The Optimization of the Cryogenic Processing Al-Cu Alloys

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Abstract

In the article was introduced the investigations defining optimization of the cryogenic processing after saturating 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°C ÷ 350°C 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.

Keywords: Investigation of DTA, Cryogenic processing, Saturates, Ages, Dispersal hardening

1. The introduction

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.

Well-known from the literature conduct in the thermal processing of the chosen alloy AlCu4, leading to the optimum effusion effect consolidations together with with coming into being microstructure, figure 1 represents. The order of the stages of hardening inclusions of the alloys of aluminum with the copper runs according to. [1] as follows:

they stood the supersaturated solution → GP I zone → GP II zone (phase θ → phase θ(Al1,6Cu4) → phase θ(Al2Cu) where the zone GP – Guiniera-Prestona zone

Fig. 1. The patern of the thermal processing (together with arising microstructure) causing the effusion consolidation of the alloy AlCu4 - the so-called traditional method [2]

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:
samples were warmed to the temperature 520 °C, kept in this nitrogen (-196 °C) and holds out 1 the hour. The course of subjected more far refrigeration to the temperature of liquid quickly surroundings in water. The next part of samples was temperature by 10 hours, and then cooled to the temperature of the position of the atoms of carbon in the nets of martenzit. The 8]. We get permeated with the carbon martenzit after tempering. differently than without her. The similar situation sets in steels [3-8]. We get permeated with the carbon martenzit after tempering. 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 [3-8]. We get permeated with the carbon martenzit after tempering. The atoms sets from hitherto existing investigations hatches tetroendonics occupy, and after the processing cryogenic octoendonics. The acceleration of effusion processes follows in the result the change of the position of the carbon atoms. There is the change of packing up strange atoms so hardened clearly 2. Material and the methodology of investigations

In investigations there are use synthetic 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. The industrial casting alloy AlCu2,8-Si10 was also subjected the cryogenic processing, found in this the way the presence of silicon as the additional component.

Full analysis leading to the optimization of the cryogenic thermal processing was conducted for the alloy Al-Cu4, 7. Samples were warmed to the temperature 520°C, kept in this temperature by 10 hours, and then cooled to the temperature quickly surroundings in water. The next part of samples was subjected more far refrigeration to the temperature of liquid nitrogen (-196°C) and holds out 1 the hour. The course of saturating and aging represents on the fig. 2.

The analysis of the process of the secretion of strengthening phase 0(Al,Cu) from permeated with alloy AlCu4, 7 was made on the basis of the DTA investigations (fig.3). Warm samples to DTA together with patterns with the speed 8°C/s to the temperature 520°C, the protective atmosphere was not applied. The large speed of warming to distinguish was applied stepping out on crooked DTA spades. Results of saturating and aging 90 °C let distinguish all four the main thermal effects. All pikes set on oneself (particularly spades II and III). The maximum first spades 100 appear in the temperature approx. °C, maximum second in approx. 200 °C, maximum third somewhat above 300 °C, and maximum fourth in 420 °C. Saturating in 141 °C causes cuts the spades of first with the shift of his maximum in the side of higher temperatures and clearly decrease spades second. Third spades is shifted in the side of lower temperatures and his maximum 280 step out in the temperature 450 °C. Saturating in 191 °C influenced minimalizing the size of effect second, however spades first moved in the side still higher temperatures, effect third was very clear - his maximum is shifted in the side of somewhat higher temperatures (approx. 270 °C), spades fourth is clear, his maximum is close 460 °C. Saturating in 300 ° it C caused the renewed weakness of effect first and second, is smaller in third’s place. Effect fourth, and his maximum steps out in the close temperature 470 °C. The great had influence on the singling out stepping out thermal effects the aging in temperatures approx. 90 ° the C. The growth of the temperature of aging caused next decrease spades first which stopped to be visible just after aging in 300 °C. The second effect stopped to be visible after aging in 191 °C, and third even marked his presence after aging in 300 ° changing the temperature of one's maximum somewhat C. Pik fourth was present on all graphs – fig.3.
Conducted investigations thermal DTA let get information about the course of phase alternatively stepping out in the process of saturating and aging alloy AlCu4, 7. Optimum temperatures of aging for alloy AlCu4, 7 were established on the basis of got results-graphs DTA and the analysis of the literature which was introduced in plan of investigations (table 1).

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 23ºC, 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.

Made from the AlCu2,8Si10 alloy was used to the investigations of the casting alloy of Si trunk of car starter (fig. 4). Investigation this has the aim the qualification of the influence the cryogenic processing on the change of propriety stamina of the multiple saturating technical alloy.

### Table 1.
The composition of settled and analyses DTA of the optimum parameters of the thermal processing samples AlCu, 7

<table>
<thead>
<tr>
<th>The kind of the thermal processing</th>
<th>Temperature [º C]</th>
<th>Time [h]</th>
<th>Cooling</th>
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<tbody>
<tr>
<td>Saturating</td>
<td></td>
<td>30 60 120 240</td>
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<tr>
<td></td>
<td>175</td>
<td></td>
<td>In water to the temperature of surroundings</td>
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<td></td>
<td>200</td>
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<td>{ the investigation of hardness Rm, Re, Ar }</td>
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<td></td>
<td>220</td>
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<td>275</td>
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<td>350</td>
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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 º C),
2. secretion of \( \Theta '' \) the second pikes (the range secretion to approx. 240 º C),
3. secretion of \( \Theta ' \) the third pikes (range of secretion to 440 º C),
4. the fourth pikes the secretion equilibrium \( \Theta \) (the range secretion to approx. 520 º 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. 5).
The hardness of samples grows up with the outflow of the time for traditional and cryogenic processing (fig. 6) in the compartment of the temperatures of aging from 175°C to 220°C. Samples the highest hardness are characterize after the processing cryogenic aging in the temperature 200°C and the time ages 240 min.

The hardness of samples diminishes with outflow of time for the range of the temperatures of aging from 275°C to 350°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 (Re, 0.2, Re) and plastic (A5). The conventional border of plasticity Re, 0.2 he increases and endurance on the expansion of Rm of the aging alloy together with with extension of the time of aging and the temperature of aging- to 220°C (fig. 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).

The change of hardness, the stamina proprieties of the alloy AlCu4.7 in the time reflect the kinetics of the secretion of consolidating phaze Θ(Al2Cu) 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°C begins from creating the zones of GP. The DTA graph of aging (fig. 3 ) shows these. The observed more far growth of stamina proprieties, he is the hardnese the result of the secretion of metastable phaze indirect Θ" and Θ', until to being establishing stable equilibrium phaze Θ(Al2Cu). While aging in higher temperatures 175- 220°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°C after 120 and 240min, are the result of the presence in microstructure partly inclusions of phaze Θ" and Θ' (fig. 9).
Fig. 9. The microstructure of the AlCu4,7 alloy after traditional (OT) processing aging in the temperature 200°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 the temperature of aging from 175°C to 350°C. The microstructure of samples after the traditional processing also changed together with the temperature from 175°C to 350°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 CuAl2 phaze.

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(Al2Cu) whose particles expand while more far aging and undergo coagulation (fig. 10).

Fig. 10. 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

Optimum parameters registered in the investigations of the alloy were chosen to the investigations of the cast of starter made from the alloy of Si Al-Cu. The influence the thermal processing on the change hardness, what set in the trunk of the starter after aging in it was analysed in temperature 200°C and the time of aging 12h with the use of the traditional and cryogenic processing drawing 11 represents.

![Fig. 11. The hardness after aging the trunk - Al-Cu2.8-Si10, in the temperature 200°C and the time of aging 12h with the use of the processing of traditional (OT) and cryogenic (OK)](image)

Fig. 11. The hardness after aging the trunk - Al-Cu2.8-Si10, in the temperature 200°C and the time of aging 12h with the use of the processing of traditional (OT) and cryogenic (OK)

The influence of the thermal processing the strength of the expansion T_{HN} F_N which set in the trunk of the starter after aging was analysed in temperature 200°C and the time of aging 12 godzin with the use of the traditional and cryogenic processing it was introduced on drawing 12.

![Fig.12. Strength max F_N after aging the trunk in temperature 200°C and the time of aging 12h with the use of the traditional processing (OT) and cryogenic (OK)](image)

Fig.12. Strength max F_N after aging the trunk in temperature 200°C and the time of aging 12h with the use of the traditional processing (OT) and cryogenic (OK)

The change of the paintings of the microstructure which set in chosen optimum samples conducted for the trunk of the starter, after saturating and aging in temperature 200°C and the time of aging 12h, and then drawing 13, illustrates with the use of the cryogenic processing.
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. The cryogenic processing of the industrial alloy was conducted in the most profitable conditions.

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.

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

References