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METHODS FOR PARAMETERS CONTROLLING AND REGULATING THE INDUSTRIAL PREMISES MICROCLIMATE

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ABSTRACT.

This article discusses the methods for controlling parameters and regulating the industrial premises microclimate. 13 different methods are described, from simple to complex integrated systems. For each method, an overview of its advantages and disadvantages is provided. The urgency of the problem and the need to find modern approaches to ensure optimal production conditions and a comfortable environment for employees are highlighted

Key words: Microclimate, Parameter Control, Regulation, Automation, Computer-Integrated Technologies, Manufacturing Innovation, Industrial Innovation.

INTRODUCTION

In accordance with the new concepts of Industry 4.0 and CPPS, it is necessary to constantly monitor many production parameters, ranging from the current parameters of the equipment to the microclimate parameters in the production premises [1]-[12]. In order to reduce the costs of re-equipping an entire production facility, monitoring systems are often created [13]-[26].

The microclimate of production premises is a set of physical parameters, such as temperature, humidity, pressure, air movement and air pollution level, which are monitored and regulated to ensure optimal production conditions and the functioning of production equipment. Microclimate is an important element for ensuring quality and production efficiency, as many processes can be sensitive to changes in these parameters. For example, high temperature can affect the quality of products, while humidity can affect the operation of equipment or the storage of raw materials.

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The relevance of the topic of microclimate control and regulation is due to growing requirements for product quality, energy efficiency of production processes, and labor protection. In the conditions of rapid technological development and increased automation of production processes, ensuring an optimal microclimate becomes critically important for the stable operation of equipment and the preservation of the health of employees. Environmental regulations, which require reducing emissions of harmful substances and improving air quality in production facilities, also play a significant role.

To ensure optimal production conditions and the functioning of production equipment, it is necessary to use effective methods of control and regulation of microclimate parameters. There is a wide range of methods to measure different aspects of microclimate, from simple instruments to complex integrated systems. Various methods and approaches can also be used here [27]-[36]. In this article, we will consider the main methods of controlling the parameters of the microclimate of industrial premises, their advantages and disadvantages.

Related works

There are a huge number of methods for monitoring and regulating the parameters of industrial premises. Let's look at some recent works devoted to this topic.

In research [37] authors developed an air dehumidifier based on Peltier elements for ensuring optimal microclimate parameters on cattle breeding premises.

The review [38] focuses on urban microclimate parameters like temperature, relative humidity, wind direction and speed, concentrating on reported variations and interlinkages.

Scientists [39] formulate the micro-climate control problem based on semi-Markov decision processes that allow for variable-time state transitions and decision making. They show the efficiency of their proposed approach via designing a smart learning thermostat that simultaneously optimizes energy consumption and occupants' comfort in a test building.

The work [40] presents researches on the organization and implementation of the project management of selection processes and the development of adequate models of interaction of many parameters of the microclimate of the technological process of raising the poultry meat breeds in industrial premises.

Study [41] proposes climate control system for large enterprises. There is presented the structure and mathematical support, air conditioning control algorithms and multifunctional software are used at the middle level of an enterprise management using decision-making system.

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Researchers in [42] solve the problem of round-the-clock monitoring of the microclimate of classrooms by developing an autonomous IoT system using edge devices to measure climatic parameters such as temperature, relative humidity, carbon dioxide level in the air, and the concentration of light air ions with data recording on a smartphone and saving on a remote server.

Classification of methods for controlling microclimate parameters of industrial premises

Analysis of methods for controlling microclimate parameters in production premises and their classification is necessary to ensure optimal working conditions, preserve the health of employees, increase production efficiency and prevent negative effects on the environment. Different methods have their advantages and disadvantages, which affect the accuracy, efficiency and cost of measurements. The classification of methods allows you to choose the best approach depending on specific conditions and production requirements. For example, direct measurements may be more effective for small spaces where high accuracy is important, while remote methods are useful for monitoring hard-to-reach areas. At the same time, methods such as thermal imaging or gas analysis provide additional information about possible problems that are not always visible using traditional means. Analysis and classification make it possible to develop a comprehensive approach to microclimate control that takes into account the specifics of the premises and the production process, optimizing equipment and maintenance costs, as well as increasing the overall safety and comfort of workers. The classification of methods for controlling microclimate parameters in industrial premises is shown in Figure 1.

Let us present a brief description of the purpose for each of the microclimate parameter control methods presented in Figure 1. The direct measurement method is used to directly measure temperature, humidity and other microclimate parameters using sensors located directly in the measurement area. The remote measurement method makes it possible to measure microclimate parameters at a distance using wireless sensors or other technologies, which allows monitoring in hard-to-reach places. The method of thermal imaging is used to visualize the temperature fields in the room, helps to identify areas with increased or decreased temperature, which may indicate problems with insulation or ventilation. A gas analysis method is designed to measure the concentration of various gases in the air, such as CO2, CO, CH4, which is important for the safety and health of workers. The method of psychrometry is used to determine the relative humidity of the air using the temperature indicators of dry and wet thermometers, which is important for comfort and preservation of materials. The method of hygrometrography is used to

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automatically record changes in humidity and temperature in the room, providing continuous monitoring of microclimate parameters. A dust measurement method is designed to determine the amount and type of dust in the air, which is important for ensuring cleanliness and health in production facilities. The acoustic emission method is used to detect cracks and other defects in materials by analyzing the sound waves emitted during the formation of cracks.

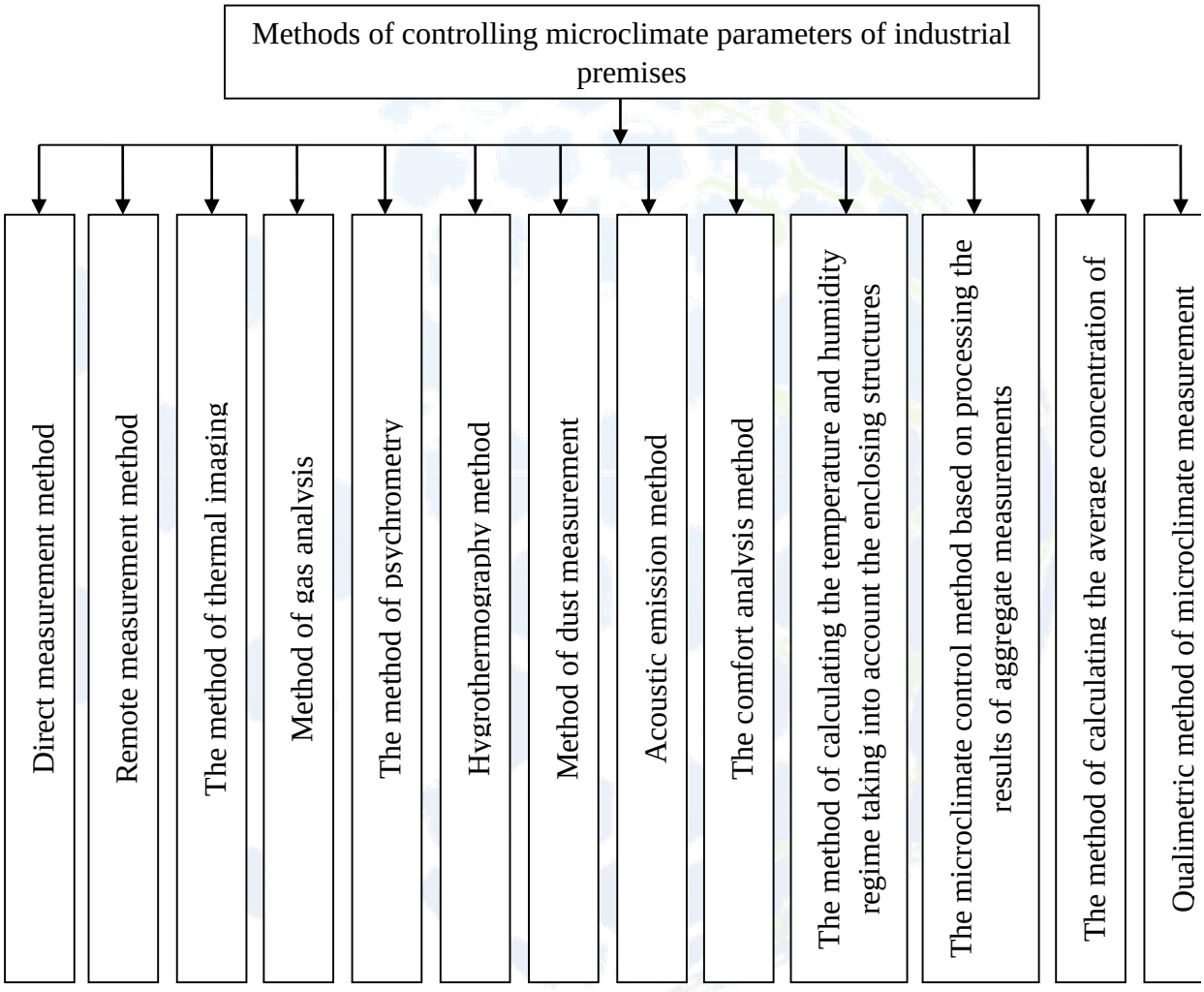

Figure 1: Classification of methods for controlling microclimate parameters in industrial premises

The comfort analysis method evaluates the comfort of indoor conditions for people based on subjective and objective indicators, such as temperature, humidity, air speed and other factors. The method of calculating the temperature and humidity regime taking into account the enclosing structures is used to calculate the optimal parameters of the microclimate taking into account the influence of walls, windows and other structures limiting the premises. The method of microclimate control is

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based on the processing of the results of aggregate measurement. It is used for the comprehensive analysis of the microclimate by processing data from various sensors, providing more accurate control of parameters. A method for calculating the average concentration of particles, designed to determine the average concentration of particles in the air based on measurements at different points, which is important for air quality monitoring. Qualimetric method of microclimate measurement is used for comprehensive assessment of microclimate parameters based on aggregate indicators, including temperature, humidity, air speed and other factors, providing comprehensive control of indoor conditions. We will compare the given methods for controlling microclimate parameters in production premises from the point of view of advantages and disadvantages, the result of the comparison is shown in Table 1.

Table 1: Comparison of advantages and disadvantages of methods of controlling microclimate parameters in production premises

Method	Advantages	Disadvantages	Basic formulas for calculation
Direct measurement method	High accuracy, ease of use	Frequent calibration may be necessary, depending on the place of installation	-
Remote measurement method	The possibility of control in hard-to-reach places	Possible low accuracy, dependence on obstacles on the way	-
The method of thermal imaging	Visualization of temperature fields, detection of problem areas	High cost of equipment, difficulty in data interpretation	-
Gas analysis method	High accuracy of	Expensiveness, the need	$C = (m/V) \cdot k$

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	gas concentration measurement	for specialized devices	C - concentration; m - mass of gas; V - volume; k - proportionality factor.
Method of psychrometry	Simplicity and reliability of measurements	The need for frequent calibration is possible, depending on external conditions	$RH = (P_w / P_s) \cdot 100$ RH - relative humidity; P_w - partial pressure of water vapor; P_s - saturated water vapor pressure
Method of hygrometrography	Automatic recording of parameters	High cost of equipment, need for regular maintenance	-
Method of dust measurement	Determination of the amount and type of dust	Expensive equipment, the need for specialized devices	$C = (m/V)$ C - dust concentration; m - mass of dust; V - volume.
Acoustic emission method	Detection of cracks and defects in materials	High cost of equipment, need for specialized personnel	-
The comfort analysis method	Evaluation of convenience for people	Subjectivity of assessments, dependence on individual feelings	$PMV = (0.303 \cdot \exp(-0.036 \cdot M) + 0.028) \cdot (M - W)$ PMV - indicator of average thermal comfort; M - metabolic activity, W - work
The method of calculating the	A comprehensive approach, taking into	The complexity of calculations,	-

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temperature and humidity regime taking into account the enclosing structures	account the specifics of the building	the need for detailed data about the building	
The microclimate control method based on processing the results of aggregate measurements	High accuracy and reliability	Difficulty of collecting and analyzing large amounts of data	-
The method of calculating the average concentration of particles	Measurement accuracy	The high cost of equipment, the need for specialized devices	$C = \sum m_i / \sum V_i$ C - average concentration, m_i - particle mass, V_i - measurement volume.
Qualimetric method of microclimate measurement	Comprehensive assessment of microclimate parameters	High cost and complexity of implementation	

A general analysis of the comparison table of methods for controlling microclimate parameters in production premises shows that each method has its own unique advantages and disadvantages that affect their applicability in different conditions. Direct and remote measurement methods provide high accuracy and flexibility, but may require frequent calibration and may depend on external conditions. Thermal imaging and gas analysis provide in-depth information on temperature and gas parameters, but require high equipment costs. Psychrometry and hygrometry are reliable for measuring humidity, while dust measurement and

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acoustic emission specialize in detecting particles and defects. Comfort analysis and the qualitative method allow to evaluate the conditions for workers, but can be subjective. Complex methods that take into account the results of aggregate measurements and the features of the structures of the premises provide more accurate and comprehensive control, although they are difficult to implement. In general, the choice of method depends on the specific needs and conditions of the production process.

CONCLUSION

13 methods are considered, each of which has its own advantages and disadvantages. The direct measurement method is characterized by high accuracy, but requires frequent calibration. Remote measurement is convenient for hard-to-reach places, although accuracy may be reduced due to obstacles. Thermal imaging and gas analysis provide in-depth analysis of temperature and gas parameters, but require significant investment in equipment. Psychrometry and hygrometry are reliable methods for measuring humidity, while dust measurement and acoustic emission specialize in detecting particles and defects. Comfort analysis methods and the qualitative method evaluate the conditions for workers, but can be subjective. Complex methods that take into account the results of aggregate measurements and the features of the structures of the premises provide more accurate and comprehensive control of the microclimate, although their implementation is difficult. The choice of the method depends on the specific needs of the production and the conditions of the room, which allows you to optimize the costs of the equipment and increase the overall safety and comfort of the workers.

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