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# Investigation of the process of heat transfer in the structure of thermal insulation materials based on natural fibres

Jiří Zach[a,*], Richard Slávik[b], Vítězslav Novák[a]

[a] *Brno University of Technology, Faculty of Civil Engineering, Institute of Technology of Building Materials and Components, Veveří 331/95, 602 00 Brno, the Czech Republic*

[b] *Brno University of Technology, Faculty of Civil Engineering, Institute of Building Structures, Veveří 331/95, 602 00 Brno, the Czech Republic*

**Abstract**

Thermal insulation materials based on natural fibres are some of the promising materials that are currently emerging on the construction market. These materials are important especially in terms of sustainable development, since they utilise renewable raw material resources or secondary materials and their production does not consume too much energy. However, a problem with these materials is the rather different behaviour during heat and moisture transport compared with conventional insulation, which is made from synthetic (foam polystyrene) or inorganic (mineral wool) materials. The paper presents the results of a practical investigation into the process of heat transfer through the structure of thermal insulation materials based on natural fibres.


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*Keywords:* Thermal insulation; natural fibres; heat transfer; moisture transport

## 1. Introduction

The energy performance of buildings is one of the main topics in contemporary civil engineering. The implementation of the requirements of the Directive 2010/31/EU of the European Parliament and the Council brings more strict requirements on the thermal insulation of buildings throughout the EU, including the Czech Republic [1]. The stricter requirements on the thermal protection of buildings are one of the main reasons for the increased

* Corresponding author. Tel.: +420-541-147-516.
*E-mail address:* zach.j@fce.vutbr.cz


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consumption of thermal insulation materials during the construction of new buildings (as well as the renovation of existing buildings). In order to reduce the environmental strain and material consumption, it is appropriate to insulate buildings with materials made from renewable or secondary materials. The research at Brno University of Technology has for many years been focused on the utilisation of natural fibres (both primary and secondary ones) for the manufacture of thermal insulation materials used in construction. However, there is a problem with the use of these materials, which is their susceptibility to moisture and changes in their thermal insulation properties due to moisture. The behaviour of these materials is different from conventional ones in terms of heat and moisture transfer (e.g. foam polystyrene or mineral wool). This is the reason why many scientific papers address the issue of their hygrothermal behaviour [2,3,4,5].

The heat transfer in the structure of natural fibre-based insulation materials is somewhat different from how it occurs in the structure of conventional ones. The reason is mainly the fact that their structure is formed by fibres of varied length, thickness and orientation. The microstructure of the fibres is also a factor.

As heat and humidity travel through the structure of this insulation, they interact with the fibres and change their water content. This process is very complicated and is unique to each type of fibres. The basic problem is that this changes a number of their properties as well, which then alters the properties of the insulation material as a whole. This involves mainly the following:

- A change in thermal conductivity of the fibres due to moisture – the change in moisture is caused by a shift in the division of the thermal and humidity field in the structure, which alters the sorption properties of the material. There is also moisture that enters the fibre structure as a result of water vapour condensation in the structure. Finally, there is moisture, which is transported through the fibres by capillary suction in the direction of the moisture or temperature gradient.
- A change in the mechanical properties of the fibres due to moisture. Changes in the fibre moisture content alter their mechanical properties, which manifests itself in the change of the fibre stiffness and the change of the insulation's volume stability in a structure. In cases where the insulation is applied loosely in a vertical structure, this may cause the fibres to subside under their own weight.
- A change in the volume of the fibres due to moisture. The volume of the fibres changes together with their mechanical properties. This alters the overall structure of the insulation and the structure becomes denser in cases where the application of the insulation prevents it from increasing its volume. At lower moisture content, this can have a positive effect. Compacting the internal structure of the insulation reduces the degree of heat transfer by radiation and convection, which can outweigh the negative factor of a higher thermal conductivity of the fibres themselves.

Fig. 1. Ice formation on a test sample caused by humid air penetration.