Description of the complex of technical means of an automated control system for the technological process of thermal vortex enrichment

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Abstract. The description of the complex of technical means of the automated system for controlling the technological process of thermal vortex enrichment was carried out as part of the project to create a comprehensive resource-saving technology and the organization of high-tech production of carbon and silicon dioxide nanostructures to improve the properties of building and structural materials. The description of the complex of technical means was made taking into account the justification for choosing the structure of the complex of technical means, the description of its functioning, the main decisions on the placement of technical means, the rationale for the application and technical requirements for equipment, as well as the justification of methods for protecting technical means. Computer equipment and data transmission equipment were selected. The described set of technical means is necessary and sufficient to achieve the goal of creating an automated control system for the technological process of thermal vortex enrichment, namely, to carry out continuous technological control of the equipment and process parameters of the automated process control system of the thermal vortex enrichment technological process; process safety in the production of MD1; collection of data on technological processes and equipment operation, their processing, display and documentation; optimization of the technological process through the use of advanced visualization tools, modern management algorithms and analysis of accumulated technological information; minimize the impact of human factors on the processes of collecting and processing information about the technological process; automatic prevention of the development of emergency situations.

1. Introduction

The development of a comprehensive resource-saving technology and the organization of a high-tech production of carbon and silicon dioxide nanostructures to improve the properties of building and structural materials includes the creation of a program complex “Automated process control system for producing MD1 and MD2 nanostructure concentrates” in terms of providing thermal vortex enrichment [1-3].

An automated process control system for thermal vortex enrichment is designed to control and control the process of thermal vortex enrichment to obtain a modifying additive based on silicon dioxide (MD1).

The purpose of creating an automated control system for the technological process of thermal vortex enrichment is:
continuous technological control of equipment operation and technological process parameters of an automated control system for the technological process of thermal vortex enrichment;

- ensuring the safety of the process in the production of MD1;

- collection of data on technological processes and equipment operation, their processing, display and documentation;

- optimization of the technological process through the use of developed visualization tools, modern control algorithms and analysis of accumulated technological information;

- minimizing the influence of the human factor on the processes of collecting and processing information about the technological process;

- automatic prevention of emergency situations.

During technical design, the following regulatory and technical documents were used:

1. GOST 34.601-90 “Automated systems. The stages of creation”.
2. RD 50-34.698-90 “Automated systems requirements for the content of documents”.

2. Structure of the complex of technical means

2.1. Justification of the choice of structure of a complex of technical means

A distributed control system was chosen as the structure of the complex of technical means of an automated control system for the technological process of thermal vortex enrichment. This structure provides independent control functions for each of the 5 lines of thermal vortex enrichment. If the equipment of adjacent departments fails, the rest continue to function normally. The same situation occurs when the integrity of the network cable is violated.

2.2. Description of the functioning of the complex of technical means

The functioning of the complex of technical means is carried out according to the developed algorithms for the processes:

- Reading and processing of analog signals;
- Management of the regulatory body;
- PID controller;
- emergency stop;
- Regeneration of bag filters.

In start-up and emergency operation of the complex is carried out in accordance with the developed start-up and emergency operation algorithms of the automated control system.

2.3. The main decisions on the placement of a complex of technical means

A control cabinet for each line of thermal vortex enrichment with a controller and input-output modules is located on the technological site of its line. Cabinets with frequency converters are located directly next to the technological equipment. Workstation of the operator of all 5 lines is located in a single operator. Graphic panels by the operator are located directly on the front doors of the control cabinets of the corresponding lines. All primary converters are located on technological pipelines, equipment in such a way as to ensure ease of maintenance, as well as fulfill the installation requirements of the devices specified in the operation manuals. The power cabinets provided for in this project are supplied from existing power panels. The power supply of the lower automation level is carried out from control cabinets.

2.4. Justification of application and technical requirements for equipment

When applying the control system, a line of Siemens controllers of the Simatic S7 1200 series was selected, which have the following features:

- universal modular programmable controller for solving tasks of different levels;
- a wide range of modules for maximum adaptation to the requirements of the task being solved;
use of local and distributed structures of input-output and simple inclusion in network configurations;
free system extension.

As a result, the following programmable logic controllers were selected as controllers:
controller of the Simatic S7-1200 series with a CPU1214C processor;
Simatic S7-1200 I / O modules.

Programmable logic controllers from Siemens, Simatic S7-1200 with S7-1214C processor have the following parameters:
operation execution time no more than 2.3 μs;
the number of channels in the local I / O system is not more than:
discrete input -146;
discrete output-142;
analog input - 67;
analog output -33.
built-in interfaces - Ethernet;
loadable memory (MMC) of at least 4 MB.

For the placement of control systems, the following reliable Rittal modular cabinet equipment was selected with the following advantages:
design reliability;
modularity, the ability to configure the cabinet to the specified requirements.

As a result, the following model was selected as the control cabinet:
AE series cabinet with dimensions 600x760x350 (WxHxD) installed on the technological site.
The controller and related equipment (power supplies, terminals, fuses, circuit breakers, etc.) are placed on standard mounting panels that are included with the cabinet.

When choosing technical means for controlling the technological process, they were guided by the following requirements:
output universal signal 4-20 mA or 0-10 V;
measurement accuracy not lower than 1%;
high reliability;
compliance with the principle of measuring the parameters of the process conditions.

As a result, the following technical means of controlling the technological process were selected:
to measure the temperature of the air entering the combustion chamber, the temperature of the air leaving the combustion chamber, the temperature of the air flow at the beginning and end of the vortex enrichment pipe, the temperature in the cooling duct, the temperature of the air entering the cooling duct, the temperature in the bag filter hopper - a temperature converter with a unified output signal Metran 2700;
for signaling the presence of material in the pipeline after the feeder - microwave detector for the presence / absence of flow of solid bulk materials MWS-DP-3;
for speed control for the M1-1 blower, the M2-1 exhaust fan, the M3-1 screw feeder - Schneider Electric Altivar Process ATV600 frequency converters;
upper and lower level alarms in the raw material hopper and in the bag filter hopper - VEGAWAVE 61 level vibration indicator;
gas flow rate into the combustion chamber - Rosemount 8800 vortex flowmeter;
measurement of compressed air pressure in the line, gas pressure in the line, pressure at the beginning of the vortex enrichment pipe, pressure at the end of the vortex enrichment pipe, pressure in the cooling duct, pressure in the clean and dirty chambers of the bag filter - series pressure sensors Metran 55;
compressed air valves for the regeneration of bag filters - SMC solenoid valves for cleaning bag filters of the VXF2 series.
2.5. Justification of methods of protection of technical means
The following measures are used to protect technical equipment from mechanical stress:

- installation of fasteners that securely fix technical means;
- installation of technical equipment in places where there are no rotating mechanical parts of technological equipment;
- laying of cable lines in protective trays, pipes of metal hoses.

It is necessary to carry out protective grounding of the primary transducers of pressure, level, temperature, flow meters, control valves. Why connect the wire PV3 1x6 or grounding conductor of the same cross section, the grounding screws of the sensors with a grounding loop.

3. Computer facilities
A personal computer with parameters not lower than the following is selected as the operator’s automated workstation (AWP):

- Intel Pentium processor (or compatible) with a clock frequency of at least 3GHz;
- RAM at least 4096 MB;
- hard drive with a capacity of at least 1 TB;
- two monitors with a resolution of at least 1280x1024;
- 101 keyboard or Windows-compatible keyboard;
- Windows-compatible mouse.

To display information on the progress of the technological process, as well as the same state of the technological equipment, KTP 1200 operator panels were selected.

All equipment is connected to the network.

4. Data transmission equipment
Connection of the KTS equipment to the data transmission network is presented in the document “Structural diagram of the complex of technical means” ABSP.441199.001 C1.

As a network for building a distributed I/O system, as well as exchanging data between automation subsystems, the industrial network Profinet was selected, which provides high-speed data exchange between devices of a decentralized peripheral.

The data transmission network provides data transfer between the controllers of the automatic process control system, the workstation of the operators and the graphic operator panels.

The main components of the data network are the following equipment with integrated ProfiBus-DP interfaces:

- SIMATIC S7 1214C controller;
- operator panel KTP 1200;
- Ethernet communicator Siemens SCALANCE XB000.

Data is transmitted via Ethernet cable. Cable and network connectors are connected using RJ-45 connectors.

5. Conclusion
The description of the complex of technical means was made taking into account the justification for choosing the structure of the complex of technical means, the description of its functioning, the main decisions on the placement of technical means, the rationale for the application and technical requirements for equipment, as well as the justification of methods for protecting technical means. Computer equipment and data transmission equipment were selected.

The described complex of technical means is necessary and sufficient to achieve the goal of creating an automated control system for the technological process of thermal vortex enrichment, namely:
the implementation of constant technological control of the operation of equipment and process parameters of an automated control system for the technological process of thermal vortex enrichment;

• ensuring the safety of the process in the production of MD1;

• collecting data on technological processes and equipment operation, their processing, display and documentation;

• optimization of the technological process through the use of advanced visualization tools, modern control algorithms and analysis of accumulated technological information;

• minimizing the influence of the human factor on the processes of collecting and processing information about the technological process;

• automatic prevention of emergency situations.

References

[1] Kondratiev V V, Karlina A I, Guseva E A, Konstantinova M V, Gorovoy V O 2018 Structure of Enriched Ultradisperse Wastes of Silicon Production and Concretes Modified by them IOP Conference Series: Materials Science and Engineering 463(4) 042064

[2] Ilyushin P, Suslov K 2019 Operation of automatic transfer switches in the networks with distributed generation IEEE Milan PowerTech, PowerTech 8810450

[3] Ershov V A, Kondratiev V V, Karlina A I, Kolosov A D, Sysoev I A 2018 Selection of control system parameters for production of nanostructures concentrates Journal of Physics: Conference Series 1118(1) 012014