

Influence of low temperatures on heat balance in easily assembled premises of different types

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Abstract

The purpose of this work was to analyze the thermal balance of easily assembled premises of different types and sizes during the periods of low average daily temperatures. The research was conducted during the winter period of 2020–2021 in the Kyiv region. The used material was easily assembled premises of different types and sizes: easily assembled ones without insulation elements; with elements of warming and premises with deep-litter. In each of the studied premises were kept 400 dairy cows. The studies were performed during two periods: the first period had ambient temperatures from -10 to -14.9 °C and the second one from -15.0 °C and below. In our studies, the average daily temperature (during the ambient temperature from -10 to 14.9 °C) in easily assembled premises with the use of insulation elements was 6.20 and 5.31 °C higher than in premises without insulation and deep-litter. A similar trend was observed during the period of lowering the ambient temperature up to 15 °C and below. Thus, the advantage of the premises without insulation constituted 6.28 °C, and of the premises with deep-litter per 5.84 °C, respectively. It was found that keeping in easy-to-assemble premises with insulation elements, the consumption of free thermal energy from the whole herd during the experimental periods was lower compared to the keeping in a boxing cowshed and a cowshed with deep litter. This is due to the smaller range of fluctuations in the average daily temperature in a room with insulation elements. A similar trend was observed for energy consumption through enclosing structures and for moisture evaporation and, accordingly, total heat consumption. In general, heat deficiency was observed during the keeping of cows in the investigated premises of easily assembled type at negative temperatures (-10–14.9 and -15 °C and above). Accordingly, the thermal balance of the premises was negative. The highest values of heat balance among easily assembled premises in both research periods were observed for keeping in rooms that used insulation elements.

Key words: cows, heat balance, easily assembled premises, low temperatures.

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1. Introduction

New technological solutions have recently been introduced into animal husbandry in Ukraine, such as livestock premises of the easily assembled type (Ruban et al., 2017; Ruban et al., 2020). The territory of Ukraine is within the temperate climate zone, with four distinct seasons. During the winter period, keeping of animals in this type of premises causes certain problems for both animals and farm staff (Broucek et al., 1991; Hempel et al., 2019; Borshch et al., 2020b). However, the conditions for keeping cows in such premises have not been fully studied: there is no data regarding heat balance, no information about the behavior of animals in the cold season, their productivity and resistance to disease (Cao et al., 2017; Borshch et al., 2019; Angrečka et al., 2020).

The technological process of livestock production is based on three main components: high genetic potential of livestock scientifically grounded feeding and watering of

animals, their keeping and care. The most effective output can be obtained only if all the above technological processes work smoothly, rhythmically and without interruption. Any violation of at least one of the components immediately leads to the loss of the planned product (Calamari et al., 2009; Borshch et al., 2021a; Borshch et al., 2021b).

Animal housing conditions are closely intertwined with the state of the microclimate in closed livestock, which is determined by a complex of physical factors (temperature, humidity, air movement, atmospheric pressure, lighting and ionization, industrial noise), gas composition of air (oxygen, carbon dioxide, ammonia, hydrogen sulfide and etc.) and mechanical impurities. The formation of the indoor microclimate depends on the local climate, volumetric planning decisions, the level of air exchange or efficiency of ventilation, heating or cooling, heat-protective properties of enclosing structures, technology of keeping and feeding, manure collection methods, density of animals, etc. (Teye et al., 2008; Rong et al., 2015).

It is known that keeping cattle in cold, damp, poorly ventilated rooms with drafts leads to reduced productivity, increased feed costs per unit of the product, increased morbidity, reduced natural resistance and immunological reactivity of the organism. The quality of livestock products is declined: milk is contaminated, acquires an ammonia odor, its acidity and bacterial contamination increase (Vaculicova et al., 2017; Borshch et al., 2020a). These and other factors can lead to a significant increase in the cost of keeping animals and obtaining products from them. Creating optimal conditions for animals primarily depends on the indoor air temperature of livestock facilities. The only source of heat in livestock facilities are the cows themselves. The use of additional heating in cowsheds is not always rational. Therefore, it is expedient to achieve reduction of heat losses through enclosing designs. Today, the construction of light livestock facilities becomes popular, so the study of thermal proper-

ties of enclosing structures and the development of measures to reduce heat losses is more than relevant.

The purpose of this work was to analyze the thermal balance of easily assembled premises of different types and sizes during the periods of low average daily temperatures.

2. Materials and methods

The research was conducted during the winter period of 2020–2021 in the Kyiv region. The used material was easily assembled premises of different types and sizes: easily assembled ones without insulation elements; with elements of warming and premises with deep-litter (figure 1). In each of the studied premises were kept 400 dairy cows. The studies were performed during two periods: the first period had ambient temperatures from -10 to -14.9 °C and the second one from -15.0 °C and below.

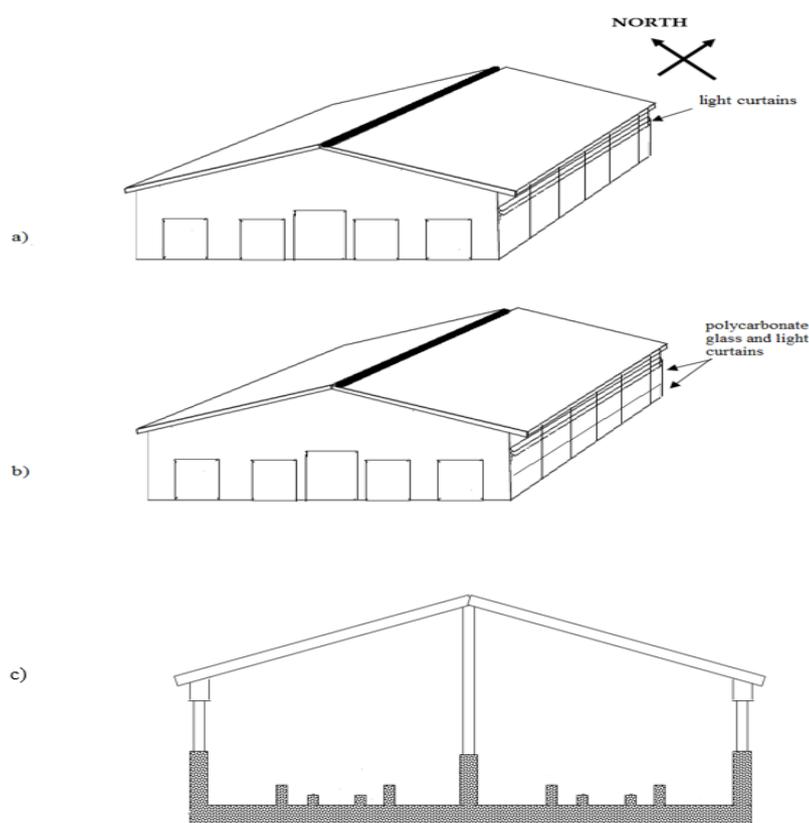


Fig 1. Type of easily assembled premises: a) without insulation elements; b) with elements of warming; c) premises with deep-litter

The average daily air temperature and relative humidity were determined according to the Kyiv Center for Hydrometeorology.

3. Results and discussion

An important element that affects the well-being and comfort of cows is the provision of thermo neutral temperature (from -5 to +25 °C) during all seasons. However, this range is not always possible due to design features and solu-

tions. This is especially true for easily assembled premises during the periods of low temperature loads. In our studies, the average daily temperature (during the ambient temperature -10 to 14.9 °C) in easily assembled premises with the use of insulation elements was per 6.20 and 5.31 °C higher than in rooms without insulation and deep litter (Table 1). A similar trend was observed during the period of lowering the ambient temperature to 15 °C and below. Thus, the advantage of the room without insulation constituted 6.28 °C, and of the room with deep litter per 5.84 °C, respectively.

Table 1

Temperature in easily assembled rooms of various sizes by 400 heads in winter

Indicator	Type of easily assembled premises					
	Without heating elements		With deep litter		With insulation elements	
The average daily ambient temperature, °C	-10– -14.9	-15 and low	-10– -14.9	-15 and low	-10– -14.9	-15 and low
The average daily temperature in the room, °C	-4.17 ± 0.07	-11.34 ± 0.12	-3.28 ± 0.14	-10.90 ± 0.21	2.03 ± 0.06	-5.06 ± 0.09
Parameters of premises (L × W × H), m	138×36×9.54		100×60×8		150×36×10.5	
Volume of the room, m ³	47394.72		48000		56700	

It has been found that that keeping in an easy-to-assemble room with insulation elements, the consumption of free thermal energy from the whole herd during the experimental periods was lower compared to the content in a boxing cowshed and a cowshed with deep litter. This is due to the smaller range of fluctuations in the average daily temperature in a room with insulation elements. A similar trend was observed in terms of energy consumption through en-

closing structures and the evaporation of moisture and, accordingly, the total heat consumption (Table 2).

The results of our researches partially coincide with the data of Polish researchers, who found that the indicators of heat balance in easily assembled premises during low-temperature periods were negative (Herbut, 2013; Angrecka & Herbut, 2015).

Table 2

Heat balance in easily assembled premises of different types and sizes for 400 heads during the periods of low temperatures

Indicator	Type of easily assembled premises					
	Without heating elements		With deep litter		With insulation elements	
The average daily ambient temperature, °C	-10– -14.9	-15 and low	-10– -14.9	-15 and low	-10– -14.9	-15 and low
Free thermal energy from all livestock, kcal/h	449600	449600	449600	449600	449600	449600
Heat consumption for air heating, kcal/h	284731.36	387371.21	277148.45	383525.43	269727.64	376582.58
Heat consumption through enclosing (windows, walls, ceiling, floor, gate), kcal/h	157356.61	207772.82	152729.20	203588.57	151572.55	200741.76
Heat consumption for moisture evaporation, kcal/h	31487.53	44397.41	29753.38	44056.33	29268.74	43827.62
Total heat consumption, kcal/h	473575.50	639541.44	459631.03	631170.33	450568.93	621151.96
Heat balance	-14975.50	-189941.44	-10031.03	-181570.33	-968.93	-171551.96

4. Conclusions

In general, heat deficiency was observed during the keeping of cows in the investigated premises of easily assembled type at negative temperatures (-10–14.9 and -15 °C and above). Accordingly, the heat balance of the premises was negative. The highest values of heat balance among easily assembled rooms during the both experimental periods were observed for keeping in the premises with insulation elements.

Conflict of interest

The authors declare that there is no conflict of interest.

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