IJDIAS International Journal of Discoveries and Innovations in Applied Sciences

| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 2 Issue: 12

Analysis of Cu-Cr materials used in Contact Welding Electrodes

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Abstract:

The article is devoted to metallographic analysis of materials of welding tips used in production. The microstructures of the most commonly used Cu alloys for contact welding electrodes are evaluated. Cu-Cr alloys. Analysis of the influence of alloying elements and alloy production technology on the final properties of electrode materials is presented.

Keywords: Copper, chrome, electrodes, contact welding, material.

1. Introduction

The most commonly used method of welding car body sheets is contact welding. Despite the fact that this is a traditional welding technology that has been used in practice for a long time, it is necessary to solve some problematic problems, the successful solution of which will lead to the satisfaction of consumers and car manufacturers. The service life of welding tips also largely depends on the material, production technology, their shape, cooling intensity and the decisive influence used in welding parameters. For the manufacture of welding tips, alloys with a higher Cu content are used, which guarantee high electrical conductivity. These alloys are used for the manufacture of tips: Cu-Cr, Cu-Al_2O_3, Cu-Zr, Cu-Cr-Zr.

The biggest problem faced by automotive welding centers is the limited service life of welding tips in the process of welding sheets with a modified surface. When welding these sheets, the service life of welding tips is much lower compared to black sheets. Their service life is rapidly shortened due to the adhesion of coatings with a low melting point to the contact surfaces of welding tips, which cause the onset of eutectic, which has a negative effect on the transition resistance during welding. That is why it is necessary to periodically clean the contact surface of the tips after the specified welding Cu-Ni-Si, Cu-Ni-Si-Cr, Cu-W and others.

2. Analysis of the current situation in the production of materials for welding tips

The contact resistance depends on the state of the surface and determines the heat release and metallurgical reactions at the interface of the electrodes. When welding galvanized steel sheets, the low contact resistance due to the high conductivity of zinc provides a significantly higher welding current than when welding bare steel. The wear of the electrode has a deeper effect of free zinc at the electrode-sheet interface.

The fusion of copper with zinc to form brass increases the resistivity on the electrode surface. This, in turn, increases the temperature of the electrode during welding. The surface of the electrode is deformed as a result of repeated heating and mechanical action at the interface, and the brass formed on the surface of the electrode is often captured by sheets, leaving a ring with golden-colored depressions on the sheets. Consequently, the zinc coating contributes to the wear of the electrode.

Cu-Cr alloys contain from 0.5% to 1.5% Cr. They are used because of their high strength, corrosion resistance and electrical conductivity. These alloys can be hardened by aging, which means a change in properties occurring at high temperature due to the precipitation of chromium from a solid solution. The strength of the hardened Cu-Cr alloy is almost twice as high as that of pure copper (230 MPa), and its conductivity is only about 15% lower than that of Cu. These high-strength alloys retain their strength also at high temperatures (1000°C). Cu-Cr alloy is very good in cold forming. The alloy is successfully used in the production of electrodes for contact spot welding, electrodes for welding seams, cable lugs, brake system parts and electrical and thermal conductors with higher strength.

The properties of Cu-Cr alloys can be improved, with the exception of Zr alloying, by arsenic alloying. Hardening occurs due to an increase in the solubility of Cr in Cu with an increase in temperature. While the process of slow cooling of the Cu-Cr alloy continues, the structure is two-phase, including chromium and the alpha phase of copper. Excellent mechanical properties are achieved due to the rapid cooling of the Cu-Cr alloy from annealing temperatures, which leads to the fact that Cr is retained together with Cu in an oversaturated solid solution.

Thus, during the aging process, a uniform distribution of precipitation occurs in the matrix. Rapid cooling does not allow the precipitation of Cr from a solid solution, so the final structure consists only of the alpha phase of Cu. First, pure Cu solidifies, then a eutectic mixture of alpha-phase Cu and Cr.

The eutectic mixture of alpha-phase Cu and Cr forms a lamellar structure in the interendritic regions. To improve the workability of the Cu-Cr alloy, alloying elements such as Se, Te and Pb are added during splitting.

Mechanical properties can be changed by adding Ti (up to 0.5%) and Be (up to 0.1%). Cu-Cr alloys are used because of their high strength and electro thermal characteristics. By adding a small amount of alloying elements, these alloys can be modified into high-strength alloys or alloys with high conductivity.

For the manufacture of welding tips, it is necessary to find a compromise between strength and conductivity, which allow the use of these alloys also under harsh welding conditions (high current – short time).

3. Methodology of experiments

Welding tips and workpieces dedicated to production of welding tips were evaluted in the experiments. Samples for observation were from bar material and were taken off by a splintery process without a thermal impact. A metallographical analysis of examined samples was done on metallographical cuts with optical ligh microscope Olympus CX-31. A metallographical analysis was carried out on Cu alloys whose standard physical and chemical characteristics are presented in Table 1.

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Table 1. Standard physical and chemical characteristics of welding tips and workpieces.

Alloy Standard	Chemical composition	Hardness HV	Electrical Conductivity %	Sample shape
Cu-Cr	Cr 1,5 Cu residue	105	65	Welding tip

The observed welding tips of standard shapes and sizes intended for contact welding are shown in figures 1.

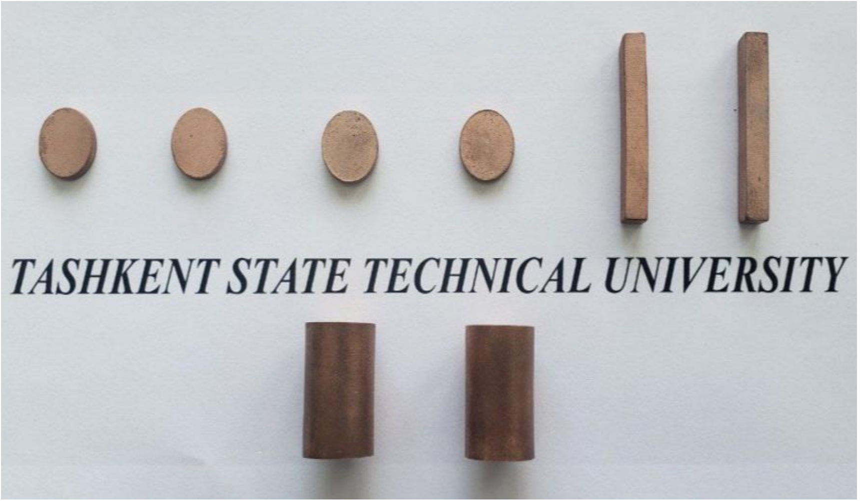

Figure1. Sample for metallographic analysis from Cu-Cr material

4. Results of metallographic analysis

At Figure 2, there is the microstructure of Cu-Cr alloy with typical rectangular double boundaries of grains of rigid solution of alfa-phase of Cu.

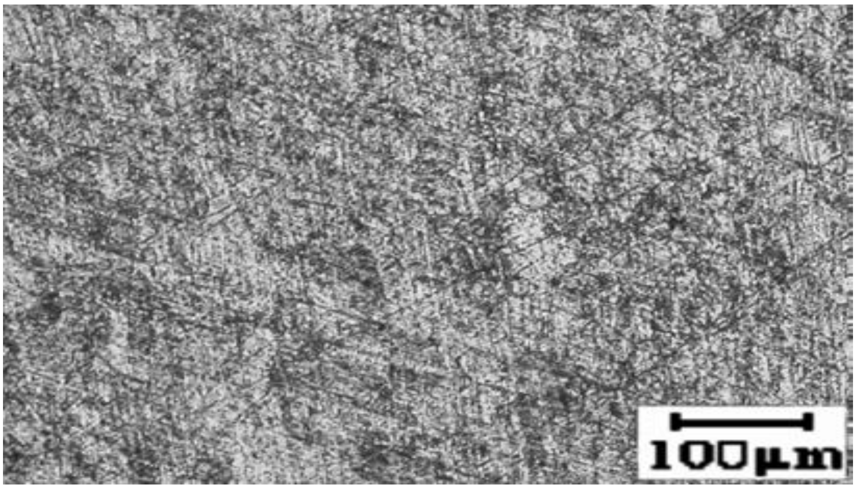

Figure 2. Microstructure of Cu-Cr alloy

In the Cu matrix – see Figure 2 relatively massive Cu grains, separated on typical platy formation is shown. For visualization of a microstructure, the following etching was used: 1g of ammonium hydroxide NH_4 OH + 2 g of ammonium persulphate $(NH_4)_2$ S_2 O_8 (2,4 %) in 100ml of distilled water.

Conclusion

Electrodes used in contact welding are currently widely used in Uzbekistan. UzAvtoprom alone imports 300,000 pieces of copper electrode for contact welding per year in the aisles. The aim of our research is to produce new types of electrodes using local raw materials.

There are several ways to reduce consumption. The development of the production of welding tips is constantly evolving. Alloys with high conductivity and hardness are observed. This allows them to be used in the application of rigid modes of contact welding.

Experimental tests conducted in our laboratories confirmed the positive effect of Cr as an alloying element in conventional Cu-Cr alloys, which led to an increase in the service life of welding electrode tips without a significant negative effect on their electrical conductivity.

The way to increase the service life of welding tips is the combination of alloying elements in copper alloys, the method of their manufacture, as well as geometric design.

Acknowledgements

This work was supported by the grant (project ID AK-001/22 (2022)) announced by The Ministry of Innovative Development.

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