UDK 669.715:669.296:546.65
Izvirni znanstveni članek

ISSN 1580-2949
MTAEC9, 39(6)221(2005)

INVESTIGATION OF THE TEXTURE OF AN RR 58 ALUMINUM ALLOY CONTAINING ZIRCONIUM AND LANTHANIDES

RAZISKAVA TEKSTURE RR 58 ALUMINIJEVE ZLITINE S CIRKONIJEM IN LANTANIDI

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Prejem rokopisa – received: 2005-07-04; sprejem za objavo – accepted for publication: 2005-11-03

The results of an investigation of the texture of an RR58 aluminum alloy containing zirconium and lanthanides are presented. The fraction of the texture components was determined by its relative intensity after a plastic deformation and precipitation heat treatment. After plastic deformation, four main texture components were found with the {220} component being dominant. After recrystallization, the {200} component appeared to be dominant over three more main components and several secondary components.

Key words: heat-resistant aluminum alloy, texture, relative intensity, zirconium, lanthanides

Prikazani so rezultati teksture RR 58 aluminijeve zlitine in njene odvisnosti od vsebnosti cirkonija in lantanidov. Delež komponent mikrostrukture je bil določen iz relativne intenzitete po plastični deformaciji in izločilnim žarjenjem. Po deformaciji so bile določene štiri glavne komponente teksture z {220} kot prevladujočo. Po rekristalizaciji je bila poleg treh glavnih in več sekundarnih prevladujoča komponenta teksture {200}.

Ključne besede: toplotno obstojna zlitina aluminija, tekstura, relativna intenziteta, cirkonij, lantanidi

1 INTRODUCTION

The mechanical and physical properties of crystals and polycrystalline aggregates with a predominant orientation (texture) are different in different directions. Orientation-dependent properties include the modulus of elasticity, the flow stress, the yield stress, the relative elongation and the magnetic properties. The texture of a deformed and recrystallized alloy also influences the corrosion behavior, because the corrosion resistance of the metal depends on the surface orientation of the grain, as well as on the content of the alloying elements[1].

The texture of metals and alloys with a low stacking-fault energy is usually well defined[2], while the texture of metals and alloys with a high stacking-fault energy is very complex, and there is no agreement on the components that define the ideal orientation.

In ref.[3] the three components of the metal texture – {1132}<111> + {123}<412> + {110}<112> – are proposed as basic. However, other combinations of texture components were also suggested[4].

The type of deformation texture in alloys strongly depends on the content of the alloying elements, and a gradual transformation of the texture from the pure metal to that of the alloys with increasing alloying-element contents was observed for a number of alloys, for example, in Cu alloys with Zn, Al and Ge[5].

The recrystallization texture depends on the same parameters as the deformation texture (alloying-element content, microstructure, processing) and, e.g., the formation of a cubic texture depends on the deformation degree, the annealing temperature, the recrystallization and the alloy composition. The rolling texture of f.c.c metals and alloys with a high stacking-fault energy is changed by recrystallization to the {100}<001> texture, known as a cubic texture. The most influential factors on the formation of a cubic texture in copper are the solute atoms of the alloying elements and the deformation degree. In comparison with copper, the formation of a cubic texture in aluminum is considerably more difficult and the most important factor in the formation of this texture in aluminum is the presence of different phases in the microstructure.

The rolling texture of f.c.c. metals and alloys with a low stacking-fault energy (alloy or brass texture) is changed after recrystallization to a texture whose average ideal orientation is approximately {113}<112>; however, other texture components are also present[5].

It is claimed that {225}<734> is the ideal orientation describing the recrystallization texture of brass more precisely; however, the texture {326}<634>, or {326}<835> was also proposed an ideal[5]. The texture is important because the properties and the behavior of metal during its fracture depend on the type and the degree of the directional orientation.

As part of a project aimed at determining the influence of zirconium and lanthanides on the microstructure and properties of heat-resistant aluminum forging alloys[1], the influence of chemical composition on the texture was also determined. In an earlier article[6] results on the polarization resistance of alloys were presented. In this work only the results of an investigation related to the effect of zirconium and lanthanides on the texture are presented.

2 EXPERIMENTAL

An RR58 alloy manufactured by melting was used as the experimental material. Zirconium was added in form of an Al-Zr5 pre-alloy and the lanthanides in the form of mischmetal (50 % Ce and 50 % other elements). The chemical composition of the alloys is given in **Table 1**.

After casting, the alloys were deformed with hot forging and cold rolling to a sample thickness of 0.5–0.6 mm. The specimens were homogenized at a temperature of 510–515 °C for 22 h, then submitted to a solid-solution treatment at 525 °C for 12 h, quenched in water at 32–35 °C and finally aged at 200 °C for 12 h.

Table 1: Chemical composition of the investigated alloys (mass fractions, *w*/%).
Tabela 1: Kemijska sestava raziskanih zlitin (masni deleži, *w*/%)

Alloy	Cu	Fe	Ni	Mg	Si	Zr	Lanthanides
1	2.10	0.96	1.21	1.28	0.30	-	-
2	2.15	0.91	1.20	1.26	0.29	0.083	-
3	2.11	0.91	1.19	1.26	0.28	0.150	-
4	2.10	0.93	1.20	1.25	0.28	0.176	-
5	2.10	0.91	1.18	1.24	0.28	0.244	-
6	2.12	0.94	1.21	1.24	0.29	-	0.15
7	2.13	0.93	1.19	1.26	0.27	-	0.25
8	2.10	0.90	1.20	1.23	0.28	0.140	0.15

The texture of all the alloys after plastic deformation and aging was determined by X-ray diffraction using diffractograms recorded on a Philips PW 1730 diffractometer with Cu radiation (35 kV, 20 mA), assuming that the share of the individual texture components was proportional to their measured relative peak intensity.

3 RESULTS AND DISCUSSION

3.1 Deformation texture

The texture was determined in the direction normal to the rolling plane. The analysis of the diffractograms shows that the {220} texture component was dominant, the presence of {111}, {200} and {311} was significant, and a minor share of the {422}, {420} and {311} components was also recorded.

The influence of zirconium and lanthanides is shown in **Figure 1** and **Figure 2**. The relative intensity of the dominant {220} texture component decreases with increasing zirconium content up to 0.15–0.18 %, and increases slowly with further zirconium content. The influence of zirconium content on the other texture

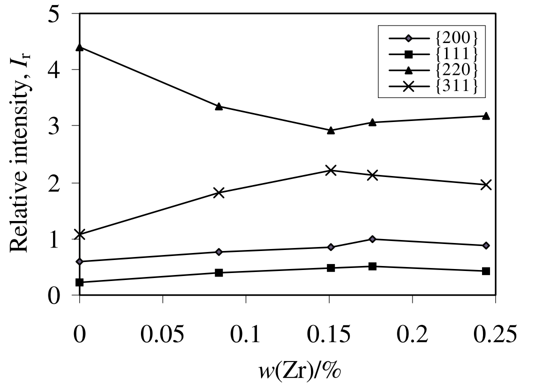

Figure 1: Influence of zirconium content on the deformation texture
Slika 1: Vpliv vsebnosti cirkonija na teksturo deformacije

components is the opposite; it is stronger on the {311} than on the two other components.

The effect of lanthanides on the change of the relative intensity of the texture components is similar to that of zirconium, as shown in **Figure 1** and **Figure 2**. It seems, however, that the addition of 0.15 % of lanthanides causes a sharper change of the texture than the same zirconium addition, as shown in the case of the alloy 8, with the content ratio 1:1 of zirconium and lanthanides.

3.2 Recrystallization texture

The recrystallization texture was determined on aged alloys. In **Figure 3** it is shown that the {200} texture component is dominant. The share of the {220}, {111} and {311} texture components is lower, but still significant, while the share of the {331}, {420} and {422} components is very small.

The influence of zirconium on the recrystallization texture is shown in **Figure 3**. The change in zirconium content has a strong influence on the dominant {200} texture component, and by increasing the zirconium content above 0.18 % the share of this texture component is decreased sharply. In parallel, above this zirconium level, a slow increase in the intensity of the {311} texture component occurs. The share of the {220}

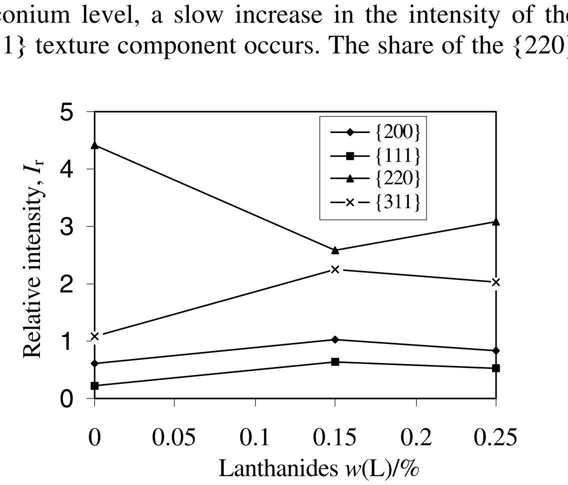

Figure 2: Influence of lanthanides content on the deformation texture
Slika 2: Vpliv vsebnosti lantanidov na teksturo deformacije

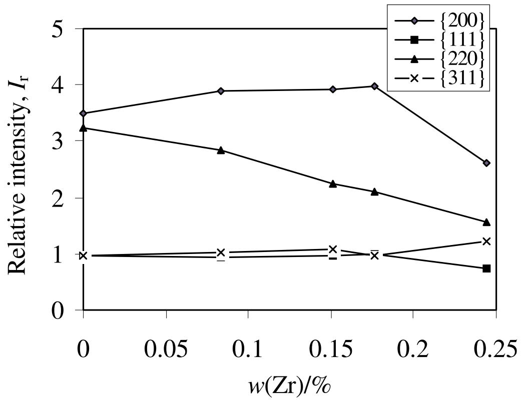

Figure 3: Influence of zirconium content on the recrystallization texture
Slika 3: Vpliv vsebnosti cirkonija na teksturo rekristalizacije

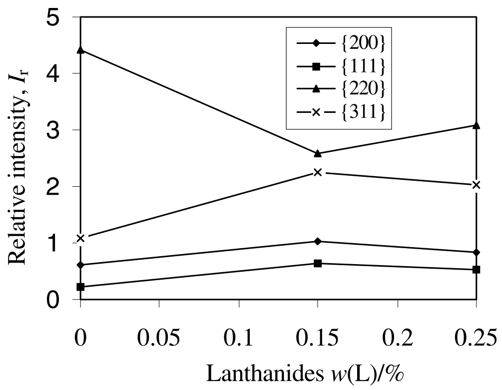

Figure 4: Influence of lanthanides content on the recrystallization texture
Slika 4: Vpliv vsebnosti lantanidov na teksturo rekristalizacije

and {111} texture components also decreases with the increasing zirconium content, the {220} component decreases more slowly.

A detailed analysis of the texture maxima from the recorded diffractograms suggests that the {331}, {420} and {422} secondary texture components are present in the recrystallized alloys in a greater share than in the deformed alloys[1].

Also, the addition of lanthanides influences the recrystallization texture (**Figure 4**) and their content significantly affects the {220} texture component. For a lanthanides content of 0.15 %, the relative intensity of this texture component is decreased almost three fold, while a further increase of lanthanides content is without influence on the share of this component. In parallel, the addition of 0.15 % lanthanides decreases the relative intensity of the {111} texture component almost two fold, while by increasing the addition of lanthanides to 0.25 %, the share of this component characteristic for the initial alloy is achieved again.

It is interesting that for alloy 8 (0.15 % lanthanides and 0.14 % Zr), the {111} component replaces the {200} texture component as being dominant. Also, the addition of zirconium to the alloy with lanthanides decreases the relative intensity of the {200} texture component and increases, to a different extent, the intensity of the other components[1].

These experimental findings are in good agreement with the theoretical prediction that the presence of precipitates of secondary phases has a strong influence on the texture, especially on the cubic texture of aluminum and its alloys[5]. The secondary microstructural phases and the initial grain size have a stronger influence on the recrystallization than on the deformation texture. Finely dispersed, secondary phases decrease the rate of nuclei and grain growth during the recrystallization. It is assumed that the nuclei formation rate is independent of the orientation and that the initially formed nuclei will have more time to grow than the those formed later. In this way, the initially formed orientation will prevail in the recrystallization structure. However, if the dispersed phases significantly hinder the growth rate of nuclei in the grains of the determined orientation, this orientation can be completely eliminated from the recrystallization texture.

4 CONCLUSIONS

Four main components are present in the texture after the deformation of the examined aluminum alloys: {220} as dominant, and {111}, {200} and {311} as the minor components. Besides these, several secondary texture components are found.

After the addition of zirconium the relative intensity of the {220} texture component is decreased up to 0.15–0.18 %, while the relative intensity of the other texture components is increased. The addition of lanthanides has a similar effect.

In the recrystallization texture of aged alloys, the {200} component is found to be dominant. Also, components such as {220}, {111} and {311} are present to a significant extent. The relative intensity of the minor texture components ({331}, {420} and {422}) is higher than that in the deformation texture.

The effect of zirconium on the {200} texture component is very strong and the share of this component is strongly decreased at a content above 0.18 % Zr.

The addition of 0.15 % lanthanides decreases the relative intensity of the {220} component by three times, and the intensity of the {111} component by about two times.

The texture component {111} is found to be dominant in alloy 8, containing lanthanides and zirconium in the ratio 1:1.

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