

DESCRIPTION

Title of Invention

VACUUM HEAT INSULATING MATERIAL, VACUUM HEAT INSULATING MATERIAL
MANUFACTURING APPARATUS, AND HEAT INSULATING BOX USING VACUUM
HEAT INSULATING MATERIAL

Technical Field

[0001]

The present invention relates to a vacuum heat insulating material, a vacuum
heat insulating material manufacturing apparatus and a heat insulating box employing
a vacuum heat insulating material.

Background Art

[0002]

As a conventional vacuum heat insulating material, one with a core material,
which includes an assembly of glass fibers, covered by an outer wrapping material is
known (Patent Literature 1). The outer wrapping material is formed by thermally
welding peripheral edge portions of two outer covering materials (films) having a gas
barrier property to each other. Hereinafter, a part in which thermal welding portions
of two outer covering materials are thermally welded is referred to as a sealing
portion. The inside of the outer wrapping material is depressurized, and the core
material is hermetically sealed inside the outer wrapping material. In order to
maintain heat insulation performance, it is necessary to suppress entry of gas from
the sealing portion to the inside of the outer wrapping material. Examples of a
vacuum heat insulating material having a configuration for suppressing entry of gas
include one in which a clearance between a thermal welding layer of one outer
covering material and a thermal welding layer of the other outer covering material in a
sealing portion continuously varies and there are thus thick-walled portions and thin-
walled portions in the thermal welding layers (Patent Literature 2). Such
configuration eliminates parts of the thermal welding layers on which an external force
is locally concentrated and makes cracking in a gas barrier layer and/or rupture of the
sealing portion difficult to occur, thereby preventing entry of gas from a ruptured part.

Also, a vacuum heat insulating material whose welding portion of an outer covering material includes a welding portion formed by means of heat sealing and a welding portion formed by means of ultrasound sealing is known (Patent Literature 3). In the heat insulating material, the welding portion formed by means of ultrasound sealing is located on the outer peripheral side relative to the welding portion formed by means of heat sealing, and a part in which a thermal welding layer is thinned is formed in the welding portion formed by means of ultrasound sealing. With such a configuration, a part of the thermal welding portion is thinned, enabling suppression of entry of gas.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Patent No. 3580315

Patent Literature 2: International Publication No. WO2010/029730

Patent Literature 3: Japanese Patent No. 4701882

Summary of Invention

Technical Problem

[0004]

In Patent Literature 1, a vacuum heat insulating material is manufactured by inserting a core material to an outer wrapping material formed in a pouched shape as a result of three sides of the outer covering materials being sealed by means of thermal welding, and then depressurizing the inside of the outer wrapping material in a depressurization chamber and thermally welding an opening port of the outer wrapping material and thereby hermetically sealing the core material. In such a manufacturing apparatus, an airflow generated inside the outer wrapping material during the depressurization may cause a part of glass fibers in the core material to suspend and stay at a thermal welding position. In such case, thermal welding is performed with the glass fiber caught at the thermal welding position. Likewise, in each of Patent Literature 2 and Patent Literature 3, thermal welding may be performed with a glass fiber caught at a thermal welding position. If thermal welding is performed with a glass fiber caught at a thermal welding portion, a through hole

extending from the sealing portion to the inside of the outer wrapping material may be formed. If the through hole is formed, the gas barrier property of the sealing portion is lowered and the degree of vacuum inside the heat insulating material is thus lowered. Therefore, the conventional vacuum heat insulating materials cannot maintain high heat insulation performance for a long period of time. Also, in each of Patent Literatures 1 to 3, air may be caught in the sealing portion during thermal welding. In such case, also, a through hole is formed and the degree of vacuum inside the vacuum heat insulating material is thereby lowered, resulting in failure to provide a vacuum heat insulating material that can maintain high heat insulation performance for a long period of time.

[0005]

The present invention has been made to overcome such problem as mentioned above, and an object of the present invention is to provide a vacuum heat insulating material that can prevent formation of a through hole extending from a sealing portion to the inside of an outer wrapping material and thereby maintain high heat insulation performance for a long period of time, an apparatus for manufacturing the vacuum heat insulating material, and a heat insulating box employing the vacuum heat insulating material.

Solution to Problem

[0006]

A vacuum heat insulating material according to the present invention is a vacuum heat insulating material including: a core material including a fiber assembly; an adsorbent to absorb at least moisture; and an outer wrapping material covering the core material and the adsorbent, the outer wrapping material having inside depressurized and hermetically sealed, and including a sealing portion formed at a peripheral edge portion thereof, at least a part of the sealing portion having a corrugated shape in cross section, the corrugated shape having crest top portions arranged at a pitch of no more than 3 mm, and trough bottom portions arranged at a pitch of no more than 3 mm, wherein a width in a thickness direction of the crest top portions in the corrugated shape and a width in the thickness direction of the trough bottom portions in the corrugated shape are each smaller than a width in the thickness direction of ridgelines in the corrugated shape.

[0007]

Also, a vacuum heat insulating material manufacturing apparatus according to the present invention is a vacuum heat insulating material manufacturing apparatus for manufacturing a vacuum heat insulating material including a core material including a fiber assembly, an adsorbent to absorb at least moisture, and an outer wrapping material including two films, the outer wrapping material covering the core material and the adsorbent with peripheral edge portions of the two films being sealed by thermal welding, an inside of the outer wrapping material being depressurized and hermetically sealed, the apparatus comprising an upper pressure-bonding tool and a lower pressure-bonding tool to press and weld thermally the peripheral edge portions of the two films from above and beneath while heating the peripheral edge portions of the two films from above and beneath, respectively, thereby thermally welding the peripheral edge portions of the two films, each of the upper pressure-bonding tool and the lower pressure-bonding tool having a welding surface having a corrugated shape in cross-section, the corrugated shape having crest top portions arranged at a pitch of no more than 3 mm, and trough bottom portions arranged at a pitch of no more than 3 mm, wherein upon thermal welding, a clearance between a crest top portion of the upper pressure-bonding tool and a crest top portion of the lower pressure-bonding tool, and a clearance between a trough bottom portion of the upper pressure-bonding tool and a trough bottom portion of the lower pressure-bonding tool are each smaller than a clearance between a ridgeline of the upper pressure-bonding tool and a ridgeline of the lower pressure-bonding tool.

[0008]

Also, the vacuum heat insulating material according to the present invention or a vacuum heat insulating material manufactured by the vacuum heat insulating material manufacturing apparatus according to the present invention can be used for a heat insulating box such as a refrigerator.

Advantageous Effects of Invention

[0009]

The vacuum heat insulating material according to the present invention, a vacuum heat insulating material manufactured by the vacuum heat insulating material manufacturing apparatus according to the present invention, and the heat insulating box employing the vacuum heat insulating material according to the present invention each exert the effect of enabling high heat insulation performance to be maintained for a long period of time.

Brief Description of Drawings

[0010]

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

5 [Fig. 2] Fig. 2 is an enlarged partial cross-sectional view of the vacuum heat insulating material in Fig. 1.

[Fig. 3] Fig. 3 is a schematic diagram of a cross-section of a sealing portion of the vacuum heat insulating material in Fig. 1.

[Fig. 4] Fig. 4 is a plan view of the vacuum heat insulating material in Fig. 1.

10 [Fig. 5] Fig. 5 is a graph indicating a relationship between an interval (pitch) of crest top portions and trough bottom portions in a sealing portion of the vacuum heat insulating material in Fig. 1, and a thermal conductivity variation amount.

[Fig. 6] Fig. 6 is a graph indicating a relationship between an angle formed by adjacent ridgelines in a sealing portion of the vacuum heat insulating material in Fig. 1, and thermal conductivity variation amount.

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[Fig. 7] Fig. 7 is a graph indicating a relationship between a width of a sealing portion of an outer wrapping material in the vacuum heat insulating material in Fig. 1, and thermal conductivity variation amount.

[Fig. 8] Fig. 8 is a schematic cross-sectional view of an apparatus for manufacturing the vacuum heat insulating material in Fig. 1 (hereinafter referred to as "sealing apparatus").

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[Fig. 9] Fig. 9 is a cross-sectional view of pressure-bonding tools in the sealing apparatus in Fig. 8 in thermal welding waiting time.

[Fig. 10] Fig. 10 is a cross-sectional view of the pressure-bonding tools in the sealing apparatus in Fig. 8 in thermal welding.

25

[Fig. 11] Fig. 11 is a cross-sectional view of a heat insulating box according to Embodiment 2 of the present invention.

Description of Embodiments

[0011]

30 Embodiment 1.

A vacuum heat insulating material 1 according to Embodiment 1 of the present invention will be described below with reference to Figs. 1 to 4. Fig. 1 is a cross-sectional diagram illustrating the vacuum heat insulating material 1. Fig. 2 is an enlarged partial cross-sectional view of the vacuum heat insulating material 1. Fig. 3 is a schematic diagram of a cross-section of a sealing portion 5 in the vacuum heat insulating material 1. Fig. 4 is a plan view of the vacuum heat insulating material 1.

[0012]

The vacuum heat insulating material 1 includes a core material 2, an outer wrapping material 3 having a gas barrier property, the outer wrapping material 3 covering the core material 2, and a moisture adsorbent 4 that absorbs moisture inside the outer wrapping material 3. At peripheral edge portions of the outer wrapping material 3, sealing portions 5 are formed by means of a sealing method such as heat sealing. As a result of the sealing portions 5 being formed with the inside of the outer wrapping material 3 depressurized to a vacuum degree of 1 to 3 Pa (pascal), the outer wrapping material 3 is hermetically sealed.

[0013]

For the core material 2, for example, a fiber assembly of, e.g., glass fibers, alumina fibers, silica alumina fibers, silica fibers, rock wool, silicon carbide fibers or unwoven fabric can be used. In Fig. 4, the core material 2 is illustrated in transparent fashion.

[0014]

The outer wrapping material 3 includes an upper film 30 and a lower film 31, and respective peripheral edge portions of these films are thermally welded to each other to form the sealing portions 5. The outer wrapping material 3 is hermetically sealed by the sealing portions 5, and the core material 2 is hermetically closed and covered by the outer wrapping material 3. The upper film 30 includes at least a thermal welding layer 30a and a gas barrier layer 30b. The lower film 31 includes at least a thermal welding layer 31a and a gas barrier layer 31b. In each sealing portion 5, the thermal welding layer 30a of the upper film 30 and the thermal welding layer 31a of the lower film 31 are thermally welded to each other. Hereinafter, the

thermal welding layer 30a and the thermal welding layer 31a are collectively referred to as "thermal welding layer 3a". Also, the gas barrier layer 30b and the gas barrier layer 31b are collectively referred to as "gas barrier layer 3b".

[0015]

5 For the thermal welding layer 3a, for example, a non-stretched polypropylene film, a high-density polyethylene film or a linear low-density polyethylene film can be used. A suitable thickness of each of the thermal welding layer 30a and the thermal welding layer 31a is 25 to 60 μm in consideration of stability in sealing quality in a depressurization and sealing process, suppression of gas entry from end portions of
10 the thermal welding layer 3a, and heat leakage from a surface due to heat transfer where a metal foil is used as the gas barrier layer 3b.

[0016]

For the gas barrier layer 3b, for example, a plastic film with a metal, a metal oxide or a diamond-like carbon vapor-deposited thereon or a metal foil can be used.
15 The outer wrapping material 3 is not limited to these examples as long as the outer wrapping material 3 is used for the purpose of reducing gas permeability. Also, for a metal oxide vapor deposition material to be deposited on the plastic film, for example, silica or alumina can be used.

[0017]

20 A first surface protection layer 3c can be provided on the outer side of the gas barrier layer 3b. For the first surface protection layer 3c, a stretched product such as a polyethylene terephthalate film, a polypropylene film or a nylon film can be used. A second surface protection layer 3d such as a nylon film can be provided on the outer side of the first surface protection layer 3c. The provision of the first surface
25 protection layer 3c and the second surface protection layer 3d enhances, e.g., bending resistance and piercing resistance. Also, the pouched shape of the outer wrapping material 3 is, for example, a shape of a four side seal pouch, a gazette pouch, a three side seal pouch, a pillow pouch or a center tape seal pouch.

[0018]

30 For the moisture adsorbent 4, for example, calcium oxide (CaO) inserted in a

perforated pouch can be used. The moisture adsorbent 4 is not limited to this example, and a substance having moisture absorption property such as zeolite can be used. In Fig. 4, the moisture adsorbent 4 is illustrated in transparent fashion.

[0019]

5 A cross-section of at least one of the plurality of sealing portions 5 provided by thermal welding in the peripheral edge portions of the outer wrapping material 3 has a corrugated shape. In the cross-section of the sealing portion 5, crests and troughs are alternately formed along a corrugation direction 57. Crests correspond to projection portions in a thickness direction 58 and troughs correspond to recess
10 portions in the thickness direction 58. With such a configuration, even where thermal welding is performed with a glass fiber caught between parts of the upper film 30 and the lower film 31 that are to form the sealing portion 5, the glass fiber can be severed by means of a height difference between a height of crest top portions 5a and a height of trough bottom portions 5b. Therefore, formation of a through hole
15 extending from an end portion 3e of the sealing portion 5 to the inside of the outer wrapping material 3 can be prevented, enabling heat insulation performance to be maintained for a long period of time.

[0020]

Each of a width 52a from a crest top portion 50a of the upper film 30 to a crest
20 top portion 51a of the lower film 31 that is thermally welded to the crest top portion 50a (that is, a width in the thickness direction 58 of a crest top portion; hereinafter referred to as "top portion width 52a") and a width 52b from a trough bottom portion 50b of the upper film 30 to a trough bottom portion 51b of the lower film 31 that is thermally welded to the trough bottom portion 50b (that is, a width in the thickness
25 direction 58 of a trough bottom portion; hereinafter referred to as "bottom portion width 52b") is smaller than a width 52c in the thickness direction from a ridgeline 50c of the upper film 30 to a ridgeline 51c of the lower film 31 that is thermally welded to the ridgeline 50c (that is, a width in the thickness direction of a ridgeline, and hereinafter referred to as "ridgeline width 52c"). Hereinafter, the crest top portion(s)
30 50a and the crest top portion(s) 51a are collectively referred to as "crest top portion(s)

5a". Also, the trough bottom portion(s) 50b and the trough bottom portion(s) 51b are collectively referred to as "trough bottom portion(s) 5b". Such configuration facilitates severing of glass fiber via the crest top portions 5a and the trough bottom portions 5b. Also, where thermal welding is performed with air caught in the parts of the upper film 30 and the lower film 31 that are to form the sealing portion 5, a layer of the caught air is severed by the crest top portions 5a and the trough bottom portions 5b. Consequently, the air is retained between the ridgeline 50c and the ridgeline 51c, enabling prevention of formation of a through hole extending from the end portion 3e of the sealing portion 5 to the inside of the outer wrapping material 3.

[0021]

Also, it is desirable that the crest top portions 5a be located at a position that is higher than an upper surface 3g of a part of the upper film 30 that is not subjected to the thermal welding, that is, an upper surface 3g of the end portion 3e of the outer wrapping material 3 and the trough bottom portions 5b be located at a position that is lower than the lower surface 3h of a part of the lower film 31 that is not subjected to the thermal welding, that is, a lower surface 3h of the end portion 3e of the outer wrapping material 3. Such configuration further enlarges the height difference between the height of the crest top portions 5a and the height of the trough bottom portions 5b, enabling glass fiber caught between the parts of the upper film 30 and the lower film 31 that are to form the sealing portion 5 in thermal welding to be reliably severed.

[0022]

Fig. 5 illustrates a relationship between a pitch 53a of the crest top portions and a pitch 53b of the trough bottom portions of the sealing portion 5 in the vacuum heat insulating material 1, and a thermal conductivity variation amount. A thermal conductivity of the vacuum heat insulating material 1 was measured by a steady method employing a thermal conductivity meter. Temperature conditions for the measurement were 37.7 degrees C for the high temperature side, 10 degrees C for the low temperature side and an average temperature of 23.85 degrees C.

Assuming that a thermal conductivity measurement value of the vacuum heat

insulating material 1 just after fabrication is an initial thermal conductivity (λ_a) and a thermal conductivity of the vacuum heat insulating material 1 after a certain period of time passed in a constant temperature and humidity bath with a temperature and a humidity fixed is a thermal conductivity (λ_b) after aging deterioration, a thermal conductivity variation amount ($\lambda_b - \lambda_a$), which is a difference between these thermal conductivities, was evaluated. Where each of the pitches 53a and 53b was no more than 3 mm, the thermal conductivity variation amount was no more than 0.5 mW/m·K; however, as each of the pitches 53a and 53b became larger than 3 mm, the thermal conductivity variation amount increased. In the case of 3.5 mm, the thermal conductivity variation amount was approximately twice that of the case of 3 mm. Therefore, in order to suppress aging deterioration in thermal conductivity, each of the pitch 53a of the adjacent crest top portions 5a and the pitch 53b of the adjacent trough bottom portions 5b formed in the sealing portion 5 is desirably no more than 3 mm.

[0023]

Where a width 54 of the sealing portion 5 (hereinafter referred to as "sealing portion width") and an angle 55 are fixed, if the pitches 53a and 53b are made small, the position of the crest top portions 5a becomes low and the position of the trough bottom portion 5b becomes high. Therefore, a length of thermal welding between the thermal welding layer 30a and the thermal welding layer 31a (hereinafter referred to as "effective welding length") becomes short. Conversely, when the pitches 53a and 53b are made large, the position of the crest top portions 5a becomes high and the position of the trough bottom portion 5b becomes low. Therefore, the effective welding length becomes large. When the effective welding length becomes large, a resistance to permeation of gas entering from the end portion 3e of the outer wrapping material 3 increases, resulting in decrease in gas permeation speed, and thus, the amount of gas permeating the inside of the outer wrapping material 3 with time decreases. Meanwhile, a ratio of the effective welding length to the sealing portion width 54, that is, distortion of the sealing portion 5 increases, and thus, a crack is generated in the vapor-deposited part or the metal foil of the gas barrier layer

3b, resulting in increase in speed of gas permeation from a surface of the outer wrapping material 3. When the pitches 53a and 53b each exceed 3 mm, the effect of distortion of the sealing portion 5 becomes larger than the effect of decrease in speed of gas permeation from the end portion 3e of the thermal welding layer 3a due to the increase of the effective welding length. This may cause a crack to be generated in the gas barrier layer 3b, which makes the effect of increase in speed of gas permeation from the surface of the outer wrapping material 3 large. Therefore, in order to prevent deterioration in time-varying heat insulation performance of the vacuum heat insulating material 1, each of the pitches 53a and 53b is desirably no more than 3 mm.

[0024]

Fig. 6 illustrates a relationship between the angle 55 formed by adjacent ridgelines 50c in the sealing portion 5 of the vacuum heat insulating material 1, and a thermal conductivity variation amount. Temperature conditions for measurement and a definition of the thermal conductivity variation amount are similar to those described with reference to Fig. 5. When the angle 55 was in a range of 90 to 160 degrees, the thermal conductivity variation amount was no more than 0.5 mW/m·K, and when the angle 55 fell out of such range, the thermal conductivity variation amount increased in two-fold or more. Therefore, in order to suppress aging deterioration in thermal conductivity, the angle 55 is desirably within a range of 90 to 160 degrees. In order to sever a glass fiber caught in the thermal welding layers, the angle 55 needs to be no more than 160 degrees. If the angle 55 exceeds 160 degrees, the glass fiber cannot be severed because such angle falls within an elastic deformation range of glass fiber. Meanwhile, if the angle 55 is less than 90 degrees, a crack may be generated in the vapor-deposited part or the metal foil of the gas barrier layer, which may result in increase in speed of gas permeation from the surface of the sealing portion 5. Therefore, in order to prevent deterioration in time-varying heat insulation performance of the vacuum heat insulating material 1, the angle 55 formed by the adjacent ridgelines 50c is preferably no less than 90 degrees and no more than 160 degrees.

[0025]

Fig. 7 illustrates a relationship between the sealing portion width 54 of the outer wrapping material 3 of the vacuum heat insulating material 1 and a thermal conductivity variation amount. Temperature conditions for measurement and a definition of the thermal conductivity variation amount are similar to those described with reference to Fig. 5. When the sealing portion width 54 was within a range of 5 to 50 mm, the thermal conductivity variation amount was no more than 0.5 mW/m·K; however, when the sealing portion width 54 fell out of the range, the thermal conductivity variation amount increased in two-fold or more. Therefore, in order to prevent deterioration in time-varying heat insulation performance of the vacuum heat insulating material 1, the sealing portion width 54 is preferably within a range of 5 to 50 mm.

[0026]

Also, from the perspective of maintaining a strength of the outer wrapping material 3 in the vicinity of a sealing portion 5 of the vacuum heat insulating material 1, a distance from an end portion 2a of the core material 2 to an end portion 5d on the core material 2 side of the sealing portion 5 is preferably no less than 10 mm and no more than 100 mm.

[0027]

For a thermal welding method of forming a sealing portion 5 in a peripheral edge portion of the outer wrapping material 3, an external heating method such as a heat sealing method or an impulse sealing method can be used. From among these methods, it is preferable to use a heat sealing method that can provide welding within a short period of time compared to the other methods. Examples of the heat sealing method include hot plate sealing, rotation roll sealing and belt sealing, and a hot plate sealing method or a rotation roll sealing method is preferable. Using a hot plate sealing method, heat sealing can be performed in a short period of time.

[0028]

Fig. 8 is a schematic cross-sectional view of a sealing apparatus 9 that performs thermal welding according to a hot plate sealing method to manufacture a

vacuum heat insulating material 1. The sealing apparatus 9 performs thermal welding by heating and pressing thermal welding portions 30b (Fig. 2) of peripheral edge portions of an upper film 30 and thermal welding portions 31b (Fig. 2) of peripheral edge portions of a lower film 3b via upper pressure-bonding tools 10 and lower pressure-bonding tools 11 that are of a metal and include a heater inside. Prior to the thermal welding, an upper holding tool 13 and a lower holding tool 14 may compress and fix the core material 2 from above and beneath via the upper film 30 and the lower film 31, respectively. Hereinafter, waiting time before thermal welding is referred to as "thermal welding waiting time", and time during which thermal welding is being performed is referred to as "thermal welding time". As a result of the thermal welding, sealing portions 5 are formed at the peripheral edge portions of the outer wrapping material 3. A cross-sectional shape of a welding surface of each of the upper pressure-bonding tools 10 and the lower pressure-bonding tools 11 has a corrugated shape, that is, a shape in which crests and troughs are alternately formed; however, in Fig. 8, the illustration is provided with this shape omitted. The shape is illustrated in Figs. 9 and 10. Here, it is only necessary that at least either the upper pressure-bonding tools 10 or the lower pressure-bonding tools 11 includes a heater inside. In order to prevent uneven sealing pressure, either the upper pressure-bonding tools 10 or the lower pressure-bonding tool 11 can be pressure-bonding tools including a heater inside and a silicon rubber sheet at a surface thereof.

[0029]

Where a non-stretched polypropylene film is used for the thermal welding layer 3a, a heater temperature in thermal welding is preferably 170 to 210 degrees C. After the thermal welding processing, a moisture adsorbent 4 is inserted in an outer wrapping material 3 after a drying process for moisture removal. Subsequently, an opening port is hermetically sealed by means of, e.g., heat sealing with the inside of the outer wrapping material 3 depressurized to a vacuum degree of 1 to 3 Pa (pascal), whereby a vacuum heat insulating material 1 can be obtained. The opening port exists at a non-welded side from among four sides of each of the upper film 30 and the lower film 31. Here, drying conditions in the drying process are

conditions that enable removal of moisture in the core material 2 and moisture in the outer wrapping material 3 covering the core material 2, and, for example, heating may be performed at 100 degrees C for two hours. The drying conditions are not limited to these conditions and any conditions that enable removal of moisture in the core material 2 and moisture in the outer wrapping material 3 covering the core material 2 can be employed. Also, the moisture adsorbent 4 may be inserted after the drying process, before the drying process or before the thermal welding process performed by the sealing apparatus 9.

[0030]

The upper pressure-bonding tools 10 and the lower pressure-bonding tools 11 of the sealing apparatus 9 in thermal welding waiting time will be described below with reference to Fig. 9. Each of a cross-sectional shape of a welding surface 10d of each upper pressure-bonding tool 10 and a cross-sectional shape of a welding surface 11d of each lower pressure-bonding tool 11 is a corrugated shape, that is, a shape in which crests and troughs are alternately formed. Fig. 9 illustrates a crest top portion 10a, a trough bottom portion 10b and a ridgeline 10c from the crest top portion 10a to the trough bottom portion 10b in an upper pressure-bonding tool 10. Also, Fig. 9 illustrates a crest top portion 11a, a trough bottom portion 11b and a ridgeline 11c from the crest top portion 11a to the trough bottom portion 11b in a lower pressure-bonding tool 11. A series of such crests and troughs is formed along a corrugation direction 17. The crests correspond to projection portions in a wave height direction 18 of the corrugated shape, and the troughs correspond to recess portions in the wave height direction 18. Although not illustrated in Fig. 9, the core material 2 and the upper film 30 and the lower film 31 sandwiching the core material 2 vertically therebetween exist between the welding surface 10d of the upper pressure-bonding tool 10 and the welding surface 11d of the lower pressure-bonding tool 11. In thermal welding waiting time, the welding surface 10d of the upper pressure-bonding tool 10 and the welding surface 11d of the lower pressure-bonding tool 11 are not close to each other, and an upper film 30 and a lower film 31 are not in contact with each other.

[0031]

An upper pressure-bonding tool 10 and a lower pressure-bonding tool 11 of the sealing apparatus 9 in thermal welding will be described below with reference to Fig. 10. In thermal welding time, a welding surface 10d of the upper pressure-bonding tool 10 and a welding surface 11d of the lower pressure-bonding tool 11 come close to each other and press an upper film 30 and a lower film 31 (not illustrated in Fig. 10; see Fig. 2) that sandwich a core material 2 vertically therebetween while heating the upper film 30 and the lower film 31. As a result of such operation, a thermal welding layer 30a of a peripheral edge portion of the upper film 30 and a thermal welding layer 31a of a peripheral edge portion of the lower film 31 are thermally welded. Each of a pitch 23a of adjacent crest top portions 10a and a pitch 23b of adjacent trough bottom portions 10b in the upper pressure-bonding tool 10, and a pitch 23a of adjacent crest top portions 11a and a pitch 23b of adjacent trough bottom portions 11b in the lower pressure-bonding tool 11 is no more than 3 mm. Also, each of an angle 24 formed by adjacent ridgelines 10c and an angle 24 formed by adjacent ridgelines 11c is desirably no less than 90 degrees and no more than 160 degrees. Also, a width 25 along a corrugation direction 17 of each of the upper pressure-bonding tool 10 and the lower pressure-bonding tool 11 is desirably within a range of 5 to 50 mm.

[0032]

A clearance (hereinafter referred to as "top portion clearance") 22a between a crest top portion 10a of the upper pressure-bonding tool 10 and a crest top portion 11a of the lower pressure-bonding tool 11, and a clearance (hereinafter referred to as "bottom portion clearance") 22b between a trough bottom portion 10b of the upper pressure-bonding tool 10 and a trough bottom portion 11b of the lower pressure-bonding tool 11 are each smaller than a clearance (hereinafter referred to as "ridgeline clearance") 22c between a ridgeline 10c between a crest and a trough of the upper pressure-bonding tool 10 and a ridgeline 11c between a crest and a trough of the lower pressure-bonding tool 11. Also, the top portion clearance 22a and the bottom portion clearance 22b are each smaller than a width 35 from an upper surface of the upper film 30 to a lower surface of the lower film 31 (hereinafter referred to as

"film width 35"; see Fig. 3). Consequently, a thickness of a sealing portion 5 of a vacuum heat insulating material 1 is thinnest in a crest top portion 5a and a trough bottom portion 5b of the sealing portion 5. These parts are referred to as "thin-walled portions 55". The sealing portion 5 is a part having a largest gas permeability in the outer wrapping material 3 and largely affects heat insulation performance of the vacuum heat insulating material 1 with time. As a result of the thin-walled portions 55 being provided in the sealing portion 5, a resistance to permeation of a gas entering from an end portion of the outer wrapping material 3 becomes large and the gas permeation speed thus becomes low. Therefore, an amount of gas permeating the inside of the outer wrapping material 3 with time decreases, enabling excellent heat insulation performance to be exerted for a long period of time.

[0033]

In the conventional techniques, where thermal welding layers are thermally welded with a glass fiber caught between the upper and lower films, a through hole is formed in a sealing portion. In particular, where a through hole extending through an outer wrapping material is formed, an amount of gas entering the inside of the outer wrapping material with time from an end portion of the outer wrapping material via the through hole increases, resulting in deterioration in time-varying heat insulation performance of the vacuum heat insulating material. Also, in the conventional techniques, where thermal welding is performed with air caught between the upper and lower films, also, a through hole is formed, resulting in deterioration in time-varying heat insulation performance of the vacuum heat insulating material.

[0034]

Contrary to the above, the vacuum heat insulating material 1 according to the present embodiment enables prevention of formation of a through hole extending from an end portion 3e of a sealing portion 5 to the inside of the outer wrapping material 3. In the vacuum heat insulating material 1, a cross-section of a sealing portion 5 formed at a peripheral edge portion of the outer wrapping material 3 by means of thermal welding has a corrugated shape, that is, a shape in which crests and troughs are continuously provided. With such a configuration, even where

thermal welding is performed with a glass fiber caught between an upper film 30 and a lower film 31 that are to form a sealing portion 5 as a result of the thermal welding, the glass fiber can be severed by means of a height difference between a height of crest top portions 5a and a height of trough bottom portions 5b. Therefore, formation of a through hole extending from an end portion 3e of the sealing portion 5 to the inside of the outer wrapping material 3 can be prevented, enabling heat insulation performance of the vacuum heat insulating material 1 to be maintained for a long period of time.

[0035]

Also, in the vacuum heat insulating material 1, a pitch 53a of adjacent crest top portions 5a and a pitch 53b of adjacent trough bottom portions 5b, which are formed in the sealing portion 5, can be made to be no more than 3 mm. With such a configuration, a gas permeation resistance can be increased while preventing generation of a cracking in the vapor-deposited part or the metal foil of the gas barrier layer 3b, enabling suppression of aging deterioration in thermal conductivity of the vacuum heat insulating material 1.

[0036]

Also, in the vacuum heat insulating material 1, each of an angle 24 formed by adjacent ridgelines 10c and an angle 24 formed by adjacent ridgelines 11c, which are formed in the sealing portion 5, can be made to be no less than 90 degrees and no more than 160 degrees. With such a configuration, a glass fiber caught between the upper film 30 and the lower film 31 can be served in thermal welding while preventing a crack from being generated in the vapor-deposited part or the metal foil of the gas barrier layer 3b, enabling suppression of aging deterioration in thermal conductivity.

[0037]

Also, in the vacuum heat insulating material 1, the sealing portion width 54 can be made to be in a range of 5 to 50 mm. Such configuration enables enhancement in effect of suppressing aging deterioration in thermal conductivity of the vacuum heat insulating material 1.

[0038]

Also, in the vacuum heat insulating material 1, a distance from the end portion 2a of the core material 2 to the end portion 5f on the core material 2 side of the sealing portion 5 can be made to be no less than 10 mm and no more than 100 mm. With such a configuration, a glass fiber caught between the upper film 30 and the lower film 31 can be severed in thermal welding while maintaining a strength of the outer wrapping material 3 in the vicinity of the sealing portion 5 in the vacuum heat insulating material 1, enabling suppression of aging deterioration in thermal conductivity.

[0039]

Also, in the vacuum heat insulating material 1, the top portion clearance 52a and the bottom portion clearance 52b can be made to be each smaller than the ridgeline clearance 52c. Such configuration facilitates severing of a glass fiber by the crest top portions 5a and the trough bottom portions 5b. Also, even if thermal welding is performed with air caught between the upper film 30 and the lower film 31, the layer of the caught air is severed by the crest top portions 5a and the trough bottom portions 5b. Consequently, the air is retained in the ridgeline clearance 52c, enabling prevention of formation of a through hole extending from an end portion 3e of a sealing portion 5 to the inside of the outer wrapping material 3.

[0040]

Also, in the vacuum heat insulating material 1, the crest top portions 5a of the sealing portion 5 can be located at a position that is higher than the upper surface 3g of the part of the upper film 30 that is not subjected to the thermal welding, that is, the upper surface 3g of the end portion 3e of the outer wrapping material 3, and the trough bottom portions 5b of the sealing portion 5 can be located at a position that is lower than the lower surface 3h of the part of the lower film 31 that is not subjected to the thermal welding, that is, the lower surface 3h of the end portion 3e of the outer wrapping material 3. Such configuration further enlarges the difference between the height of the crest top portions 5a and the height of the trough bottom portions 5b, enabling a glass fiber caught between parts of the upper film 30 and the lower film 31 that are to form the sealing portion 5 in thermal welding to be more reliably be

severed.

[0041]

The sealing apparatus 9 according to the present embodiment can manufacture a vacuum heat insulating material 1 that can maintain a thermal conductivity for a long period of time. In the sealing apparatus 9, a cross-section of each of the upper pressure-bonding tool 10 and the lower pressure-bonding tool 11 has a shape in which a series of wave shapes is provided, that is, a shape in which a series of crests and troughs is provided. With such a configuration, even where thermal welding is performed with a glass fiber caught between the parts of the upper film 30 and the lower film 31 that are to form the sealing portion 5, the glass fiber can be severed by means of the height difference between the height of the crest top portions 5a of the sealing portion 5 and the height of the trough bottom portions 5b. Therefore, the sealing apparatus 9 can manufacture a vacuum heat insulating material 1 including no through hole extending from an end portion 3e of a sealing portion 5 to the inside of an outer wrapping material 3 and enabling heat insulation performance to be maintained for a long period of time.

[0042]

Also, in the sealing apparatus 9, each of the pitch 23a of adjacent crest top portions 10a and the pitch 23b of adjacent trough bottom portions 10b in the upper pressure-bonding tool 10 and the pitch 23a of adjacent crest top portions 11a and the pitch 23b of adjacent trough bottom portions 11b in the lower pressure-bonding tool 11 can be made to be no more than 3 mm. Such configuration enables manufacture of a vacuum heat insulating material 1 including no crack generated in the vapor-deposited part or the metal foil of the gas barrier layer 3b, having a high gas permeation resistance in the sealing portion 5 and enabling a thermal conductivity to be maintained for a long period of time.

[0043]

Also, in the sealing apparatus 9, each of the angle 24 formed by adjacent ridgelines 10c and the angle 24 formed by adjacent ridgelines 11c can be made to be no less than 90 degrees and no more than 160 degrees. Such configuration enables

manufacture of a vacuum heat insulating material 1 including no crack generated in the vapor-deposited part or the metal foil of the gas barrier layer 3b, including no through hole extending from the sealing portion 5 to the core material 2 and enabling heat insulation performance to be maintained for a long period of time.

5 [0044]

Also, in the sealing apparatus 9, the width 25 along the corrugation direction 17 of each of the upper pressure-bonding tool 10 and the lower pressure-bonding tool 11 can be made to be within a range of 5 to 50 mm. Such configuration enables manufacture of a vacuum heat insulating material 1 that can maintain a thermal conductivity for a long period of time.

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[0045]

Also, in the sealing apparatus 9, the top portion clearance 52a and the bottom portion clearance 52b formed by the upper pressure-bonding tool 10 and the lower pressure-bonding tool 11 can be made to be smaller than the ridgeline clearance 52c. Such configuration facilitates severing of a glass fiber caught between the upper film 30 and the lower film 31 of the vacuum heat insulating material 1 by the crest top portions 10a and 11a and the trough bottom portions 10b and 11b. Also, where thermal welding is performed with air caught between the upper film 30 and the lower film 31, a layer of the caught air is severed by the crest top portions 10a and 11a and the trough bottom portions 10b and 11b. Consequently, the air is retained in the ridgeline clearance 52c, enabling manufacture of a vacuum heat insulating material 1 that includes no through hole extending from the end portion 3e of the sealing portion 5 to the inside of the outer wrapping material 3 and can maintain heat insulation performance for a long period of time.

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[0046]

Here, if a cross-section of a sealing portion 5 provided on at least one side from among four sides of the outer wrapping material 3 in Fig. 4 has a corrugated shape, the effect of being able to maintain heat insulation performance of the vacuum heat insulating material 1 can be obtained. Each of cross-sections of sealing portions 5 provided on the four sides is made to have a corrugated shape, enabling

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maximization of the heat insulation performance maintaining effect.

[0047]

Embodiment 2.

Fig. 11 is a cross-sectional view of a heat insulating box 40 according to Embodiment 2 of the present invention. The heat insulating box 40 is, for example, a refrigerator. In the heat insulating box 40, vacuum heat insulating materials 1 are disposed in parts of a closed space formed by an inner box 41 of an ABS resin and an outer box 42 of a steel plate, and a space other than the spaces in which the vacuum heat insulating materials 1 are disposed is charged with an urethane foam heat insulating material 43 in a foamed manner. Here, each of the vacuum heat insulating materials 1 in the present embodiment is the vacuum heat insulating material 1 according to Embodiment 1. The vacuum heat insulating materials 1 can be manufactured by the manufacturing method according to Embodiment 1. Where the heat insulating box 40 is a refrigerator, a configuration of the part other than the part illustrated in Fig. 11 is similar to that of a common refrigerator, and thus, illustration and description thereof will be omitted. The heat insulating box 40 according to the present embodiment exerts the effect of enabling heat insulation performance to be maintained for a long period of time and thus enabling reduction in power consumption.

Reference Signs List

[0048]

1 vacuum heat insulating material 2 core material 3 outer wrapping material 30 upper film 31 lower film 3a, 30a, 31a thermal welding layer 3b, 30b, 31b gas barrier layer 30c, 31c first surface protection layer 30d, 31d second surface protection layer 35 film width 4 moisture adsorbent 5 sealing portion 50a, 51a crest top portion 50b, 51b trough bottom portion 50c, 51c ridgeline 9 sealing apparatus 10 upper pressure-bonding tool 11 lower pressure-bonding tool 12 depressurized space 13 upper holding tool 14 lower holding tool 40 heat insulating box 41 inner box 42 outer box 43 urethane foam heat insulating material

CLAIMS

[Claim 1]

A vacuum heat insulating material comprising:
a core material including a fiber assembly;
an adsorbent to absorb at least moisture; and
an outer wrapping material covering the core material and the adsorbent, the outer wrapping material having inside depressurized and hermetically sealed, and including a sealing portion formed at a peripheral edge portion thereof, at least a part of the sealing portion having a corrugated shape in cross section, the corrugated shape having crest top portions arranged at a pitch of no more than 3 mm, and trough bottom portions arranged at a pitch of no more than 3 mm,
wherein a width in a thickness direction of the crest top portions in the corrugated shape and a width in the thickness direction of the trough bottom portions in the corrugated shape are each smaller than a width in the thickness direction of ridgelines in the corrugated shape.

[Claim 2]

The vacuum heat insulating material of claim 1, wherein an angle formed by adjacent ridgelines in the corrugated shape is no less than 90 degrees and no more than 160 degrees.

[Claim 3]

The vacuum heat insulating material of claim 1 or 2, wherein a width of the sealing portion in a corrugation direction of the corrugated shape is no less than 5 mm and no more than 30 mm.

[Claim 4]

The vacuum heat insulating material of any one of claim 1 to 3, wherein a distance from an end portion of the core material to an end portion on a core material side of the sealing portion is no less than 10 mm and no more than 100 mm.

[Claim 5]

The vacuum heat insulating material of any one of claims 1 to 4, wherein a lower boundary in a thickness direction of the crest top portions in the corrugated shape is located at a position that is higher than an upper surface of an end portion of the outer wrapping material, and an upper limit in the thickness direction of the trough bottom portions in the corrugated shape is located at a position that is lower than a lower surface of the end portion of the outer wrapping material.

[Claim 6]

A vacuum heat insulating material manufacturing apparatus for manufacturing a vacuum heat insulating material including a core material including a fiber assembly, an adsorbent to absorb at least moisture, and an outer wrapping material including two films, the outer wrapping material covering the core material and the adsorbent with peripheral edge portions of the two films being sealed by thermal welding, an inside of the outer wrapping material being depressurized and hermetically sealed,
the apparatus comprising an upper pressure-bonding tool and a lower pressure-

bonding tool to press the peripheral edge portions of the two films from above and beneath while heating the peripheral edge portions of the two films from above and beneath, respectively, thereby thermally welding the peripheral edge portions of the two films,

each of the upper pressure-bonding tool and the lower pressure-bonding tool having a welding surface having a corrugated shape in cross-section,

the corrugated shape having crest top portions arranged at a pitch of no more than 3 mm, and trough bottom portions arranged at a pitch of no more than 3 mm,

wherein upon thermal welding, a clearance between a crest top portion of the upper pressure-bonding tool and a crest top portion of the lower pressure-bonding tool, and a clearance between a trough bottom portion of the upper pressure-bonding tool and a trough bottom portion of the lower pressure-bonding tool are each smaller than a clearance between a ridgeline of the upper pressure-bonding tool and a ridgeline of the lower pressure-bonding tool.

[Claim 7]

The vacuum heat insulating material manufacturing apparatus of claim 6, wherein an angle formed by adjacent ridgelines in the corrugated shape is no less than 90 degrees and no more than 160 degrees.

[Claim 8]

The vacuum heat insulating material manufacturing apparatus of claim 6 or 7, wherein a width in a corrugation direction of the corrugated shape is no less than 5 mm and no more than 50 mm.

[Claim 9]

A heat insulating box employing the vacuum heat insulating material of any one of claims 1 to 5.