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EFFECT OF PLASTIC DEFORMATION THE METAL FOR ELECTRODE ON ELECTRIC ARC

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Abstract

The paper presents the results of an experimental study to determine the effect of the degree of plastic deformation of the low-carbon steel electrode wire (0.23% carbon) on the burning of an electric arc. Before testing, the wire samples were compressed to different degrees of deformation. During the study, the effect of the dispersion of the dislocation cellular structure of cold-deformed steel on the process of burning an electric arc was determined and the effect of the ferrite grain size was estimated. It was found that for an electrode made of low-carbon steel, the effect of resistance to the process of burning an electric arc from the side of ferrite grain boundaries with large misorientation angles exaggerates the effect of sub- and grain boundaries. The state of a solid solution acquires the effect of the presence of an additive contribution in the structure of steel sub- and grain boundaries.

Keywords: welding wire, electric arc, low carbon steel, cold plastic deformation, substructure, ferrite, grain size

When using electric arc welding technologies, one of the parameters that directly affects the quality of the welded joint is the stability of the electric arc burning. Traditionally, this property is improved by adding components with low ionization potential to the electrode coating (flux) [1, 2]. On the other hand, the burning of the welding arc can be affected by the state of the metal wire, which undergoes a certain degree of plastic deformation and, as a result, changes its initial properties [3, 4], including electrical conductivity. Therefore, the purpose of the research was to determine the influence of the degree of plastic deformation of the electrode wire from low-carbon steel on the burning of the electric arc.

Methodology

A wire from low-carbon steel with a carbon content of 0.23 % was used as the electrode. For uniform distribution of cementite particles in the ferrite matrix, steel was heated to a temperature above Ac3, quenched in water and subjected to tempering at a temperature of 650 °C for 1 hour.

Electrodes for research were obtained by plastic deformation blanks at room temperature to different degrees of deformation. The initial diameter of the blank was selected in such a way that after deformation by the required value, the electrode for research had same final diameter (1 mm). One part of the electrodes was used to study influence to dispersed cell structure of dislocation of cold-deformed steel on the process of electric arc combustion, the second part to assess influence of the ferrite grain size. Different grain sizes were obtained by annealing at a temperature of 650 °C, deformed wire at different degrees of deformation.

The study structure of the steel after annealing was carried out under a light microscope, and after cold deformation - under a transmission electron microscope (UEMV-100K). The size of the ferrite grain and dislocation cells was determined by quantitative metallography methods. The study of the electric arc combustion process was carried out under conditions direct electric current, direct and reverse polarity, using a PSG-500 converter.

Results

Formally, by analyzing process of burning an electric arc, it was determined that, regardless of its polarity, an increase at degree deformation of the metal is accompanied by an increase at magnitude of the electric current.

Moreover, the above-mentioned nature of the influence is preserved for the steel of electrode after annealing. Along with a qualitatively identical nature influence of sub- and microstructural elements of the steel on the process of burning an arc, there are some differences. They are that in comparison

with a monotonic inversely proportional relationship between the current strength and size of the ferrite grain, an extremum is formed on the dependence for deformed steel. The need to determine the mechanism influence of the steel structure prompted used of the relationship between the current magnitude and the surface tension force during formation a drop of liquid metal.

According analysis of the constructed correlations the electric current strength from a grain size of the ferrite and diameter to cells of dislocation, different resistance to arc burning was determined off subboundaries of the plastically deformed steel and boundaries of the ferrite grain after its annealing. It is necessary to take into account that grain boundaries formed by the mechanism of their movement during development processes of collective recrystallization have a large disorientation angles. As a result, their presence at steel structure should contribute to a greater extent to an increase in current strength during arc burning compared to the substructure.

Indeed, when a cell structure of dislocation is formed in plastically deformed steel, subboundaries arise, have small disorientation angles and to a lesser extent contribute to an increase in the arc current strength. Moreover, when extrapolating dependence of the electric current magnitude on the size of the grain or sub grain to an infinitely large size (similar to a single crystal), influence of the solid solution state was determined. The above position is confirmed by the dependence state of the solid solution (ferrite) on the method of forming a steel structure: cold plastic deformation or recrystallization annealing.

Thus, to conducted studies determined that for electrode of the low-carbon steel, resistance to the electric arc burning process from the side of ferrite grain boundaries with a large disorientation angles more significantly compared to the influence of sub-boundaries. In addition, influence magnitude of the electric current from the presence of sub- and grain boundaries at steel structure, the solid solution state makes an additional additive contribution.

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ЕФЕКТ ПЛАСТИЧНОЇ ДЕФОРМАЦІЇ МЕТАЛУ ЕЛЕКТРОДУ НА ЕЛЕКТРИЧНУ ДУГУ

Анотація

У роботі представлено результати експериментального дослідження з визначення впливу ступеня пластичної деформації дроту електроду з низьковуглецевої сталі (0,23 % вуглецю) на горіння електричної дуги. Перед випробуванням зразки дроту обтискували на різні ступені деформації. Під час дослідження визначали вплив дисперсності дислокаційної чарункової структури холодно деформованої сталі на процес горіння електричної дуги й оцінювали вплив розміру зерна фериту. Встановлено, що для електроду з низьковуглецевої сталі, ефект опору процесу горіння електричної дуги з боку меж зерен фериту з великими кутами разорієнтації перебільшує вплив субмеж. До впливу від присутності в структурі сталі суб – і меж зерен адитивного внеску набуває стан твердого розчину.

Ключові слова: зварювальний дріт, електрична дуга, низьковуглецева сталь, холодна пластична деформація, субструктура, ферит, розмір зерна

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