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CHARACTERISTICS OF CuCrTiAl ALLOY AFTER PLASTIC DEFORMATION

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Preliminary Note – Prethodno priopćenje

The development of the automotive industry leads to the search for newer construction materials, but also those used in the production process. Although many types of joints are used in vehicles, resistance welds remain the dominant one. The commonly used alloy for welding caps (CuCrZr) is already well known and therefore newer alloys and technologies for their production are sought to increase service life, and thus reduce production costs.

Precipitation hardening CuCrTiAl alloy was analysed in this article. After casting, CuCrTiAl alloy was subjected to cold and hot deformation and then tested for its usability. The obtained results confirmed the potential of this alloy to make electrodes for resistance welding.

Key words: CuCrTiAl alloy, plastic deformation, precipitation hardening, microstructure,mechanical properties

INTRODUCTION

There are many studies on resistance spot welding [1,2] and the phenomena occurring during it, both in the electrode and in the welded material [3-6]. They focus mainly on the currently used alloy (CuCrZr). However, there are also other alloys and materials in the literature that could theoretically replace those currently used [7,8]. There are studies on modifications to the technology of producing welding caps [9], which are aimed at improving their operational parameters, and thus reducing operating costs [10]. This topic is so interesting that there were even attempts to use modern severe plastic deformation technologies in order to improve the properties of the CuCrZr alloy [11].

Bearing in mind the above, it was found that it is important to use the knowledge of phenomena in the field of not only the selection of alloys for specific applications, but also the impact of plastic forming and heat treatment technology in the search for better usability of materials for welding caps. Only the combination of all three issues gives hope for improving the properties of resistance welding electrodes. To achieve the assumed goals, knowledge from articles [12,13] and the team members` experience were used to develop the CuCrTiAl alloy and its heat and plastic treatment technology.

EXPERIMENT

After testing many CuCrTiAl alloys, alloy shown in Table 1 was determined for further research.

Table 1 **Chemical composition of used CuCrTiAl alloy/wt.%**

Cr	Ti	Al	Cu
0,81	0,24	0,064	balance

This alloy was cast by continuous horizontal casting. Figure 1 shows a block diagram of the research carried out.

The experiments were carried out on samples with dimensions of ø 14 x 20 mm. Heating to hot deformation was carried out using an induction coil, where the heating time was 30 seconds. The temperature was controlled using an Optris pyrometer, and the compression strain rate was 10 s^{-1}. After hot deformation, the samples were cooled in water. Cold deformation was carried out on samples with the same geometry, but with a strain rate of 10^{-1} s^{-1}. The set deformation in both cases was similar and amounted to about 60 %. Hardness was

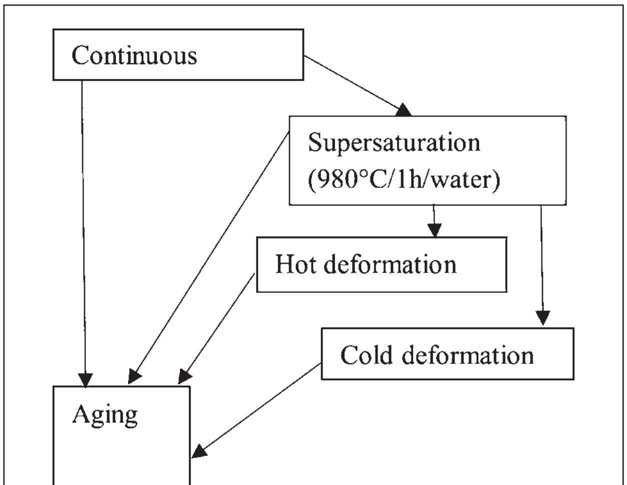

Figure 1 Scheme of the experiment.

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measured using the Vickers method and conductivity using the eddy current method on all samples. A Future-Tech FM-700 microhardness tester and a Foester Sigmatest 2.069 device were used for the tests. Additionally, structure studies were carried out using scanning microscopy of selected variants.

RESULTS

The cast bars were characterized by the conductivity of 25,4 MS/m and the hardness of 97 HV. Due to the small diameter of the bars and the intensive cooling during casting, aging was carried out without prior supersaturation, the purpose of which was to check the quality of supersaturation during casting. The results of this experiment are shown in Figures 2 and 3.

The experiment showed no significant effect of supersaturation on the effects of aging. However, in order to maintain the purity of the measurement, it was decided to use the supersaturation treatment for all tested variants.

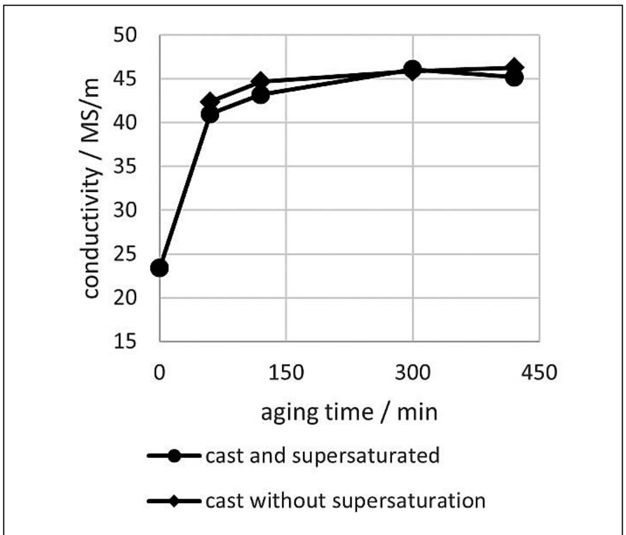


Figure 2 The influence of aging time on the conductivity of cast CuCrTiAl alloy.

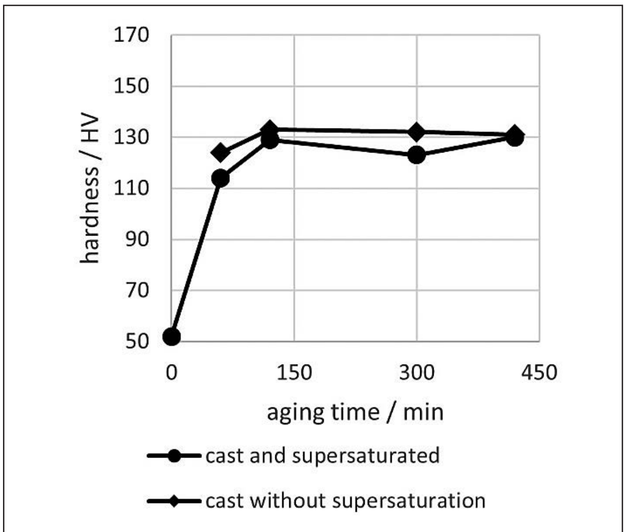


Figure 3 The influence of aging time on the hardness of cast CuCrTiAl alloy.

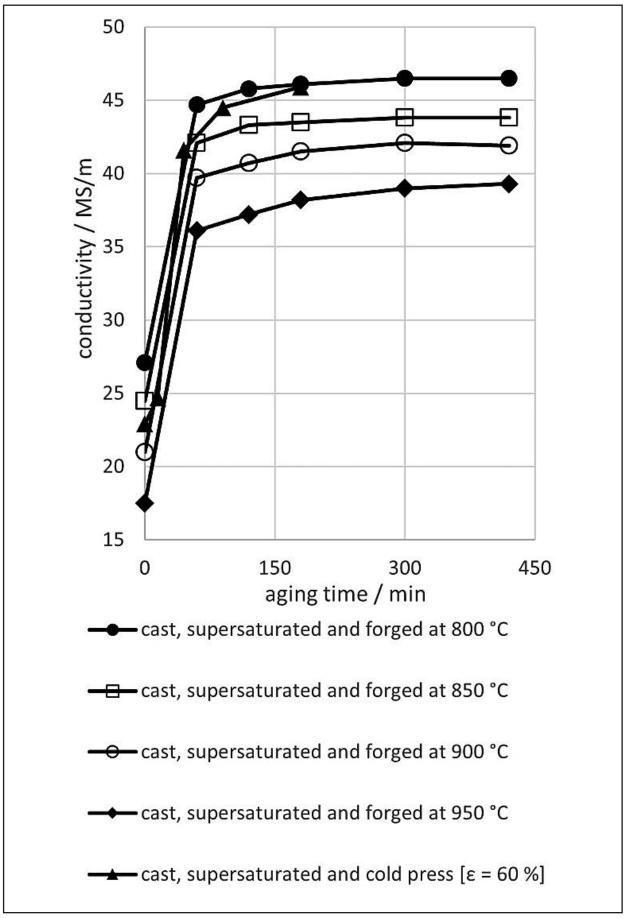


Figure 4 The influence of aging time on the conductivity of pressed CuCrTiAl alloy

Next, cold and hot deformation tests were carried out (Figures 4 and 5)

Results show that in the case of hot deformation in the tested alloy, although higher deformation temperatures improve the hardness, they worsen the conductivity, and the intermediate temperatures (800 and 850 °C) have the tested parameters at the level of the commercial CuCrZr alloy, the conductivity of which is 44-48 MS/m, and the hardness of 140-166 HV after plastic working and heat treatment. The most interesting result, however, is the sample aged after cold deformation, which after 90 minutes of aging achieved the hardness of 166 HV, i.e., in the upper limit of the conventional alloy, and the conductivity of 44,5 MS/m.

The hot-deformed and aged sample had a homogeneous structure (Figure 6a). Energy Dispersive Spectroscopy (EDS) analysis (Figure 6b) showed primary precipitates of chromium (point 3 in Figure 6b) and Ti and Al oxide particles.

The grain size in the material after cold deformation and aging, was similar to that in the material after hot deformation (850 °C) and aging (Figure 7a), however, in this variant, the primary precipitates of chromium are visible at the grain boundaries in the structure. Additionally, Ti and Al oxide particles were identified (Figure 7b).

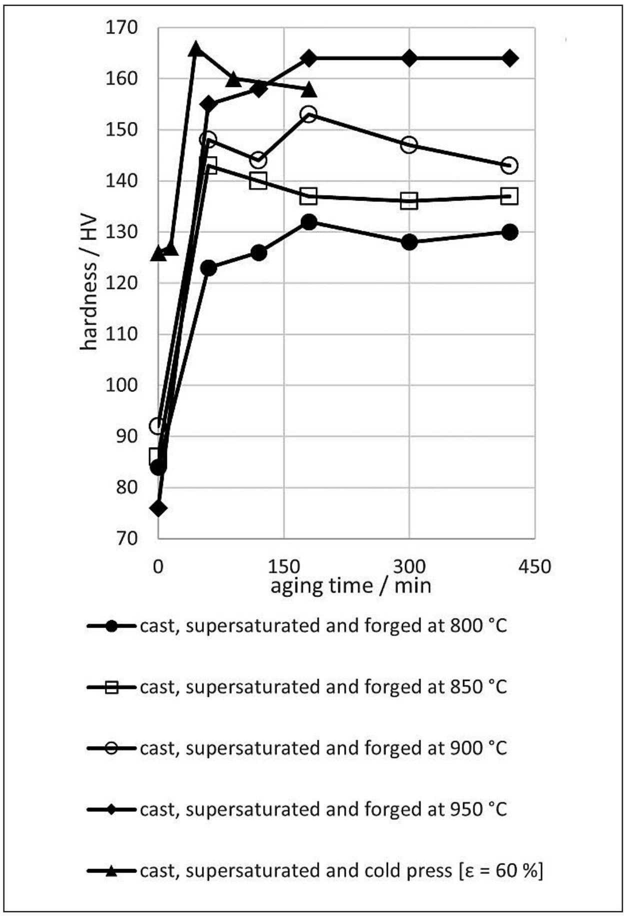
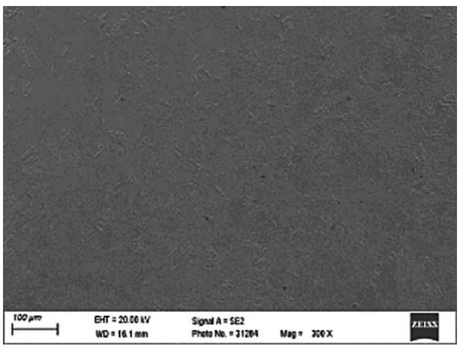
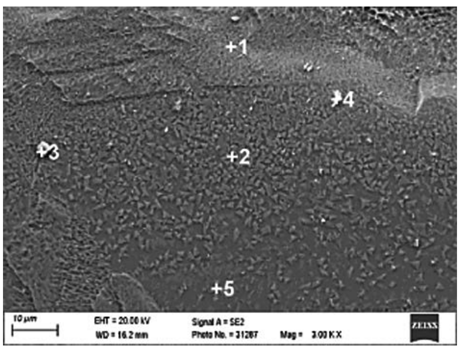


Figure 5 The influence of aging time on the hardness of pressed CuCrTiAl alloy.

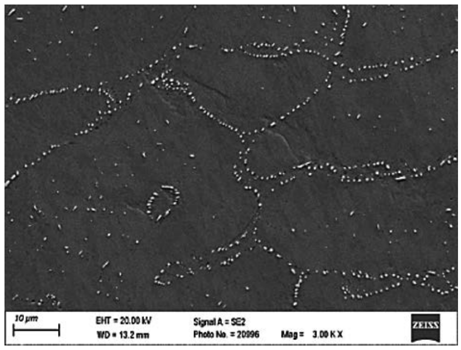


a)

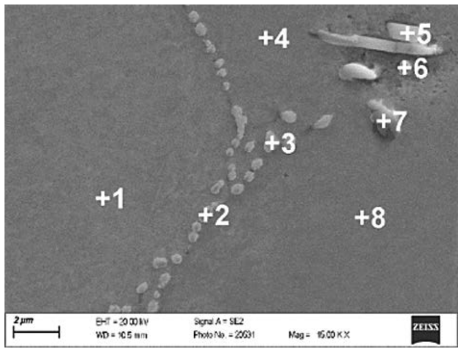


b)

Figure 6 Microstructure and EDS analysis of the CuCrTiAl alloy after hot deformation and aging at 480 °C for 2 hours, where the individual points have the following chemical composition (wt. %): 1. Cu-97,8, Cr-2,1, Al-0,1; 2. Cu-99,4, Cr-0,6; 3. Cu-5,1, Cr-82,4, Ti-3,2, P-9,2; 4. Cu-50,8, Cr-2,7, Ti-0,2, Al-26,2, O-20,1; 5. Cu-99,3, Cr-0,6, Al-0,1.



a)



b)

Figure 7 Microstructure a) and EDS analysis of the CuCrTiAl alloy after cold deformation and aging at 480 °C for 90 minutes, where the individual points have the following chemical composition (wt. %): 1. Cu = 99,10, Cr = 0,62, Al = 0,28; 2. Cu = 85,24, Cr = 14,46, Ti = 0,15, Al = 0,15; 3. Cu = 94,20, Cr = 5,56, Al = 0,24; 4. Cu = 99,09, Cr = 0,61, Ti = 0,04, Al = 0,26; 5. Cu = 35,78, Cr = 63,38, Ti = 0,16, O = 0,65, Al = 0,04; 6. Cu = 79,80, Cr = 1,60, Ti = 6,81, O = 7,36, Al = 4,43; 7. Cu = 71,24, Cr = 27,68, Ti = 0,19, O = 0,85, Al = 0,03; 8. Cu = 99,05, Cr = 0,80, Al = 0,14.

SUMMARY

1. The tested CuCrTiAl alloy after continuous casting to the size of ø 14 mm does not require supersaturation, because both samples without and with supersaturation after aging at 480 °C maintain comparable conductivity and hardness.
2. Hot deformation of the tested alloy at the temperatures of 800 and 850 °C followed by aging causes an increase in conductivity and hardness to the level of the CuCrZr alloy currently used for the welding caps.
3. Cold deformation and aging allowed the tested alloy to obtain high hardness (166 HV) and satisfactory conductivity (44,5 MS/m).
4. Although the structure of the cold-deformed and aged material has a grain size similar to that of the hot-deformed and aged sample, it shows a strong localization of primary chromium precipitates at the grain boundaries.
5. Cu0.8Cr0.2Ti0.1Al alloy, both after cold and hot deformation, shows comparable conductivity and hardness, which will be the subject of further research.

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Note: M. Krystowska is responsible for English language, Gliwice, Poland.