

DESCRIPTION

VACUUM HEAT-INSULATING MATERIAL, HEAT-INSULATING BOX, AND
PRODUCTION METHOD OF VACUUM HEAT-INSULATING MATERIAL

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Field

[0001] The present invention relates to a vacuum heat-insulating material, a heat-insulating box, and a production method of a vacuum heat-insulating material.

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Background

[0002] There is a conventional vacuum heat-insulating material used as a heat-insulating material for a refrigerator and other devices, in which a core material made of inorganic fiber, and an adsorbent that adsorbs water are covered with an outer wrapping material having a gas barrier property, and the inside of the outer wrapping material is depressurized and hermetically sealed (see Patent Literature 1, for example). The adsorbent is wrapped with a wrapping material made of a laminated film including Japanese paper and polyethylene.

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[0003] Furthermore, there is an adsorbent wrapping method using a conventional wrapping material, in which the adsorbent is filled in a glass container (see Patent Literature 2, for example).

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[0004] There is another adsorbent wrapping method using a conventional wrapping material, in which an adhesive tape or an adhesive agent is used (see Patent Literature 3, for example).

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Citation List

Patent Literatures

[0005] Patent Literature 1: Japanese Patent No. 3507776

Patent Literature 2: Japanese Patent Application
Laid-open No. H7-269780

Patent Literature 3: Japanese Patent Application
Laid-open No. H11-325386

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Summary

Technical Problem

[0006] A vacuum heat-insulating material has a configuration including a core material made of a fiber aggregate, an adsorbent that adsorbs at least water, and an outer wrapping material that covers the core material, in which the inside of the outer wrapping material is depressurized and hermetically sealed. The adsorbent itself is in a form of powder or granules and is used in a state of being wrapped with a wrapping material for easier handling. The wrapping material is required to pass a greater amount of gas to be adsorbed per unit time, that is, required to have a high air permeability.

[0007] However, as described in Patent Literature 1, a general wrapping material needs to be formed of a laminated film that includes a sealant layer made of polyethylene or polypropylene for hermetically sealing the adsorbent by heat seal. Therefore, there is no choice but to use a wrapping material formed of a laminated film with a low air permeability, which reduces the gas absorbing speed within the vacuum heat-insulating material. Accordingly, there is a problem in that it is difficult to obtain a vacuum heat-insulating material with a high heat-insulation performance.

[0008] In Patent Literature 2, the adsorbent is filled in the glass container. Also in this case, the sealing portion of the container is heat-sealed as illustrated in FIG. 3 of Patent Literature 2.

[0009] Furthermore, when the adsorbent is hermetically

sealed in the wrapping material using an adhesive tape or an adhesive agent without using heat seal as described in Patent Literature 3, low-molecular components included in the adhesive tape or the adhesive agent are vaporized
5 within the vacuum heat-insulating material. Therefore, there is a problem in that the vaporization reduces the degree of vacuum within the vacuum heat-insulating material, and accordingly degrades the heat-insulation performance of the vacuum heat-insulating material.

10 [0010] The present invention has been achieved to solve the above problems, and an object of the present invention is to provide a vacuum heat-insulating material, a heat-insulating box, and a production method of a vacuum heat-insulating material, in which a highly-breathable wrapping
15 material is used to increase the gas absorbing speed within the vacuum heat-insulating material, and the heat-insulation performance is improved.

Solution to Problem

20 [0011] To solve the above described problem and achieve the object, a vacuum heat-insulating material according to the present invention includes: a core material made of a fiber aggregate; an adsorbent that adsorbs at least water; a wrapping material that is configured using a breathable
25 sheet member and that wraps the adsorbent; and an outer wrapping material that covers the adsorbent wrapped with the wrapping material, and the core material. An inside of the outer wrapping material is depressurized and hermetically sealed, and the adsorbent is wrapped with the
30 wrapping material without using heat seal.

Advantageous Effects of Invention

[0012] According to the present invention, by using a

highly-breathable wrapping material, the gas absorbing speed within the vacuum heat-insulating material increases; and thus a vacuum heat-insulating material, a heat-insulating box, and a production method of a vacuum heat-insulating material; having an improved performance can be provided.

Brief Description of Drawings

[0013] FIG. 1 is a cross-sectional view illustrating a schematic configuration of a vacuum heat-insulating material according a first embodiment of the present invention.

FIG. 2 is a diagram illustrating a schematic configuration of twist wrapping with a wrapping material.

15 FIG. 3 is a diagram illustrating a schematic configuration of folding wrapping with a wrapping material.

FIG. 4 is a diagram illustrating a schematic configuration of ligating wrapping with a wrapping material.

20 FIG. 5 is a cross-sectional view illustrating a schematic configuration of a heat-insulating box according to a second embodiment of the present invention.

Description of Embodiments

[0014] Exemplary embodiments of a vacuum heat-insulating material, a heat-insulating box, and a production method of a vacuum heat-insulating material according to the present invention will be explained below in detail with reference to the accompanying drawings. The present invention is not limited to the embodiments.

30 [0015] First embodiment.

FIG. 1 is a cross-sectional view illustrating a schematic configuration of a vacuum heat-insulating material 1 according a first embodiment of the present

invention. In the following drawings including FIG. 1, the dimensional relation between constituent members, the shape of each constituent member, and the like may sometimes be different from the actual ones. Specific dimensions of the respective constituent members, and the like need to be determined in view of the following descriptions.

[0016] As illustrated in FIG. 1, the vacuum heat-insulating material 1 includes: a core material 10 made of a fiber aggregate; an outer wrapping material 20 that covers the core material 10 and that has a gas barrier property; an adsorbent 30 that is inserted in the inside of the outer wrapping material 20 and that adsorbs at least water; and a wrapping material 31 that wraps the adsorbent 30.

[0017] The interior space of the outer wrapping material 20 is depressurized and hermetically sealed by hermetically sealing the opening in a depressurized state to the degree of vacuum of approximately 1 to 3 Pa. For example, the vacuum heat-insulating material 1 has a shape of a substantially-rectangular flat plate as a whole.

[0018] The core material 10 has a configuration in which fiber aggregates such as glass wool are laminated, for example. Generally, when the fiber aggregate is glass wool, it is produced by a centrifugation method, and when the fiber aggregate is resin fiber, it is produced by a spunbond method. However, the type of the fiber aggregate and the production method of the fiber aggregate are not particularly limited. The core material 10 may include a binding agent that binds the fiber aggregates together.

[0019] For example, the outer wrapping material 20 is used in existing vacuum heat-insulating materials, and is a laminated film having a multilayer structure. For example, this multilayer structure has a configuration in which,

from the innermost side (the side of the core material 10), a polyethylene layer, an aluminum-evaporated layer, a polyethylene-terephthalate layer, and a stretched nylon layer on the outermost layer are laminated in this order.

5 The configuration of the outer wrapping material 20 is not limited to the configuration described above. The outer wrapping material 20 may include an alumina-evaporated layer, a silica-evaporated layer, an ethylene-vinyl alcohol layer, and a polypropylene layer. The configuration of the
10 outer wrapping material 20 is not particularly limited as long as it has a gas barrier property.

[0020] The adsorbent 30 can adsorb at least water, and is in a form of powder or granules. The adsorbent 30 is calcium oxide, for example. The adsorbent 30 is not
15 limited to calcium oxide, and the adsorbent 30 may include silica gel or zeolite. Further, the adsorbent 30 is not particularly limited as long as it has at least a water-adsorbing property. The adsorbent 30 may be configured by combining adsorbents having different compositions as long
20 as the adsorbent 30 includes a material having at least a water-adsorbing property.

[0021] The wrapping material 31 is formed of a highly-breathable material such as paper, non-woven fabric, or a porous-plastic film; and wraps the adsorbent 30 without
25 using heat seal. The configuration of the wrapping material 31 is not particularly limited as long as it is breathable. It is preferable that the air permeability of the wrapping material 31 be not less than $5 \text{ cm}^3/\text{cm}^2/\text{s}$ and not more than $50 \text{ cm}^3/\text{cm}^2/\text{s}$. It is more preferable that the
30 air permeability of the wrapping material 31 be not less than $10 \text{ cm}^3/\text{cm}^2/\text{s}$ and not more than $30 \text{ cm}^3/\text{cm}^2/\text{s}$.

[0022] A wrapping mode of the adsorbent 30 according to the present embodiment will be described next. FIGS. 2 to

4 are diagrams illustrating modes in which the adsorbent 30 is wrapped with the wrapping material 31.

[0023] FIG. 2 is a diagram illustrating a schematic configuration of twist wrapping with the wrapping material 31. As illustrated in FIG. 2, the adsorbent 30 is sealed in the wrapping material 31 by twist wrapping. The wrapping material 31 configured in a bag form is twisted on the opening side to be sealed. The method of twist wrapping is not limited to a method of twisting one side of the wrapping material 31 as illustrated in FIG. 2. A method of twisting both sides of the wrapping material 31 may alternatively be used. In the latter case, the wrapping material 31 in a sheet form is twisted on the both sides to be sealed.

[0024] FIG. 3 is a diagram illustrating a schematic configuration of folding wrapping with the wrapping material 31. As illustrated in FIG. 3, the adsorbent 30 is sealed in the wrapping material 31 by folding wrapping. The shape of folding wrapping is not limited to that illustrated in FIG. 3. Any shape may be employed as long as the adsorbent 30 is sealed in the wrapping material 31.

[0025] FIG. 4 is a diagram illustrating a schematic configuration of ligating wrapping with the wrapping material 31. As illustrated in FIG. 4, the wrapping material 31 is ligated with a fastener 32, in which the adsorbent 30 is sealed. The fastener 32 may be a binding material such as a staple, a band, or a cord. However, the fastener 32 is not particularly limited as long as it can fasten the opening of the wrapping material 31. After the twist wrapping is performed, the wrapping material 31 may be further fastened with the fastener 32.

[0026] A production method of the vacuum heat-insulating material according to the present embodiment will be

described next. The adsorbent 30 is wrapped in units of a specified quantity (for example, 10 g) with the wrapping material 31 in advance using a general-purpose filling and wrapping machine, without using heat seal. The adsorbent
5 30 wrapped with the wrapping material 31 is stored hermetically in an aluminum laminated bag in units of one piece or multiple pieces for the purpose of preventing absorption of at least water until the adsorbent 30 is used. At this time, for the purpose of further suppressing
10 absorption of at least water, the interior of the aluminum laminated bag may be depressurized and hermetically sealed. The method of hermetically storing the adsorbent 30 wrapped with the wrapping material 31 is not limited to the method that uses an aluminum laminated bag. A method of storing
15 the adsorbent 30 in an airtight container such as a pail may be applied. It is also adequate that the filling and wrapping machine described above is disposed in a vicinity of a vacuum wrapping machine that depressurizes the interior space of the outer wrapping material 20 to the
20 degree of vacuum of approximately 1 to 3 Pa and that hermetically seals the opening, in order that immediately before the interior space of the outer wrapping material 20 is depressurized, the adsorbent 30 is wrapped with the wrapping material 31 without using heat seal, and then the
25 adsorbent 30 wrapped with the wrapping material 31 is used. [0027] Next, the core material 10 and the outer wrapping material 20 are dried to remove water therefrom. The drying is performed in a state where the core material 10 is covered with the outer wrapping material 20 on a
30 condition that water can be removed from the core material 10 and the outer wrapping material 20 (for example, heating at 100°C for two hours). The drying condition is not limited thereto, and may be any conditions as long as water

can be removed from the core material 10 and the outer wrapping material 20. It is also adequate to cover the core material 10 with the outer wrapping material 20 after the core material 10 and the outer wrapping material 20 are dried separately from each other.

[0028] Next, the adsorbent 30 wrapped with the wrapping material 31 is inserted in the inside of the outer wrapping material 20. The step of inserting the adsorbent 30 wrapped with the wrapping material 31 in the inside of the outer wrapping material 20 is not limited to being performed after the core material 10 and the outer wrapping material 20 are dried. This step may be performed before the drying.

[0029] Next, the vacuum wrapping machine described above is used to depressurize the inside of the outer wrapping material 20 to the degree of vacuum of approximately 1 to 3 Pa. In the depressurized state, a heat-sealed portion is formed at the opening of the outer wrapping material 20 by heat seal or other methods. Thus, inside of the outer wrapping material 20 is depressurized and sealed. Through the steps described above, the vacuum heat-insulating material 1 is obtained.

[0030] Effects of the present embodiment will be described next. The vacuum heat-insulating material 1 of the present embodiment includes: the core material 10 made of a fiber aggregate; the adsorbent 30 that adsorbs at least water; the wrapping material 31 that wraps the adsorbent 30 and that is formed of a breathable sheet member; and the outer wrapping material 20 that covers the core material 10 and the adsorbent 30 wrapped with the wrapping material 31, where the inside of the outer wrapping material 20 is depressurized and hermetically sealed. The adsorbent 30 is wrapped with the wrapping

material 31 without using heat seal. Due to this configuration, a breathable sheet member such as paper, non-woven fabric, or a porous-plastic film, any of which has a high air permeability, can be used solo as the wrapping material 31 for the adsorbent 30. Therefore, the gas absorbing speed within the vacuum heat-insulating material 1 is accelerated. Accordingly, the vacuum heat-insulating material 1 with a high heat-insulation performance can be obtained.

10 [0031] A comparison between a case where Japanese paper is used as the wrapping material 31 of the present embodiment and a case where a laminated film of Japanese paper and polyethylene is used as a general wrapping material will be made. When Japanese paper is used as the wrapping material 31 of the present embodiment, the air permeability of Japanese paper is $28 \text{ cm}^3/\text{cm}^2/\text{s}$. In contrast, when a laminated film of Japanese paper and polyethylene is used as a general wrapping material, the air permeability of the laminated film of Japanese paper and polyethylene is $3 \text{ cm}^3/\text{cm}^2/\text{s}$. When Japanese paper is used as the wrapping material 31 of the present embodiment, a greater amount of gas can pass through it per unit time. This can increase the absorption rate of the adsorbent 30. In cases where the same core material, the same outer wrapping material, and the same adsorbent are used, the vacuum heat-insulating material 1 in which Japanese paper is used as the wrapping material 31 of the present embodiment has a heat conductivity of $1.8 \text{ mW}/(\text{m}\cdot\text{K})$ while a vacuum heat-insulating material in which a laminated film of Japanese paper and polyethylene is used as a general wrapping material has a heat conductivity of $2.0 \text{ mW}/(\text{m}\cdot\text{K})$. Therefore, according to the vacuum heat-insulating material 1 of the present embodiment, a vacuum heat-insulating

material with a high heat-insulation performance can be obtained.

[0032] Additionally, the vacuum heat-insulating material 1 of the present embodiment can suppress time degradation in the heat-insulation performance. Assuming the same core material, the same outer wrapping material, and the same adsorbent are used, when the vacuum heat-insulating material 1 in which Japanese paper is used as the wrapping material 31 of the present embodiment is stored for 30 days under an environment where the air temperature is 25°C and the relative humidity is 60%, the heat conductivity is increased by 0.1 mW/(m·K); while when the vacuum heat-insulating material in which a laminated film of Japanese paper and polyethylene is used as a general wrapping material is stored for 30 days under the environment where the air temperature is 25°C and the relative humidity is 60%, the heat conductivity is increased by 0.2 mW/(m·K). Therefore, according to the vacuum heat-insulating material 1 of the present embodiment, a vacuum heat-insulating material having a high heat-insulation performance for a long term can be obtained.

[0033] Second embodiment.

A heat-insulating box according to a second embodiment of the present invention will be described. In the first embodiment described above, the vacuum heat-insulating material and its production method have been described. The heat-insulating box with a high heat-insulation performance can be obtained by using the vacuum heat-insulating material 1 according to the first embodiment.

[0034] FIG. 5 is a cross-sectional view illustrating a schematic configuration of a heat-insulating box 2 according to the present embodiment. In the present embodiment, a heat-insulating box of a refrigerator will be

described as an example.

[0035] As illustrated in FIG. 5, the heat-insulating box 2 includes an inner box 40 and an outer box 41. In a space between the inner box 40 and the outer box 41, the vacuum heat-insulating material 1 is provided. The vacuum heat-insulating material 1 is provided in close contact with outer wall surfaces of the inner box 40, for example. In the remaining portion of the space between the inner box 40 and the outer box 41, excluding the vacuum heat-insulating material 1, a urethane-foam heat-insulating material 42 is filled. Other parts of the heat-insulating box 2 are identical to those of a heat-insulating box of a general refrigerator and thus illustrations and descriptions thereof are omitted.

15 [0036] In the present embodiment, the vacuum heat-insulating material 1 with a high heat-insulation performance described in the first embodiment is used, and therefore the heat-insulating box 2 with a high heat-insulation performance can be obtained. In the present embodiment, the vacuum heat-insulating material 1 with a higher heat-insulation performance than the urethane-foam heat-insulating material 42 or other materials is used. Therefore, the heat-insulating box 2 with a higher heat-insulation performance than a heat-insulating box in which only a urethane-foam heat-insulating material is used as a heat-insulating material can be obtained. Accordingly, a refrigerator that includes the heat-insulating box 2 can reduce power consumption.

[0037] In the heat-insulating box 2 of the present embodiment, the vacuum heat-insulating material 1 is in close contact with the outer wall surfaces of the inner box 40. However, the vacuum heat-insulating material 1 may be in close contact with inner wall surfaces of the outer box

41. Further, by using a spacer or other devices, the vacuum heat-insulating material 1 may be provided in the space between the inner box 40 and the outer box 41 so as to be in close contact with neither the inner box 40 nor the outer box 41.

[0038] The present invention is not limited to the above embodiments, and various modifications can be performed.

For example, in the second embodiment described above, the configuration has been described as an example, in which

the vacuum heat-insulating material 1 is used in the heat-insulating box 2 of a refrigerator that includes a cold source. However, the present invention is not limited thereto. For example, the vacuum heat-insulating material 1 may also be used in a heat-insulating box of a heat-retaining storage that includes a heat source, or in a heat-insulating box that does not include a cold source or a heat source (for example, a cooler).

[0039] The vacuum heat-insulating material 1 may also be used as a heat-insulating member of a cooling device or a

heating device in an air conditioner, a vehicle air conditioner, a water heater, and other devices, as well as in a heat-insulating box. Furthermore, the vacuum heat-insulating material 1 may be used not only in a box with a predetermined shape, such as a heat-insulating box, but may also be used in a deformable heat-insulating bag that includes an outer bag and an inner bag, or in other heat-insulating containers.

[0040] The embodiments and modifications described above may be combined with each other.

Industrial Applicability

[0041] The present invention is useful as a vacuum heat-insulating material, a heat-insulating box, and a

production method of a vacuum heat-insulating material.

Reference Signs List

[0042] 1 vacuum heat-insulating material, 2 heat-insulating box, 10 core material, 20 outer wrapping material, 30 adsorbent, 31 wrapping material, 32 fastener, 40 inner box, 41 outer box, 42 urethane-foam heat-insulating material.

CLAIMS

1. A vacuum heat-insulating material comprising:
a core material made of a fiber aggregate;
an adsorbent that adsorbs at least water;
5 a wrapping material that is configured using a
breathable sheet member and that wraps the adsorbent; and
an outer wrapping material that covers the adsorbent
wrapped with the wrapping material, and the core material,
where an inside of the outer wrapping material is
10 depressurized and hermetically sealed, wherein
the adsorbent is wrapped with the wrapping material
without using heat seal.
2. The vacuum heat-insulating material according to claim
15 1, wherein the adsorbent is sealed in the wrapping material
by twist wrapping or folding wrapping.
3. The vacuum heat-insulating material according to claim
1, wherein the wrapping material is ligated by ligating
20 wrapping, in which the adsorbent is sealed.
4. The vacuum heat-insulating material according to any
one of claims 1 to 3, wherein an air permeability of the
wrapping material is not less than $5 \text{ cm}^3/\text{cm}^2/\text{s}$ and not more
25 than $50 \text{ cm}^3/\text{cm}^2/\text{s}$.
5. The vacuum heat-insulating material according to claim
4, wherein the wrapping material is paper, non-woven fabric,
or a porous-plastic film.
- 30 6. The vacuum heat-insulating material according to any
one of claims 1 to 5, wherein the adsorbent is calcium
oxide, silica gel, or zeolite.

7. A heat-insulating box including the vacuum heat-insulating material according to any one of claims 1 to 6.

5 8. A production method of a vacuum heat-insulating material, the method comprising:

a step of wrapping an adsorbent that adsorbs at least water with a wrapping material configured using a breathable sheet member, without using heat seal;

10 a step of covering the adsorbent wrapped with the wrapping material, and a core material made of a fiber aggregate with an outer wrapping material; and

a step of depressurizing and hermetically sealing an inside of the outer wrapping material.

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