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MODELING OF THERMAL REGIME OF MANUFACTURING PREMISES USING GRAPH THEORY

The data on the application of graph theory to model the thermal state of the working area of industrial facilities on the example of agricultural building department piglets and sows.

Key words: graph theory, department of piglets and sows, thermal state.

Наведено дані щодо застосування теорії графів для моделювання теплового стану робочої зони виробничих приміщень на прикладі сільськогосподарської будівлі цеху поросят і свиноматки.

Ключові слова: теорія графів, цех поросят і свиноматок, тепловий стан.

Statement of the problem.

The process of maintaining thermal conditions in production facilities are known to define the basic characteristics of heating systems, such as their type, capacity, working principle and others. This technological features of heating systems can maintain the required temperature in the work zone facilities.

This paper discussed the problem of keeping the thermal state space industrial complexes in the case of agricultural livestock building, including plant piglets and sows. Livestock buildings are characterized by their relatively large geometrical dimensions, complicating the job of providing a microclimate. Therefore, for such premises promising direction is the use of combined heating systems that are based on background air and special local heating to maintain certain temperature parameters directly in the habitats of animals. The combination of different heating systems in a complex complicated engineering calculations determine the necessary parameters of the microclimate. This is due primarily to the different heat exchange processes that occur directly in the places of thecnological process. Therefore, investigation of thermal modes of production facilities is very important.

Analysis of recent research and publications.

Requirements of practice calculating the thermal regime in the technological areas of industrial facilities, including agricultural, cause necessity of in-depth studies of thermal processes in work areas. Various aspects of this area of research is devoted to a number of studies [1, 4, 5, 6].

Formulation of paper objectives.

This work is devoted to peculiarities of the temperature industrial premises. Special attention was paid to the modeling of heat transfer processes in the technological area plant piglets and sows using graph theory.

The main material.

For simulation of thermal interactions in plant piglets and sows the basis is the theory of graphs. Zone sows being presented as a system of heat capacities, participating in heat exchange and interact with sources of heat. In the study area singled heat capacity: air of technological zones (Z); envelope (E); sow (S), and the source of heat: heating panel (Q_{pan}); sow (Q_{s}); air (Q_{a}); envelope (Q_{env}),that were depicted as the top (V_1) graf (G_1). Heat flows q_i, that meet heat transfer between the i-unit sources of heat and heat capacities shown on the graph as edges (E_1), that connect the tops (fig.1).

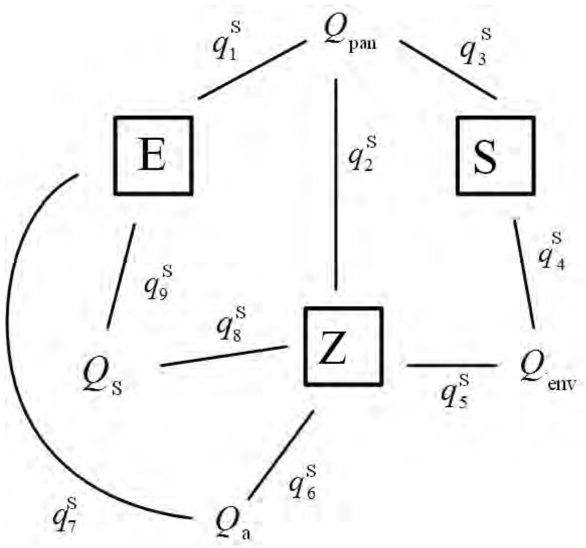

Fig. 1 Graf of heat flow zone stays sows.

Thus the set of graph vertex is:

$$V_1(G_1) = \{E; S; Z; Q_{pan}; Q_{env}; Q_a; Q_S\} \tag{1}$$

and the plurality of edges:

$$E_1(G_1) = \begin{Bmatrix} (Q_{pan}, E); (Q_{pan}, Z); (Q_{pan}, S); (Q_{env}, E); (Q_{env}, Z); \\ (Q_a, Z); (Q_a, E); (Q_S, Z); (Q_S, E) \end{Bmatrix} \tag{2}$$

For thermal capacitances included in the graph as the tops number of edges is equal to:

$\deg(E) = 3,$

$\deg(S) = 2,$

$\deg(Z) = 4.$

Incidence matrix M_1 for graf G_1, in which the rows correspond to the tops (heat capacities) and columns – edges (heat flows) has the form:

	q_1^S	q_2^S	q_3^S	q_4^S	q_5^S	q_6^S	q_7^S	q_8^S	q_9^S
E	1	0	0	0	0	0	1	0	1
S	0	0	1	1	0	0	0	0	0
Z	0	1	0	0	1	1	0	1	0

(3)

	E	S	Z	Q
E	0	Q_{E-Z}	Q_{E-S}	$Q_{pan}^O + Q_S^O + Q_a^O$
S	Q_{S-E}	0	$Q_{S\text{-}Z}$	$Q_{pan}^S + Q_{env}^S$
Z	Q_{Z-E}	Q_{Z-S}	0	$Q_{pan}^Z + Q_{env}^Z + Q_a^Z + Q_S^Z$

(4)

For keeping pigs zone based on graph theory constructed graph of heat flows (Fig. 2) that displays the relationship of thermal capacities of air (A), envelope (Env) and piglets (P) with sources of heat mat ($Q_{h.m}$), infrared heater ($Q_{i.h}$) ,envelope (Q_{env}), air (Q_a) and piglets (Q_P).

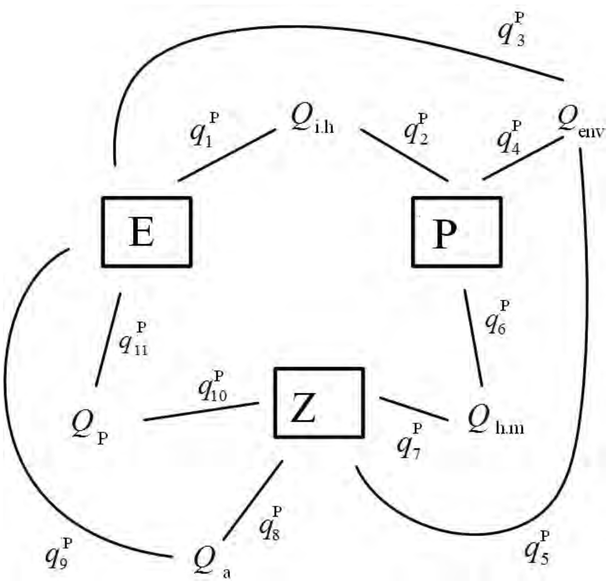

Fig. 2. A simple graph of heat flows zone being piglets.

Accordingly, the set of vertices $V_2(G_2)$ and edges $E_2(G_2)$ is:

$$V_2(G_2) = \{\text{E; P; A;} Q_{\text{i.h}}; Q_{\text{env}}; Q_{\text{h.m}}; Q_{\text{a}}; Q_{\text{P}}\}, \quad (5)$$

$$E_2(G_2) = \begin{Bmatrix} (Q_{\text{i.h}}, E); (Q_{\text{i.h}}, \text{P}); (Q_{\text{env}}, \text{E}); (Q_{\text{env}}, \text{P}); \\ (Q_{\text{env}}, \text{P}); (Q_{\text{h.m}}, \text{P}); (Q_{\text{h.m}}, \text{Z}); (Q_{\text{a}}, \text{Z}); \\ (Q_{\text{a}}, \text{E}); (Q_{\text{P}}, Z); (Q_{\text{P}}, \text{E}) \end{Bmatrix}, \quad (6)$$

For heat capacities that characterize the thermal state of zone stays of piglets the number of edges:

$\deg(\text{E}) = 4,$

$\deg(\text{P}) = 3,$

$\deg(\text{Z}) = 4.$

Incidence matrix M_2 for graf G_2:

	q_1^{P}	q_2^{P}	q_3^{P}	q_4^{P}	q_5^{P}	q_6^{P}	q_7^{P}	q_8^{P}	q_9^{P}	q_{10}^{P}	q_{11}^{P}
E	1	0	1	0	0	0	0	0	1	0	1
P	1	0	0	1	0	1	0	0	0	0	0
Z	0	0	0	0	1	0	1	1	0	1	0

, (7)

Extended matrix with display of heat sources:

	E	P	Z	Q
E	0	Q_{E-P}	Q_{E-Z}	$Q_{i.h}^{E} + Q_{\text{env}}^{\text{E}} + Q_{\text{P}}^{\text{E}} + Q_{\text{a}}^{\text{E}}$
P	Q_{P-E}	0	$Q_{P\text{-}Z}$	$Q_{\text{i.h}}^{\text{Пор}} + Q_{\text{env}}^{\text{Пор}} + Q_{\text{h.m}}^{\text{Пор}}$
Z	Q_{Z-E}	Q_{Z-P}	0	$Q_{\text{env}}^{\text{Z}} + Q_{\text{h.m}}^{\text{Z}} + Q_{\text{a}}^{\text{Z}} + Q_{\text{P}}^{\text{Z}}$

, (8)

The thermal state department piglets and sows can be represented as a simple graph G_3 (fig. 3), which is a combination of simple graphs that reflect the processes of heat exchange stay zones of sows G_1 and piglets G_2.

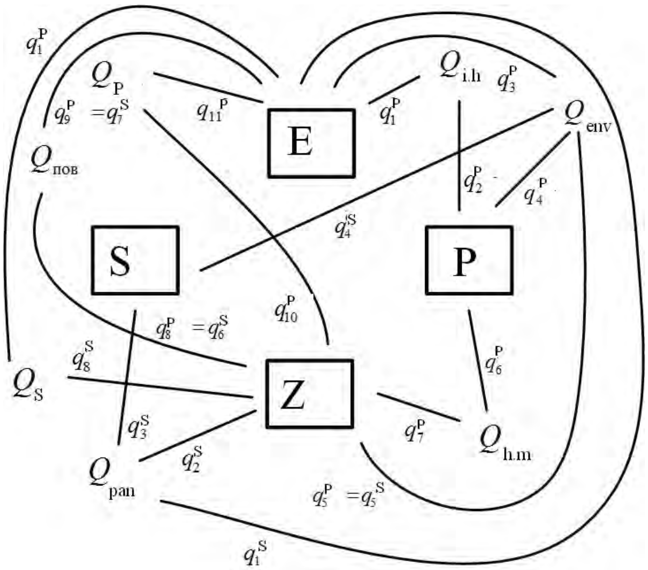

Fig. 3. A simple graph of heat flows zone being piglets and sow.

Thus:

$$G_3 = G_2 \cup G_1 \text{ та } V_3 = V_2 \cup V_1 \wedge E_3 \cup E_1$$

At the same time is made connection the same vertices belonging graphs G_1 and G_2, while leaving the incident edges. Extended matrix of thermal capacities with the reflection of heat sources is as follows:

	Е	П	Пор	Св	Q
E	0	Q_{E-Z}	Q_{E-P}	Q_{E-S}	$Q_P^E + Q_S^E + Q_a^E + Q_{pan}^E + Q_{i.h}^E + Q_{env}^E$
Z	Q_{Z-E}	0	Q_{Z-P}	Q_{Z-Z}	$Q_P^Z + Q_{h.m}^Z + Q_{env}^Z + Q_{pan}^Z + Q_S^Z + Q_a^Z$,
P	Q_{P-E}	Q_{P-Z}	0	Q_{P-S}	$Q_{i.h}^P + Q_{env}^P + Q_{h.m}^P$
S	Q_{S-E}	$Q_{S\text{-}Z}$	Q_{S-P}	0	$Q_{pan}^S + Q_{env}^S$

(9)

Based on the extended matrix (9) formulated a system of balance equations describing the thermal processes in conditions that are considered.

Conclusions.

The mathematical model is the basis of the specified methods of calculating temperatures departments piglets and sows with combined heating systems. Application of graph theory in modeling these processes, makes it possible to identify patterns of thermal processes, the flow of which is directly in the places of stay animals.

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