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# ANALYSIS OF THE FACTORS THAT DETERMINE THE CONDITIONS FOR THE CONSTRUCTION OF A THERMODYNAMIC MODEL IN THE DESIGN OF A SYSTEM FOR PROVIDING HYGROTHERMAL CONDITIONS FOR GROWING INSECTS

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**Summary.** The factors that determine the conditions for creating a thermodynamic model when designing an air conditioning system for growing insects are analysed. The stages of building a thermodynamic model for the design of a subsystem for providing hygrothermal conditions for insect rearing are formed. The structure of the initial data for the construction of air treatment processes in thermodynamic systems with the provision of optimal technological parameters of the technocenosis. Using a thermodynamic model of the microclimate creation system in the d-h diagram of humid air, studies of heat and mass-humidity treatment processes provide information on the required load and volume of systems for providing abiotic factors. Using the method of graphical analysis, it is possible to determine the optimal methods of controlling the polytropic processes of preparing the air of the abiotic environment until it reaches certain temperature and humidity characteristics.

**Keywords**: *air conditioning, thermodynamic model, air temperature, relative humidity, air flow.*

**Introduction.** The system analysis of energy-efficient systems for the provision of abiotic factors for entomological production meets the conditions of joint optimisation of both the structural parts of the system and the system. The goal of using system analysis in the design of energy efficient systems is to develop the system, its subsystems, and components to achieve the target functions - optimal efficiency and cost-effectiveness. Considering the specifics of energy-efficient systems for providing abiotic factors, they include an air conditioning system.

**Materials and methods.** The method of analysis of the construction of a thermodynamic model for entomological production was used. Theoretical study of thermal and humidity processes of air treatment in air conditioning systems for entomological laboratories.

**Results and discussion.** The general hierarchical structure of the initial data is shown in Figure 1, which shows the existence of four interrelated groups of initial data. These groups have not only directed, but also inverse relationships. To clarify the place and relationship of the model calculation information in the overall hierarchical structure of the input data, it is necessary to analyse in more detail some features of its individual components. Currently, information about the external climate is usually presented in the form of a *d-h* diagram.

In general, reliably obtained climate information characterises its probable essence, but considering other information used in the tasks being solved, a situation may arise where an uncertain result is obtained for choosing the optimal solution of the systems. The form of presentation of climate information should facilitate the identification of the criticality of the resulting solution in relation to this factor i.e., to a possible change in the recurrence time at the "sites" of the external climate area. Therefore, information on temperature and relative humidity with an indication of the repeatability of these parameters within elementary areas seems to be the most appropriate.

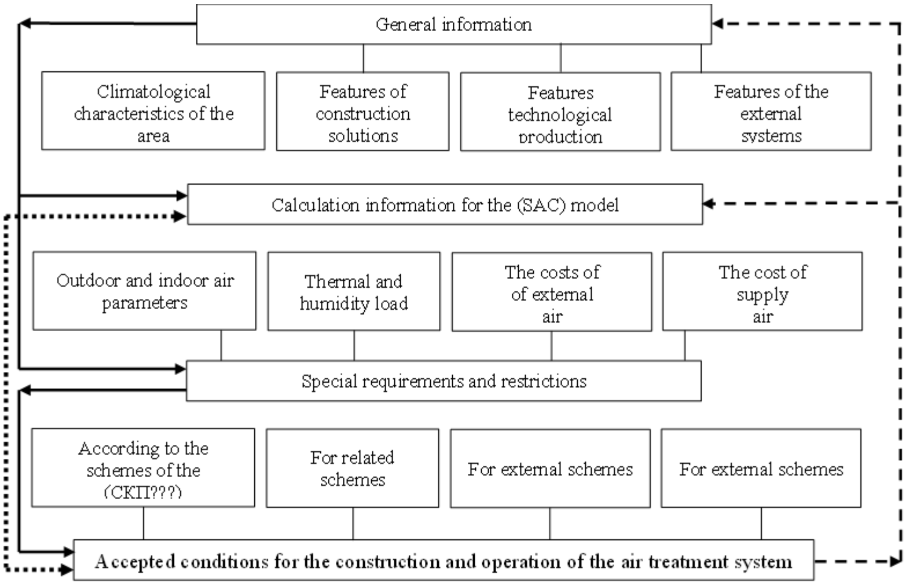

Figure 1. Hierarchical structure of initial conditions for the problem

Outdoor air parameters $(-)H_i$ are temperature and enthalpy (02.04.05 91) specified for a particular area and season (summer, winter). To build the outdoor climate area, the data of 16350-80 (15150-69) – Climatogram of temperature and humidity complex of outdoor climate parameters are used. It is constructed in a $d$-$h$ diagram based on the given values of temperature ($t$, $^oC$) and relative humidity ($\varphi$, %). The resulting curve is limited to all outdoor climate parameters that can be observed throughout the year in each area. Figure 2 shows the climatogram for the city of Odesa.

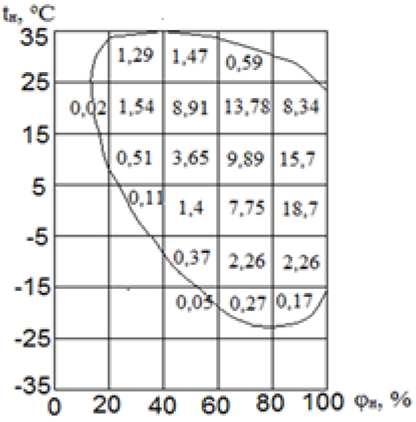

Figure 2. Climatogram for Odesa city

The meteorological parameters of the indoor air environment are presented deterministically, in accordance with the regulatory documentation, considering both hygienic and technological requirements of entomological production. Normalised indoor parameters are represented by a point (-) at $t=const$, $\varphi=const$; lines (-) $t=const$, $\varphi=var$ or (-) $\varphi=const$, $t=var$, or a region (□) $\varphi=var$, $t=var$, limited by the permissible limits of temperature change t and relative humidity φ. The choice of indoor climate parameters will depend on the purpose of the room. Information about the parameters for entomological production will always be represented by a certain area in the *d-h* diagram. For the mathematical model of the air preparation system, the parameters of the exhaust and recirculated air are indicated alongside the required parameters in the diagram. Air exchange coefficient:

$$K_1 = \left(H_{\text{в}} - H_{\text{п}}/H_{\text{р}} - H_{\text{п}}\right),$$

where $H_в$, $H_p$ are the enthalpies of the air supplied to the room and the air removed, respectively.

The requirements for the provision of parameters are divided into three groups. The first group includes cases where deviations are not limited in size, but their total duration in hours over the calculation period is specified. The second group includes cases where the limits of parameter deviations are known in terms of magnitude for the design period without specifying a continuous duration of deviations. The third group includes cases for which the magnitude and continuity of deviations are set for the period of the production cycle or work shift. The number of repeated deviations per shift or cycle may be normalised.

Information on the limits of permitted deviations shall be presented in a *d-h* diagram. The duration of these deviations is expressed in hours or percentage of the calculation period.

To model an optimal air handling system, the outdoor air flow rate must be known:

- the unavoidable minimum $G_{z\,min}$; $G_{z\,max}$
- and the maximum expedient $G_{z\,max}$.

The value of $G_z$ min is determined under the condition of sterility and gas composition of the air $G_{gc}$, considering the conditions of compensation for the air removed from the work area by local exhaust systems or technological equipment of entomological production $G_{obl}$, provided that the calculated backup $G_p$ is maintained. The minimum unavoidable outdoor air consumption $G_{oz}$ min is determined by the highest value of $G_{gs}$ or the sum of $G_{obl}$ and $G_p$.

Since the removal of metabolic products that cause an uneven distribution of harmful emissions, which disturbs the gas composition and purity of indoor air, is systemic in entomological production, air flow is one of the determining factors affecting heat and cold consumption. The supply air flow rate significantly affects the technical and economic performance of the system, so it appears as a control parameter of the model.

**Conclusions.** For the design of an air conditioning system for entomological production, it is presented in the form of a thermodynamic model. The built thermodynamic model will provide:

- the ability to generalise the initial factors into a form of calculation information that allows to select the optimal variant of the air conditioning system, the composition of subsystems and their operating modes for the annual cycle;
- studying the nature of the relationship between the determining parameters of systems and subsystems depending on the operating conditions and functional and technical characteristics of equipment and automation facilities;
- representation of the defining parameters in the form of coordinates of the system state, the use of which will allow to calculate the technical and economic indicators of both any of the subsystems and the system.

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