Description of information support of the automated control system for the technological process of thermal vortex enrichment

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Abstract. The information support of the automated control system for the technological process of thermal vortex enrichment is described. Solutions for the organization of information support, collection and transmission of information have been developed. A classification and coding system has been built. The intra-machine information base is organized according to the principle of dividing into high-level and low-level databases. It is possible to maintain an off-machine information base by creating reports for outputting information in the form of logs on paper. The composition of the information base in terms of databases is given.

1. Introduction
The automated control system for the technological process of thermal vortex enrichment is part of a project to create an integrated resource-saving technology and organize high-tech production of nanostructures based on carbon and silicon dioxide to improve the properties of building and structural materials. Information support for the automated control system for the technological process of thermal vortex enrichment consists of high-level and low-level databases. All databases are provided complete and ready to go [1-3]. The database is filled only by software specialists. Changing database fields is provided by the user interface. All DBMS maintenance procedures, including health diagnostics and data backup, must be performed in accordance with the general principles of DBMS administration [4, 5].

The organization of the information base does not provide for integration with external information resources. For the subsystem of integration with external information resources, databases of other subsystems are used [6-8].

Information from the databases is displayed on the screen of the operator's workstation and operator panels in varying degrees of detail. Through visualization systems, changes can be made to a limited number of database fields [9]. High-level databases can be accessed by external information systems.

2. Organization of information support
Low-level data from monitoring and control devices are stored in the energy-dependent memory of the controller on an electronic medium (NFlash micro memory card). Access to data from other AS is closed with the exception of trusted sources and receivers [10-13].
Top-level data to maintain continuous long-term archives of all process parameters, a hard-magnetic disk (HDD) and Microsoft SQL databases are used. Data can be accessed by means of OPC, ODBC, SQL queries.

3. Organization of collection and transmission of information
The information consists of data coming from the following sources:
- sensors and primary converters;
- frequency converters;
- executive mechanisms;
- operator panels;
- automated workstations (AWP);
- personal computers (PC).

According to the intensity of the incoming information, they are divided into:
- continuous (operator panels, sensors and primary converters, frequency converters, PC, AWP);
- frequent (executive mechanisms);
- rare (switches).

By volume, the information is divided into:
- small (sensors and primary converters, frequency converters, etc.);
- medium (operator panels, remote data collection stations);
- large (AWP, PC).

The collection of information is carried out in automatic mode with diagnostics about the state of information quality.

4. Building a classification and coding system
Data classification:
- raw process parameters;
- processed process parameters;
- DB of regulators;
- DB of regulatory bodies (RO);
- discrete variables;
- others.

Class encoding:
- Raw process parameters
  \[ \text{RAW}_* ** \]
  where * – measured parameter, ** – short name of the position

- Processed process parameters
  \[ * _ ** \]
  where * - measured parameter, ** - short name of the position

- DB of regulators
  \[ \text{FROM}_* ** \]
  where * - adjustable parameter, ** - short name of the position

- DB of regulatory bodies (RO)
  \[ V _ * ** \]
  where * - location of RO installation, ** - short name of the position

- DB of archive parameters
  \[ * _ ** _ SUM \]
  where * - measured parameter, ** - short name of the position

- Discrete variables
  \[ * _\text{ALARM} / HI / LO / ON / OFF \]
where * is the measured parameter or the short name of the position, HI / LO / ON / OFF is selected depending on the type of the sensor in the triggered state (logical unit).

- Others.

The rest of the parameters are coded logically for reasons of a clear concept of what information the variable carries [14-16].

5. **Formation of database numbers DB**

DB "Reading and processing analog signals" is as follows.

Primary measuring devices: the position of the primary converter is taken from the automation circuit ABSP.441199.001 C3 (the number before the separator in the form "," ); this value is multiplied by 10 and the line number is put at the end (from 1 to 5).

The rotational speed is of the blower, smoke exhauster, feeder auger motors and the position of the actuator. The position of the primary measuring transducer in the circuit of which the regulating device is involved is taken. This value is multiplied by 10, the zero at the end changes to 7 and the line number is put at the end (from 1 to 5) [17-18].

DB "Control of the regulatory body" and DB "PID-regulator" includes the following.

The position of the primary measuring transducer is taken in the loop of which this regulator is located, this value is multiplied by 10, the zero at the end changes to the number 1 and at the end the line number is put (from 1 to 5).

DB "Archive values of process parameters" consists of the following.

Primary measuring devices: the DB number of the DB "Reading and processing analog signals" is taken and the zero before the line number is changed to 8.

The rotational speed of the blower motors, the smoke exhauster, the feeder auger and the position of the actuator: the DB number of the database "Reading and processing analog signals" is taken and the number 5 before the line number is changed to 8.

6. **Organization of the in-machine information base**

The information base is organized according to the following principle:

- Low-level databases:
  - DB "Reading and processing of analog signals";
  - DB "Management of the regulatory body";
  - DB "PID-controller";
  - DB "Archive values of process parameters".

- High-level databases:
  - DB "Long-term archive of process parameters";
  - DB "Alarms and warnings".

The structure of the in-machine information base is shown in Fig. 1.
7. **Organization of the off-machine information base**

The out-of-machine information base is built on the regulatory process indicators, ore and concentrate sampling logs, as well as on the basis of technical data of the applied control, management and regulation devices. In accordance with which information is entered into the in-machine databases through the user man-machine interface of the used SCADA system [19-20].

Keeping logs of process indicators is not provided, since the system, at the user's request, can issue the necessary information on paper. But the process data can be recorded in the journals of shift, daily, monthly or annual work [21-23].

8. **Composition of information support**

The databases of the lower level of the automated system are described in tables 1 - 4.

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**Figure 1.** Algorithm for reading and processing analog signals.
Table 1. DB "Reading and processing of analog signals".

| No | Designation       | Code   | Name                                                      |
|----|-------------------|--------|-----------------------------------------------------------|
| 1  | T_vozd_in         | DB 101 | Temperature of the air entering the combustion chamber   |
| 2  | T_vozd_out        | DB 201 | Air temperature at the exit of the combustion chamber     |
| 3  | T_beg_react       | DB 301 | Air flow temperature at the beginning of the vortex enrichment tube |
| 4  | T_end_react       | DB 401 | Air flow temperature at the end of the vortex enrichment tube |
| 5  | T_cool            | DB 501 | Air flow temperature in the cooling gas duct              |
| 6  | T_in_cool         | DB 601 | Air temperature entering the cooling gas duct             |
| 7  | T_prod_bunk       | DB 701 | Bag filter bin temperature                               |
| 8  | P_gas             | DB 801 | Gas pressure entering the burner                          |
| 9  | P_air             | DB 901 | Compressed air pressure                                  |
| 10 | P_out_topk        | DB 1001| Pressure at the beginning of the vortex enrichment tube   |
| 11 | P_cool            | DB 1101| Cooling duct pressure                                    |
| 12 | P_in_filtr        | DB 1201| Pressure in the dirty bag filter chamber                  |
| 13 | P_out_filtr       | DB 1301| Pressure in the clean chamber of the bag filter           |
| 14 | F_gas             | DB 1401| Gas consumption entering the combustion chamber           |
| 17 | FREQ_M1_1         | DB 257 | Blower M1-1. Rotation frequency.                         |
| 18 | FREQ_M2_1         | DB 1157| Smoke exhauster M2-1. Rotation frequency.                 |
| 19 | FREQ_M3_1         | DB 1557| Material feed screw drive M3-1. Rotation frequency.       |
| 20 | Poloz_5_1         | DB 557 | Gate 5-1s position                                       |

Table 2. DB "Management of the regulatory body".

| No | Designation  | Code | Name                                      |
|----|--------------|------|-------------------------------------------|
| 1  | V_F_air_cool | DB 551| Regulator of air supply to the cooling flue|

Table 3. DB "PID-controller".

| No | Designation    | Code  | Name                                      |
|----|----------------|-------|-------------------------------------------|
| 1  | C_T_vozd_out   | DB 251| Combustion chamber temperature controller  |
| 2  | C_P_cool       | DB 1151| Vacuum regulator in the cooling gas duct |

### Table 4. DB "Reading and processing of analog signals".

| No | Designation            | Code  | Name                                                      |
|----|------------------------|-------|-----------------------------------------------------------|
| 1  | T_vozd_in_Sum          | DB 181| Temperature of the air entering the combustion chamber   |
| 2  | T_vozd_out_Sum         | DB 281| Air temperature at the exit of the combustion chamber    |
| 3  | T_beg_react_Sum        | DB 381| Air flow temperature at the beginning of the vortex enrichment tube |
| 4  | T_end_react_Sum        | DB 481| Air flow temperature at the end of the vortex enrichment tube |
| 5  | T_cool_Sum             | DB 581| Air flow temperature in the cooling gas duct             |
| 6  | T_in_cool_Sum          | DB 681| Air temperature entering the cooling gas duct            |
| 7  | T_prod_bunk_Sum        | DB 781| Bag filter bin temperature                               |
| 8  | P_gas_Sum              | DB 881| Gas pressure entering the burner                         |
| 9  | P_air_Sum              | DB 981| Compressed air pressure                                  |
| 10 | P_out_topk_Sum         | DB 1081| Pressure at the beginning of the vortex enrichment tube |
| 11 | P_cool_Sum             | DB 1181| Cooling duct pressure                                   |
| 12 | P_in_filtr_Sum         | DB 1281| Pressure in the dirty bag filter chamber                 |
| 13 | P_out_filtr_Sum        | DB 1381| Pressure in the clean chamber of the bag filter          |
| 14 | F_gas_Sum              | DB 1481| Gas consumption entering the combustion chamber          |
| 15 | FREQ_M1_1_Sum          | DB 1581| Blower M1-1. Rotation frequency.                        |
| 16 | FREQ_M2_1_Sum          | DB 1681| Smoke exhauster M2-1. Rotation frequency.                |

The databases of the lower level of the automated system are described in tables 5, 6.

### Table 5. DB "Long-term archive of process parameters".

| No | Designation            | Name                                                      |
|----|------------------------|-----------------------------------------------------------|
| 1  | T_vozd_in.PV           | Temperature of the air entering the combustion chamber    |
| 2  | T_vozd_out.PV          | Air temperature at the exit of the combustion chamber     |
| 3  | T_beg_react.PV         | Air flow temperature at the beginning of the vortex enrichment tube |
| 4  | T_end_react.PV         | Air flow temperature at the end of the vortex enrichment tube |
| 5  | T_cool.PV              | Air flow temperature in the cooling gas duct             |
| 6  | T_in_cool_PV           | Air temperature entering the cooling gas duct            |
| 7  | T_prod_bunk.PV         | Bag filter bin temperature                               |
| 8  | P_gas.PV               | Burner gas pressure                                      |
| 9  | P_air.PV               | Compressed air pressure                                  |
| 10 | P_out_topk.PV          | Pressure at the beginning of the vortex enrichment tube   |
| 11 | P_cool.PV              | Cooling duct pressure                                    |
| 12 | P_in_filtr.PV          | Pressure in the clean chamber of the bag filter          |
| 13 | P_out_filtr.PV         | Pressure in the dirty bag filter chamber                 |
| 14 | F_gas.PV               | Gas consumption entering the combustion chamber          |
| 15 | F_air.PV               | Combustion air consumption                               |
| 16 | F_air_cool.PV          | Air flow entering the cooling gas duct                   |
| 17 | FREQ_M1_1.PV           | Blower M1-1. Rotation frequency.                        |
| 18 | FREQ_M2_1.PV           | Smoke exhauster M2-1. Rotation frequency.                |
| 19 | FREQ_M3_1.PV           | Material feed screw drive M3-1. Rotation frequency.      |
| 20 | Poloz_5_1.PV           | Gate 5-1s position                                      |
| 21 | C_T_vozd_out.PV        | Temperature control from the combustion chamber          |
| 22 | C_P_cool.PV            | Regulation of vacuum in the cooling gas duct             |
| 23 | C_F_air.PV             | Combustion air flow control                              |
| 24 | C_F_air_cool.PV        | Regulation of air supply to the cooling flue             |
| 25 | C_FREQ_M3_1            | Material feed screw drive M3-1. Speed control.           |
### Table 6. DB "Alarms and warnings".

| No | Designation     | Name                                               |
|----|-----------------|----------------------------------------------------|
| 1  | Burner_alarm    | Burner. Crash.                                    |
| 2  | bunk_1_HL       | Feedstock bin. Upper level.                        |
| 3  | bunk_1_LL       | Feedstock bin. Lower level.                        |
| 4  | mater_on        | Material availability                             |
| 5  | bunk_2_HL       | Product hopper. Upper level.                       |
| 6  | bunk_2_LL       | Product hopper. Lower level.                       |
| 7  | M1_1_on         | Blower M1-1. Work.                                |
| 8  | M1_1_alarm      | Blower M1-1. Frequency drive failure               |
| 9  | M2_1_on         | Smoke exhauster M2-1. Work.                       |
| 10 | M2_1_alarm      | Smoke exhauster M2-1. Frequency drive failure      |
| 11 | M3_1_on         | Material feed screw drive M3-1. Work               |
| 12 | M3_1_alarm      | Material feed screw drive M3-1. Frequency drive failure |
| 13 | P_cool          | The lower value of the vacuum in the tube of vortex enrichment |
| 14 | P_delta_filtr_  | The upper value of the pressure drop in the baghouse filter |
| 15 | T_cool          | The temperature in the cooling flue is close to the upper limit |
| 16 | T_out           | Upper combustion chamber temperature               |
| 17 | T_out           | Lower combustion chamber temperature               |
| 18 | T_out           | The temperature in the combustion chamber is close to the upper value |
| 19 | T_out           | The temperature in the combustion chamber is close to the lower value |
| 20 | T_cool          | Upper temperature level in the cooling flue        |

### 9. Conclusion

Information support of the automated control system for the technological process of thermal vortex enrichment consists of high-level and low-level databases. The collection of information is carried out automatically with diagnostics about the state of the quality of information from sensors, transducers, buttons and switches, automated workstations, operator panels, personal computers.

The developed classification of data and coding of classes makes it possible to fully structure information, which is clearly reflected in the presented composition of the information base. Generation of reports for maintaining an off-machine database is based on the regulatory process indicators, ore and concentrate sampling logs, as well as on the basis of the technical data of the control, management and regulation devices used.

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