Automation of air-conditioning systems with controlled microclimate in the Russian penitentiary system

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Abstract. The global development of information technology is increasingly integrated into all spheres of human life and is no exception to the technological field in which one of the most promising is the development of air conditioning systems with controlled microclimate. This study discusses some aspects of climate control using programmable logic microcontrollers. This study improves the efficiency of the use of air traffic control systems in the penitentiary system of the Russian Federation through the use of modern achievements of science and technology. The article presents two options for using different levels of automation in climate control systems in closed rooms of the Russian penitentiary system, depending on the volume of production, the algorithms of the climate control system are considered.

1. Introduction
Successful production associated with maximum productivity inextricably depends on the complete information security of all processes that take place, which, in turn, directly depends on the level of implementation and use of modern information technologies. One of the directions of development of the production complex in the institutions of the penitentiary system is the use of climate control systems in enclosed spaces. The use of confined spaces in the penitentiary system allows to minimize the effect of seasonality in the production process. It is no secret that in winter prices for seasonal products increase significantly, and this can become a profitable direction for the implementation of the off-budget component of the production activities of the penitentiary system institutions. As a rule, the construction of enclosed climate-controlled production facilities in institutions is carried out in large numbers or their construction does not require large financial costs. The main expenses are mainly related to the payment of electricity bills. Thus, with the proper level of intensification of special production, institutions will receive insufficiently expensive and at the same time guaranteed high-quality and safe products throughout the year with a guaranteed market, primarily oriented to their own consumption. At the same time, the often low profitability of using closed climate-controlled premises in penitentiary institutions is associated with low technical equipment of the latter and a lack of qualified personnel with sufficient knowledge in this area. One way to solve this problem is to introduce the latest technologies, sensors, robotic systems and other devices into the production process control in order to increase productivity and, consequently, the economic efficiency of their use in the production of penitentiary institutions.
2. Technology and collected data in IOT platform

Currently, technologists have accumulated a large amount of empirical knowledge of environmental factors that can be processed using IoT technologies. The technology under consideration provides on-site collection of certain data, such as indoor temperature, humidity, lighting. If we add environmental data to them, this combination of factual information and knowledge will provide a context for the data specific to the region. The accumulated contextual data in the future will allow you to simulate the operation of a particular farm and will help in the preparation of forecasts and productivity. As with weather forecasts, a risk analysis will be available to determine the optimal time to start and end production processes. This will ultimately allow production to maximize results and reduce operating costs. Progressive ideas are embedded in hardware technologies, such as the use of vehicles with GPS-navigators, which are effectively controlled by remote access, given the forecast of external factors. But all this is not cheap. Sub-factories will have to look for funds to use advanced technologies in order to get the most out of their investments, reduce capital costs, minimize operating costs, ensure high profitability and remain competitive. To reduce costs, you need to create a model of equipment collaboration, for example, “equipment as a service” or a pay-per-use model. Thus, equipment manufacturers offering similar business models will facilitate the introduction of intelligent manufacturing solutions. And to manage these business models, IoT platforms are required to collect data for monitoring technology and its predictive maintenance, to ensure the operation of an automated computing system and to maintain a new operating system model - this is all that improves the availability of equipment and its efficiency.

The technologies of using solar panels in the organization of autonomous closed production facilities are also considered. To create the comfortable conditions necessary for special production, it is proposed to use intelligent control systems based on fuzzy logic. This technology saves energy and other resources through the efficient use of solar energy. The idea is based on a scheme that uses special sensors in production rooms to control process parameters, with which information is transmitted to controllers. In addition, this system has the ability to remotely control the basic parameters of the internal environment of industrial premises. According to the developers, the theoretical provisions of this model were tested experimentally and showed its effectiveness in solving the microclimate protection problem.

In addition, the technology of cloud storage and processing of accumulated data is actively used in the development of foreign researchers, such as the use of the MACQU (Management Control for Quality) technology platform of high-tech industries with a controlled environment and energy consumption optimization. But, despite the diversity of the proposed solutions, it should be noted that at the moment there are no computer programs with a reliable mathematical model adapted to Russian conditions. In addition, there is a national software procurement regime that prohibits the purchase of software developed in foreign countries.

3. Programmable logic controllers as a way to controlled microclimate

At the same time, it is indisputable that the experience of foreign countries in the application of innovative technologies based on the use of information-computer systems and production automation is advanced and requires its study and use, provided that it is adapted to Russian conditions. In our opinion, the relevant areas in relation to enclosed spaces are automation of such parameters as air humidity, air temperature, lighting, which we propose to automate using programmable logic controllers [3, 4,5].

The basic scheme of managing life support systems, based on the control of the main parameters of the internal microclimate, can be represented in the form of Figure 1. To ensure efficient production, such parameters of the internal microclimate as illumination, temperature and relative humidity should be within the specified limits. The change in illumination is regulated by turning the number of fixtures on or off, a change in air humidity due to the use of active ventilation is possible, a change in air temperature due to turning on or off the heater sections. As a rule, a typical indoor climate control scheme is based on the use of the on-off relay control law when
the equipment turns on when the monitored parameter reaches the minimum parameter and turns off when the maximum parameter is reached.

Figure 1. The concept of automated management of the control system.

We propose a scheme to automate the basic parameters of the equipment to create and maintain optimal parameters of the microclimate implemented on the basis of a programmable logical controller. To regulate parameters and manage lighting, heating, ventilation, air and soil hydration systems, a fuzzy logic management algorithm has been implemented. At the same time, the control system includes air temperature sensors (T1, T2, T3, ..., Tn), humidity sensors (W1, W2, W3, ..., Wan), soil moisture sensors (W11, W12, W13, ..., W1n), light sensors (E1, E2, E3, ..., En), programmable logical controller, power relays.

Climate parameters are controlled using the controller, as follows, the information from the sensors is analyzed by the controller, and depending on their parameters, the corresponding power relays are connected, connecting the microclimate systems.

Lighting regulation is carried out by the inclusion or disconnection of lamps to ensure optimal duration of daylight hours for plants.

The air temperature is maintained during the period of operation of the greenhouse in the specified parameters, due to the use of heating systems at low temperatures and ventilation systems with increasing temperature.

Air humidity is maintained by spraying water with nozzles controlled by special valves by means of power relays.

Humidification of the soil is carried out by a drip irrigation system controlled by electromagnetic valves with the corresponding signals of the microcontroller [7].

The choice of the type of programmable logic controller is determined by the degree of automation of the control system, as well as its size.
For small control systems with a small degree of automation, for example, only with a soil moisture system, it is possible to use controllers with a touch panel, own display and input/ output subsystem. An example of such a controller is ОВЕН ПЛК73. Its characteristics: 2 additional serial interfaces, 8 universal analog inputs, 8 digital inputs and 8 outputs, 4 of which can be analog. The outputs can be one of four types: relay output, transistor discrete output, analog output 4-20 mA or 0-10V. To expand the number of outputs, an MP1 module or other input/output modules connected via RS-485 can be used.

For large control systems with a high degree of automation, it is advisable to use programmable logic controllers with a modular architecture that allows you to build automation systems of any complexity and distribution. An example of such a controller is the ЧГП-РТ Industrial Controller manufactured by «ОСАТЕК» company. Its features: housing options - 4, 8, 13 connection modules, up to 53,000 discrete/analog I/O channels, scalability up to 255 passive chassis, PC-compatible active chassis processor module, power redundancy and hot-swapable modules, support 4x Ethernet 100TX, RSTP protocol, 4x RS422 / 485, speed up to 5000 kBaud, wall/panel mounting, 19 inch rack.

The flowchart describing the operation of the microclimate control system of the greenhouse consists of controlling the ventilation, heating, irrigation and lighting systems presented on figure 2.

![Flowchart](image)

**Figure 2.** Control system microclimate control algorithm.

It is assumed that at the initial moment the operator sets the optimal (normalized) values of the microclimate parameters favorable for a particular production. Next, the program compares the current parameters of temperature, humidity and light transmitted from sensors located in different production facilities with the specified normalized values of these indicators and gives a signal to turn on or turn off the actuators, which in turn leads to a change in the parameters of the controlled microclimate.
registered by the sensors [8,9]. So, the algorithm of the program for maintaining the microclimate for ventilation, heating and lighting systems is similar, we give a block diagram of the algorithm for the example of adjusting the air temperature by the heating system.

According to the presented algorithm, a program code will be developed in the CODESYS programming environment, according to which the programmable controller will automatically control the system of maintaining the microclimate of the control system. In our opinion, the implementation of the control of the microclimate system in the control system implemented on the basis of the ПЛК73, ЧГП-РТ controllers, or their analogs, will have initially minimal cost, with high reliability and high-speed operation. In addition, the controllers of these brands are manufactured by Russian companies, which will not create obstacles for the purchase of such climate control systems for control systems when they are used for the needs of the penitentiary system.

4. Conclusion
The global development of information technology is increasingly being integrated into all spheres of human life and is no exception to a special technological area in which one of the most promising is the development of enclosed spaces with a controlled microclimate. This study examines some aspects of climate control using programmable logic microcontrollers. This study helps to increase the efficiency of the use of closed rooms in the penal system of the Russian Federation through the use of modern achievements of science and technology, as well as to increase the security of the system.

The paper provides two options for using different levels of automation of the control systems of the Russian criminal-executive system, depending on the volume of production, the algorithms of the microclimate management system in the control systems are considered.

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