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AIR MOVEMENT CHARACTERISTICS INSIDE A COW BARN WITH NATURAL VENTILATION UNDER NO-WIND CONDITIONS IN THE WINTER SEASON

Summary

The paper presents results of air movement observations inside a cow barn (Fermbet construction type) adapted for a loose housing system. The conducted experiments made it possible to determine directions and characteristics of ventilated air flux in selected areas of the building as well as mark out areas where air stood still. In addition, the study offers recommendations regarding effective ventilation systems in the occupied zone under no-wind conditions.

Keywords: cow barn, no-wind conditions, natural ventilation, air movement

INTRODUCTION

The main role of an effective barn ventilation system is to provide fresh air into the occupied zone and protect cows from thermal stress or excessive draughts, irrespective of outside weather conditions. Thermal conditions inside a barn, which do not ensure sufficient cooling in the summer season and do not protect animals from draughts in winter, negatively impact cow welfare, thus impairing the final economic result [Romaniuk 2004, Lewandowski 2008].

The natural ventilation system inside a barn generally consists of the following components: side curtain walls facilitating air flow into the building, ridge skylights, whose additional role is to remove used air from the building, or ridge vents; another important element is a suitable pitch of the roof facilitating air circulation [Morcing 1999].

Managing air circulation in barns with side curtain walls wide open is particularly difficult due to changeable wind direction and speed, large number of ventilation openings, obstacles encountered by air flux, such as partition walls, construction pillars, etc., increased evaporation from animal body surface, or finally large cubic capacity of the barn, which affects air movement inside the building [Chodanowicz et al. 2009].

Appropriate positioning of side curtain walls, aided by ventilation fans, may be of justified and key importance during the so-called no-wind conditions, particularly at heat waves when animals are exposed to thermal stress. In such case, an effective ventilation system helps to decrease critical temperature of animals, which positively affects productivity [Kaczor 2007, Daniel 2008].

The objective of the study was to determine air movement characteristics in a loose cattle-housing barn with natural ventilation at no-wind conditions in the winter season. Taking into account temperature differences between outside and inside air, this time of the year should be conducive to natural ventilation systems.

MATERIALS AND METHODS

Field studies were conducted from November 2008 till February 2009 in a Fermbet-type barn for 176 milk cows at a cattle farm belonging to the Institute of Zootechnology at the University of Agriculture (Zakład Doświadczalny Instytutu Zootechniki w Balicach) situated in the village of Kobylany (fig. 1).

Figure 1. Satellite view of the cow barn in Kobylany

The building dimensions are 67.13 m × 24.55 m; additionally, there are two extensions in the south-eastern wall. Construction characteristics: reinforced concrete Fermbet-type structure, 3 aisles with pillars every 6.0 m situated along the building. The cross-section is distinctive for its ceiling of varying heights. The knee wall of the higher part is equipped with ventilation openings. The main entrance doors are situated on the south-eastern and south-western sides of the building.

The middle part of the barn is covered with a double-pitched roof with the pitch of 45°. The external aisles are covered with a flat roof with the pitch of 4°. The extensions are covered with a mono-pitched roof connected with the main roof of the barn at the eaves, roof pitch: 12°.

The ventilation system of the building consisted of side curtain walls on longitudinal walls, which served as inlet openings, and a ridge vent.

Field research included observation of movement of smoke produced by smoke generators, with curtain walls and entrance doors wide open, in six characteristic points of the building. Smoke generator distribution has been presented in fig. 2.

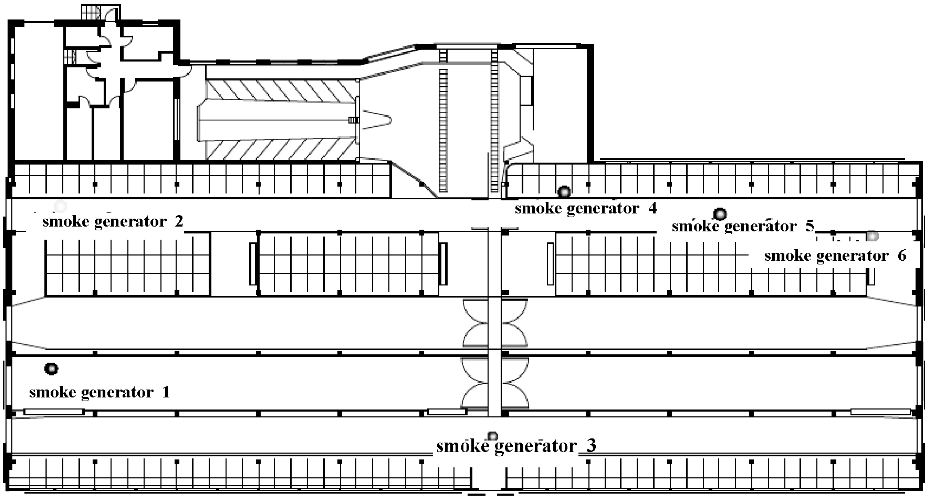

Figure 2. The distribution of smoke generators in six characteristic points of the building during the experiment – an overview

All the results of smoke movement observations have been documented through photographs, video recordings, and short sketches with written comments. Based on these records, experiment outcomes have been analyzed, which led to the creation of diagrams of air movement inside the building in vertical and horizontal sections.

RESULTS

Under no-wind conditions and with curtain walls and entrance doors wide open (wind velocity lower than 0.5 $m \cdot s^{-1}$), the air moved along longitudinal corridors of the barn (marked in red and purple). In the vicinity of stalls and the manure corridor, certain smoke turbulences appeared (marked in blue and navy blue) (figure 3 and 4). At the north-western wall, some of the smoke (marked in yellow) moved across the cow barn between the open curtain walls and got out of the building through openings in the gable wall (figure 3 and 4). The observed air movement occurred most of all above the occupied zone (just below the ceiling), which points to the lack of suitable barn ventilation system.

The vertical air movement was momentarily very rapid. In most cases, smoke produced by a smoke generator moved quickly upwards towards the roof ridge and outlet openings above the ceiling. In this zone, certain smoke turbulences could be observed and afterwards the smoke escaped outside the barn (figure 4 and 5).

However, at times the air swelled inside the building instead of escaping outside and created standstill zones.

Based on the analysis of observation results, it was possible to determine the localization of such zones (fig. 6) with a recommendation to install fans (air mixers) in these particular spots equipped with an inclination adjustment facility. Their role would be to transfer the used air horizontally or vertically towards the open doors and curtains at no-wind conditions.

Figure 3. The movement of smoke from smoke generators in six characteristic points of the main hall with curtain walls wide open – an overview

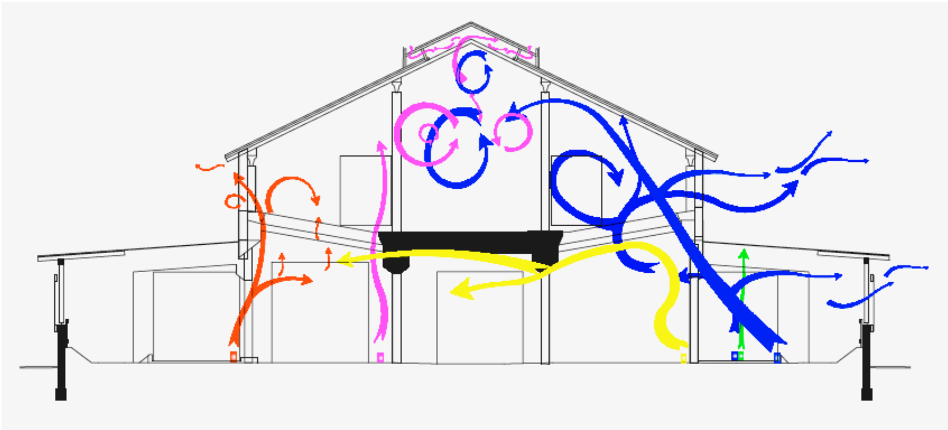

Figure 4. The movement of smoke from smoke generators in six characteristic points of the main hall with curtain walls wide open – a cross-section

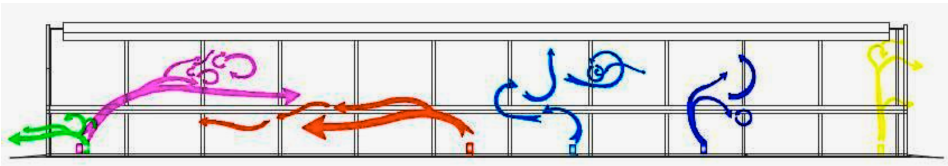

Figure 5. The movement of smoke from smoke generators in six characteristic points of the main hall with curtain walls wide open – a vertical section

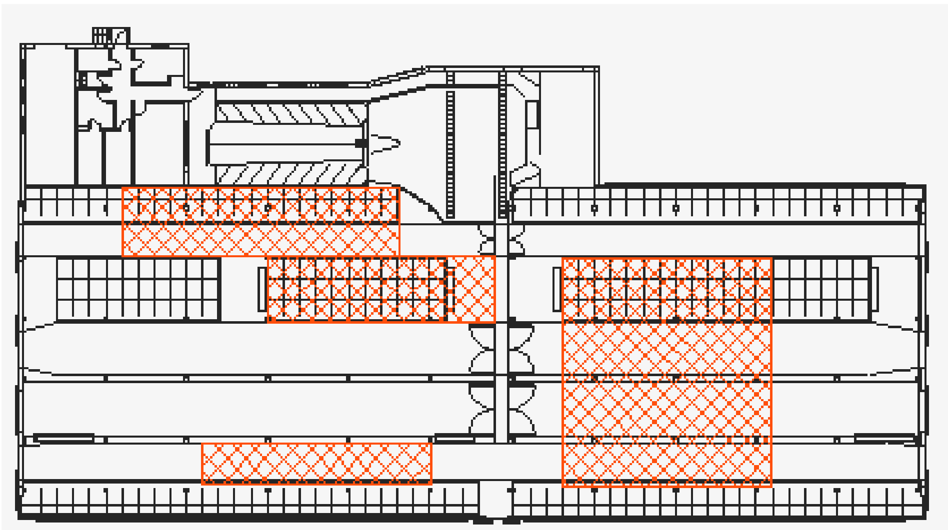

Figure 6. An overview of the cow barn with zones where used air stood still (marked in red)

CONCLUSIONS

Based on the result analysis, we can conclude that:

1. In the researched period, under no-wind conditions, the natural ventilation of the barn did not work effectively, which contributed to the deterioration of microclimatic conditions in the occupied zone.
2. In the researched period, the ridge vent and outlet openings in the roof did not work effectively. The air above the ceiling, despite remaining in continuous movement, did not fully escape outside through the opening in the ridge.
3. The openings in side and gable walls, both at the floor and roof level, played a significant role in an air exchange processes.
4. It is possible that, under no-wind conditions (especially in the summer season), the poor ventilation system may contribute to a sudden and dangerous increase of carbon dioxide, hydrogen sulphide and ammonia concentration; it may be also unable to provide sufficient cooling, which will negatively impact the final economic result.
5. Since it was possible to determine zones where air stood still, the recommendation is to introduce an additional active cooling system in the summer with the help of fans installed over animal stalls.

REFERENCES

Chodanowicz B., Woliński J., Wolińska J. 2009. "Wentylacja w oborach bez izolacji termicznej". *Inżynieria Rolnicza*. 6 (115). pp. 17-21.

Daniel Z. 2008. "Wpływ mikroklimatu obory na mleczność krów". *Inżynieria Rolnicza*. 9 (107). pp. 67-73.

Kaczor A. 2007. *Wiadomości Rolnicze – Polska*. 1/2007(29), Instytut Zootechniki – Państwowy Instytut Badawczy w Krakowie.

Lewandowski E. 2008, *Farmer* 02/2008.

Morsing S., Zhang G., Strom J.S. 1999. "Naturlig ventilation af stalde: Dimensionering". *Gron Viden* no 13.

Romaniuk W. 2004. " Systemy utrzymania krów mlecznych" . Materiały szkoleniowe.

Systemy utrzymania bydła., IBMER, Warszawa.

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