MODERN TECHNOLOGIES FOR APPLYING THE THERMAL INSULATIONS BASED ON CELLULOSE FLAKES

Eng. Daniela FIAT, PhD stud, ICECON SA, daniela.fiat@icecon.ro
Eng. Mirela LAZĂR, PhD stud, ICECON SA, mirela.lazar@icecon.ro

Abstract: The paper presents cellulose thermal insulations based on cellulose flakes applied "in situ", by blow-out under pressure. This mechanized method is using pneumatic systems with complex adjustments in order to obtain different densities and flow rates, when spraying the cellulose fibbers into the spaces to be insulated.

Keywords: thermal insulation cellulose, pneumatic system, spraying

Currently are known and used various products and ecological materials for constructions thermal insulation of both new buildings and rehabilitation of existing old buildings.

The thermal insulating materials based on polymeric natural fibre have a great variety of characteristics that assure an efficient insulation for the reduction at energy costs through compliance the ecological conditions [1].

By using of the ecological building materials it can be reduced the major impact that buildings have on the environment.

Also reducing energy loss in a building (residential, office, industrial, social, and so on) by improving of thermal insulation is of particular importance for the environment and resources conservation.

The cellulose is a naturally occurring polymer containing more than 3000 molecules of glucose (polysaccharide) [2] obtained from wood, cotton, reed and straw. This is indeed an ecological product used as insulating material.

The paper is the most commonly waste encountered (41% of total household waste) and is an important source of cellulose fibbers. The paper being fabricated from cellulose it biodegradable and is decomposing more easily than other wastes (ex. plastics that are practically not biodegradable).

Recycling the paper brings very important benefits in: industrial water costs reducing (approx. 60%), air pollution (about 75%), electricity (about 45%), and water pollution (approx. 45%).

From cellulose, as a result of special processing, thermal insulations can be obtained, which are applied by "in situ" spraying and it represents an alternative to other synthesis insulating materials (expanded polystyrene, extruded polystyrene, polyurethane foam) that are used now a days. The cellulose based material can be applied in new construction as well as old ones.

The based on cellulose products used for insulations consist of cellulose fibbers produced from waste paper, by mechanical crushing, together with additives: flame retardant substances (boric salts, boric acid) that are forming insulating layers, through swelling and mechanical dry blowing. The insulating material is used specific for its purpose and destination, with different thicknesses (range of densities from 28-65 kg/m$^3$), table no. 1.
Table 1 - The density depending on field of application [3]

<table>
<thead>
<tr>
<th>Area of application</th>
<th>Density range [kg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical: cavity insulation in exterior-interior walls by mechanical process</td>
<td>38-65</td>
</tr>
<tr>
<td>Pitched: cavity insulation in roofs (pitch &gt; 10⁵) by mechanical process</td>
<td>38-65</td>
</tr>
<tr>
<td>Horizontal: cavity insulation in flat roofs and floor constructions by mechanical process</td>
<td>38-65</td>
</tr>
<tr>
<td>Horizontal: cavity insulation in ceilings and non circulated terraces (pitch ≤ 10⁵) by mechanical process</td>
<td>28-40</td>
</tr>
</tbody>
</table>

The isolating with cellulose fibres is used for the applications where the insulation material can be blow-out in order to fill the space in the vertical or horizontal cavities, or is free swollen in horizontal, curved or slightly inclined cavities.

The insulation material based on cellulose fibbers cannot be inserted into the constructions in which this is exposed rainfall. It is not known the effect that this insulation material has on metal corrosion.

The cellulose is an organic material obtained from recycled paper and additives are needed to make it fire retardant and antifungal. The cellulose fibbers (Fig. 1) are used mainly for insulating concave spaces between the beams of the roof, the underside of the balconies, of the interior ceilings covered with drywall, walls with wood beams, because it offers more thermal and acoustic comfort.

The cellulose soft fibbers are adequate for the vapour diffusion, good compensating of moisture and good insulating.

![Cellulose flakes](image)

Fig. 1 - Cellulose flakes
The characteristics cellulose flakes are shown in table 2 [3].

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Test method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, kg/m³</td>
<td>ISO 18393-1 [4]</td>
<td>30</td>
</tr>
<tr>
<td>Water absorption, kg/m²</td>
<td>EN 1609 [5]</td>
<td>15.2</td>
</tr>
<tr>
<td>Water vapour diffusion resistance factor (μ)</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Air flow resistance, kPas/m²</td>
<td>EN 29053 [6]</td>
<td>5.3</td>
</tr>
<tr>
<td>Thermal conductivity (λ10), W/(mK)</td>
<td>EN 12667 [7]</td>
<td>0.0370</td>
</tr>
<tr>
<td></td>
<td>EN ISO 10456 [8]</td>
<td>(density 28-65 kg/m³)</td>
</tr>
<tr>
<td>Reaction to fire, class</td>
<td>EN 13501-1 [9]</td>
<td>B-s2,d0*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(density 30-65 kg/m³, layer thickness ≥ 100 mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(density 30-65 kg/m³, layer thickness ≥ 40 mm)</td>
</tr>
</tbody>
</table>

* applied between two plates, as follows:
- a wood based panel, density of the board 680±50 kg/m³, board thickness ≥ 12±20 mm, reaction to fire of the board: class D;
- Calcium silicate board, density of the board 870±50 kg/m³, board thickness ≥ 11±20 mm, reaction to fire of the board: class A2.

The cellulose is thus an alternative to the traditional materials and can be installed quickly by a specialized team who hold a special pump to blow-out the cellulose.

Another advantage presented by the use of cellulose for thermal insulation in housing is the sound absorption, providing an enhanced acoustic comfort. The use of cellulose helps in hardening the structures, where is blow-out. The cellulose being installed under pressure, in "the box" formed by the wall and the finishing element (gypsum board, panelling, OSB) creates a sandwich type wall with a cellulose core and having the density high enough, to increases the walls and roofs resistance to static and dynamic loads.

The blow-out application method makes the material to be used, also, to increase the thermal insulation layer of new or existing buildings, by the blow-out from the inside, over the initial layer of insulating material (Figures 2 and 3). The estimates cost for the cellulose insulations are about 15 - 20% of the costs of installation of a traditional system to insulation and anticipated life span is of about 50 years.
Fig. 2 - Houses with wood structure

Fig. 3 - Houses with classical structure

The material insulating based on cellulose fibbers fire behaviour, depends on the flame retardant degree of the product and of the materials between which it is applied.

The fields of application can be:
1. In walls (Fig. 4):
   - insulation blow-out for cavities in the exterior walls
   - insulation blow-out for cavities in the partition walls

Fig. 4 - Thermal insulation based on cellulose in walls

2. In roofs:
   - blow-out insulation over flat roofs with top cover and ventilated cavity (Fig. 5);
   - blow-out insulation for unventilated pitched cavities, full rafters insulation.
It was to be noted the water vapour impermeable foil that covers the closed space in which it is the cellulose is blow-out under pressure and compacted, resulting the thermal insulating core.

The applying technologies can be: classical blow-out, open blow-out and manually application.

The mechanical dry blowing is performed with the aid of a pneumatic system (Fig. 6), with complex settings in order to obtain different densities and flow rates, that transports the cellulose fibbers from the lorry, thru a flexible tube up to the floor, wall or attic where is made the thermal insulation is applied, by spraying.

The method is similar to casting of concrete using the concrete pumps, in both cases it obtain a continuous and homogeneous material application, in increased accuracy conditions.
And last but not least, application time is much diminished. The cellulose fibbers perfectly adhere on the surface where they are applied, forming a continuous layer without cracks, voids and that is not subject to damages under the external factors actions or its own weight.

a) Classical blow-out (with a hose, with nozzle)

Depending on the application, respectively the construction, the blow-out is performed by a hose or nozzle (Fig. 7). This is the most common application method. It is used to insulate the spaces between the rafters in the attic and in the walls with the uprights. The cellulose fibbers adhere one to the another and form a felt layer is such a way, that it is obtain a thermal insulating precise, continuous, seamless and without joints layer, which is it perfect pressed. Using the blow-out mechanical system all the cavities are filled at the necessary density.

Fig. 7 - Application with flexible tube

b) Open blow-out (Fig. 8)
- Ideal application for a continuous insulation, seamless, without additional bonding and seamless in the floors cavities under the wood elements for lining.

Fig. 8 - Open blow-out
c) Manually application

It is used especially for the floor insulation where a low insulation density is required. The cellulose must be dispersed by hand or better using a mixer before being used. The filling of the cavity is done manually and this method is used in the vertical area of open construction, such as: the one side open resistance walls (where HVAC systems are installed), or intermediate walls.

REFERENCES

[3] European Technical Approval ETA06/0076;