Modeling of technological processes of heat supply, as a tool for assessing the state of objects of the property fund and engineering networks of enterprises

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Abstract. The approach to the mathematical modeling of technological processes of production, manufacture and consumption energyresources on the property fund facilities and engineering networks is presented. This approach is defining the information support system analysis of the kinetic changes of thermodynamic parameters sequentially occurring thermal processes in the flows of heat transfer agent in a closed structures of heating energy working in the recycle mode of the heat flow. It is determined the possibility of setting and solving problems of energyefficiency on the objects with close cycle operating and working in the fluctuation mode of the environmental parameters.

Technological network processes of heat and power supply of objects of property fund representing multi-stage dynamic systems of heat flows in network structures of heat consumption, accompanied by kinetic change of thermodynamic parameters of the heat carrier, change of thermal potential in closed circuits of circulating heat supply, the mathematical model is written in the form of a recurrent system of differential equations determining the change in the thermodynamic potential of thermal energy In networks those Provision of food.

Local identification of model equations determines the condition of high reliability of information support for the development of control systems for heat and power supply processes at the consumption objects.

Mathematical modeling of technological processes of power supply of objects of property fund and engineering networks of enterprises determines the possibility of solving the problem of energy and resource saving, optimization of energy consumption regimes, provision of sanitary and hygienic standards in premises in conditions of fluctuations in temperature parameters of the environment.

A systematic information approach is being implemented to solve the problem of efficient use of fuel resources in the conditions of stabilization of power supply modes at power consumption facilities.

The information approach of the mathematical modeling procedure can be represented by recording the balance equations of the dynamics of the change in the thermodynamic parameters of thermal networks.

The task of managing the intensity of energy production in conditions of optimal energy supply to consumers is recorded by a system of differential equations of kinetic variation that determine the parameters of the coolant in the structural chain of technical equipment in heat production, distribution and consumption of thermal energy with provision of sanitary hygienic thermal regimes in the premises.

The intensity of accumulation of the thermal potential is determined by the relation:

$$Q = \int_{\tau_0}^{\tau_\text{к}} m_{i;j} \cdot I(\tau) d\tau \qquad\qquad (1)$$

where $m_{i;j}$- Flow rate of coolant (m^3/hour);$I(\tau)$ – enthalpy of the heat agent (kJ/m^3); here $I(\tau) = c_v \cdot t(\tau)$; c_v – bulk heat capacity of coolant;$t(\tau)$ – temperature of heat agent ($°K$).

In this task, the state of the control object is considered as a multidimensional, vector variable of the change in the energy potential of the coolant flow Q (kJ), the components of which determine parametric parameters, such as the volume flow of the heat carrier m (m3 / h), and the thermodynamic temperature T (K).

The vector state of the control object in the form of a network power supply system at the objects of the property fund and engineering networks of enterprises and, in particular, housing and communal services objects is determined by the change in the thermal potential of the heat carrier Q in a continuous flow in a certain range of values or a finite set of values.

The variable parameter of the technological process of heat supply should be determined such a current indicator as the temperature of the coolant t_i on the i-th section of the supply network, while such an indicator as the volume flow of the coolant in the relevant sections of the power network should be defined as a given and constant value m_i

The generalized form of the mathematical model of thermal networks of heat production and heat supply is written in the form of a set of recurrent differential equations of the dynamic change in the energy potential of the coolant flow estimated by the heat energy index as the coolant temperature. This approach determines the possibility of developing a system for optimal management of energy consumption objects based on the principles of system analysis of the thermodynamic state of the flow at certain stages and sections of the network structure of its operation and regulation by parametric feedback indicators.

The structural diagram of thermal heat and power networks of heat supply at the objects of the property fund and engineering networks of enterprises, presented in Fig. 1, determines the solution of the problem of minimizing the consumption of thermal energy in conditions of ensuring the normative operating modes of the facility based on temperature characteristics.
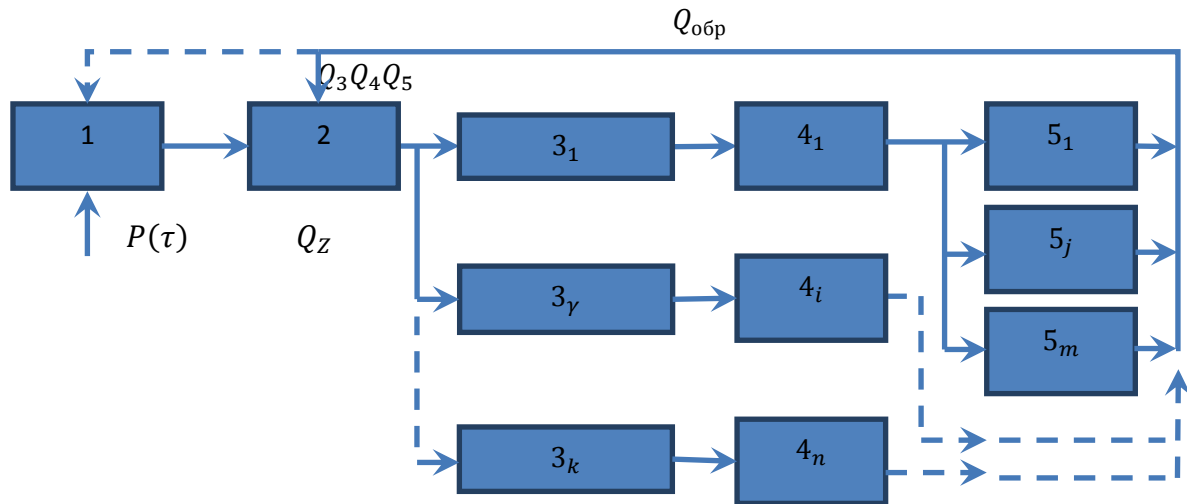
Fig.1 Structural diagram of heat and power supply in consumption networks: G - heat agent (natural gas, superheated steam); Q_{ij} - heat flow; $Q_{обр}$ excess-return flow of the coolant; $P(\tau)$ - the heat agent consumption; 1. heating boiler; 2. Boiler heat treatment of thermal conditions of the coolant; 3. the coolant supply line; 4. Nodal objects of heat consumption; 5. local heat consumers.

The balance ratio of the heat-energy flow pulse in accordance with the one shown in Fig. 1 technological structure scheme of heat and power supply in consumption networks is recorded in a generalized form in the form of a set of recurrence relations of instantaneous change in the heat content of the heat flow in a closed cyclic circulating heat and power supply system with respect to:

$$\Delta Q_1 = \left(\left(\left(\Delta Q_2 + \Delta Q_\Sigma \right) - \sum_{\gamma=1}^{k} \Delta Q_\gamma \right) - \sum_{\gamma=1}^{k} \sum_{i=1}^{n} \Delta Q_{ij} \right) - \sum_{\gamma=1}^{k} \sum_{i=1}^{n} \sum_{j=1}^{m} \Delta Q_{\gamma ij} \quad (3)$$

where: $\Delta Q_1, \Delta Q_2, \ \Delta Q_\Sigma, \Delta Q_\gamma, \Delta Q_{ij}, \Delta Q_{\gamma ij}$, Respectively, the energy flow of the formation energy in the boiler room, the output in the boiler, the flow of the heat carrier in the return line, the heat loss in the main network pipeline, the decrease in the thermal load at the γi nodal heating site, at the γij local heat consumption section.

The generalized recurrence equation for modeling the technological process of heat exchange in the structural system of heat supply to consumers of complex nodal objects of the property fund and engineering networks is a recurrence relation written in the form of a set of initial equations:

$$Q_1(\tau) = \mu \int_{\tau_0}^{\tau} P(\tau) \Delta H d\tau \ \rightarrow min$$

$$=> \int_{\tau_0}^{\tau} m_\tau(\tau) \cdot c_v \cdot t_2(\tau) d\tau - \sum_{\gamma=1}^{k} \int_{\tau_0}^{\tau} \int_{L=0}^{L_\gamma} K_\gamma \cdot f_\gamma \cdot \left(t_\gamma(\tau) - Q(\tau) \right) dL \cdot d\tau$$

$$- \sum_{\gamma=1}^{k} \sum_{i=1}^{n} \int \Delta Q_{\gamma J}(\tau) d\tau$$

$$- \sum_{\gamma=1}^{k} \sum_{i=1}^{n} \sum_{j=1}^{m} \left[\int_{0}^{\tau} V_{\gamma ji} \cdot c_v^{\text{н}} d\tau - \int_{0}^{\tau} Z_{\gamma ji} \cdot S_{\gamma ji} \cdot \left(T_{\gamma ji}(\tau) - U(\tau) \right) d\tau \right]$$

The identification of the generalized relationship is carried out by parametric indicators of the change in the value of the heat flux at the local points of the consumption node.

The recorded mathematical model of the technological process of production and consumption of heat energy resources on the objects of the property fund in the form of a recurrence relation determines the possibilities for setting and solving a number of management tasks:

- Deep elaboration of information support is provided for all parametric indicators both for all local analysis points and for the cumulative system as a whole.

- It is possible to evaluate all local sites and the structure as a whole in the parametric indicators of consumption and losses. The problem of eliminating bottlenecks is being solved.

- the theoretical and practical basis of development and implementation of ACS-TP operating in the mode of providing consumers with standard sanitary and hygienic life-support conditions is laid down; minimization of energy and resource saving, energy losses, minimization of payments by consumers for energy services.

- The presented approach to modeling the processes of use and consumption of material and energy resources in production systems can be considered as an opportunity for a deep level of information support in the development of an optimal control system.

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