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POSSIBILITIES OF THE AEROGEL APPLICATION IN BUILDING

The paper presents the aerogel, material which can be more widely used in building. The examples of the use of aerogel and the results of laboratory tests connected with the insulation properties are presented. It seems that the aerogel, due to its good thermal characteristics can improve the energy efficiency of buildings.

Key words: insulation in buildings, insulation materials, energy efficiency, transparent barriers, aerogel.

Описується аерогель – матеріал, який може бути ширше використаний у будівництві. Наведено приклади використання аерогелю і результати лабораторних випробувань, пов'язані з ізоляційними властивостями. Аерогель, завдяки його хорошим теплотехнічним характеристикам, може поліпшити енергоефективність будівель.

Ключові слова: ізоляція будівель, ізоляційні матеріали, енергоефективність, прозорі бар'єри, аерогель.

Introduction

The rising costs of conventional energy production, the EU directives obliging member countries to reduce energy consumption and greenhouse gas emissions are the green light to look for more and more effective thermal insulations even at a relatively high cost of production. The insulating material, which appears to meet the increasing demands, can be – aerogel – nanoporous material, ultra-light and transparent, for the first time received nearly eighty years ago, by Samuel S. Kistler – American chemist.

Production of aerogel

In the production of an aerogel is used chemical method involving the reaction of tetrafunctional alkoxysilanes extremely diluted with water vapor (for example, $Si(OCH_3)_4$) in an inert atmosphere. In the first step, as a result of hydrolytic condensation is soft silica gel. Before the created silica foam is completely congeal, slowly is reducing the pressure in the reactor, until the almost complete vacuum and as a result is a rapid increase in volume of the gel.

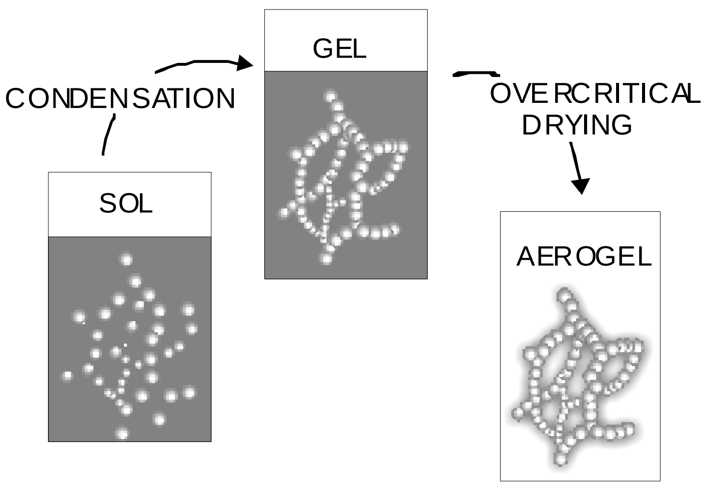

Fig. 1. Diagram of aerogel formation

In the final stage of production, the reactor is carefully filled by inert gas again and at the same time the temperature is increasing, which leads to the end of the condensation reaction, and the durable aerogel is ready.

Properties of aerogel products

The aerogel structure consists of a rigid skeleton like a spatial truss which surrounds pores having sizes of 10 – 200 nm. The porosity is from 90 to 99%. The density, depending on the method of production is from 2 to several dozen kg/m^3 [1]. Despite the low density material has a high compressive strength. The pure material has hydrophilic properties, therefore in contact with the water can cause damage to the internal structure. However, due to chemical modification, aerogel is the hydrophobic material and is suitable for general use. It has a very low thermal conductivity – thermal conductivity factor ranges from 0.013 to 0.03 W/mK. This is due primarily to limited conduction through the internal structure and convection (pore dimensions are comparable to the free path of air molecules) and a high absorption of radiation by silica, which also can be increased by modifying the aerogel using carbon compounds. These properties make this material may be an excellent thermal insulation, the thermal resistance may correspond to three times thicker insulation with traditional materials. Currently available aerogel insulations are in various forms: granules, tapes, plates (Fig.2). Because from the thermal conductivity of the aerogel depends the operating temperature, which can range from -270° C to +650° C, the final products are appropriately modified to preserve the best performance under certain, specific conditions.

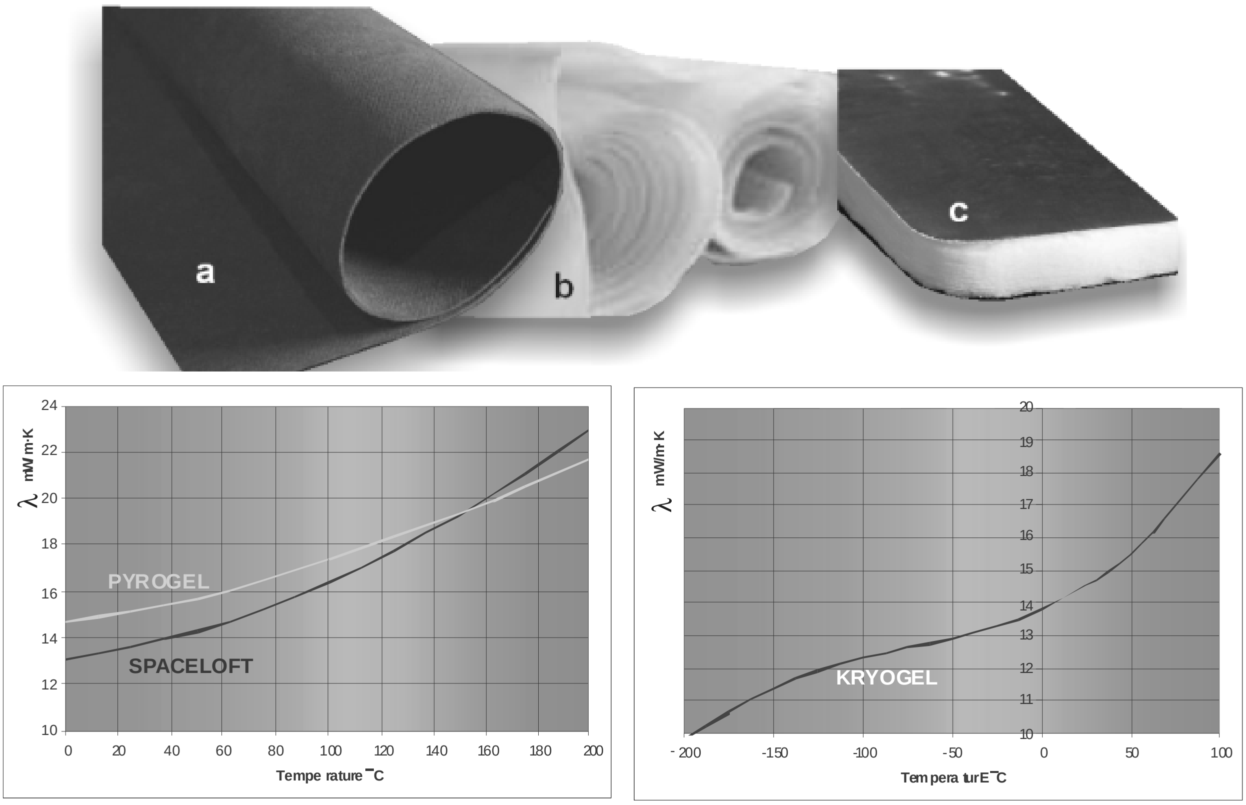

Fig. 2. Examples of the aerogel insulation and dependence of the thermal conductivity to the operating temperature: a) Pyrogel, b) Spaceloft, c) Kryogel [7]

In addition to these thermal insulation properties, aerogel has also another attribute, which is particularly attractive to architects – transmits light. This ability opens up new possibilities for the design external walls, which in addition to the traditional functions (protection from weather conditions, cold, heat, noise), can also to deliver scattered light to rooms. Aerogel in the composite with glass improves thermal insulation (thermal and acoustic of windows).

Practical application of aerogel

Windows with aerogel granulate insert is shown in Fig.3. The window has a U-value of 0.4 W/m^{2}K.

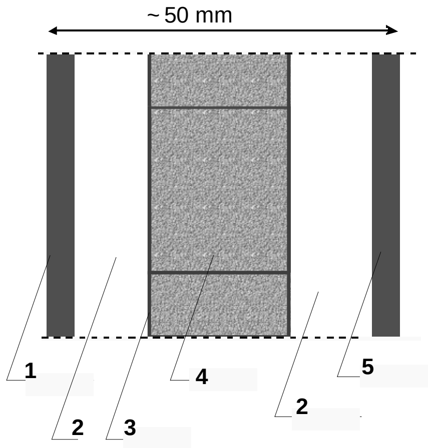

Fig. 3. Diagram of a window with an aerogel insert [3]
1 glass, 2 xenon, 3 acrylic skeleton, 4 aerogel granulate, 5 glass with reflective layer

Aerogel insulation can be integrated with the facade of the building, such example is presented on the Fig. 4.

Fig. 4. Aerogel insulation integrated into the facade of the building [11]

Another example of aerogel using in the envelope of the house are wall panels of 7 cm thick (Fig. 5, 6). They are translucent but not transparent and therefore they deliver light to the room without causing glare. They have a U-value = 0.28 W/m^{2}K and reduce noise of 5 dB [10].

Fig. 5, 6. Examples of the use of aerogel panels (hall and gym) [9]

Aerogel in solar collectors

The aerogel can be used in solar systems; collectors, thermal-storage walls, etc.(Fig.7). Placed in solar collectors in the space between the glazing and the absorber increases their efficiency by significantly reducing heat loss from the surface [3].

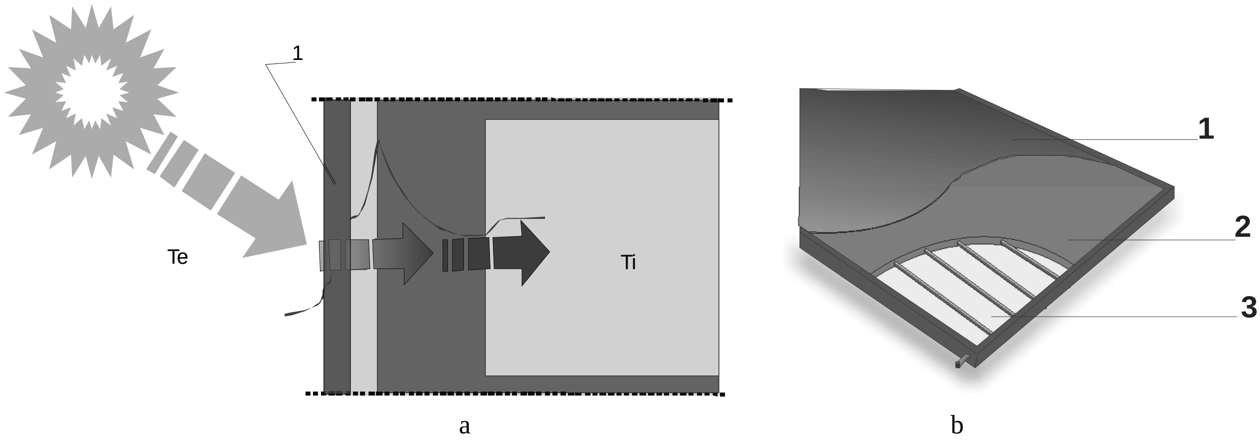

Fig. 7. Diagrams of the aerogel panels application: a) thermal-storage wall, b) solar collector
1. glazing of solar collector, 2. aerogel panels, 3. insulation of solar collector

Experimental studies of thermal properties of glass sets

Laboratory tests of thermal properties for two traditional sets of glass and also glazing with single chamber with nanogel, were made at the Department of Building Engineering, Rzeszow University of Technology. The results show high thermal insulation system with nanogel (U = 0.6 W/m^2K). On the Fig. 8, there are heat fluxes for glass sets, the horizontal axis shows the test time, while the vertical axis represents heat flux. Tests were conducted at a temperature difference of 25° C.

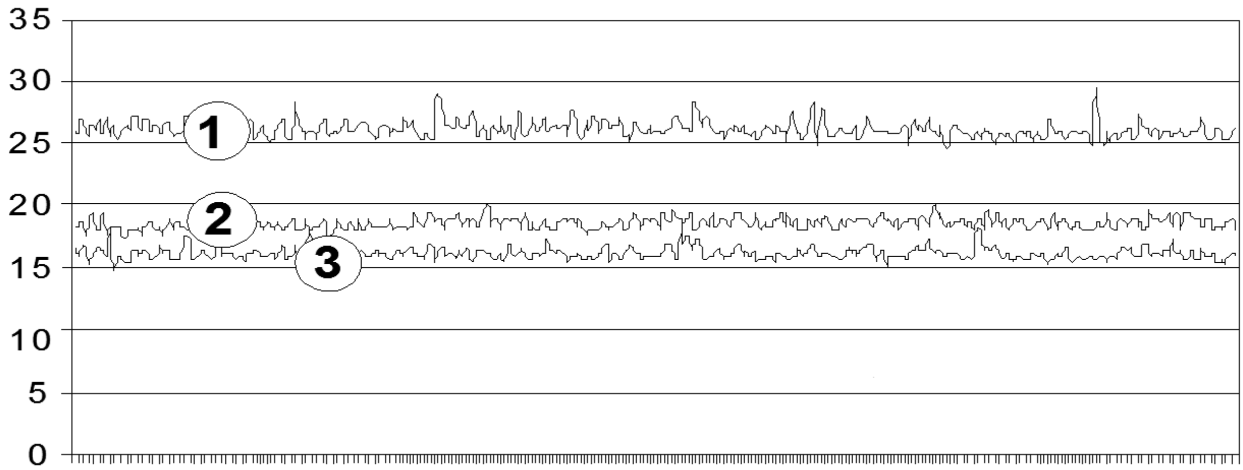

Fig. 8. Graph of heat flux:
1 – single-chamber glazing,
2 – two-chamber glazing,
3 – single-chamber glazing with nanogel

Conclusions

It seems that the aerogel can be more widely used in buildings, which are made in low-energy standard. Until recently was thought, that the aerogel can not replace typical transparent windows. By using scientific research, modern aerogel glass was developed, which apart from the low thermal conductivity (about 0.02 W/mK) has a good transparency [4, 5, 6]. The use of aerogel in architectural objects can be beneficial both in terms of energy efficiency as well as improve the esthetics of the building. These are the right directions for the development of a modern and low-energy building.

Fig. 9. Modern aerogel glass [8]

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