Bulletin of the *Transilvania* University of Braşov • Vol. 3 (52) - 2010
Series I: Engineering Sciences

THE INFLUENCE OF HEAT TREATMENT TEMPERATURE ON DIFFUSION ZONE AT SILICONIZED BRASS

Zoltan MARKOS[1]

Abstract: *The paper presents the siliconized biphasic brass test results. The thermochemical treatment has been done in a powdery medium with paste, in sealed boxes. The siliconized brass presents high mechanical characteristics and corrosion resistance. After the micro-structural investigations with scanning electronic microscope (SEM) and EDAX analysis, it has established the Si, Zn and Cu atoms diffusion mechanism in the siliconized superficial zone. At different temperatures of treatment are obtained diffusion zones of various hardness and mechanical properties.*

Key words: *siliconizing temperature, brass, diffusion zone properties.*

1. Introduction

The siliconizing thermochemical treatment aims the obtaining of a diffusion layers enriched in Si for pieces surfaces. The brass siliconizing has a positive influence over the mechanical properties of resilience and tenacity. These properties are preserved both at high temperatures and low temperatures (temperature of liquid azoth –183 ^{o}C). Also, the presence of silicon atoms in diffusion layer presents a high corrosion resistance.

Brass siliconized components may show a very good property in the case of some friction components (bushings, bearings etc.) that carry work in corrosive environment and at extreme temperatures.

In the area of diffusion, the Si atoms replace some of the zinc atoms in solid solution α (the solid solution of Zn atoms in Cu). Since Si has a large equivalence coefficient (1% Si is equivalent with 10% Zn), narrows the solid solution α domain, strongly diminishes the Zn solubility in Cu. Si dissolves the Zn in the form of interstitial solid solutions in the diffusion zone.

The Cu solubility curve shows a maximum solubility in solid state (11.25 at% Si at the peritectoid temperature - 842 ^{o}C) [4], [5]. The diffusion zone is formed chemical compounds with formula: $Cu_{33}Si_7$, $Cu_{15}Si_4$ and $Cu_{19}Si_6$. These precipitates are coherent with the parent (Cu) phase across close packed planes.

In brass, even a low concentration of Pb worse mechanical properties and plasticity, because it is practically insoluble in the parent phase. The lead separate at crystal limits and form an easy fusible eutectic. The negative influence of lead is possible

[1] Dept. of Materials Engineering and Welding, *Transilvania* University of Braşov.

to decrease with sub critical annealing, applied after cold straining. For all that, at biphasic brass (α+β') is possible to admit a low quantity of lead, for increasing the cutting property.

2. Experimental Details

The siliconizing process has been come out in boxes with welded lids, in a pulverous environment, with paste. There have been utilized prismatic samples (10×10×12 mm), made of CuZn38Pb2Mn2 - AmXT2 (STAS 199/1-73 - ISO 1388-77). As active substance has been used ferro-silicon (with 73% Si) [1]. The activating agent employed was ammonium chloride (NH_4Cl). The paste has been done with soda water glass ($Na_2O \cdot nSiO_2$).

The experimental tests have been done at different temperatures (600 °C, 650 °C and 700 °C) during 4 hours. Cooling of samples was done with low speed (the samples were found in the siliconizing box) [3].

3. Results and Discussion

The chemical compositions were established based on EDAX analysis is presented in Table 1.

The variations of chemical composition in diffusion layers can be seen in Figures 1, 2, and 3.

Analyzing the values obtained from microanalysis, we can see an increase in thickness of layer with increasing temperature (from 0.4 mm to 0.9 mm). Also, with increasing temperature increases the concentration of silicon in the diffusion zone (from 4.19 to 6.12 at% Si).

Also Si has a large equivalence coefficient, one atom of Si may replace four Zn atoms, narrows the solid solution α domain, and strongly diminishes the zinc solubility in Cu [2]. Also can be observed a diffusion of zinc atoms towards to the core of piece, which is more pronounced at lower temperatures and much slower with the increase of temperature.

Diffusion zone hardness increases with temperature treatment (Figure 4). The increase of layer hardness (until 350…400 μHV) explains away to form copper silicides ($Cu_{33}Si_7$, $Cu_{15}Si_4$ and $Cu_{19}Si_6$) with high hardness. At high concentration of silicon, in the diffusion layer is possible to appear the phase γ'. The γ' phase is an electronic compound Cu_5Zn_8 (with a ratio $n_e/n_a = 21/13$) with a very high hardness.

The microanalysis at scanning electron microscope (SEM) shows the reduction of lead inclusions (under the form of white points - Figure 5) in the diffusion zone. The Pb atoms diffuse towards the core of piece.

The variation of chemical composition on the diffusion zone Table 1

Temp.	El. at%	Distance from margin to core [mm]										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
600 °C	Si	4.19	3.97	2.65	1.98	0.94	0.44	-	-	-	-	-
	Zn	22.98	27.49	31.38	32.71	32.20	36.95	-	-	-	-	38.12
	Cu	72.83	68.54	65.97	65.32	62.86	62.61	-	-	-	-	61.88
650 °C	Si	4.78	4.51	4.30	3.05	2.59	2.41	2.50	1.79	1.01	0.71	-
	Zn	25.62	28.33	29.14	31.99	36.69	37.56	38.6	37.16	36.27	37.38	-
	Cu	69.60	67.16	66.56	64.96	60.71	60.03	59.44	61.05	62.72	61.91	-
700 °C	Si	6.12	5.28	3.67	3.15	2.80	2.16	1.53	1.48	1.17	1.28	0.88
	Zn	25.72	26.67	30.40	29.88	31.70	32.57	33.30	35.09	37.72	41.51	39.30
	Cu	68.16	68.05	65.93	66.97	65.50	65.27	65.17	63.43	61.11	57.21	59.82

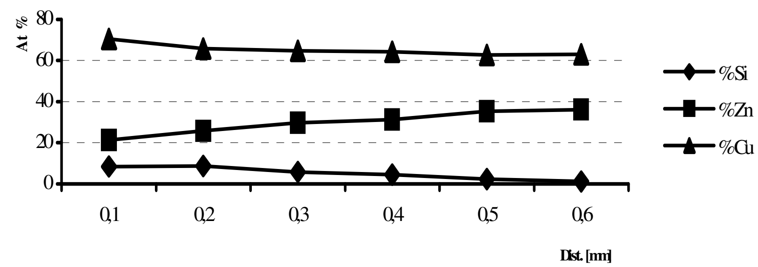


Fig. 1. *The variation of chemical compositions of the siliconizing brass at 600 ^oC - 4 h*

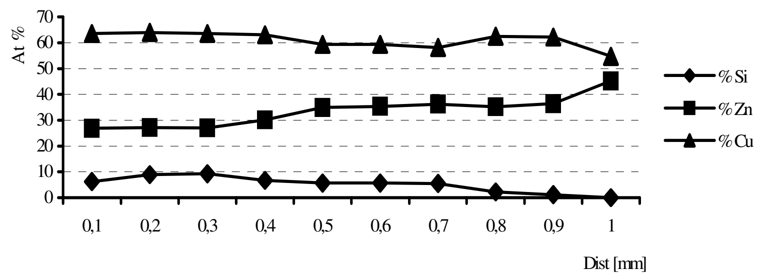


Fig. 2. *The variation of chemical compositions of the siliconizing brass at 650 ^oC - 4 h*

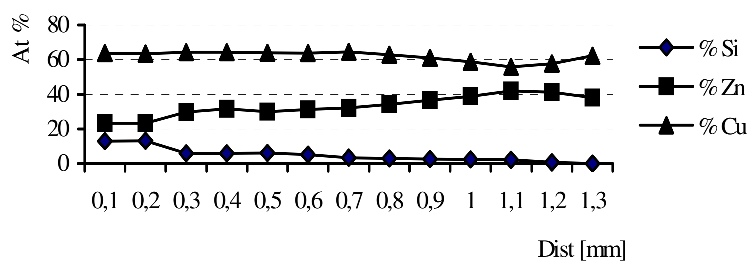
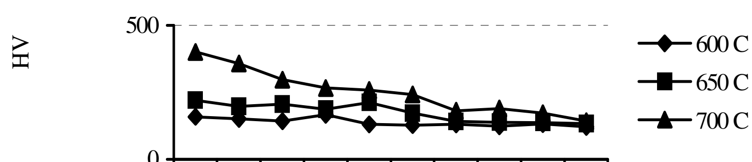


Fig. 3. *The variation of chemical compositions of the siliconizing brass at 700 ^oC - 4 h*



	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,9	1	1,1
600 C	158	151	143	166	131	128	130	124	132	121
650 C	221	198	206	187	212	172	141	138	137	133
700 C	401	357	297	266	258	242	181	189	172	142

Dist [mm]

Fig. 4. *The variation of the microhardness*

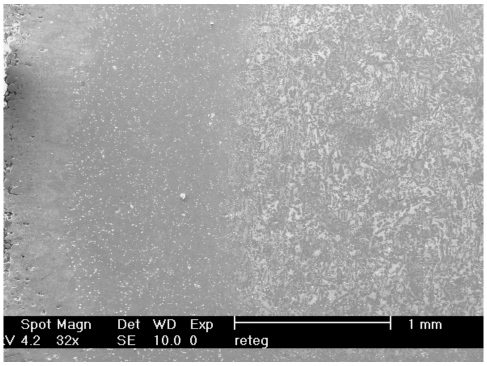


Fig. 5. *The SEM analysis of the brass siliconized at 650 ^{0}C - 32X*

3. Conclusions

In function of the temperature used for thermochemical treatment, diffusion zones with different thickness and Si concentration may be obtained.

With the increase of temperature, the diffusion layer thickness increase, as well as the silicon concentration.

Also, it can be observed a diffusion of Zn atoms towards to center of pieces, which is more pronounced at 600 ^{o}C and much slower with the 700 ^{o}C.

The Si atoms determine Pb atoms to diffuse towards the core of samples. Reducing the concentrations of lead in diffusion zone, improved the mechanical properties of pieces.

References

1. Dulămiţă, T.: *Tratamente termice şi termochimice* (*Heat Treatment and Thermochemical*). Bucureşti. Editura Tehnică, 1990.
2. Markos, Z., Florea, R.G., Balteş, L., Gliga, P.: *Study Concerning of Diffusion Layers At Siliconizing Brass.* In: Proceedings of the International Conference on Materials Science and Engineering, BRAMAT'05, Braşov, 24-26 February 2005, p. 54.
3. Markos, Z.: *Diffusion Mechanism of Silicon and Zinc at Siliconizing Brass* In: Second International Conference "Mechanics and Machine Elements", Sofia, Bulgaria, 3-5 November 2005, p. 229.
4. Markos, Z., Novac, Gh., Balteş, L., Radu, G., Gliga, P.: *Diffusion Study of Cu-Zn Alloys at Siliconizing*. In: Tratamente Termice şi Ingineria Suprafeţelor **3** (2003) No. 1-2, p. 121.
5. Massalski, T.B.: *Binary Alloy Phase Diagrams.* Second Edition, ASM International, USA, 1990.