more than by 65 % and did not exceed 50–60 MPa which is proved by efficiency of this kind of treatment.

On the basis of results of the carried out experiments on EDT of specimens of longitudinal and circumferential butts the following technological recommendations on pulsed treatment of problematic welded elements of hulls of small ships of alloy AMg6 were worked out: before EDT of welds in the compartment of a ship it is necessary to clean the area being treated from foreign objects, tool, cable and hose lines; to provide access of manual tool to the area of treatment at the distance of not less than 20 mm from the fusion line of a weld; not to admit positioning of manual tool in a specified point of treated surface for more than one current discharge; to perform EDT in lower and horizontal position of manual tool in the direction from middle to edges of a weld; to perform EDT of circular and circumferential welds in broken order.

On the basis of developed recommendations the treatment of structural elements of welded hulls of TC of alloy AMg6 in the amount of seven units was performed. The EDT of welded joints of tip and stern compartments and also some areas of load-carrying section after repair welding was performed (Figure 4).

In the period of navigation of 2009 the monitoring was made on welded joints of ship hulls, where EDT after repair welding was performed. The results of inspection showed that for the current period TC ran without damages from 300 up to 1320 km, no traces of damages in a form of microcracks in treatment area were detected.

Figure 4. EDT of welded joints of stern strengthening of TC hull

Therefore it can be concluded that EDT is the efficient method of prolonging the service life of thin-wall hull structures of aluminium alloys after repair welding.

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HIGH-QUALITY HOSE PACKS FOR UNDERWATER WELDING AND CUTTING

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Considered are examples of design of special cable products to be used with mechanized equipment for semi-automatic welding, surfacing and cutting. Possibilities of new cable developments for manufacture of hose holders are shown, their advantages and technical characteristics are analyzed, and fields of their efficient application were outlined. Special attention is given to cables employed to power semi-automatic systems operating under extreme conditions.

Keywords: *arc welding, semi-automatic devices, service lines, cable, hose holder, structure, manufacture, service conditions*

The mechanized equipment for welding, surfacing and cutting is traditionally upgraded through improving characteristics of welding current sources, feed mechanisms, control and regulation systems [1, 2] etc. Consideration is also given to other components of this type of the equipment. These are the elements of service lines (welding cables, hose holders), which are based on special cable [3]. The problems addressed with the help of semi-automatic devices are so diverse (various electrode wires, environment and service conditions etc.) that they require a special approach to elements of the service lines and, naturally, determine differences in their designs. And whereas the problem of selection of welding cables for conventional conditions is solved through a choice of what is already commercially manufactured in sufficient quantities and proved good (for example, flexible trailing weld-

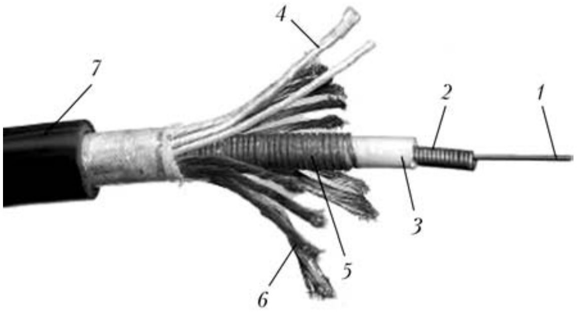

Figure 1. Appearance of cable KPESGU for mechanized welding equipment (*1*–*7* — see the text)

ing cable KOG), special service conditions (mechanized underwater welding) require cables with new characteristics. To a greater extent, this concerns the cable products underlying development and manufacture of domestic different-application hose holders. The main function of a guide channel in the hose holder is to provide feed of an electrode wire without jerks and jams at a preset algorithm of movement in modulated working modes, and movements with regulated pulse components.

The aim of the present study is to consider the possibility of using them in semi-automatic systems for solid and flux-cored electrode wire welding by an example of new developments of special cables.

Up to now the semi-automatic devices for gas-shielded welding have been completed with hollow electric welding cables of the KPES grade. A hollow internal channel in them is made in the form of an externally insulated steel spiral with a power conductor and control conductors wound on it, and a rubber skin applied on top. In addition, the use was made of cables of the KPESG grade and foreign cables of similar design. The hollow internal channel in them is made in the form of a polymeric, sufficiently rigid tube with a power conductor and control cables wound on it, and a rubber skin applied on top. In their technical level, these electric welding cables do not meet the up-to-date requirements. Main disadvantages of these cables are their significant rigidity and short life time. Besides, design of the KPES cable does not provide for a shielding gas to be fed via it to the welding zone, and design of the KPESG cable does not guarantee that the channel will retain its shape after kinks of the cable and application of transverse loads to it, which cause deformation of the plastic channel, thus hampering installation of a removable guide channel for wire into it.

Technical characteristics of cables for mechanized welding equipment

Nominal section of conductor, mm^2		Nominal diameter of channel tube, mm		Diameter of spiral of channel, mm, not more than
Main	Control	Internal	External	
10	From 0.35 to 1.00	5.0	6.5	8.3
12		5.0	6.5	8.3
16		5.0	6.5	8.3
25		6.5	8.1	10.0
35		6.5	8.1	10.0
35		7.5	9.5	11.3
50		7.5	9.5	11.5
70		7.5	9.5	11.9
50		9.0	11.0	12.9
70		9.0	11.0	13.4

To avoid the said disadvantages of the welding cables, the Design Bureau of the E.O. Paton Electric Welding Institute in collaboration with SPA «Vitok» Ltd. developed and manufactured the new designs of hollow reinforced flexible electric welding cables of the KPESGU grade with a rubber skin and of the KPESGUV grade with a polyvinylchloride (PVC) skin. These cables are intended to supply the direct current at an operating voltage of up to 100 V, or the 50 Hz frequency alternating current at a voltage of up to 42 V, to feed the electrode wire and shielding gas to the welding zone, and feed the control signals.

Appearance of a hollow flexible reinforced electric welding cable with copper conductors is shown in Figure 1. It comprises hollow elastic plastic or rubber channel *3* wound around with metallic single-wire cylindrical spiral *5*, with the strands *6* of the main conductor and control conductor *4* wound on it, and protective rubber or PVC skin *7* applied on top of them. Channel *3* provides feeding of a shielding gas to the welding zone. Also, it houses replaceable steel spiral *2* for feeding of welding wire *1*. A replaceable tube from fluoroplastic or carbon-reinforced plastic is installed instead of the steel replaceable spiral when using this design for development of a hose holder to feed wires of aluminium alloys.

The presence of the hollow channel in the form of elastic polymeric tube wound around with a cylindrical metallic spiral provides a substantial increase in flexibility of the cable at any ambient temperature and in its life time, as well as retention of the cylindrical form of the elastic polymeric tube (channel) at any kinks of the cable. This ensures an easy change of the replaceable guide channel (replaceable steel spiral or plastic channel), which fails rather quickly because of its wearing by the welding wire.

Quantity and nominal cross-section of the conductors (main and control), nominal inside diameter of the channel and outside diameter of the cable are given in the Table.

Tests of different designs of the hose holders made by using the above cable proved their high reliability. Comparison with the hose holders of the well-known German Company BINZEL was carried out in worst-case situations at sharp kinks of the cable (at an angle of 90° or more) with a kink radius formed under a load of 200–300 kN. This is a case that often takes place in manipulation with the hose holder, in particular, in transportation or turning of the feed mechanism because of pulling of the hose holder. Feeding of the wire through the channel of the BINZEL hose holder is hampered after a few such cycles, whereas the hose holder based on the KPESGU cable retains its performance. Tests of said cable in a set with the hose holder, conducted by feeding different-diameter electrode wires of Sv-08G2S type through its channel showed that the 1.2 mm diameter wire can move with allowable outlet speed fluctuations at a channel length of 3.5–4.5 m, and the 1.6–2.0 mm diameter wire — at a channel length of 6 m. Thus, it is obvious that the new design of the cable provides significant widening of the maintenance zone for semi-automatic welding and surfacing devices.

The KPESGU cables are gradually introduced into designs of modern types of the hose holders manufactured in Ukraine (PPMWE, Ilnitsa) and Russia («Linkor» Company, Stavropol).

It should be noted that manufacture of cables with sections of the main conductors, sections of the control conductors, their quantity, diameters of elements of the channel and cable other than those indicated in the Table is permitted after agreement with a consumer.

Development of a cable to power electric drives of the feed mechanisms and systems for control and regulation of the semi-automatic devices for welding and cutting at significant depths (more than 200 m) is a very difficult problem [4].

We conducted integrated investigations of mechanical strength and electric characteristics (heating, attenuation of control signal and voltage drops on power wires) of the cable. The flexible, armored and reinforced cable of the KGBU grade, the cross-section of which is shown in Figure 2, was developed and manufactured by SPA «Vitok» Ltd.

The cable is designed for control of the equipment for underwater welding at direct current voltage of up to 220 V. It is made from flexible copper conductors insulated by PVC elastron: two conductors *1* with the 2.5 mm^2 section, three twisted pairs of conductors *2*, *3* and *5* with the 0.75 mm^2 section, screened with foiled film (forlsan, alumoflex) and copper wire *4* with the not less than 0.15 mm diameter, laid longitudinally under the foiled film.

All twisted pairs and conductor are twisted around central conductor. Polyethyleneterephtalate film PET-E *6* with overlap of not less than three layers, flexible armor in the form of turns of single-wire spiral *7* made from the (0.85 ± 0.10) mm thick and (2.5 ± ± 0.3) mm wide flat steel wire with an axial gap between its turns, which is not more than two widths of the wire, reinforcing polyester threads *8* and PVC skin *9* are laid in series over the twisted conductors.

Conductors of the twisted pairs are stranded with each other at a strand pitch of not more than 10 external diameters of the strand. The foiled film is wound on a twisted pair with overlap of not less than 10 %.

The external diameter of the cable is not more than 20.5 mm, the minimum internal radius of a kink loop of the cable is not less than its 7 external diameters, and tensile strength of the cable is not less than

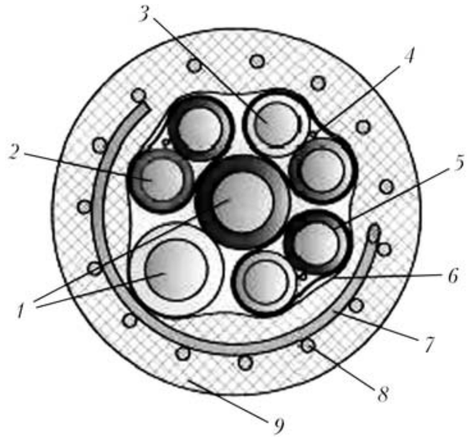

Figure 2. Cross-section of cable for semi-automatic underwater welding and cutting device (*1–9* — see the text)

1900 N. An estimated weight of the cable is 0.61 kg/m.

The presence of the flexible steel flat wire armor provides the required strength characteristics of the cable in axial and radial directions (in the case of operation in deep-water environment) by maintaining the necessary flexibility.

Tests of the cable, including in water environment with 3.5 % salinity, showed its high quality. It has almost no analogues to the combination of its parameters.

Unique equipment for continuous winding of non-rotating metal single-wire cylindrical spirals on any billets, for example, in the form of flexible tubes, cable conductors, including twisted ones, was developed and manufactured on the basis of inventions [5, 6] by «Vitok» Ltd. for production of the above cables. Many new designs of load-carrying cables featuring an increased flexibility, enhanced explosion, electrical and fire safety properties are developed and manufactured by using such spirals as a flexible armor. Their service life increased not less than three times, compared to cables with similar conductors but without flexible armor. These developments can be used for welding, surfacing and cutting equipment operating under extreme conditions.

It should be noted that Ukraine has a high-efficiency enterprise «Vitok», which manufactures the high-quality wide-application cables. This enterprise is fitted with the in-house equipment providing a complete manufacture cycle by using advanced materials. The enterprise can develop and produce special designs of cables by request of a customer and in correspondence with his requirements.

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