ARCHIVES
of
FOUNDRY ENGINEERING

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

ISSN (1897-3310)
Volume 10
Issue 1/2010

221 – 225

38/1

Influence of the selected alloy additions on limiting the phase γ formation in Cu-Zn alloys

J. Kozana, St. Rzadkosz*, M. Piękoś
Department of Moulding Materials, Mould Technology and Foundry of Non-ferrous Metals, Faculty of Foundry Engineering, AGH University of Science and Technology,
ul. Reymonta 23, 30-059 Kraków, Polska
* Corresponding author. E-mail address: rzadkosz@agh.edu.pl

Received 21.07.2009; accepted in revised form 31.08.2009

Abstract

Influence of the selected alloy additions into copper and zinc alloys was investigated in order to find out the possibility of limiting the precipitation of unfavourable phase γ. The observation of microstructures and strength tests were performed. The results of metallographic and strength investigations indicate positive influence of small amounts of nickel, cobalt or tellurium. The precise determination of the influence of the selected alloy additions on limiting the gamma phase formation will be the subject of further examinations.

Keywords: Brass, Copper alloys, Structures and properties of alloys

1. Introduction

Alloy additions of such elements as manganese, aluminium, silica, lead or iron, apart from the basic elements, it means copper and zinc, are used in casting special brasses. The task of such additions is influencing the microstructure and due to this, improving the selected properties, casting, mechanical, anticorrosive as well as technological. An application of other special alloy additions forms specific brass groups characterised by strictly determined technological or usable properties. Cobalt, nickel and tellurium were selected as elements which can favourably change certain properties of brasses and constitute an alternative for the additions being currently applied. The obtained results are presented in the hereby paper.

Melts for testing were performed in the casting laboratory in the Department of Moulding Materials, Mould Technology and Casting of Non Ferrous Alloys. Charging materials were melted in a chamotte-graphite crucible in the induction thyristor furnace of medium frequency and in the resistory furnace. Melts were performed according to the casting art.

Samples for the analysis of chemical composition, metallographic tests and strength tests were prepared from individual melts, according to the applied standards.

CuZn44 alloy – characterised by the phase β’ microstructure with eventual precipitates of phase γ - was applied as the initial alloy for estimating the influence of the selected elements. The selected chemical composition is a continuation of the previous investigations [1,2] aimed at the assessment of the disadvantageous influence of the phase γ (causing brittleness of CuZn alloys). Cobalt, nickel and tellurium as the applied alloy additions, according to Guillet’s coefficients [3], should favourably influence the limitation of the phase γ precipitation. The investigations were aimed at analysing their influence on the microstructure and strength propertie

2. Influence of cobalt as alloy addition for CuZn alloys

Pure cobalt in the amount of 0.5 to 2% was introduced into CuZn44 alloy. The obtained results are presented below.

Fig. 1a. CuZn44, Magnification 100x

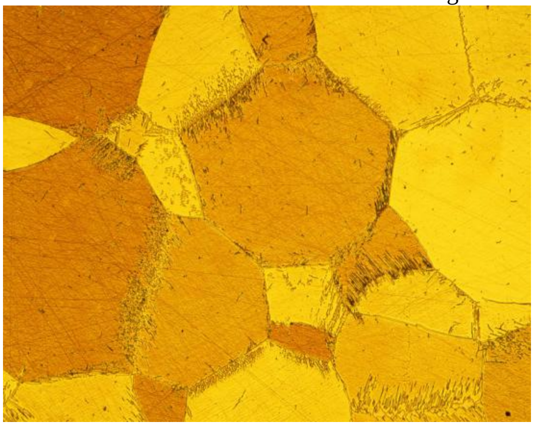

Fig. 1b. CuZn44Co0.5; Magnification 100x

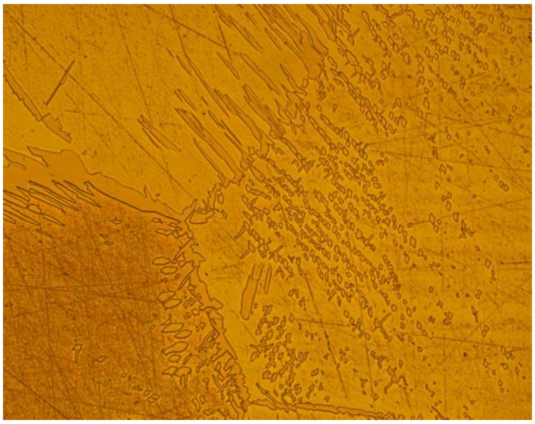

Fig. 1c. CuZn44Co0.5; Magnification 500x

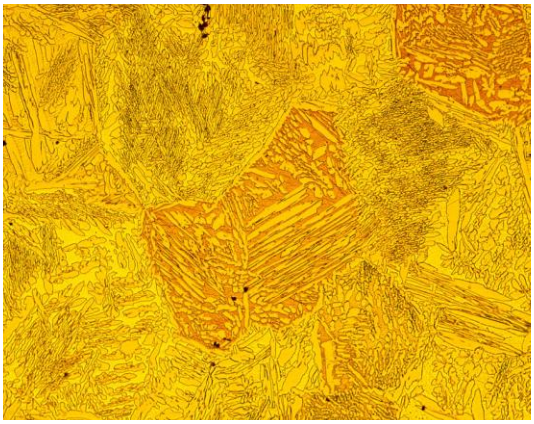

Fig. 1d. CuZn44Co2; Magnification 100x

Fig. 1e. CuZn44Co2; Magnification 500x

Fig. 1a-e. Microstructures of brass CuZn44 with addition of Co, etched by Mi15Cu

The presented microstructural images indicate that cobalt introduced into brass of phase β' structure causes a decrease in grain size and forms precipitates on grain boundaries. When the participation of cobalt is higher, around 2%, phases are precipitated on the whole surface of the microstructure.
Changes in microstructures also cause changes in properties. The basic tests of: tensile strength, ductility and hardness, that are presented in Table 1, indicate small changes in strength and an increase of hardness.

Table 1.
Influence of additions of Co on mechanical properties (R_m, A_5 and HB) of brass CuZn44

Addition Co [%]	R_m [MPa]	A_5 [%]	HB
-	433	19	118
0.5	412	16	124
2.0	431	23	110

Analysis of the obtained strength results and microstructure images of the examined alloys allows for inferring that small addition of cobalt causes precipitates mainly on grain boundaries of phase β', which leads to a negligible decrease of tensile strength and slightly worsens ductility.
Higher amount of cobalt in the alloy causes the formation of uniformly distributed precipitates. Those microstructural changes do not influence strength significantly while simultaneously slightly change ductility.

3. Influence of nickel as alloy addition for CuZn alloys

Analogical investigations as for cobalt were carried out for additions of nickel. Initial CuZn44 alloy and additions of Ni from 0.5 to 2% were used. According to Guillet's coefficients copper and nickel exhibit very similar influence on the microstructure of CuZn alloys.
Both elements adopt coefficient values from +0.5 to -1.5.
The results of microstructure observations as well as strength tests are presented below.

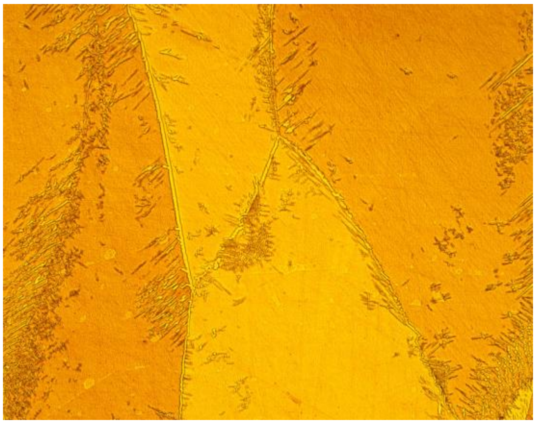

Fig. 2a. CuZn44Ni0.5; Magnification 100x

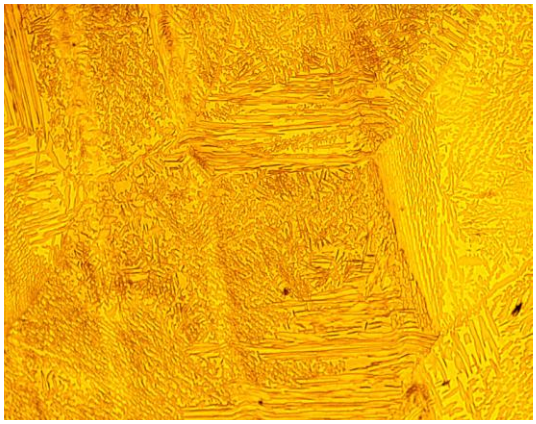

Fig. 2b. CuZnNi1.5; Magnification 100x

Fig. 2a, b.: Microstructures of brass CuZn44 with addition of Ni, etched by Mi15Cu

Table 2.
Influence of additions of Ni on mechanical properties (R_m, A_5 and HB) of brass CuZn44

Addition Ni [%]	R_m [MPa]	A_5 [%]	HB
-	450	19	118
0.5	434	18	124
1.5	437	18	130

It can be stated, on the basis of the microstructural images, that nickel in an amount of approximately 0.5% caused formation of precipitates on grain boundaries of phase β'. When the addition of nickel was approximately 2% the microstructural image reminded a packet structure of phases α + β'. However, distinct changes in the microstructure do not cause significant changes in strength and ductility

4. Influence of tellurium as alloy addition for CuZn alloys

In order to estimate the influence of tellurium as addition to CuZn alloys, the initial CuTe alloy - of tellurium content in the range from 5 to 20% - was prepared. The image of the selected microstructure and the SE picture are presented below.

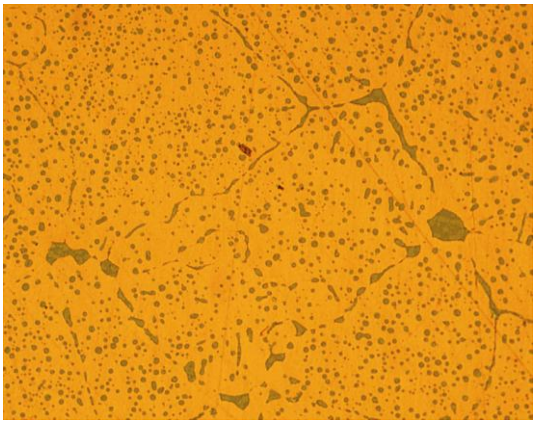

Fig. 3a. CuTe20; Magnification 100x

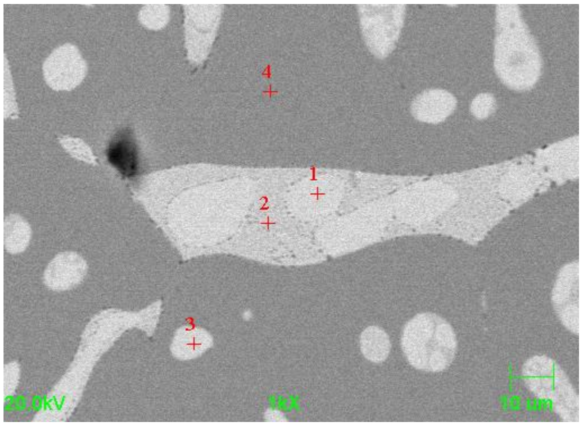

Fig. 3b. CuTe5; Magnification 1000x

Fig. 3. a - Microstructures of cooper alloy with addition of Te, etched by Mi15Cu, b - SE picture with marking of the points, which were subjected to X-ray microanalysis

Precipitates of CuTe phases in copper are well seen in the microstructure. Those precipitates are also visible on grain boundaries.

Table 3.
Results of X-ray microanalysis for Fig. 3b

	Cu		**Te**	
	at %	**wt %**	**at %**	**wt %**
1	66.263	49.447	33.737	50.553
2	73.778	58.353	26.222	41.647
3	64.919	47.960	35.081	52.040
4	99.722	99.444	0.278	0.556

At the successive stage of investigations trials of tellurium introduction into brass were performed. This element was introduced in the foundry alloy CuTe20 form as well as the pure element. In spite of the melting temperature of tellurium being near 450 ^{o}C, (similarly as of zinc) introduction of tellurium is not specially difficult. Tellurium introduced under the surface of liquid metal dissolves slowly without forming a melting loss. In continuation of examinations the melts - in order to obtain CuZn44 alloy with 2% addition of tellurium - were performed.
The results of the microstructural and strength examinations of the obtained alloys are presented below.

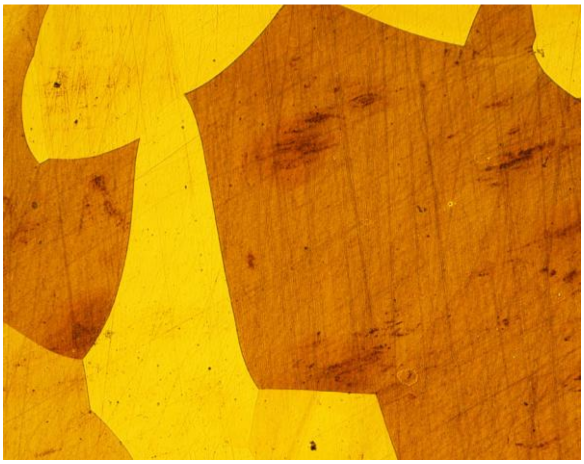

Fig. 4a. CuZn44; Magnification 100x

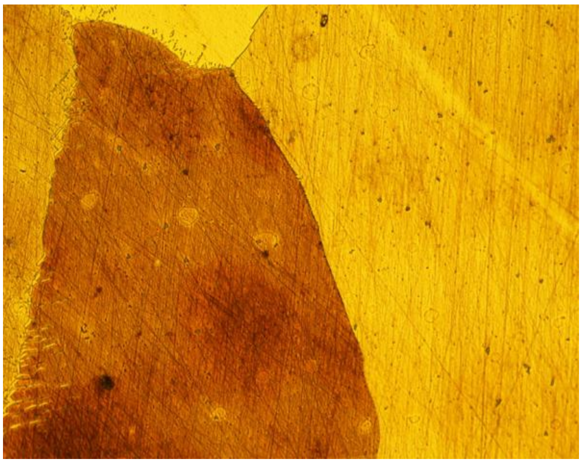

Fig. 4b. CuZn44Te1.5; Magnification 100x

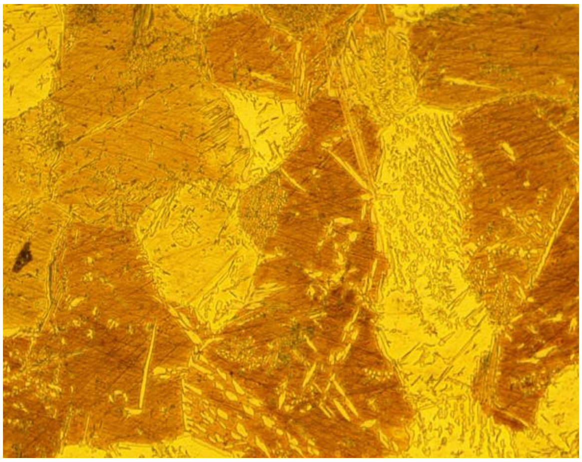

Fig. 4c. CuZn44Te2; Magnification 100x

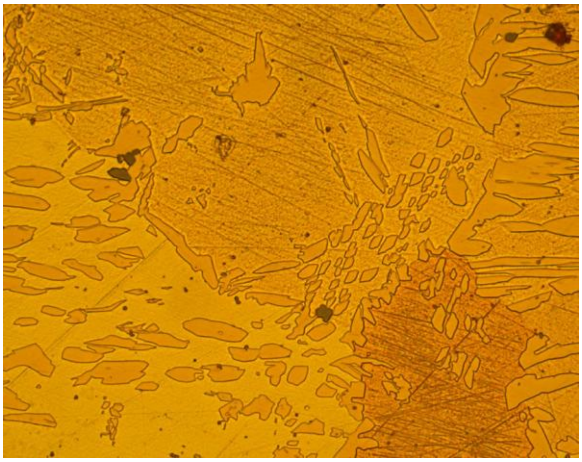

Fig. 4d. CuZn44Te2; Magnification 500x

Fig. 4 a, b. Microstructures of brass CuZn44 with addition of Te, etched by Mi15Cu

Table 4.
Influence of additions of Te on mechanical properties (R_m, A_5 and HB) of brass CuZn44

Addition Te [%]	R_m [MPa]	A_5 [%]	HB
-	433	19	118
1.5	386	12.6	133
2.0	380	13	130

On the basis of analysis of the microstructure pictures and strength properties it can be stated that tellurium introduced into CuZn44 alloy changes its microstructure from monophase into diphase. The formed phases (when tellurium participation equals 2%) cause decreasing of strength properties.

5. Conclusions

The applied specific alloy additions, cobalt, tellurium and nickel, into brass of the phase β' structure cause changes of grain sizes, formation of precipitates and small changes of strength properties. Their influence on other properties will be the subjects of further examinations.

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