СЕКЦІЯ 5
ЗВАРЮВАННЯ ТА СПОРІДНЕНІ ПРОЦЕСИ І ТЕХНОЛОГІЇ. МАТЕРІАЛОЗНАВСТВО

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METHODOLOGY OF A QUANTITATIVE ASSESSMENT OF WELDING AND TECHNOLOGICAL CHARACTERISTICS OF COVERED ELECTRODES

The main parameters of the welding mode, which are traditionally used to assess the stability of mass transfer, are the duration of the short circuit of the arc gap ($\tau_{s.c..}$, ms), the cycle duration - the period of formation and transfer of the drop ($T_{s.c.}$, ms), current value (maximum - I_{max} and minimum - I_{min}, A); current rise rate (V_{rise} $I_{w.}$ та V_{drop} $I_{w.}$, A/s) [1, 2]. In addition, for example, in publication [3] the authors propose to use as a criterion of stability the standard deviations of the duration of the short circuit ($\sigma\ \tau_{s.c.}$) and their frequency ($\sigma\ T_{s.c.}$), while the authors of publications [2, 3] speak of rms deviation of the amplitude value of the current ($\sigma\ I_{w.}$), short-circuit current ($\sigma\ I_{w.max}$) and the coefficient of variation of the rate of increase in the short-circuit current ($K_v\ I_{w.max}$). Thus, there is no single standardized methodology for determining the stability of the welding process and the choice of research methodology depends on the parameters of the object of study.

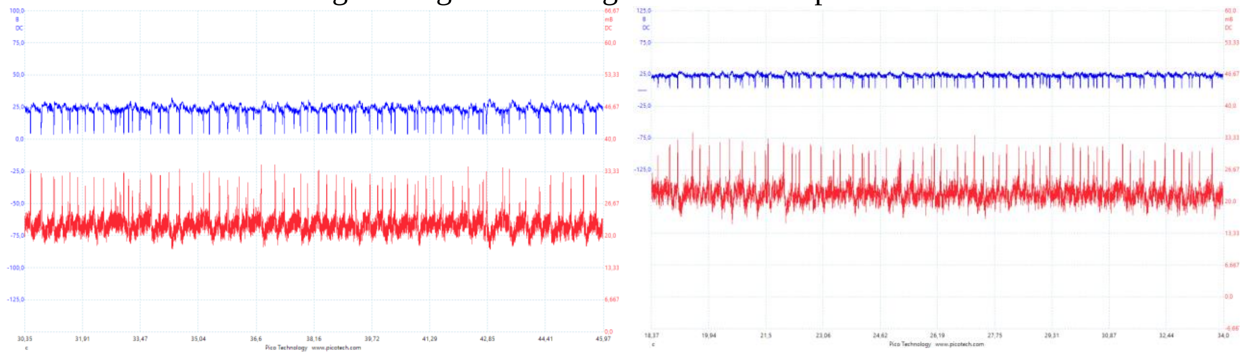
First, it should be noted that the vast majority of certified electrodes have a basic type of coating. Arc burning for this type of covering occurs exclusively with short-circuits of the arc gap. In this regard, our work studies the stability of the welding process with electrodes with the main type of coating. Based on the analysis of existing relevant publications and previous research, we have selected the following criteria for assessing the stability of the mass transfer process: the average frequency of short circuits – fav.; standard deviation of the frequency of short circuits - σ; coefficient of variation of the frequency of short circuits - Kvf = σ / fav.; the estimated mass of the drop, defined as the physically obvious ratio of the mass melting rate to the mass transfer frequency mav. = dM / fav.

The calculated mass of the drop is necessary for comparison with the critical mass of the drop $m_{dr.}$, which constitutes one of the limiting criteria for assessing the stability of the process. The authors took as the critical mass the mass of the drop with a diameter equal to the diameter of the electrode (for example, for an electrode with a diameter of 4 mm $m_{dr.}$ = 0.26 g.). Thus, the first condition of the process stability is inequality $m_{av.} < m_{dr.}$

The given statistical markers of mass transfer (short circuits) characterize the stability of the process; however, they do not fully determine the convenience and quality of welding. All previous researchers have noted the importance of increasing the frequency and decreasing the weight of the drop for improving the convenience and quality of welding [1-4]. In this regard, considering that the average frequency of short circuits cannot be completely objective for comparison since it varies within the limits described by the coefficient of variation, our work for the first time introduces a new indicator - the critical mass transfer frequency, which equals to the difference between the mean frequency and the standard deviation of frequency – $f_{dr.} = f_{av.} - \sigma$. Accordingly, under such conditions the formation of drops with an average maximum size is possible $m_{max} = dM / f_{dr.}$, which can be further taken into account for comparison with the critical mass of the drop $m_{dr.}$

The reliability of the obtained results depends on the methods of their gathering and processing. In this regard, we performed the measurement and recording of electrical parameters as well as their statistical characteristics using a measuring system PicoScope 4444 and PicoScope 6 software. They allow to automatically determining the arithmetic mean and standard deviation of the welding current and voltage and additionally the mass transfer frequency.

The effectiveness of medodika was tested on the products of PJSC "PlasmaTech". Traditionally, a mixture of iron powders PZHRV 2.200.28 (TU 14-1-5365-98) and DIP 400 30W (EN 10204 3.1) was used for the production of UONI-13/55 "PLASMA" electrodes at the company's enterprises. After purchasing of a set of equipment at Atomising System Ltd. (England), it became possible to produce iron powder of its own production. Welding was performed in the lower position in the following modes: welding current - 160A, arc voltage - 24V, welding speed - 14cm / min. Characteristic oscillograms are shown in Fig. 1. The obtained average indicators of stability criteria of electrode melting in the given welding conditions are provided in Table 1.



a) b)

Fig. 1. – Oscillogram of current (75mV = 500A) and arc voltage during welding: a) – traditional technology; b) – advanced technology.

Table 1 – Criteria for the stability of welding process

Electrode manufacturing technology	Average frequency, $F_{av.}$, Hz	Critical frequency, $F_{dr.}$, Hz	Coefficient of variation, $K_{vf.}$, %	Average drop mass, $M_{av.}$, gr	Critical drop mass, $m_{max.}$, gr
traditional	3.7	3.53	6.2	0.161	0.168
advanced	4.14	3.92	5.3	0.148	0.156

Welding with electrodes that contain optimized iron powder of own production in the coating allows to significantly increase the stability of the process and increase the frequency of mass transfer. In absolute units, the average mass transfer rate increased by 10.6%, the critical mass transfer rate increased by 9.9%, and the coefficient of variation decreased from 6.2% to 5.3%. Characteristically, the average drop weight decreased by 8.1%, moreover the maximum average drop weight (0.156 g) is less than the average drop weight (0.161 g) for traditional electrode manufacturing technology, which is a significant positive effect and allows to improve considerably the welding and technological properties of the electrodes and improve the quality of welding in general.

The proposed method of estimating the criteria for stability of the welding process with covered electrodes with the main type of coating (mean frequency of short circuits, standard deviation of short circuit frequency, coefficient of variation of short circuit frequency, estimated average drop weight and, in addition, the critical average frequency of short circuits) allows assessing quantitatively and with high reliability the stability parameters of the welding process.

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CRACKING RESISTANCE OF MOLYBDENUM-RHENIUM ALLOY FOR ARMATURES OF THERMOELECTRIC CONVERTERS (TC)

Industrial thermoelectric converters (TC) of the immersion type work in conditions of a large gradient of shock measured temperatures, mechanical, chemical and, in some cases, radiation influence of an aggressive environment [1].

The structural element of the TC is the protective fitting, which has high requirements: a) ensuring the specified accuracy of temperature measurement in a certain interval with minimal inertia in relation to the heat flow; b) mechanical strength at thermal shocks; c) exclusion of direct contact of thermoelectrodes with the controlled environment (hermeticity and gas tightness); d) lack of influence of the armature material on the electrodes; e) sufficient operating resource; g) acceptable technological processing [2].

Molybdenum is used as an armature material for high-temperature TCs operating in environments up to 2000^0C. Unlike the rest of the refractory metals, it has a number of positive properties that are acceptable for ensuring the workability of the structure: high melting point and modulus of elasticity, low coefficient of thermal expansion, high indicators of thermal resistance and thermal conductivity, small cross-section of thermal neutron capture. However, in the process of operation, the material of the armature is recrystallized, starting from the contact surface with the environment. Further grain growth into the depth of the armature wall depends on the intensity of thermal shocks and the metallurgical purity of molybdenum [3].

The combined effect of thermo-mechanical stresses and structural unevenness contribute to the manifestation of molybdenum's typical disadvantages - a tendency to crack formation and brittleness.

The main technological measures to improve the mechanical properties of reinforcement are riveting (rolling) and recrystallization heat treatment, as well as alloying, mainly to ensure technological and operational plasticity.

The promising alloy Mo+Re (3.5%) was studied for the resistance to crack formation in the material after rolling, as well as after heat treatment by annealing ($T^0_{annealing}$ = 1200...2000^0C; step 200^0C; holding time $t_{annealing}$ = 1h) under mechanical loading at a constant speed (v= $69\cdot10^{-5}$ m/s) at the temperature of the external environment ($T^0_{testing}$= -50...200^0C). The tests were carried out on samples measuring 48·8·2mm along the rolling line along the longer side with a 4·0.2 mm notch; the IMASH-20-75 installation.

J(Jc) is the integral and stress intensity factor KQ(KQc), which were calculated according to GOST-25.506-85 methods, [4] (Fig. 1, 2).

The results of the research show that in the temperature range (-50...+20^0C) the fracture energy is spent only on the nucleation of the crack with the subsequent one-moment decay of the sample, and at temperatures higher than +20^0C part of the energy is spent on the growth of the crack, which