

# The Preliminary Heating at Welding Copper and Steel

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**Abstract** Stability of process of welding of copper with copper and copper with steel is provided with a special thermal cycle which includes preliminary heating before welding. Difficulties welding copper and steel are connected with its physical and chemical properties, high affinity of copper to oxygen, the low temperature of melting of copper, considerable absorption by liquid copper of gases, various sizes of coefficients of heat conductivity, linear expansion etc. In view of high heat conductivity of copper the most part of heat entered at welding is removed from heat input zone that leads to necessity of supply to a place of welding considerably a more heat, than at welding other metals. More rational is the local heating. Using impulse heating of welded details at welding copper and steel instead of gas flame lowers carbonization of details' surfaces. Uniformity of welded details microstructure is provided. Welding defects caused by non-uniform heating are eliminated.

**Keywords:** impulse source of heating, welding of copper with steel, welded details, microstructure, details fusion line

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## 1. Introduction

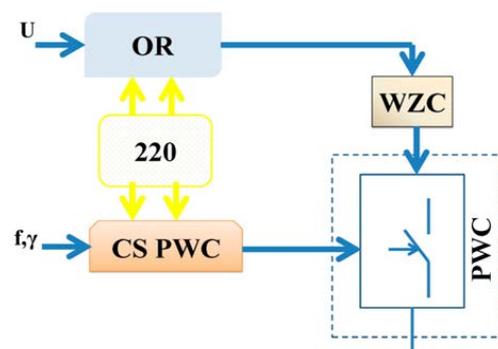
Improvement of technology of welding and methods directed on increase of reliability of welded compounds of copper with steel, increase of mechanical properties of ready details an important task of welding branch of mechanical engineering. In welding processes, the input parameters have greater influence on the mechanical properties of the weld joints. The heat conductivity of red copper is good, so we should choose welding methods with high heat efficiency and concentrated heat quantity. It is beneficial if the heat efficiency is high and the energy is concentrated. In practice the local heating is produced by the different sources of heat up to heating by gas-oxygen torches, by a welding arc etc. Modern development of the production gas welding equipment more wide use for this aim of the special gas-oxygen burners of type GZU (Russia), working on gas mixture or natural gas. However the way of gas preliminary heating has many shortcomings [1]. Therefore researches of pulse preliminary heating of details before welding are executed.

## 2. Experimental Procedure

Therefore welding of copper with steel is carried out with preliminary and attendant heating [1]. Applying preliminary heating the thermal condition regulation of welded connection is carried out. However, despite of the quite good results received at gas-flame preliminary.

Heating this way has some lacks:

- Oxidation of metals superficial layer and additional carbonization of superficial layer of copper and steel.
- Difficulty of regulation temperature on the side of copper and on the side steel.
- Complication of regulation temperature on the thickness of metal (At increase of metal thickness various layers of metal heat up differently - closer to a surface metal gets warm up to higher temperature) [2]. With the purpose of removal of the above-mentioned defects applied is the impulsive heating of metal by the currents of rectangular form. In this case the forced heating of the local site to the necessary temperature is provided and the size of thermal influence zone is decreased [3]. The generator of a pulsing current of the rectangular form has been applied for this purpose with power up to 2 kW with adjustable frequency, porosity and current size (Figure 1) [4].



**Figure 1.** The structural diagram of a pulse current generator; OR - the operated rectifier, CS PWC a control system of the pulse-width converter, WZC - a working zone contact

The rectangular form current allows to make the forced heating of a detail with high speed up to temperatures at which there is a qualitative welding process of copper with steel (amount of energy in time unit at the rectangular form pulsing current has 2 times more energy in time unit than the variable sinusoidal form current does). Welding wire with powder obtained according to research [5].

Research microstructures executed by means of microscope. In technology of arc types of welding the weld-fabricated guy-sutures appear with the use of parent metal and flux cored electrode at formed in the narrow zone of crystallization molten metal. The metal of the weld fabricated guy-sutures is estimated on indexes by analogical to the parent metal: durability, plasticity, viscosity and to other indexes. The special value at welding has maintenance of carbon over 0,3%, that results in the loss of plasticity of zone of the weld-fabricated guy-sutures, in addition, maintenance of admixtures in the copper of Bi, Pb, S and O result in formation of eutectic connections also resulting in the loss of plasticity of the weld-fabricated guy-sutures. Samples for metallographic analysis were cut mechanically from sites that cover all areas of the weld: direct suture, heat-affected zone, and exciting area of basic metals steel and copper, and in a direction transverse to the weld and along the weld heat affected zone. Mechanical polishing carried out on the special polishing machine Monfasupal № 1381550 with a circle with a diameter of 200 mm fitted by felt. Frequency of rotation of a circle from the electric motor is equal 800 rpm. Cloth moistens with polishing liquid which give continuously or periodically. To a rotating circle with cloth press the ground surface a sample and in the course of polishing turn. Polish to a total disappearance *песок* and receiving a smooth surface that borrows at well ground surface of 5-10 min.

The microstructures of the samples were studied on microscope ERNST LEIST GmbH Dialux.

For all options that were investigated were determined conditions providing the formation of high-quality weld metal during welding. Metallographic study of thin sections of welded joints showed that in all cases the structure of the weld metal welding and biphasic. For weld metal compound copper-containing mild steel, iron to 2% of typical coarse cast structure.  $\epsilon$ -solid phase solution of iron in copper, with iron concentration less 1,8% fine-grained structure of the seam, chopped inclusions and  $\alpha$ -phase. With an iron content of more than 2%, there are round or outlet inclusion  $\alpha$  - phase solid solution of copper in iron. Photo weld copper to steel (Figure 2).



Figure 2. Welding copper to steel using a pulsed preheating, a-steel; b-copper

Good formation of a seam and lack of defects – result of pulse preliminary heating.

Mechanical properties of a welded seam are influenced by a microstructure of border of alloy age. Than more dendrites of iron at the alloy age line especially are stronger a welded seam and plasticity of a seam decreases cause such defects cracks on alloy age border. At research of a microstructure of a welded seam of Figure 3 it is visible that the structure as steel and copper at the line of alloy age has uniform character. Dendritnoye a structure of steel prevails the more, than farther from the alloy age line. On an axis of a welded seam copper and steel hashing the uniform.

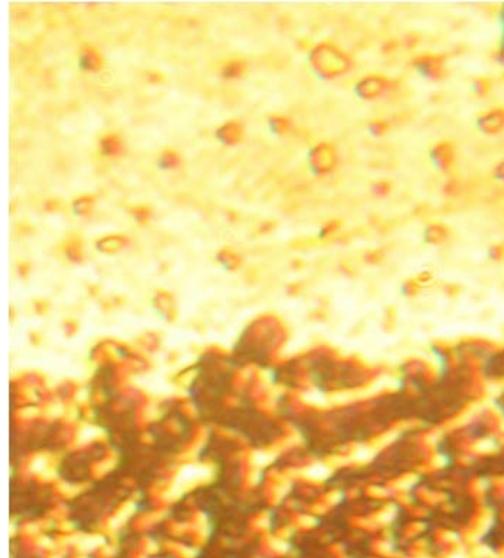


Figure 3. line steel alloying with copper

The photo shows a uniform distribution of the dendrites of iron in the fusion line. Mechanical properties of the weld shown good results.

However applying traditional gas heating the alloy age line Figure 4 is more sated with dendrites of iron and has lower mechanical properties.

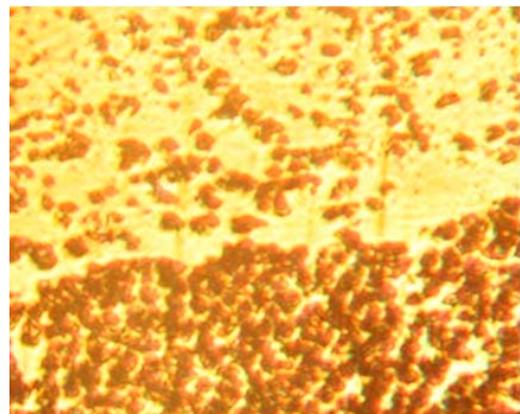
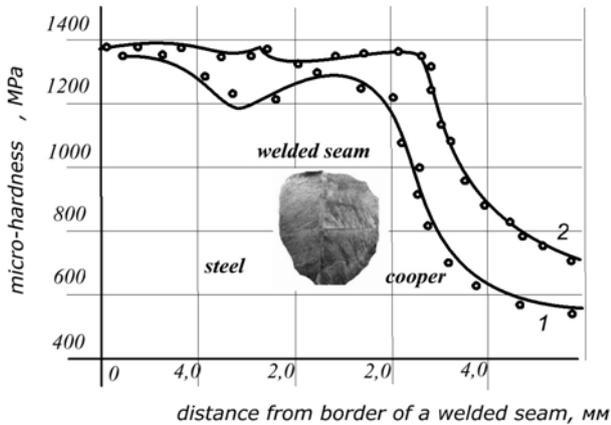


Figure 4. The raised maintenance of dendrites iron at the alloy age line

To define plastic properties of a welded seam it is possible if to measure micro-hardness. In Figure 5 the schedule of dependence of micro-hardness from a distance border of a welded seam is shown.

Micro-hardness of border alloy age from steel has insignificant growth; it is connected with bigger concentration of iron in a welded seam. However on

border of alloy age there is a jump micro-hardness the copper parties of border of alloy age above, than for the annealed copper because of existence of dendrites of iron in heat affecter zone.



**Figure 5.** The dependence of micro-hardness from a distance border of a welded seam. 1. welding without heating, 2. welding with preliminary heating

### 3. Conclusions

1. It is raised a plastic zone of thermal influence, the metal workability after welding is improved.
2. The findings, thus applying a pulse preheating rid of the defects inherent in gas-fired.

3. Lack oxidation of metals superficial layer and additional carbonization of superficial layer of copper and steel.
4. Fine adjustment of regulation temperature on the side of copper and on the side steel with generator of a pulsing current.
5. Applying preliminary heating it is possible to increase plasticity of a heat affecter zone.

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