IMPROVEMENT OF RELIABILITY OF CONVERTERS OF RENEWABLE ENERGY CONSIDERING THE CHARACTERISTICS OF PROBLEM AREAS

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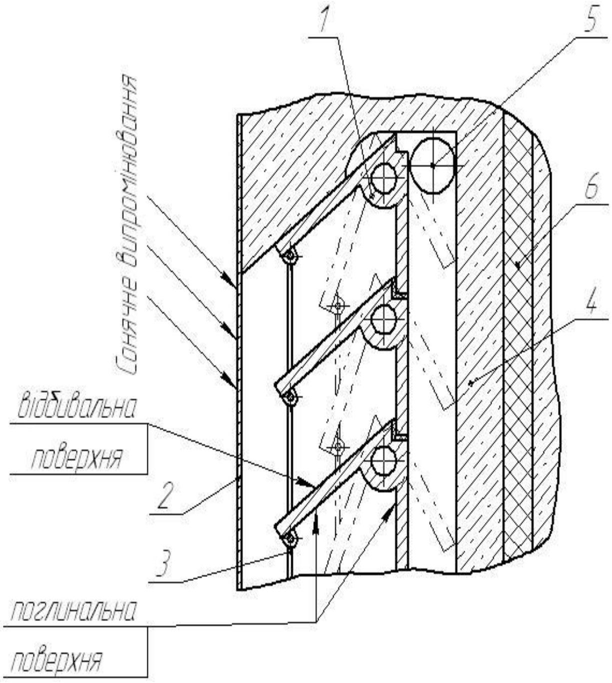
While using solar radiation, heat of the environment etc. in systems of air conditioning, it is reasonable to take into account that simple mechanical connection of renewable energy converters to the objects of traditional architecture can lead to an increase in the load on the design and not always a successful change in the thermal engineering parameters of the base enclosing structures and the architecture of the constructions.

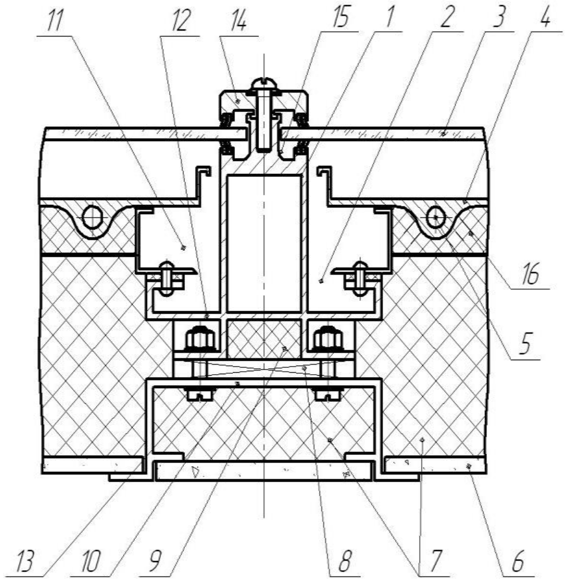
It is possible to eliminate these disadvantages by using air-conditioning converters in climate systems; in particular, such innovative design as energy-active fences. Such converters of renewable energy sources (RES) [1-4] allow to receive, transform, redistribute and accumulate energy in a controlled manner. Their use provides a positive energy balance between the energy from solar radiation and the environment and its losses.

Such constructive elements of the climate system as the RES converters like energy-active fences combine both passive and active elements of the structure. In addition to preventing the microclimate from environmental degradation, in the design of energy-active fences, the functional direct-regulated conversion of energy from the environment and solar radiation to thermal and/or electrical energy, transportation, accumulation, supply/discharge and radiation of thermal energy is established. These functions are realized by introducing in the design of the RES converter the energy-sensitive layers and elements, the channels of transport of the coolant, energy accumulation zones. Examples of such constructs [3] are presented in Fig. 1, 2.



1 – heat exchanger tubes, 2 – translucent coating, 3 – traction, 4 – wall of construction, 5 – ventilation duct, 6 – thermal insulation

Figure 1 – Converter of RES (energy-active fence), which prevents overheating of the building



1, 10 – rafters, 2, 11 – compartments, 3 – glass, 4 – heat absorbing element, 5 – channel with heat carrier, 6 – sheathing, 7 – thermal insulation, 8, 9 – insulating gaskets, 12 – outlet tray, 13 – bolts, 14 – fasteners, 15 – gutters

Figure 2 – A version of the RES converter with closed sections

The multilayer construction of RES converters in heat engineering is heterogeneous. They represent multi-layered complex systems made of various materials. The peculiarity of the technological use of the converters of RES is the presence of a large number of fastening elements, inter-panel joints, corner joints etc. on the base structures of construction (walls, roofs). Therefore, it is important to have information about the features of the heat engineering characteristics of the problem areas.

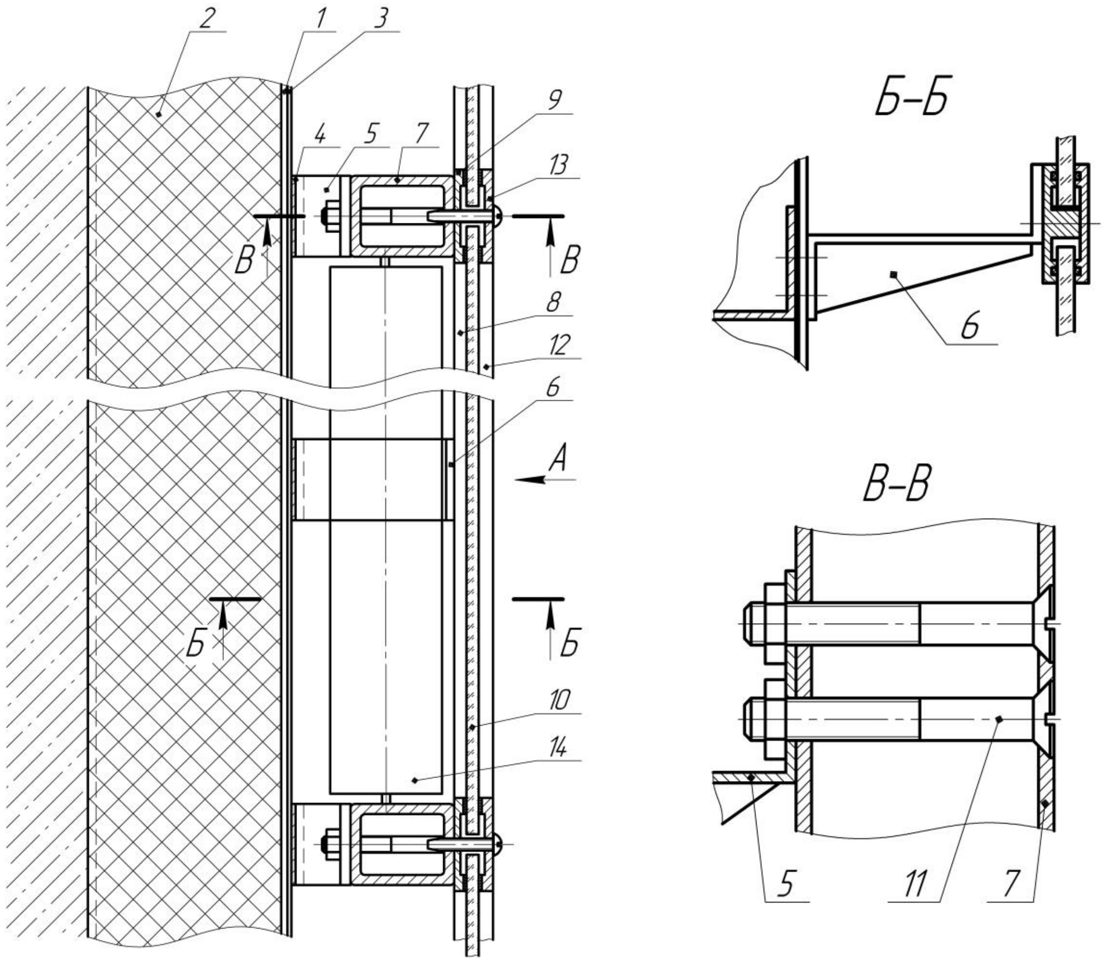
Estimation of the peculiarities of the thermophysical properties of such structures and their interfaces with the basic constructions can be carried out according to several standard methods.

In accordance with the methodology presented in [5], it is valuable to determine the heat-engineering properties of converters of RES:

- determination of the mean value of the resistance of heat transfer (this index must exceed the resistance required by the normative documents);

- determination of the required heat-protective properties of the least protected areas (this is necessary to ensure temperatures above dew point and to exclude condensation conditions).

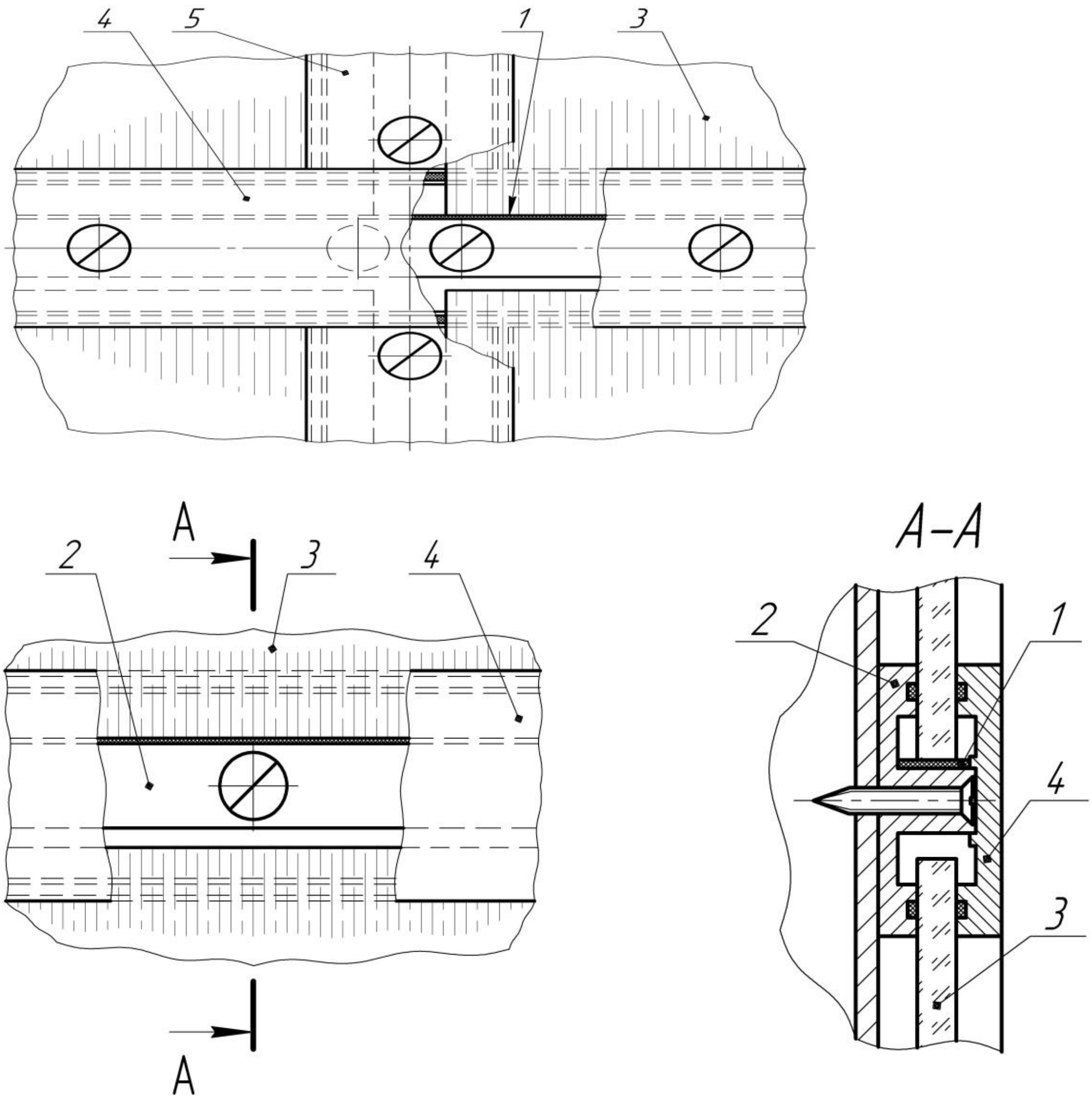
But such methods are rather complicated in the calculation, since it is necessary to take into account a large data array related to various physical and technical factors that affect the characteristics of the elements of the design of the converter and the basic elements of the structure.



1 – Z-profile; 2 – mineral wool insulation; 3 – wind barrier; 4 – clamping strap; 5 – bracket; 6 – auxiliary bracket; 7 – stand; 8 – horizontal aluminum profile; 9 – vertical aluminum profile; 10 – translucent thermal insulation; 11 – screw with a nut; 12 – horizontal decorative aluminum profile; 13 – vertical decorative aluminum profile; 14 – blocks of blinds; 15 – window

Figure 3 – An example of the location of the converter of RES on the basic construction structures and mounting elements

Therefore, in prediction of thermal engineering features of structures that use the power supply system with converters of RES, which are integrated in the basic constructions, it is necessary to take into account thermal inhomogeneity. The change in thermotechnical properties is determined by the presence of structural elements made of metal or other materials, i.e. determines the appearance of bridges of cold in such areas. Losses that accompany excessive conjugates, joints make up 47% of the total thermal loss of structures. These factors influence the temperature and humidity fields during the operation of the structures.



1 – rubber gasket; 2 – horizontal aluminum profile; 3 – translucent thermal insulation; 4 – horizontal decorative aluminum profile; 5 – vertical decorative aluminum profile

Figure 4 - Mounting elements for translucent insulation

In order to determine the thermophysical parameters of the conjugation basic structure – converter of RES it is proposed to use an objective parameter – the reduced resistance to heat transfer. This indicator allows estimating the influence of technological conjugates when placing the reactors on the base structures of RES. In accordance with [6-8], the reduced resistance of heat transfer is understood as a value equal to the ratio of the air temperature difference washing the multi-layered enclosing structure to its average area of specific heat flux in the stationary thermal regime. For a geometrically complex fence, the reduced resistance to heat transfer is a value equal to the resistance to the heat transfer of a uniform fence, the heat flux through which is equal to the heat flux through the complex conjugation under consideration.

The reduced resistance to heat transfer makes it possible to increase the reliability of determining the loss of heat through the i-th layer of the multi-layered interface the basic fence–converter of RES. In accordance with [6, 7], heat losses through the i-th layer of constructive conjugation are determined in accordance with the mathematical dependence:

$$Q = \frac{F_i}{R_T^{np}} t_B - t_H \cdot n \cdot l + \beta_i \tag{1}$$

where: Q – loss of heat through the i-th layer of the interface basic guard-converter of RES, W;

F_i – surface area of the structural interface, m^2;

R_T^{np} – reduced resistance of the heat transfer of the interface basic fencing-converter of RES, m^2 s / W;

t_B, $t_н$ – design temperatures inside the room and outside air, ^{0}C;

β – coefficient, that takes into account the level of heat loss through the interface the basic fence – converter of RES.

The advantage of using such indicator as the value of the reduced resistance of heat transfer is that it takes into account the peculiarities of the formation of the thermal coupling regime of the basic fence–converter of RES, i.e. takes into account the features of the angular sections, protruding sections, heat-conducting inclusions etc.

This approach allows promptly calculating of structures' thermal characteristics, the basic designs of which integrate RES converters. The calculated data will be decisive in determining the level of buildings' energy savings.

In accordance with the proposed methodology, the determination of the change in the values of the heat transfer coefficient or resistance to heat transfer for coupling, the basic fence–converter of RES is performed individually for each thermal inclusion (technological fastenings, joints, etc.) in accordance with the methodology presented in [8, 9], possibly by a simplified scheme or by calculating 2 or 3-dimensional temperature fields. It is assumed that the influence of the difference in the temperature field of each inclusion on the temperature field of the conjugate elements is not taken into account in the baseline fence–converter of RES. At the same time, the account of the influence of heat-conducting inclusions and thermal-engineering inhomogeneities is based on the European standard [10].

The above resistance of the heat transfer of the interface section, the basic fence–converter of RES can be calculated in accordance with the expression:

$$R_T^{np} = \frac{1_i}{K + \sum l_j \psi_j + \sum \eta_k \chi_k} = \frac{1}{K + \sum \Lambda K} \quad (2)$$

where: K – coefficient of heat transfer in the design hood, W / m^2 s.

At the same time, the heat transfer coefficient is calculated by the formula:

$$K = \frac{1}{R_T^{np}} = \frac{1}{\frac{1}{\alpha_B} + \sum_S \left(\frac{\delta}{\lambda}\right)_S + \frac{1}{\alpha_H}} \quad (3)$$

where: R_T^{np} – conditional resistance to heat transfer over the interface surface basic fence–converter of RES, m^2 s / W;

Ψ_j – specific heat losses through linear heterogeneity of the j-th type of coupling basic fence–converter of RES, W / m^2 s;

l_j – length of linear heterogeneity of the fragment of the j-th type, per $1m^2$ of the fragment of interface the basic construction–converter of RES, m / m^2;

X_k – specific losses of heat of interface basic construction–converter of RES through point inhomogeneity of the k-th type, W / ^{0}C;

N_k – the number of point inhomogeneities of the k-th type, which is clinging to $1m^2$ of the interface fragment the basic construction–converter of RES, pcs / m^2.

In accordance with the presented methodology, it is possible to simplify the assessment of the effect of heat transfer of various interfaces in the basic construction–RES converter.

Mentioned heat transmission resistance, which is proposed to use as a criterion for evaluating the thermal characteristics of the conjugate base fence–converter of RES, enables to set the level of the thermal protection in these areas objectively and quickly.

The use of the proposed methodology allows consideration of the features of operation of certain problem areas of constructive interfaces, including those that are technologically equipped with the largest number of thermal conductive inclusions per unit area, i.e. to determine the worst heat-shielding characteristics by which heat losses of building premises should be determined.

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