Proceedings of the 15th International Conference on Manufacturing Systems – ICMaS
Published by Editura Academiei Române, ISSN 1842-3183
"Politehnica" University of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania, 26 – 27 October, 2006

THE NEW BRONZES OF REPLACEMENT OF THE Cu-Be ALLOYS FOR THE INCREASING OF THE CAPACITY OF PLASTIC DEFORMATION AND CUTTING

Petrică CORĂBIERU, Anişoara CORĂBIERU, Ştefan VELICU, Cristian PREDESCU

Abstract: *Replacement of the bronze grades with beryllium type CuCo2Be and CuBe2CoNi as per SR ISO: 1993 with alloys type CuNi3SiMn and CuNi4AlSi, elaborated was for the first time in the country at I.N.C.D.F. Iasi; The alloys achieved are compatible with CuCo2Be and CuBe2CoNi as it concerns the mechanical-electrical characteristics and the behaviour in service; The bronzes of replacement are more profitable, they are not noxious during the elaboration or machining; CuNi3SiMn tested for the manufacture of the contact electrodes and CuNi4AiSi for elastic membranes, obtaining results comparable with those of the classic materials; At CuNi4AlSi the thermal-mechanical treatment has been applied – the increase of the hardness with at least 15–20 HV units and the reduction of the ageing time.*

Key words: *bronze, replacement, Cu-Be alloys, system.*

1. INTRODUCTION

The utilization on a large scale of the bronzes with beryllium in the industry is explained by the fact that they possess a very valuable complex of chemical, physical and mechanical proprieties, hard to be obtained at other materials categories. Moreover, these alloys are non-magnetic, they don't produce sparks at striking and they have very good technological proprieties.

Due to several special qualities of the metallic beryllium (the best permeability at X rays, big capacity of reflection of the neutrons, small efficient section of neutrons adsorption), this one has acquired a priority field of utilization – nuclear energetic – that has transformed it into a strategic technical element. As a result, the bronzes with became very expensive materials that are difficult to secure, in the last period of time these ones entering in the category of scanty materials.

This major difficulty and also the fact, not without importance, that in the production process of the Cu-Be alloys some difficulties appear (the big noxiousness of the beryllium and its compounds during the elaboration and machining), in the world, has conducted to the intensification of the research activities in what concerns the obtaining of new copper alloys without beryllium that by their proprieties are able to substitute the bronzes with beryllium, for certain fields of utilization of these ones.

In conformity with the study with the manufacture proceedings in the world, the methods and automatic installations for the manufacture of the Cu-Be alloys at international level present the drawback of a technological complexity of following of the technological parameters in comparison with the manufacture technology proposed for the new bronzes of substitution type CuNi3SiMn and Ni4AlSi for electrodes for electrical spot welding by pressure, springs, elastic diaphragms with a good electrical conductivity, by the permanent control of the elaboration process and mechanical-thermal processing. This one can be achieved on an automatic line, succeeding to eliminate the drawbacks given by the technological processes complexity, some of the technological operations being effected simultaneously, succeeding the strict following during the process of the main technological parameters and characteristics of the finished product by the permanent control of the process of elaboration and mechanical-thermal processing.

To obtain the welding electrodes, springs and diaphragms of alloys type CuNi3SiMn and CuNi4AlSi will consist the subject of a future invention patent, having this way a contribution at the enrichment of the national scientific and technologic patrimony, at the protection of the industrial property and at the growth of the Romanian products competitiveness.

The proposed technology presents possibilities of enlargement of the technological conception of manufacture of these items that can be applied also in other fields like: aeronautics, military technique, and shipbuilding.

CuNi3SiMn and CuNi4AlSi alloys selected as possible alloys of replacement of bronzes with Be, present the specific characteristics of these last ones, i.e. they can modify their values of mechanical parameters by treatments of putting in bath and ageing, that guarantees to obtain the needed values. Also, the copper matrix being in an enough big proportion (93-95%), can ensure to these ones electrical and thermal characteristics close to those of the bronze qualities with beryllium, CuCo2Be and CuBe2CoNi.

The proposed theme is impressive by respect to the technologies achieved for the time being, on national and international plan, due to the following aspects:

- technological flow with a reduced number of operations; the proposed technology can be implemented with average investments on the technological flows already existent at the economical agents potential users; manufacture cost lower than that of the items achieved with complex technologies used in the world; character of innovation and complexity on national plan; decrease of the importations of electrodes for electrical spot welding by pressure, springs, elastic diaphragms; mechanical characteristics and durability comparable with that of the items manufactured on international plan;

- quality level comparable with that imposed by the norms of the European Union in the field;
- high reliability in service; growth of the productivity in the manufacture process.

2. RESEARCH AND OBTAINED RESULTS

At the elaboration high purity materials have been used (electrolytic and refined) – guarantee of the obtaining of the pre-established chemical composition.

The alloying elements have been introduced in the alloys by certain pre-alloys of adequate composition.

In order to avoid the losses by burnings and oxidations the elaboration by electro-magnetic induction in vacuum has been used; the directional solidification of the liquid metal by means of the iron mould with cooler has been used.

The hot deformed ingots (forging and extruding) and cold deformed ingots (rotating forging and drawing).

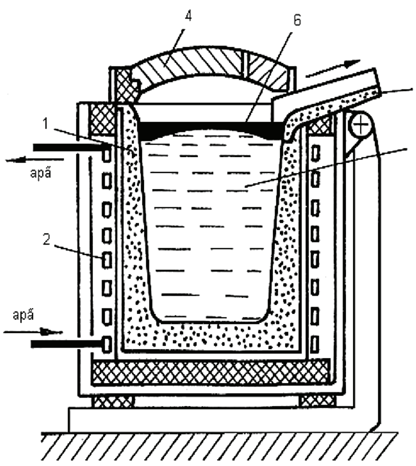

Fig. 1. Induction furnace which was been used: 1 – melting crucible based Al_2O_3; 2 – inductor; 3 – casting gutter; 4 – furnace output; 5 – metal bath; 6 – layer slag.

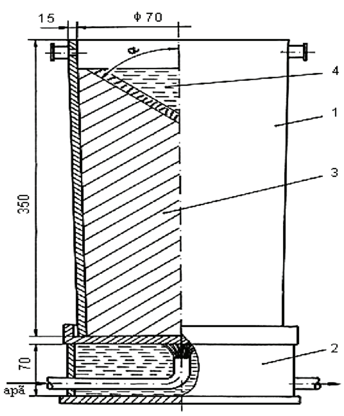

Fig. 2. Ansamble mould – tube cooler: 1 – mould; 2 – cooler; 3 – solidification alloy; 4 – liquid alloy; α = angle of solidification front.

The deformed alloys with reduction ratio bigger than 95% has ensured a good compactness and a high chemical and structural homogeneity.

The half-products submitted at salt hardening and ageing–physical-mechanical characteristics settlement.

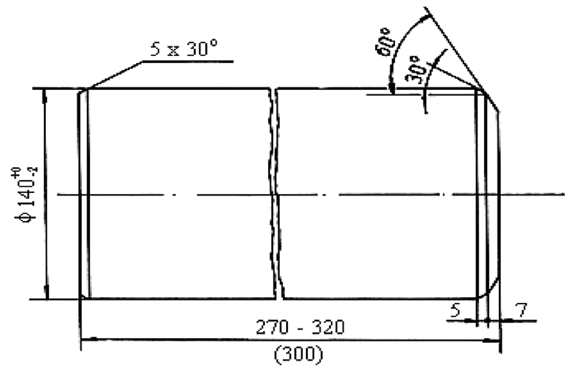

Fig. 3. Form and dimensions size of round billet hot extrusion.

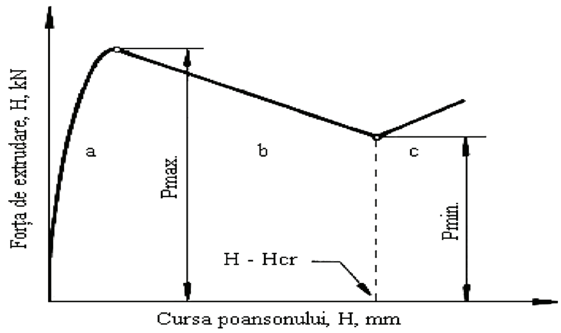

Fig. 4. Variation of force varying with stroke mandrel to forward hot extrusion: *a, b, c* – period of deformation.

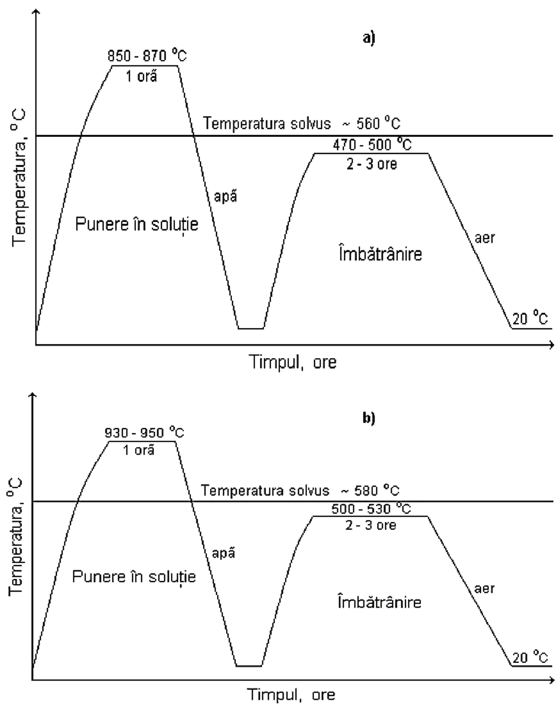

Fig. 5. Heat treatment diagrams of replacement alloys: a) for CuNi3SiMn alloy; b) for CuNi4AlSi alloy.

Table 1

Mechanical and resilience properties after martempering and tempering

Properties	Alloys			
	CuNi3SiMn	CuCo2Be*)	CuNi4AlSi	CuBe2CoNi*)
R_m	700–720	700–840	1100–1150	1100–1340
R_{02}	540–560	560–580	–	–
A_{05}	10–12	8–15	1–1,4	2–3
E	109–112	–	118–120	120–123

*) dates for equivelent alloys: Berylco 10 şi Berylco 25 (DIN 17666 W)

Table 2

Electrical properties of the replacement alloys

Alloys	Rezistivity, at 20°C, μΩ·m		Conductivity, MS/m (% IACS)	
	hardened	seasoning	hardened	seasoning
CuNi3SiMn	0.1031– 0.0907	0.0493– 0.0446	9.70–11.02 (16.72–19.0)	20.3–22.4 (35.0–38.62)
CuCo2Be	–	0.043478*)	–	23.0**) (39.65)
CuNi4AlSi	0.1938– 0.1815	0.0828– 0.0810	5.16–5.51 (8.9–9.5)	12.08–12.,35 (20.82–21.29)
CuBe2CoNi	–	0.083333*)	–	12.0**) (20.69)

*) values true to STAS 10624-76; **) values true to STAS 10624-88

The structures of the alloys studied by optical microscopy (for the nature of precipitates obtained after the ageing) and diffraction with X rays (measurements of the net constants, mosaic blocks dimensions and internal stresses of class II and III).

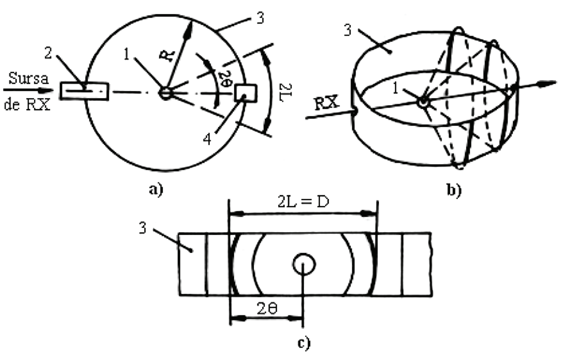

Fig. 6. Display scheme of Debye – Scherrer diffraction method: a) relative position source – sample – shadowgraph; b) intersection of diffractions cones with shadowgraph; c) debye grame image: 1 – sample for study, 2 – collimator, 3 – shadowgraph, 4 – cleat.

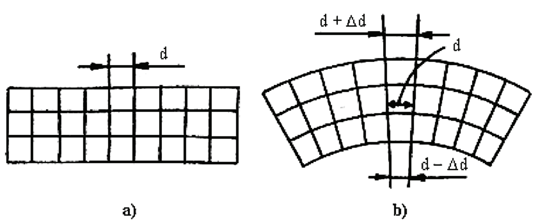

Fig. 7. Spalls of mosaic block grating : a) ideal grating; b) deformed grating.

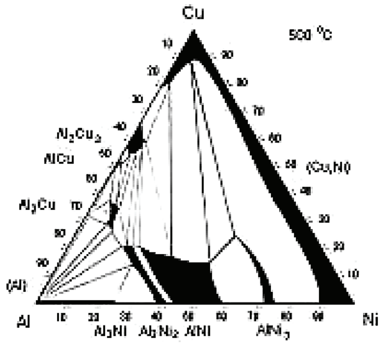

Fig. 8. Al-Cu-Ni system complete isothermal section at 500°C.

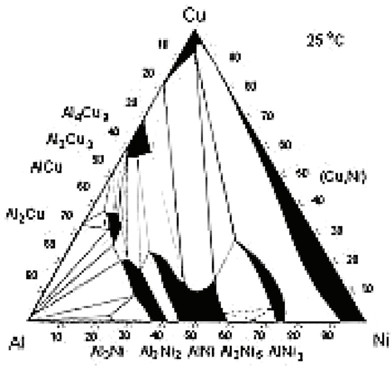

Fig. 9. Al-Cu-Ni system complete isothermal section at 25°C.

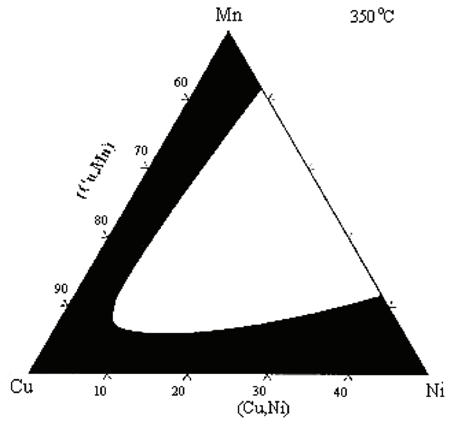

Fig. 10. C-Mn-Ni system partial isothermal section at 350°C.

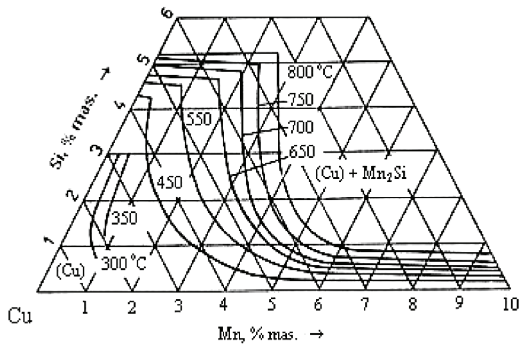

Fig. 11. Cu-Mn-Si system partial isothermal section.

3. CONCLUSIONS

The main technical-scientific contributions brought of framework are referring to:

Conception, achievement and characterization of two new alloys destined to the replacement, for certain domains of feasibility, of some bronzes with beryllium, scanty, strategically materials and that present very harmful effects on the staff that participates at the processing of these ones

Achievement of installations and devices necessary to the alloys processing like the melting pot for the induction elaboration and the ingot chill for the achievement of the directed solidification of the ingot

Achievement of many installations necessary to the characterization of the conceived alloys: installation for the study of the variation of the electrical resistivity depending on the temperature, installation for the determination of the elastic modulus based on the resonance method (adaption), device for the measurement of the contact electric resistance by the volt-ammeter method, the technique of the crossed conductors (in co-operation)

Based on the effected studies, we conceived the sketches of distribution of the axial and radial remanent stresses on the section of a drawn wire

Based on some worked out technical documentations, the two alloys of replacement achieved, together with the technologies of manufacture of these ones, have been homologated, the following normative papers being approved:

- CS 110/89 – "Round bars of CuNi3SiMn alloy for contact electrodes";
- CS 113/89 – "Contact electrodes for spot welding of CuNi3SiMn alloy";
- CS 2147/92 – "Forged bars of CuNi4AlSi alloy".

Based on the technical norms of above, important quantities of these alloys have been produced by microproduction, have been delivered under different forms (forged bars, extruded bars, wires), toward many beneficiaries of the country. Besides the fact that the material destined to the component fabrication must be a very good electric and thermal conductor, it must also be hard enough and not to get deformed during welding; at the same time it must have a high softening point in order to suffer no structural alterations with unfavourable consequences as the result of the process heating. The important factors for this component are: hardness, electric conductivity and softening point. In the operation, the elastic components with high conductivity are subjected to a complex periodic stress at torsion and tensions and, as a consequence, the material it is made of must have high elastic and hardness characteristics.

Ni, Si and Mn contribute at the increasing of the processing (machining) capacity by cutting (cutting speed increases with 10%) and plastic deformation (degrees of up to 20% can be applied).

4. PERSPECTIVES

From the point of view of the extension of the utilization fields of the alloys achieved, for the time being new studies and testing are made as, for example, experimentation as materials for electric fixed or sliding contacts or as antifriction materials. The replacement alloy CuNi3SiMn has been used experimentally as material for the manufacture of the ear of the soldering bit for electronic component parts, obtaining already promising results (double activity time in comparison with the ears of wire of ϕ 2 mm of electrolytic Cu)

In the area of replacement of the Be bronzes, the researches aiming to find new replacement alloys are in full progress. In this moment, are in finalization stage the research works aiming the achievement of a new replacement alloy for the bronze with content of 2.3–2.6% Be (BrBe 2,5).

Getting new data referring to the characterization of the replacement alloys achieved both from technical and scientific point of view will create new perspectives in what concerns the maximum exploitation of the capacities of these ones and of the extension of the feasibility fields.

REFERENCES

[1] Popescu, V. (1976). *Forging and extruding metals and alloys*, Edit. Didactică şi Pedagogică, Bucharest.

[2] Teodorescu, Al. (1975). *Technology of metal extruding*, Edit. Tehnică, Bucharest.

[3] Geru, N. (1967). *Metal properties and control physical method*, Edit. Didactică şi Pedagogică, Bucharest.

[4] Gheorghies, C. (1990). *Fine structures control of metals with X-ray*, Edit. Tehnică, Bucharest.

[5] *** (1978). *Traitement thermique du cuivre et de ses alliages*, Traitement Thermique, nos. 121–130, Paris.

[6] Ignat, C., Dobrea, V., Scanteianu, N., Isachi, P. (1996). *Realisation of copper alloy intended to the production of contact electrodes for resistance welding*, XXVIII Kraftwerkstechnisches Kolloquim, Tehnische Universitat Dresden, Germany, vol. II, pp. 165.

[7] Ignat, C., Dobrea, V. (1994). *The study of physical-mechanical characteristics in some alloys of the Cu-Ni-Al-Si-Cr system, with the thermal treatment,* The First International Congress in Material Science and Engineering, vol. XL (XLIV), fasc. 1–2, pp. 297–301, Iaşi.

[8] Ignat, C., Dobrea, V. (1997). *Studies concerning the multi-component alloys of copper with Ni, Al, Si, Cr and Mn*, The Second International Congress in Material Science and Engineering, vol. XLIII (XLVII), fasc. 1–2, pp. 78–82, Iaşi.

[9] Baraboi, A., Dobrea, V., Ignat, C. (1998). *L'utilisation de l'alliage CuNi3SiMn dans la construction des contacts electriques*, International Conference on Applied and Theoretical Electricity, vol. 2, pp. 17–22, Craiova.

[10] Baraboi, A., Ignat, C., Adam, M., Dobrea, V. (1994). *Research about the using of the CuNi4AlSi material in electric contacts construction*, 4-th International Conference on optimization of electric and electronic equipments, Braşov, pp. 103–108.

Authors:

Petrica CORĂBIERU, S.C. PRESUM PROIECT S.A. Iaşi, E-mail: pcorabieru@yahoo.com

Anişoara CORĂBIERU, S.C. PRESUM PROIECT S.A. Iaşi, E-mail: acorabieru@yahoo.com

Ph.D. Eng., Ştefan VELICU, Professor, "Politehnica" University of Bucharest, E-mail: velstefan@hotmail.com

Ph.D. Eng., Cristian PREDESCU, Professor, "Politehnica" University of Bucharest, E-mail: predescu@ecomet.pub.ro