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RESEARCH AND DEVELOPMENT OF "SMART GREENHOUSE"

Abstract.

A smart greenhouse is a self–regulating microclimate suitable for plant growth, thanks to the use of sensors, actuators and monitoring and control systems that optimize growth conditions and automate the growing process. This study showed that the climatic conditions inside the greenhouse are not always favorable for the development of plants. A control system based on fuzzy logic, which has shown its effectiveness. The controller allowed us to regulate the internal temperature and humidity with proper control and controllability of the actuators to obtain the desired values.

Keywords: smart greenhouse, sensor, temperature.

Introduction.

Automation of greenhouses [1] implies the management and monitoring of climate parameters that can be adjusted. Automation of microclimate maintenance contributes to better growth and increased productivity, as well as reduces the cost of manual labor.

There is a need for a high degree of automation and mechanization of technological processes. In general, the management system can be considered as the relationship of several management processes and objects. The generalized goal of control automation is to increase the efficiency of using the potential capabilities of the control object.

There are the following three types of microclimate management systems.

1. Manually operated. They include visual control of plant growth, manual watering of plants, switching on and off temperature controls, manual spraying of fertilizers and pesticides. This takes a lot of time, there is a high probability of human error and, consequently, these settings are less accurate and unreliable.

2. Partially automated. These installations are a combination of manual control and partial automation and are similar to manually controlled installations in many respects, however, they reduce the labor costs associated with watering and parameter control.

3. Fully automated. These are complex installations that are well equipped to respond to most of the climatic changes occurring inside the greenhouse.

These systems are based on the principle of feedback, which helps them to respond effectively to external stimuli. Although such installations are able to regulate a large number of parameters and solve possible problems related to the human factor, they are quite expensive.

Let's list a number of problems that are associated with the aforementioned systems.

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1. The complexity associated with tracking changes in climatic parameters such as air humidity, soil moisture, illumination, soil pH, temperature and others that directly or indirectly regulate plant growth.

2. High maintenance costs, the need for qualified technical personnel. Modern installations use mobile technologies as communication systems and wireless data collection systems, providing global access to information in their farms. But this is due to restrictions of various kinds, such as the complexity of the design, difficult repairs and high price.

3. Most of the commercial greenhouse automation projects are being developed for greenhouse complexes with an area of several hectares, while the greenhouse automation market for farms and individual farms remains ignored.

Methods and models.

A Smart Greenhouse is a fully, or almost completely, automated system that allows you to adjust the microclimate [2]. Modern greenhouse complexes are built multi-span according to standard projects, they are equipped with the necessary engineering systems for maintaining the microclimate: heating, irrigation, ventilation and air circulation, drainage, water supply and sewerage, lighting. All these systems are designed for large enterprises. They are difficult to install and operate, and also have a high cost. These systems are not applicable for private or small farms.

In order for the plants to develop properly, bloom abundantly and bear fruit, it is necessary to provide them with:

– Regular watering;
– High illumination;
– Systematic ventilation;
– Optimal air and soil temperature.

It is very difficult to do this manually, but automation of the greenhouse allows minimizing human participation in agricultural labor. A Smart Greenhouse is a collection of sensors and actuators connected to a controller. The automated greenhouse can be controlled remotely – the devices independently register the set parameters and, in accordance with them, provide automatic watering, ventilation and lighting in the greenhouse.

Greenhouse automation implies tracking various indicators and managing the microclimate for plant growth [3].

A Smart Greenhouse is capable of controlling:

– heat – preventing overheating or freezing of plants;
– water – since precipitation does not fall into the greenhouse, it is necessary to manage watering of plants;
– light – additional illumination of plants or their darkening;
– air consumption and humidity – a tightly closed greenhouse will lead to increased humidity and lack of oxygen and carbon dioxide for plants, depending on the time of day;
– insects – it is possible to prevent the penetration of harmful insects into the greenhouse or to provide comfortable living conditions for useful ones.

For better plant growth, it is necessary to simultaneously control more of these indicators [4].

This can be provided by the following systems:

– irrigation – regular water supply according to a certain schedule;
– ventilation – turning fans on or off, or opening and closing vents;

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– nutrient dosage – with the help of soil analysis, nutrients can be distributed through the irrigation system;

– pest control – automatic spraying of plants.

For greater automation and microclimate regulation, all these systems must be controlled simultaneously and form one large system that can optimize their operation [5]. Maintaining the set climatic parameters is an integral part of the normal functioning of the microclimate system. The selection of optimal, close to ideal conditions for growth, in this work, for plants is an important part, because the microclimate is based on them [6].

The main tasks of the automatic control system are:

– air temperature control;

– control of the irrigation system;

– control of lighting installations.

Previously, automation of greenhouse operation was an expensive, and sometimes not a recoupable procedure, but at the moment the solution to this problem is not so expensive and pays off completely, and in the future, brings even greater benefits [7].

The automated greenhouse management system allows you to leave plants that are too demanding to the conditions unattended for an indefinite period. The system analyzes changes in the microclimate inside the greenhouse and reacts to them by activating certain components of the system, which allows you to maintain growing conditions for a long period of time.

An automated greenhouse involves performing a number of operations without human intervention, namely:

– maintaining the required temperature parameters inside;

– automatic watering of plants by drip irrigation;

– mulching of the soil layer.

The automated control system is shown in Figure 1.

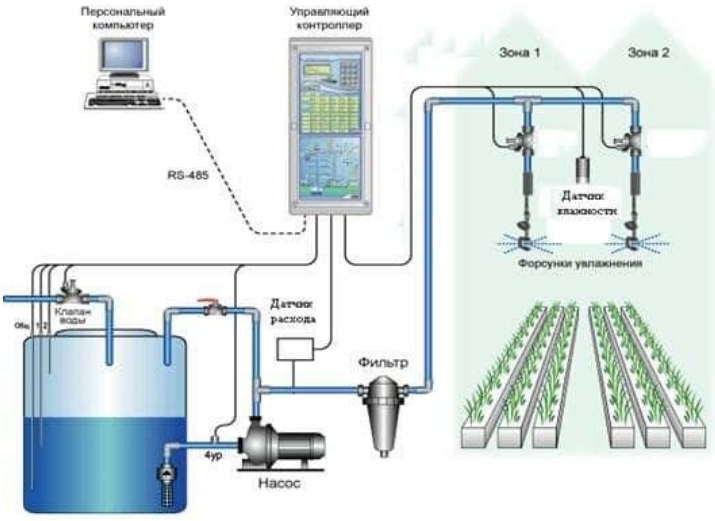

Figure 1 – Automated control system (http://teplicno.ru/obustr/umnaya-teplica.html)

Smart greenhouses can be classified as follows:

– autonomous – all systems operate exclusively on thermal or solar energy;

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– energy–dependent - the elements are powered from the supplied power grid. Each type has its own advantages and advantages about the importance of which disputes between summer residents do not subside to this day. However, there are disadvantages. So, for example, a smart greenhouse operating from the power grid causes a significant consumption of electricity, when it is turned off, the most adverse consequences may occur for plants.

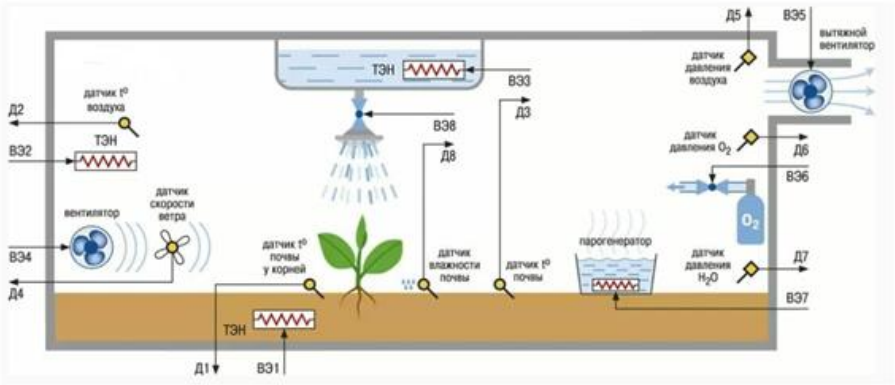

Figure 2 - Operation diagram of a smart greenhouse

Discussion of the results.

Microcontrollers are a programmable chip that allows you to control various electronic devices. The microcontroller contains one or more processor cores, memory, and programmable input and output peripherals [8].

As a result of a comparative analysis, Arduino Nano was selected among a wide range of platforms

The Arduino Nano is a full—featured analog of the Arduino Uno, but placed on a miniature board. A special feature is the absence of its own socket for external power supply, the use of the FTDI FT232RL chip for USB-Serial conversion and the use of a mini-USB cable for interaction instead of standard USB. The board has pin contacts, thanks to them, the placement of the Arduino is possible directly on the breadboard. The advantage of the Arduino Nano is its compactness, relatively similar in capabilities to the Arduino Uno, the absence of the need for soldering, as well as the prevalence of the wire used to connect the board to the computer. Consider the characteristics of the board:

– Microcontroller - Atmel ATmega168 or ATmega328
– Operating voltage (logic level) - 5 V
– Input voltage (recommended) - 7-12 V
– Input voltage (limit) - 6-20 V
– Digital Inputs/Outputs - 14 (6 of which can be used as PWM outputs)
– Analog inputs - 8
– Constant current through input/output - 40 mA
– Flash memory - 16 KB (ATmega168) or 32 KB (ATmega328) with 2 KB used for bootloader • RAM - 1 KB (ATmega168) or 2 KB (ATmega328)
– EEPROM - 512 bytes (ATmega168) or 1 KB (ATmega328)
– Dimensions - 1.85 cm x 4.2 cm

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Arduino Nano can be powered via a Mini B connection, or from an unregulated 6-20 V (pin 30), or an adjustable 5V (pin 27), external power supply. The source with the highest voltage is automatically selected [9].

To ensure favorable conditions for plant growth, it is also necessary to monitor the environment. The DHT-11 sensor is used as an environmental sensor.

The DHT11 sensor consists of two parts: a hydrometer and a capacitive temperature sensor. A hygrometer measures the humidity of the air. There is also a controller in the sensor that performs analog-to-digital conversions to transmit a digital signal to the microcontroller [10].

– Humidity measurement accuracy ±3%RH (in the range of 20...80%RH)
– Pressure measurement accuracy ±1.0 hPa (in the range of 300 . . . 1100 hPa)
– Temperature measurement accuracy ±0.5 °C (in the range -40...+85 °C)

Conclusions.

A smart greenhouse is a self – regulating microclimate suitable for plant growth through the use of sensors, actuators and monitoring and control systems that optimize growth conditions and automate the growing process. This study showed that the climatic conditions inside the greenhouse are not always favorable for the development of plants. A control system based on fuzzy logic, which has shown its effectiveness. The controller allowed us to regulate the internal temperature and humidity through proper control and control of the actuators to obtain the desired values.

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