AUTOMATION OF THE TECHNOLOGIES FOR ELECTRIC ARC WELDING AND WELD OVERLAY USING A MODULAR SYSTEM WITH PROGRAM CONTROL

Plamen TASHEV[1], Yavor LUKARSKI[2], Asen TASEV[3]

[1, 2]*Institute of metal science, equipment and technologies with hydroaerodynamics center "Acad. A. Balevski"-Bulgarian academy of sciences, e-mail:* weld@abv.bg,
e-mail: lukarski@ims.bas.bg
[3]*Institute of welding AD, e-mail:* iza_ad@mail.bg.

Abstract: *The present-day welding production tends to limit or completely eliminate the manual activities, as the manual and semi-mechanized welding is replaced by automated welding.*

The advantages of the mechanized welding, and especially the entirely automated or robotic welding are well known, namely: increased performance; precise control of the welding mode parameters; reduced amount of dissolved hydrogen in the weld metal compared to manual electric arc welding.

The present paper discusses the possibilities for application of a module intended for mechanized and automated welding using different methods of electric arc welding. The main parameters of the module are determined and the schematic diagram necessary for the design of the module is developed. The possibilities of the module for welding of different shaped model details are shown.

Keywords: *welding, weld overlay, mechanization, module with CNC*

1. General information on welding processes

The development of technologies, the design of new alloys, the increase of the requirements for strength and durability of the construction are the reason for the emergence of different welding methods. The variety of welding methods is also due to the increasing requirements for the joints of non-detachable structures, the high requirements for increased speed, productivity and efficiency of production processes. In addition, it is possible that such advanced methods as laser and plasma welding may enter the practice at some stage of the development of technology [Tongov, 2009].

In addition to joining two or more metal workpieces, welding processes are also used to protect workpieces exposed to different types of wear in order to acquire specific surface properties, e.g., increased wear resistance. The process is called surfacing or weld overlay. Although surfacing is mainly used to restore worn workpieces to a state in which they can work again, it is worth applying surfacing preventively on completely new workpieces and tools in order to extend their service life. In this way, these details can be made of cheaper materials and the surface characteristics can be acquired by applying a layer with the necessary qualities [www. karnes.bg].

The development of the means for mechanization, automation and robotization of the welding processes is a particularly topical direction in welding production both in our country and worldwide. There are a number of examples for creating opportunities for robotization of welding production through the use of specialized machines built on a modular principle, as well as mass-produced transport systems and robots with general industrial purpose in the implementation of specialized technological lines [Petkova, 2015].

This is the specific task solved in the presented report: to demonstrate the qualities of the system designed by the team for automated welding and surfacing of various workpieces.

2. Mechanization and automation of welding/surfacing processes

2.1. Background

Mechanization and automation of mechanization and automation of production are among the main ways to increase the productivity of welding work and to improve their quality. In modern production in Europe and the world there is a widespread penetration of mechanized and robotic welding methods. Most often the automation is introduced in productions with a large volume of welded structures. It is also necessary to maintain a consistently high quality of welding. In most cases, mechanized and automated welding is limited to the implementation of straight, circular and spiral seams [Hristov, 2008]. The development of a modular system for mechanization and automation of electric arc welding processes allows for fast and efficient construction of specialized welding machines [Tashev, 2009, Tashev, 2010, Jasnau, 2000].

The development of the means for mechanization and automation of the welding processes with computer numerical control (CNC) is especially actual for the welding production. The CNC system of welding processes, subject of this publication, has been developed by engineers and technoogists of the Institute of Welding AD and researchers and specialists from the Institute of Metal Science, Equipment and Technologies "Acad. A. Balevski" to the Bulgarian Academy of Sciences. It presents a set of linear module and rotary module for mechanized and automated welding of different types of seams and weld overlay of different types of surfaces by moving the welding tool.

2.2 Working-out the module

The CNC system is intended both for independent work of either module and for their joint work for mechanized and automated welding of rectilinear, circular, spiral continuous and intermittent movements of the welding tool (welding torch) with possibilities for application of a wide range of electric arc welding processes. The welding torch is attached by means of a torch holder (TH) to the movable element of the linear module. If necessary, a positioning module (PM) is added to the TH to approach or move the torch away from the welded (weld overlay) surface.

An exemplary construction combining the linear module and the rotary module is shown schematically in Fig.1. Fig. 2 shows a photograph of the appearance of the CNC system. The two modules are clearly visible, as well as the welding torch holder and the torch itself. The workpiece that has to be restored by weld overlay is attached to the rotary module.

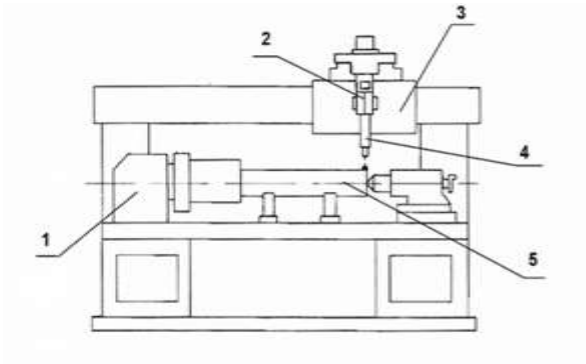

Figure 1: *Combined use of the two modules:1 - rotary module; 2 - holder of the welding torch;3 – linear module; 4 - welding torch; 5 - workpiece.*

Figure 2: *Appearance of the CNC system with rotary and linear modules and control panel visible on the left.*

3. Technological tests of the created system

3.1. Testing the system

The measurement data are controlled, registered and recorded using software MultiLab by means of two sensors DT 148 attached to the rotary module and the linear module. DT 148 consists of optic coding device connected with the main axis of the sensor (Fig. 3) and measures the angular position of the module with high resolution [Petkova, 2017].

The CNC of the modular system for automation of the welding processes is developed with controllers of Siemens AG. Several standard programs are set for the main cases of welding and surfacing. For example, in case of welding with the rotation module the set values are diameter of the workpiece, speed of welding, beginning and end of the weld [Petkova, 2015, Petkova, 2016]. The program calculates the length of the weld and the rotation speed of the work table (Fig. 4).

Figure 3: *Optical coding device connected with the main axis of the sensor*

Figure 4: *Display for operation control of the rotary module*

The control system must provide the possibility for electric arc welding in the following processes:

- Welding in protective gas environment with melting electrode, process 13;
- Electric arc welding in inert gas with non-melting electrode, process 14;
- Plasma welding, process 15;
- Laser-hybrid welding. In this method, the load capacity of the linear module must be taken into account.

In processes 13, 14 and 15, the linear module can be used autonomously or in combination with the rotary one.

For illustration some variants of cyclograms of different modes of operation of the modules are given below (Figs. 5 to 10).

3.2. Implementation of the innovative modular system

A number of experiments have been carried out on the modular system constructed in this way for automated welding or surfacing of various workpieces.

3.2.1 Welding

Fig. 11 (a) shows welding of two plugs to a cylinder. As can be sees, the workpiece is attached cantilevered on the rotator, and the torch is positioned on the linear module. The arrangement in Fig. 11 (b) is similar.

3.2.2. Overlay welding

Fig. 12 (a, b, c) shows a workpiece that is overlay welded in order to extend its work cycle to achieve economic and environmental effect. The openings in the front area of the details show that they were clamped on both sides between the rotary module and the rear seat of the linear module.

The conducted visual and ultrasonic inspection of the welded and overlay welded piexes showed the absence of any defects in the welds.

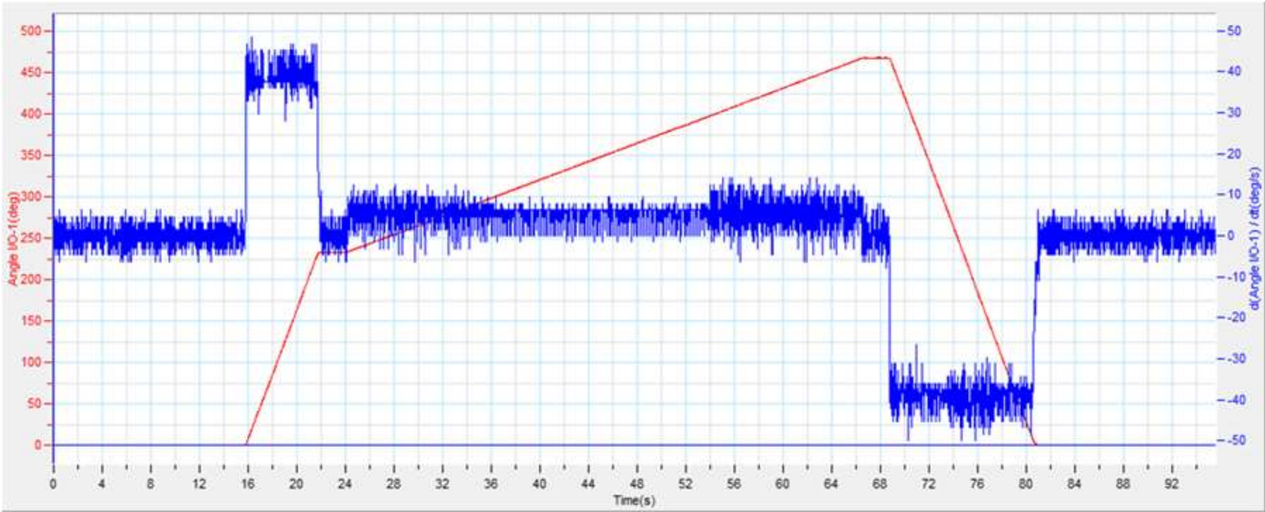

Figure 5: *Speed and displacement of the linear module performing working movement - continuous weld*

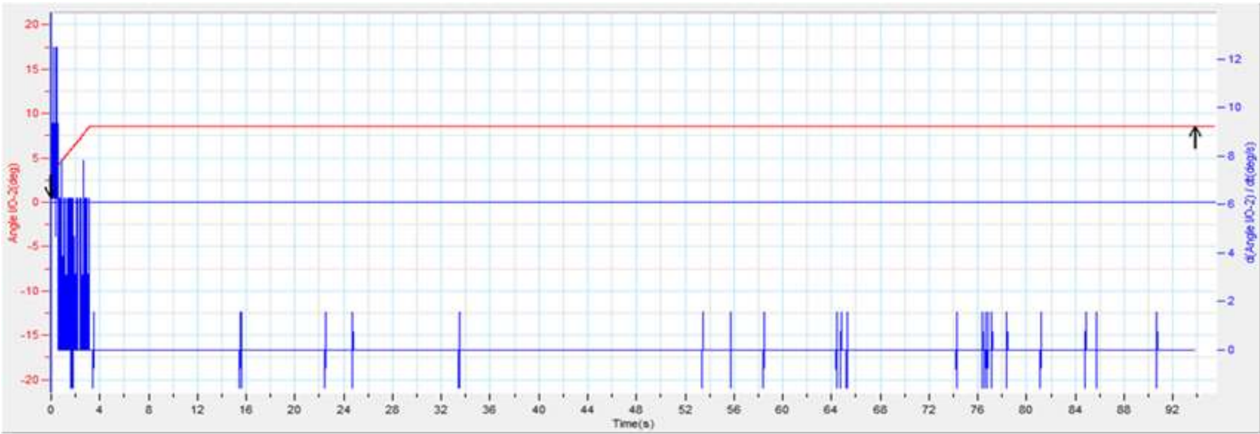

Figure 6: *Speed and displacement of the rotary module performing positioning - continuous weld*

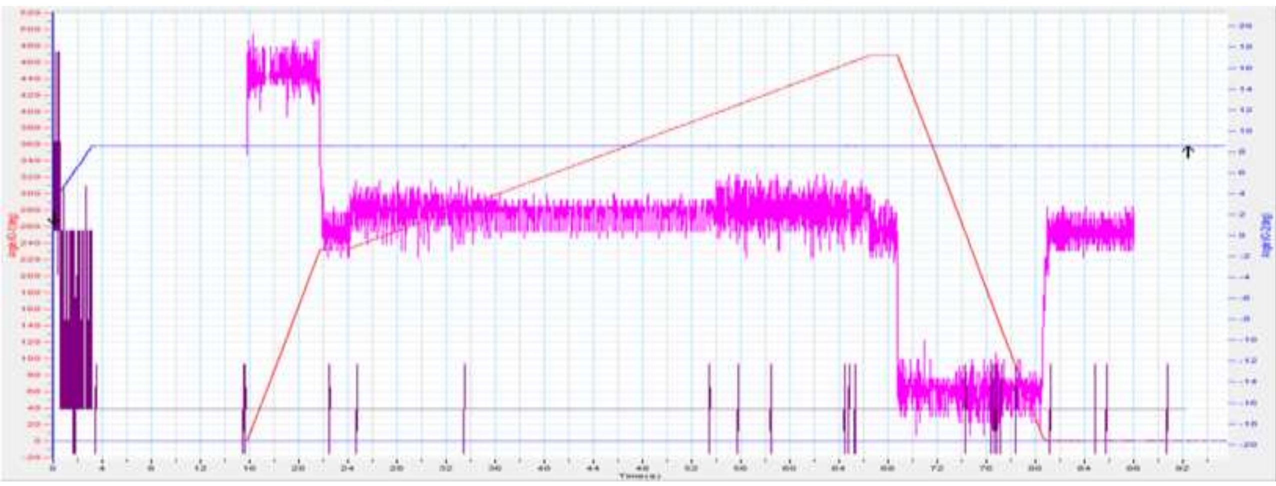

Figure 7: *Speed and displacement during simultaneous operation of the two modules - continuous weld. The linear module performs working movement, and the rotary module performs positioning*.

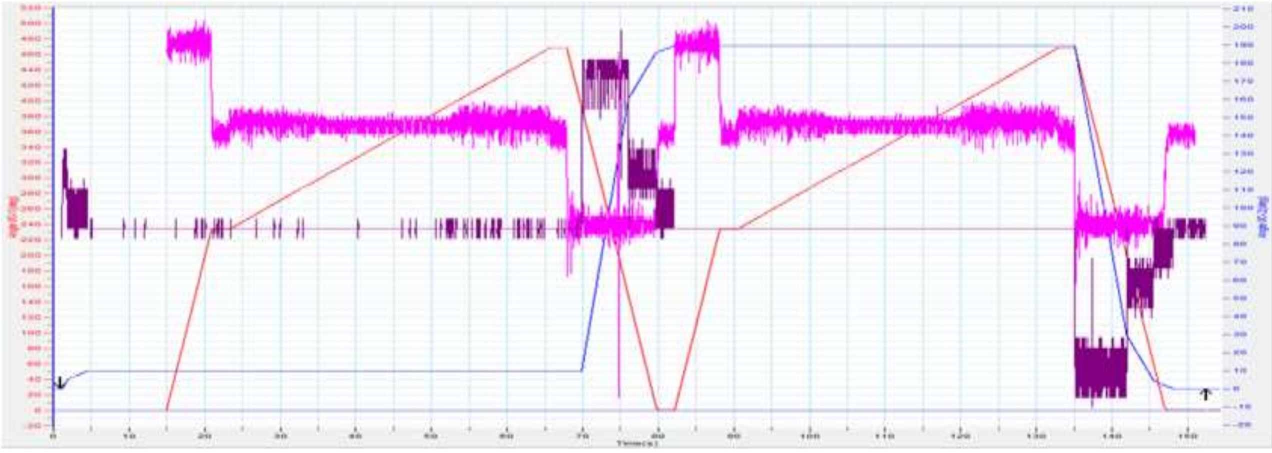

Figure 8: *Speed and displacement during simultaneous operation of the two modules - interrupted weld. The linear module performs working movement, and rotary module performs positioning*

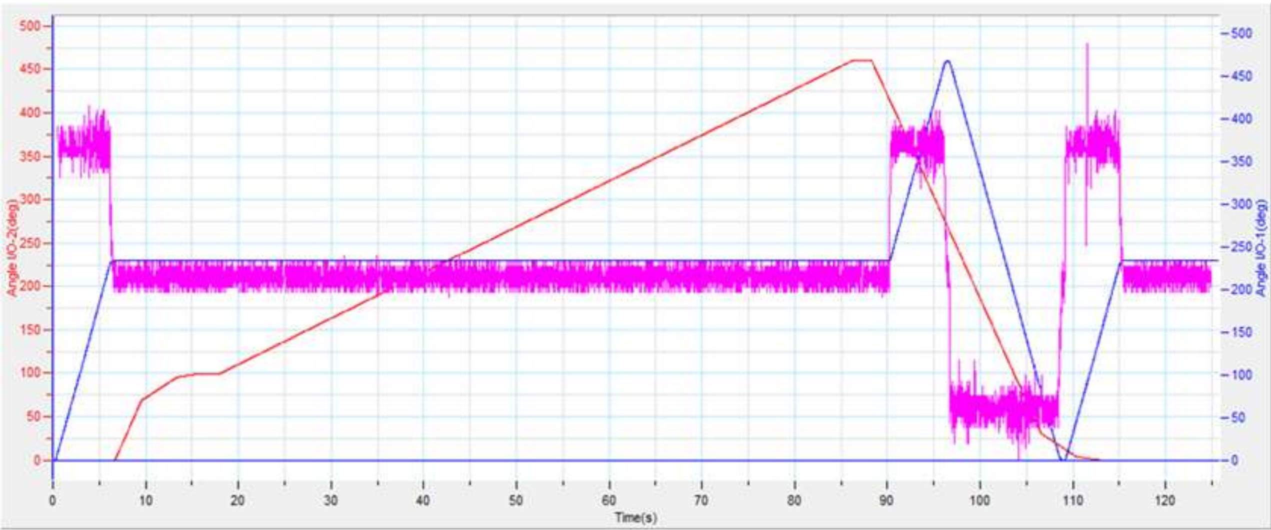

Figure 9: *Speed and displacement of the rotary module during welding – continuous weld*

Figure 10: Speed and displacement of the linear module during positioning – continuous weld

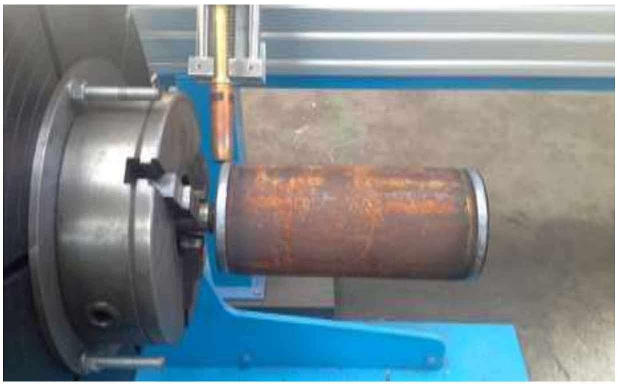

Figure 11 (a), (b): *Welding plugs to a cylinder*

a *b* *c*

Figure 12: *Workpieces subjected to overlay welding using the modular complex: a – the piece is subjected to mechanical processing before overlay welding; b – the piece is overlay welded using the modular complex; c – the piece after finishing mechanical processing*.

5. Conclusions

A prototype of module for automated welding (surfacing, overlay welding) of workpieces has been designed and manufactured.

The technological parameters of the module and its control are determined, giving the opportunity for welding and surfacing of workpieces up to 100 kg; microprocessor control and speed control range in the range of 0,1-6,0 min^{-1}. Based on the measurements made, it was established that:

- The preset parameters, i.e. speeds of movement, geometry of the welds and geometry of welding (surfacing) on a helical line are performed successfully;
- The modules are managed successfully in independent and joint work.

The examinations of the workpieces subjected to welding and surfacing do not show structure defects of the welds.

References

1. [Tongov, 2009] Tongov, M., *Welding.* Technical University, Sofia, 2009, (in Bulgarian).
2. Manual for welding during repair and restoration, ESAB International AB, Office Bulgaria, E-mail: esab@netbg.com, www. karnes.bg (in Bulgarian).
3. [Petkova, 2015] Petkova, G., Tashev, P., Tasheva, T. *Analysis of the possibilities for mechanization and automation of welding technologies using different welding methods*, Scientific Bulletins of NTSM, "Days of Non-Destructive Testing 2015", issue. 2 (165), pp. 193-196, ISSN 1310-3946 (in Bulgarian).
4. [Hristov, 2008] Hristov S. *Trends in the development of welding technology*, Machines, Technologies, Materials, № 1, 2008 (in Bulgarian).
5. [Tashev, 2009] Tashev P., Hristov, S. *Modular system for mechanization of welding processes*, Scientific Notices of NTSM, "Days of Non-Destructive Testing 2009", issue 1 (111), pp. 300-305, ISSN 1310-3946 (in Bulgarian).
6. [Tashev, 2010] Tashev P., Hristov, S., *Laser-hybrid welding in shipbuilding, Mechanics*, Transport, Communications, art ID: 470, Bulgarian, № 2, 2010, article № 0477, ISSN 1312-3827 (in Bulgarian).
7. [Jasnau, 2000] Jasnau, U., Hoffman J., *Nd: YAG-Laser-Msg-Hybridschweißen Von Aluminium-legierungen im Schiffbau*. Dvs-Berichte Band 225, 2000, ISBN 3-87155-683.
8. [Petkova, 2017] Petkova G., Tashev, P. and Lukarski, Y. *Functional test of control of an automated welding system*, Proceedings of 6th National Conference "Metallurgy, Hydro- and Aerodynamics, National Security '2017", May 29-30, 2017, Sofia, pp. 46-50, ISSN 1313-8308 (in Bulgarian).
9. [Petkova, 2015] Petkova G., Tashev, P. and Tasheva. E. *Determining the main parameters in the design of a module for automated welding of rotary parts*, Sat. Reports of the 5th Nat. conf. "Metallurgy, Hydro- and Aerodynamics, National Security' 2015", October 22–23, 2015, Sofia, pp. 165-169, (in Bulgarian).
10. [Petkova, 2016] Petkova G., Tashev P. *Development of methodology and testing of the main parameters of a welding rotator with digital program control*, Scientific Bulletins of NTSM, "Days of Non-Destructive Testing 2016", issue 1 (187), Sozopol, Bulgaria, pp. 110-113, (in Bulgarian).