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Studying the space of microclimate parameters of production premises

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Abstract: The aim of the study is to find out, based on the project's approach, the main components of the project on the research of the microclimate of industrial premises, and to substantiate, develop and apply a means of geometric analysis of the graphic dependencies of its parameters. A comparative analysis of the graphic dependencies indicates the significant effect of local exhaust ventilation on the character of the temperature field in the room. The comparative analysis of results makes it possible to analyze the insulation of isotherms, that is, the effect of local exhaust ventilation on the nature of their location in a cutting plane. The practical significance of the scientific results obtained in the work is to develop a new methodical approach based on the combination of physical and geometric modeling using a constructive device of applied multidimensional geometry, which can be an instrumental basis for the purposeful study of similar technological processes in the production premises.

Keywords: isotherms, infrared heater, working zone, exhaust ventilation

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Introduction

Ensuring the effective implementation of technological processes of production in the industrial sector is extremely important at the present stage of development of the European economy, which is characterized by rational and economical use of energy resources while ensuring the proper quality of products. An important condition for industrial premises is to observe the comfort of the microclimate

in the technological zone. Heaters and ventilation systems are used to provide regulatory requirements. Their effective work is possible when rational modes of operation of the corresponding technological equipment are used.

The development of appropriate approaches to the creation of industrial heating and ventilation systems for industrial buildings, the choice of means and the study of the parameters of the process constitute one of the most promising ways in ensuring the parameters of the microclimate in industrial premises.

The analysis of recent research and publications into the science concerning the study of the microclimate of industrial premises indicates the direct impact of the technological system of maintaining the microclimate on the state of the production process in the working area. The parameters of the microclimate, namely air temperature and air movement are investigated in scientific works (Gumen et al., 2017a; Gumen et al., 2017b; Petras & Kalus, 2000; Spodyniuk & Zhelykh, 2010; Yurkevich & Spodyniuk, 2015) separately. Thus, in (Spodyniuk & Zhelykh, 2010) the process of utilization of heat by an exhaust outlet is investigated. Scientific investigations (Gumen et al., 2017b; Yurkevich & Spodyniuk, 2015) present the results of the study in the form of isotherms of the temperature field in the premises, taking into account the work of the infrared heating system and local ventilation system.

Scientific research, however, does not contain a methodologically grounded scientific approach to the process of organizing and choosing the processing means of the obtained experimental results, taking into account the project approach (Khmel et al., 2016) to the organization and implementation of the industrial process.

The selection of previously unsettled parts of the general problem points to a limited number of scientific publications concerning the provision of a comfortable microclimate in industrial premises. Using the tools of project-oriented management provides an opportunity to highlight the main components of the study and choose the only method of preparation and theoretical analysis of the experimental results obtained.

The aim of the study is to find out, on the basis of the project's approach, the main components of the project on the research of the microclimate of industrial premises and to substantiate, develop and apply a means of geometric analysis of the graphic dependencies of its parameters.

1. Experimental studies

It is important to develop appropriate measures and means to ensure the proper conditions for the industrial process. It is clear that the provision of proper conditions in the working area requires that priority research be carried out on the impact of microclimate parameters on the industrial process, in the first place providing recommendations for ensuring rational values of microclimate parameters in accordance with regulatory documents. Such studies, again, require compliance with a certain sequence in their implementation, that is, the project approach.

Therefore, from the diversity of the parameters of ensuring the proper conditions in the working area, we distinguish the main ones: indoor air temperature and air movement. To conduct the research, laboratory equipment should be universal and ensure the implementation in full.

Figure 1 shows the scheme of the installation, in which research was carried out on the temperature of internal air in the working area of the production premises.

An example of an experimental installation shows the work of the infrared heating system in conjunction with local exhaust ventilation. The installation of such a system in industrial premises will provide a sufficient microclimate while simultaneously heating objects in the working area and removing some of the heated air from the upper zone, with the possibility of further utilization.

Exhaust outlet 5 is connected to fan 3 via air duct 4. Infrared heater 2 is designed to heat the working area of the room. Measurements of temperature and air were carried out using thermoanemometer 8. At coordinate grid 7, measurements were carried out at fixed intervals in both the vertical and horizontal plane. The surface temperature was measured by infrared pyrometer 9.

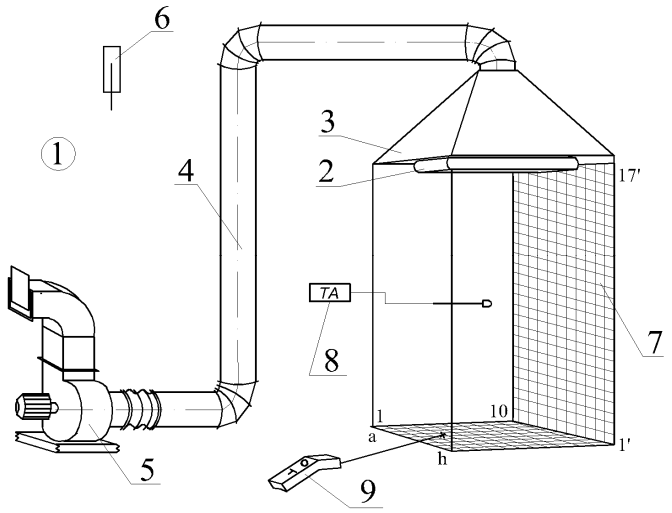

Fig. 1. Scheme of the experimental installation (own study): 1 - room; 2 - infrared heater; 3 - exhaust outlet; 4 - air duct; 5 - ventilator; 6 - thermometer; 7 - coordinate grid; 8 - thermoanemometer ATT-1004; 9 - infrared pyrometer "NIMBUS-530"

When studying the work of local exhaust ventilation the temperature fields in room space 1 are compared with ventilator 5 switched off and on. The study of the temperature fields in room 1 in both cases was carried out by measuring the temperature of the air with thermometer 6 and using coordinate meter 7. For cross-section 1-1 (Fig. 1), under the exhaust outlet, a cutting plane parallel to one of the planes *xz* of coordinate meter 7 was carried out. The results of measurements were given by the isotherms in the cross-section with the measurements of the height of the room *h* and the coordinate *x* of room 1 with a constant value of coordinate *y* that is the width of the room (Fig. 2a, b).

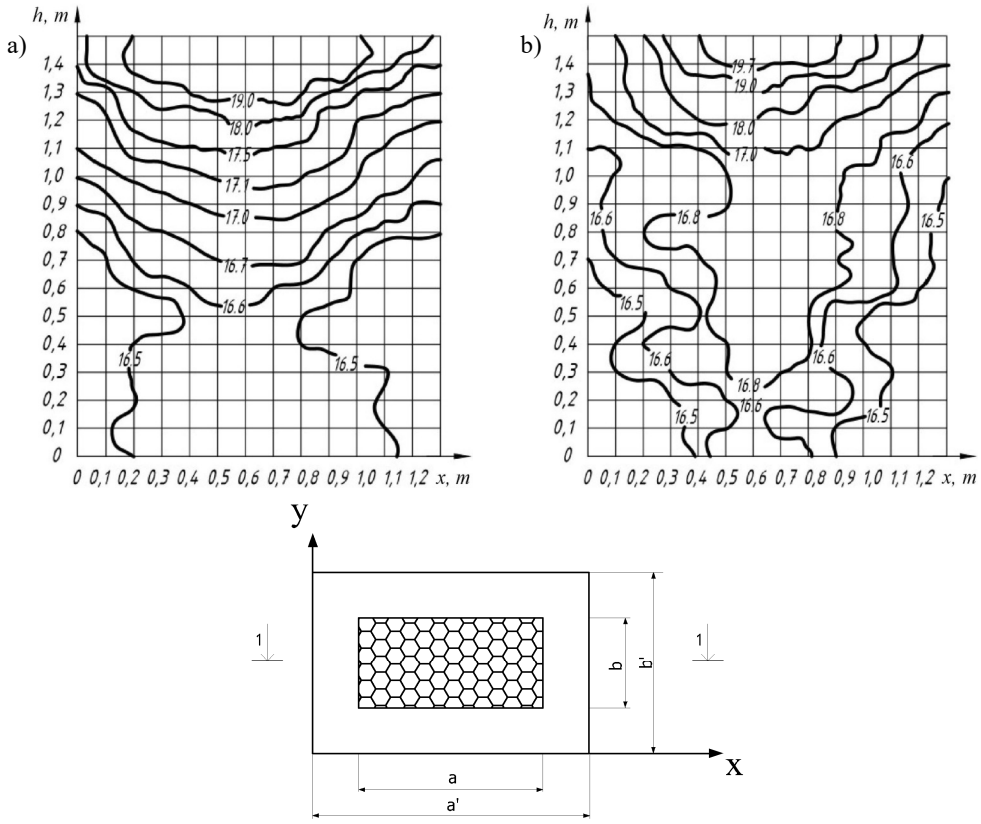

Fig. 2. Isotherms of cross-section 1-1 (*own study*):
a, b - dimensions of the infrared heater; a', b' - dimensions of the exhaust outlet

A comparative analysis of graphic dependencies indicates the significant effect of local exhaust ventilation on the character of the temperature field in the room.

In the absence of local exhaust ventilation (Fig. 2a) there is a flat character of the isotherm location at a height of $h \geq 0.6$ m. At this height, the isotherms are slightly constricted and extend upwards when the fan is turned on. In both cases, each of the isotherms has a minimum. In addition, when the fan is on, there is an orderly movement of air up to exhaust outlet 3, in the upper and middle part of the cross-section 1-1, and in the vicinity of the exhaust conduit isotherms are damper (Fig. 2b).

2. Results and discussion

The comparative analysis of Figures 2a and 2b makes it possible to analyze the insulation of isotherms, that is, the effect of local exhaust ventilation on the nature of their location in a cutting plane. It is convenient to characterize such a density as the greatest values of the excess of the isotherm height Δh at a certain interval Δx; common to the isotherms is the interval Δx = 0.3-0.8 m.

The values of Δh for some of the isotherms constructed in cutting plane 1-1 are summarized in Table 1.

Table 1. The value of the slope of some isotherms Δh (*own study*)

Isotherm		16.5	16.6	17	18	19
Δh, m	without a fan	0.45	0.11	0.1	0.09	0.08
	with a fan	>1.4	0.3	0.1	0.11	0.15

With an increase in the velocity of the flow of tidal air from 0.1 to 0.2 m/s, the isotherm of 24°C dropped from a height $h = 1.5$ m to a height of $h = 0.9$ m, that is 60%. With an increase in the velocity v of the flow of tidal air from 0.2 m/s to 0.35 m/s it dropped to a height of 0.55 m.

Exceeding Δh height of isotherm 24°C across the entire gap $\Delta x = 0$-7 m is 0.18 m for the velocity of the flow of tidal air $v = 0.1$ m/s; 0.45 m for $v = 0.2$ m/s; 0.46 m for $v = 0.35$ m/s.

The working zone is represented as a system of heat capacities between elements of which heat exchange is happening and interacting with heat sources (Fig. 3) (Gumen et al., 2017a; Petras & Kalus, 2000; Yurkevich & Spodyniuk, 2015). The infrared heating system provides the necessary comfortable conditions while simultaneously working with local exhaust ventilation. The nature of the distribution of temperature fields depends on the effect of the exhaust outlet mainly on the upper part of the heating zone. This pattern of distribution makes it possible to conclude that the given design of the local exhaust ventilation can localize the convective component of the infrared heater together with the products of incineration in the upper part of the working area and further utilize this heat and use it for the heating needs of the room.

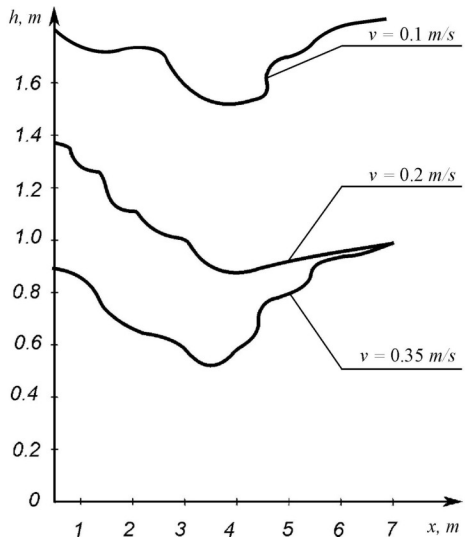

Fig. 3. Effect of the velocity of the inflow air on the location of isotherms (*own study*)

Thus, the use of such a system, on the one hand, will improve the microclimate in the working area of the production premises at the expense of partial removal of gas hazards together with exhaust air, and on the other hand, save energy.

Conclusions

It is shown that the involvement of a project-oriented approach makes it possible to implement a project effectively and study the parameters of the microclimate of industrial buildings.

The geometrically grounded method for processing experimentally taken parameters and the determination of those values that is difficult or impossible to determine in the conditions of an experiment is suggested and tested on examples.

The practical significance of the scientific results obtained in the work is to develop a new methodical approach based on the combination of physical and geometric modeling using a constructive device of applied multidimensional geometry, which can be an instrumental basis for the purposeful study of similar technological processes in production premises.

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Badanie parametrów mikroklimatu w pomieszczeniach produkcyjnych

Streszczenie: Celem badania jest opracowanie głównych elementów projektu dotyczących badania parametrów mikroklimatu pomieszczeń przemysłowych oraz opracowanie i zastosowanie metody analizy geometrycznej zależności graficznych do oceny tych parametrów. Analiza porównawcza zależności graficznych wskazuje na znaczący wpływ lokalnej wentylacji wyciągowej na charakter pola temperaturowego w pomieszczeniu. Analiza wyników umożliwia ocenę uzyskanych izoterm charakteryzujących wpływ lokalnej

wentylacji wyciągowej na ich położenie w płaszczyźnie cięcia. Praktyczne znaczenie wyników uzyskanych w pracy polega na opracowaniu nowego podejścia metodycznego opartego na połączeniu modelowania fizycznego i geometrycznego, co może stanowić podstawę do badania podobnych procesów technologicznych w pomieszczeniach produkcyjnych.

Słowa kluczowe: izotermy, promiennik podczerwieni, strefa pracy, wentylacja wyciągowa