



## Ways of providing comfortable conditions in livestock complexes

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### ABSTRACT:

The microclimate in livestock buildings must meet all zoohygienic requirements. The ambient airflow must be uniform in order to prevent drafts. The analysis of the current state of heating and ventilation systems in agricultural buildings showed that the important factor in the design and use of such rooms is the application of energy-saving technical solutions to maintain comfortable conditions. The nature of the velocity field distribution in the area of the exhaust outlet allows the conclusion that the solution used is able to localize the convective component of the infrared emitter, which allows for better heat recovery from the exhaust air. This improves the energy efficiency of such a system. As a result of the studies, graphical and analytical dependencies were obtained to determine the rate of air intake through the outlet. These can be used at the stage of calculating the microclimate parameters for the premises of agricultural complexes.

### KEYWORDS:

infrared heating; exhaust outlet; air velocity; isolines

## 1. Introduction

Livestock buildings should meet many requirements regarding specific zootechnical standards and conditions. They relate to the use of pro-ecological animal breeding technologies and appropriate equipment, ensuring adequate indoor microclimate conditions as well as hygienic and sanitary conditions. In addition, emphasis is placed on economical energy consumption, minimizing work inputs and its safety in relation to personnel. The favorable environment in which farm animals stay stimulates life processes in their body and increases productivity. The basis is the appropriate shaping of the values of microclimate parameters inside buildings intended for animal breeding, such as air temperature and relative humidity in accordance with zoohygienic requirements [1-3]. In addition to air temperature and relative humidity, indoor air velocity and air composition have a significant impact on animal health and productivity. The airflow around the animals must be even, to prevent drafts adversely affecting animals staying indoors. Ventilation loss is also unfavorable, especially in winter, when the animals stay in enclosed spaces for a long time. At that time, air pollution is rising systematically, the main source of which are the animals living in buildings and the process of breeding them. The amount of air pollutants such as carbon dioxide or ammonia, as well as the moisture content, affects the appearance and weight of the animals. With poor ventilation, animals become lethargic, their appetite deteriorates, productivity can decrease, and various diseases can occur. Therefore, sufficient attention should be given to efficient heating and ventilation systems that could

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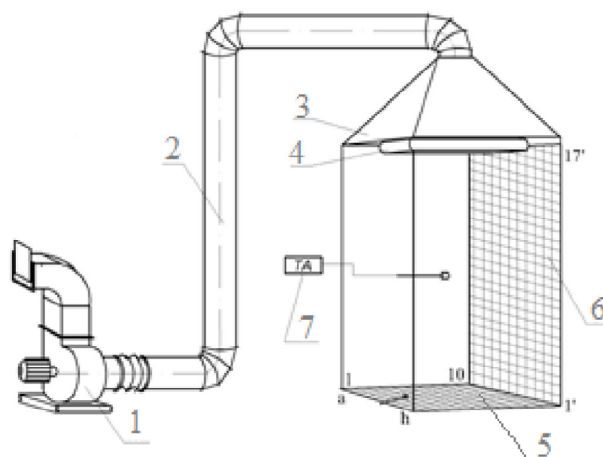
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provide and maintain an adequate level of indoor microclimate conditions in livestock complexes and thus animal comfort.

## 2. Experimental studies

The analysis of the current state of heating and ventilation systems in agricultural premises showed that the important factor is the use of energy-saving technical means to maintain comfort conditions. Therefore, a study was conducted of a system that combined an infrared emitter for local heating and an outlet to remove air pollution from the upper part of the animal's residential area. The design is versatile and combines a heating and ventilation unit.

Figure 1 shows a diagram of the installation, where studies of air velocity and coverage of the exhaust outlet were conducted [4, 5].



**Fig. 1.** Scheme of the experimental setup: 1 - fan; 2 - air duct; 3 - exhaust outlet; 4 - infrared heater; 5 - coordination grid on black surface; 6 - vertical coordination grid; 7 - thermo-anemometer ATT-1004

The studies were conducted on the effective operation of the exhaust outlet. The installation imitated the system of local exhaust ventilation in the premises of agricultural complexes, namely in a poultry house. The installation allows, to some extent, the removal of harmful gases and thus provide the necessary microclimate in the poultry house. Exhaust outlet 3 was connected to fan 1 through air duct 2. Infrared heater 4 is designed to heat the zone where the poultry is located. Measurements of air movement were carried out using thermo-anemometer 7 in the plane of the exhaust outlet. For its uniform determination, coordinates 5 and 6 were used, which allowed measurements to be made at fixed intervals both in the vertical plane and in the horizontal plane [6, 7]. As a result of the study, the suction velocity of the outlet and its area of action were determined. The results of the experiment are presented in graphical form and are shown in Figure 2:

$$\bar{v} = \frac{v_{xy}}{v_0}$$

where:  $v_{xy}$  - air velocity at the point with coordinates  $x$  and  $y$  [m/s];  $v_0$  - air velocity at the entrance to the outlet [m/s].

Plots of relative velocities of exhaust air are constructed, on the basis of which, the range of the exhaust umbrella and the distribution of the velocity field in the corresponding cross sections were estimated (Fig. 2). As a result of the proposed design of an infrared heater with an exhaust outlet, more efficient removal of contaminated air, and therefore the amount of heat, by increasing the range of the suction torch occurs.

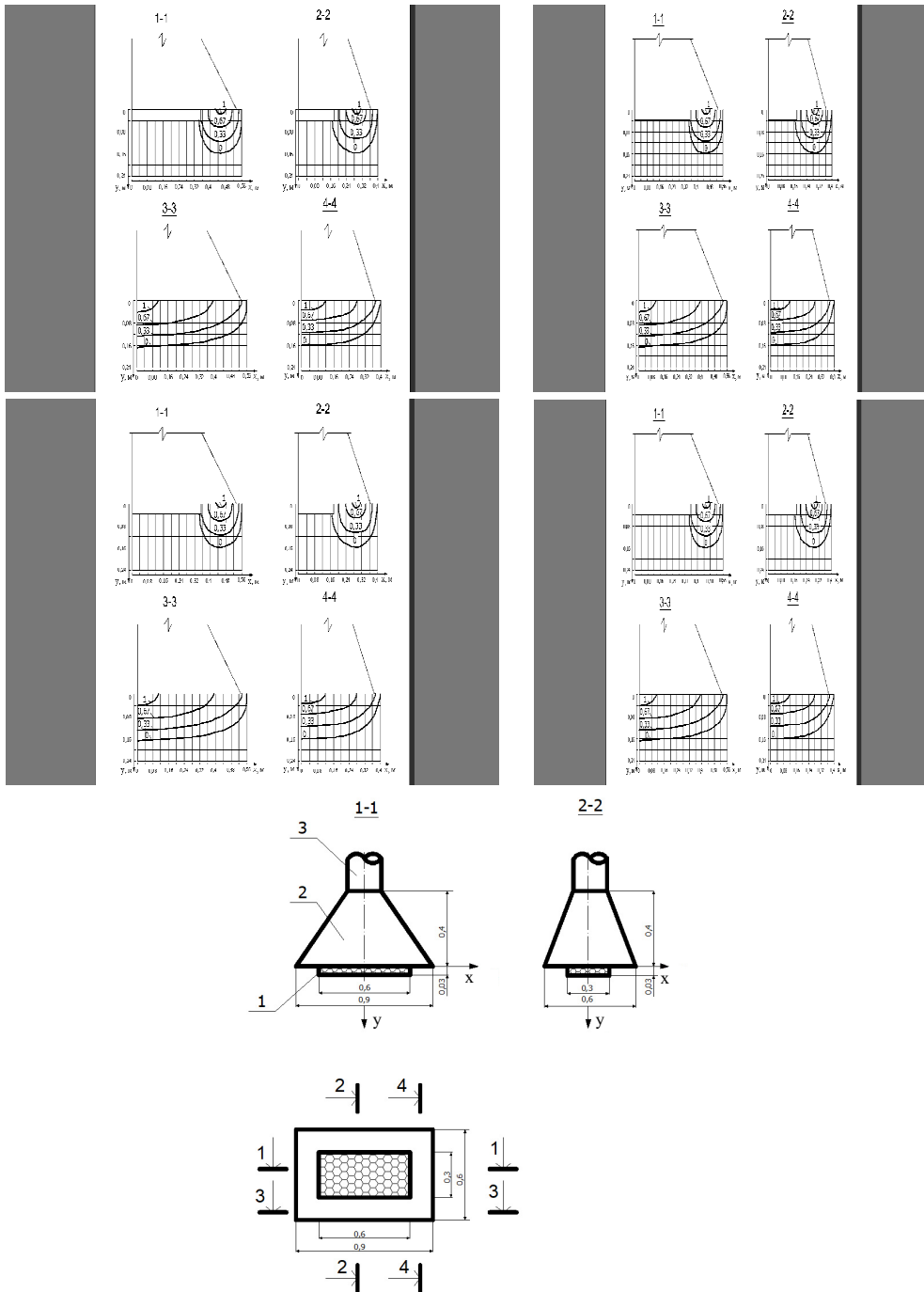


Fig. 2. Diagrams of velocities of exhaust outlet in cross sections 1-1, 2-2, 3-3, 4-4

There is a uniform distribution of isolines along the perimeter of the suction hole. For the convenience of engineering calculations, a graphical dependence was constructed to determine the area of the outlet and the rate of air absorption (Fig. 3).

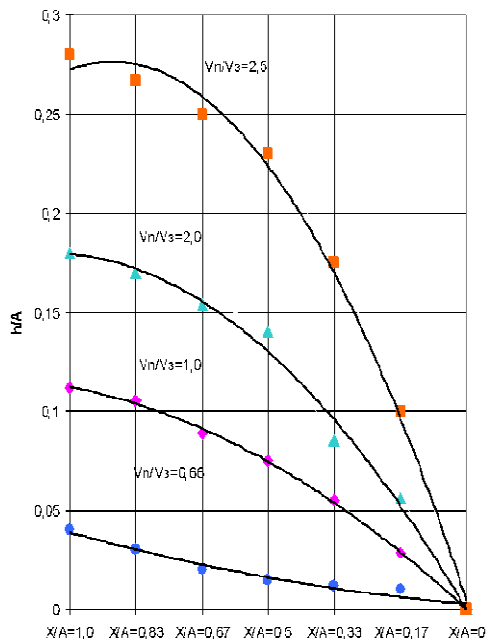


Fig. 3. Graph of dependence of air suction rate on the width and coverage of outlet

These graphical dependencies were approximated and the analytical dependencies were obtained for different values  $V_n/V_3$ :

for  $V_n/V_3 = 2.5$

$$\frac{h}{A} = 0.2509 - 0.0095 \left( \frac{X}{A} \right)^2 + 0.0311 \frac{X}{A};$$

for  $V_n/V_3 = 2.0$

$$\frac{h}{A} = 0.1779 - 0.0045 \left( \frac{X}{A} \right)^2 + 0.006 \frac{X}{A};$$

for  $V_n/V_3 = 1.0$

$$\frac{h}{A} = 0.1166 - 0.002 \left( \frac{X}{A} \right)^2 - 0.0023 \frac{X}{A};$$

for  $V_n/V_3 = 0.66$

$$\frac{h}{A} = 0.0484 + 0.0005 \left( \frac{X}{A} \right)^2 - 0.0102 \frac{X}{A}.$$

where:  $V_n$  - air movement inside the room [m/s], accepted,  $V_n = 0.2$  m/s [3];  $V_3$  - suction speed in the outlet opening,  $V_3 = 0 \div 0.3$  m/s;  $h$  - the vertical distance from the underside of the suction opening of the outlet to the surface of the source of contaminated air [m];  $A$  - the smallest side of the outlet,  $A = 0.6$  m;  $X$  - horizontal distance between the side of the outlet and the source of excretion [m].

The nature of the velocity field distribution in the range of the exhaust outlet allows the conclusion that the design is able to localize the convective component of the infrared emitter and subsequently recycle heat from the exhaust air. This improves the energy-saving component of such a system and, in addition, the exhaust air will be partially eliminated from polluted air.

### 3. Conclusions

Ensuring and keeping appropriate microclimate conditions in livestock buildings creates good health conditions, influences the proper functioning of the body, its productivity and maintains good animal condition. The basic factors determining the correct microclimate are the temperature and relative humidity of the air, as well as the concentration of harmful gases. Livestock emits heat into the environment, carbon dioxide, ammonia and steam. Long-term residence of animals in adverse environmental conditions, such as low temperature, high relative humidity or poor indoor air quality leads to excessive heat loss from animal organisms, difficulty in breathing, deterioration of digestive processes, and thus weakens immunity, decreases appetite, increases diseases and creates a drop in productivity.

A properly functioning heating and ventilation system for livestock buildings is a basic factor in maintaining the proper temperature and indoor air quality, eliminating harm to animals, drafts that result from high airflow speed and ensures adequate comfort for farm animals. As a result of the research, graphical and analytical dependences were obtained, which allow the determination of the suction rate of the outlet. They can be used at the stage of calculating the microclimate parameters for the agricultural complex.

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## Sposoby zapewnienia warunków komfortu w kompleksach inwentarskich

### STRESZCZENIE:

Mikroklimat w budynkach inwentarskich musi spełniać wszystkie wymagania zoohigieniczne. Przepływ powietrza w otoczeniu musi być równomierny, aby zapobiec przeciągom w pomieszczeniach. Analiza obecnego stanu systemów ogrzewania i wentylacji obiektów gospodarskich wykazała, że ważnym punktem w projektowaniu i użytkowaniu takich pomieszczeń jest zastosowanie energooszczędnych rozwiązań technicznych w celu utrzymania warunków komfortu. Charakter rozkładu prędkości powietrza w obszarze jego wylotu pozwala stwierdzić, że zastosowane rozwiązanie jest w stanie zlokalizować element konwekcyjny emitera podczerwieni, co pozwoli na lepsze odzyskanie ciepła z powietrza wywiewanego. To poprawia energooszczędność takiego systemu. W wyniku badań uzyskano zależności graficzne i analityczne zależności określające szybkość zasysania powietrza przez wylot. Zależności te można stosować na etapie wyznaczania parametrów mikroklimatu dla pomieszczeń w kompleksach inwentarskich.

### SŁOWA KLUCZOWE:

ogrzewanie na podczerwień; otwór wylotowy; prędkość przepływu powietrza; izolacje