Automation and optimization of the technological process of the peak hot-water boiler plant with justification of regulation parameters

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Abstract. The paper presents the development of an automated control system for the peak PTVM-180 boiler. The selection of sensors, the selection of a programmable logic controller, the development of an automated workstation and visualization of the process, including the selection of effective parameters are presented.

1. Introduction

The energy program and the main directions of economic and social development for 2010 and the period until 2030 in Russia have outlined a broad prospect for improving and developing the country’s fuel and energy complex. Further development of energy capacities and a significant increase in electricity production through the introduction of powerful block plants, the introduction of energy-saving equipment and technology, and the provision of a stable supply of heat and electricity to all sectors of the economy are envisaged [1]. Namely, it is planned to replace small, inefficient boiler houses with combined heat and power plants using organic and nuclear fuel and enlarged boiler houses. These works should be accompanied by an increase in labour productivity, a decrease in the cost of production of electric and thermal energy, and an increase in the reliability of power equipment [2].

The development of the energy industry, heating is accompanied by the development of new technologies for the production of heat and electric energy, the development of designs of steam and hot water boilers, their auxiliary equipment, the development of new types of fuel, and the improvement of the control and measurement equipment of equipment controls. For a relatively short period of development of the energy industry, the capacity of boiler plants has significantly increased, and heating has been widely developed [3].

2. Description of the structure and automation points of the installation

Peak heating cogeneration boiler PTVM-180 (Figure 1) with a heating capacity of 180 GCal / h is designed to cover the peaks of heating loads of the heat and power plant (HPP). The heat output of the boiler is regulated by a change in the number of working burners with a constant flow of network water through the boiler and a variable temperature difference. The boiler is connected to a group
chimney, ensuring the operation of the boiler with a natural draft in the entire load range in accordance with the temperature schedule [4, 5].

The feed pipe consists of two chambers with a diameter of 720x12 mm (steel 20), located under the boiler. From one chamber (inlet), water is supplied through eight pipes of 273x10 mm (steel 20) to the ends of the lower chambers of the side and double-light screens passes through them and passes through the pipes of the side and double-light screens into a collection manifold, which is a welded pipe structure. From the prefabricated collector, water through 176 sections of the convective part of the boiler enters the upper input chambers of the front and rear screens. From the water chambers through 24 pipes 159x4.5 (steel 20), the front and rear screens enters eight collectors 273x8 mm (steel 20) and through their ends - into the second (entrance) chamber 720x12 mm [6].

![Figure 1. Appearance of the PTVM-180 boiler.](image)

The PTVM-180 boiler is a tower type, water-tube, radiation direct-flow, with forced circulation. The change in the heating capacity of the boiler is carried out by changing the number of working burners with a constant flow of water and a variable temperature difference. The boiler is equipped with 20 gas-oil burners with an individual blast fan type VTs-14-46 No. 6.3 on each burner. There is no air heating in the boiler. The boiler performance is regulated by turning on or off one or several burners. The limits of regulation of productivity are 30-100%. Changing the load of the boiler is done by changing the temperature of the water, the flow rate of which is maintained constant [7].

3. Monitoring and control of technological equipment of the boiler

A sensor is a measurement tool designed to generate a signal of measurement information in a form convenient for transmission, further conversion, processing and (or storage), but not amenable to direct perception by the observer. Automated process control system (APCS) is designed to control and control the technological equipment of the boiler [8].

Analog and discrete signals are fed to the input modules of the controller. The power supply unit of the controller provides power to the sensors.

The operation of the actuators is controlled by starters, from which the actuator actuators of the shut-off and control valves are powered. The controller transmits information about the state of the process to the automation of the workplace (AWP) of the operator. It is shown in Figure 2.
4. **Industrial logic controller selection**

An industrial logic controller is a software-controlled automatic device having a set of inputs and outputs connected to executive devices of the control object. It does not require serious maintenance and works without human intervention [9].

The sensors, converters, regulators and fittings used, as a rule, have standard output signals with one of the following parameters:

a) analogue (current 0...5, 0...20, 4...20 mA and voltage 0...10, 0...20 mV) for monitoring and regulation of technological parameters;

b) discrete, such as “dry contact”, for signalling warning, emergency values of technological parameters, as well as for monitoring the position of valves.

The main characteristics of the selected controllers and their comparison are presented in Table 1.

| Controller and its characteristics | Segnetics Pixel1212 | OVEN 73 | SIMATIC S7-200 |
|-----------------------------------|---------------------|--------|----------------|
| Processor                         | ARM926EJ-S          | RISC processor based on the core ARM-7, 32 discharge, 50 Mhz | CPU 224XP |
| Integrated RAM, Kb                | 128                 | 448    | 228            |
| Quantity analog inputs/outputs    | 8(input-output)     | 8/4(input-output) | 2AI+1AO (input-output) |
| Quantity discrete inputs/outputs  | 9(input-output)     | 8/4     | 14DI+10DO (input-output) |
| Communication interface           | RS485(protocol), ModBUS-RTU, LonWorks, Ethernet | RS-485, RS-232 | MPI or PROFIBUS |
5. Temperature sensors, pressure meter, flowmeter and torch sensor selection

A thermoelectric converter is a pair of conductors of various materials connected at one end and forming part of a device that uses the thermoelectric effect to measure temperature, as shown in Figure 3 [10].

A pressure sensor is a primary transducer in which the output signals depend on the pressure of the medium being measured, be it steam, gas or liquid, shown in Figure 4. Modern technological processes cannot do without devices of this type. They are used in industrial control systems of various industries.

A device that measures the volumetric flow rate or mass flow rate of a substance, that is, the amount of substance (volume, mass) passing through a given flow cross-section, for example, the cross-section of a pipeline per unit time is shown in Figure 5. If the device has an integrating device (counter) and serves for the simultaneous measurement and quantity of a substance, it is called a flow meter [11].

The selected torch sensor - flame monitoring relay "SL-90-1 / 220E" in Figure 6, from the manufacturer "General".
Figure 4. Pressure sensor «Metran 55».

Figure 5. Flowmeter «Metran 350».

Figure 6. Sensor-relay for flame control " SL-90-1/220E».

The design of the program is made in the language LD (Relay circuit language). The main program PTVM_PRO runs in cycles (Figure 8).

On the video frame "Visualization of the program for controlling the gas ring" an example of valve control is given, indicating the percentage of opening and the state of open / closed. It is possible to set the task. Indicate the position and percentage of opening(Figure.9).

6. **Program operation algorithm**
The development of the algorithm of the program is presented in Figure 7, is important and is necessary to facilitate the task of writing the program itself.
Figure 7. Algorithm of the program.
7. Conclusion
The article presents the development of an automated control system for the peak PTVM-180 hot water boiler. The choice of sensors, the choice of a programmable logic controller, the development of an automated workstation and visualization of the process, including the selection of effective parameters are presented. Energy-efficient, automated equipment for automated process control systems was produced. A list of instrumentation necessary for the implementation of the project has been compiled. A program for the controller has been developed to automate a peak boiler using a signal and designed a control program in the language of relay circuits.
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