

DESCRIPTION

Title of Invention

VACUUM HEAT INSULATING MATERIAL, HEAT INSULATING BOX USING
VACUUM HEAT INSULATING MATERIAL, AND MANUFACTURING METHOD
5 OF VACUUM HEAT INSULATING MATERIAL

Technical Field

[0001]

The present invention relates to a vacuum heat insulating material and a
heat insulating box using this vacuum heat insulating material, and particularly to
10 a vacuum heat insulating material and a heat insulating box suitable for use in
cooling equipment and a manufacturing method.

Background Art

[0002]

As an existing vacuum heat insulating material used as a heat insulating
15 material of a heat insulating box in a refrigerator or another apparatus, there is a
core material formed of an assembly of glass fiber and covered with an outer
cover material having a gas barrier property, with the interior of the outer cover
material reduced in pressure and sealed (see Patent Literature 1, for example).

[0003]

20 The vacuum heat insulating material with the interior of the outer cover
material thus reduced in pressure has the bulky assembly of glass fiber covered
with the outer cover material and subjected to the pressure reduction and sealing
to be reduced in thickness, and reduces the effect of convection and thermal
conduction of gas inside the outer cover material to improve heat insulation
25 performance. In general, the heat transfer mechanism of a heat insulating
material is caused by thermal conduction, radiation, and convection of solid and
gas components. Meanwhile, the effect of thermal conduction and convection of

the gas component is small in the vacuum heat insulating material with the interior of the outer cover material reduced in pressure and sealed. Further, the effect of radiation is little in the use in a temperature range of normal temperature or lower. It is therefore important to suppress thermal conduction of the solid component in the vacuum heat insulating material applied to a refrigerator or another apparatus used in the temperature range of normal temperature or lower. Accordingly, various forms of fiber have been reported as vacuum heat insulating core materials excellent in heat insulation performance. In recent years, severe competition for energy saving has led to a strong demand for a vacuum heat insulating material thin yet excellent in heat insulation performance, particularly for a fiber assembly with high heat insulation performance serving as the core material.

[0004]

As a method of reducing the thermal conductivity of a vacuum heat insulating material, there is a method of orienting glass fiber forming the vacuum heat insulating material in a direction perpendicular to a heat insulating direction, to thereby suppress heat transfer by the glass fiber (see Patent Literature 2, for example).

[0005]

Further, there is a method of performing heat-compression molding on glass fiber with binder by a dry method, and not only orienting the glass fiber perpendicularly to a heat transfer direction but also adding short fiber having a length of 100 μm or less by 40 to 70%, to thereby cut off the heat transferred through the fiber and reduce the solid thermal conductivity (see Patent Literature 3, for example).

[0006]

Further, there is a vacuum heat insulating material with excellent heat insulation performance including, as the core material, a glass fiber laminate formed of glass fiber having a mean fiber diameter of 2 to 5 μm by a dry method not using binder, in which the mixing ratio of shots (lumps) is 0.5 mass% or less, the mean particle diameter of the shots is 150 μm or less, and the ratio of glass fiber having a fiber length of 500 μm or more is 80% or more (see Patent Literature 4, for example).

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Patent No. 3580315 (abstract, Fig. 1)

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 9-4785 (abstract)

Patent Literature 3: Japanese Patent No. 3513143 (paragraph [0006])

Patent Literature 4: Japanese Unexamined Patent Application Publication No. 2009-155172 (abstract)

Summary of Invention

Technical Problem

[0008]

Although glass fiber forming a vacuum heat insulating material may be laminated as oriented in a direction perpendicular to a heat insulating direction as a method of reducing the thermal conductivity of the vacuum heat insulating material, simply laminating the glass fiber as oriented in the direction perpendicular to the heat insulating direction increases the solid thermal conductivity owing to the presence of the heat transferred through the glass fiber, limiting the reduction of the initial thermal conductivity of the vacuum heat insulating material.

[0009]

Further, the method of binding glass fiber with binder by heat-compression molding increases the cost of power for heating and the cost of materials of the binder, thereby failing to obtain the vacuum heat insulating material at low cost, and also causing a problem of increased deterioration of the thermal conductivity over time. This is because, when the vacuum heat insulating material is formed, a low-molecular gas component is discharged from the binder in a vacuum and reduces the degree of vacuum.

[0010]

Further, the dry method not using binder has a problem that the fiber angle is not controllable in the state of the vacuum heat insulating material, even if the length of the glass fiber and the weight ratio of the short fiber are controllable.

[0011]

The present invention has been made to solve the above-described problems, and aims to provide a vacuum heat insulating material excellent in heat insulation performance and controllable in terms of the weight ratio of short fiber, the mean fiber angle, and the standard deviation thereof, a heat insulating box using the vacuum heat insulating material, and a manufacturing method of the vacuum heat insulating material.

Solution to Problem

[0012]

A vacuum heat insulating material according to the present invention includes a core material formed of a fiber assembly and an outer cover material covering the core material, with an interior of the outer cover material reduced in pressure and sealed, wherein a weight ratio of fiber having a fiber length of 1.85 mm or less in the core material is 11 wt% or less of an entirety of this core material.

Advantageous Effects of Invention

[0013]

Since the weight ratio of the fiber having the fiber length of 1.85 mm or less in the core material is 11 wt% or less of the entirety of the core material in the vacuum heat insulating material according to the present invention, it is possible to shorten heat paths in a heat insulating direction of the core material and minimize the effect of the fiber having the fiber length of 1.85 mm or less, which is a factor degrading the heat insulation performance. It is therefore possible to obtain high heat insulation performance.

Further, with the weight ratio of the fiber having the fiber length of 1.85 mm or less set to 11 wt% or less of the core material, fiber having a fiber length of 1.85 mm or more is likely to be oriented perpendicularly to the heat insulating direction of the core material, making it possible to minimize the effect of the fiber having the fiber length of 1.85 mm or less, which is oriented in the heat insulating direction of the core material and is a factor degrading the heat insulation performance. It is therefore possible to obtain a vacuum heat insulating material excellent in heat insulation performance.

Moreover, with the vacuum heat insulating material of the present invention applied to a heat insulating box of a refrigerator or another apparatus, the heat insulating effect of the product is increased, making it possible to reduce the thickness of a wall of the product and increase the internal volume in a limited space of the product.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a graph illustrating the relationship between a thermal conductivity and a weight ratio of fiber having a fiber length of 1.85 mm or less in

a core material of a vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is an optical microscope photograph taken in measurement of a mean fiber length of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is an optical microscope photograph taken in measurement of a mean fiber angle of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a graph illustrating the relationship between the thermal conductivity and the mean fiber angle of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a graph illustrating the relationship between the thermal conductivity and a fiber angle standard deviation of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a cross-sectional view illustrating the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 7] Fig. 7 is a schematic diagram illustrating a manufacturing method of the vacuum heat insulating material according to Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a schematic diagram illustrating a heat insulating box according to Embodiment 2 of the present invention.

Description of Embodiments

[0015]

Embodiment 1

In a vacuum heat insulating material according to Embodiment 1 of the present invention, the weight ratio of fiber having a fiber length of 1.85 mm or

less (hereinafter occasionally referred to as the "short fiber") in a fiber assembly forming a core material is 11 wt% or less, preferably 8 wt% or less, of the core material. Herein, the weight ratio of the fiber having the fiber length of 1.85 mm or less (short fiber) means the measurement value measured by the following method.

[0016]

(Measurement Method of Weight Ratio of Short Fiber)

100 ml of weighed fiber was placed in a beaker, added with 50 ml of distilled water, and diffused for five minutes in an ultrasonic cleaner. Thereafter, lumps of fiber each having two or more strands of fiber in contact with each other were removed as much as possible in one minute with precision tweezers, and remaining fiber (short fiber) having failed to be picked up with the precision tweezers was filtered off and dried. The short fiber remaining on filter paper was weighed and divided by an initial fiber amount to obtain the weight ratio thereof.

[0017]

Fig. 1 is a graph illustrating the relationship between the thermal conductivity and the weight ratio of the fiber having the fiber length of 1.85 mm or less in the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention. The vertical axis represents the thermal conductivity [mW/m·K], and the horizontal axis represents the weight ratio [wt%] of the fiber having the fiber length of 1.85 mm or less.

As obvious from this result, the thermal conductivity was substantially constant at 2.0 mW/m·K or less when the weight ratio of the fiber having the fiber length of 1.85 mm or less was in a range of 11 wt% or less of the core material. Meanwhile, if the weight ratio of the fiber having the fiber length of 1.85 mm or less exceeds 11 wt% of the core material, the thermal conductivity increases to 2.0 mW/m·K or more.

According to the above-described result, the weight ratio of the fiber having the fiber length of 1.85 mm or less forming the vacuum heat insulating material having the thermal conductivity of 2.0 mW/m·K or less is 11 wt% or less of the core material.

5 The mean fiber length of the short fiber in the foregoing measurement method was obtained by the following method.

[0018]

(Measurement Method of Mean Fiber Length)

10 A few drops of approximately a few milligrams of the short fiber diffused in water were placed onto a laboratory dish, and moisture was evaporated therefrom in a high-temperature vessel at 110 degrees Celsius. The dried fiber was observed with an optical microscope (at a magnification of 20 to 100 times), and the length of each of 20 strands of fiber at a given point was measured to one hundredth of a millimeter. This measurement was performed at five points,
15 and the mean of the lengths of 100 strands of fiber in total was determined as the mean fiber length.

[0019]

20 Fig. 2 is an optical microscope photograph taken in the measurement of the mean fiber length of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention.

25 As a result of measurement of the mean fiber length of the short fiber in the measurement of the weight ratio according to the present measurement method, it was revealed that the mean fiber length was 0.50 mm and a standard deviation σ was 0.45 mm. That is, in the core material forming the vacuum heat insulating material having the thermal conductivity of 2.0 mW/m·K or less, the weight ratio of the fiber having the fiber length of 1.85 mm or less corresponding to the mean short fiber length + 3σ is 11 wt% or less of the core material. The

standard deviation σ is a criterion for evaluating the spread width (variation) of the distribution of data. In a fiber length range with a maximum fiber length of 1.85 mm obtained with the mean short fiber length + 3σ , 99.73% of all data of the lengths of the collected strands of short fiber is distributed.

5 [0020]

In the fiber assembly forming the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention, the mean of a fiber angle φ to a plane perpendicular to the heat insulating direction of the core material is 14 degrees or less. Herein, the mean of the fiber angle φ to the plane perpendicular to the heat insulating direction of the core material (mean fiber angle) means the measurement value measured by the following method.

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[0021]

(Measurement Method of Mean Fiber Angle)

Fig. 3 is an optical microscope photograph taken in the measurement of the mean fiber angle of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention, and a measurement example is illustrated in the drawing.

15

That is, to maintain the thickness in the state of the vacuum heat insulating material, the exterior of the vacuum heat insulating material was hardened with an epoxy resin, and thereafter an epoxy resin was poured into the interior of the core material in a vacuum and hardened. After the hardening, a central portion of the vacuum heat insulating material was cut along a horizontal plane extending along the heat insulating direction, and the cut surface was polished and observed with an optical microscope, with a plane perpendicular to the heat insulating direction of the core material set as a horizontal plane (0 degrees) serving as a reference for the angle. On the assumption that fiber cross sections were all elliptic, a length a [μm] of a major axis and a length b [μm] of a

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minor axis of each of strands of fiber on a screen and an angle θ [degrees] formed by the major axis and the horizontal plane serving as the reference for the angle were measured to one hundredth of a micrometer, one hundredth of a micrometer, and one hundredth of a degree, respectively, at a given point in the cut surface excluding a peripheral area thereof having a width of 1 mm. The measurement results were substituted into the following equation (1) to calculate the fiber angle ϕ [degrees], and this measurement was performed at two points. The mean of the fiber angles ϕ of 200 strands of fiber in total was determined as the mean fiber angle. Herein, while the angle θ represents the angle formed by the major axis of an ellipse and the horizontal plane, the fiber angle ϕ represents an angle having the angle formed by the major axis of the ellipse and the horizontal plane and the angle formed by the cut surface taken into account.

[0022]

[Math. 1]

$$\phi = \tan^{-1} \frac{\sin \theta}{\sqrt{\cos^2 \theta + \frac{b^2}{a^2 + b^2}}} \dots \dots \dots (1)$$

[0023]

Fig. 4 is a graph illustrating the relationship between the thermal conductivity and the mean fiber angle of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention. The vertical axis represents the thermal conductivity [mW/m·K], and the horizontal axis represents the mean fiber angle [degrees].

As obvious from this result, the thermal conductivity was substantially constant at 2.0 mW/m·K or less when the mean fiber angle was in a range of 14 degrees or less. Meanwhile, it was revealed that the thermal conductivity increases to 2.0 mW/m·K or more if the mean fiber angle exceeds 14 degrees.

According to the above-described result, the mean fiber angle of the core material forming the vacuum heat insulating material having the thermal conductivity of 2.0 mW/m·K. or less is 14 degrees or less.

[0024]

Fig. 5 is a graph illustrating the relationship between the thermal conductivity and a fiber angle standard deviation of the core material of the vacuum heat insulating material according to Embodiment 1 of the present invention. The vertical axis represents the thermal conductivity [mW/m·K], and the horizontal axis represents the fiber angle standard deviation [degrees].

As obvious from this result, the thermal conductivity was substantially constant at 2.0 mW/m·K or less when the standard deviation of the fiber angle was in a range of 12 degrees or less. Meanwhile, it was revealed that the thermal conductivity increases to 2.0 mW/m·K or more if the standard deviation of the fiber angle exceeds 12 degrees.

According to the above-described result, the standard deviation of the fiber angle of the core material forming the vacuum heat insulating material at 2.0 mW/m·K or less is 12 degrees or less.

[0025]

The presence of an inflection point in each of the relationships between the weight ratio of the fiber having the fiber length of 1.85 mm or less and the thermal conductivity, between the mean fiber angle and the thermal conductivity, and between the fiber angle standard deviation and the thermal conductivity is explicable by the percolation theory. For example, the weight ratio of the fiber having the fiber length of 1.85 mm or less will now be considered. One of factors degrading the heat insulation performance of a VIP (vacuum insulation panel) is fiber oriented in the heat insulating direction of the VIP. Since the shorter the fiber is, the more likely the fiber is to be oriented in the heat insulating

direction of the VIP, a reduction in short fiber is expected to improve the heat insulation performance. The effect thereof on the heat insulation performance is small, however, unless multiple strands of fiber oriented in the heat insulating direction are layered to connect heat paths in the heat insulating direction.

5 [0026]

In the present invention, the fiber having the fiber length of 1.85 mm or less is defined as the short fiber, and it is considered that the less this short fiber is, the higher the heat insulation performance is. It was revealed as a result of an experiment that the thermal conductivity was constant when the weight ratio of the short fiber was 11 wt% or less of the core material, and that the thermal conductivity sharply increased when the weight ratio of the short fiber exceeded 11 wt% of the core material. This suggests that the point at which the weight ratio of the fiber having the fiber length of 1.85 mm or less is 11 wt% of the core material is an inflection point at which multiple strands of fiber oriented in the heat insulating direction are layered, sharply increasing the connection of heat paths in the heat insulating direction (the critical point of percolation).

15 It is considered for the above-described reason that the relationship between the weight ratio of the fiber having the fiber length of 1.85 mm or less and the thermal conductivity has an inflection point. Similar consideration is further applicable to the presence of an inflection point in each of the relationships between the mean fiber angle and the thermal conductivity and between the fiber angle standard deviation and the thermal conductivity.

20 [0027]

Fig. 6 is a cross-sectional view illustrating the vacuum heat insulating material according to Embodiment 1 of the present invention.

25 In Fig. 6, a vacuum heat insulating material 1 includes a core material 2 formed of a fiber assembly, an outer cover material 3 having a gas barrier

property and covering the core material 2, and a moisture adsorbent 4 that adsorbs moisture inside the outer cover material 3 to suppress deterioration over time. The outer cover material 3 has an interior reduced in pressure to a vacuum degree of 1 to 3 Pa (pascals) and an opening port sealed with, for example, a heat-sealed, welded seal portion 5.

[0028]

The core material 2 may be glass fiber, alumina fiber, silica-alumina fiber, silica fiber, rock wool, silicon carbide fiber, or nonwoven fabric, but is not particularly specified.

[0029]

The outer cover material 3 includes at least a gas barrier layer and a heat-welded layer, and may be provided with a surface protection layer as necessary. The gas barrier layer may be a plastic film or metal foil with metal, metallic oxide, or diamond-like carbon vapor-deposited thereon, but is not particularly specified, and any material usable for reducing gas permeation may be used.

Further, the material of metallic oxide vapor-deposited on the plastic film may be silica or alumina, but is not particularly specified.

[0030]

The heat-welded layer of the outer cover layer 3 is highest in gas permeation rate among films forming the outer cover layer 3, and properties of the heat-welded layer significantly affect the heat insulation performance over time of the vacuum heat insulating material. In consideration of the stability of a sealing quality in the pressure reduction and sealing process, the suppression of gas penetration from an end surface of a heat-welded portion, and heat leakage from a surface due to thermal conduction occurring when a metal foil is used as the gas barrier layer, 25 μm to 60 μm is suitable for the thickness of the heat-welded layer.

[0031]

The material of the heat-welded layer may be a non-stretched polypropylene film, a high-density polyethylene film, or a linear low-density polyethylene film, but is not particularly specified.

5 [0032]

Moreover, it is possible to further provide a surface protection layer on the outside of the gas barrier layer. A stretched product of a polyethylene terephthalate film, a polypropylene film, or a nylon film may be used as the surface protection film. If a nylon film is further used on the outside, folding resistance and piercing resistance are improved.

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[0033]

Further, the bag shape of the outer cover material 3 may be that of a four-side sealed bag, a gusset bag, a three-side sealed bag, a pillow bag, or a center-tape sealed bag, but is not particularly specified.

15 [0034]

The moisture adsorbent 4 is calcium oxide (CaO) placed in a breathable bag, for example. The moisture adsorbent 4 is not limited only to CaO, and may be anything with a moisture adsorbing property, such as zeolite, for example, without being particularly limited.

20 [0035]

A description will now be given of a manufacturing method of the vacuum heat insulating material 1 according to Embodiment 1 of the present invention.

The core material 2 used in the vacuum heat insulating material 1 according to Embodiment 1 is formed of a glass fiber assembly manufactured by a dry method not using binder, for example. The core material 2 formed of this glass fiber assembly has a low bulk density, which results in poor handleability and poor insertability into the outer cover material 3 in the manufacture of the

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vacuum heat insulating material 1. It is therefore necessary to increase the bulk density by processing to handle the glass fiber assembly as the core material 2.

[0036]

Fig. 7 is a schematic diagram illustrating a manufacturing method of the vacuum heat insulating material according to Embodiment 1 of the present invention.

A machining device 6 includes a compression mechanism 7 that compresses the core material 2. The core material 2 is adjusted to a width and length necessary for the vacuum heat insulating material 1, and then is placed in the machining device 6. Herein, the thickness of the core material 2 is ten times the thickness of the vacuum heat insulating material 1.

[0037]

Then, the core material 2 is repeatedly compressed by the compression mechanism 7. The pressure applied in the compressions is preferably 0.02 to 0.07 MPa, more preferably 0.02 to 0.04 MPa. The number of compressions is preferably 50 to 1000. With the compressions performed under the above-described conditions, the fiber is gradually displaced and repeatedly rearranged while the fiber having the fiber length of 1.85 mm or less maintains the weight ratio thereof before the compressions, and the core material 2 is obtained in which the mean and the standard deviation of the fiber angle φ to the plane perpendicular to the heat insulating direction of the core material 2 are 14 degrees or less and 12 degrees or less, respectively.

[0038]

If the pressure applied in 50 to 1000 compressions exceeds 0.07 MPa, the fiber ruptures, and the weight ratio of the fiber having the fiber length of 1.85 mm or less reaches or exceeds 11 wt% of the core material 2, preventing a vacuum heat insulating material excellent in heat insulation performance from being

obtained. A reason therefor is considered to be short fiber filling or clinging to spaces in main fiber and causing thermal conduction between the fibers and along the thickness direction of the core material, thereby degrading the heat insulation performance.

5 [0039]

Meanwhile, if the pressure applied in 50 to 1000 compressions falls below 0.02 MPa, the rearrangement due to the displacement of the fiber is unlikely to occur, preventing the mean of the fiber angle ϕ to the plane perpendicular to the heat insulating direction of the core material 2 from being controlled to be 14
10 degrees or less, and preventing a vacuum heat insulating material excellent in heat insulation performance from being obtained. Further, without an increase in the bulk density, the handleability and the insertability into the outer cover material 3 are not improved, preventing efficient manufacturing of the vacuum heat insulating material.

15 [0040]

The material 2 processed to have a high bulk density is then inserted into the outer cover material 3 and subjected to a drying process to remove moisture therefrom. Thereafter, the moisture adsorbent 4 is inserted therein, and the opening port is sealed by heat sealing with the interior of the outer cover material
20 3 reduced in pressure to a vacuum degree of 1 to 3 Pa (pascals), to thereby obtain the vacuum heat insulating material 1. The drying process may be performed under a condition enabling removal of moisture from the core material 2 and the outer cover material 3 covering the core material 2, such as heating at 100 degrees Celsius for two hours, for example. The heating condition,
25 however, is not limited thereto, and may be any condition enabling removal of moisture from the core material 2 and the outer cover material 3 covering the core material 2.

Further, the moisture adsorbent 4 is not limited to being inserted after the drying process, and may be inserted before the drying process or before the compression of the core material 2 and the outer cover material 3 covering the core material 2 with the machining device 6.

5 [0041]

The vacuum heat insulating material 1 according to Embodiment 1 of the present invention has been evaluated in terms of the thermal conductivity, the weight ratio of the fiber having the fiber length of 1.85 mm or less, and the mean and the standard deviation of the fiber angle φ to the plane perpendicular to the heat insulating direction of the core material 2. The thermal conductivity was measured with a thermal conductivity meter by a steady method. The measurement was conducted under measurement conditions of 37.7 degrees Celsius on a high-temperature side, 10 degrees Celsius on a low-temperature side, and a mean temperature of 23.85 degrees Celsius. The thermal conductivity was 2.0 mW/m·K or less when the weight ratio of the fiber having the fiber length of 1.85 mm or less was 11 wt% or less of the core material 2, and the mean and the standard deviation of the fiber angle φ to the plane perpendicular to the heat insulating direction of the core material 2 were 14 degrees or less and 12 degrees or less, respectively. It was revealed from the above result that the vacuum heat insulating material processed by the method of Embodiment 1 and satisfying the foregoing conditions has excellent heat insulation performance.

20 [0042]

Embodiment 2

In Embodiment 1 described above, the vacuum heat insulating material 1 and a manufacturing method thereof have been described. With the use of this vacuum heat insulating material 1, it is possible to provide a heat insulating box of a refrigerator that consumes low power. Fig. 8 is a schematic diagram

illustrating a heat insulating box according to Embodiment 2 of the present invention (a heat insulating box of a refrigerator is illustrated in Embodiment 2), and parts in the drawing corresponding to those of Embodiment 1 described above are assigned with the same signs.

5 In Fig. 8, a heat insulating box 8 includes an internal box 9 formed of an ABS resin, an external box 10 formed of a steel plate, the vacuum heat insulating material 1 disposed on one surface (on the side of the internal box 9) of the space between the internal box 9 and the external box 10, and a urethane foam heat insulating material 11 foamed to fill the space between the internal box 9 and the external box 10 excluding the vacuum heat insulating material 1. A surface of the internal box 9 and a surface of the external box 10 common to each other are respectively formed with openings (not illustrated), and an opening and closing door (not illustrated) is provided to the openings. Since the other parts of the heat insulating box 8 are not different from those of a heat
10 insulating box used in a common refrigerator, illustration and description thereof will be omitted.

[0043]

 In the heat insulating box 8 of the above-described refrigerator, the area in which the vacuum heat insulating material 1 is disposed is not limited, and may
20 be all or a part of the space formed between the internal box 9 and the external box 10. Further, the vacuum heat insulating material 1 may be disposed inside the above-described opening and closing door.

[0044]

 In the heat insulating box 8 of the refrigerator configured as described
25 above, with the combined use of the vacuum heat insulating material 1 of the present invention as embedded in the urethane foam heat insulating material 11,

the heat insulating effect is further increased, and an energy saving effect due to the reduction in power consumption and other factors is obtained.

Reference Signs List

[0045]

- 5 1 vacuum heat insulating material 2 core material 3 outer cover material 4 moisture adsorbent 5 welded seal portion 6 machining device 7 compression mechanism 8 heat insulating box 9 internal box 10 external box 11 urethane foam heat insulating material

CLAIMS

[Claim 1]

A vacuum heat insulating material comprising a core material formed of a fiber assembly and an outer cover material covering the core material, with an interior of the outer cover material reduced in pressure and sealed,

wherein a weight ratio of fiber having a fiber length of 1.85 mm or less in the core material is 11 wt% or less of an entirety of the core material.

[Claim 2]

The vacuum heat insulating material of claim 1, wherein a fiber angle representing a direction of the fiber having the fiber length of 1.85 mm or less relative to a plane perpendicular to a heat insulating direction of the core material has a mean of 14 degrees or less.

[Claim 3]

The vacuum heat insulating material of claim 2, wherein a standard deviation of the fiber angle of the fiber having the fiber length of 1.85 mm or less relative to the plane perpendicular to the heat insulating direction of the core material is 12 degrees or less.

[Claim 4]

A heat insulating box comprising an external box and an internal box disposed inside the external box,

wherein the vacuum heat insulating material of any one of claims 1 to 3 is disposed between the external box and the internal box.

[Claim 5]

A manufacturing method of a vacuum heat insulating material comprising:

a step of repeatedly compressing an assembly of glass fiber a preset number of times under a preset pressure in a thickness direction with a load-

controllable compression mechanism, to thereby form a core material in which a weight ratio of fiber having a fiber length of 1.85 mm or less is 11 wt% or less;

a step of inserting the core material into an outer cover material, and
reducing pressure in an interior of the outer cover material to a preset vacuum
5 degree; and

a step of sealing an opening port of the outer cover material while the
outer cover material is reduced in pressure.

[Claim 6]

The manufacturing method of a vacuum heat insulating material of claim 5,
10 wherein the assembly of glass fiber is compressed 50 to 1000 times under a
pressure of 0.02 to 0.07 MPa with the compression mechanism.