Effects of heat treatment and deformation on tensile strength and conductivity of Cu-Cr-Zr alloy doped with lanthanum and yttrium

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Abstract

Copper chromium zirconium alloy Cu-0.684Cr-0.077Zr-0.012La-0.020Y mixed with lanthanum and yttrium，after treatment at different solid temperatures, through metallographic microstructure and energy spectrum analysis, determine the alloy solid solution temperature is 920℃. After solution treatment at 920℃, the alloy underwent 40%, 60% and 80% deformation after quenching and water cooling, the results showed that after 60% deformation, 520℃ and 0.5 hour aging treatment, the alloy could obtain better comprehensive performance, with tensile strength of 527MPa and electrical conductivity of 73%IACS.

Introduction

In this paper, the changes of conductivity and tensile strength of Cu-Cr-Zr alloy with the addition of trace rare earth elements La and Y in the aging process were studied, and the aging precipitation characteristics of Cu-Cr-Zr-La-Y alloy and the influence of trace rare earth elements La and Y on the properties of Cu-Cr-Zr alloy were discussed in combination with its microstructure.

Methods

The raw materials used in the experiment were Cu-Cr50 (50%(mass fraction)Cr)、Cu-Zr40 (40%(mass fraction)Zr)、Cu-La50 (50.08%(mass fraction)La) and Cu-Y25 (25.68%(mass fraction)Y). The residual was standard cathode copper with purity of 99.9%(mass fraction). The alloy is smelted by ZG-0.02510kg vacuum medium frequency induction melting furnace,the final composition (%(mass fraction)) of the alloy is Cu-0.684Cr-0.077Zr-0.012La-0.020Y(hereinafter referred to as Cu-Cr-Zr-La-Y). After casting, the alloy ingot was forged into 1cm thick plate after the riser was cut,the skin was removed and the solid solution was treated. Both solution treatment and aging treatment were carried out in SX-5-12 box-type resistance furnace. After solid solution, the conductivity and tensile strength of the alloy samples were measured after aging. The conductivity sample size is 200mm×10mm×15mm. The conductivity was measured by sigma 2008 digital eddy current metal conductometer. CMT5305 microcomputer was used to control the tensile strength of the electronic universal testing machine. The metallographic samples were mechanically polished and impregnated with FeCl3, anhydrous ethanol and concentrated hydrochloric acid.

Results

Effects of solution at different temperatures and aging at 520℃ on microstructure of alloy.

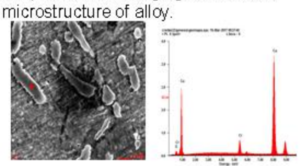


Fig.1 Undissolved matter energy spectrum analysis of Cu-Cr-Zr-La-Y alloy solid solution at 960℃ for 1.5 h and ageing at 520℃for 2 h

Energy spectrum analysis of Cu-Cr-Zr-La-Y was performed for the undissolved material at 960℃ for 1.5h and aging 520℃ for 2h. As shown in fig.1, it is divided into Cr (5.67%) and Cu (the rest). The matrix grains are very coarse and agglomerate, indicating that the solid solution temperature at this time is relatively high and the solid solution temperature should be lowered.

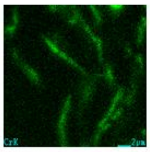


Fig.2 Line scanning analysis of Cu-Cr-Zr-La-Y alloy solution at 960℃ for 1.5h

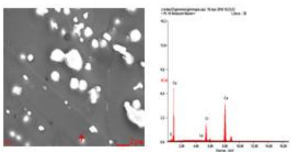
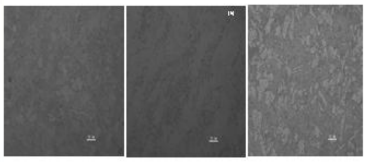


Fig.3Cu-Cr-Zr-La-Yalloy was dissolved in solution at 960℃ for 1.5h and aged at 520℃ for 2h.detect the energy spectrum analysis of rare earth elements

Surface scanning was performed on Cu-Cr-Zr-La-Y alloy with solid solution at 960℃ for 1.5h and aging at 520℃ for 2h, as shown in fig.2. It could be clearly seen that Cr rich phase was precipitated in large amounts and distributed in the form of strip aggregation. The Cu-Cr-Zr-La-Y alloy, which was dissolved in solution at 960℃ for 1.5h and aged at 520℃ for 2h, was tested for the energy spectrum analysis of rare earth elements.As shown in fig.3, the rare earth elements because of the adding quantity is less, the purifying grain boundary and contribution to the strength of alloy fine-grain strengthening effect is not big, but a small amount of rare earth elements because of its role can help purify the grain boundary secondary Cr rich phase at the grain boundary precipitates, help alloy precipitation strengthening effect.



(a) 960℃ solution 1.5 h	(b) 940℃ solution 1.5 h	(c) 920℃ solution 1.5 h

Fig.4 Microstructure of Cu-Cr-Zr-La-Y alloy with different solid solution temperature and aging

Fig.4 (a)、(b) and (c) show the metallographic microstructure of the Cu-Cr-Zr-La-Y alloy after 1.5 hours of solid solution at 960℃、940℃ and 920℃, quenching and cooling, and aging at 520℃ for 2h. The microstructure of Cu-Cr-Zr-La-Y was similar at different temperatures. Due to quenching stress, many quenching twins [6] occur in the alloy in fig.5(a) and fig.5(b), and the grains are relatively small. Most of these grains are distributed at the grain boundary.

The alloyCu-Cr-Zr-La-Y was dissolved in solution at 920℃ for 1.5h with different deformation and aging at 520℃. The tensile strength and conductivity of the alloy were shown in fig.5.

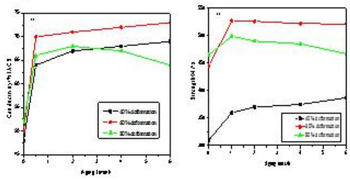


Fig.5 Relationship curves between conductivity(a) and tensile strength(b) of Cu-Cr-Zr-La-Y alloy and deformation amount after solid solution at 920℃ for 1.5h, quenching and water cooling, dealing with different deformation amount and aging at 520℃

Fig.5 shows the curve of the relationship between the conductivity, tensile strength and deformation of cu-cr-zr-la-y alloy after solution at 920℃ for 1.5h and the deformation of 40%, 60% and 80% after quenching and water cooling respectively. It is generally believed that after the cold deformation of the alloy, the aging phase nucleation point is increased, making the precipitated phase more diffuse and more evenly distributed, reducing the effect of discontinuous precipitates and thus improving the properties of the alloy [8].

Deformation on the influence of the conductivity and the influence law of temperature on conductivity is consistent, namely deformation, the greater the conductivity recovery is faster, as shown in fig.6 (a), at less than 60% of deformation degree, the conductivity of the alloy with the increase of the deformation degree rise. According to fig.6 (b), the tensile strength of the alloy increases with the increase of deformation degree. This is because the cold deformation in the alloy import a large number of dislocation, form work hardening, namely with the increase of deformation degree, increase of dislocation density, the dislocation reactions and delivery aggravate each other, the result is a fixed jog, dislocation tangles and other obstacles, in order to cause dislocation is difficult to through these obstacles and be limited within a certain range of movement.

Conclusions

(1) When the solid solution temperature at 960℃ and 940℃, the alloy grain is relatively large and Cr particles appear clustered and distributed in strips. After the solid solution at 920℃, no undissolved matter is found in the matrix. Solid solution at 920℃for 1.5 hours is the best solid solution treatment process of Cu-0.684Cr-0.077Zr-0.012la-0.020Y alloy.
(2) Cu-0.684Cr-0.077Zr-0.012La-0.020Y alloy was dissolved in solution at 920℃ for 1.5h,quenched water cooling, 60% deformation, aging at 520℃ for 0.5h, the best performance conductivity is 73%, the tensile strength is 527MPa.

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