MODELING OPTIMAL GEOMETRICAL PARAMETERS THERMAL INSULATION SHELL ENERGY EFFICIENT BUILDINGS

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***Summary.* Analytical and graphical methods of determining the optimal geometric parameters insulating shell energy efficient buildings considering heat loss, revenues the heat from solar radiation, the impact of wind on criteria of a given level of energy efficiency of buildings is developed.**

***Keywords:* optimization of geometrical parameters, energy-efficient buildings, face shape, geometric modeling, heat resistance.**

Formulation of the problem. Improving the energy efficiency of buildings is possible through the use of positive environmental impact thermal power that can be achieved by optimizing the geometric parameters (resistance to heat) each insulating shell construction. In this regard in the design of energy efficient buildings there is a need to develop ways to determine optimal resistance to heat walling based heat, warm revenues from solar radiation, wind exposure, provided that a given level of energy efficiency of buildings.

Analysis of recent research. In the paper[1] is discussed the optimization of insulation parameters in general terms without regard sided shape of the building. Problem Solving multiparameter optimization in terms of minimizing heat loss through the building envelope devoted to the work [2], but not the predetermined level of heat loss through the building envelope. In particular, there is no graphic solutions for this problem.

Formulation of Article purposes. Suggest analytical and graphical methods optimize resistance to heat insulating building envelope structures for a given level of heat loss.

Main part. The ***analytical method*** of optimizing heat resistance of walling at a given level of total heat loss through the building envelope ΔQB for heating period was developed.

Currently, several geometric parameters of resistance to heat transfer walling are being optimized. For this mathematical model consists of heat balance $\Delta Q_{\text{гр}i}$ of each face of the building, which takes into account the thermal resistance ($R_{\text{ст}}$, $R_{\text{в}i}$) opaque and translucent structures, space structures ($S_{\text{в}i}$, $S_{\text{ст}i}$), geometric parameters of orientation for the arrangement of windows on the facade of the building ($A_{\text{в}i}$, $\omega_{\text{в}i}$), etc.

The mathematical model of heat balance of the building faces can be represented as:

$$\Delta Q_{\text{гр}_i} = \frac{S_{\text{ст}_i}}{R_{\text{ст}_i}} \cdot \left(t_{\text{в}_i} - \left(t_{\text{з}_i} + \frac{r_i \cdot I_{\text{ср}_i}}{\alpha_{\text{зст}_i}} \right) \right) \cdot N_{\text{діб}} + \frac{S_{\text{в}_i} \cdot D_{d_i}}{R_{\text{в}_i}} - Q_{\text{ср}_i} \cdot K_i \cdot \zeta_i \cdot \varepsilon_{\text{o}_i} \cdot S_{\text{в}_i} . \quad (1)$$

Solving this problem is reduced to optimize the linear function with several variables using a computer. The parameters of resistance to heat transfer ($R_{\text{ст}i}$, $R_{\text{в}i}$) translucent and opaque structures are changeable.

The total thermal resistance of opaque and of translucent constructions is minimized:

$$\sum \left(R_{\text{в}_i} S_{\text{в}_i} + R_{\text{ст}_i} S_{\text{ст}_i} \right) \rightarrow \min . \quad (2)$$

The system limits

Number of heat loss through walling of corresponds to a building and energy efficiency, and is unchangeable:

$$\Delta Q_{\text{Б}} = \sum \Delta Q_{\text{гр}_i} = \text{const.} \quad (3)$$

Number of heat insulation is minimized, thus geometric parameters of resistance to heat transfer of heat insulation are limited respectively [3]:

$$0{,}5 \leq R_{\text{в}_i} \leq 0{,}75. \qquad 0{,}5 \leq R_{\text{в}_i} \leq 0{,}75. \quad (4)$$

Depending on the settings specified building restriction where $t_{\text{з}_i}$ - the actual outside temperature (degrees); $t_{\text{в}i}$ - Internal air temperature (degrees); r_i - albedo surface the building face ; $I_{\text{ср}_i}$ - Energy air illumination by short-wave radiation (W/м^2); $\alpha_{\text{зст}i}$ - heat transfer coefficient between the outer surface of the enclosure and the outside air; $R_{\text{ст}_i}$ - Resistance to heat of nontransparent fencing structures (м^2 · K/W); - $N_{\text{діб}}$ - the number of days of heating period [3]; $R_{\text{в}i}$ - resistance to heat translucent fencing structures (м^2 · K/W) [3]; D_{di} - the number of heating degree-days period [3]; $S_{\text{ст}i}$ - square opaque faces fencing structures (м^2); $Q_{\text{ср}_i}$ - the amount of solar radiation, that comes during the heating period (kW · h/м^2); K_i - ratio of actual cloud conditions affecting incoming solar radiation [3]; ζ_i - coefficient taking into account shading window aperture by opaque elements [3]; ε_{o_i} - ratio relative to incoming solar radiation of translucent constructions [3]; $g = \zeta_i \cdot \varepsilon_{\text{o}}$ – factor glazing windows.

Solving this problem is reduced to optimize the linear function with a computer using several variables by Hook-Jeeves method.

Graphic way to determine the rational heat resistance of opaque structures to ensure the specified level of heat ($\Delta Q_{\text{ст}_i} = \text{const}$) through the opaque envelope to improve the energy efficiency of the building is proposed to use reasonable resistance to heat, depending on the azimuth orientation.

Rational heat resistance $R_{стрi}$ is calculated as follows:

$$R_{\text{стр}_i} = \frac{N_{\text{діб}}}{\Delta Q_{\text{ст}_i}}\left(t_{\text{в}_i} - \left(t_{\text{з}_i} + \frac{\rho_i \cdot I_{\text{ср}_i}}{\alpha_{\text{зст}_i}}\right)\right). \qquad (5)$$

To automate of calculations was developed PAP *Polar*, which is used to build the model of rational resistance to heat transfer $R_{\text{стр}i} = f(A_\sigma)$, depending on the azimuthal orientation of the building. But to 50 percent of heat loss of the building envelope occurs through the translucent structures, so method of rational modeling resistance to heat transfer of translucent constructions will consider on.

Graphic rational way of determining resistance to heat transfer of translucent constructions

To ensure the specified level of thermal balance $\Delta Q_{\text{В}i}$ = const translucent designs (warm revenues and heat from solar radiation (SR) during the heating season) were found analytical dependencies for determination of rational resistance to heat transfer structures .

Rational heat resistance of windows $R_{\text{вр}i}$ is determined by:

$$R_{\text{вр}_i} = \frac{D_{di}}{\Delta Q_{\text{в}i} + Q_{\text{ср}_i} \cdot K_i \cdot \zeta_i \cdot \varepsilon_{\text{в}i}}. \qquad (6)$$

A computer program and graphic models were built $R_{\text{вр}i} = f(A_\sigma)$ of rational resistance to heat transfer (translucent structures (Fig. 1) (providing 100, 80, 60, 40 kW · h / m^2 degree heat balance during the heating season) that can be used at the stage of architectural design.

To determine the resistance to heat, transfer and rational arrangement of windows on the faces of the building sided shape with graphic model obtained $R_{врi} = f(A_\sigma)$ apply and drawings of the building. This building plan compounds with the models, and the designer interactively on the computer determines rational level resistance to heat transfer translucent structures and zones rational, acceptable and the undesirable location of windows in the building envelope.

Conclusions. Were developed an analytical and graphical methods of determining the optimum and efficient heat transfer resistance of translucent and opaque fencing structures taking into account environmental influence of thermal power considering a provided specified level of heat loss through walling and provide a given level of energy efficiency of buildings.

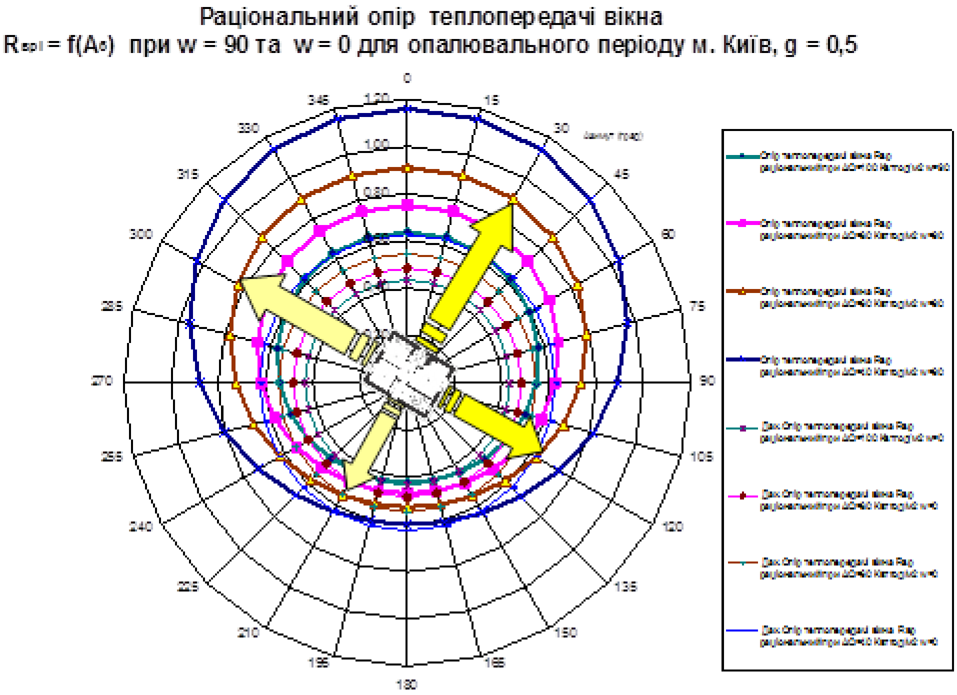

Fig. 1. Definition of rational resistance to heat transfer, depending on the orientation of windows and zones rational arrangement of windows on the facade of the building.

Literature

1. *Сергейчук О. В.* Оптимізація розподілу утеплювача по поверхні будівлі при заданому класі його ефективності / О. В. Сергейчук // Матеріали VI Міжнародної Кримської науково-практичної конференції «Геометричне та комп'ютерне моделювання: енергозбереження, екологія, дизайн». – Сімферополь, 2009. – С. 44–49.
2. *Мартинов В. Л.* Багатопараметрична оптимізація гранних енергоефективних будівель / В. Л. Мартинов // Матеріали VII Міжнародної науково-практичної конференції «Геометричне моделювання, комп'ютерні технології та дизайн: теорія, практика, освіта». – Ужгород, 2011. – С. 135–139.
3. Теплова ізоляція будівель : ДБН В.2.6-31:2006. – [Чинні від 2007-04-01] // Мінбуд України. – К. : Укрархбудінформ, 2006. – 65 с. – (Державні будівельні норми України).