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Review

Vacuum insulation panel products: A state-of-the-art review and future research pathways

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HIGHLIGHTS

- State-of-the-art review of vacuum insulation panel products.
- Future research pathways for vacuum insulation panels.
- Vacuum insulation panel cores and envelopes.
- Vacuum insulation panel properties.
- Vacuum insulation panels for building applications.

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ABSTRACT

Vacuum insulation panels (VIP) are regarded as one of the most upcoming high performance thermal insulation solutions. At delivery, thermal conductivity for a VIP can be as low as 0.002–0.004 W/(mK) depending on the core material. VIPs enable highly insulated solutions, and a measure to reduce the energy usage in both hot-water applications, cold applications and for the construction industry in general. This study gives a state-of-the-art review of VIP products found available on the market today, and explore the future research opportunities for these products.

VIPs have been utilized with success for applications such as freezers and thermal packaging, and during the last decade they have also been used for building applications in increasing numbers, where one of the main driving forces is the increased focus on e.g. passive houses, zero energy buildings and zero emission buildings. Hence, VIPs are now in the early market stages as a building product. Implementation of VIPs in various building constructions have given an increased interest in the possibilities of this product, both in new and refurbished constructions. Even though there is not enough data to conclude the effect over a lifetime of a building yet, the immediate result in decreased energy usage can be seen. However, the problem of guaranteeing a set lifetime expectancy, along with high costs, are some of the major reasons why VIPs are met with scepticism in the building industry. Aiming to give better quality assurance for the users, make further advances in envelope technologies and the development of core materials, along with a further cost reduction, are crucial aspects for VIPs to become a competing thermal insulation solution for buildings.

Contents

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1. Introduction

The world today relies on a large amount of fossil fuels to produce energy. The continued use of fossil fuels will strain our resources, as well as lead to large amounts of pollution, especially through CO_2 emissions. The heating and cooling of buildings require a considerable amount of energy. A reduction in energy usage for the building sector will have a beneficial effect on CO_2 emissions. In the European Union buildings represent 40% of the total energy usage, and the existing building stock represents the single largest potential sector for energy savings [19]. By the principle of the Kyoto Pyramid, the most cost effective method of reducing energy usage is to provide better thermally insulated buildings.

To reach the demanded *U*-values with traditional insulation materials, buildings are required to have walls up to 50 cm thick. This leads to more complex building details and transportation of thicker materials to the building sites [28].

One of the most promising building insulation materials in its early stages of commercialization now, is vacuum insulation panels (VIP). VIPs have an insulation performance which normally ranges from 0.004 W/(mK) in pristine condition to typical 0.008 W/(mK) after 25 years of ageing. This is 5–10 times better, depending on ageing, than traditional insulation used in buildings today [28]. Therefore, VIPs enable highly insulated constructions for walls, roofs and floors, especially within refurbishing of older buildings where space is often limited. Integrating VIPs successfully into constructions requires careful planning with regard to its durability, the lack of flexibility, thermal bridging and lifetime expectations [60].

Especially the uncertainties around expected lifetime is a crucial factor for scepticism concerning VIPs. Research is being conducted on determining ways of interpreting in situ measurements and conduct reliable accelerated ageing tests. The need to better understand the mechanisms of ageing and general loss of thermal resistance over time has been mentioned by Simmler and Brunner