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STUDY OF THE INFLUENCE OF THE HEAT TREATMENTS ON THE HARDNESS OF THE ECOLOGICAL QUATERNARY ALLOYS

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Abstract: *The hardness of the ecological quaternary alloys type CuNiSiM and CuNiAlSi are modified depending on the variation of the parameters of ageing heat treatment. The main technological parameters of the ageing treatment that influence directly the hardness of the quaternary alloys are the ageing temperature and the time of maintaining at ageing. The values of the ageing technological parameters have been determined experimentally.*

Keywords: *hardness of the ecological quaternary alloys.*

1. INTRODUCTION

The main technological parameters for the hardening heat treatments into a salt solution for the ecological quaternary alloys have been determined tracing the variations of these ones with the temperature and taking into consideration the results of the structural analysis effected by optic microscopy, respectively the nature of the phases and the size of the crystalline grains.

As by optic microscopy the phase precipitated in the aged alloys can not be put in evidence than after their separation from the matrix and their effect on the mechanical characteristics is in diminution, the determination of heat treatment parameters is achieved only by experiments. Series of ageing heat treatments have been achieved with the purpose of studying the influence of the ageing temperature and maintaining time on the hardness, the optimum values of the heat treatment parameters being established based on the obtained results. The variations of the hardness depending on ageing technological parameters have been studied on two quaternary alloys type CuNiSiMn and CuNiAlSi.

2. EXPERIMENTAL LABORATORY CONDITIONS

The way of modification of the quaternary alloy hardness depending on the variation of the parameters of ageing heat treatment was studied on four charges separately elaborated for each alloy, as follows: for a first series of treatments the maintaining time was kept constant at a value considered optimum and the treatment temperature was modified between certain limits; for a second series of treatments the temperature was kept at the optimum value and the treatment time was modified in a well precise interval. For all treatments the heating have been effectuated in an electric furnace in an Argon atmosphere and the cooling of the samples have been made by immersion in cold water, in order to don't modify the established treatment times. Even if the samples have been hardened simultaneously, i.e. at the same technological parameters, it was ascertained that the hardness of the alloys in hardened condition vary from a charge to another. The explanation consists in the existence of small compositional differences caused by the impossibility of the exact reiteration of the conditions of elaboration-casting for each charge. Subsequently the charges have been ordered depending on the values obtained after hardening.

3. RESULTS OF THE LABORATORY EXPERIMENTS

The results of the measurements of hardness effectuated into the framework of the laboratory experiments are presented in the Tables 1 and 2 for the quaternary alloys type CuNiSiMn and Tables 3 and 4 for the quaternary alloys type CuNiAlSi. Representing in a graphic the values of the hardness depending on the temperature, respectively the ageing type, we obtain the limits of the variation of the hardness of the quaternary alloy type CuNiSiMn (Fig. 1 and 2). Representing in a graphic the values of the hardness of the alloy CuNiAlSi indicated in the Tables 3, 4 and 5 depending on the temperature, respectively the ageing time the graphics of the Fig. 3 and 4 are obtained.

Table 1

Variation of the hardness of the ecological quaternary alloy type CuNiSiMn with the ageing temperature, for a maintaining time of 3 hours

Charge	Hardness HV 30, in the conditions:				
	Hardened	aged 3 hours, at the temperature:			
	850°C/1h/ water	470 °C	500 °C	550 °C	600 °C
01	61	182	207	180	150
02	73	192	218	189	160
03	85	203	220	209	155
04	90	224	230	225	165

Table 2

Variation of the hardness of the quaternary alloy type CuNiSiMn with the maintaining time at ageing temperature of de 500 °C

Charge	Hardness HV 30, in the conditions:					
	hardness 850°C/1h/water	aged at 500 °C during :				
		1 h	2 h	3 h	4 h	5 h
01	62	180	191	208	183	169
02	73	190	200	219	182	172
03	85	210	210	220	205	185
04	90	210	220	230	218	190

Table 3

Hardness variation of the ecological quaternary alloy CuNiAlSi with the ageing temperature for a maintaining time of 2.5 hours

Charge	Hardness HV 30, in the conditions:				
	hardened 950°C/2 h/water	aged 2,5 hours, at the temperatures:			
		450 °C	480 °C	500 °C	530 °C
05	141	305	329	350	355
06	133	290	304	330	335
07	124	293	304	316	321
08	110	290	301	310	313

Table 4

Variation of the hardness of the ecological quaternary alloy CuNiAlSi with maintaining time at ageing temperature of 500 °C

Charge	Hardness HV 30, in the conditions:						
	hardened 950°C/1h/water	Aged at 500 °C during:					
		1 h	1,5 h	2 h	2,5 h	3 h	4 h
05	141	310	329	335	350	352	330
06	133	310	318	322	330	334	313
07	124	305	312	314	315	329	303
08	110	300	306	307	310	317	300

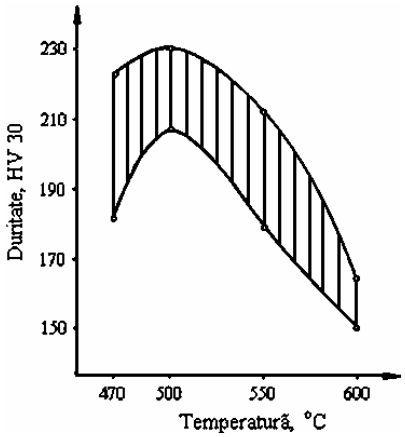

Fig. 1. Range of variation of hardness of the alloy CuNiSiMn with the ageing temperature for a maintaining time of 3 hours.

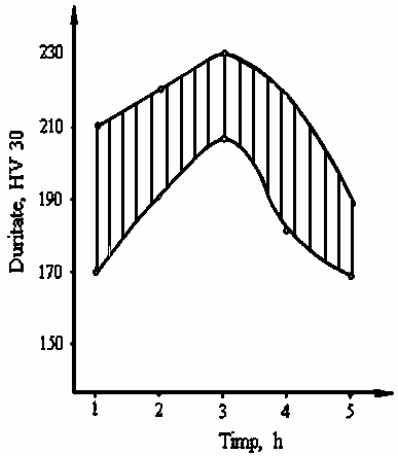

Fig. 2. Range of variation of hardness of the alloy CuNiSiMn with the maintaining time at the ageing temperature of 500 °C.

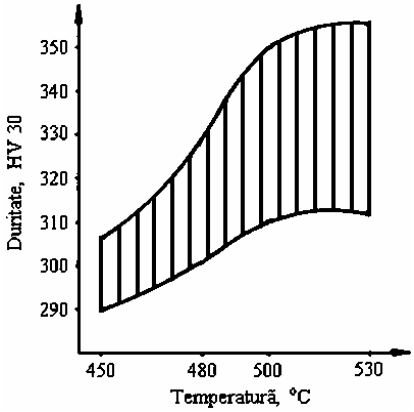

Fig. 3. Limits of variation of hardness of ecological quaternary alloy CuNiAlSi with the ageing temperature, for a maintaining during 2.5 hours.

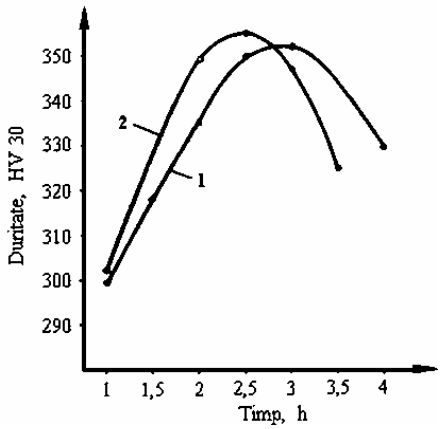

Fig. 4. Curves of variation of hardness of ecological quaternary alloy CuNiAlSi with the maintaining time at the temperatures of 500°C (1) and 530°C (2).

4. METALLOGRAPHIC RESEARCHES

The heat treatments of the ecological quaternary alloys CuNiSiMn and CuNiAlSi influences directly the microstructure of the complex alloys.

Metallographic researches by optical microscopy have been effected on the specimens of ecological alloys at the level of the superficial layer.

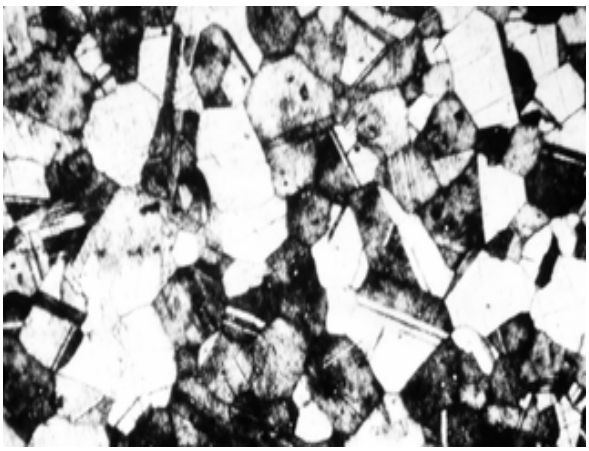

Fig.5. Microstructure of the ecological quaternary alloys Cu-NiSiMn-hardened 850°C/1h/water→polyhedral granules of solid solution+annealing macle, (100:1).

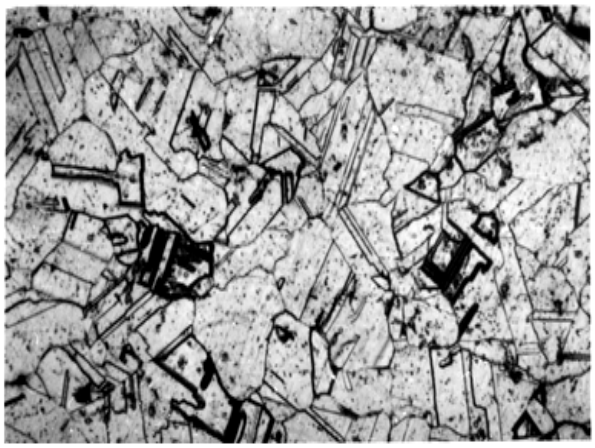

Fig.6. Microstructure of the ecological quaternary alloys Cu-NiAlSi-hardened 950°C/2h/water→polyhedral granules of solid solution+annealing macle, (100:1), pickling:ammonium persulphate.

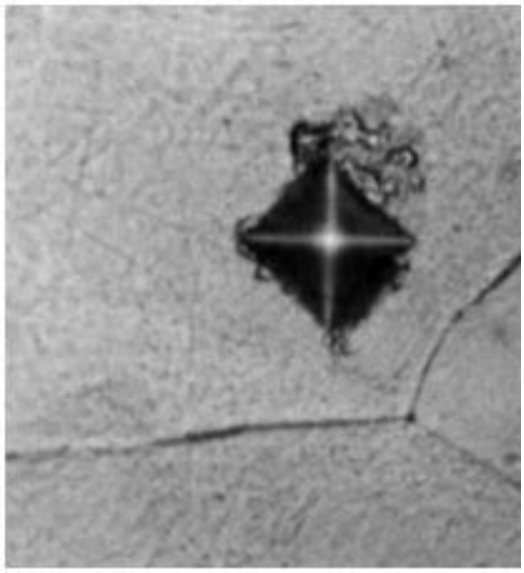

Fig.7. Microstructure of the ecological quaternary alloys Cu-NiSiMn-hardened;-granule limits; -indentation Vickers hardness test, (500:1); pickling:ammonium persulphate, (F = 90 daN/mm^2).

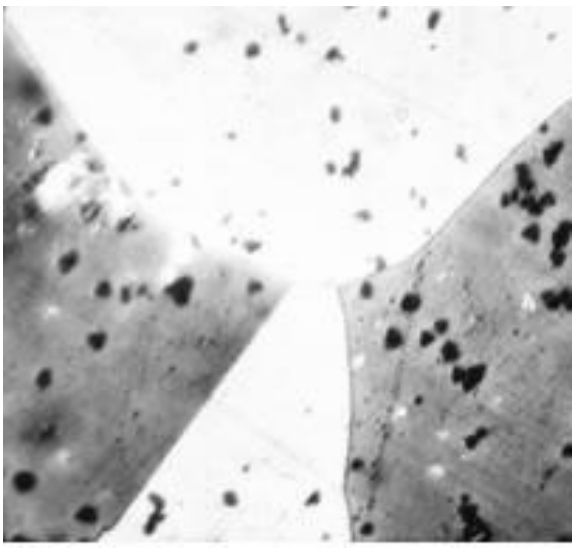

Fig.8. Microstructure of the ecological quaternary alloys Cu-NiAlSi- irregular precipitates in matrix; pickling: ammonia copper chloride, (500:1).

Fig.9. Microstructure of the ecological quaternary alloys Cu-NiAlSi- precipitates in ecological alloy; -electronics microscopy (2000:1).

5. CONCLUSIONS

- The range of variation of the hardness of the ecological quaternary alloys with the ageing temperature is restraint, the value of the maximum of the hardness is as big as the ageing temperature is bigger and it is reached in a shorter time;
- The same values of the hardness of the quaternary alloys can be obtained at different maintaining times, situated before or after the position of maximum of the graphic, phenomenon useful in the establishment of the alloys characteristics;
- The maximum hardness of the quaternary alloys is obtained at a maximum ageing temperature and an optimum maintaining time;
- Microstructure of the ecological quaternary alloys hardened CuNiAlSi and CuNiSiMn contain polyhedral granules of solid solution + annealing macle + irregular precipitates in matrix;

- Metallographic researches by optical microscopy have been effected on the speciments of ecological quaternary alloys CuNiSiMn and CuNiAlSi at the level of the superficial layer.

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