity of pure copper. The thermal diffusivity increases slightly with quenching. The best thermal conductivity was achieved after the quenching from 800 °C.

- DSC curve of quenched brass showed two endothermic reactions indicating the melting of a lead phase (around 325 °C) and disordering of β' phase (around 460 °C).

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