HARDWARE-SOFTWARE COMPLEX FOR AUTOMATED CONTROL AND MONITORING OF THE VACUUM SYSTEM OF THE COATING SETUP "BULAT-6"

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The hardware-software complex for automated control and monitoring of the vacuum system of the coating setup "Bulat-6" is presented. Its use provides the stability of the process of obtaining and maintaining the required vacuum in the plant. The complex is built on the basis of the software-logic controller (PLC) type ELC-22 XLogic.

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INTRODUCTION

Every year the demand for plasma arc coatings deposition of different type of materials increases. Coating deposition is one of the effective methods for protecting products from corrosion, and is also widely used to impart valuable special properties to the surfaces of products [1].

For a long time, various manufacturers produced coating equipment as "Bulat" type device. The production fleet of such setups is quite significant. When working on such setups, there is a noticeable an essential dispersion in the parameters of the obtained products. This is due to the instability of the plant's technological processes. To guarantee the stability of the process of surface modification and the repeatability of the quality of the results allows the use of automation tools [2]. In view of their absence at regular setups, it became necessary to equip the "Bulat" setups with such facilities.

At the Institute of Plasma Physics of the NSC KIPT KIPT works on automation of existing "Bulat" setups. In this paper, we present a hardware-software complex for the automated control and monitoring of the vacuum system of a modernized vacuum arc-coating setup.

MAIN PART

Setup of plasma electric arc coating "Bulat" represents the complex electrical equipment and consists of several elated systems that ensure its functioning (Fig. 1).

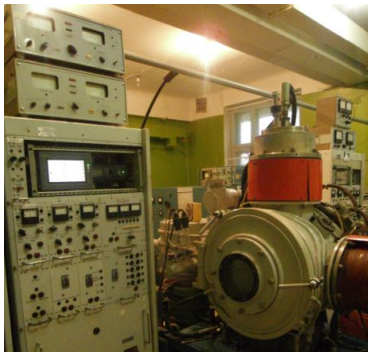

Fig. 1. Appearance of the "Bulat-6" installation (control rack with controller and vacuum chamber)

One of them is the vacuum system, which represents the object of automation of the "Bulat" setup at this stage of the work. Vacuum system "Bulat" is designed to obtain vacuum in the working chamber, which is necessary for a particular technological process, and maintain its value within the specified limits. The composition of the main equipment, location and interrelationships of the units of the vacuum system are shown in Fig. 2.

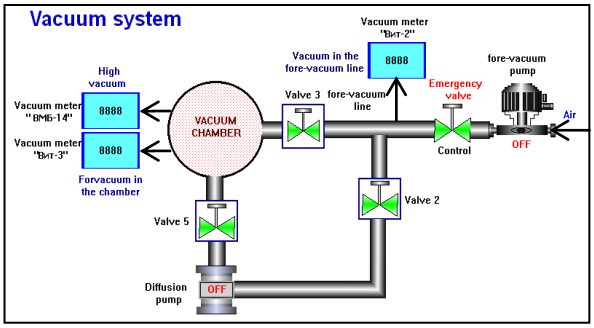

Fig. 2. Vacuum system of the "Bulat" setup

The vacuum system includes the following equipment and units of the "Bulat" setup, the operation of which is to be automated:

– vacuum working chamber;
– forevacuum pump;
– diffusion pump;
– forvacuum line;
– valve 2 (forvacuum pump – diffusion pump);
– valve 3 (forevacuum pump – camera);
– valve 5 (diffusion pump – chamber);
– vacuum ionization-thermocouple vacuum "ВМБ14";
– vacuum ionization-thermocouple "ВИТ3";
– vacuum ionization-thermocouple "ВИТ2".

The application of the automation system allows to increase the productivity of the setup by automatically maintaining the necessary vacuum values in comparison with manual control.

With a constant value of the supported vacuum, the complex ensures the stability of the modes of carrying out the technological processes of coating deposition. The system provides automatic dosing of the working gas inlet. The negative influence of the human factor is

exclude. The hardware and software complex for automated control and monitoring of the vacuum system of the "Bulat-6" setup includes:

– software and logic controller type ELC-22DC-DA-R- N-HMI XLogic;

– expansion modules for input/output of analog, digital signals and providing relay outputs ELC-E-16DC-DA-R;

– modular power supply on DIN-rail MDR-60-24;

– touchscreen graphic panel Samkoon UNSK-070AS;

– Ethernet switch;

– a personal computer (laptop).

The listed elements (except for the laptop) are structurally mounted in the crate CAMAC (Fig. 3).

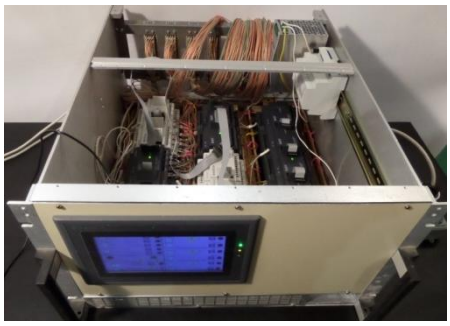

Fig. 3. Hardware-software complex

The main element of the hardware-software complex is the industrial program logic controller XLogic. It implements the exchange of commands and data with expansion modules, provides interaction with the units of the "Bulat-6" setup. All actions are performed according to the programmed algorithm.

The controller provides input into the system of 8 analog, 6 discrete signals and the inclusion of 8 relay channels. The controller stores the recorded programs and configuration data of each of the expansion modules. The controller is equipped with an Ethernet module for communicating with devices and computer networks using a switch.

The presence of such a module allows to expand the communication capabilities of the complex, which are necessary to create a fully functional and efficient automatic control and management system.

The controller has a built-in display and a keyboard for tuning modes of operation and testing, serial ports RS232 and USB for connecting expansion modules of various types.

The expansion modules ELC-E-16DC-DA-R are designed for inputting discrete/analog signals and implementing relay outputs. They provide input into the system up to 8 discrete signals, up to 4 analog signals and switching of 8 relay channels.

The input and output signals of the PLC have the following parameters:

– analog input – 0...+10 V;

– discrete input: "0" – ≤ 3V, "1" – ≥ 8 V;

– relay channels: maximum switching current at 220 V – 10 A/2 A (active/inductive load).

The colored Samkoon UNSK-070AS touch panel is designed to enter commands for controlling the operation of the vacuum system and displaying the mnemonical scheme of the vacuum system. On the mnemonical scheme serving as the operator panel, the current values of technological parameters and the state of the units of the vacuum system are displayed. If there are extraordinary or emergency situations, a corresponding warning appears. The touch panel has the following options:

– the size is 7" (16:9);

– resolution – 800×480;

– touch panel – yes;

– memory – 128 Mb / FLASH + 64 Mb DDR.

All modules and components of the CAMAC crate are connected by cables with separable and screw connections. As the communication interface between the controller and the expansion modules of the PLC, the interface with the Modbus RTU protocol is used. The crate is connected to the control rack "Bulat" by six 40-core cables. The crate is connected to the AC mains 220 V.

The controller is equipped with an expansion port. It allows you to connect up to 16 expansion modules to the controller additionally.

As the communication interface between the PLC, the operator panel and the personal computer, an Ethernet interface is used. The interconnection is via an Ethernet switch.

The automated system allows to control the following elements of the vacuum system of the setup:

– valves status (open/closed);

– the state of the fore-vacuum and diffusion pumps (on/off);

– pressure control in the fore-vacuum line;

– control of pressure in the vacuum chamber.

To monitor the condition of the units of the "Bulat" setup (the position of valves, flaps, dampers, the current position of the electrical equipment, etc.); the automation system uses discrete signal input channels.

Measurement of the pressure value at various points of the vacuum system is carried out using analog-to-digital converters of analog input modules. The control of valves, pumps and measuring devices is implemented by means of PLC relay channels.

The parameters of the setup real signals differ from the operating parameters of the PLC signals and in most cases are unacceptable. In order to bring them into conformity, devices for coordination with the object object (DAO) have been developed. They include units for normalization and amplification of signals, as well as galvanic isolation of electrical circuits. The decoupling is implemented on the basis of integrated analog and digital optocouplers.

Control and monitoring of the vacuum system in the automated mode is realized by the executable program which is loaded in the controller's memory. The progress of the process is displayed on the Samkoon touch panel and on the monitor screen of the remote personal computer. The staff has the ability to monitor the process and operatively influence the its implementation. The developed mnemonic scheme has a high cognitiveness (ability to perceive and process external information) to facilitate the support, adjustment and control of the technological process. A package of programs for the management and

monitoring of the modernized vacuum system of the "Bulat" setup was developed. It consists of a working program and a set of test programs for manual and automatic modes. Programs for monitoring the condition of valves, pumps and controlling their operation have been developed. Programs are written in the language of functional block diagrams (FBD) for PLCs. The software has a multi-page structure. An example of FBD control of a vacuum system is shown in Fig. 4.

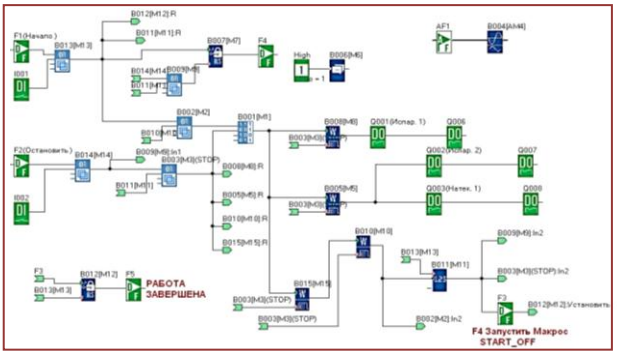

Fig. 4. FBD control of the vacuum system

Initialization of the necessary parameters for the program executed by the PLC module is performed by a complementary program developed with the help of SK Workshop software.

The hardware and software complex for automation can easily be configured to perform a specific task using the software XLogicSoft. For the purposes of software support of the hardware part of the complex, the total address space of all XLogic crate modules and graphic mnemonic elements was organized. Each module was assigned an individual address and installed mechanically using microswitches. In the regular automated operation mode of the vacuum system, in accordance with the programmed algorithm, the necessary valves, diffusion, fore-vacuum pumps and measuring devices are switched on/off.

The process is displayed on the interactive mnemonical schema. In the event of emergency situations, such as worsening of pumps, violation of vacuum in the system, the program responds operatively to the event, starting the execution of emergency programs.

In the process of debugging the modules of the hardware and software complex for automation of the vacuum system of the "Bulat" setup, the interaction of the electronic and software components included in its structure was worked out.

CONCLUSIONS

The automation of the vacuum system made it possible to reduce the influence of the human factor on the coating process and to increase the technological capabilities of the "Bulat-6" setup. Modular design of the developed automated vacuum system makes it easy to adapt the system to the changed number and types of signals and to load it on a similar setup.

Despite its low cost, XLogic controllers have excellent quality and meet the highest requirements of international standards. Logic controllers XLogic have become a worthy alternative to expensive equipment of well-known brands, for example, Simens.

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ПРОГРАММНО-АППАРАТНЫЙ КОМПЛЕКС ДЛЯ АВТОМАТИЗИРОВАННОГО УПРАВЛЕНИЯ И КОНТРОЛЯ ВАКУУМНОЙ СИСТЕМЫ УСТАНОВКИ «БУЛАТ-6»

С.П. Губарев, А.В. Леонович, Р.М. Муратов, Я.Н. Незовибатько, Г.П. Опалева, В.С. Таран, М.И. Золототрубова

Представлен аппаратно-программный комплекс для автоматизированного управления и мониторинга вакуумной системы установки для нанесения покрытий «Булат-6». Его использование обеспечивает стабильность процесса получения и поддержания требуемого вакуума в установке. Комплекс построен на базе программно-логического контроллера (ПЛК) типа ELC-22 XLogic.

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