The Calculation of Economic Heat Protection and Energy Efficiency of the System of External and Internal Protections in Stock and Poultry Buildings

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Abstract--- *The article discusses ways to improve the technical and economic efficiency of the use of the heliobiological heating system, including the use of rational heat occupied local materials with a thickness of 0.025, 0.0.35, 0.05 m of external and internal fences to ensure optimal energy efficiency in stock and poultry buildings.*

Keywords--- *Heat Transfer, Livestock and Poultry Facilities, External and Internal Fences, Thermal Protection.*

I. INTRODUCTION

The microclimate of closed stock and poultry buildings is formed in a special way. It depends on a large number of factors, including the climatic conditions of a given area, the radiation thermal and humidity conditions of the building envelope, the level of air exchange, and the solar bio-energy heating, sewerage and lighting systems. Also building materials should be low heat conductive, i.e. have little ability to conduct heat through the entire thickness from one surface with higher temperature to another surface with lower temperature.

The role of the optimal microclimate is especially growing in the context of the widespread implementation of intensive methods of animals keeping and young animals raising (reducing of the area of buildings per animal, tiered poultry placement, year-round keeping without walking content, increase in the concentration of production, etc.). Under these conditions, there are increasing requirements to ensure uniformity of temperature and humidity fields throughout the animals' placement zone, accuracy of regulation of air parameters, reduction of energy resource losses due to more complete solar bioenergy heat, and environmental protection from pollution by ventilation emissions [1,2].

II. THE MAIN FINDINGS AND RESULTS

In order to adopt the most optimal option, reduction of heat losses through external walls and prevention of condensation of water vapour on walls, possible heat losses through external fences of trusses are determined depending on change of heat transfer resistance at constant difference of internal and external air temperatures, as well as change of cost of additional capital costs for increase of thermal resistance. According to [1 - 4], enclosing

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structures are selected according to the economically feasible heat transfer resistance of that design option, which ensures the lowest reduced costs, but no less than the required value. The calculated heat transfer resistance R_0^{mp} reflects only hygiene requirements, significantly lower (approximately 1.5: 3 times) the heat transfer resistance of the external and internal enclosing structures used in stock and poultry buildings provides savings in fuel and energy resources. It must be significantly increased by introducing correction factors that take into account the conditions of the regions of construction, space-planning and design solutions in stock and poultry buildings.

Instruments and equipment were used during field observation. The temperature was measured with copper-constant thermocouples, which were attached with plasticine to the internal and external surfaces of the test enclosure. The average temperature values obtained during the observation period are rounded to 0.1^{0}C. Thermocouples and thermometers via multipoint switch PTI-M were connected to electronic voltmeter B7-21A, by means of which thermo-emf of each sensor were determined. Relative humidity was determined by a BM-4M psychrometer. A laser contact-free optical pyrometer RaungerMX Raytek (Germany) was used to investigate temperature fields. Preliminary thermal imaging examination of panel surface is carried out to select optimal arrangement of sensors taking into account structural features of the investigated enclosure. At the same time the enclosing structure is subjected to thermal impact and temperature field is removed with the help of pyrometer PSI-14. This makes it possible to detect thermally homogeneous zones and thermal conductive inclusions disposition, their configuration and dimensions.

Results of natural thermal engineering investigations of thermal protection properties of non-transparent external fences when considering two options: blind wall "A" and ventilated wall panel "B."

In the first one, the lump sum costs for 1 m^2 panel are current (costs for solar bioenergy heating) - 1250 sums per 1m^2. In the second - respectively 960 sum. According to the current methodology, we choose the second option with lower costs. The second decision of the structural element is made advantageous as an option also with lower reduced costs, i.e., the lowest.

Increasing the thermal protection of structural elements <<A>> and << B >>, we get one result. Based on the general objective of increasing thermal protection, livestock and poultry premises at a minimum cost, there is no need to switch to the second version of the structural element <<A>>, therefore, when considering the element << B >> it is enough to accept the second option. By comparing the costs and results, for each sum of additional one-time costs in the <<A>> variant, we reduce the operating costs for heating by 1900 sums per and << B >> 1 m^2 panel, while in the variant << B >> respectively 1600 sum.

Thus, the formula for the given costs, as well as the data, the methodological approach to assessing the increase in thermal protection, the livestock and poultry premises and structures are incorrect. A comprehensive approach to the appointment of cost-effective thermal protection of the system of external and internal fencing, stock and poultry buildings and various structures (fruit and vegetable storages, equal or mixed heliogreenhouses, etc.) should be ensured, taking into account their orientation, aspect ratio and blocking of several buildings or block sections in a row for optimizing their heat storage capacity [5].

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The prices of fuel and energy resources influence the choice of effective designs at the given costs. Their planned change in innovative technology with the existing choice of cost-effective designs. As a result, the ratio of lump-sum and current costs will change in the formula of the presented costs. In view of the change in prices, a situation arises when newly developed designs are theoretically already ineffective.

Despite the fact that [6] regulates the use of wholesale prices in the formula of reduced costs, in the practice of design they use the cost of industrial structures, which changes the result of choosing effective structural solutions. This is due to the fact that the price takes into account the operational qualities of structures (increased heat transfer resistance), as a result, the above costs do not decrease by the amount of saved operating costs, since most of them go to the wholesale price of the structure.

In our opinion, the use of wholesale prices is more correct, since the stimulation of construction enterprises in the production of warmer structures should go within the framework of the national economic efficiency of their application. As calculations show, the influence of the mentioned factors of the effectiveness of heat protection measures E should be eliminated by the maximum reduction in operating costs for heating for each additional one-time costs

$$E = \frac{\Delta M}{\Delta C}.$$

From table 1 it is seen that the considered factors do not affect the determination of the effectiveness of various structures of the external and internal covered by the proposed method, which allows us to develop a stable approach to the choice of design solutions. The effectiveness of heat protection measures and the sequence of their implementation must be evaluated taking into account the one-time and current costs of the overall heat balance in stock and poultry buildings. For this, ΔM should be determined taking into account the influence of the specific weight of the external and internal fences in the heat balance in stock and poultry buildings, ΔC - on 1 m^2 panel.

Let's consider the data on the effectiveness of thermal protection in stock and poultry buildings.

In a number of farms of the Republic of Uzbekistan, during the construction of livestock buildings, the panels from the reed and guza-paya shelves were widely used as wall material, and the wall thickness of the premises from these materials did not exceed, as a rule, 2.5-3 sm.

When the temperature of the outside air drops to -8-10 ^{0}C, the walls of such rooms are covered by continuous thermal adlam, and the temperature of the indoor air is sometimes understood to be 0 ^{0}C. Meanwhile, in many regions of the republic in winter, the temperature of the air often drops to -15 ^{0}C or more, which causes a sharp drop in air temperature inside the livestock buildings.

Equally important are the formation of the microclimate in rooms for young animals, the heat-shielding properties of ceiling ceilings. It is known that due to vertical convection air flows, the temperature of the latter at the stream is higher than in the zone of young animals. With low heat-shielding properties of the ceiling and insufficient insulation, there is a large heat leak through the ceiling. Therefore, in severe weather conditions in the north, the Republic must be done in young livestock buildings for young animals, maternity wards, dispensaries. In calf houses

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with attic re-roofing, the thickness of the insulation-filling on the ceiling should be at least 20 cm (reed layer, soil mortar layer, narrow soil layer and soman clay mortar layer). We have developed a combined heliogreenhouses of cattle-breeding premises, windows and gates should be insulated so that heat loss through them would be minimal. This is achieved by arranging wall cladding with clay-plated mortars and a recessed double-skinned gate. At the outer gate, it is necessary to arrange tanbours, and from the inside, air-thermal zeves.

It should be noted that the main factor shaping the microclimate in livestock buildings is the need to constantly monitor and automatically regulate the state of the air environment in order to eliminate or weaken negative factors and, in turn, strengthen or create new positive air properties.

The norms of temperature and relative humidity in rooms for animals and poultry are shown in table 1.

Table 1: Norms of Temperature and Relative Humidity in Rooms for Animals and Poultry

Premises	Temperature (degree)	Relative humidity (%)
Cowhouses Under tethered keeping Without tethered keeping	 8-10 5-8	 65-70 65-70
Maternity departments and preventive clinics	15-18	70
Calf-houses	12-16	65-70
Premises for young growth and store-cattle	10-12	70
Temporary covered and heated enclosures	10-12	75
Stables	4-6	80
Poultry-houses for adult hens; Under floor keeping Under coop keeping	 12-16 16-18	 65-70 70
Young growth chickens in age: From 1 to 30 days under brooders etc. From 31 to 60 days under brooders etc.	 20-25 20-22	 60-70 60-70

The norms of technological design of livestock and poultry farms regulate the speed of air movement in the corresponding premises in winter within 0.2-0.5 m / s. In rooms for young animals, lower air speeds are recommended.

Standards of air velocity in rooms for animals and poultry are shown in table 2.

Table 2: Standards for the Speed of Air Movement in Rooms for Animals

Premises	Speed of air movement, m/s	
	During cold season	During summer
Cowhouses and premises for young growth	0,5	1,0
Maternity departments with preventive clinics, calf-houses, milk rooms	0,3	0,5
Premises for adult hens and turkeys	0,3	0,6
Premises for adult ducks	0,5	0,8
Premises for young growth chickens, turkeys and ducks	0,2-0,3	0,5

As you can see, the local ones are the most effective - clay-coated outer and inner panels on flexible connections 1.5 cm thick livestock and poultry premises on heliobioenergy fishing. The heat transfer resistance of the external

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fences, regardless of the installation of solar receivers on them, is calculated taking into account the compactness of space-planning decisions using the shape factor in stock and poultry buildings or structures [7]

$$R_0 = \frac{(t_B - t_H) \cdot n \cdot A \cdot B}{4C \cdot \chi \cdot l \cdot q_c}$$

where

$$q_c = 45{,}9 + 223{,}3 \frac{2(A+B)}{A \cdot B},$$

under m=9, t_H = - 10° C;

$$q_c = 59{,}3 + 167{,}8 \frac{2(A+B)}{A \cdot B},$$

under m=5, t_H = - 10° C, m=9, t_H = - 8° C.

Since the specific perimeter of the external walls as the ratio of their perimeter to the total area of livestock and poultry premises is a special case of the space-planning coefficient and is applicable.

The effectiveness of the designs of external fences, taking into account the influence of various factors (on 1m^2 structure)

Panel design	Thickness, sm	Loss of operating costs, sum on 10^3 extra charge with a glance			
		Manufacturing cost of production on 1 m^2	List prices 1 m^2	Twice increase in price on fuel and energy resources	Solar-biogas heat
Single-layer on clay-adobe bricked $\gamma = 900\, kg/m^3$	1,0 1,5 2,0	- 1,18* 1,07	- 1,87* 1,71	- 2,35* 2,14	- 0,69 0,89
Clay layered On firm lacing On flexible lacing	1,5 1,5 2,0 2,5	2,12* 1,58 3,05* 2,6	1,65* 1,01 1,28* 1,26	5,45* 3,17 10,1* 5,21	2,18 1,22 2,19 3,1

* Cost-effective design of external fences.

Consequently, within the specific perimeter of the external walls of buildings and structures 0.24 / 0.35 m^{-1} [8], it is necessary to process the dependence of the specific heat consumption on the specific perimeter of the external walls (%) using one of the methods of mathematical statistics; revealed that

$$q_c = f\left(\frac{P}{F_H}\right) f \frac{(A+B)^2}{A \cdot B}$$

where P is the perimeter of the outer walls, m; F_H - the total area of stock and poultry buildings.

Thermotechnical researches of the panels took place at internal air temperature of $t_в$ =20^{0}C, relative humidity of 60% and an outdoor temperature of $t_н$=-5,2^0 C.

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To fully characterize the structure under consideration, we analyze the temperature distribution obtained during heat technical tests. Temperatures on the inner surface of the wall turned out to be 16.5-17 ^{0}C.

The temperature difference between the inner surface and the ventilated wall panel was

$$\Delta t = t_{в} - \tau_{в} = 21{,}1 - 17 = 4{,}1^0 C.$$

Results of natural thermal engineering investigations of heat-protective properties of non-transparent external fences when considering two options: blind wall - wall panel are given in Fig.1

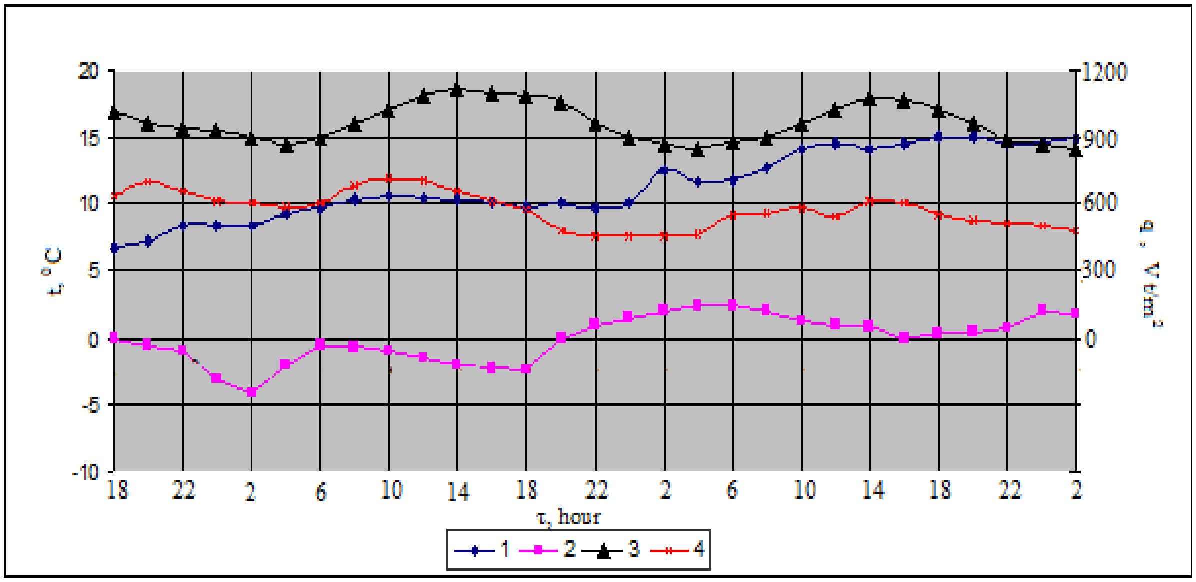

Fig. 1: Diagram of Air Temperature and Heat Flux Changes During the Observation Period: 1 - Temperature of Air Inside the Production Room; 2 - Temperature of External Air; 3 - Heat Flow through the Control Section of the Wall; 4 - Heat Flow through the Ventilated Wall Panel

III. CONCLUSION

Thus, the regional climatic conditions of the external environment and the heat engineering regime in stock and poultry buildings are determined by the influence of solar radiation: the presence, absence and duration of its exposure. Therefore, external fences, depending on their location, condition of the outer surface, space-planning decisions, etc., perform their heat-shielding and operational functions in full or in part. The authors proposed a method for determining the type and size of cost-effective thermal protection of exterior, interior and ceiling fencing, taking into account measures to improve the design of thermal protection in livestock and poultry facilities, taking into account energy savings and the possibility of reducing heat loss through a system of enclosing structures through the use of rational space-and-planning and structural solutions.

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Symbols accepted in the paper [9, 10]:

$K = \frac{F_{ct} + F_{kp}}{F_0} = \frac{2(A+B)\cdot m \cdot l + AB}{m \cdot A \cdot B}$ – compactness factor, evaluation criterion for space-and-planning solutions of buildings; $x = \frac{2(A+B)}{4C}$ - building shape factor, building energy efficiency criterion; A, B - building dimensions in plan, m; C is the side of the isometric square, m; m, ℓ - number of floors and floor height, m.

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