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UDC 669

AUTOMATED COMPLEX OF MULTI-LEVEL SYSTEM FOR RESEARCH IN GASDYNAMIC MODES IN STAGES OF METALLURGICAL SER TYPE UNIT*

ABSTRACT. The article presents the developed low-temperature gas-dynamic model of self-organizing jet-emulsion aggregate and the laboratory complex created on its basis. The automated system of the laboratory complex control is shown, as well as the detail description of the automated system components used for measurement and analysis of temperature, excess and deferential pressure. The interaction pattern of the automated system components with splitting to the subsystems of the upper and the lower levels is described. A diagram showing the data movement in the automation system and pathways of control and adjustment parameters is also presented. The developed laboratory complex control software is outlined. The invented laboratory complex gives wide opportunities to study gas dynamics in energy-consumed units. It can also be used in the academic activity to carry out laboratory research.

The laboratory complex helps to find out more about a self-organizing process and conduct a research in the self-organization area using processes in jet-emulsion type aggregates as an example.

KEY WORDS. SER type unit, sensor, controller, object interaction diagram, data traffic pattern.

In recent years there has been an increasing interest to processes and industrial units of liquid-phase restoration, SER type unit being one of them [1].

This is due to the fact that the traditional sintering and coke-oven and blast- furnace technology is inconvenient and highly elaborate, there is anticipated coke shortage and a possibility to use cheap low-grade fine ore and waste.

Still, in terms of energy saving the process like this needs further improvement. With off-gases, the temperature of which is about 1600^0 C, approximately half the energy of the source fuel when emitted into the environment is wasted. Such heat losses substantially reduce the COP of metallurgical units, while the attempts of full thermal energy development in the working process chamber can lead to unwanted results and commonly affect adversely the output of major produce [2].

* V. P. Tsymbal, S. P. Mochalov. A method for producing metals from ore materials and a unit for its implementation. RF Patent 2272849. PCT Bulletin. 9. 2006. P. 12

Therefore, fuel economy by simultaneous reducing heat losses from off-gas and integral utilization of combustion products for technological, engineering and chemical energy cascading is a prospective line of development [3]. To reach ultimate energy efficiency special setups can be used. In these setups combustion products give up energy gradually moving from high-temperature level to moderate and low-temperature levels with the aim to recover heat to the fullest degree [4].

Chemical energy can be used as well [5]. However, it is gas dynamics process that mainly influences heat transfer. It is with the aim to study gas dynamics in SER type unit and energy-consumed units that the low-temperature gas-dynamic model of self-organizing jet-emulsion aggregate has been created (Fig. 1). It gives an opportunity not only to study gas dynamics in two-phase media, but also to carry out multipurpose laboratory and practical research for all basic levels of automation system.

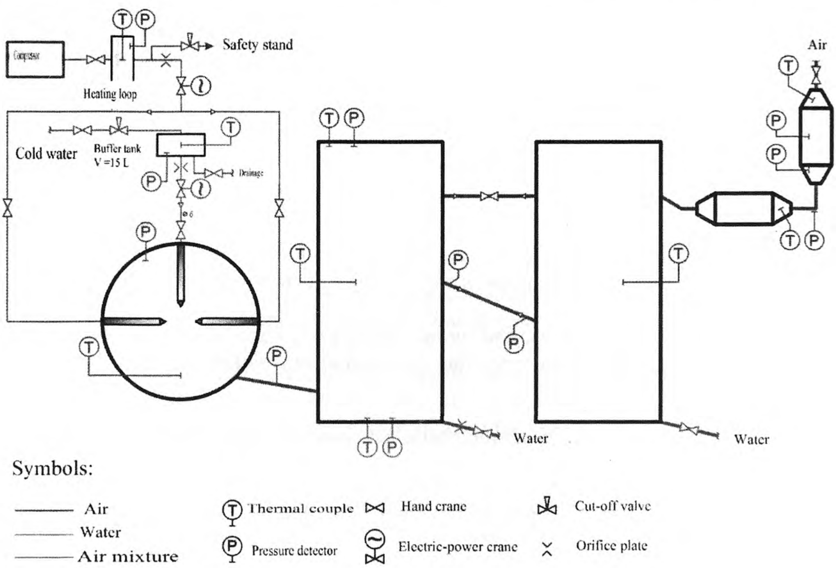


Fig. 1. Diagram of automation laboratory setup

The main tasks performed with the help of the complex:

1. overall control, adjustment, management of mechanisms, systems and processes;
2. ensuring consistent equipment operation;
3. equipment diagnostics and monitoring;
4. prevention of emergency situations;
5. acquisition and storage of information on laboratory work;
6. analysis and preparation of conclusions on the most efficient use of the process.

Let us consider creation of automation system of the laboratory setup that is made up of automation cabinet, agent delivery system, reaction units, programmable logic controller (PLC), sensors, shut-off valve electric drive.

The automation cabinet contains three MBA-8 analog input modules, two BP14-D4.4-24 multiple power units, one MU110-224.8R discrete output module.

Reaction units comprise five items: oscillator of spherical shape, pelletizer, refining pit, exhaust-heat boiler, boiling-bed vessel, all cylindrical form. The units are made from plexiglass.

The 'heart' of the setup is a PLC-150 programmable logic controller made by OVEN Company. The controller has a number of advantages: it has no operation system, gives an opportunity to work on any non-standard protocol, broad options for self-check, software hot-swap, an internal battery, and a real-time clock. PLC configuration is defined by RS-485 interface and CoDeSys software package of the personal computer [6].

Professional automation system development is closely connected with CoDeSys software package, the primary function of which is application software development using IEC 61131-3 standard programming languages. The software package consists of two parts: CoDeSys programming environment and CoDeSys SP run-time system. CoDeSys package runs on a computer and is used when a program is being prepared. Programs are compiled into a quick machine code and are downloaded to the controller. CoDeSys SP works in the controller, providing code loading and debugging, input/output and other service functions.

Note that temperature, excess pressure, differential pressure (the amount used) are measured in the system. For this purpose in the setup OVEN PD 100-DI0, 6–311–1.0 excess pressure sensors, Elemer AIR-10/M1-DD 1457 differential pressure sensors and OVEN DTPL 204–00.40/0.6 thermal converters are used. To control agent flow, shut-off valve electric drive is used.

Figure1 shows points of connection of sensors and location of shutoff and control valves. The automation system of the laboratory setup consists of two subsystems [7]:

- gas supply control and regulation subsystem;
- charge material control and monitor subsystem.

Gas supply control and regulation subsystem. The compressor delivers purge air through the pipeline which is consistently equipped with a valve, a heating circuit (with a pressure sensor and thermal converter) and a normally closed shut-off valve. Measuring diaphragm and electric control valve are necessary to control air delivery. There are also air delivery manual valves. Into the jet-emulsion reactor the air is delivered via two side injection valves.

Charge material control and monitor subsystem is a water pipeline 15 mm in diameter with a manual valve and a normally open valve in series. There is a pressure sensor and a thermal converter in the buffer tank. Further there is a measuring diaphragm and electric control valve, followed by a 6 mm pipeline narrowing. Water (charge material) is delivered to the reactor through the upper injection valve.

Figure 2 shows automation system object interaction diagram.

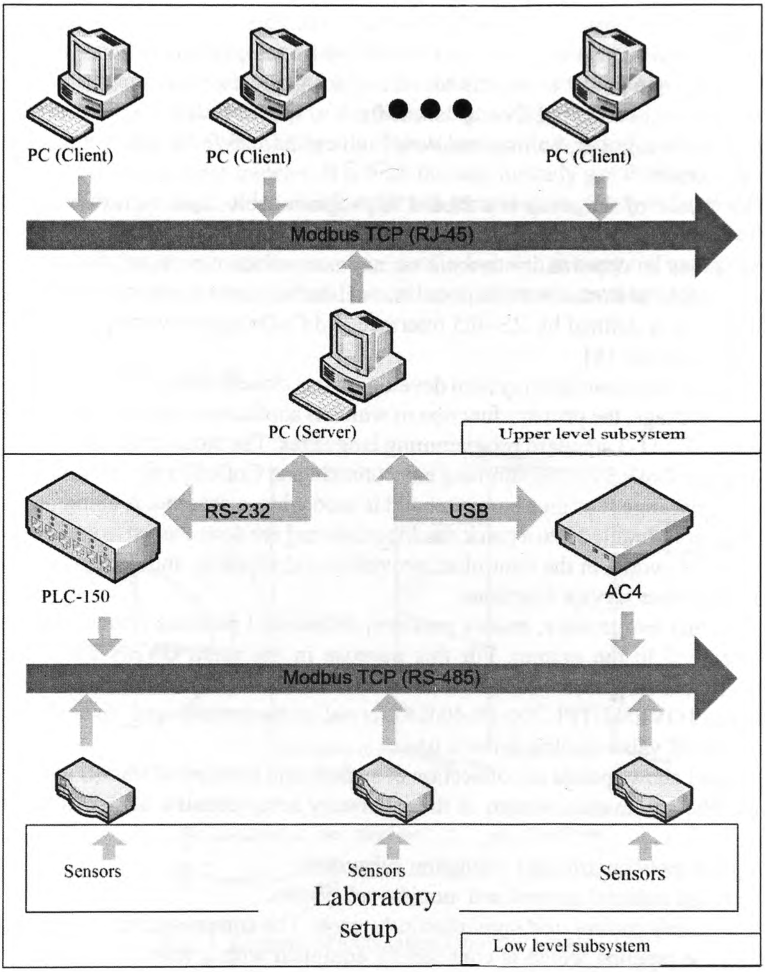


Fig. 2. Automation system object interaction diagram

In the first place it is worth singling out two subsystems of upper and lower levels. The first subsystem connects the back-end computer with front-end computers and PLC. The connection is based on ModbusTCP using RJ–45 interface (local network). RJ–45 interface provides any computer in the local network (front-end computers) access to automation system control interface. To have this access it is necessary to install AgreGate SCADA system on front-end computers. Using the local network as data transmission network is the reason why ModbusTCP is used (ModbusTCP/IP).

The subsystem of the lower level combines elements of automation (PLC, MBA-8, sensors). The communication in this system is done via Modbus using RS-485 interface, which is nowadays considered the standard of communication between electronic means of automation.

Thus, to transmit data from the lower to the upper level, there are three alternate transmission channels. RJ-45 (LAN) interface is the main channel, and COM and USB interfaces are used as backup ones. When on one of the channels connection is broken OPC-Server automatically switches over to the backup channel in the following order: RJ-45, COM, USB. This solution can significantly improve system reliability.

Figure 3 shows data movement pattern in the automation system. We note that either control or setting parameters are transmitted in the information subsystem.

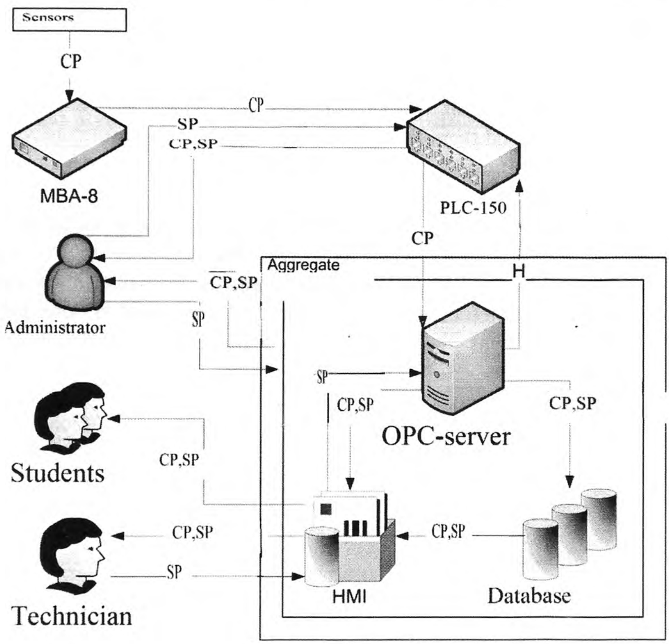


Fig. 3. Data movement pattern in the information subsystem

Control parameters include: temperature in the heating circuit (air heating) pressure in the heating circuit (air heating), temperature in the buffer tank, pressure in the buffer tank, temperature in the oscillator, pressure in the oscillator, temperature in the refining pit at 3 points; pressure in the refining pit at 3 points, temperature in the pelletizer, pressure in the pelletizer at 2 points.

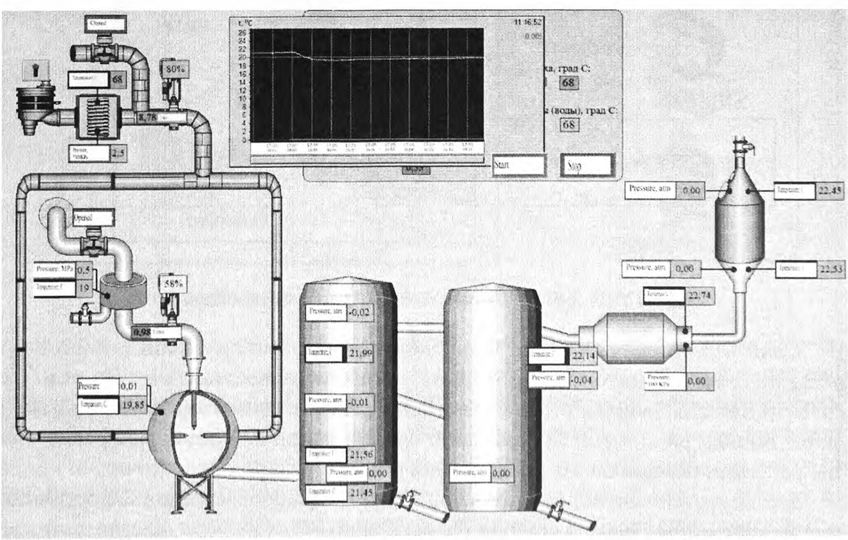
Setting parameters include: consumption of the reagents entering the oscillator; temperature of the reagents entering the oscillator.

Control parameters are transmitted from sensors in the form of analog signal to a MVA-8 analog input module and then MVA-8 converts it into digital and transmits the data to the PLC. After that the OPC-server receives data from the PLC. From the OPC-server the data appear in the database (in the OPCHDA-HistoricalDataAccess mode) and in HMI (in the OPCDA-DataAccess mode).

It is essential to store historical data in the OPCHDA mode as it makes it possible to conduct various studies of processes in SER type units. To create and maintain RESEARCH and PROTOCOL databases, up-to-date database management system (MS SQL) is used [8, 9]. Data transfer is performed via the DBMS LectusModbus OPC/DDE server. The data from the PLC-150 (directed by CoDeSys) via Ethernet protocol Modbus TCP enter the PC, namely the LectusModbus OPC/DDE server program. Next, the OPC DA (DataAccess) specification is used; real-time data are coming into SCADA-system and are displayed on the screen form (Fig. 4) and recorded in the MS SQL database.

Setting parameters play an important role in the system as they determine the unit operation mode. The value set of setting parameters by default necessary for the complex to operate is written in the PLC memory bank. If the need arises, the setting parameters can be changed from the HMI. These changes are transmitted via OPC-server to the PLC. In its turn, the PLC changes the setting parameters by default to the supplied.

The laboratory complex is mainly used by students, a technician and an administrator. All these users have access to view the values of control and setting parameters in the HMI SCADA-system. However, only the technician and administrator may specify setting parameters. This separation of access right is done for security reasons.



The present automated laboratory complex offers a wide range of thoughts for researchers in academic and scientific areas and enables in practice to get familiarized with a self-organizing process. In addition, along with using the laboratory complex there is an opportunity to master automation system structure as well as SCADA system. It is possible to change the setting parameters in the system, to conduct research in the field of self-organization [10] using the processes in the SER type units as an example.

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