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Analysis of weldability of copper and copper alloys

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ABSTRACT: This article provides an analysis of the weldability of copper and copper alloys

KEY WORDS: copper, welding, brass, bronze, oxygen, hydrogen

I. INTRODUCTION

When welding copper, it is necessary to take into account the specific properties of this metal, the main ones being high thermal conductivity, high fluidity and significant activity of the metal when interacting with oxygen and hydrogen in the molten state. Due to the high thermal conductivity of copper (almost 6 times greater than that of steel), for fusion welding it is necessary to use heating sources with high thermal power, as well as increased heat input compared to steel. For example, arc welding is performed at increased currents with electrodes of large diameters. High thermal conductivity also leads to very significant cooling rates of the weld metal and heat-affected zone and a short residence time of the weld pool in the liquid state. This impairs the formation of the seam and causes difficulties during metallurgical processing of the bath. Good weld formation can be maintained by preheating, which ensures a more even distribution of heat in the weld pool. In addition to eliminating defects (undercuts, sagging, cracks, porosity), preliminary and concomitant heating of the base metal improves the conditions for crystallization of the weld, reduces internal stresses and eliminates the tendency of the weld metal to form cracks. Products with a thickness of more than 10-15 mm are heated with a gas flame, a dispersed arc and other methods to the following temperature: copper - 250-300°C, brass - 300-350°C, bronze - 500-600°C.

II. LITERATURE SURVEY

Due to the high thermal conductivity of copper, special requirements are placed on the types of joints and fusion welding techniques. Uniform formation of seams can be achieved only with a symmetrical location of the heating source in relation to the edges being welded. Therefore, it is convenient to weld butt joints or those approaching them in terms of the nature of heat dissipation into the parts being welded. Copper T-joints and lap joints are difficult to make. [1]

The high fluidity of copper, which is approximately 2-2.5 times higher than that of steel, does not allow one-sided butt welding to be carried out on the fly with complete penetration of the edges and good formation of a seam on the reverse side. [2]

Single-pass butt welds require the use of backing pads that fit tightly to the metal being welded: copper, graphite, dry asbestos, flux pads, etc. The high fluidity of copper also makes welding in a vertical and especially overhead position difficult. Vertical seams can be welded using the argon arc method on copper up to 10 mm thick. [3]

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In this case, special technological methods are used aimed at reducing the size of the weld pool and reducing the fluidity of the metal by alloying it with silicon. This difficulty also applies to welding circumferential seams with a horizontal axis of rotation. Welding such seams is feasible only if the smallest dimensions of the weld pool are ensured and the minimum time for the metal to remain in the liquid state. Welding circumferential seams becomes more complicated as the diameter of the product decreases and the thickness of the metal increases. [4,5]
Since copper actively absorbs gases - oxygen and hydrogen, which have a negative effect on the mechanical properties of welded joints and increase their susceptibility to porosity and crystallization cracks, during welding measures must be taken to reliably protect the weld metal from contamination by harmful impurities - gases. Corresponding requirements must be presented to welding materials. [6]

III. METODOLOGY

A major obstacle to welding is porosity associated with the release of hydrogen dissolved in copper during the cooling and crystallization of the weld metal. The reason for the release of gas bubbles is a decrease in the solubility of hydrogen during crystallization of the seam. The high cooling rate due to the high thermal conductivity of copper creates favorable conditions for the formation of pores. Pores and cracks can also be caused by water vapor formed as a result of the reaction of hydrogen with copper oxide. If carbon monoxide is present, it may interact with copper oxide. The resulting carbon dioxide, without having time to escape from the metal, also causes porosity. The absence of boiling of the weld pool when welding copper with copper wire aggravates the process of pore formation. Boiling of the bath when welding other metals, such as steel, helps remove gases from the liquid metal. A serious difficulty encountered when welding copper is the tendency of seams to form crystallization cracks, which is facilitated by its specific thermophysical properties: large coefficients of thermal expansion and thermal conductivity, significant shrinkage during solidification, and others. Impurities present in copper, and primarily oxygen, antimony, bismuth, sulfur and lead, form low-melting eutectics with the metal, which accumulate at the boundaries of crystallites and reduce their strength. Thus, lead, which forms oxides (PbO, PbO_2, PbO_3), gives a low-melting eutectic with a melting point of 326°C, and bismuth, which forms oxides (BiO, Bi_2O_3, Bi_2O_5), gives a eutectic with a melting point of 270°C. Therefore, the content of impurities in copper intended for welded structures is limited (oxygen - up to 0.03%; bismuth - up to 0.003%; antimony - up to 0.005%; lead - up to 0.03%). For critical structures, the content of harmful impurities in copper should be even lower (oxygen - up to 0,01%; bismuth - up to 0,0005%; lead - up to 0,004%). For particularly critical products operated at high temperatures and in vacuum or reducing hydrogen-containing atmospheres, it is recommended to use oxygen-free copper with an even lower oxygen content—less than 0,003%—as a structural material.
To avoid brittleness of welds at elevated temperatures as a result of the formation of Cu_2S — Cu eutectic, the sulfur content in the copper being welded should be less than 0,1%. Phosphorus in small quantities (up to 0,1%) has a beneficial effect, as it is a weld deoxidizer and converts oxides into slag. Silicon and manganese can also be deoxidizers when welding copper, but they are less effective than phosphorus.
Copper welds are characterized by a coarse-grained columnar structure, due to the high thermal conductivity of the metal. Intense heat removal from the weld axis into the base metal creates favorable conditions for directional crystallization—pulling large-sized crystallites in the direction of the heat flow. The coarse-crystalline structure of the seams increases their tendency to form crystallization cracks.
The thermophysical properties of copper cause significant deformations of welded products and increased residual welding stresses.
At temperatures above 200°C, the strength of copper decreases with a simultaneous decrease in ductility (unlike other metals, such as steel, in which a decrease in strength at elevated temperatures is associated with an increase in ductility). In the temperature range of 250–550°C, at which the plasticity of copper reaches minimum values, cracks can occur. In this regard, rigid fastenings should be avoided. It is not recommended to make seams in two passes, since the first pass already creates a rigid fastening. Tacks should be replaced with sliding fasteners. Forging seams, which are used to increase their ductility, cannot be carried out in the specified temperature range.
When moving from welding copper to welding alloys based on it - brasses and bronzes - additional difficulties arise. When welding brass, zinc can evaporate (its boiling point is 907° C, that is, lower than the melting point of copper), which leads to the formation of pores.
Zinc vapor combines with oxygen to form zinc oxide, which, like the vapor itself, is toxic and is released in the form of a dense white cloud. Therefore, when welding brass, special requirements are placed on the ventilation of the welder's workplace. Preheating the metal and increasing the welding speed can reduce the spreading of liquid brass and reduce the evaporation of zinc. Due to intense zinc evaporation and burnout, its concentration in the weld metal decreases. Additional introduction of silicon or manganese into the weld reduces zinc losses. Silicon has the most beneficial effect:

a thin oxide film formed on the surface of the weld pool prevents the evaporation of zinc. In this regard, the additive made from the LK 62-0,5 alloy is very effective.

Welding bronzes is accompanied by the appearance of brittleness and a decrease in strength at high temperatures. Burnout of impurities can lead to the formation of pores and cracks, and changes in the composition of the seam. When welding aluminum bronzes, refractory aluminum oxide Al_2O_3 is formed, which also negatively affects the formation of the seam: the melting of the metal worsens, pores and cracks appear. Since aluminum oxide does not dissolve in bronze, it contaminates the weld metal in the form of non-metallic inclusions and reduces the mechanical properties of welded joints.

To obtain high-quality seams, it is necessary to destroy the oxide film. This is achieved by using special halogen fluxes during arc welding. Tin bronzes in the molten state and during crystallization do not form a sufficiently strong film impenetrable to gases on the metal surface. Therefore, the metal can become saturated with gases, including hydrogen, which leads to the appearance of pores in the weld. Copper-tin alloys have a very long solidification range, much longer than other types of copper alloys. This promotes the formation of crystallization cracks. Measures are taken against the occurrence of cracks aimed at reducing stresses in welds, in particular, they do not allow parts to be fastened as rigidly as when welding steel.

The most suitable for welding are silicon (about 30% Si, 15% Zn) and low-silicon (3.0% Si, 15% Zn) bronzes. Silicon-manganese bronzes (about 3% Si, 1% Mn) have good welding properties. A thin film of silicon oxide isolates the weld pool from interaction with gases. Unlike aluminum oxide film, it easily dissolves in flux.

IV.CONCLUSION

The results of the research performed were the necessary basis for choosing the optimal copper welding method

REFERENCES

[1]. Khudoyorov S.S., Dunyashin N.S., Ermatov Z.D., Sadikov J.N., Saidakhmatov A.S., Abdurakhmonov M.M. Study interaction of metal with complex gases containing oxygen in manual arc welding// International Journal Of Advanced Research in Science, Engineering and Technology – India, 2023. – Vol.10, № 1 (January). – pp. 20324 – 20328

[2]. Ermatov Z.D., Dunyashin N.S., Galperin L.V., Nikitin V.N., Sadykov Zh.N. Fusion welding technology and equipment. T: Fan va texnologiyalar nashriyot-matbaa uyi, 2023. -220 p.

[3]. Ermatov Z.D. Welding of special steels and alloys. T: Fan va texnologiyalar nashriyot-matbaa uyi, 2023. - 180 p.

[4]. Verkhoturov A.D. Methodology for the creation of welding consumables: monograph - Khabarovsk: Publishing House of the Far Eastern State University of Railway Engineering, 2009. - 128 p.

[5]. Khudoyorov S.S., Galperin L.V, Dunyashin N.S., Ermatov Z.D., Saidakhmatov A.S., Abdurakhmonov M.M. Study interaction of molten metal and slag in arc welding// International Journal Of Advanced Research in Science, Engineering and Technology – India, 2022. – Vol.9, № 9 (September). – pp. 19771 – 19775

[6]. Khudoyorov S.S., Galperin L.V., Dunyashin N.S., Ermatov Z.D., Saidakhmatov A.S., Abdurakhmonov M.M. Study of the refining process in electric arc welding// International Journal Of Advanced Research in Science, Engineering and Technology – India, 2022. – Vol.9, № 12 (December). – pp. 20244 – 20249

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