ARCHIVES
of
FOUNDRY ENGINEERING

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

ISSN (1897-3310)
Volume 8
Issue 4/2008

81 – 86

16/4

Assessment of aluminium and silicon influence on strength properties and a microstructure of nickel brasses

J. Kozana*, S. Rzadkosz, M. Piękoś
Faculty of Foundry Engineering, AGH University of Science and Technology
ul. Reymonta 23 30-059 Kraków
*Corresponding author. E-mail address: jkozana@agh.edu.pl

Received 17.07.2008; accepted in revised form 25.07.2008

Abstract

An influence of aluminum and silicon on strength properties and a microstructure of nickel brasses was investigated.

Keywords: Nickel brasses, Mechanical properties, Microstructure

1. Introduction

Properties of cast brasses depend on their chemical composition. Apart from zinc, which is a main component in special brasses, additions of Ni, Al, Si and others can be present. A microstructure and an occurrence of individual structural components are changing when the chemical composition changes. Apart from basic phases such as α, β' and γ, in a majority of special brasses intermetallic phases, rich in Al, Si, Fe, Mn or Ni, also appear. Alloy additions of nickel, aluminium and silicon cause changes in a microstructure, which means changes of strength, elasticity and hardness.

2. Methodics and conditions of performing tests

Melts for tests were performed in the Foundry Laboratory in the Department of Moulding Materials, Mould Technology and Casting of Non-Ferrous Metals. Prepared charge materials were melted in the chamotte-graphite crucible in the thyristor induction furnace of medium frequency. Samples for analysis of their chemical composition, metallographic tests and strength investigations were prepared from individual melts.

Properties of brasses depend first of all on zinc participation. Apart from the zinc content as the basic alloying constituent, properties of brass can be improved by using alloy additions such as Ni, Al or Si. Influences of Al and Si on brasses containing approximately 40% of zinc were estimated. According to Guillett's coefficients nickel as alloy addition influences a microstructure similarly to copper, while aluminium and silicon similarly to zinc. At high zinc contents, approximately 44 %, an addition of nickel significantly inhibits the microstructure formation of undesirable phase γ, while additions of aluminium and silicon forming intermetallic phases strongly influence the microstructure and strength properties.

Changes of strength properties of brass CuZn40Ni6 corresponding to changes in aluminium addition, in the range to approximately 2%, are presented in Fig. 1.

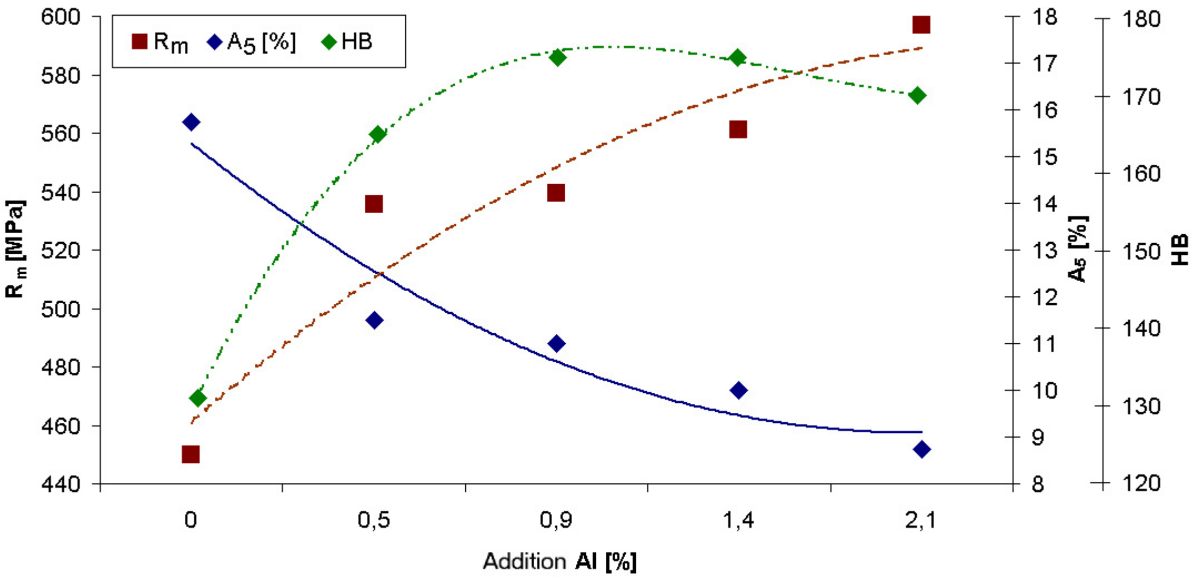


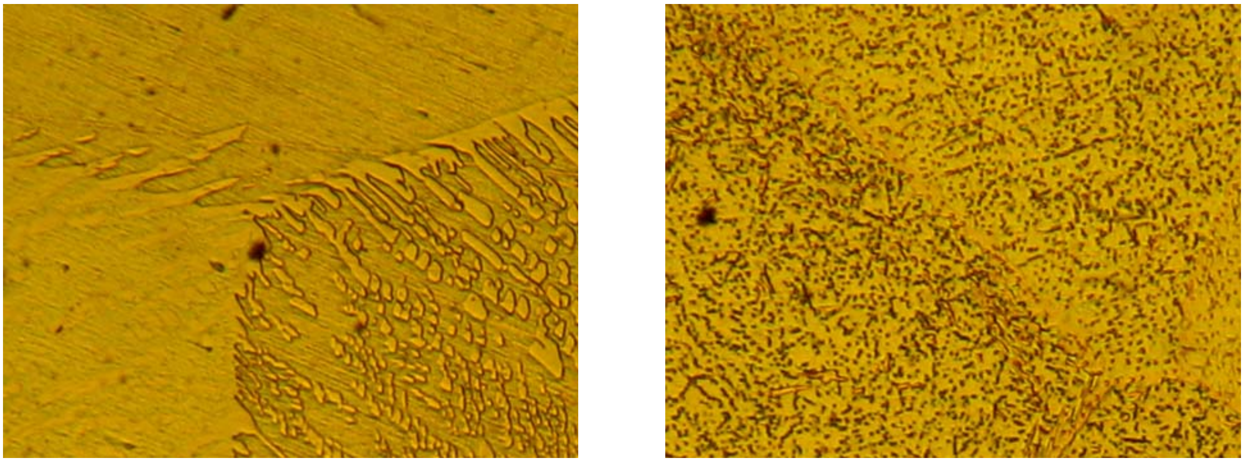
Fig. 1. Influence of aluminium addition on mechanical properties (R_m, A_5 and HB) of brass CuZn40Ni6

As can be seen from data given in Fig. 1, changes of strength and elasticity after the introduction of aluminium are quite distinct. Tensile strength was increased by nearly 40 % while hardness increased from 130 HB to 175 HB.

At bigger additions of Al the elongation decreases nearly two times.

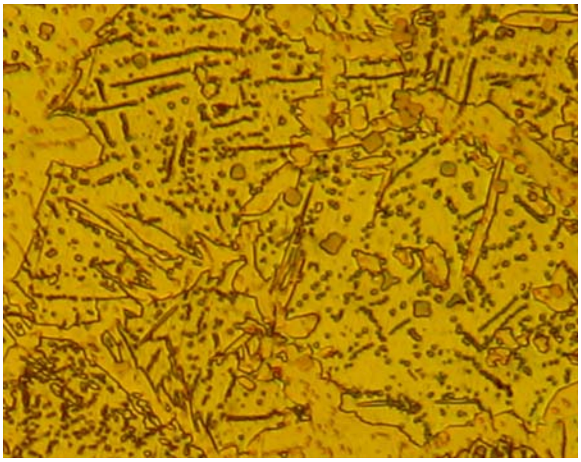
Changes in strength, elongation and hardness caused by the introduction of aluminium into the brass are caused by changes in the microstructure, which is presented in Fig. 2a-e.

Examples of microstructure photographs are given in Fig. 2a-e.

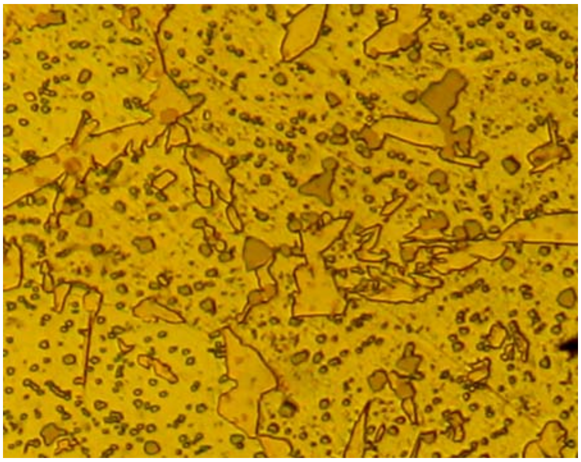


a) b)

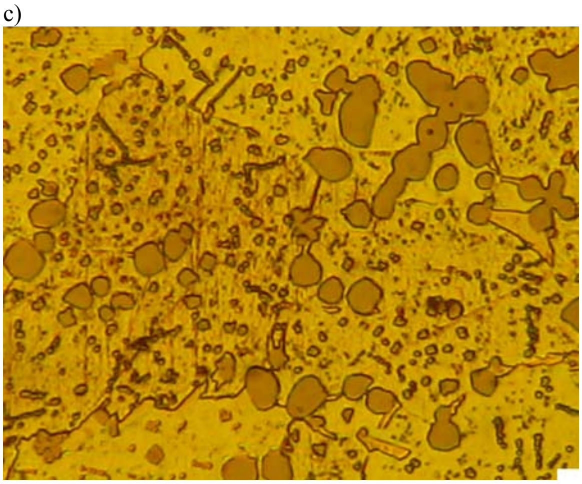
Fig. 2a-b. Microstructures of brass CuZn40Ni6 with addition of Al, etched by Mi15Cu, enlargement 500x, a) CuZn40Ni6; b) CuZn40Ni6Al0.5



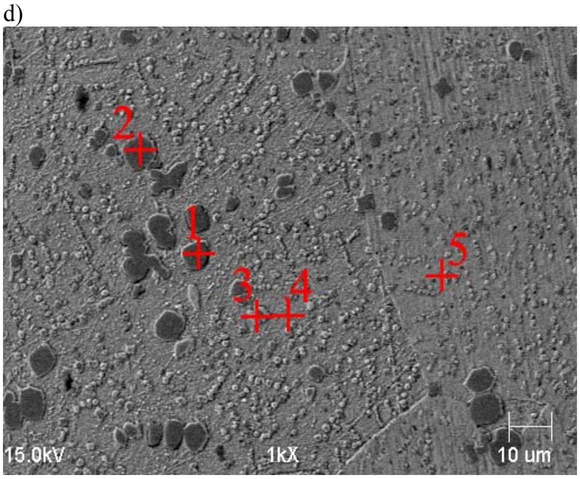
c)



d)



e)



f)

Fig. 2c-e. Microstructures of brass CuZn40Ni6 with addition of Al, etched by Mi15Cu, enlargement 500x, c) CuZn40Ni6Al0.9; d) CuZn40Ni6Al1.4; e) CuZn40Ni6Al2.1, f) SE picture, surface topography of a brass sample CuZn40Ni6Al2.1 with marking of the points, which were subjected to X-ray microanalysis

Table 1.
Results of X-ray microanalysis for Fig. 2f

	Cu	Zn	Ni	Al	Fe
			wt. %		
1	12,9	19,2	55.0	10,4	1,5
2	15,2	10.0	60,9	10,4	2,8
3	49,9	45,9	2.0	0,3	0,7
4	47,8	49,9	1,4	0,3	0,2
5	48,8	47.0	2,9	0,1	0,6

The obtained results indicate, that:

- Initial brass exhibits grain structure $\alpha + \beta'$ with a large participation of phase β';
- Increased addition of aluminium is accompanied by a grain comminution;
- Precipitates of intermetallic phases of NiAl type occur within grains.

In the successive stage of tests silicon was introduced into the brass of a similar composition as previously. An influence of silicon on strength properties of tested brasses is weaker than at addition of aluminium. Fig. 3. presents changes of strength, elongation and hardness accompanying silicon additions. Silicon causes small changes of strength and significant worsening of elasticity. At small additions of silicon strength increases by approximately 10 % and then decreases. Elasticity decreases nearly three times at high silicon content (app. 1 %). Hardness increases from app. 140 HB to app. 165 HB with an increase of silicon in the brass.

Effects of changes in microstructure of brass CuZn41Ni6 with additions of silicon are presented in Fig. 4a-d.

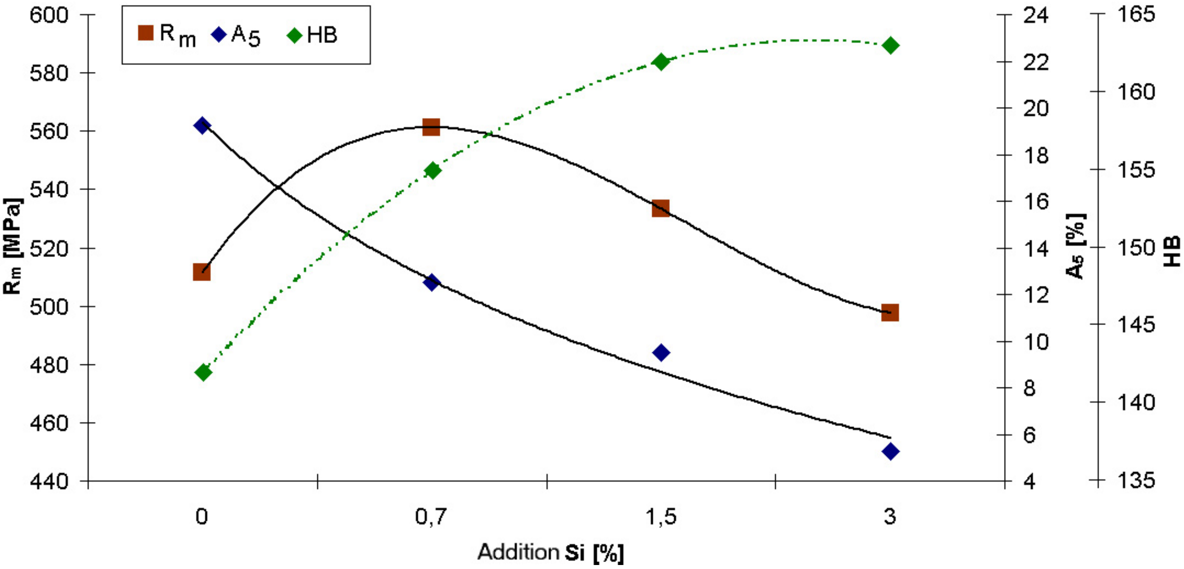
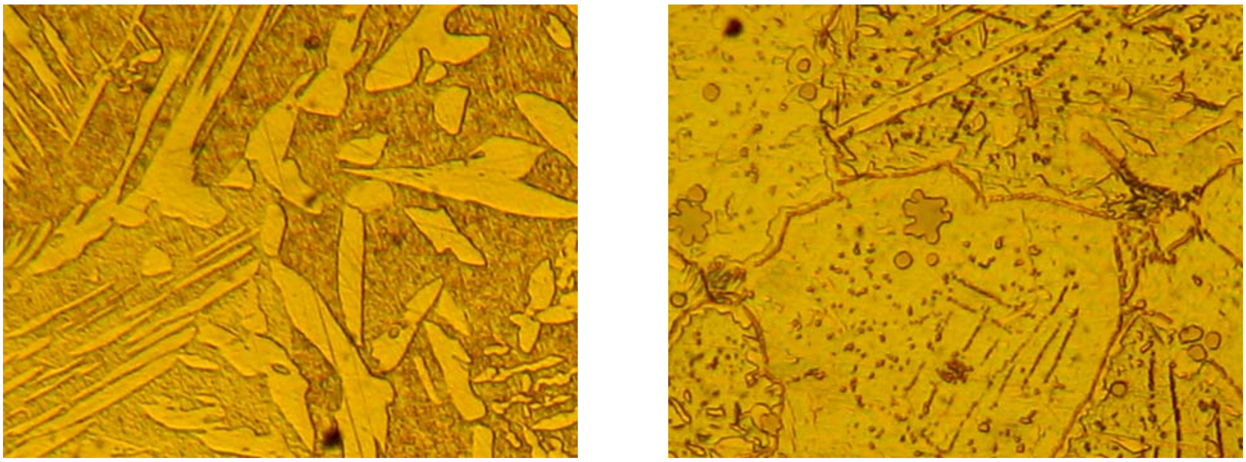
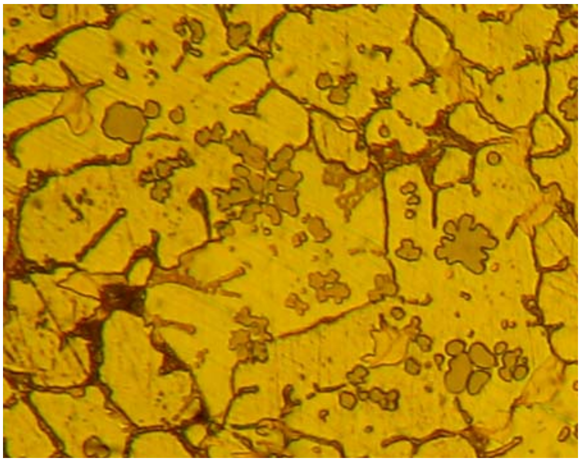


Fig. 3. Influence of additions of silicon on mechanical properties (R_m, A_5 and HB) of brass CuZn41Ni6

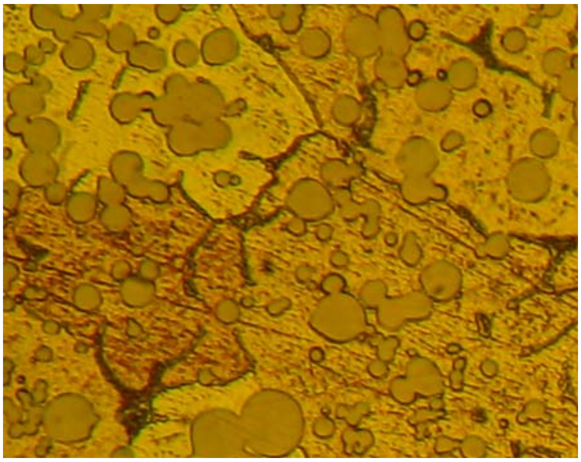


a) b)

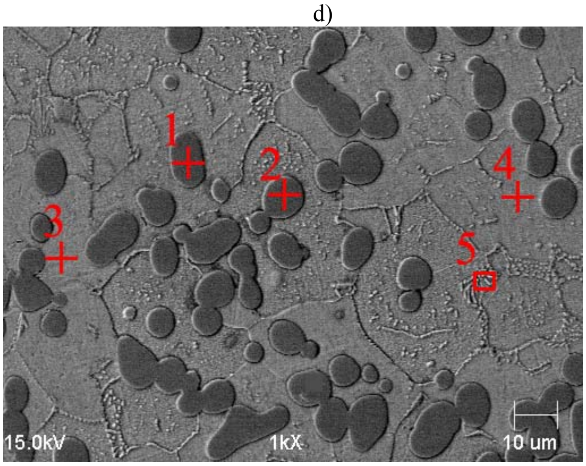
Fig. 4a-b. Microstructures of brass CuZn41Ni6 with addition of Si, etched by Mi15Cu, enlargement 500x
a) CuZn41Ni6; b) CuZn41Si0,7



c)



d)



e)

Fig. 4c-d. Microstructures of brass CuZn41Ni6 with addition of Si, etched by Mi15Cu, enlargement 500x
c) CuZn41Si1,5; d) CuZn41Si3,1, e) SE picture, surface topography of a brass sample CuZn41Ni6Si3,1 with marking of the points, which were subjected to X-ray microanalysis

Table 2.
Results of X-ray microanalysis for Fig. 4e

	Cu	Zn	Ni	Si	Fe
			wt. %		
1	9,1	7,5	53	10,7	18,3
2	3,9	6,9	55,3	11,8	21,5
3	51,1	44,7	2,4	0,4	1,2
4	48	49	0,9	0,1	1,2
5	51,4	35,8	8,6	2,1	1,6

Changes in crystal structure are seen:

- Packet type of structure α+β' changed into more dendritic form of compact rounded crystallites;
- Intermetallic phase in a form of grey rounded precipitates of nickel silicide appeared.

3. Conclusions

Analysis of the obtained results indicates that addition of aluminium significantly change strength, elasticity and hardness of the nickel brass.

Increased additions of aluminium cause distinct diminutions of grains in the microstructure. Precipitates of intermetallic phases of γ type as well as of NiAl type appear within grains.

Additions of silicon cause – in the tested brass CuZn41Ni6 – relatively small changes of tensile strength. At adding of app. 1% of silicon strength increases by app. 10% and then decreases. Elasticity decreases nearly three times at a high silicon content. In the microstructure of the initial alloy of the packet type structure rounded precipitates of intermetallic phase of the nickel silicide type appeared.

References

[1] Cz. Adamski, S. Rzadkosz, Non-ferrous metals metallurgy and casting. Zinc and cooper alloys. Wyd. AGH, Kraków 1992 (in Polish).

[2] K. Sękowski, Microstructure Atlas. PWN, Kraków 1978 (in Polish).

[3] Z. Górny, J. Sobczak, Nowoczesne tworzywa odlewnicze na bazie metali nieżelaznych. Wyd. ZA-PIS, Kraków 2006 (in Polish).