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AUTOMATION OF WELDING PROCESSES WITH USE OF MECHANICAL WELDING EQUIPMENT

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The article gives examples of robotization, automation and mechanization of welding and related processes based on mechanical welding equipment (MWE). The composition of complexes and installations applied for welding or surfacing processes includes both serial models of MWE, as well as specially designed ones, taking into account individual features of the product design and technological peculiarities of its manufacture. The wide range of solved problems and the possibility of the domestic manufacturer of MWE to design and manufacture modern high-tech complexes and installations for welding and surfacing are shown. The possibility of designing special MWE for new welding and surfacing technologies in the composition of robotic complexes and automatic installations is noted. 9 Ref., 6 Figures.

Keywords: *arc welding, surfacing, mechanical welding equipment, automation, mechanization*

The performance of welding operations is associated with the need to use a complex of equipment which, often with the participation of welder, provides welds of specified quality and configuration. The influence of dimensions and shape of semi-products, the quality and accuracy of assembly, as well as the change in workpiece dimensions due to thermal deformations on welding conditions is greater than of any other technological process of metal treatment. Therefore, many requirements are specified and great attention is paid to the equipment used for welding operations [1–4].

Depending on the range of components the composition of the complex of technologically interconnected equipment, which provides welding operations, includes:

- power source and welding machine with units of control, adjustment of the process and electrode holder;
- mechanical and auxiliary equipment designed to manipulate workpiece being welded in the process of weld laying-on and to fix and move welding machines;
- technological assembly and welding devices which provide fast and accurate assembly of parts for welding, their holding in the required position during operation and prevention or reducing the distortion of workpiece to be welded.

In each individual case the complex or welding installation can have all the abovementioned elements or some of them. As far as significant time is spent on auxiliary, assembly and additional works, reducing the efficiency of application of advanced high-efficient welding methods, the shortening of production cycle and a high quality of welds can be achieved only with the complex mechanization and automation of welding, assembly and auxiliary operations. The level of complex mechanization determines the presence of technological devices, mechanical, auxiliary and other equipment (transport, control and the like) in the composition of installation [1–5].

As is known, the installation for automatic welding contains devices for laying, assembly and rotation of workpiece being welded, welder's platform and other equipment. In it, at least, two basic operations of welding process are mechanized: electrode feeding and arc movement along the edges being welded. Accordingly, the installations, where only one of these operations is mechanized, are considered to be installations for semiautomatic welding [1–4].

The presence of mechanical and auxiliary equipment in the composition of welding installation has a decisive importance for complex mechanization of welding process. According to the work [6], mechanical welding equipment (MWE) includes: horizontal, vertical and universal manipulators, roller and balancing rotators; chain tilters; pipe rotators. In addition, this type of equipment also includes welding gantries, trolleys, welder tables, and also columns for welding automatic and semiautomatic machines.

Some rigging or the simplest models of auxiliary MWE can be manufactured by the machine-building

Figure 1. Installations for surfacing and restoration of parts: RM-09 (*a*); RM-15 (*b*); IZRM-05 (*c*)

enterprises, in the technological cycle production of which the welding works are present, themselves at their own production facilities. However, often in such cases they turn to the specialists of specialized enterprises who are ready to offer a professional, complex solution for automation and mechanization of welding and related processes.

In Ukraine, an enterprise like that is the PJSC «Ilnitskiy plant of mechanical welding equipment» («IZMSO»), which started its activities since 1964. This enterprise was created for designing and implementation of equipment for automation and mechanization of welding operations. Beginning from the moment of its foundation, it mastered the production of ever more new types of MWE and simultaneously increased the volume of production, which allowed a full satisfaction of the country's needs. In close cooperation with the All-Union Planning and Design Institute for Welding Production (VISP), the production of welding rotators (universal, horizontal, vertical, roller), as well as columns for automatic and semi-automatic welding machines was mastered. Together with the E.O. Paton Electric Welding Institute the production of new models of torches of such types as A1231 and GDPG-305 for electric arc welding was mastered, as well as modernization of the torch A-547uM was carried out. The joint work of Ukrainian partners made it possible to produce the equipment and complexes for surfacing and restoration of parts of metallurgical companies and repair plants.

This is confirmed by such complexes as: RM-04, RM-05, RM-06, RM-09 (Figure 1, *a*)

- for automatic arc surfacing of wheels of hoisting cranes; RM-15 (Figure 1, *b*) is the universal installation for surfacing of rope blocks of up to 2.5 m diameter and other cylindrical and plane parts; RM-165 and IZRM-05 (Figure 1, *c*)
- for automatic arc surfacing of small-sized cylindrical parts with diameter of up to 0.5 m, length of up to 1 m and mass of up to 120 kg; RM-10 — for surfacing of rolling tool with diameter of up to 0.6 m, length of up to 2 m, mass of up to 5000 kg and a number of other installations. Depending on the design features and mass-dimensional characteristics of the deposited workpieces, the installations include universal manipulators, columns, roller rotators, welder tables of the PJSC «IZMSO» production in their serial or special version.

To increase the degree of technical and technological characteristics of the produced MWE, the specialists of the PJSC «IZMSO» carry out constant modernization of the manufactured products to provide the possibility for the consumer to install, activate and use systems with new technological solutions and all advantages of modern welding and surfacing equipment, for example, with pulsed technologies. Thus, in a close cooperation with the SE «EDTB of the E.O. Paton Electric Welding Institute of the NAS of Ukraine» the modernization of the installation IZRM-05 was made to enable its equipping with gearless systems for electrode wire feed on the basis of brushless electric motors with the control from computerized regulators. Such systems provide operation with modes modulation and controlled pulsed electrode wire feed. The new feeding systems due to efficient control of electrode metal transfer and reduction of heat inputs to the workpiece in the combination with the considered equipment allow:

- obtaining welding-surfacing with energy- and resources-saving effects;
- reducing deformation of product;
- providing quality process in all spatial positions, including producing horizontal welds in vertical plane and in overhead position.

The rationality of applying manipulators, rotators, mobile columns, and recent developments in the welding and surfacing equipment in the systems is predetermined also by the ability of this equipment to maintain the preset parameters of working movement even in long cycles, with a high degree of accuracy for the working tool positioning. As an example, it can be noted that moving welding columns can perform a high-efficient welding of long products such as of deck type with the possibility of high-precision scanning of relief of surfaces being welded, which is pro-

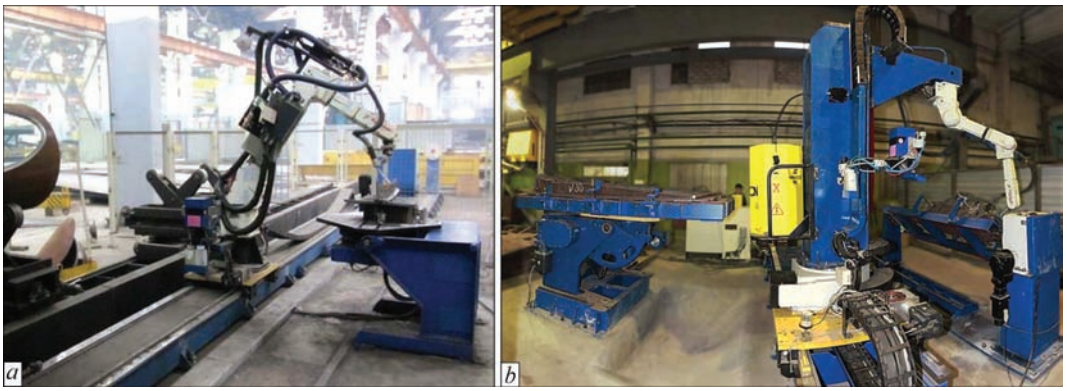

Figure 2. Robotic complexes with application of universal manipulator (*a*), universal and double-post horizontal manipulator (*b*)

vided by using modern computerized electric drives and sensors of distance to the surface being welded.

The next example of complex automation and robotization of welding, surfacing and cutting processes with the use of products of the PJSC «IZMSO» production is the developments of the holding Company «Belfingrupp». This Company specializes in designing and development of robotic technologies and deals with industrial robotics. The specialists of «Belfingrupp» developed and implemented the robotic complex (RTC), which solves such problems as cutting pipes of different diameters and lengths along the complex 3D trajectories. This RTC not only provides a high-precision cutting of holes, but also cutting and trimming of pipes. The equipment allows cutting pipes with a length of up to 12 m and a diameter of up to 1.2 m (Figure 2, *a*).

RTC (Figure 2, *b*) solves more universal tasks for arc welding. The presence of two different types of manipulators in the composition of RTCmanufactured by the PJSC «IZMSO» guarantees the possibility of welding a large and diverse range of products. At present, both RTCs are put into operation and involved in serial production.

There is a large number of realized projects of complex automation and mechanization of welding and surfacing processes, proposed by the experts of the PJSC «IZMSO» using a special MWE of the own design.

They include the complex for welding railway tank cars (Figure 3, *a*) for the PJSC «Kryukov railway car building works», consisting of the bicycle type column KVT-05 and roller rotator. For the Share Holding Company «NIKIMT-Atomstroy» the complex (Figure 3, *b*) of mechanized welding of pipelines with diameter of up to 0.3 m, length of up to 6 m and mass of up to 2000 kg, used at nuclear power engineering facilities, as well as the complex (Figure 3, *c*) for welding elements of up to 2 m in diameter and mass of up to 3000 kg in the active zone of nuclear reactors were designed and manufactured. In the case presented in Figure 3, *b* the complex consisted of a special double-post horizontal rotator, including column for welding machine, and in Figure 3, *c* it consisted of universal manipulator, roller stand and column. The last complex (Figure 3, *c*) was equipped with the special system for butt tracking, which allowed making correction of the rotation speed of driving rolls of the stand to obtain a constant welding speed. For the LLC «MPVF» Energetik», a unique welding complex was developed (Figure 3, *c*), including the special column T-31060 with more than 3 m travel of working body along the horizontal and vertical and the tandem roller stand with a load capacity of up to 5000 kg, which were interconnected by the software. The complex carries out two-sided automatic submerged arc welding of longitudinal and circumferential welds of steam boiler drums, shells of vessels of large diameter and thickness.

In addition, the unique models of MWE were designed and manufactured for the LLC «MPVF «Energetik» at the PJSC «IZMSO», among which the moving gantry (Figure 4, *b*) for welding workpieces with length of up to 7 m and the installation (Figure 4, *c*) for semi-automatic submerged arc welding of circumferential and longitudinal inner welds of vessels of up to 3 m length and the diameter from 0.4 m. The installation (Figure 4, *c*) consists of the column with a stationary beam. At the end of the beam the flux hopper, welding torch and elements of welding process monitoring system are installed. The gantry and the column (Figure 4, *b*, *c*) are able to move along the rail track at a welding speed. Also, to carry out mechanization of welding and related processes, the universal manipulator with a load capacity of 7000 kg (Figure 4, *a*) and the balancing rotator with a load capacity of 40000 kg (Figure 4, *d*) were designed and manufactured for the Ilyich Iron and Steel Works in Mariupol.

The features of the manipulator are the increased dimensional characteristics of a faceplate (1.4 m diameter) and the presence of water cooling of spindle and bearing units of the table. Moreover, the balanc-

Figure 3. Complexes of automation and mechanization of welding processes with use of special MWE

ing rotator has an ability to move along the rail track and, depending on diameter of the workpiece, change the distance between the rollers supports.

It should be noted that in addition to serial equipment, the enterprise solves problems of creating unique equipment with high operation characteristics.

Figure 4. Unique models of MWE: universal manipulator of 7000 kg loading capacity (*a*), moving gantry (*b*), installation for semi-automatic submerged arc welding of circumferential and longitudinal inner welds (*c*), balancing rotator with a load capacity of 40000 kg (*d*)

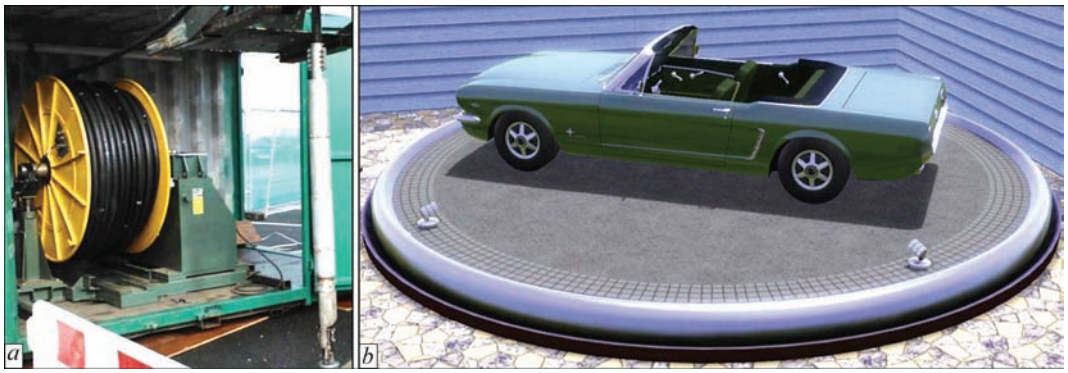

Figure 5. Some other variants for application of MWE: uncoiler for dipping and lifting of welding machine (*a*), demonstration rotating podium (*b*)

The mechanized welding equipment or its separate units and mechanisms can be used also for manufacture of other products. As an example, the development and manufacture of different types of uncoilers (Figure 5, *a*) or demonstration equipment (Figure 5, *b*) can be noted.

A smooth start, providing a stable frequency of spindle and torque rotation over a long period of time, ability of smooth adjustment of the spindle frequency rotation, ability to regulate the speed of gaining the required frequency of its rotation and a high reliability of rotator assemblies were quite appropriate during solution of technical assignment on the development of complex for automatic underwater welding [7] and providing the dipping and lifting of welding machine from the depth of about 200 m, as well as in designing and manufacture of uncoiler for cable assemblies of the deep-water welding complex described in the work [8]. In its turn, the design scheme of vertical rotator is suitable for demonstration rotating podium, which is used, for example, at the automobile exhibitions.

The equipment for new welding and surfacing technologies is developed, in which the oscillation processes are used which allow improving the surfacing process with the increase of its efficiency and obtaining a finely-dispersed structure of the deposited layer [9]. Figure 6 shows installation with controlled oscillations of the product being surfaced, designed and manufactured at the PJSC «IZMSO» according to the technical assignment of the E.O. Paton Electric Welding Institute of the NAS of Ukraine.

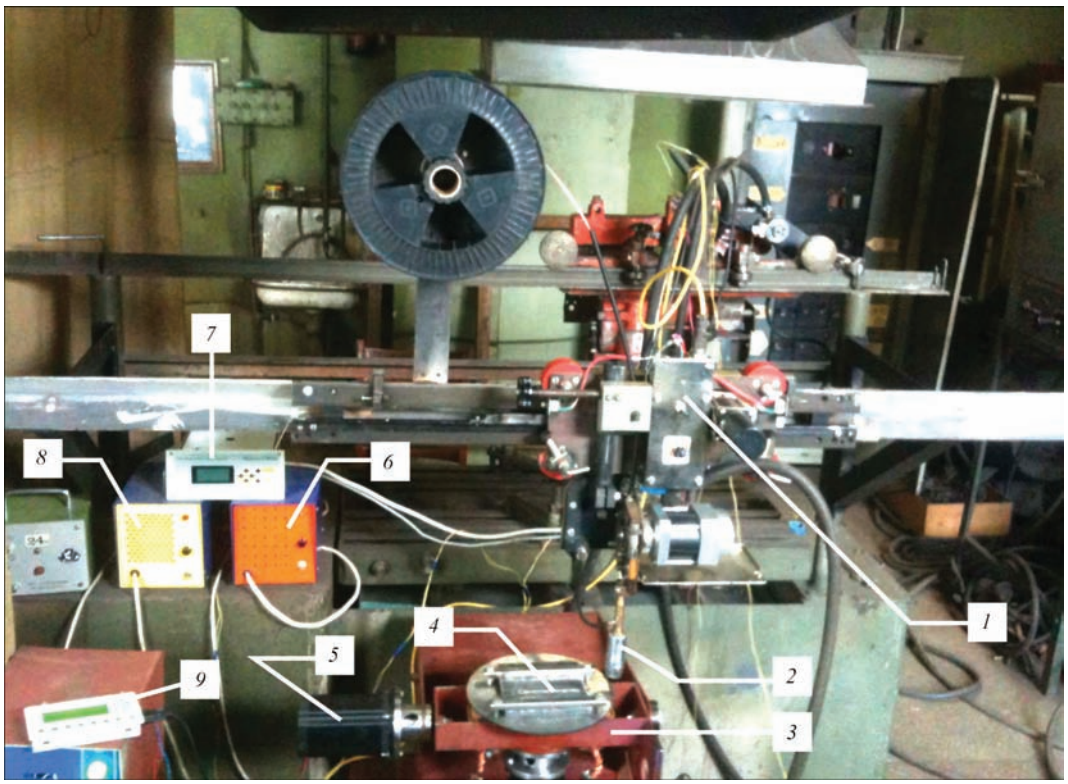

Figure 6. Scheme of installation for surfacing with a movable bed: *1* — control panel for torch moving; *2* — torch; *3* — bed; *4* — part being deposited; *5* — motor, imparting oscillations to the workpiece; *6* — power supply unit of control panel, pos. 1; *7* — indicator of torch speed movement; *8* — power supply unit of motor, pos. 5; *9* — programmable panel for control of motor operation mode, pos. 5

Conclusions

1. As before, MWE remains one of the demanded types of equipment necessary to provide automation and mechanization of welding and related processes, which helps to increase labor efficiency and ensure the specified quality.

2. The application of modern gearless systems for feeding electrode wire on the basis of brushless electric motors with control from computerized regulators provides operation of controlled pulsed electrode wire feed and imparts MWE with new technological capabilities.

3. The use of modern step-type and brushless electric drives, rotation frequency converters of the shaft of asynchronous motors and other electronics greatly facilitates the integration of individual MWE into welding and surfacing complexes, installations and robotic centers under the common control.

4. The modern production of MWE has the opportunity to produce a wide range and model line of serial MWE, and is also ready to develop and manufacture a special MWE taking into account individual wishes of customers.

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