ARCHIVES
of
FOUNDRY ENGINEERING

ISSN (1897-3310)
Volume 7
Issue 2/2007
147 – 152

31/2

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

The influence of the cryogenic processing after saturating on propriety AlCu4,7 cast alloy

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Received 08.02.2007; Approved for print on: 12.03.2007

Summary
In the article was introduced the investigations defining influence of the cryogenic processing after saturating on the processes of the effusion consolidation of the alloy AlCu4,7. The qualification of the influence this processes was planned (in the function of temperature and time) on microstructure and the mechanical proprieties of this alloy. There are accept the wide range of the temperature $175^oC \div 350^oC$ there made possible the settlement of the influence of the temperature of aging on the kinetics of the break-up of the permeated with solution α and then on the change of microstructure and mechanical proprieties. There were applied the times of aging from 30 to 240 min. Results of investigations were compared with results after such thermal processing itself without the cryogenic processing after saturating.

Key words: investigation of DTA, cryogenic processing, saturates, ages, dispersal hardening .

1. The introduction

In the technique, and especially sea air, car the use of aluminum or the alloys of aluminum finds. The alloys of aluminum are applied where higher properties in the comparison with aluminum and are required universally there.

The cryogenic processing after saturating and then aging the alloy AlCu4, 7 have the principal influence on enlargement of the properties higher than the applied traditional methods of hardening.

In the result of the cryogenic processing the cramp of every solid body follows - the dimensions of elementary mobile phone change. Atoms approach to each other on clearly smaller distances. They are possible solutions in the face of this:

1. change of the dimension of the atom.
2. more thick packing up atoms in the crystalline net.

Second solution is true seems in the alloys of metals. If this is the change of packing up strange atoms so hardened clearly influences sail effusion processes particularly in alloys. In the initial stages of the secretion the decisive part play in Vacancy these alloys. In the face of this the hypothesis, that effusion processes in the permeated with alloys of aluminum will run differently than without her. The similar situation sets in steels [1-6]. We get permeated with the carbon martenzit after tempering. He results that during the cryogenic processing of martenzit there are change of the position of the atoms of carbon in the nets of martenzit. The atoms sets from hitherto existing investigations hatches tetroendonics occupy, and after the processing cryogenic octoendronics. The acceleration of effusin processes follows in the result the change of the position of the carbon atoms. There is the formed emission of carbides smaller and more spread [4-5]. The similar sequence appears while aging alloys Al-Cu.

Mechanism of effusion of intermetallic phaze from the permeated with solution of α-Al is the basis to the obtainment of good mechanical proprieties. From conducted earlier investigations of the influence of cryogenic processing after saturating on the processes of aging [10, 11], he results that processing this accelerates the processes of aging. The similar influence exerts now as they hardened stood on the course of absolving [2,3, 4,5] and the similar result can call out - the enlargement of mechanical properties. These properties are the result setting while aging effusion processes. One can notice the influence of the cryogenic processing after comparing with the properties of the got meringues of the cryogenic processing. Checking this hypothesis is the aim of our work.

In the aim of the settlement of the mechanism of the secretion of strengthening phaze $\theta(Al_2Cu)$ from permeated with alloy AlCu4,7 was made the DTA investigation. The influence of the conditions the process of effusion strengthening, temperature and the time of aging for traditional processing and cryogenic processing on microstructure and mechanical proprieties was established on the basis of microscopic investigations, the measurements of hardness, the static test of the expansion.

2. Material and the methodology of investigations

In investigations there are use alloy AlCu4, 7 about the composition to chemical Al 94,85 %, Cu 4,69 %, Fe 0,20 %, Si 0,08 % different approx. 0,15 %, in which the content Cu is close the maximum of content in the permeated with solid solution.

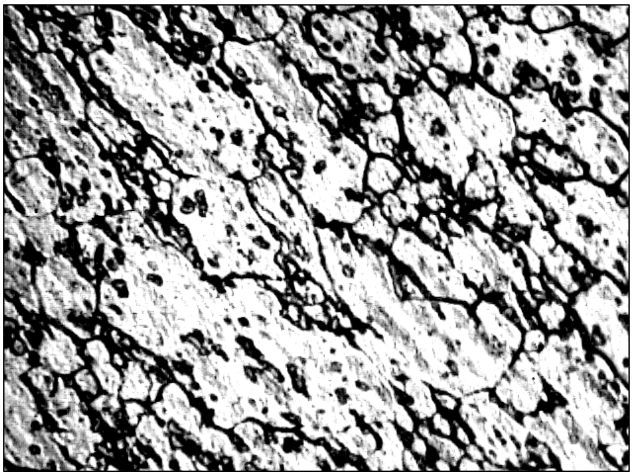


Fig. 1. The structure of the alloy AlCu4, 7 - visible emission of th$_e$ Al_2Cu of the area 240x.

The structure of the alloy consisting from the solid solution α and Al_2Cu inclusion was passed on fig.1.

Samples were warmed to the temperature 520^{o}C, kept in this temperature by 10 hours, and then cooled to the temperature quickly surroundings in water. The the next part of samples was subjected more far refrigeration to the temperature of liquid nitrogen (-196^{o}C) and holds out 1 the hour.

The course of saturating and aging represents on the fig. 2.

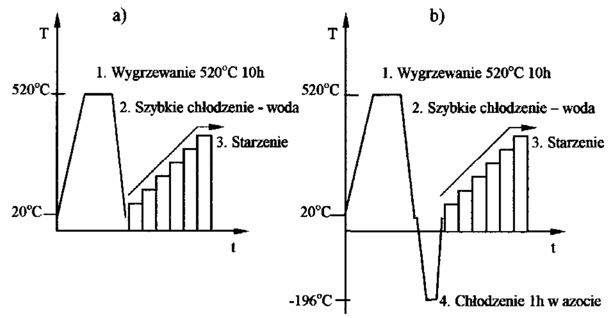


Fig. 2.. The patern of the course of saturating and aging: a) without cryogenic processing (so-called traditional method), b) with the cryogenic processing.

The analysis of the process of the secretion of strengthening phaze $\theta(Al_2Cu)$ from permeated with alloy AlCu4, 7 was made on the basis of the DTAinvestigations (fig.3).

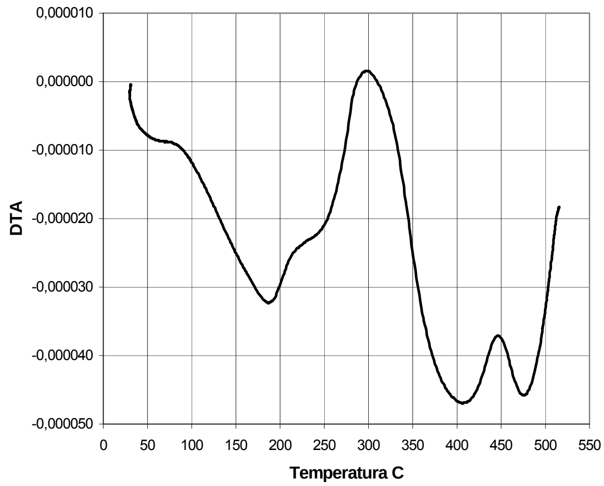


Fig. 3. The DTA graph of aging while warming continuous after saturating 10h / 520 ° C and cooling in water.

Warm samples to DTA together with patterns with the speed 8ºC/s to the temperature 520^{o}C, the protective atmosphere was not applied. The large speed of warming to distinguish was applied stepping out on crooked DTA spades.

The hardness of the alloy was qualified in the test Brinella. The extension relative of the alloy and the endurance on the expansion was qualified in the static test expansion. The dimensions of samples to the investigations of endurance on the expansion were executed with the heads thread. The machine stamina INSTRON model 4485 was applied , the speed of the expansion of 3mm / the faces, the range of the head measuring 200kN, temperature 23^{o}C, moisture 38%.

Metallographic sight was made to the investigation of the microstructure the alloy on the transverse samples sections. The observations of microstructure were conducted using the optical metallographic microscope OE-4 PZO. Samples were digested the Keller reagent.

3. The results of investigations and their analysis

The results of the DTA investigations represented all four stages of appearing while aging the alloys Al-Cu of phaze. Comparing these results with the literature, that the maxima are shifted in the side of higher temperatures somewhat. Received results allow to the following interpretation:

1. zone *G-P* - the first pikes (range of secretion to 90 ° C),
2. secretion of *Θ*" the second pikes (the range secretion to approx. 240 ° C),
3. secretion of *Θ*' the third pikes (range of secretion to 440 ° C),
4. the fourth pikes the secretion equilibrium *Θ* (the range secretion to approx. 520 ° C).

The change of the mechanical proprieties of the alloy AlCu4, 7 was qualified in dependence from temperature and the time of aging with the traditional and cryogenic processing on the basis of the measurements of hardness. It was affirmed that the hardness of the studied alloy depended on conditions of effusion strengthening (fig. 4).

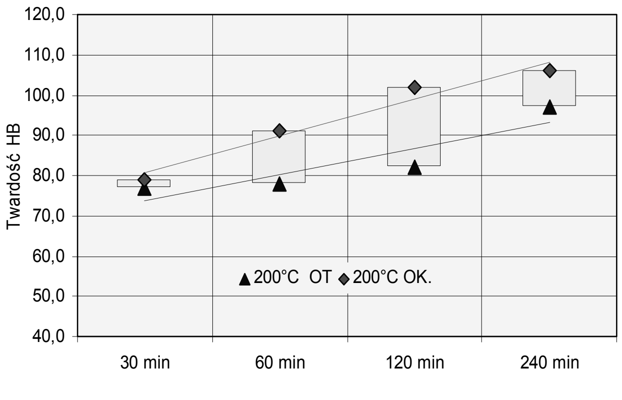


Fig. 4. The comparison of hardness after aging in temperature 200^{o}C and the time of aging 30-240min with the use of the processing of traditional (OT) and cryogenic (OK).

The hardness of samples grows up with the outflow of the time for traditional and cryogenic processing (fig. 4) in the compartment of the temperatures of aging from 175^{o}C to 220^{o}C, samples the highest hardness are characterize after the processing cryogenic aging in the temperature 200^{o}C and the time ages 240 min.

The hardness of samples diminishes with outflow of time (fig. 5) for the range of the temperatures of aging from 275^{o}C to 350^{o}C. But he is higher in the relation to the traditional processing for the majority of samples subjected hardness to the cryogenic processing. Cryogenic processing and the conditions of strengthening also influence stamina proprieties ($R_{0,\ 2}$, R_m) and plastic (A_5). The conventional border of plasticity $R_{0,2}$ he increases and endurance on the expansion of R_m of the aging alloy together with with extension of the time of aging and the temperature of aging- to 220^{o}C (fig. 6, 7). The more far growth of the temperature of aging and the time of aging causes lowering of border of plasticity and endurance on expansion (fig. 8, 9).

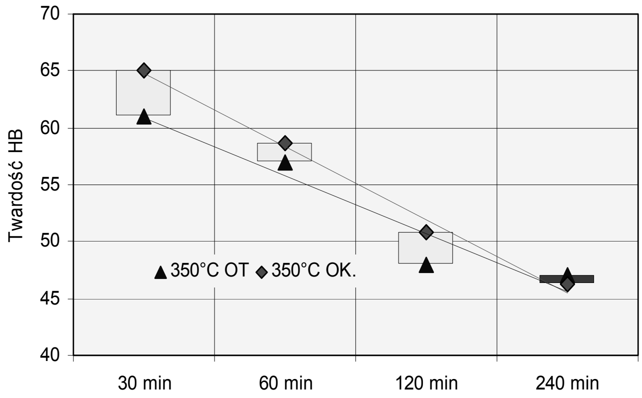


Fig. 5. The comparison of hardness after aging in temperature 350^{o}C and the time of aging 30-240min with the use of the processing of traditional (OT) and cryogenic (OK).

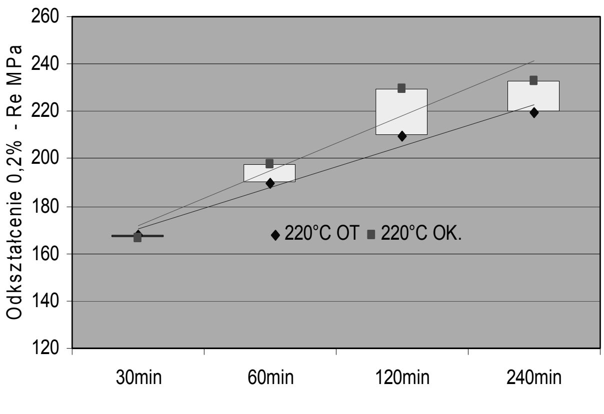


Fig. 6. The comparison of the value the border of plasticity after aging in the temperature 220^{o}C with the use of the traditional processing (OT) and cryogenic (OK).

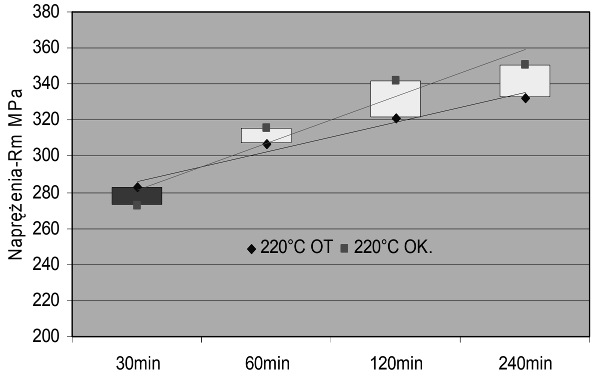


Fig. 7. The comparison of the endurance value on expansion after aging in the temperature 220^{o}C with the use of the traditional processing (OT) and cryogenic (OK).

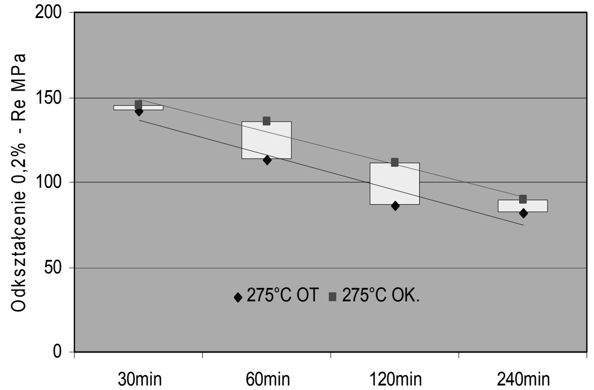


Fig. 8. The comparison the value of the border of plasticity after aging in the temperature 275^{o}C with the use of the traditional processing (OT) and cryogenic (OK).

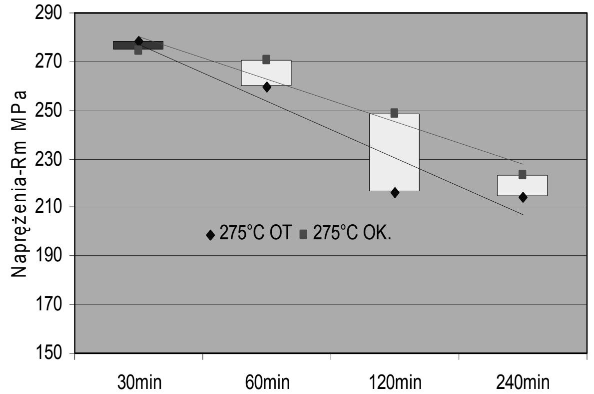


Fig. 9. The comparison of the endurance value on expansion after aging in the temperature 275^{o}C with the use of the traditional processing (OT) and cryogenic (OK).

The change of hardness, the stamina properties of the alloy AlCu4,7 in the time reflect the kinetics of the secretion of consolidating phaze Θ(Al_2Cu) in dependence from temperature and the time of aging. The comparison results own investigations from given literature he allows to thesis , that mechanism of aging alloy AlCu4, 7 in the temperature about 100^{o}C begins from creating the zones of *GP*. The DTA graph of aging (fig. 3) showns thyse. The observed more far growth of stamina proprieties, he is the hardnesses the result of the secretion of metastable phaze indirect Θ'' and Θ', until to being establishing stable równowagowej phaze Θ(Al_2Cu). While aging in higher temperatures 175- 220^{o}C does not step out the stage of arising oneself the zones of *GP*, and the strengthening the alloy is the result of the secretion metastable phaze indirect Θ'' and Θ', they are this the strong emission which they strengthen the alloy. Maximum stamina proprieties, hardness appear in investigations in the temperature 200^{o}C after 120 and 240min, are the result of the presence in microstructure partly inclusions of phaze Θ'' and Θ' (fig. 10, 11)

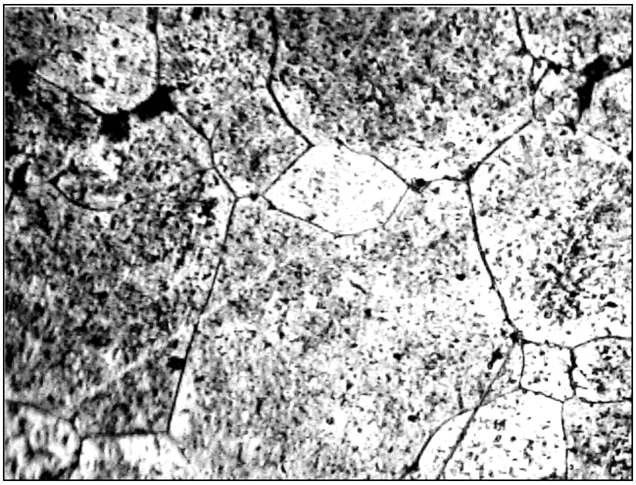
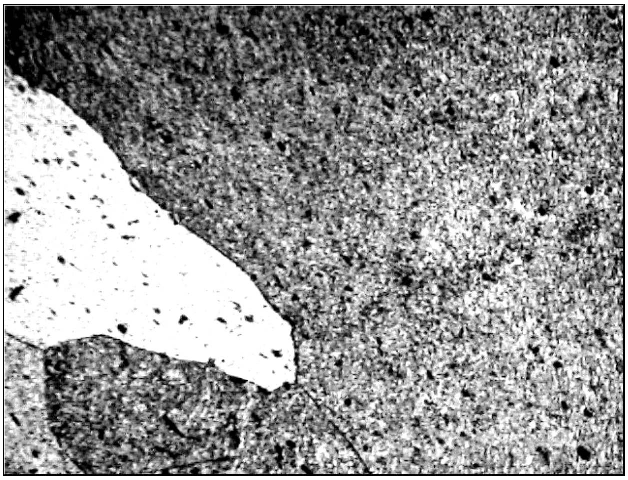


Fig. 10. The microstructure of the AlCu4, 7 alloy after traditional (OT) processing aging in the temperature 200^{o}C and the time of aging the 240min of the area 240x.

The microstructure of samples after saturating and cryogenic processing and aging changed together with with the temperature of aging from 175^{o}C to 350^{o}C. The microstructure of samples after the traditional processing also changed together with with the temperature from 175^{o}C to 350^{o}C, until to the atrophy of the grains of the warp, he follows the spaces of the alloy. The very large difference steps out in microstructure between samples aging in this alone temperature and the same time of aging. They differ not only size of the grains of the warp, but also the emission of $CuAl_2$ phaze.



Rys. 11. The microstructure of the AlCu4, 7 alloy after cryogenic (OK) processing aging in the temperature 200°C and the time of aging the 240min of the area 240x.

The use of the higher temperature of aging 275-350°C the time shortens to appearing oneself higher usable proprieties to 30min, and these fall after the longer time of aging the value. Decrease these is caused propriety appearing phaze equilibrium Θ(Al_2Cu) whose particles expand while more far aging and undergo coagulation (fig. 12, 13).

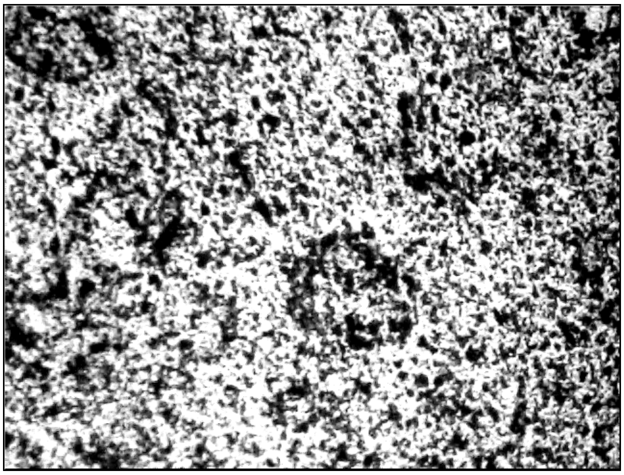


Fig. 12. The microstructure of the AlCu4, 7 alloy after traditional (OT) processing aging in the temperature 350°C and the time of aging the 240min of the area 240x.

4. Recapitulation and conclusions

Conducted investigations the influence of cryogenic processing after saturating on the aging processes of the AlCu4.7 alloy clearly showed, that the cryogenic processing accelerates in the range from 175°C to 220°C the processes of aging and small steps out her influence in compartment 220°C to 350°C (fig. 14).

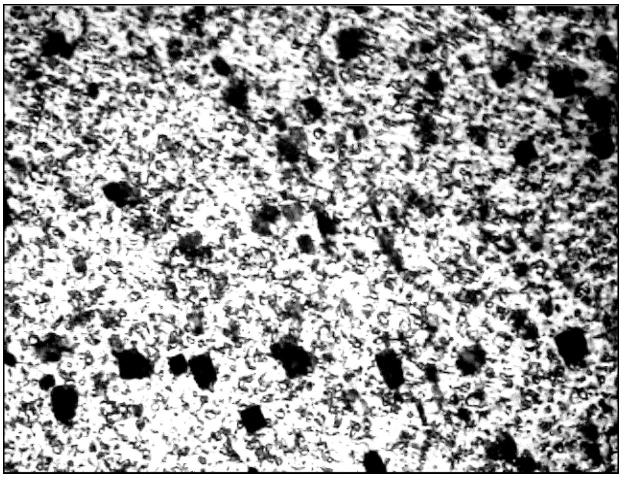


Fig. 13. The microstructure of the AlCu4, 7 alloy after cryogenic (OK) processing aging in the temperature 350°C and the time of aging the 240min of the area 240x.

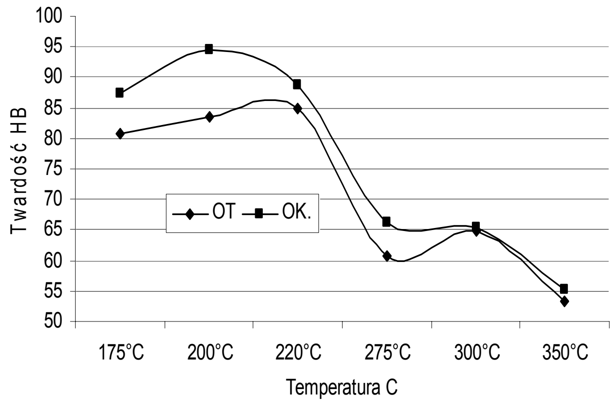


Fig. 14.. Influence of cryogenic processing on the acceleration the aging process.

It was showed that the cryogenic processing after saturating exerted the very essential influence on the course of effusions processes and could played the essential part in the process of aging. Raising usable and stamina proprieties hardened of aluminum alloys was affirmed. Interesting for these investigations magnificent oneself change in the profiles of propriety until aging. The explanation of the causes of being shaping propriety of the studied alloy was got on the basis conducted simultaneously metallographic investigations. The cryogenic processing influenced even schedule of the particles of phase strengthening Al_2Cu (θ) in the solid solution of the warp and decrease of the size of crystals in the comparison with the microstructure of the alloy after the traditional processing.

Described investigations were treated as the indication of the advisability of utilization the cryogenic techniques to improving the propriety of casts from light alloys..

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