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THE MODELING OF THE FORMATION OF TEMPERATURE FIELDS IN THE AIR FRAMEWORK OF CULTIVATION CONSTRUCTIONS

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The main regularities of the processes of convective heat transfer in air of greenhouses are considered in the calculation of complex heat transfer and placement of temperature fields.

Keywords: cultivation structure, temperature field, air exchange, convective flow, heating, thermophysical calculation, power system.

Introduction. The getting high and stable yields in buildings protected ground depends on how accurately comply with the necessary microclimate parameters whose values are given by specialists in the field agrobiologic plants and regulated guidelines applicable regulations. Two major problems are facing before the growers: the production of sufficient vegetables in off season period and provide seedlings of vegetable crops for open ground. The security engineering depends directly on the efficiency of heating and ventilation parameters such as temperature, relative humidity, carbon content. Therefore, the protected ground needs further improvement and development of sustainable heating and ventilation systems at the lowest cost of energy and capital costs of engineering equipment in the intensive development of vegetable. The efficiency and economical operation of greenhouses largely depends on ensuring they have the necessary parameters of air environment with heating and ventilation. We know that from being placed in air temperature field cultivation facilities, largely depends on the degree of accuracy of calculation of thermal structures like grid. You need to know for consideration of heat and mass transfer, which creates a microclimate in the room, following: a) the requirements for indoor climate and the factors affecting of them; b) the laws of interaction fence with internal and external environments; c) the heat and mass transfer processes heating and cooling surfaces and the air flows of air conditioning in the room; d) phenomena that occur in structures and materials in the transmission through them heat, moisture and air; e) the characteristics of climate and the laws of changing these characteristics. Greenhouses make up more than 70% of the total area of constructions of protected ground. The modeling allows you to test changes in the range of fluctuations of external and internal temperatures of 6 to 60 ºC. The selected range covers almost all important temperature that occurs when operating cultivation facilities. Ability to use only average values in calculating the greenhouse because the greenhouses there are small temperature pressure, so depending on temperature changes in streams close to the line. The degree of precision thermal calculation buildings as energy system largely depends on the reliability of information on air temperature distribution in the room. In cultivation process design rules [3] and other agricultural buildings and structures regulated value of average air temperature in the working area. On this basis, it is important that it is necessary to determine the quantitative relationships that take let go from normalized values inside air temperature to values other characteristic temperature of ambient air in the building.

The problem. The solutions of problems are related to energy and resource conservation in the state's economy, including the construction of agricultural production buildings, possibly in many directions. One of them is a methodical approach that defines the structure of the energyaerodynamic that takes into account the complex factors that shape the thermal conditions of the building and the character of her energy processes. On the basis of the main regularities of convective heat transfer in the air greenhouses in the calculation of heat should be checked depending convective and radiant heat transfer to confirm the fundamental correctness of drawing up the basic system of equations in expanded form. It is important to ensure the ability to accurately calculate the heat balance and thus use the average values.

The purpose of research. The purpose of these studies was to investigate the distribution of temperature in the air space of greenhouses.

The results of the research. The test methods for calculating heat most widespread cultivation facilities - unheated and heated was given as the base of the research. The fence was made of ordinary glass and film. It was proposed lower and upper heaters with different power for heating plants cultivation. Unheated cultivation facility can be attributed to the lower greenhouse heating and it is taken into account in the calculations. If heat is studied at the fence of ordinary glass, it must be considered that the glass opaque to infrared radiation, so the heat transfer glazing and heat convection and carried out jointly radiation. It is strictly adhere to the norms of the parameters of air in greenhouses, according to [3], because there is a limit to the minimum and maximum temperature in the greenhouse, and the term of the temperature depending on the specialization of the structure. The minimum temperature in the greenhouse in the calculation of heating permitted for a period not more than one day. In greenhouses where grown vegetable crops and seedlings for planting in the greenhouse, the temperature should not be lower than the 15 ºC, and if designed for growing seedlings in open ground, the temperature should be no lower than 12 ºC. The maximum temperature of indoor air in greenhouses allowed 30 ºC when grown vegetable crops; 25 ºC - for growing seedlings, that followed must be planting in the greenhouse; 18 ºC - for growing seedlings, that followed must be planting in open ground. The seedlings are need to maintain a temperature equal to the outdoor temperature during the hardening. But it must be clearly supported by the requirement that the duration of the maximum temperature allowed for 5 ... 10 hours.

The diagram of the heat balance cultivation facilities into account the following parameters:

- the total heat flux from the soil;
- the transfer of heat from the ground to the air convection;
- the heat that is spent on evaporation from the soil;

- the amount of moisture that evaporates;
- the heat flows radiated soil and perceived inner surface of translucent fence;
- the heat that is released during condensation on the inner surface of the fence;
- the amount of moisture that condenses;
- the thermal convection flow of air in the space facilities to the inner surface of the fence;
- the convection of the heat flow from the fence to the outside air;
- the amount of the heat radiated from the outer surface of the outer fence;
- the consumption of the heat for ventilation;
- the moisture is removed from the room through the air;
- the heat that are coming from the heaters to heat the indoor air.

The heat engineering calculation in accordance with the general theory of energy balance reduces to solving the system of equations: the heat balance of the entire building; the balance of moisture; the heat balance equation in the ground; the heat balance equation for the fence. In addition, the calculations are must use parameters that define the energy state of the system: the geometrical and physical steel, and the surface temperature of the soil and fences; the internal air temperature in the working area (near the soil surface) and at the inner surface of the fence, the relative humidity, the ambient air parameters (temperature, relative humidity, wind speed, rain) and air. The heat which are losing through the floor are no more than 9% of total energy consumption, and it is the small proportion, that is why the balance equation from the surface of the ground is not checked. It is shown in the studying of the proportion of each component in the equation of the heat balance of the entire structure in unheated buildings at a fraction of radiant component has at least 80% of the energy, and the convection plays a secondary role; the share convection in the heated greenhouses accounts for approximately 40 ... 45% of total energy consumption. It is proved that the temperature in the cloud-night temperature would remain strictly constant and in the cloudless nights overnight ranges 1 ... 3 ºC, which suggests the night mode as a stationary. The physical picture of thermal processes in construction gives grounds for the use of selected dependencies and average values for parameters can be difficult to calculate the heat in the greenhouse and get the value that we are interested. We can to consider quantitative relationships that allow to move from the normalized values of average air temperature in the working area $t_в$ to the values of the other characteristic temperature of ambient air in the building [1, 3]: the temperature which deleted ventilation $t_{ух}$; the average temperature around the entire inner surface of walling $t_{в.п}$ or separately near the walls $t_{в.п.}^{c}$, near the cover $t_{в.п.}^{п}$, etc. The main source of the accumulation of knowledges about the laws of the formation of temperature fields in construction volumes was still only the experiment in laboratory and field conditions that was followed by the treatment with the desired data to establish relationships. The dependencies between the temperatures are can be represented as the parametric factors:

$$r_{t_{ух}} = \frac{t_в - t_н}{t_{ух} - t_н}, \qquad (1)$$

$$r_{tв.п.} = \frac{t_в - t_н}{t_{в.п.} - t_н}, \quad (2)$$

$$r^{п}_{tв.п.} = \frac{t_в - t_н}{t^{п}_{в.п.} - t_н}, \quad (3)$$

$$r^{с}_{tв.п.} = \frac{t_в - t_н}{t^{с}_{в.п.} - t_н}, \quad (4)$$

where $t_н$ – the temperature of the ambient air, ° C.

We can to calculate the basic components of the heat balance of buildings with the help of the formulas (1) ... (4): the heat consumption for ventilation and heat loss through the building envelope (the walls and the cover) [2, 4]. Possible the case where is $r_t = 1$, that the heat in the building is $Q_0 = Q_0^p$, then we can conclude that the temperature at each point of the surrounding air is the same in the volume. The value Q_0^p describes the heat required to cover all types of heat in the building, which creates the uniform temperature field in the volume. Thus, we can conclude that the ratio r_t can be calculated using the following formula:

$$r_t = \frac{Q_0^p}{Q_0}, \quad (5)$$

That the ratio r_t - is the ratio of the heat release from the heating which spent to compensate for heat loss in the building with a uniform temperature field of the surrounding air ($t_b = t_{ух} = t^{c}_{B.n} = t^{n}_{B.n} = t^{пол}_{в.п}$) to the same index of energy balance in the same building with the some uneven temperature field ($t_b \neq t_{ух} = t^{c}_{B.n} = t^{n}_{B.n} = t^{пол}_{в.п}$). Thus it can be concluded that the value r_t can be classified as a factor that allows evaluating the effectiveness of the considered buildings as the energy system. In this system the volume created by the characteristics of temperature field with the help of the aggregate effect of heating and ventilation devices and walling to equalizing with a similar structure in which the temperatures were reached equation in the air facilities. The coefficient of efficiency has depends on the combined effect of several factors. First of all the thermal efficiency walling has been estimated, but it is also has been determined from the thermophysical characteristics of heating and ventilation devices. For heat consumption are the most effective cultivation facilities with lower heating as in glass and translucent film with fences. Estimated that [1] the heat in the block glass greenhouse at lower heating has costs in 1.73 times less than the top, and 1.56 times than the heating side; in the hangar greenhouses - respectively 2.0 times less than the top and side heating glass at the fence, and 1.52 times than the top of the heating film at the fence. As regarded the most difficult night mode operation of greenhouses in the winter with no ventilation, the problem was reduced to simulation of temperature fields with the free air convection in closed volume with a different arrangement of heaters evenly over the corresponding square models: the lower heating - above ground at the workplace; the toper heating - near the inner surfaces translucent cover; the lateral heating - the inner surface of the translucent wall between the units and block greenhouses. It was concluded that there is a significant difference in the character formation of temperature fields in different spans every block greenhouse heating mode. But by fundamental differences in temperature fields at different ways of heating: at the bottom - the air intensively mixed throughout the volume of the greenhouse, the temperature gradient and the height is virtually nonexistent; at toper heating - there is a large temperature difference in height greenhouses, with no process of turbulent air movement in its scope; in the lateral heating - virtually no heat transfer by convection, while in the area above the heater there is intense turbulent mixing and there is virtually no temperature difference in height (similar to the lower heating). The same phenomenon was observed in the hangar greenhouses, so you can classify it as a kind of the floor temperature. It was determined that the combination of different types of heating temperature distribution shift from specific to one type of heating to another occurs abruptly. In different ways and different placement of heaters consumed power was the following: 1) the possibility of calculation of heat (the radiant along with the convective) by cumulative accounting components of the formulas that right for the each heat separately; 2) it was founded that the heat engineering calculation may be used the averaged temperature values.

We conducted equalization of values obtained from direct heat measurements to assess the reliability of the parametric values of the coefficients obtained by formulas (1) ... (4). The good convergence of values that were compared indicates the reliability of the results. These calculation methods can be used for the engineering calculations of the cultivation facilities in the design and in the research.

Conclusions. The model of calculating formation temperature fields in air cultivation facilities for evaluating the effectiveness of cultivation facilities as energy system was created. The model of calculation can be used as the thermal calculation poultry and the livestock farms.

REFERENCES

1. Anuphriev, Leonid Nikolaevich Thermophysical calculations of the agricultural production buildings / L. N. Anuphriev. - M.: Buildpublishing house, 1974. – 216 p.

2.Maximov G. A. The movement of the air during operation of ventilation and heating systems / G. A. Maximov, V. V. Derugin. - L.: Buildpublishing house, 1972. – 99 p.

3.STD 10-95. Standards of technological design of the greenhouses and the greenhouses for growing vegetables and seedlings ; introduced 01.07.1996; M. : Publishing standards, cop. 1996. – 96 p. - (The system of standards on information, librarianship and publishing).

4.Sukach S. V. System approach to the mathematical modeling of the ventilation systems / S. V. Sukach // Weapons systems and military equipment. — 2016. — № 3. — P. 137-143.

5.Energy Saving Technologies. How to save on the heating: [the electronic resource]: the access mode: http://polarsol-spb.ru/tekhnologii/ - Title screen.

МОДЕЛИРОВАНИЕ ФОРМИРОВАНИЯ ТЕМПЕРАТУРНЫХ ПОЛЕЙ В ВОЗДУШНОЙ СРЕДЕ КУЛЬТИВАЦИОННЫХ СООРУЖЕНИЙ

Мартынова Е.Б.

Ключевые слова: культивационное сооружение, температурное поле, воздухообмен, конвективний поток, обогрев, теплофизический расчёт, энергетическая система.

Резюме

Рассмотрены основные закономерности процессов конвективного теплообмена в воздухе теплиц при расчёте сложного теплообмена и размещения температурних полей.

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Summary

The main regularities of the processes of convective heat transfer in air of greenhouses are considered in the calculation of complex heat transfer and placement of temperature fields.