Control of the servo drive and the regulating body of the software

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Abstract. This paper presents control of the servo drive and the regulating body of the software complex “Automated process control system for the associated production of concentrates of nanostructures MD1 and MD2”. The developed algorithm is designed to control a two-position valve with an electric drive by “open / close” commands. It allows to carry out: control in manual and automatic mode, control of extreme positions and excess torque on the drive shaft; blocking of work in automatic mode with a command to close; determination of the priority of the close command; delay when reversing to stop the drive.

1. Introduction
At present, environmental issues [1, 2] and including of industrial waste as additives in various materials [3-7] are becoming increasingly important. One of these is micro silica. It is a waste, the volume of which is tens of thousands of tons per year in many countries of the world. Currently, various methods of enrichment and processing of industrial waste have been developed. In the course of developing a technology, it is also necessary to think about its automation, using advanced technologies in the field of mechanical engineering, cybernetics and robotics. One of such technologies and examples of automation are [8-12], which must be solved in conjunction with the development of silicon production processes [13-16]. After developing the technology as part of the development of the automated process control system, we developed the servo drive control and the software regulator.

2. Servo control
This algorithm is designed to control a motorized ON / OFF valve with open / close commands. The algorithm allows:

- control in manual and automatic mode;
- control of extreme positions and excess torque on the drive shaft;
- blocking of work in automatic mode with a command to close;
- priority of the close command;
- delay in reverse to stop the drive.

Input data are represented in the BOOL and TIME types; output in type BOOL (Tables 1-4). The solution algorithm is presented in Figure 1.
Information used

Table 1. Input data.

| No | Input information array name | Description | Data type | Range of values |
|----|-------------------------------|-------------|-----------|----------------|
| 1  | MAN                           | Manual control | BOOL     | TRUE, FALSE   |
| 2  | MAN_OPEN                      | "Open" command in manual mode | BOOL     | TRUE, FALSE   |
| 3  | MAN_CLOSE                     | "Close" command in manual mode | BOOL     | TRUE, FALSE   |
| 4  | EN                            | Work permit command in automatic mode | BOOL     | TRUE, FALSE   |
| 5  | V_OPEN                        | mode | BOOL     | TRUE, FALSE   |
| 6  | V_CLOSE                       | Open command in automatic mode | BOOL     | TRUE, FALSE   |
| 7  | FO                            | Close command in automatic mode | BOOL     | TRUE, FALSE   |
| 8  | FC                            | End position signal "open" | BOOL     | TRUE, FALSE   |
| 9  | FAULT                         | Closed end position signaling | BOOL     | TRUE, FALSE   |
| 10 | T_OPEN                        | Signaling of excess torque on the drive shaft | TIME    | T#1ms .. T#9999s |
| 11 | T_CLOSE                       | Opening time | TIME    | T#1ms .. T#9999s |
| 12 | T_STOP                        | Stop time of the electric drive | TIME    | T#1ms .. T#9999s |

Solution results

Table 2. Output data.

| No | Input information array name | Description | Data type | Range of values |
|----|-------------------------------|-------------|-----------|----------------|
| 1  | TGT_STATE                     | Steady state command | BOOL     | TRUE, FALSE   |
| 2  | WORKING                       | Work signal | BOOL     | TRUE, FALSE   |
| 2  | STOPING                       | Stop signal | BOOL     | TRUE, FALSE   |
| 4  | FB ERR                        | Feedback error | BOOL     | TRUE, FALSE   |
| 5  | OPEN                          | Opening signal | BOOL     | TRUE, FALSE   |
| 6  | CLOSE                         | Close signal | BOOL     | TRUE, FALSE   |

Test case requirements

Input data are selected from valid ranges of values.

Table 3. Input data for testing.

| No | Input information array name | Selection for testing |
|----|-------------------------------|------------------------|
| 1  | MAN                           | TRUE - manual mode, commands EN V_OPEN V_CLOSE are ignored; FALSE - automatic |
| 2  | MAN_OPEN                      | On the front command to open in manual mode |
| 3  | MAN_CLOSE                     | On the edge of the command to close in manual mode |
| 4  | EN                            | TRUE - automatic control is allowed, FALSE - V_OPEN V_CLOSE |
Table 3. Input data for testing.

| No | Input information array name | Selection for testing |
|----|------------------------------|------------------------|
| 5  | V OPEN                       | On the front command to open in automatic mode |
| 6  | V CLOSE                      | On the edge of the command to close in automatic mode |
| 7  | FO                           | Signal from actuator: TRUE open end position, FALSE otherwise |
| 8  | FC                           | Signal from actuator: TRUE closed end position, FALSE otherwise |
| 9  | FAULT                        | Signal from the drive: TRUE excess torque on the shaft of the electric drive, FALSE otherwise |
| 10 | T OPEN                       | In the range of values |
| 11 | T CLOSE                      | In the range of values |
| 12 | T STOP                       | In the range of values |

**Solution Algorithm**

![Diagram](image)

**Figure 1. Solution algorithm.**
Table 4. Output data.

| No | Input information array name | Test results |
|----|-------------------------------|--------------|
| 1  | TGT_STATE                     | Steady state of the command at the block level TRUE - opening, FALSE - closing |
| 2  | WORKING                       | When a control signal is issued: TRUE - open or close, FALSE - no control signal |
| 3  | STOPING                       | When the steady state of a command is changed at the block level while the drive is running: TRUE - after the change, the time T STOP has not passed, FALSE - has passed |
|    |                               | Feedback error: TRUE - during WORKING, the end position has not been reached during T_OPEN or T_CLOSE, FALSE - otherwise or after a new command has been given from the input |
| 4  | FB_ERR                         | Open signal: TRUE - when the steady state of the command at the block level changes to open for the time T_OPEN, FALSE - otherwise either FO or FAULT or STOPING |
| 5  | OPEN                           | Closing signal: TRUE - when the steady state of the command at the block level changes to close for the time T_CLOSE, FALSE - otherwise, either FC or FAULT or STOPING |
| 6  | CLOSE                          |                                         |

Here we see that the rational algorithm allows manual and automatic control, and mercury control is available when needed. The logical use is shown of control of extreme positions and excess torque on the drive shaft. An innovative blocking of automatic operation with a closing command is proposed. The priority of the close command is analyzed.

Reverse delay set to stop drive.

3. Results and discussion

This algorithm is designed to control a three-position regulator (PO) with open / close / stop commands with a built-in automatic stepping PI-controller.

It is used to control a three-position regulating body with the possibility of manual control and automatic regulation of various process parameters.

Input data are represented in the WORD, BYTE, REAL, INT types; the output is in type BYTE and REAL (Tables 5-8).

Information used

Table 5. Input data.

| No | Input information array name | Description                  | Data type | Range of values |
|----|-------------------------------|------------------------------|-----------|-----------------|
| 1  | COM_RST                       | Resetting controller settings| Bool      |                 |
| 2  | LMNS ON                       | Manual control               | Bool      |                 |
| 3  | LMNUP                         | "Open" command in manual mode| Bool      |                 |
| 4  | LMNDN                         | "Close" command in manual mode| Bool      |                 |
| 5  | LMNR_HS                       | End position signal "open"   | Bool      |                 |
| 6  | LMNR_LS                       | Closed end position signaling| Bool      |                 |
| 7  | CYCLE                         | Block call time              | Time      | T#1ms .. T#9999s|
| 8  | SP_INT                        | Regulation task              | Real      |                 |
Table 5. Input data.

| No | Input information array name | Description                                      | Data type | Range of values   |
|----|-------------------------------|--------------------------------------------------|-----------|-------------------|
| 9  | PV_IN                         | Adjustable value (position PO)                   | Real      |                   |
| 10 | GAIN                         | Gain                                             | Real      | 0 .. 99999        |
| 11 | TI                           | Integration time                                 | Time      |                   |
| 12 | T_STOP                       | Stop time of the electric drive                  | TIME      | T#1ms .. T#9999s  |

Solution Algorithm

Figure 2. Solution Algorithm.
Solution results

Table 6. Output data.

| No | Input information array name | Description | Data type | Range of values |
|----|------------------------------|-------------|-----------|-----------------|
| 1  | QLMNUP                       | Opening signal | Bool | QLMNUP          |
| 2  | QLMNDN                       | Close signal  | Bool | QLMNDN          |
| 3  | QLMNST                       | Stop signal   | Bool | QLMNST          |
| 4  | ER                           | The amount of mismatch (error) | Real | ER              |
| 5  | PV                           | Adjustable value | Real | PV              |

Test case requirements

Input data are selected from valid ranges of values.

Table 7. Input data for testing.

| No | Input information array name | Selection for testing |
|----|------------------------------|------------------------|
| 1  | COM RST                      | False                  |
| 2  | LMNS ON                      | Check operation with manual control - True, in automatic mode - False |
|    | LMNUP                        | When LMNS ON = True, True - command to open |
| 3  | LMNDN                        | With LMNS ON = True, True - close command |
| 4  | LMNR HS                      | True, False            |
| 5  | LMNR LS                      | True, False            |
| 7  | CYCLE                        | T#100ms                |
| 8  | SP INT                       | In the range of values |
| 9  | PV IN                        | In the range of values |
| 10 | GAIN                         | In the range of values |
| 11 | TI                           | In the range of values |
| 12 | DEADB W                      | In the range of values |

Table 8. Output data.

| No | Input information array name | Test results |
|----|------------------------------|--------------|
| 1  | QLMNUP                       | With LMNS ON = True and LMNUP = True and LMNR HS = False: True – opening |
|    |                              | With LMNS_ON = False and LMNR_HS = False: True - opening according to the regulation law |
|    |                              | With LMNS ON = True and LMNDN = True and LMNR LS = False: True - close |
| 2  | QLMNDN                       | With LMNS_ON = False and LMNR_LS = False: True - closing according to the regulation law |
| 3  | QLMNST                       | With QLMNUP = False and QLMNDN = False: True - stop |
Table 8. Output data.

| No | Input information | Test results                                      |
|----|-------------------|---------------------------------------------------|
| 4  | ER                | Numerical value - difference between PV IN - SP INT |
| 5  | PV                | PV IN value                                       |

To check the adequacy of the developed algorithm, many examples and test problems were worked out, some of which are given above. After analyzing the test results, one can draw conclusions about the effectiveness of the developed control of the servo drive and the regulating body of the software.

4. Conclusion

In order to develop the including of industrial waste in subsequent production cycles and the production of additives on their basis, a system for their automation was created.

The developed algorithm is designed to control a two-position valve with an electric drive by “open / close” commands and allows to carry out: control in manual and automatic mode, control of extreme positions and excess torque on the drive shaft; blocking of work in automatic mode with a command to close; determination of the priority of the close command; delay when reversing to stop the drive.

References

[1] Konyuhov V Yu, Gladkih A M, Galyautdinov I I and Severina Y D 2019 Economic aspects of green technologies *IOP Conf. Ser.: Earth Env.* 350 012036
[2] Konyuhov V Yu, Konstantinova M V and Gladkih A M 2019 Determination of restored units spectrum of equipment and development of the assembly unit repair method at industrial enterprises *J. of Phys.: Conf. Ser.* 1353 012047
[3] Svintsov A P, Galishnikova V V and Stashevskaya N A 2020 Dataset on the effect of nano-modified additives of concrete mixes technological properties for winter concreting *Data in Brief* 31 105756
[4] Galishnikova V V, Abdo Sh and Fawzy A M 2020 Influence of silica fume on the pervious concrete with different levels of recycled aggregates *Magazine of Civil Engineering* 93 71-82
[5] Ponomarev A, Steshenko D, Rassokhin A 2018 Development of technology for production of fire-resistant nanocomposite constructional rebar and structural elements based on it *MATEC Web of Conferences* 245 04001
[6] Gozbenko V E, Kargapoltsev S K and Karlina A I 2019 Synthesis and structure of sulfur-containing polymers based on polymer industrial waste applied for rail lubrication *IOP Conf. Ser.: Earth Env.* 229 012021
[7] Gozbenko V E, Kargapoltsev S K and Karlina A I 2019 Environmental benefits of new industrial waste-based lubricant compositions *IOP Conf. Ser.: Earth Env.* 229 012020
[8] Kondratiev V V, Nebogin S A, Sysoev I A, Gorovoy V O and Karlina A I 2017 Description of the test stand for developing of technological operation of nano-dispersed dust preliminary coagulation *Int. J. of Appl. Engineering Research* 12(22) 12809-12813
[9] Ershov V A, Gorovoy V O, Nebogin S A, Govorkov A S and Suharov A S 2019 System of process control for associated concentrate nanostructures production *J. of Phys.: Conf. Ser.* 1384 012010
[10] Nebogin S A, Ershov V A, Gorovoy V O, Govorkov A S and Suharov A S 2019 The main types of jigging machines structures *J. of Phys.: Conf. Ser.* 1384 012034
[11] Ershov V A, Kondratiev V V, Karlina A I, Kosnov A D and Sysoev I A 2018 Selection of control system parameters for production of nanostructures concentrates *J. of Phys.: Conf. Ser.* 1118 012014
[12] Nekrasov I V, Sheshukov O Y, Metelkin A A, Sivtsov A V and Tsymbalist M M 2016 Slag conditions in electrosmelting: A review *Steel in Translation* 46(6) 435-442
[13] Sivtsov A V, Yolkin K S, Kashlev I M and Karlina A I 2020 Processes in the Charge and Hearth Zones of Furnace Working Spaces and Problems in Controlling the Batch Dosing Mode during the Smelting of Industrial Silicon and High-Silicon Ferroalloys *Metallurgist* 64(5-6) 396-403

[14] Yolkin K S, Yolkin D K, Nemarov A A, Sysoev I A and Karlina A I 2018 Conduct of reduction smelting of metallic silicon: Theory and practice *IOP Conf. Ser.: Mater. Sci. Eng.* 411 012029

[15] Strakhov V M, Surovtseva I V, Elkin D K, Elkin K S and Cherevko A E 2012 Low-ash carbon reducing agents for electrothermal silicon production *Coke and Chemistry* 55(5) 172-175

[16] Rozhikhina I D, Nokhrina O I, Yolkin K S and Golodova M A 2020 Ferroalloy production: State and development trends in the world and Russia *IOP Conf. Ser.: Mater. Sci. Eng.* 866 012004