A thermal insulation product is provided comprising a loose fill insulation for insulating an interior of a hollow or open space in a structure and at least one phase change material dispersed in the loose fill insulation.
LOOSE FILL INSULATION PRODUCT HAVING PHASE CHANGE MATERIAL THEREIN

FIELD OF THE INVENTION

[0001] The present invention relates to insulation products, and more specifically to loose fill insulation products and methods of making the same.

BACKGROUND OF THE INVENTION

[0002] Thermal insulation for buildings and other structures is available in the form of mats, batts, blankets and loose fill. Mats, batts and blankets are flexible constructions containing various fibers and are generally prefabricated before being brought to a construction site and installed. In contrast, loose fill thermal insulation includes a large number of discrete fibers, flakes, powders, granules and/or nodules of various materials. The loose fill can be poured or blown into hollow walls or other empty spaces to provide a thermal barrier.

[0003] The use of phase change materials in insulation systems has been proposed as a means of better moderating the transfer of heat between the interior and exterior of a structure. For example, U.S. Pat. No. 5,770,295 to Alderman describes a multi-layered insulation product having a layer of phase change material sandwiched between two insulation layers.

[0004] While approaches such as Alderman have focused on reducing heat loss through prefabricated insulation products, such as fiberglass mats, they have not addressed how to improve the insulation properties of loose fill insulation. Therefore, there remains a need for a cost effective loose fill thermal insulation product that can better moderate the transfer of heat between a structure’s interior and exterior.

SUMMARY OF THE INVENTION

[0005] A thermal insulation product is provided comprising a loose fill insulation for insulating an interior of a hollow or open space in a building structure and at least one phase change material dispersed in the loose fill insulation. In one embodiment, the at least one phase change material is dispersed uniformly in the loose fill insulation and comprises at least one n-paraffin material having a phase change temperature between about 63°F-85°F. A method of making a thermal insulation product is also provided comprising the step of dispersing at least one phase change material in a loose fill insulation for insulating an interior of a hollow or open space in a structure.

[0006] Incorporating a phase change material into a loose fill insulation product provides an improved insulation product for regulating heat transfer between the interior and exterior of a structure. Flammability of the phase change material is not a concern if the loose fill insulation is installed behind dry wall or a flame retardant is added to the loose fill insulation. The loose fill insulation can be customized to optimize its performance in various climates by simply selecting the phase change material that has a phase transformation temperature best suited to the climate. More than one phase change material may be selected to further customize the loose fill insulation for the selected climate. Better regulating the heat transfer between the interior and exterior of the structure can move the heating or cooling load to times when energy prices are less expensive and potentially reduce the need for a heating and/or cooling cycles, thereby saving energy and money.

[0007] The above and other features of the present invention will be better understood from the following detailed description of the preferred embodiments of the invention that is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings illustrate preferred embodiments of the invention, as well as other information pertinent to the disclosure, in which:

[0009] FIG. 1 illustrates a method of applying a phase change material to loose fill insulation during manufacture thereof; and

[0010] FIG. 2 illustrates a method of applying a phase change material to loose fill during application thereof.

DETAILED DESCRIPTION

[0011] As used herein, “phase change material” (PCM) means a “latent” thermal storage material, such as one that uses intermolecular physical bonds to store and release heat. The thermal energy transfer of a phase change material occurs when the material changes from a solid to a liquid, or from a liquid to a solid form, although with some PCMs thermal energy transfer occurs when the material changes from a solid to a softer solid and vice versa. Initially, the solid-liquid PCM performs like a conventional storage material in that its temperature rises as it absorbs heat. Unlike a conventional storage material, when a PCM reaches the temperature at which it changes phase (its melting point), it absorbs large amounts of heat without getting hotter. When the ambient temperature in the space around the PCM material drops, the PCM solidifies, releasing its stored latent heat. A PCM absorbs and emits heat while maintaining a constant temperature. Within the human comfort range of 68°F-86°F (20°C to 30°C), latent thermal storage materials are very effective. These materials reportedly can store from 5 to 14 times more heat per unit volume than sensible heat storage materials such as water, masonry or rock.

[0012] As used herein, “heat of fusion” means the amount of heat required to convert a unit mass of a solid at its melting point into a liquid without an increase in temperature.

[0013] Provided herein is a loose fill insulation product having a phase change material dispersed therein. The loose fill insulation can be in the form of fibers, flakes, powders, granules and/or nodules of various materials. The loose fill insulation is of the type for insulating an interior of a hollow or open space in a building structure, e.g., a house, office, or other building structure. Preferably, the loose fill can be compressed during storage to save space, and then expanded or “fluffed-up” with air or another gas when poured or blown into a hollow wall or other empty space of a structure. The loose fill can include organic materials, inorganic materials or both. Examples of organic loose fill materials include animal fibers, such as wool; cellulose-containing vegetable fibers, such as cotton, rayon, granulated cork (bark of the cork tree), redwood wool (fibersized bark of the redwood tree), and recycled, shredded or ground newspaper fibers;
and thermoplastic polymer fibers, such as polyester; and expanded plastic beads. Examples of inorganic loose fill materials include diatomaceous silica (fossilized skeletons of microscopic organisms), perlite, fibrous potassium titania-
te, alumina-silica fibers, microquartz fibers, opacified collo-
idal alumina, zirconia fibers, alumina bubbles, zirconia bubbles, carbon fibers, granulated coal, cement fibers, graf-
tite fibers, rock fibers, slag fibers, glass wool and rock
wool. The loose fill can include one or more varieties of
loose fill material. In an exemplary embodiment, the loose
fill insulation includes OPTIMA® fiberglass loose fill insu-
lation available from CertainTeed Corporation, Valley
Forge, Pa.

[0014] When manufactured and compressed during stor-
age, the loose fill particles forming the compressed loose fill
are dimensioned so as to have an equivalent sphere with a
diameter generally smaller than 3 cm, preferably from 0.1 to
1 cm. In one embodiment, after the compressed loose fill is
decompressed, expanded and processed through a blowing
hose, the loose fill particles forming the expanded loose fill
are each dimensioned so as to just fit within a sphere having
a diameter of from 0.1 to 4 cm, preferably from 0.5 to 2 cm.

[0015] The thermal insulation product including the phase
change material can be formed by dispersing, preferably
uniformly, the phase change material in the loose fill before
or at the same time as the loose fill is poured or blown into
an interior, empty space of a hollow or open object, such as
a hollow wall (before application of the drywall) or an attic
(if the loose fill and PCM meet applicable flammability
standards). Methods of pouring and blowing loose fill are
well known in the art and will not be repeated here in detail.
Generally, blowing loose fill involves feeding compressed
loose fill into a blower where it is mixed with a gas, such as
air, expanded, processed through a blowing hose, and then
blown into a hollow or open structure to form thermal
insulation.

[0016] In embodiments, a mixture including one or more
phase change materials and a dry binder (i.e., an adhesive
later activated by water at the time of installation of the loose
fill) can be sprayed onto or otherwise mixed with the loose
fill before the loose fill is compressed and/or when the loose
fill is decompressed. Also, a mixture including one or more
phase change materials and a binder (i.e., an adhesive) can
be mixed with the loose fill by spraying on the loose fill at
or near the end of the blowing hose before the loose fill is
installed in a hollow or open space. The binder serves to
join and hold the phase change material and the loose fill
insulation together. The binder can be organic or inorganic.
The organic binder can include an organic water based
binder such as an acrylic latex or a vinyl acetate latex. The
organic binder can also include a sprayed hot melt adhesive
such as a thermoplastic polymer. The inorganic binder can
include an inorganic bonding agent such as sodium silicate
or a hydraulic cement. Evaporation of the liquid from
the liquid mixture on the loose fill results in a loose fill thermal
insulation product with the phase change material and/or
binder dispersed in the loose fill. In various embodiments,
the phase change material and the binder can be added to the
loose fill at the same time or at different times. A mineral oil
can be used instead of or in addition to the binder for the
purpose of dust reduction. In other embodiments, rather than
providing the phase change material in a liquid mixture, the
phase change material may be provided to the loose fill in its
liquid state or as a powder or fiber and, optionally, along
with a mineral oil and/or binder as described above.

[0017] FIG. 1 shows an embodiment in which loose fill
insulation is fed through a loose fill transport duct 10 into
mixer 20 to form a mixture of loose fill and phase change
material. The phase change material may be provided, for
example, in liquid form. In one embodiment, the phase
change material is provided in a form that prevents leaking
or spread of the phase change material after phase change
into liquid form, such as by providing the phase change
material in microcapsules, in permeated plastic pellets (e.g.,
polyester pellets saturated with melted PCM material (e.g.,
a paraffin)), in a hydrophilic silica powder, in granulates,
such as natural porous diatomaceous earth particles, in a
portion of the fibers, including on a portion of the fibers, of
the loose fill insulation or a combination thereof. In embodi-
ments, a dry binder (to be later activated by water or other
material during loose fill application) and/or mineral oil can
also be added in the loose fill transport duct 10 or added in
and mixed in mixer 20 with the loose fill and phase change
material. The phase change material can be added directly to
the mixer 20 and/or to the loose fill transport duct 10. The
mixture is then fed to compressor/packager 30, where the
mixture is compressed to remove air and increase density
and packaged as compressed loose fill 40 including the
phase change material.

[0018] FIG. 2 shows that compressed loose fill 40 can
then be fed via a chute or hopper 50 into a blower 60. Blower
60 uses gas to decompress, expand and process the com-
pressed loose fill 40 including the phase change material
through a corrugated blowing hose 70. From blower 60,
expanded loose fill 90 is blown into an open space 80 to
provide thermal insulation. In other embodiments, phase
change material, binder (e.g., dry binder) and/or mineral oil
is added along with the compressed loose fill to blower 60,
and the blower 60 both mixes the phase change material,
binder and/or mineral oil with compressed loose fill and
expands the compressed loose fill. If dry binder is added in
the blower, the binder is activated with water applied at or
near the end of the blowing hose at the time the loose fill is
installed in a cavity. In still other embodiments, the phase
change material, water, binder and/or mineral oil is added to
expanded loose fill in a liquid spray application injected at
or near the end of the blowing hose 70 or sprayed on the
expanded loose fill 90 as it exits the blowing hose 70 and is
blown into the open space 80. In the embodiment where
the binder is added at or near the end of the blowing hose 70,
liquid binder is preferred.

[0019] After application of the loose fill insulation includ-
ing the phase change material to a structure, when the
temperature in a room rises above the phase change mate-
rial’s transition temperature (the point at which the material
changes phase), the phase change material absorbs heat and
melts, maintaining its temperature until fully melted and
limiting heat transfer. As the air temperature decreases,
the phase change material releases the stored heat and returns
to a solid state. The phase change material or materials selected
for dispersion in the loose fill insulation is selected based on
the environment of the structure in which the loose fill
insulation will be installed, i.e., the phase transition tem-
perature is selected as appropriate based on the temperature
characteristics and fluctuations of an environment that affect
the heating and cooling characteristics of a structure. The
environment may be a heating environment (e.g., northern cold environments), a cooling environment (e.g., southern warm environments) or a heating and cooling environment (e.g., north-eastern United States). Some literature has reported that the transition temperature for maximizing residential heating and cooling benefits using a phase change material is 77°F (25°C). Still, some literature has suggested that the transition temperature should be near standard or suggested room temperatures of 65-72°F (18.3-22.2°C) for heating dominated climates or 72-79°F (22.2-26.1°C) for cooling dominated climates, or at a temperature that is slightly higher (e.g., 1-2 degrees) than the average room temperature.

[0020] In one embodiment, the phase change material has a relatively high phase change temperature between about 77.0 to about 85.0°F, and preferably about 83°F. This phase change material can slow the transfer or heat energy from the outside of a structure (such as during summer) to the inside of the structure. One exemplary phase change material for this purpose is octadecane, which has a melting point of about 83°F. In another embodiment, the phase change material has a relatively low phase change temperature between about 63.0 to about 72.0°F, and preferably about 65°F. This phase change material can slow heat transfer from the inside to the outside during winter. An exemplary phase change material for this purpose is hexadecane, which has a melting point of about 65°F. By slowing heat transfer, the phase change materials may also move the heating and cooling load to off peak hours when energy costs may be lower. These waxes, i.e., hexadecane and octadecane, may be mixed with the loose fill insulation in liquid or dry form, such as with a carrier such as microcapsules. Assuming the phase change material is provided to the loose fill insulation as a liquid or other non-encapsulated or bound form, once installed and after phase change to liquid form, these waxes should have sufficient viscosity to substantially maintain the uniform dispersion within and throughout the loose fill insulation.

[0021] Flammability of the phase change material is not a concern with loose fill insulation that is installed behind drywall, such as gypsum drywall that is normally fire retardant. A fire retardant additive can also be added to the loose fill insulation.

[0022] In one embodiment, the phase change material is provided as about five to twenty-five percent of the dry weight of the loose fill insulation product. The at least one phase change material may include the low phase change temperature material for slowing heat transfer from the inside to the outside, the high phase change temperature material for slowing heat transfer from the outside to the inside, an intermediate phase change temperature material (i.e., with a phase change temperature between the low and high phase change temperatures (e.g., e.g., n-heptadecane with a melting point of about 72°F), or two or more phase change materials, e.g., both a low phase change temperature material and a high phase change temperature material to provide both functions; for example, a 50-50 mix of octadecane and hexadecane may be employed.

[0023] In an exemplary embodiment, the phase change material includes a paraffin wax (e.g., n-tetradecane (C-14), n-pentadecane (C-15), n-hexadecane (C-16), n-heptadecane (C-17), n-octadecane (C-18), n-nonadecane (C-19), etc.) although other materials may be appropriate in certain embodiments, such as a Glauber salt (sodium sulfate dehydrate), calcium chloride hexahydrate, linear crystalline alkyl hydrocarbons, fatty acids and esters, polyethylene glycols, long alkyl side chain polymers, solid state series of pentachlorothiophenol, pentaglycerine, neopentyl glycol, low melting metals and alloys, quaternary ammonium clathrates and semi-clathrates, salt hydrates, and olefins. Paraffins are generally preferred as they are relatively inexpensive and widely available at different melting temperatures, which depend on the carbon chain lengths thereof. Unless encapsulated, salt hydrates are not preferred because they absorb water, which decreases their effectiveness, and salt hydrates may be corrosive to some building materials.

[0024] The following are some exemplary phase change materials that may be appropriate for dispersion within the loose fill, along with the respective heats of fusion.

<table>
<thead>
<tr>
<th>Compound/ Product Name</th>
<th>Melt Point °C</th>
<th>Melt Point °F</th>
<th>Heat of Fusion (kJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexadecane</td>
<td>18.17</td>
<td>64.7</td>
<td>236</td>
</tr>
<tr>
<td>Heptadecane</td>
<td>22.00</td>
<td>71.6</td>
<td>214</td>
</tr>
<tr>
<td>Octadecane</td>
<td>28.18</td>
<td>82.7</td>
<td>244</td>
</tr>
<tr>
<td>Butyl Stearate</td>
<td>19.00</td>
<td>66.2</td>
<td>140</td>
</tr>
<tr>
<td>Propyl Palmitate</td>
<td>19.00</td>
<td>66.2</td>
<td>186</td>
</tr>
<tr>
<td>1 Dodecanol</td>
<td>17.50</td>
<td>63.5</td>
<td>398.5</td>
</tr>
<tr>
<td>Rubitherm RT25</td>
<td>25.00</td>
<td>77.0</td>
<td>121.1</td>
</tr>
<tr>
<td>Rubitherm RT27</td>
<td>28.00</td>
<td>82.4</td>
<td>170</td>
</tr>
<tr>
<td>Rubitherm RT20</td>
<td>22.00</td>
<td>71.6</td>
<td>172</td>
</tr>
<tr>
<td>Rubitherm PX27</td>
<td>28.00</td>
<td>82.4</td>
<td>112</td>
</tr>
<tr>
<td>Rubitherm GR27</td>
<td>29.00</td>
<td>82.4</td>
<td>72.1</td>
</tr>
<tr>
<td>TEAP TH 29</td>
<td>29.00</td>
<td>84.2</td>
<td>200.1</td>
</tr>
</tbody>
</table>

[0025] The Rubitherm products are all available from Rubitherm GmbH of Hamburg, Germany. The Rubitherm products with designations “RT” are narrow cut, highly crystalline n-paraffin content materials. The Rubitherm product with designation “PX” is available in powder form where a phase change material is contained within a secondary supporting structure including a hydrophilic silica powder. When in liquid form, the phase change material does not leak out of the powder, resulting in the bound phase change material always being a solid in its macroscopic form. The Rubitherm product with designation “GR” is contained within a secondary support structure including a natural porous diatomaceous earth particle. When in liquid form, the phase change material does not leak out of the granulate, resulting in the bound phase change material always being a solid in its macroscopic form. The TEAP TH 29 product, available from PCM Thermal Solutions of Naperville, Ill., is an inorganic hydrated salt.

[0026] Providing phase change materials in drywall or other prefabricated products has met with some resistance from manufacturers because of the number of different climates serviced by their products. Manufacturing several different products with each product having a specific phase change material having a transition temperature tailored to a specific climate can add significant expense to the manufacturing and distribution process. One advantage of providing the phase change material on-location during the application process (FIG. 2), which is likely not practical with non-loose fill insulation, is that the loose fill insulation need not have the phase change material dispersed therein.
prior to packaging (FIG. 1), meaning, in this embodiment, that the loose fill insulation manufacturing process need not be changed. In this embodiment, the installer can simply select the phase change material that best fits the installation environment, with possible suggestion from the manufacturer of the loose fill insulation.

Incorporating a phase change material into a loose fill insulation product provides an improved insulation product for regulating heat transfer between the interior and exterior of a structure. Flammability of the phase change material is not a concern if the loose fill insulation is installed behind dry wall or a flame retardant is added to the loose fill insulation. The loose fill insulation can be easily customized to optimize its performance in various climates by simply selecting the phase change material that has a phase transformation temperature best suited to the climate. More than one phase change material may be selected to further customize the loose fill insulation for the selected climate. Better regulating the heat transfer between the interior and exterior of the structure can move the heating or cooling load to times when energy prices are less expensive and potentially reduce the need for a heating and/or cooling cycles, thereby saving energy and money.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly to include other variants and embodiments of the invention that may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

What is claimed is:
1. A thermal insulation product comprising:
   a loose fill insulation for insulating an interior of a hollow or open space in a building structure; and
   at least one phase change material dispersed in said loose fill insulation.

2. The product of claim 1, wherein the loose fill insulation comprises fibers selected from the group consisting of cellulose-containing fibers, synthetic polymer fibers, rock wool fibers, glass fibers and shredded or ground recycled newspapers.

3. The product of claim 1, wherein the at least one phase change material is dispersed uniformly in the loose fill insulation.

4. The product of claim 1, further comprising a mineral oil and/or binder dispersed in the loose fill insulation.

5. The product of claim 1, wherein said at least one phase change material comprises an n-paraffin.

6. The product of claim 5, wherein said at least one phase change material comprises hexadecane, heptadecane and/or octadecane.

7. The product of claim 1, wherein the phase change material is coupled to a carrier.

8. The product of claim 7, wherein the carrier comprises microcapsules, plastic pellets, silica powder, porous diatomaceous particles, a portion of the fibers of said loose fill insulation or a combination thereof.

9. The product of claim 1, wherein said at least one phase change material comprises a phase change material having a melting point between about 77.0-85°F.

10. The product of claim 1, wherein said at least one phase change material comprises a phase change material having a melting point between about 63.0-72°F.

11. The product of claim 1, wherein said at least one phase change material comprises a first phase change material having a melting point between about 77.0-85°F and a second phase change material having a melting point between about 63.0-72°F.

12. The product of claim 1, wherein said at least one phase change material comprises a phase change material having a melting point between about 63-85°F.

13. A method of making a thermal insulation product, comprising the step of dispersing at least one phase change material in a loose fill insulation for insulating an interior of a hollow or open space in a building structure.

14. The method of claim 13, further comprising positioning the loose fill insulation in an interior of a hollow or open space in a structure.

15. The method of claim 14, wherein the positioning step comprises pouring or blowing the loose fill insulation into the interior of the hollow or open space.

16. The method of claim 15, wherein the at least one phase change material is dispersed in the loose fill insulation before the loose fill insulation is positioned in the interior of the hollow or open object.

17. The method of claim 13, wherein the at least one phase change material is dispersed uniformly in the loose fill insulation.

18. The method of claim 13, wherein the loose fill insulation comprises fibers selected from the group consisting of cellulose-containing fibers, synthetic polymer fibers, rock wool fibers, glass fibers and shredded or ground recycled newspapers.

19. The method of claim 13, further comprising the step of dispersing a mineral oil and/or binder in the loose fill insulation.

20. The method of claim 13, wherein said at least one phase change material comprises an n-paraffin.

21. The method of claim 20, wherein said at least one phase change material comprises hexadecane, heptadecane and/or octadecane.

22. The method of claim 13, wherein said at least one phase change material comprises a phase change material having a melting point between about 77.0-85°F.

23. The method of claim 13, wherein said at least one phase change material comprises a phase change material having a melting point between about 63.0-72°F.

24. The method of claim 13, wherein said at least one phase change material comprises a first phase change material having a melting point between about 77.0-85°F and a second phase change material having a melting point between about 63.0-72°F.

25. The method of claim 13, wherein said at least one phase change material comprises a phase change material having a melting point between about 63-85°F.

26. The method of claim 13, wherein the phase change material is coupled to carrier.

27. The method of claim 26, wherein the carrier comprises microcapsules, plastic pellets, silica powder, porous diatomaceous particles, a portion of the fibers of said loose fill insulation or a combination thereof.

28. The method of claim 13, further comprising the steps of:
   packaging the loose fill insulation prior to dispersing said phase change material;
   opening said packaging; and
pouring or blowing the loose fill insulation into an interior of a hollow or open space, wherein said dispersing step occurs after said opening step.

29. A thermal insulation product comprising:

a loose fill insulation for insulating an interior of a hollow or open space in a building structure; and

at least one phase change material dispersed uniformly in said loose fill insulation, said phase change material comprising at least one n-paraffin material having a phase change temperature between about 63-85°F.

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