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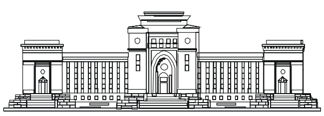

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ACS OF THE SET OF HYDROCYCLONES WITH A VARIABLE GEOMETRY IN THE SYSTEM OF HAR TPP

Abstract. The paper deals with hydraulic ash removal (HAR) at TTP. A new design of hydrocyclones with variable geometry was proposed. In this paper, automation control system for hydrocyclones with variable geometry was proposed and practically implemented. The parameters of the proposed system operation were determined. Description of controls and process equipment is given. A general block diagram and mimic diagram of automated control system for hydrocyclones with variable geometry was constructed in GENIE SCADA-system. Developed ACS of the hydrocyclone allows to carry out pilot studies to assess the performance of the proposed design of the hydrocyclone with variable internal geometry. Development of ACS of the HAR process at TPP and boilers will provide undrained operation, elimination of periodic or continuous purging discharges into water bodies and optimization of the parameters ash waste transported to ash dumps.

Keywords: hydraulic ash removal, thermal power plants, ACS, variable geometry, hydrocyclone, ash dump, microprocessor.

Introduction. Relevance of the research. In connection with the aggravation of environmental issues it is of particular relevance to create effective centrifugal separators for separation of liquid heterogeneous systems for the process of wastewater and gas emission purification from the fine particles. Promising devices for the separation of liquid heterogeneous systems are hydrocyclones.

Intensive introduction of hydrocyclones in industry is due to the number of significant advantages [1] compared to devices that perform similar tasks, but operating on the other principles, such as clarifiers, thickeners, classifiers and others. In some cases, hydrocyclones are used in conjunction with this equipment, significantly increasing the reliability and overall separation efficiency.

Currently, there is essentially no research summarizing hydraulics and pumping units of hydrocyclones operating under different physical conditions.

Existing hydrocyclones are designed for separation of specific homogeneous suspension, that is, regardless of the incoming fluid separation size of particles does not change. This problem is acute in the use of hydrocyclones at TTP. Coal arriving at TTP often has a different quality, so when cleaning the boiler with water, resulting liquid has different composition characteristics every time. Installed hydrocyclones clean the income flow only from particles of a certain size, so each cleaning cycle requires the adjustment of the hydrocyclone parameters so the purified water has the characteristics of the standards.

Goal of the study. The aim of this work is to improve the effectiveness of the separation of ash condensations products due to changes in the geometry of the cyclone using a micro-processor control circuit.

Research tasks statement. The use of hydrocyclones and hydrocyclone units in vari-ous industrial processes, where technology often need to change the output parameters in time or, on the contrary, to keep them strictly at a certain level, regardless of the varying input parameters, set the task of designing and creating a way to control the operation of hydrocyclones automatically.

At present, this issue has received the greatest develop-ment in the mining and coal industries [2].

A large number of the methods of the control of hydrocyclone operation used in the production and proposed in the literature does not allow to evaluate adequately each of them individually in relation to the conditions of their work.

Thus, to achieve the above mentioned goal it is necessary to solve the following tasks:

• to develop the design of hydrocyclone with variable in-ternal geometry;
• to develop the microprocessor-based ACS of hydrocyclone;
• to develop the hydrocyclone control units;
• to select the technological equipment;
• to develop the mimic diagram showing schematically the controlled process.

Theory. On this basis, the methods of control of hydrocyclone operation using generalizing principles are to be analyzed.

Control methods, which are currently most widely used, are assigned to the one of three groups, as using different prin-ciples, or combinations of them.

The first group includes the methods which use the princi-ple of changing the geometric dimensions of the elements of hydrocyclones structures; the second group of methods is those which use the principle of changing the pulp physical properties and (or) mechanical properties of the solid part of the slurry (the unit of the hydrocyclone or placed inside the device), the third group includes the methods which use the principle of pressure variation within the hydrocyclone, which occurs without changing the geometric dimensions of structural elements and physical properties of the feed slurry.

At present, the largest number of the methods to control the operation of hydrocyclones can be attributed to the first group [3]. This is apparently due to the positive sides of it such as simplicity in manufacturing and operation of the structural elements in its implementation; the possibility of regulating a number of devices or systems; a large adjustment range.

However, there are also disadvantages, the main of which are: the lack of smooth regulation; irrational use of energy costs; large and uneven wear of regulated units placed either in the zone of the greatest abrasion (sand nozzle) or in zones influencing substantially the flow pattern within the hydrocyclone (inlet and drain pipes), changing the geometric dimensions of which also leads to the rearrangement of the mode of the hydrocyclone, whereby the method has a low reliability, and fails to obtain stable technological parameters.

The second group of methods to control the operation of the hydrocyclones [4], and others have the following advantages: smooth regulation; constancy of the technological parameters over time; a large range of regulation and others.

However, the main drawback, such as the inability to control the input parameters of the pulp at some sites (e.g. in hydraulic engineering), as even in the closed technological schemes it is not always possible (if the system has a large volume) due to a large inertia, prevents wide use of the methods belonging to the second group and makes them impossible to use in hydraulic engineering.

Methods to control the operation of hydrocyclones of the third group [5] have the following advantages: energy efficiency; ease of implementation and operation; smooth operation; high reliability; the possibility of switching to manual or automatic adjustment and others. At the same time, these methods fit efficiently into the alluvium control technology in irrigation systems in mountain and piedmont areas. Based on this, it can be concluded that the methods referred to the third group are those to use in regulation of hydrocyclones in irrigation and drainage systems.

However, the ultimate choice of the method for controlling the operation of hydrocyclones using one or other principle or combination of them, must be done by comparing the feasibility when bound to a specific object. In the same time both the specific conditions of the proposed work of hydrocyclones and the methods to control them should be taken into account.

Proposition and the results of implementation.

The problem to be solved in this work is to improve the effectiveness of the products separation of by changing the geometry of the cyclone using a microprocessor control circuit [6-8].

The technical result of the use of a new hydrocyclone with variable geometry [9, 10] is the automation of products separation process, reduction of the time of separation, extension of the service life of the hydrocyclone. Fig. 1 shows a typical hydrocyclone without changing the internal geometry, and Fig. 2 shows the proposed hydrocyclone with variable internal geometry.

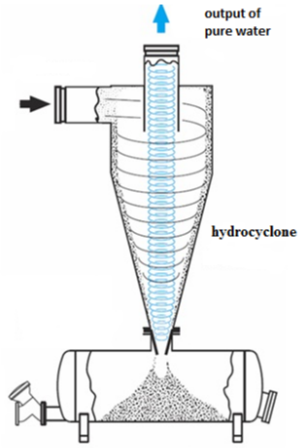

Figure 1 - A typical hydrocyclone

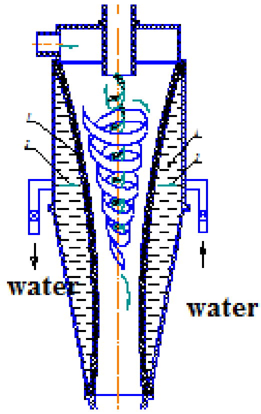

Figure 2 - The proposed hydrocyclone with variable internal geometry

Development of ACS of hydrocyclone, control units and selection of process equipment. Automation scheme based on hydrocyclones geometry control has been developed to control the operation of the set of hydrocyclones in the overall scheme of technological process of HAR. Fig. 3 shows the functional diagram of the automation system to control the hydrocyclones.

The automation system is based on CPU188-5 IBM-PC compatible industrial controller of FASTWEL company. The controller software was developed in C++. The upper level is associated with the medium level by Modbus protocol. Modbus is a communication protocol, based on client-server architecture and developed by Modicon for the use in programmable logic controllers (PLC). It became de facto standard in the industry and is widely used for the connection of industrial electronic equipment. For data transition, it uses RS-485, RS-422, RS-232 serial lines and others, as well as TCP/IP network.

Devices from different manufacturers, that support the Modbus protocol, are easy to integrate into a single automation network. The market represented almost the entire range of necessary equipment, from simple input-output modules to inverters. All universal SCADA/HMI systems support this protocol.

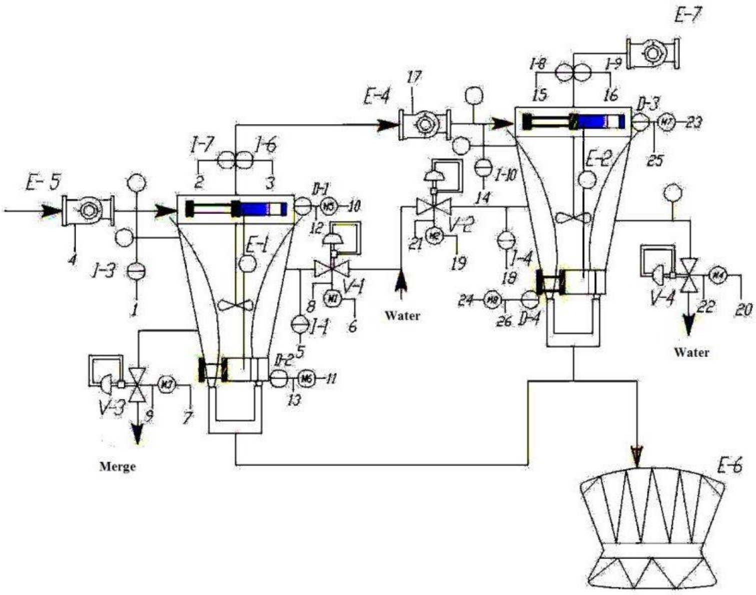

Figure 3 - Functional diagram of hydrocyclones automation control system

Process parameters are controlled by sensors with standardized output signal. The signal from the sensors is fed to 5V32-01 "current-voltage" conversion module (manufactured by ANALOG DEVICES). Next, the signal is inserted in the memory of the controller by AMUX-32 input-output module where the signal is processed and transmitted to the computer in the developed upper level software, written in C#, where the process can be visualized.

After processing, the signal from the controller is supplied to the output charge, and starts an actuator that controls the regulator.

Hydrocyclones automation control system loops are:

1. The unit for the monitoring of pressure of sulfur and slag supply to the cyclone E-1 is shown in Fig. 4.

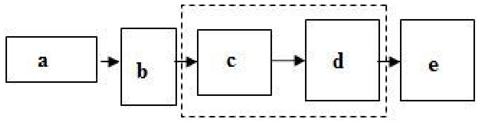

Figure 4 - The unit for the monitoring of pressure of sulfur and slag supply to the cyclone E-1

Symbols in the figure have the following meanings:
a) pressure sensor I-3;
b) "current-voltage" conversion module (5B32-01);
c) analog signals input/output module (AMUX32C) - analog input;
d) controller (CPU188-5);
e) computer.

2. Circuit of the concentration I-7 and pressure I-6 control at the outlet of the hydrocyclone E-1 is shown in Fig. 5.

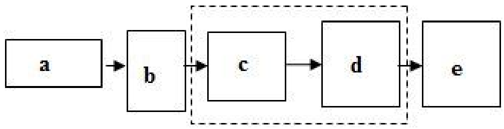

Figure 5 - Circuit of the concentration I-7 and pressure I-6 control at the outlet of the hydrocyclone E-1

Symbols in the figure have the following meanings:
a) concentration I-7 and I-6 pressure sensor;
b) "current-voltage" conversion module (PSA-01);
c) analog signals input/output module (AIMUX-32) - analog input;
d) controller (CPU188-5);
e) computer.

3. Minimization of concentration I-7 and pressure I-6 of slag and ash at the outlet of hydrocyclone E-1. Minimization is due to the following control systems.

3.1 Control of the pressurized feeding of slag and ash to the hydrocyclone (controlled by I-3, pressure changes due to changes in E-5 pump rotation speed).

The block diagram is shown in Fig. 6.

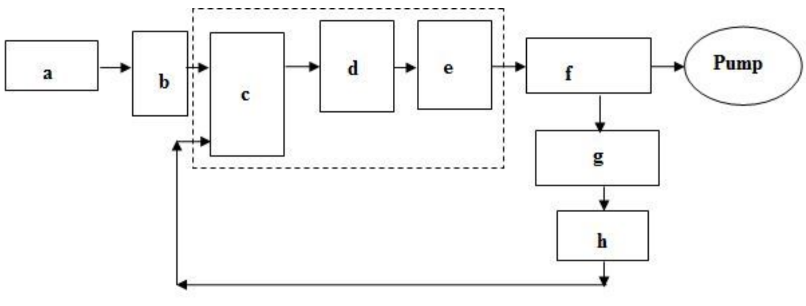

Figure 6 - Theblockdiagramof the control of the pressurized feeding of slag and ash to the hydrocyclone

Symbols in Fig. 6 have the following meanings:
a) pressure sensor I-6, concentration sensor I-7 (see paragraph 2) and pressure sensor I-3;
b) "current-voltage" conversion module (PSA-01);
c) analog signals input/output module (AMUX32C) - analog input;
d) controller (CPU188-5);
e) analog signals input/output module (AIMUX-32) - analog output;
f) MICROMASTER 420 frequency converter;
g) "current-voltage" conversion module (PSA-01);
h) E-5 pump rotation speed; the degree of V-1 and V-3 regulators opening and closing (indicators).

3.2 Changes in the hydrocyclone geometry by changing the pressure in a sealed rubber insert (controlled by I-1 sensor), regulated by water supply (V-1 valve) and drain (V-3 valve).

The block diagram is shown in Fig. 7.

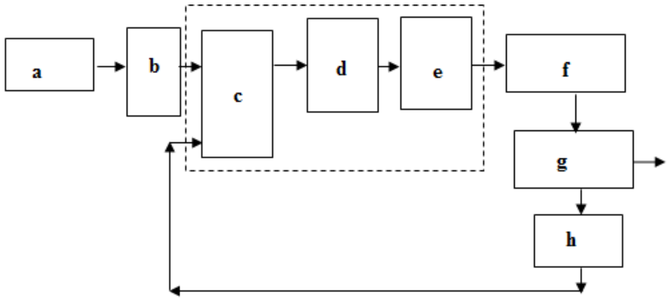

Figure 7 -The block diagram of the modification of the hydrocyclone geometry by changing the pressure in the sealed rubber insert

Symbols in Fig. 7 have the following meanings:
a) pressure sensor I-6, concentration sensor I-7 and pressure sensor I-1;
b) "current-voltage" conversion module (PSA-01);
c) analog signals input/output module (AMUX32C) - analog input;
d) controller (CPU188-5);
e) discrete signals input/output module (TBI-24 0/C) - discrete output;
f) PCLD-8115 relay outputs module;
g) The opening/closing degree of regulator V-1 and V-3;
h) ESA position.

4. Regulation (minimization) of the concentration I-7 and pressure I-6 at the outlet of the hydrocyclone E-1 due to changes in D-1 and D-2 valve position is shown in Fig. 8.

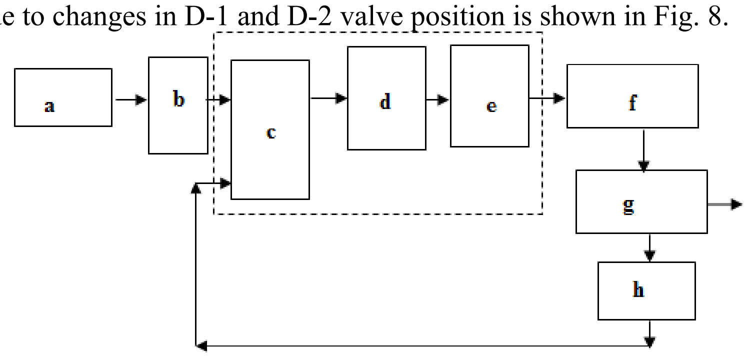

Figure 8 - Circuit of concentration and pressure control at the outlet of the hydrocyclone due to changes in valves position

Symbols in Fig. 8 have the following meanings:
a) pressure sensor I-6, concentration sensor I-7 and D-1 and D-2 displacement sensors;
b) "current-voltage" conversion module (PSA-01);
c) analog signals input/output module (AMUX32C) - analog input;

d) controller (CPU188-5);
e) discrete signals input/output module (TBI-24 0/C) - discrete output;
f) PCLD-8115 relay outputs module;
g) D-1 and D-2 valves positions;
h) ESA position.

The use of GENIE SCADA-system eliminates the need for controller, but there is the need in the acquisition of IO modules, which are directly connected to the computer. Software implementation schemes in GENIE SCADA-system are shown in Fig. 9-13.

1. Control of pressure of sulfur and slag supply to the cyclone E-1:

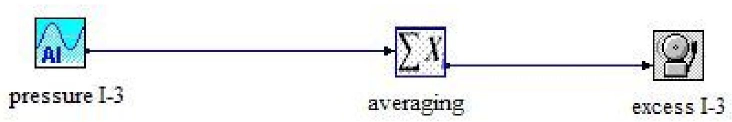

Figure 9 -Circuit of the control of pressure of sulfur and slag supply to the cyclone E-1

2. Concentration I-7 and pressure I-6 control at the outlet of the hydrocyclone E-1:

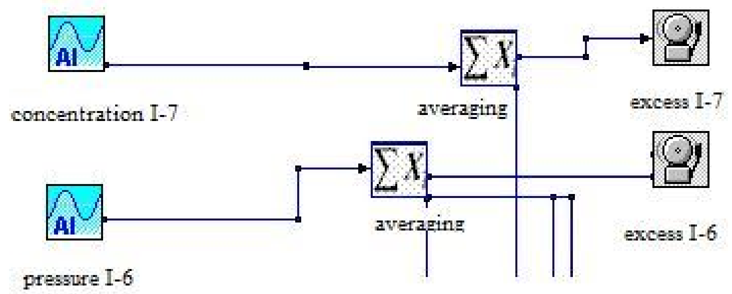

Figure 10 -Circuit of concentration I-7 and pressure I-6 control at the outlet of the hydrocyclone E-1

3 Control of slag, ash feed at the input of the hydrocyclone and pressure in the hydrocyclone rubber insert

3.1 Control of pressurized feed of slag and ash in a hydrocyclone (controlled by I-3, pressure changes due to changes in E-5 pump rotation speed).

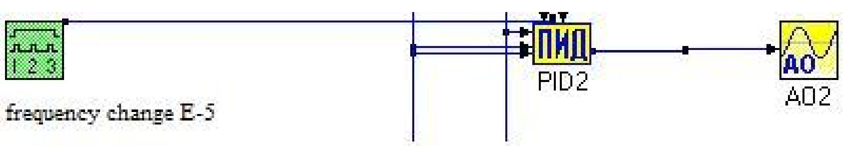

Figure 11 -Circuit of the control of pressurized feed of slag and ash in a hydrocyclone

3.2 Changing the geometry of the hydrocyclone by changing the pressure in the sealed rubber insert (controlled by I-1 sensor), regulated by water supply (valve V-1) and drain (valve V-3).

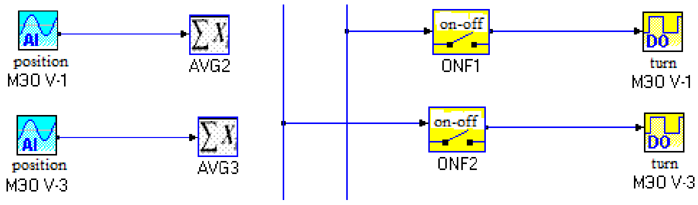

Figure 12 -Circuit of changing the geometry of the hydrocyclone by changing the pressure in the sealed rubber insert

4. Regulation (minimization) of the concentration I-7 and pressure I-6 at the outlet of the hydrocyclone E-1 by changing the position of D-1 and D-2 valves.

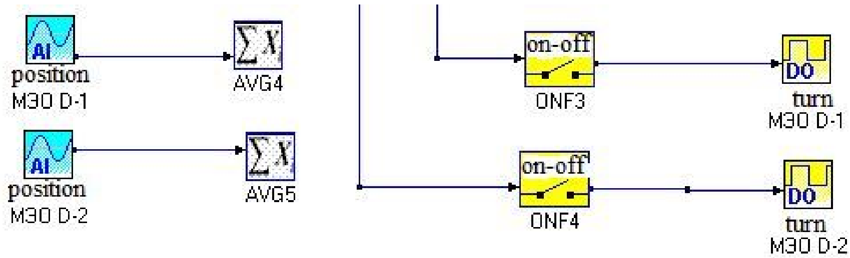

Figure 13 -Circuit of regulation (minimization) of the concentration I-7 and pressure I-6 at the outlet of the hydrocyclone E-1

Fig. 14 is the mimic diagram of the automated control system of hydrocyclones. Mimic diagram depicts schematically the controlled process and serves for visualization of the process.

This mimic diagram is made in GENIE SCADA-system in "forms editor" and is a flow diagram of the hydrocyclones operation process.

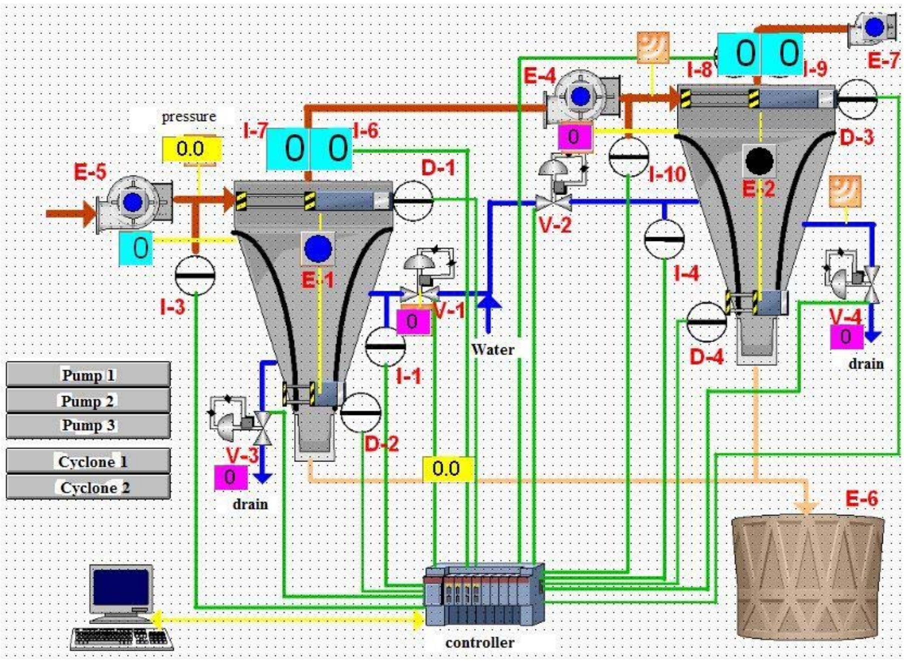

Figure 14 -Flow diagram of the hydrocyclones operation process. Forms editor

Conclusions. In this paper, automation control system for hydrocyclones with variable geometry was proposed and practically implemented. The parameters of the proposed system operation were determined.

The upper-level controller control program, determining the operating modes of CPU188-5 controller of Fastwell company and providing the control of the operation of the automated control system for hydrocyclones due to the regulation of the cyclone geometry elements, is given.

Control units and process equipment was described. Control loops of the automated system of the hydrocyclone were described: the circuit of the control of pressure of initial pulp supply into the cyclone, the circuit of the concentration and pressure control at the hydrocyclone outlet, th the circuit of the control of pressure of intermediate pulp supply into the cyclone, the circuit of modification of hydrocyclone geometry by changing the pressure in the sealed rubber insert, as well as the circuit of the concentration and pressure control at the hydrocyclone outlet due to changes in the valve position.

ACS of the hydrocyclone allows to carry out the pilot studies to assess the performance of the proposed design of the hydrocyclone with variable internal geometry.

The general block diagram was designed in GENIE SCADA-system. The mimic diagram of ACS of the hydrocyclones with variable geometry was developed, which allows to visualize the HAR process.

Development of ACS of the HAR process at TPP and boilers will provide undrained operation, elimination of periodic or continuous purging discharges into water bodies and optimization of the parameters ash waste transported to ash dumps.

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ЖЭС ГИДРАВЛИКАЛЫҚ КҮЛЖОЮ ЖҮЙЕСІНДЕ ГЕОМЕТРИЯСЫ БАСҚАРЫЛАТЫНГИДРОЦИКЛОНДАР БАТАРЕЯСЫН АВТОМАТТЫ БАСҚАРУ

Аннотация. Мақалада ЖЭС гидравликалық күлді жою сұрақтары қарастырылған. Жаңа геометриясы өзгеретін гидроциклонның құрылымы ұсынылған. Осы жұмыста геометриясы өзгеретін гидроциклондарды автоматты басқарудың сұлбасы ұсынылып отыр және аталған сұлба тәжірибеде жүзеге асқан. Ұсынылған жүйенің жұмыс параметрлері анықталған. Басқару элементтері мен технологиялық құралдардың сипаттамасы берілген. Геометриясы өзгеретін гидроциклонарды автоматты басқарудың сұлбасы мен GENIE SCADA-жүйесіндежалпы блок сұлбалары жасалған.Жасалған автоматты басқару жүйесі ұсынылған ішкі геометриясы өзгеретін гидроциклондардың жұмыс істеу қабілетін бағалау бойынша эксперименттік зерттеулерге мүмкіндік береді. Жасалған АБЖ ЖЭС мен қазандақтардың күлжою технологиялық процесінтерінде уақыт сайын немесе тұрақты ұрлеу суларын тоғандарға ағызуды жояды және күлқожды қалдықтарды күл үймесіне тасымалдау кезінде параметрлерін оңтайландырады.

Түйін сөздер: гидравликалық күлжою, ЖЭС, АБЖ, өзгеретін геометрия, гидроциклон, күл үймесі, микропроцессор.

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АСУ БАТАРЕЙ ГИДРОЦИКЛОНОВ С УПРАВЛЯЕМОЙ ГЕОМЕТРИЕЙ В СИСТЕМЕ ГЗУ ТЭС

Аннотация. В статье рассмотрены вопросы гидрозоло-удаление (ГЗУ) на ТЭС. Предложена принципиально новая конструкция гидроциклонов с изменяемой геометрией. В данной работе предложена и практически реализована схема автоматизации системы управления гидроциклонами с из-меняемой геометрией. Определены параметры работы предложенной системы. Произведено описание элементов управления и технологического оборудования. Разработана общая схема блоков в SCADA-системе GENIE и мнемосхема автоматизированной системы управления гидроциклонами с изменяемой геометрией. Разработанная АСУ гидроциклона позволяет провести экспериментальные исследования по оценке работоспособности предложенной конструкции гидроциклона с изменяемой внутренней геометрией. Разработка АСУ технологическим процессом ГЗУ ТЭС и котельных позволит обеспечить бессточный режим работы, устранить периодические или постоянные сбросы продувочных вод в водоемы и оптимизировать параметры транспортируемых в золоотвал золошлаковых отходов.

Ключевые слова: гидрозолоудаление, ТЭС, АСУ, изменяемая геометрия, гидроциклон, золоотвал, микропроцессор.

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