The Accounting of heat losses and infiltration during the work with a microclimate of rooms in broiler production

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Abstract. The condition of the air environment in modern agricultural buildings is provided by means of the microclimate air conditioning systems (MACS). However traditional MACS and their equipment are quite expensive, power-intensive and difficult in operation. Therefore relevant is a problem of development and use of simpler, reliable, energy-efficient systems and devices of conditioning of a microclimate for creation and maintenance of the required technological parameters of the air environment providing decrease in energy consumption and increase in efficiency in poultry farming has important social value. Air conditioning system of a microclimate of the agricultural building has to represent complex application active (air conditioning systems) and passive (external protections) engineering means. Need of recirculation of air is caused by considerable overexpenditures of warmth during the cold period of year and cold during the warm period of year. It is connected with the fact that norms of air exchange for the warm and cold periods of year differ several times, at the same time the total value of air supply remains to a constant. Infiltration is an unorganized air intake to room through leakage of buildings protections under the influence of thermal and wind pressure and, possibly, due to the work of mechanical ventilation. Accounting losses of heat in poultry-farming rooms and dispensing of ventilation volume, the major factor is the air infiltration through construction and enclosing structures that significantly affects the gas consumption for space heating and on the final cost of production.

1. Introduction
Currently there is an active reconstruction of premises for maintenance of animals and other objects for premises for maintenance broiler chickens. Since these premises were built many years ago, heat-insulating and air-tightness of such buildings are poor [1–3].

Broiler chickens are very demanding on the parameters of microclimate. Calculating the minimum ventilation, the broiler production manager must know the amount of infiltration losses which should be considered when determining the minimum air exchange every day. In addition, it is necessary to know how much heat is lost through the enclosing structures. In the case of large heat losses through the enclosing structures, it is possible to offer a feasibility study on insulation of premises with a payback period of investment [4–6].

2. Choice of Calculation Method
There are two methods of calculating losses through enclosing structures and infiltration:

1. by using the gas flow spent on compensation for losses (in the case of a gas flow meter).
2. by the time of operation of gas generators (in the absence of gas flow meter).

Since many poultry-farming premises do not have a gas flow meter (usually a single meter for several premises), the second option is more preferable. Nevertheless, the option of determining losses through enclosing structures and infiltration by using the gas flow spent on compensation for losses is the most accurate and requires detailed consideration.

The determination of losses through enclosing structures and infiltration, regardless of the selected method, is carried out in 3 stages: the determination of heat losses through enclosing structures with disconnected combined extract-and-input ventilation, the determination of total losses for infiltration and through enclosing structures with included exhaust ventilation, and the determination of losses amount for infiltration.

Let consider in more detail the steps in the case of choosing the definition of heat loss and infiltration by using the time of gas generators operation.

3. Results and considerations
Since many poultry-farming premises do not have a gas flow meter (usually a single meter for several premises), the second option is preferable. The determination of losses through enclosing structures and infiltration is carried out in 3 stages.

3.1 The determination of heat losses through enclosing structures with turned-off ventilation
3.1.1 Phase 1
The result will be most accurate if measurements are taken in the dark or in cloudy weather [7].

It is necessary to turn off exhaust ventilation, to close all extract and input valves, to pack off and to insulate tunnel exhaust fans and extract tunnel louver, all doors should be closed. Then, install the gas generators in the automatic position. During at least 24 hours, the poultry house must be heated to a temperature of 32.5°C. At the same time the temperature of the house should be higher than the temperature of the street.

After warming up the poultry house, it is possible to begin to carry out the corresponding measurements of heating operating time. Modern microclimate controllers automatically record the heating time. During the measurements it is necessary to make sure that all the heaters are in good order and the settings correspond to the declared power.

The measurements should be at least 3 with an interval of 60 minutes. At the time of each measurement it is necessary to record outdoor and indoor temperature.

Settlement part is below:
1. The general operating time on each group $t_k$, for all period of measurements, minute, min

$$t_k = \sum_{k=1}^{n} t_{ki},$$

where $t_{ki}$ is operating time of $i$ measurement of $(k)$ group, min; $n$ are measurements; $k$ are groups.

2. Pays off heat from $(k)$ group of heating $N_k$, kW.

$$N_k = \frac{P_k \times t_k \times L_k}{60},$$

where $P_k$ is power of a gas generator in the $(k)$ group, kW; $L_k$ is number of gas generators $(k)$ group, pcs.

3. Total heat from all groups $(N)$, kW

$$N = \sum_{k=1}^{m} N_k ,$$
where \( m \) are groups.

4. The difference between internal and external temperature \( T, ^\circ C \)

\[
T = T_{\text{building}} - T_{\text{outdoor air}}
\]

5. Heat losses through enclosing structures are determined \( q_{\text{losses}}, \text{ kW}^\circ \text{C} \)

\[
Q_{\text{poten}} = \frac{N}{n \times T}
\]

### 3.1.2 Phase 2. The determination of heat losses for infiltration with turned-on ventilation

The result will be most accurate if measurements are taken in the dark or in cloudy weather. This stage is a continuation of the 1st stage and all its conditions must be met except that the ventilation will be tuned to the working static division (all inflow is closed at the same time). At the same time air will pass through defects of building structures and leakage of inlet valves. The measurements should be at least 3 with an interval of 60 minutes. At the time of each measurement it is necessary to record outdoor and indoor temperature.

1. The required quantities are determined by Equations (1), (2), (4).
2. Further it is necessary to find total heat from all groups spent for losses through enclosing structures and infiltration \( N_{\text{los, inf}}, \text{ kW} \)

\[
N_{\text{poten infil}} = \sum_{k=1}^{m} N_{k}
\]

### 3.1.3 Phase 3. The determination of air volume for infiltration

Knowing the difference of the spent heat between the 2nd and 1st measurement steps, it is possible to calculate the volume of infiltration air. Infiltration will be the same during the whole period of the poultry, and this must be taken into account when calculating the minimum daily ventilation.

1. Amount of heat for infiltration, \( \text{ kW} / \text{h} \):

\[
N_{\text{inf}} = \frac{N_{\text{poten infil}} - N}{n}
\]

2. Amount of infiltration, \( \text{m}^3/\text{h} \).

\[
V = \frac{360000}{C \times P_{\text{outdoor air}} \times T}
\]

where \( C = 1005 \text{ kJ/kg } \cdot ^\circ \text{C} \), air specific heat, \( P_{\text{outdoor air}} \)-solidity of outdoor air, \( \text{kg/m}^3 \), according to an Equation (9):

\[
P_{\text{outdoor air}} = \frac{353}{273 + T_{\text{outdoor air}}}
\]

### 3.2 The determination of heat loss with gas flow

#### 3.2.1 Phase 1. The determination of heat losses through enclosing structures with disconnected extract-and-input ventilation

The conditions of experiment are the same as in the method considered above.

The record of readings of gas flow is necessary at the beginning and at the end of experiment. The readings record of indoor and outdoor temperature is necessary at the beginning and at the end of the experiment. The duration of the experiment is at least 3 hours.
Further sequence is below:

1. The determination of the amount of heat expended on losses through enclosing structures according to the Equation (10), kW:

\[ N = 10.1 \times L, \quad (10) \]

where 10.1 is the lowest heat of gas combustion from Russia; \( L \) is the difference of counter reading, m³.

2. The difference of indoor and outdoor temperature is calculated using, \( T \) °C the following Equation (4).

3. The heat losses through enclosing structures is calculated using \( q_{los} \), kW/°C the following Equation (5).

**3.2.2 Phase 2. The determination of heat losses for infiltration with turned-on ventilation**

The conditions of experiment are the same as in the method considered above.

The record of gas flow readings is necessary at the beginning and at the end of experiment. The readings record of indoor and outdoor temperature is necessary at the beginning and at the end of experiment. The duration of experiment is at least 3 hours.

Knowing the difference of the gas meter readings according to the Equation (11), we determine the amount of total losses through enclosing structures and infiltration, kW:

\[ N_{los, inf.} = 10.1 \times L_{los, inf}. \quad (11) \]

where \( L_{los, inf.} \) is the difference of the gas meter readings of the 2nd stage, m³.

**3.2.3 Phase 3. The determination of air volume for infiltration**

Using Equations (7–9) we determine the amount of air passing through the leakage of structural elements of premises.

Therefore, working with the ventilation system every day it is important to consider all factors affecting on ventilation. At the same time infiltration is hardly the most significant size which influences on operation of ventilation system. It allows to dose with high precision air exchange in poultry-farming premises.

The determination of heat loss amount for infiltration and heat loss through enclosing structures must be made with a certain periodicity. It is connected with the fact that the majority of heat-insulating materials as well as joint sealing means have limited service life. It is recommended to make schedules of change of above-mentioned losses and, in the case of jumps, look for causes using devices which allow to define locally places in premises with the increased heat conductivity or depressurizations of walls joints, side valves or in other places.

**4. Summary**

Therefore, when you daily work with the ventilation system it is important to consider all factors affecting on ventilation. At the same time infiltration is hardly the most significant size which influences on operation of the ventilation system. It allows to dose with high precision air exchange in poultry-farming premises.

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