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Prospects for the Application of Deformed Materials with Increased Physical and Mechanical Properties

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Abstract: The paper shows that increasing the physical and mechanical properties of materials, in particular increasing the hardness and decreasing the thermal conductivity, can be achieved with the help of pre-recrystallization heat treatment due to the grinding of the polygonal substructure to the nanoscale size. The possibility of thermal stabilization of the polygonal substructure of steels by combined deformation has been proven, which ensures the practical application of pre-recrystallization heat treatment for the regulating springs of membrane valves of pipelines made of steel 70 (2CS67).

Keywords: pre-recrystallization heat treatment; physical and mechanical properties of steels, thermal stabilization, polygonization substructure.`

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LABORATORY COMPLEX UPE-500 FOR DETERMINING WELDING AND TECHNOLOGICAL CHARACTERISTICS OF COATED ELECTRODES

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Abstract: The article presents the methodology of a quantitative assessment of welding and technological characteristics of covered electrodes using UPE-500 complex, which provides high stability of the process of control welding in all spatial positions in automatic mode. The complex is equipped with the PicoScope 4444 measuring system with PicoScope 6 software that traces and

statistically processes with high-reliability parameters of stability of welding process, which allows controlling in real-time mode the quality of production of commercial batches of electrodes.
Keywords: assessment methodology, automatic mode, covered electrode, stability of welding process.

The stability of arc burning during manual metal arc welding with covered electrodes has a decisive role in the quality of welding. In this regard, manufacturers of welding materials make considerable efforts to improve this characteristic and control it in the process of manufacturing of covered electrodes. Scientific research and industrial company "AMITI" LLC (Mykolaiv), on the request of PrJSC "PlasmaTek" (Vinnytsia) has designed and manufactured a laboratory complex UPE-500 (TU U 27.9-20864642-003:2021) that enables the manufacturer to monitor product quality by quantitative indicators in online regime [1]. The Bi-Auto principle of operation is embedded in the algorithm of the complex, which provides for automatic fixation, processing and recording of received data with simultaneous stabilization of welding modes that is also performed in automatic mode. The complex performs fixation of electrical parameters of arc burning, as well as of their statistical characteristics, using the PicoScope 4444 measuring system and PicoScope 6 software.

Automatic welding with covered electrodes in manual metal arc welding modes has its own specific characteristics, which were taken into account by the developers when designing the UPE-500 complex. For instance, the automatic stabilization of the arc voltage is complicated by low current density (minimum about 10A/mm^2). In this case, ensuring a positive coefficient of static stability of the power system “power source - arc – product” definitely requires the use of power sources with a steeply falling characteristic [2], and the stabilization of the arc voltage is ensured by changing the length of the arc, that is, the speed of feeding the electrode material [3]. Similar systems for changing the feed rate are known as automatic arc voltage control (AAVC) systems with negative feedback on the arc voltage. Such systems are successfully used for automatic submerged arc welding under a layer of flux, which differs from manual metal arc welding by higher current density (minimum approx. 80A/mm^2) and process stability. A comparison of existing AAVC systems showed that their use at a current density of less than 50A/mm^2 is limited by the high (approx. 30ms) electromechanical constant of the electrode material supply complex mechanism [4]. In this regard, in order to reduce the electromechanical constant of the covered electrode feeding mechanism, the UPE-500 complex uses a system with a stepper motor and a ball-screw transmission, which makes it possible to reduce the electromechanical constant to the level of ≈ 1ms. The reduction of the electromechanical constant, combined with the use of a suitable mathematical apparatus and a controller possessing necessary speed of response, makes it possible to use a proportional-integral-differential (PID) control system to stabilize the arc voltage. As a result, the known equation of the law of change in the rate of supply of the electrode material [4]:

$$\mathrm{Vr} = \mathrm{Kcon}\ (\mathrm{Ua} - \mathrm{Us}), \tag{1}$$

converts to:

$$\mathbf{Vr} = \mathbf{Kconp}\ (\mathbf{Ua} - \mathbf{Us}) + \mathbf{Kconi} \times \int_0^t (\mathbf{Ua} - \mathbf{Us})\mathbf{dt} + \mathbf{K\,cond}(\mathbf{Ua} - \mathbf{Us})/\mathbf{dtVr} = \mathbf{Kconp}\ (\mathbf{Ua} - \mathbf{Us}) + \mathbf{Kconi} \int_0^t (\mathbf{Ua} - \mathbf{Us})\mathbf{dt} + \mathbf{Kcond}(\mathbf{Ua} - \mathbf{Us})/\mathbf{dtVr} = \mathrm{K}\mathbf{conp}\ (\mathbf{Ua} - \mathbf{Us}) + \mathrm{K}\mathbf{coni} * \int_0^t (\mathbf{Ua} - \mathbf{Us})\mathbf{dt} + \mathrm{K}\mathbf{cond} * (\mathbf{Ua} - \mathbf{Us})/\mathbf{dt}, \tag{2}$$

where Vr is the feed rate; Ua, Us are actual and specified arc voltage; Kconp, Kconi, Kcond are proportional, integral and differential control coefficients accordingly. Overall, the use of a more advanced AAVC system in the UPE-500 complex allows to stabilize the arc voltage at the minimum current density, which is typical for manual arc welding.

The complex allows to carry out welding with the use of various power supplies, both of direct and alternating current. It is strictly forbidden to use welding power supplies with oscillators, stabilizers, or other pulsed high-voltage devices to stabilize the arc. The complex consists of three parts: the control panel with port for connection of the personal computer, the unit of measurement and switching, with a possibility of connection of the oscilloscope, and the manipulator. The appearance of the manipulator is shown in Fig. 1.

The manipulator imitates in automatic mode the moves characteristic to the welder's movement of the welding tool across and along the joint and the electrode feed during welding with a covered electrode. At the same time, the function of dynamic regulation of the feed rate with the feedback stabilizes the arc voltage, which in its turn fixes the length of the arc with high accuracy. The complex also provides digital recording of parameters and video recording of the welding process. In addition, the complex is connected to the central server of the enterprise, which allows controlling the quality of electrode production online. All the information obtained is archived, which makes it possible to have a database for further statistical analysis in order to determine the optimal ways to improve electrode production.

Fig. 1. Exterior appearance of the manipulator.

To ensure high-quality test welding using the UPE-500 complex, welding process specifications (WPS) have been developed for butt-welded and corner joints, as well as for surfacing in all spatial positions. Specifications of welding processes are prepared in accordance with the requirements of the standard DSTU ISO 15609-1: 2019. Welding and surfacing technologies are certified in accordance with the requirements of DSTU EN ISO 15614-1: 2019 and DSTU EN ISO 15614-7: 2019. The characteristic outer appearance of joints welded using the UPE-500 complex is shown in Fig. 2.

The capabilities of the complex allow to quantify the melting stability of electrodes that are mass-produced and to automatically compare the obtained data with the reference standards, which allows to ensure the desired quality of electrode production. In addition, the laboratory complex can be used to assess the effective range of parameters of the welding mode of specific brands of electrodes, arc elasticity (recommended range of arc length during welding), the impact of covering components and their condition on the melting stability of electrodes, as well as for testing new brands of electrodes to launch their mass production, resolving customer complaints questioning the quality of electrodes, and solving a lot of other matters accompanying modern electrode production. This principle of operation allows obtaining authentic characteristics of the melting stability of the electrodes, without subjective intervention of the operator.

a) b)

Fig. 2. Outer appearance of butt weld (a) and fillet weld (b) joints in welding positions: a) - overhead; b) – horizontal-overhead.

CONCLUSION

The UPE-500 laboratory complex performs welding in all spatial positions in automatic mode with simultaneous stabilization of the process and carries out automatic fixation, processing and recording of the received data, which allows to quantitatively evaluate the welding and technological characteristics of covered electrodes without the subjective intervention of the operator.

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ВПЛИВ ЕЛЕКТРОІМПУЛЬСНОГО СПІКАННЯ НА СТРУКТУРУ І ВЛАСТИВОСТІ Ti-Al ПОРОШКОВОГО МАТЕРІАЛУ

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Анотація. В роботі проаналізовано технології твердофазного та електроімпульсного спікання на структуру і властивості порошкового матеріалу Ti-Al. Для досліджень застосовано методи комп'ютерної металографії, рентгеноструктурного аналізу, методику визначення теплопровідності.

Ключові слова: порошкові матеріали, спікання, металографічні дослідження, рентгеноструктурний аналіз, теплопровідність

Порошкова металургія є одним із сучасних технологічних методів отримання виробів з заданими фізико-механічними властивостями. Порошкова металургія є одним із сучасних