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THERMAL-CONTAINING MATERIALS BASED ON PHASE TRANSITION IN THE CONSTRUCTION INDUSTRY

Abstract. The article presents a brief analytical review and possible ways of obtaining heat-accumulating materials with an optimal specific heat. The resulting heat-accumulating materials are characterized by the following properties: high enthalpy of phase transition and density; the required operating melting temperature; high heat capacity, both in solid and liquid phases; absence of stratification of heat-accumulating material and temperature stability; low thermal expansion and low shrinkage upon melting; weak chemical activity (inertness) to structural materials. The technical and scientific novelty of the work is the production of heat-accumulating materials, with a reduction in heat losses, increased heat storage capacity due to an increase in enthalpy of phase transition, protecting buildings from overheating in the summer and overcooling in winter.

Keywords: thermal-accumulating materials, constructions, temperature, heat capacity, crystallization.

The impact of energy on the economy can be safely attributed to the number of determinants of modern social development. The energy problem is one of the key technical, economic and social problems facing humanity. Ensuring energy demand entails not only the development of the energy complex, but also rational consumption, energy saving, the involvement of new renewable energy sources in the energy balance, construction and reconstruction of energy efficient and energy-active buildings.

One of the promising areas of energy conservation in power buildings is the use of heat storage. The process of heat accumulation is associated with providing comfortable conditions in the premises of residential and public buildings using various heat-storage materials (TAM), the accumulation of heat in which is produced through the use of thermal properties [1-4].

As passive TAM, building materials such as concrete, brick, stone, and wood are traditionally used, which have high heat capacity. These materials directly absorb and radiate absorbed energy upon heating and subsequent cooling.

In the expanded version, various compositional mixtures are widely used as TAM of the passive type [5-7]. However, it should be noted the low heat capacity of such materials, and, consequently, the low (thermal) heat-accumulating capacity of the structure.

Undoubtedly, the development of heat-accumulating materials in the form of polymer composites with additives of industrial waste to produce materials with the optimum specific heat is of great interest.

In materials with the latent heat of accumulation, heat transfer occurs during a phase transition when the material passes from solid to liquid state. These materials are called phase-transfer TAMs. The property of such TAMs to increase the heat capacity during the phase transition is used in the development of effective wall panels, multi-layered enclosing structures with a layer of heat-accumulating material, and also in heat accumulators. A classic example of the use of phase-transfer TAMs is to maintain the room temperature by periodically absorbing and releasing the heat of the phase transition during the day and night.

At present, multilayered wall panels of the building with phase-transition TAM have been applied [8-10]. Such panels provide a reduction of heat losses, increase thermal-accumulating ability due to an increase of enthalpy of phase transition, protect buildings from overheating in summer and supercooling in winter.

To increase the accumulating capacity and to ensure the regulation of the thermal conditions of the rooms, it is recommended to use wall panels with a special layer of phase-transfer thermal-accumulating material.

The thermal efficiency of application of thermal-accumulating material on the basis of paraffins with the solid-liquid phase transition in the enclosing structures of the building was investigated in [11]. The aim of the study was to study the dynamics of cooling of a room with thermal (heat)-accumulating material in wall constructions.

The thermal-accumulating material is adopted with the following characteristics: melting point $T_ф = 20{,}12^0 C$; density of liquid phase $\rho_ж = 770\, кг/м^3$; density of solid phase $\rho_{тв} = 900\, кг/м^3$; heat capacity of liquid phase $c_ж = 3{,}04\, кДж/(кг{\cdot}^0 C)$; heat capacity of solid phase $c_{тв} = 2{,}91 кДж/(кг{\cdot}^0 C)$; thermal conductivity of the liquid phase $\lambda_ж = 0{,}21 Вт/(м \cdot К)$; thermal conductivity of the solid phase $\lambda_{тв} = 0{,}3 Вт/(м \cdot К)$.

External wall - three-layer: the first layer (internal) - from heat-accumulating material; second layer - insulation thickness 250 mm; thermal conductivity $0{,}06 Вт/(м \cdot К)$; the third layer is made of brick thickness 510 mm. Room volume 37,5 m^3 hight 2,5 m, width 3 m, length 5 m, area of the outer wall, minus the area of the window 6,5 m^2, thickness of heat-accumulating material was taken 10,50 and 100 mm. In figure 1 shows the graphs of the change in air temperature in the room.

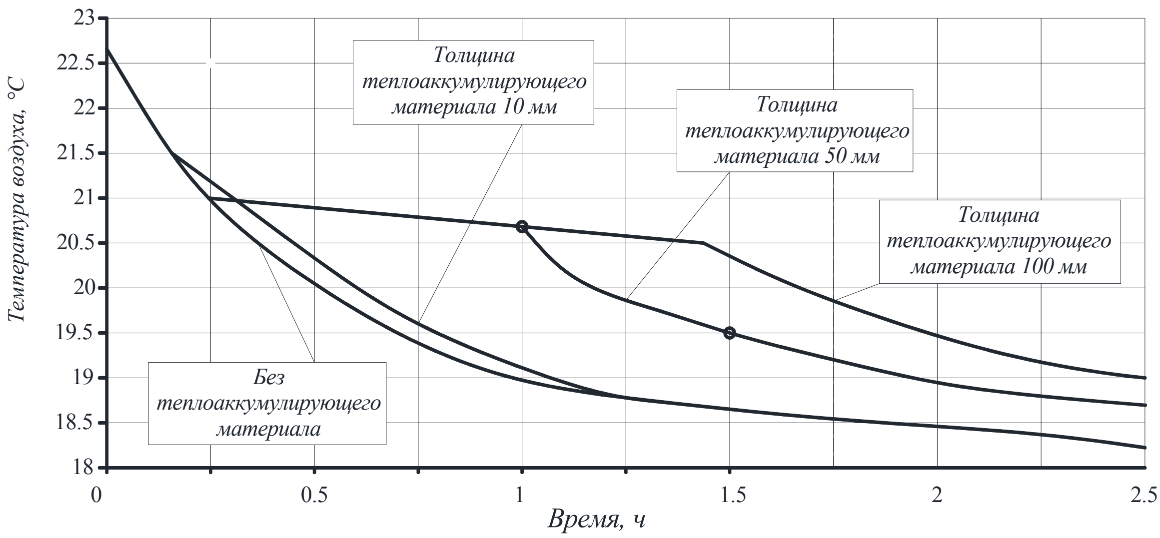

Figure 1 – Change in air temperature in the room

According to the idea of work, when the temperature of the outer surface of the layer of heat-accumulating material is reduced to the crystallization temperature, the thermal-accumulating material passes from the liquid state to the solid state, releasing the heat of the phase transition. The temperature of the TAM layer throughout the entire thickness becomes equal to the temperature of the phase transition. As crystallization, the boundary of the phase transition shifts to the inner surface of the fence. The process is completely completed when the boundary of the phase transition reaches the inner surface of the TAM. This process is reflected by a horizontal plot on the graphs of the air temperature change in the room of figure 1. After the TAM crystallization process is complete, the cooling process again passes the regime of regular heat exchange.

Thus, the use of TAM in enclosing structures retains the internal air temperature of the room for a longer time within acceptable limits, increasing the time of comfortable stay in the room.

Currently, work is underway to develop encapsulated TAM for inclusion in the finishing layer of the fence. For example, BASF has developed a heat-accumulating material for a phase transition based on paraffins, which are microcapsules made of polymers. Inside the microcapsules, there is a paraffin-based material that has a phase transition at temperatures close to room temperature [12].

Microcapsules are incorporated into various finishing materials. Capsules have high strength and do not change the technology of working with building materials. Excess heat of absorption during the day, at night, is released back, which "smoothes out" the temperature fluctuations, creating a comfortable climate in the room.

In the design of exterior enclosures of buildings, solar energy active use systems have been widely used in recent years, which are based on a limited combination in the construction of a layer of material with a large heat-storage capacity and a heat-insulating layer. Ficture 2 shows the energy-active design of a fence with a heat storage panel [13].

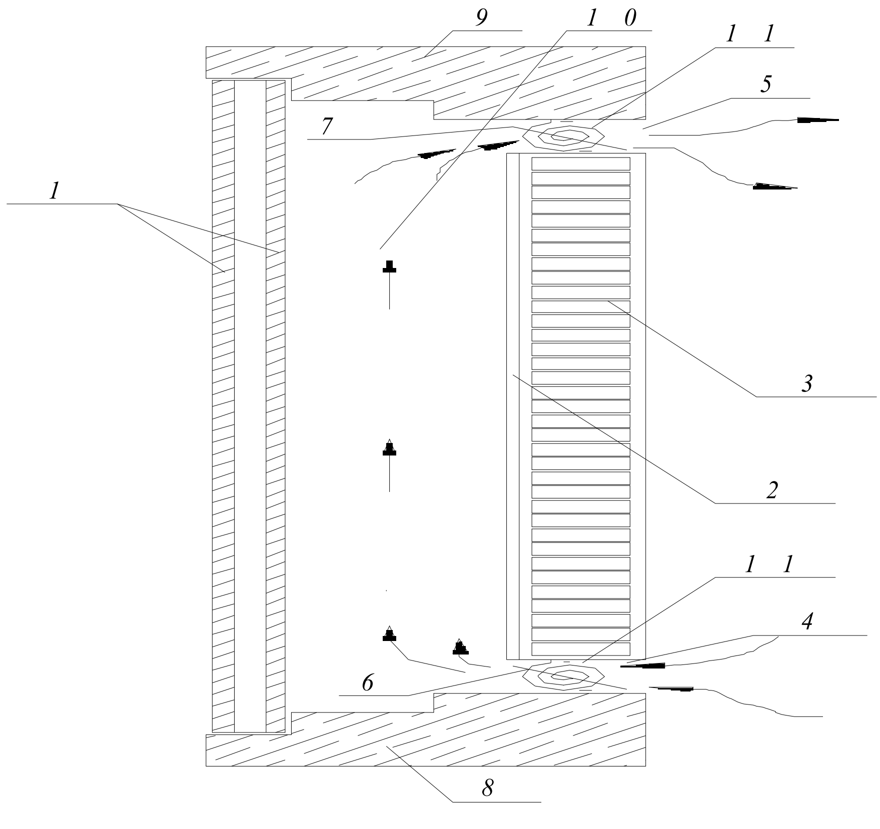

Figure 2 – Energy-efficient fence construction with heat storage panel:
1 – double translucent coating; 2 – reflective foil film; 3 – wall panel; 4 and 5 – openings in the upper and lower parts of the fence, respectively inlet and outlet; 6 and 7 – thermostatically controlled dampers; 8 and 9 – respectively, the lower and upper parts of the fence; 10 – the channel; 11 – thermostats, regulating flaps

Together with the heating of air in channel 10, according to the principle of the Trombus-Michel wall, a heat storage panel filled with phase-transition TAM based on paraffin is heated up to the melting temperature of TAM and above. The energy-efficient design of the fence ensures a reduction in heat losses and an increase in the energy efficiency of the building. At the same time, the heat capacity of the enclosure increases due to the use of a heat storage panel with a phase-transfer heat-storage material, since its melting enthalpy is greater than the heat capacity of the materials used. Heat accumulation in the fence panel regulates the thermal regime in the room, and the heat-reflecting layer of the foil and the heat-storage pane with the phase-transition heat-storage material serve as a heat-shield layer in the enclosure.

Note that the effectiveness of TAM depends not only on the design of the fence, wall panels or heat storage devices, but also on the use of the most effective materials used as phase-transfer TAMs.

The accumulating material developed by us on the basis of the phase transition used in construction is supposed to have the following properties:

– high enthalpy of phase transition and density;
– the required operating melting temperature;
– high heat capacity, both in solid and liquid phases;
– lack of stratification of heat-accumulating material and temperature stability;
– low thermal expansion and slight shrinkage during melting;
– weak chemical activity (inertness) to structural materials.

Thus, the scope of TAM in the construction industry is very wide, which justifies the need to develop new materials adapted to operational conditions of buildings.

The solution to this problem lies in a strict scientific approach and the need for a systematic study of the thermophysical characteristics of TAM, ensuring the stability of these characteristics, as well as intensifying research and using multicomponent TAMs with high values of the heat of phase transition.

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ТЕПЛОАККУМУЛИРУЮЩИЕ МАТЕРИАЛЫ НА ОСНОВЕ ФАЗОВОГО ПЕРЕХОДА В СТРОИТЕЛЬНОЙ ИНДУСТРИИ

Аннотация. Представлены краткий аналитический обзор и возможные способы получения теплоаккумулирующих материалов, обладающих оптимальной удельной теплоемкостью. Полученные теплоаккумулирующие материалы характеризуются следующими свойствами: высокую энтальпию фазового перехода и плотность; необходимую эксплуатационную температуру плавления; высокую теплоемкость, как в твердой, так и в жидкой фазах; отсутствие расслоения теплоаккумулирующего материала и температурную стабильность; низкое термическое расширение и незначительную усадку при плавлении; слабую химическую активность (инертность) к конструкционным материалам. Технической и научной новизной работы является получение теплоаккумулирующих материалов, с уменьшением тепловых потерь, повышенной теплоаккумулирующей способностью за счет повышения энтальпии фазового перехода, предохраняющие здания от перегрева летом и переохлаждения зимой.

Ключевые слова: теплоаккумулирующие материалы, конструкции, температура, теплоемкость, кристаллизация.

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ҚҰРЫЛЫС ИНДУСТРИЯСЫНДАҒЫ ФАЗАЛЫҚ АУЫСУ НЕГІЗНДЕ АЛЫНАТЫН ЖЫЛУАККУМУЛЯЦИЯЛАУШЫ МАТЕРИАЛДАР

Аннотация. Мақалада оңтайлы меншікті жылусыйымдылық қасиетіне ие жылуаккмуляциялаушы материалдарды алу мүмкіндігі мен қысқаша аналитикалық әдебиеттік шолулар берілген. Алынған жылуаккмуляциялаушы материалдар келесі қасиеттерге ие болатыны анықталды: фазалық ауысудың жоғарғы энтальпиясы мен тығыздылығы, қажетті эксплуатациялық балқу температурасы, қатты және сұйық фазадағы жоғарғы жылусыйымдылық, жылуаккмуляциялаушы материалдардың қабаттануының болмауы мен температуралық тұрақтылығы, төменгі термиялық кеңеюі және балқу кезінде азғана шөгуі, конструкциялық материалдарға әлсіз химиялық белсенділігі (инерттілік). Бұл жұмыстың техникалық және ғылыми жаңалығы жылуаккмуляциялаушы материалдардыалу кезінде келесі факторлар: жылу шығындардың төмендеуі, қыстақатты суықтаудан және жазда қызып кетуден ғимаратты қорғайтын, фазалық ауысу кезінде энтальпия арттыру арқылы жылу сақтау қабілеті артуы ескерілген.

Түйін сөздер: жылуаккмуляциялаушы материалдар, конструкциялар, температура, жылусыйымдылық, кристаллизация.

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