building insulation, temporary insulation systems, such as cargo covers or the like, and insulation lining, for example in shipping boxes or containers.

PCMs are also available in a flexible form in "ice cube" bags. However, any increase in pressure on free-flowing liquids within such bags can transfer to the seams of the bag and lead to catastrophic failure.

There remains a need in the art for improved thermal insulation. It is an object of the invention to address at least one of the above problems or another problem associated with the prior art.

SUMMARY

There is provided a flexible insulation material comprising a flexible porous medium defining a pore volume, and a phase change material (PCM) within the pore volume.

In one aspect of the disclosure there is provided a flexible insulation material comprising a flexible porous medium comprising fibres and defining a pore volume, and a phase change material (PCM) within the pore volume wherein the phase change material fills in the range of from 40 to 95% of the pore volume, and a remaining part of the pore volume comprises air.

It has been found that a PCM can hold its position within a pore volume of a porous medium. This can mitigate or prevent pooling of the PCM.

The insulation material is flexible in the sense that it has at least some ability to flex or bend. Different degrees of flexibility may be desirable for different applications.

Advantageously, in various examples, the flexible insulation material may be capable of bending under its own weight. A suitable method for determining whether a material can bend under its own weight is the Pierce cantilever test ASTM D1388.

In the Pierce cantilever test a specimen of the material to be tested is cut to 200 mm x 25 mm. The sample is then gradually slid over the edge of a platform of a Pierce cantilever device. As the leading edge of the specimen projects from the platform, it may bend under its own weight, until the leading edge of the specimen makes contact with a sloping surface of the device angled downwards at an angle $\theta = 41.5°$. The overhanging length (l) of the specimen is measured using a graduated ruler. The measured length (l) is multiplied by a scaling factor to give a value for the bending stiffness (G) in Nm.

of from 2 to 30 ºC. In an example the PCM may change phase at a temperature in the range of from 10 to 30 ºC, optionally in the range of from 15 to 25 ºC. In another example, the PCM may change phase at a temperature in the range of from 0 to 10 ºC, optionally in the range of from 2 to 8 ºC.

Suitably the insulation material may constitute a PCM layer. Discrete amounts of PCM may be distributed, preferably substantially evenly, within a PCM layer.

Suitably, the PCM layer may have a thickness in the range of from 0.5 to 10 mm, such as in the range of from 1 to 5 mm, e.g. in the range of from 1.5. to 3 mm. Suitably, the insulation material may be presented as a sheet or a roll.

The disclosure also provides an insulation laminate comprising a layer including flexible insulation material as defined herein and one or more supplementary layers.

In another aspect the disclosure provides an insulation laminate comprising a layer including flexible insulation material according to any preceding claim and one or more supplementary layers wherein the flexible insulation material is sandwiched between first and second ones of said supplementary layers.

The supplementary layers, and indeed the insulation laminate as a whole, may advantageously be flexible, at least when the PCM is in a liquid state and optionally also when the PCM is in a solid state. Optionally, the insulation laminate may bend under its own weight in the sense of the Pierce test cited hereinabove.

Advantageously, the flexible insulation material may be sandwiched between first and second supplementary layers. Conveniently, the flexible insulation material may be surrounded by said one or more layers. This can assist in containing the PCM. Advantageously, the flexible insulation material may be encapsulated by the one or more supplementary layers. For example, the laminate may take the form of a pouch containing the flexible insulation material.

The one or more supplementary layers may comprise a barrier layer for resisting penetration of the PCM from the flexible insulation material layer out of the insulation laminate. A barrier layer may suitably comprise a monolithic or microporous film. Examples of monolithic films include cellulosic films,

(e.g. the walls and the top and bottom of a load) or may be located in discrete areas, such as the walls, to provide protection to the most at risk locations of the load. In the case of cargo covers, this is generally considered to be the top of the load. Insulation laminates may be arranged in any combination of the above locations to provide optimum thermal protection. The laminates or pouches may be joined together to form a continuous insulation layer in order to limit thermal bridging.

In various examples, insulation laminates according to examples of the disclosure may be removably incorporated in a cargo cover to create an integrated PCM cargo cover solution. Insulation laminates may, for example, be integrated by gluing to the inner layers of the cargo cover or by the creation of pockets in the inside of the cover. Such pockets may be formed from fabric, netting, webbing or film.

Advantageously, pockets may be formed from a low emissivity material to further increase the thermal protection provided by the cover. To further enhance thermal performance, low emissivity pockets may be combined with flexible thermal insulation, for example layers of PET wadding, bubble wrap, glass or mineral wool, 3-D spacer fabric or open or closed cell foam.

Optionally, the cargo cover may be as defined or described in PCT/GB2018/050286, which is incorporated herein by reference. For example, the cargo cover may be as described in claim 62 of PCT/GB2018/050286 as originally filed. The insulation laminate of such a cargo cover may be as described in relation to any example of the disclosure herein.

In other applications, the insulation material or insulation laminate may advantageously be deployed so as to be in direct (heat conducting) contact with a product to be insulated. In this manner, a temperature equilibrium can be more readily maintained between the product and the PCM, which may enhance the PCM’s performance.

The disclosure also provides a container internally lined with an insulation material or insulation laminate as defined herein.

The container may comprise walls that are more rigid than the insulation material or insulation laminate, at least when the PCM is in a liquid state. Suitably, the container may comprise a cardboard box. Alternatively, the container may comprise a metal or wood crate or a shipping container.

The container may be lined on a plurality of sides. Optionally, all sides of the container may be lined so that items shipped therein are surrounded by lining of the insulation material or insulation laminate. For example, the container may have side walls, a bottom wall and a top wall, and each of the side, top and bottom walls may be lined with the insulation material or insulation laminate.

Advantageously, the insulation material or insulation laminate may be flexed to line a plurality of sides of the container. Thus the insulation material or insulation laminate may form a wrap that lines a plurality of sides of a container.

The insulation material or insulation laminate may be affixed to an inner wall of the container, for example with adhesive or other means known in the art.

The disclosure provides a method of making an insulation product, for example an insulation material, laminate, cargo cover or lined container according to any example of the disclosure, the method comprising applying a phase change material (PCM) to pores of a flexible porous material to form a flexible insulation material. The PCM and/or flexible porous material may be as described anywhere herein.

Suitably, the method may comprise forming a laminate with the flexible insulation material and one or more supplementary layers, the supplementary layers. The supplementary layers may be as described anywhere herein.

Optionally, the method may comprise sealing one or more side edges of the laminate. In particular, the method may comprise forming a pouch from the one

CLAIMS

1. A flexible insulation material comprising a flexible porous medium comprising fibres and defining a pore volume, and a phase change material (PCM) within the pore volume wherein the phase change material fills in the range of from 40 to 95% of the pore volume, and a remaining part of the pore volume comprises air.

2. The insulation material of claim 1, wherein the insulation material is flexible when the PCM is in a solid state.

3. The insulation material of any preceding claim, wherein the material is vapour permeable.

4. The insulation material of any preceding claim, wherein the fibres have a mean fibre diameter in the range of from 1 to 10 μm, optionally in the range of from 2 to 5 μm.

5. The insulation material of any preceding claim, wherein the porous medium comprises a polymeric non-woven material, optionally melt-blown.

6. The insulation material of any preceding claim, wherein the PCM is organic and/or hydrophobic.

7. The insulation material of any preceding claim, wherein the phase change material changes phase at a temperature in the range of from 5 to 30 °C.

8. An insulation laminate comprising a layer including flexible insulation material according to any preceding claim and one or more supplementary layers wherein the flexible insulation material is sandwiched between first and second ones of said supplementary layers.

9. The insulation laminate of claim 8 wherein the one or more supplementary layers comprise a barrier layer for resisting penetration of the PCM from the flexible insulation material layer out of the insulation laminate.

10. The insulation laminate of claim 9, wherein the barrier layer comprises a monolithic film.

11. The insulation laminate of any one of claims 8 to 10, wherein the one or more supplementary layers comprise a reflective layer having an emissivity of less than 0.5, preferably less than 0.3, more preferably less than 0.25 and most preferably less than 0.2.

12. The insulation laminate of any one of claims 8 to 11, wherein the one or more supplementary layers comprise a support layer, the support layer optionally comprising a fibrous woven or non-woven material.

13. The insulation laminate of any one of claims 8 to 12 comprising a sealed pouch of the insulation material.

14. A cargo cover comprising an insulation material or insulation laminate according to any preceding claim.

15. The cargo cover of claim 14 comprising a plurality of flexible insulation laminates, each laminate being joined to, or arranged to be joined to, at least one other of the laminates, wherein one or more of the laminates is a laminate according to any one of claims.