CREATION OF MICROCLIMATE IN BUILDINGS FOR LIVESTOCK BREEDING IN CONDITIONS OF CHANGING CLIMATE IN SLOVAKIA

JAROSLAV ŠOTTNÍK
National Agricultural and Food Centre - Research Institute for Animal Production Nitra, Hlohovecká 2, 951 41 Lužianky, Slovakia

At present, in the process of microclimate creation in buildings for animal breeding it is vital to consider variations in climate conditions in Slovakia. There are big differences between summer and winter seasons, up to 50-60 K. In these climatic conditions there are high demands on ventilation systems and reduction technologies in order to reduce the negative impact of physiologically abnormal environment on the production, and reproduction parameters, on animal health and the exclusion of their mortality. In the article the requirements for airflow, which is an essential means of heat and pollutants removal from animal body and breeding area with an efficient ventilation system in building, are defined. Besides this, the efficient reduction technology has to be added in order to prevent and reduce the impact of the increased air temperature according to set criteria for different breeds of livestock. Systems under exploitation as well as the options of reduction technologies involved in different range in the process of heat reduction in building were analyzed. Very timely are also current requirements on the development of new trends - their theoretical handling and verification in modern breeding practice.

Keywords: microclimate in buildings, provision of technological facilities, ventilation systems, reduction measures

The issue of microclimate creation in Slovakia

The current livestock breeding, if it is to be implemented in the required quality as a result of efficient production, requires optimal breeding conditions, environment including microclimate and welfare. When considering livestock, we are talking about the creation of conditions in the whole complex of the criteria for different species and categories of animals.

The progressive farming practice daily convinces us about the necessity to respect physiologically substantiated requirements and demands of various types and categories of livestock for optimal parameters of indoor climate in livestock buildings.

The issue of the microclimate creation in Slovakia has a relatively large range of conditions in different regions and different seasons.

For creating of optimal microclimate in livestock building climate of the region (the country), continental climate, is crucial. We understand the climate as a long-term weather regime with all its peculiarities, varieties and variability, through which it manifests itself in that place. When analyzing climate of the Slovak Republic, we base it on the geographical position of its territory in Europe, or in Central Europe and the relevant belonging to climate zone and area. The territory of Slovakia belongs, in terms of global climate classification, to northern temperate climatic zone with regular changes of four seasons and variable weather, with a relatively even distribution of rainfall throughout the year. The climate in Slovakia is affected by the prevailing westerly airflow in temperate latitudes between permanent pressure systems, the Azores anticyclone and the Icelandic depression. The western airflow brings from the Atlantic moist ocean air of temperate latitudes. It moderates temperature amplitude during the day and year and it brings atmospheric precipitation. Under suitable synoptic conditions it may influence the weather in Central Europe.

Technological and breeding conditions for the processes of microclimate creation

Technical and breeding conditions are an integral part of farming systems and their different parametric solutions for different species and categories of animals. Their big differentiation directly defines and determines the requirements in the process of specification to optimize microclimate elements. Differentiated conditions of climate creation for different types and categories of farm animals are in principle divided into bedding and without bedding operations. Bedding operations, if they are properly run, with the provision of the required amount of bedding and its regular supply, if it is timely exchanged together with manure removal, contribute to microclimate improvement - thermal comfort, concentration reduction - reduction of harmful gases. Currently there is the tendency to use the bedding as a source of biomass for heating.

In contrast, the systems without bedding increase the demands on ventilation performance, the need for heat, usually with younger animals whose physiological requirements are closely related to preservation of their basic life functions and survival, healthy growth in the future. For the both technological operations it is necessary to ensure and provide the required storage capacity for farmyard manure and liquid manure and its technological equipment. In compliance with the EU's criteria storage is currently required for six months.

Building solutions for climate proofing in buildings

The principle is that a decisive factor for the quality of microclimate is in the first place the building itself, its thermal and insulation characteristics and the composition of suitable materials and their dimensions. In terms of operating optimum, generally useful are objects with a balanced heat balance in winter, which ensures the stability of microclimate parameters of the internal environment in the summer and in transitional periods. The decisive factor, which in modern buildings is not always appreciated, is the heat accumulation in construction systems, as from it claims for compensation are derived, i.e. modification of external microclimate elements and their time course, or their shift in the inner course different for winter and summer operation period and their mutual interconnection. If the required building and technological criteria on the environment or physiological and production aspects of animal husbandry are not met, they have equally big economic impact on the pluses or minuses.

Thermal insulation in livestock buildings

Thermal insulation in buildings is an essential factor for achieving thermal comfort even in buildings for animal husbandry. When designing and constructing buildings for animals, different requirements of various livestock types and categories of have to be respected.

Differentiated requirements on the microclimate parameters are given by the relevant prescriptive standards.

What is important is to determine the acceptable tolerance in the construction and technological solutions and possible permissible tolerance towards physiological requirements of organisms. They should not act negatively towards the set norm for maintaining comfort criteria - parameters that will ensure the desired production. In principle, there should not generate such states of microclimate environment which would cause bodily harm or which have such a course that they would cause mortality of young animals, or animals included in production holdings.

Thermally uninsulated buildings

In modern animal husbandry with the intention of saving investment resources the current practice both abroad and in Slovakia successfully uses either thermally uninsulated building or open buildings as well.

Equipment and design of such building with specially designed, isolated supply and ventilation systems and their regulatory elements has to be adjusted to the above mentioned specific focus. The principle of optimizing the operation of such buildings is that in the winter there has to be regulated operation of ventilation, but not to its maximum closure - "sealing". On the contrary, in summer the ventilation has to be at its maximum possible opening, but draft has to be avoided as it is equally undesirable and harmful also in the animal husbandry. Buildings of that type are used mainly in cattle breeding which requires ensured and balanced nutrition, optimal diet. At present the design of such buildings has advanced towards their improvement in different seasons, especially of those elements which ensure regulation in winter and summer, space construction of open buildings.

Technical equipment for improvement of the microclimate creation

The basis for checking of microclimate parameters is their focused operation through the course of the observed period what has to be confirmed by the results of comparative tests with their intended - design definition range. For the animal husbandry it is important to monitor acceptable tolerances in the building and technology solutions as well as options of permissible tolerance against physiological and production criteria - the body requirements.

Technical factors to optimize microclimate creation

The function of the ventilation system

has to be designed and implemented with varying ventilation performance,

- Max. in summer,
- Min. in winter,

with continuous regulation or, at least, with a stepped control during the whole year operation. At present it seems to be vital to ensure minimum ventilation in the winter and increase its required performance in the transitional periods up to its maximum in the summer.

Ventilation performance

In cattle breeding

The required ventilation performance 400 $m^3.h^{-1}$ provides basic orientation which is set at the correction for the annual utility 5000 kg. ks^{-1}. According to foreign sources it is up to twice as much 850 $m^3.h^{-1}$ and more. To cool the given amount of the air with the capacity from 200 to 300 animals in the building is already a demanding technical and economic problem.

In hog breeding

For this kind of animals the requirements on ventilation performance are rather differentiated according to the source, regulation. Abroad the requirements are significantly higher than in the Slovak standards. Ventilation performance during the summer period is processed according to the draft of standard DIN 18 910. Generally, there are two levels of ventilation performance in compliance with summer temperature range (STR) - I or II {I) < 261) °C , II) > 261) °C} and specific housing conditions for the second STR. Adverse conditions increase the level of ventilation performance to a higher range, or increased ventilation efficiency.

Ventilation performance is in accordance with ASAE Standard 1987, 1997

Maximum summer ventilation performance:

- for sows with piglets it is 849.6 /$m^3.ks^{-1}.h^{-1}$/;
- for other categories of pigs it is from 61.2 to 169.2 /$m^3.ks^{-1}.h^{-1}$/;
- for gilts sows and boars it is from 205.2 to 424.8 /$m^3.ks^{-1}.h^{-1}$/ .

As to Slovak climate conditions the given summer maximum values of the ventilation performance are unreasonably high.

Conversion factor: 1 ($m^3.ks^{-1}.s^{-1}$) .10-2 = 36 /$m^3.ks^{-1}.h^{-1}$/

In Sweden, the requirements on ventilation in breeding sows are up to 680 $m^3.h^{-1}$ in the summer, the minimum ventilation required is 1/10, i.e. 68,2 $m^3.h^{-1}$ (Halverson, Marlene). In Mechanical Ventilation for Pig Housing Larry D. Jacobson recommends ventilation performance by category of pigs equally high - max. ventilation performance for sows in the range up to 850 $m^3.h^{-1}$, for those which did not start fattening regime 59.5 $m^3.h^{-1}$, for those in fattening regime - from 127.5 to 204 $m^3.h^{-1}$ $m^3.h^{-1}$, fattening, sows without bedding 255 $m^3.h^{-1}$, for boars up to 510 $m^3.h^{-1}$.

In poultry breeding - fattening broilers

Recommended ventilation performance for poultry broilers by Danielle Jacques (2002) is between 0.02 and 7.6 $m^3.h^{-1}.ks^{-1}$.

According to Joseph M. Zulovich the ventilation performance is for:

broiler	hen
8,5 m3 $ks^{-1}.h^{-1}$.	10,2 m^3 $ks^{-1}.h^{-1}$.

Defra recommends maximum ventilation performance for 2 kg broiler 9,7 $m^3.h^{-1}$ Harry Huffman states as a minimum dimension for fans 0,06 –10,2 $m^3.ks^{-1}.h^{-1}$.

Airflow

Airflow is basic dynamic parameter in the system of housing objects and for establishing secondary functions within a ventilated area and its technological limitations in breeding system.

Roles of airflow in the space

Essential tasks of the airflow are:

- to transport the needed oxygen from outside into the breathing space and take stuffy CO^2 out into the environment,
- to release heat, water vapor and noxious gases distracted from the bodies and divert them from the breeding area,
- to divert the remaining heat and metabolic substances in space in compliance with the criteria for keeping the microclimate (temperature, relative air humidity, concentration of harmful gases) in the occupied zone and in the breathing zone.

Heat and substance load must be transported without apparent draft.

In cattle breeding there is the general criterion for airflow defined in relation to the ventilation system, whereas the ventilation systems must not allow negative effect of draft. The airflow in cattle housing can be dimensioned in the range between 0.5 $m.s^{-1}$ to $m.s^{-1}$.

In cattle breeding

It is possible to solve the reduction by means of increased airflow in lying and feeding area if the level of airflow is min around 1 $m.s^{-1}$, currently the detected level of the airflow is usually lower. The airflow for the environment with increased temperatures set through the calculation allows even higher values from 1.75 to 2 $m.s^{-1}$, for example, for the temperature 30 °C is the calculated flow 1.75 $m.s^{-1}$. Attaining of this state needs to be encouraged both through technology and investment, since the airflow has a significant compensatory effect during a summer temperature extreme /Šottník, 2001/.

In hog breeding the desired values for the airflow are more differentiated and there are distinguished three limit values for different categories of pigs, depending on the air temperature: for min. 0.05-0.1 $m.s^{-1}$, for optimum 0.2-0.3 $m.s^{-1}$, for max. 0,3-0,5-2 $m.s^{-1}$.

In poultry breeding - fattening broilers

In relation to the desired reduction of the heat load the current approach to the dimension of airflow has to be reassessed as far as its criteria the recommended airflow is significantly higher. In order to improve the heat dissipation from bodies and building premises it is necessary to increase the airflow above the occupied zone to the level of 0.75-1 $m.s^{-1}$ and more if the air temperature is extremely high.

Application of the airflow according to the normative indicators

The principle of determining the airflow v_i is equally valid according to the air temperature, and namely for $\mathbf{t_n}$, $\mathbf{t_i}$ and for **t** - internal air temperature at which the air flow is assessed.

Airflow is an essential factor in establishing ventilation system suitable for circulatory airflow ratios. Furthermore, it is important in determining the secondary function of airflow within the ventilated area, such as the technological limitations of space, e. g. in a stall, a cage and so on. The role of the airflow in the area is to remove the excess heat. Heat and substance load must be transported without any apparent drafts.

Airflow in the functional elements

Airflow in the functional elements as a basic calculation parameter is microclimatic differentiated and it depends on the specific microclimatic - circulation conditions.

Supply and airflow

Increased attention in the context of proposals for the modernization of animal housing should be paid to construction and technical solutions of airflow inlet, to its limited flow according to the season, to the type and category of farmed animals and to the need to alter the function of the ventilation system while respecting the criterion for the compensation by increased airflow. At increased temperatures, the desired airflow is in the range from 0.5 -1 $m.s^{-1}$ to a maximum of 2 $m.s^{-1}$ (in the summer extremes of up to 3 $m.s^{-1}$, according to the foreign resources), which are determined by the type and category of animals kept and temperature conditions. The attention should also be paid to the airflow as to a key indicator of the function of the ventilation system, especially in the application of natural ventilation system, whose function can be tested through the analysis of airflow in the functional elements of the supply and removal of the air ventilation slits, windows, side doors and front gates, and so on.

Systems and components reducing the heat load in stables

Housing - stall, hall and their thermal and insulation properties, passive components, shielding run - overlap among feeding areas

The operational use of the building, its occupancy and its optimization from the viewpoint of thermal load, reducing the risk of stress state. Transitional reduction of operation - use of housing capacity.

The ventilation system - its performance, regulatory system and the efficient use of the airflow speed in the heat dissipation system - harmful substances from bodies and farming environment, tunnel ventilation system

Additional - sliding ventilation to increase the reduction of stress in the zone occupied by the animals through the increased airflow /e.g. Stir Fan 36 " /

Adiabatic - evaporative system and its components of the air cooling

Spraying - spraying the space where the animals live - cattle, pigs, spraying constructions of the housing.

Aerosol - pressure systems and their technical combinations.

The cooling system PAD - pads, walls, columns and their combinations with the spraying elements, ventilation units.

Rotation systems of aerosol scattering, pressure spraying, jet scattering and their combinations with fans for scattering into the space

Sliding ventilation combined with the aerosol scattering of spraying.

Evaporative cooling units - tower system cooling.

Cumulative assessment of the process of heat reduction in the current conditions of animal husbandry under the conditions of continental climate

Process of the heat load reduction in buildings for animal husbandry has several dimensions within the optimization of breeding environment. It is focused on reducing the impact of increased and high air temperatures on performance parameters, indicators of reproduction and health conditions. In principle, the main point is to avoid the heat stress, hyperthermia and to exclude dying of animals what has been often found even in our conditions; this has been documented mainly in breeding poultry (broilers), in breeding chickens under the conditions of factory farming. These were caused generally by abnormal environment of the microclimate, especially at the end of the fattening period. At that time, there cumulate factors of excessive occupation of the premises and behaviour of farmed

chickens, their high weight and excessive density on the housing space. Under these conditions there was insufficient removal of heat from the body to the environment and from the breeding areas into the external environment. The reasons are to be found in wrongly planned housing, in ventilation systems.

Being aware of the above mentioned it should be noted that some construction and technological solutions - "standard conditions" are not able to modify the microclimate according to the newly defined criteria for different species and categories of animals. The whole process has to be understood in connection with the buildings dimensioning, their thermal and insulation properties, the intensity of ventilation and heat reduction technology in the emerging climate change.

Particularly under the conditions of frequently occurring extreme temperature conditions there arise such states which become the subject of requirements on heat reduction through up to now unconventional procedures and technical solutions in animal husbandry.

Defining extreme temperature conditions and their impact on livestock

During the previous and current summer periods there were recorded very extreme temperature conditions. The temperature conditions clearly caused heat stress with all the negative consequences on livestock farming. This occurs under conditions where the body heat production exceeds its losses. The effects of heat stress are defined by both the change in physiological functions of the body, negative impacts on its production and reproductive functions.

Dairy cattle and beef cattle is the basis for determining the boundaries effect of the temperature 25 °C. For cows with a good level of production the significant decrease starts from the temperature of 25 °C and above, and 50 % Rv.

To check the process some indexes have been proposed:

THI Thermo Humidity Index, based on this index DI - Discomfort Index has been factually defined

THI = 0,6 t_{db} + 0,4 t_{wb} - is according to R. S. Gates, et al. (1995), temperature and humidity index - TVI = 0,6t_s + 0,4t_m

DI - Discomfort Index - designed by GARGILL and STEWARD is calculated as follows: THI = = 0,72 (t_{db}+ t_{wb}) + 40,6

New technological solutions for microclimate creation

It is envisaged that in future it will be required to reconstruct also stables - building housings with almost zero energy use. This will be contributed by an efficient design "Solar stable, house".

CONCLUSION

Currently in the process of microclimate creation in buildings for animal husbandry there is the requirement to take into account variations in climate conditions in Slovakia. This means a significant differentiation in different regions, seasons and in year-of-year routing - are large fluctuations in climatic factors. Fundamental differences are observed both in summer and in winter, up to 50-60K, which means the temperatures of 20 (-25) °C in winter and 30 (+ 35) °C in the summer (maximum 40 °C). In the design - implementation under the climatic conditions there are high demands on the ventilation systems and reduction devices to reduce negative consequences of abnormal physiological environment on the production, reproductive parameters and the state of health of animal husbandry, or on elimination of their mortality. In the paper the requirements for airflow, which is an essential means of heat and harmful substances removal from the body and the breeding area, with an efficient ventilation system animal housing is defined. To this efficient reduction technology must be assigned with the aim to prevent and reduce the impact of increased air temperatures, according to the criteria for each livestock species. The used systems were analyzed and possibilities of reduction techniques differently involved in the process of the heat reduction in the building space. Very timely are also current requirements on the development of new trends - their theoretical handling and verification in modern breeding practice.

In the new technological solutions for microclimate creation there will be required also reconstruction of stables - building housings with almost zero energy use. This will be contributed by an efficient design "Solar stable, house". Design of buildings with passive cooling and ventilation".

Likewise, final constructions of buildings will have to ensure also the requirements on environmental protection.

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