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ENERGOACTIVE MULTILAYERED CONSTRUCTION OF FENCING WITH A THERMAL-ACCUMULATING LAYER

Abstract. In work, based on the principle of operation of systems of passive use of solar energy, an energy-active multi-layer construction of a building fence with a heat-accumulating layer of increased thermal efficiency was developed. The choice and the design decision of the developed design of the energy-active fencing is substantiated. The effectiveness of the application of the structure is based on the fact that the construction of the enclosure includes a heat-accumulating layer of phase-transfer heat-accumulating material based on liquid paraffins and a heat-reflecting coating that increase the heat-storage capacity and increase the energy efficiency of the enclosure. The technical result of the developed fence design is an increase in resistance to the heat transfer of the fence, an increase in the heat storage capacity of the outer fence, and overall, a reduction in heat losses and an increase in the energy efficiency of the building.

Keywords: heat-accumulating materials, energy efficiency, construction, paraffin, heat transfer.

Introduction. Creation of conditions for reducing energy intensity and increasing energy efficiency by reducing energy consumption and reducing the ineffective use of fuel and energy resources is the main goal of the state program "Energy saving-2020" and ensures energy and environmental security of the country, stimulates the introduction of new innovative solutions and relates to the strategic tasks of the state [1].

Reduction of heat losses in buildings now depends on the competent design of external fences, and the degree to which they meet modern requirements for thermal protection of buildings. So close attention to the design of energy-efficient enclosing structures is explained, on the one hand, by the important place they occupy in the structure of the building, and on the other hand by the role they play in solving the problem of saving energy resources and raising the level of thermal protection of buildings.

Setting the purpose of the work. In the design of exterior enclosures of buildings, passive solar energy systems have been widely used in recent years, which are based on an organic combination in the construction of a layer of material with a large heat-accumulating capacity and a heat-insulating light-penetrating layer [2-6]. In the process of insolation, the transparent layer passes to the inner layer solar radiation and prevents the heat transfer in the opposite direction due to the greenhouse effect by thermal radiation, thermal conductivity and convection from the surface of the heat-storage layer.

In this connection, based on the principle of operation of systems of passive use of solar energy, the goal was to develop an energy-active multi-layer fencing structure of a building with a heat-accumulating layer of increased thermal efficiency.

Justification of the choice of the constructive solution. As an analog of the energy-active design, the working principle and construction of a flat solar collector with an air coolant were chosen [7]. In solar heating systems, a flat solar collector is one of the main elements that effectively use the energy of solar

radiation to heat an air or liquid coolant. A feature of energy-efficient flat solar collectors, and primarily of the heat-absorbing layer in it, is the ability to actively absorb heat not only of direct, but diffusive as well as reflected radiation, both in cloudless skies and in light cloud cover.

Recently, a number of systems and instruments have been developed that use the energy of solar radiation to power the building's premises [8,9]. However, these systems have not yet found wide application due to their relative high cost, lack of proper justification of the technical and economic efficiency of their use in the enclosing structures of buildings to increase the resistance to heat transfer of the fence and the generation of additional heat for heating the building.

Important in the development of energy-efficient fencing structures is the choice of the type of coolant. When determining the type of coolant of the reservoir, it is important to take into account factors such as the level of comfort created, the climate of the terrain, the compatibility of the reservoir with the building design, the simplicity and relative cost of the reservoir design.

According to the purpose of the work, the possibility of saving energy for heating using solar energy is considered, therefore, air-active air-type structures that provide a relatively simple way of transferring solar heat to a room will be more preferable.

When they are used, there are no problems associated with the addition of additional antifreeze additives to the coolant to prevent multiple freezing and thawing in liquid systems.

When solving the problem of compatibility of heat-storage structures with the design of external fencing, it is important to take into account the advantage of placing an energy-efficient air-type structure in the walls of the south or south-west orientation or to integrate them into the fence construction in the deaf or fence piers.

It is known that when placing energy-efficient structures on the roof of a building, the length of the ducts to heated rooms or to the heat accumulator, usually located close to the ground level, increases, which reduces the efficiency of the system. Therefore, the merit of energy-efficient air-type structures is their greater compatibility and organic connection with the outer enclosing structures of the building, which allows to increase the thermal efficiency of external fences in the process of solar insolation.

Energy-efficient air-type structures also have a lower cost compared to liquid systems due to the possibility of reducing costs for installation, repair and maintenance.

When justifying the dimensions of the energy-active structure, it should be taken into account that in order to achieve the best heat transfer conditions between the heat storage material and the circulating air, the panel should be placed in the structure at a small distance from its internal surfaces in order to obtain the greatest possible pressure drop. However, one should keep in mind the lower specific and volumetric heat capacity of air, and therefore the dimensions of the space for air circulation should be optimized for each specific energy-active construction.

The efficiency of solar energy-active designs largely depends on the choice of heat-accumulating material in the panel. Perspective and economically expedient heat-accumulating materials are energy-saving materials with a hidden form of energy storage, which include phase-transfer heat-accumulating materials [10-12]. In phase-transfer heat-storage materials, the transfer of thermal energy occurs during a phase transition, when the material passes from a solid state to a liquid state. Unlike the known heat-accumulating materials in phase-transfer heat-accumulating materials, the heat release occurs due to the creation of a crystalline structure, and the accumulation is due to the destruction of the structure during melting.

When using phase-transfer heat-accumulating materials in enclosing structures, a number of requirements are imposed, the essential ones being: the maximum enthalpy of melting and phase transition of the material from solid to liquid; required operating temperature of melting and phase transition and its high stability; good reproducibility of the thermophysical properties of the material over a large cycle of melting and crystallization; compliance with environmental safety standards; inertness with respect to structural materials.

In the energy-active construction, in accordance with the results of the scientific justification [13], the material of a phase transition based on commercial paraffins is adopted as the heat-accumulating material. The heat-accumulating material based on paraffins adopted in the fence design is distinguished by its high heat capacity and relatively low melting point of the phase transition, insignificant shrinkage and corrosive inertness with respect to the metal.

The thermal performance of energy-active structures with a heat storage panel is affected by the velocity of the coolant in the channel. Experience in the design of solar collectors shows that the air consumption per 1 m² of the solar panel varies from 5 to 30 liters/s, but it is noted that the optimal air flow rate is usually 10-14 liters/m²·s. It is taken into account here that its increase from 10.1 to 15 l/m²·s leads only to a slight improvement in the thermal performance of the panel, causing an increase in energy consumption for air pumping.

It is known that the efficiency of a solar energy-active panel and the density of incident solar radiation depends on the orientation of the translucent panel. In view of the fact that the design being developed is located or built into vertical outer fences, the highest intensity of the solar radiation flux for a vertical surface falls on the horizon of 2000-2900. This orientation corresponds to the south and south-west direction. However, it should be noted that strict orientation to the south or to the south-west of the vertical enclosure with heat storage panels is not critical, since a slight (up to 150) deviation of the vertical guard from this sector causes a slight decrease in thermal performance.

This indicates the advisability of using energy-active structures with heat-storage layers on the external surface of buildings that are not only strictly latitudinal, but also on buildings oriented with small deviations from this direction.

When choosing translucent coatings for energy-efficient structures, it should be borne in mind that an increase in their number raises thermal productivity, but at the same time leads to a significant increase in its cost. However, practice shows that the optimal for the purposes of space heating is the use of double-pane glazing of the thermo-accumulating panel.

One of the most difficult questions in designing an energy-efficient design, as an analog of a flat solar collector, is to ensure the impermeability and tightness of its connections. The prevention of leakage of the heat-transfer medium has not less value for an air-storage heat-storage panel than for a liquid-type reservoir. Infiltration of cold air through the joints of the translucent coating and leakage of heated air through the connections of ducts and air ducts can significantly reduce the heat and power characteristics of the panel. Therefore, the tightness of the joints of the constructed energy-active design was considered one of the important factors in ensuring the efficiency of its operation.

Description of the developed fencing construction. Thus, the study of construction experience and a review of the results of research on the operation of energy-active structures and on the design of flat solar collectors has made it possible to determine ways to solve a number of technical issues on the development of an energy-active design and increase its thermal efficiency.

As a result of the analysis of various fencing design variants, the following constructive solution of the energy-efficient design adapted to hot climatic conditions was chosen and satisfying the compatibility problems of the designed structures with the external enclosing structures of the building in accordance with figure.

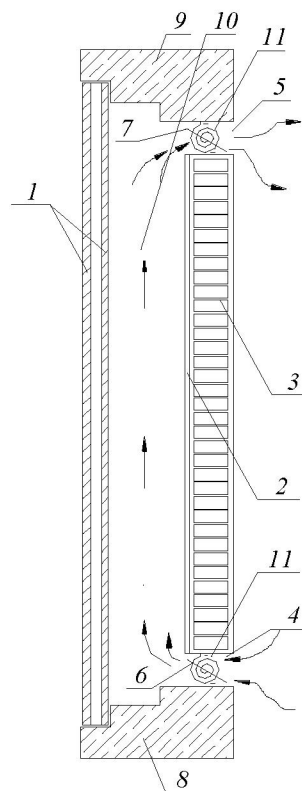
The technical result of the developed fence design is an increase in the resistance to the heat transfer of the fence and an increase in the heat storage capacity of the outer fence using a wall panel with heat-accumulating material based on commercial paraffins in their construction.

The effectiveness of the developed design is based on the fact that the construction of the enclosure includes a heat-accumulating layer of phase-transfer heat-accumulating material based on liquid paraffins and a heat-reflecting coating that increase the heat-storage capacity and increase the energy efficiency of the enclosure.

The developed energy-efficient construction of the building wall enclosure includes a double translucent coating 1, a reflective foil 2 film, a wall panel 3 filled with phase-transfer heat-storage material, based on commercial paraffins with a melting point of 25-50 °C and a total enthalpy of melting and phase transition 205-212 J/g. The dimensions of the module of the structure along the external faces are assumed to be equal to the size of the window sash and the pier. In the upper and lower parts of the guard there are channels 4 and 5, in which the thermostatable shutters 6 and 7 are installed. The guard has a lower 8 and a top 9 part. The heat medium flows through the inlet 4 and is discharged through the outlet 5, passing through the duct 10. The flaps are controlled by the thermostat 11.

To ensure high tightness of the butt joints of air ducts and a translucent coating, weatherproof glue is used. To tightly connect the energy-efficient structure to the window or wall binder, a special presser and elastic airtight gaskets are used.

Energy-active design of the enclosure
with a thermo-accumulating layer



Solar radiation, penetrating through the transparent double coating 1, enters the reflective foil 2. The air heated by the foil 2 rises through the channel 10 and exits from the outlet 5 into the room, and cold air enters through the inlet at the level of the floor 4. Thus, air circulation and space heating are carried out. Together with the heating of the air in the channel 10, the heat accumulating panel is heated, filled with phase-transfer heat-accumulating commercial paraffin, to the melting temperature and above. If the air in the room is heated above the permissible temperature, the shutters 6 and 7 that regulate the thermostat 11 are closed, the sun's rays heat the air in channel 10, and part of the solar energy passes through the retro-reflective layer 2 to the inner heat-storage panel 3 and, while heating it, accumulates in it. At night and overcast, indoor air is heated from the wall panel 3, both with open and closed flaps. Due to the tight contact between the heat reflective layer 2 and the panel 3, the heat from the panel is transmitted to the room when the flaps are closed. Layer 2 serves as a heat-reflecting layer for the inner panel 3, which in its turn, due to the phase transition (crystallization) of the heat-accumulating liquid paraffin, keeps the heat in the room. Regulation of air temperature in the room is carried out by regulating the degree of air circulation through the channel 10 by opening the shutters 6 and 7 controlled by the thermostat 11 more or less. When the room temperature rises, the damper under the influence of the thermostat is covered and due to the heat in the room the heat storage material of panel 3 melts and accumulates heat, when the temperature decreases - the flaps open and the heat is transferred to the building.

Justification of the developed fencing construction. To justify the thermal efficiency of the application of the energy-active multi-layered construction of the enclosure with the heat-accumulating layer, calculations were performed by the method [14]. Calculations were made for a two-story individual residential building with a total area of 120 m² for the climatic conditions of the city of Turkestan. The thermal efficiency of the building fencing was estimated by the specific consumption of heat energy for heating for the heating season, depending on the area of the fence. The calculation results showed that the specific heat consumption for heating the building with the traditional structural solutions of the building was 95 kJ/(m²·°C·day), and for the area of energy-active structures 20 and 40 m², 89 kJ/(m²·°C·day) and 84 kJ/(m²·°C·day). The share of heat compensated by the use of energy-active structures of the fence with a heat-storage layer, with the area of energy-active structures 20 m² was 6% and at an area of 40 m² – 11%.

Conclusions. The proposed constructive solution of the energy-efficient multi-layered fencing provides a reduction in heat losses and an increase in the energy efficiency of the building. At the same time, the fence structure has an increased heat capacity due to the use of the heat-storage layer from the phase-transition heat-accumulating material based on the commodity paraffin. The accumulation of heat in the fence panel regulates the thermal regime in the room, and the heat-reflecting layer of the foil and the heat-accumulating layer from the phase-transition heat-storage material serve as a heat-shield layer in the enclosure.

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ЭНЕРГОАКТИВНАЯ МНОГОСЛОЙНАЯ КОНСТРУКЦИЯ ОГРАЖДЕНИЯ С ТЕПЛОАККУМУЛИРУЮЩИМ СЛОЕМ

Аннотация. В работе, основываясь на принципе работы систем пассивного использования солнечной энергии, представлены данные по разработке энергоактивной многослойной конструкции ограждения здания с теплоаккумулирующим слоем повышенной тепловой эффективности. Обоснован выбор и описано конструктивное решение разработанной конструкции энергоактивного ограждения. Эффективность применения конструкции основана на том, что в конструкцию ограждения входит теплоаккумулирующий слой из фазо-переходного теплоаккумулирующего материала на основе жидких парафинов и теплоотражающее покрытие, которые увеличивают теплоаккумулирующую способность и повышают энергоэффективность ограждения. Техническим результатом разработанной конструкции ограждения является повышение сопротивления теплотеплопередаче ограждения, увеличение теплоаккумулирующей способности наружного ограждения, и в целом, уменьшение тепловых потерь и увеличение энергоэффективности здания.

Ключевые слова: теплоаккумулирующие материалы, энергоэффективность, конструкция, парафин, теплопередача

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ЖЫЛУАККУМУЛЯЦИЯЛАУШЫ ҚАБАТТЫ ЭНЕРГОБЕЛСЕНДІ КӨПҚАБАТТЫ ҚОРШАУ КОНСТРУКЦИЯЛАРЫ

Аннотация. Жұмыста күн энергиясын пассивті қолдану жүйесі жұмысына негізделген, жылу тиімділігі жоғары жылу аккумуляциялаушы қабаты бар ғимараттардың энергобелсенді көпқабатты қоршау конструкциялары жасалынғаны жайында мәліметтер берілген. Жасалынған энергобелсенді қоршау конструкциясының құрылымдық шешімі негізделіп, айқындалған. Конструкциялардың қолдану тиімділігі сұйық парафиндер негізінде фазалық ауысу қабілетті жылу аккумуляциялаушы қабат пен жылу шашыратушы беткейден құралатын қоршау конструкцияларының жылу аккумуляциялаушы қасиеті мен қоршаулардың энерготиімділігін жоғарылататын оңтайлы құрамына негізделеді. Жасалынған қоршау конструкциясының техникалық нәтижесі қоршаулардың жылу өткізуді қарсылығын жоғарылату, сыртқы қоршаулардың жылу аккумуляциялаушы қабілетін күшейту, жылуды жоғалтуды төмендету және ғимараттардың энерготиімділігін өсіру болып табылады.

Түйін сөздер: жылу аккумуляциялаушы материалдар, энерготиімділік, конструкция, парафин, жылу берілу.