in which $f_{cutoff} = (2\pi fRC)^{-1}$ (here, R, C are the resistance and capacity of the component elements), time constant is not less than 100 ms [1]. Here it turns out to be impossible to achieve the required fast control of beam current for welding with pulsed modulation of beam current, or apply secondary-electron systems of following the butt of the edges being welded in real time, when it is necessary to set and stabilize beam current during 5 ms pulse.

When resistive current sensor is mounted in the high-voltage circuit of these power sources, the feedback signal has a low noise level, the need for its filtration is eliminated, and fast control of beam current becomes possible. Such a solution, however, makes the equipment more complicated and less reliable [2].

In inverter power sources with high-frequency transformation of mains voltage mounting current feedback resistor in the plus circuit of the power source is applicable due to the fact that frequencies of the variable component lie in the high frequency region (f = 20–30 kHz) (Figure 2). Filters with 2–3 kHz cutoff frequency can be applied for filtering these components that corresponds to time constant $t <$ < 0.2 ms.

Thus, current feedback resistor in electron beam sources of accelerating voltage operating at industrial frequency should be mounted in the rectifier high-voltage circuit, and in inverter power sources with high-frequency transformation of mains voltage, it is rational to place it in the rectifier plus circuit.

1. Moshits, G., Khorn, P. (1984) *Design of active filters*. Moscow: Mir.
2. Nazarenko, O.K., Lanbin, V.S. (2007) Investigation of high-voltage control circuits of welding electron beam current. *The Paton Welding J.*, **5**, 17–20.

THESES FOR A SCIENTIFIC DEGREE

E.O. Paton Electric Welding Institute of the NAS of Ukraine

On October 6, 2010, V.I. Dzykovich defended his thesis for Candidate of Sciences on «Investigations and development of the materials for wear-resistant surfacing based on spheroidized granules of the tungsten carbides».

The analysis of existing materials for surfacing of wear-resistant composite alloys based on fragmented particles of the tungsten carbide was carried out. It is shown that the spherical shape of particles due to maximum volume of spherical particle at minimum specific surface area is the most perspective for improvement of quality of deposited layer, decrease of a level of dissolution of reinforcing particles during surfacing, enhancement of operating abilities of the composite coatings and increase of a volume fraction of wear-resistant granules in the deposited layer.

The thesis substantiates selection of a method of thermocentrifugal sputtering of refractory materials for obtaining spherical tungsten carbide particles for their application as a wear-resistant phase in a composition of the materials for composite surfacing.

Using mathematical modeling of a method of thermocentrifugal sputtering of tungsten carbide the corresponding equations connecting the main parameters (thermal characteristics of heat source, speed of rotation) with the process efficiency and dimension of the forming tungsten carbide (relite) granules are proposed, and, as a result, the mechanism for control of granulometric composition of tungsten carbide $WC-W_2C$ spheroidized granules was developed. A formula for calculation of a rotation speed of spindle assembly of the unit for sputtering of material of the necessary granulometric composition was obtained.

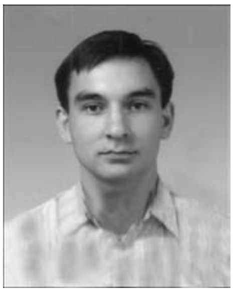
The technology for melting of source materials with application of induction heating was developed that allows obtaining the ingots for the thermocentrifugal sputtering of high quality eutectic composition.

Investigations of influence of ingot quality for sputtering on structure, properties and stochiometric composition of obtained spherical particles of the tungsten carbides were carried out. In comparison of the spheroidized granules of tungsten carbides with analogues of the well-known foreign companies it was determined that the particles made using the thermocentrifugal sputtering have the maximum values of microhardness and uniformity of chemical and phase composition.

The technology for thermocentrifugal sputtering of refractory materials using plasma arc as a heat source, and commercial equipment were developed on the basis of obtained theoretical and experimental results. The optimum mode for sputtering of tungsten carbide ingots is welding current of 550–600 A at arc voltage of 38–40 V. At that, the optimum speed of vertical feed for ingot makes 0.12–0.18 mm/s. A speed of ingot rotation is the basic parameter influencing granulometric composition of the spherical sputtering particles. At that, a change of the frequency of rotation from 1200 up to 10000 rpm allows obtaining particles of 1000–50 μm in size.

The investigations of morphometry characteristics of spheroidized granules of the tungsten carbides $WC-W_2C$ were carried out for the first time, and it was determined that all testing powders have very stable and uniform indices on shape of particles. A yield of the tungsten carbide spheroidized granules by 15–20 % higher than that of the source material in separation of a nonspheric constituent from the composition of finished material that has positive influence on the operation of dosing units in some methods of surfacing.

Surfacing materials for deposition by different methods of wear-resistant composite layers based on the tungsten carbide spheroidized granules were developed. The maximum concentration of reinforcing phase in the deposited layer (up to 50 %) was achieved in surfacing of the test samples owing to the biggest volume of spherical particles at minimum specific surface area as compared to the fragmented particles. The minimum dissolution of the particles (up to 5–10 %) in the deposited layer is achieved due to absence of the concentrators of non-uniform heating of particles (spherical shape has no sharp angles). At the same time, there are no secondary iron-tungsten carbides which, significantly, embrittle deposited layer, in the alloy matrix, in particular, based on nickel and copper. Wear resistance of the samples, deposited by different methods using spheroidized granules, on average is 25 % higher of that of the samples with fragmented particles of the tungsten carbides. This is explained by increased microhardness of spheroidized granules, absence of the defects in a form of pores and cracks in them, as well as minimum content of the brittle phases in the alloy matrix.



E.O. Paton Electric Welding Institute of the NAS of Ukraine

On October 6, 2010, T.R. Ganeev (Chernigov State University of Technology) defended his thesis for Candidate of Sciences on «Advancement of a technology for copper to molybdenum diffusion welding».

The thesis is dedicated to development of the technology for a vacuum diffusion welding of molybdenum to copper.

The thesis proposes to apply a low-energy ion treatment in glow-discharge plasma to the molybdenum surface preliminary coated with a copper layer for development of intermediate layer during it welding with copper. This will increase a static strength and heat resistance as well as reduce electric resistance of the welded assemblies.

The methods of molecular dynamics were used in the thesis for detection of the ways of influence of low-energy ions on properties of near-surface molybdenum layers. A relationship between energy of ions bombarding metal surface and location of displacement maximum of molybdenum atoms was determined through mathematical modeling of the process that allowed calculating a mode providing the best conditions for implantation of the atoms of covered with copper layer in the molybdenum.

The thesis presents a mode of ionic etching determined by the methods of polarization resistance and limiting wetting angle allowing increasing the quality of molybdenum surface preparation before thermal vacuum spraying on it of copper layer. The mode providing spraying of a layer of necessary thickness is proposed.

A range of modes for the ion treatment of molybdenum surface covered with copper layer was found at which a modified layer with mechanical properties providing welded sample with a smooth changing of microhardness from copper to molybdenum is formed.

Series of investigations for determination of influence of proposed series of operations on service characteristics of the welded joint was carried out. At application of modified layer 15 % increase of the width of copper diffusion zone in molybdenum is shown with the help of a method of X-ray spectrum analysis. The mode of copper to molybdenum welding was determined providing increase of shear strength of the joint up to 110 MPa, i.e. full-strength copper.

Using experimental X-ray method and method of mathematic modeling 30–35 % reduction of residual equivalent stresses in obtained welded joints, 5 time increase of strength at thermal cycling in comparison with pure Cu–Mo joint as well as 20 % reduction of specific electric resistance are shown in comparison with the welded joint obtained on traditional technology with nickel interlayer application.

The technology for manufacture of the molybdenum anodes by vacuum diffusion welding method was developed on the basis of carried out investigations.