

DESCRIPTION

Title of Invention

VACUUM HEAT INSULATOR AND HEAT INSULATING BOX USING THE SAME

Technical Field

5 [0001]

The present invention relates to a vacuum heat insulator and a heat insulating box, such as a refrigerator, using the same.

Background Art

[0002]

10 Hitherto, urethane foam has been used as a heat insulator used in a heat insulating box such as a refrigerator. However, in recent years, a form in which a vacuum heat insulator having better heat insulation performance than urethane foam is embedded in urethane foam and used in combination with the urethane foam becomes mainstream from demands of markets for energy saving, space saving, and
15 increase in capacity. Such a vacuum heat insulator is used in a heat insulating box for a heat retaining storage and refrigerating and cooling equipment such as a vehicle air conditioner and a water heater, in addition to a refrigerator.

[0003]

20 A vacuum heat insulator is formed by inserting powder, foam, a fiber body, or the like as a core into an outer package composed of a plastic laminate film using aluminum foil as a gas barrier layer, and the internal pressure thereof is kept in vacuum at several pascals or less.

Furthermore, in order to suppress decrease in the degree of vacuum that becomes a factor for decrease in the heat insulation performance of the vacuum heat
25 insulator, an adsorbent that adsorbs gas or moisture is disposed in the outer package.

[0004]

Powder such as silica, foam such as urethane, a fiber body, or the like is used as the core of such a vacuum heat insulator. At present, inorganic fibers having

excellent heat insulation performance, such as glass fibers and ceramic fibers, become mainstream (e.g., see Patent Literature 1 and Patent Literature 8).

[0005]

However, when dust of glass fibers flies off and is attached to the skin, the mucosa, or the like of an operator during manufacture of vacuum heat insulators, the operator may get stimulated. Thus, handleability and workability for glass fibers become problematic.

[0006]

In addition, when a situation of recycling is considered, for example, with regard to refrigerator, each product is crushed at a recycling plant, and glass fibers are subjected to thermal recycling together with urethane waste. However, the glass fibers decrease the combustion efficiency and become residue, and thus the recyclability is poor.

[0007]

Thus, vacuum heat insulators exist in which organic fibers such as polypropylene fibers, polylactide fibers, aramid fibers, LCP (liquid crystal polymer) fibers, polyethylene terephthalate fibers, polyester fibers, polyethylene fibers, cellulose fibers, and polystyrene fibers are used as the material of the core other than glass fibers (e.g., see Patent Literature 2 and Patent Literature 7).

[0008]

As vacuum heat insulators using these fibers, for example, vacuum heat insulators exist in which a fiber body has a flocculent shape or is composed of laminated sheets in order to improve the heat insulation performance (e.g., see Patent Literature 3 and Patent Literature 4), and vacuum heat insulators exist in which sheets are laminated such that fiber orientations thereof alternate with each other in order to improve the heat insulation performance (e.g., see Patent Literature 5 and Patent Literature 6).

Thus, heat insulation performance is realized in which the thermal conductivity of the vacuum heat insulator using fibers as a core is about 0.002 W/mK.

[0009]

However, with regard to a vacuum heat insulator using organic fibers such as polyester as a core, when a product such as a refrigerator into which the vacuum heat insulator is incorporated is broken down by a facility at a recycling center, organic fibers are entangled with iron scraps and the like which are valuables. This is because present shredding equipment for heat insulating boxes such as a refrigerator at a recycling center is designed and manufactured only for existing heat insulating boxes using urethane heat insulators, and thus long-fiber nonwoven fabrics of tough and flexible resins such as polyester may be insufficiently shredded. Thus, the quality of recycled products is decreased.

[0010]

It is possible to solve such a problem of the quality of recycled products being decreased due to entanglement of organic fibers with iron scraps and the like which are valuables, when a core is used in which slit-like processed portions are formed so as to extend inwardly from a surface portion such that the core is easy to break (e.g., see Patent Literature 9 and 10).

Citation List

Patent Literature

[0011]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 8-028776 (pages 2 and 3)

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2002-188791 (pages 4 to 6, Fig. 1)

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2005-344832 (pages 3 and 4, Fig. 1)

Patent Literature 4: Japanese Unexamined Patent Application Publication No. 2006-307921 (pages 5 and 6, Fig. 2)

Patent Literature 5: Japanese Unexamined Patent Application Publication No. 2006-017151 (page 3, Fig. 1)

Patent Literature 6: Japanese Examined Patent Application Publication No. 7-103955 (page 2, Figs. 3 and 4)

Patent Literature 7: Japanese Unexamined Patent Application Publication No. 2006-283817 (pages 4 and 5)

Patent Literature 8: Japanese Unexamined Patent Application Publication No. 2005-344870 (page 7, Fig. 2)

5 Patent Literature 9: Japanese Unexamined Patent Application Publication No. 2000-283643 (Abstract, Fig. 1)

Patent Literature 10: Japanese Unexamined Utility Model Registration Application Publication No. 62-156793 (Fig. 1)

Summary of Invention

10 Technical Problem

[0012]

However, a vacuum heat insulator using a core in which slit-like processed portions are formed so as to extend inwardly from a surface portion has enhanced breakability but has excessively decreased strength. Thus, the core is easy to fall
15 apart, and the productivity of the vacuum heat insulator is deteriorated.

[0013]

The present invention has been made to solve the above-described problems, and it is a first object of the present invention to improve the shredability of a vacuum heat insulator-applied product when the product is recycled. In addition, it is another
20 object of the present invention to provide a vacuum heat insulator whose core is hard to entangle with iron scraps and the like which are valuables, thereby allowing recyclability to be improved, and whose core is hard to fall apart during production of the vacuum heat insulator, thereby allowing the productivity of the vacuum heat insulator to be improved; and a heat insulating box using the same.

25 Solution to Problem

[0014]

In a vacuum heat insulator according to the present invention, a core composed of laminated sheet-like fiber assemblies is enclosed in a gas-barrier outer package, and an internal pressure thereof is reduced. The sheet-like fiber
30 assemblies are subjected to perforation processing.

[0015]

In addition, in a heat insulating box according to the present invention, the above vacuum heat insulator is disposed between an outer box and an inner box.

Advantageous Effects of Invention

5 [0016]

According to the present invention, since the fiber assemblies constituting the core are subjected to the perforation processing, it is possible to obtain a vacuum heat insulator that allows its handleability during manufacture, and its shredability at a home appliance recycling center to be improved and a heat insulating box using the vacuum heat insulator, without deteriorating heat insulation performance.

Brief Description of Drawings

[0017]

[Fig. 1] Fig. 1 is a perspective view of a vacuum heat insulator according to Embodiment 1 of the present invention.

15 [Fig. 2] Fig. 2 is an exploded perspective view of Fig. 1.

[Fig. 3] Fig. 3 is a detail view of a core in Fig. 2.

[Fig. 4] Fig. 4 is an enlarged plan view of a single sheet-like long-fiber nonwoven fabric constituting the core in Fig. 3 and an A-A cross-sectional view thereof.

20 [Fig. 5] Fig. 5 is a plan view showing a sheet-like fiber assembly constituting a core for explaining Specification Example 1 of perforation processing in Fig. 4.

[Fig. 6] Fig. 6 is a graph showing the relationship between the length of a non-processed portion at a perforation of the sheet-like fiber assembly constituting the core and an extension percentage.

25 [Fig. 7] Fig. 7 is a graph showing the relationship between the length of a slit-like processed portion at the perforation of the sheet-like fiber assembly constituting the core and an extension percentage thereof.

[Fig. 8] Fig. 8 is a plan view showing a sheet-like fiber assembly constituting a core for explaining Specification Example 2 of the perforation processing in Fig. 4.

[Fig. 9] Fig. 9 is a graph showing the relationship between the interval between perforations in the sheet-like fiber assembly constituting the core and an extension percentage thereof.

[Fig. 10] Fig. 10 is a plan view showing a sheet-like fiber assembly constituting a core for explaining Specification Example 3 of the perforation processing in Fig. 4.

[Fig. 11] Fig. 11 is an explanatory diagram of Specification Example 4 of the perforation processing in Fig. 4.

[Fig. 12] Fig. 12 is an explanatory diagram of Specification Example 5 of the perforation processing in Fig. 4.

[Fig. 13] Fig. 13 is an explanatory diagram of Specification Example 6 of the perforation processing in Fig. 4.

[Fig. 14] Fig. 14 is a process diagram showing a method for laminating a nonwoven fabric and a method for manufacturing a core.

[Fig. 15] Fig. 15 is a schematic explanatory diagram of a heat insulating box according to Embodiment 2 of the present invention.

Description of Embodiments

[0018]

[Embodiment 1]

In Figs. 1 and 2 for explaining a vacuum heat insulator according to Embodiment 1 of the present invention, a vacuum heat insulator 1 is composed of a bag-like gas-barrier container 2 (hereinafter, referred to as "outer package") having an air barrier properties, and a core 3 and an adsorbent 4 enclosed in the outer package 2. The adsorbent 4 is a moisture adsorbent or a gas adsorbent and adsorbs moisture, within the outer package 2, which is a cause of decrease in heat insulation performance.

[0019]

Among the four sides of the outer package 2, three sides other than an opening 2a are closed by heat sealing. As indicated by an arrow a, the core 3 is inserted into the outer package 2 through the opening 2a, and the internal pressure of the outer package 2 is reduced to a predetermined degree of vacuum in a state where the core

3 is enclosed in the outer package 2. Then, the opening 2a is closed by heat sealing, whereby the vacuum heat insulator 1 is produced.

[0020]

Fig. 3 is a perspective view showing in detail the core 3. The core 3 is composed of a laminated body 5 and has a structure in which a long-fiber nonwoven fabric 6 which is a sheet-like fiber assembly is continuously wound, as indicated by an arrow b, from an inside to an outside such that about several hundreds thereof are laminated, and the substantially cylindrical laminated body 5 obtained thus is pulled in the winding direction, folded, and pressed in an up-down direction.

[0021]

Thus, the laminated body 5 is formed in a single plate shape composed of an upper plate portion 5a and a lower plate portion 5b formed in a plate shape when the laminated body 5 is folded; and bent portions obtained by bending the portions connecting the upper plate portion 5a and the lower plate portion 5b, that is, bending portions 5c and 5d which are end portions of the laminated body 5 in the winding direction.

When the laminated body 5 is used as the core 3, a single plate-like vacuum heat insulator 1 having substantially uniform thickness is produced. It should be noted that in Fig. 3, the arrow a indicates a direction in which the core 3 is inserted into the outer package 2.

[0022]

Fig. 4 is an enlarged plan view of the single sheet-like long-fiber nonwoven fabric 6 constituting the laminated body 5 in Fig. 3 and an A-A cross-sectional view thereof.

The long-fiber nonwoven fabric 6 is composed of a large number of fibers 7. However, since the large number of fibers 7 are not connected to each other, the large number of fibers 7 collapse when being lifted, and thus it is impossible to make a sheet therefrom.

[0023]

In order to prevent this, the large number of fibers 7 are formed into a sheet shape (this is referred to as a web), and then the fibers 7 are fused together by thermal embossing, thereby making the long-fiber nonwoven fabric 6 whose fibers do not fall apart. Reference sign 8 indicates a thermally embossed portion where the fibers 7 are fused together by thermal embossing, a region other than the thermally embossed portions 8 is in a state of being the fibers 7. By adjusting the proportion of the thermally embossed portions 8 to the entire sheet, it is made possible to handle as a sheet without deteriorating the heat insulation performance of the fibers 7.

[0024]

Thus, the handleability during manufacture of the vacuum heat insulator 1 is greatly improved, but the shredability at a recycling center is deteriorated as described above. Therefore, by providing a perforated portion in which a perforation 9 is formed, elongation of the long-fiber nonwoven fabric 6 during shredding is suppressed, and both desired handleability and desired shredability are achieved. It should be noted that in the present invention, in order to suppress elongation of the long-fiber nonwoven fabric 6 during shredding at a recycling center and improve the handleability and the shredability, the processed portion of the perforation 9 in which slit-like processed portions (hereinafter, may be referred to merely as "processed portion") 9a and non-processed portions 9b are alternately repeated, or a grid-like processed portion defined by a half-cut portion 9d where the long-fiber nonwoven fabric 6 is not completely cut in its thickness direction, is provided in the long-fiber nonwoven fabric 6, as described later (Figs. 5 to 13 and the explanation thereof). In the following description, they are collectively referred to as a perforated portion or perforation processing. In other words, the slit-like processed portions include processed portions formed by complete cutting or half-cut portions formed by half cutting.

[0025]

<Material of fibers>

Resin fibers are used as the fibers constituting the core 3 of the vacuum heat insulator 1, and polyester fibers, polypropylene fibers, polystyrene (hereinafter,

referred to as PS) fibers, polylactide fibers, aramid fibers, liquid crystal polymer (hereinafter, referred to as LCP) fibers, polyphenylene sulfide (hereinafter, referred to as PPS) fibers, or the like may be used.

[0026]

5 When fibers having heat resistance such as LCP fibers or PPS fibers are used, it is possible to improve the heat resistance of the core 3. When fibers having large diameters are used, it is possible to improve the compression creep properties of the core 3. In the case where it is desired to obtain both properties, when fibers having heat resistance and fibers having a large diameter are mixed and used, the vacuum
10 heat insulator 1 is obtained which has excellent compression creep properties, high heat resistance, and high heat insulating properties.

[0027]

 Meanwhile, PS fibers have a low solid thermal conductivity, and hence improvement of the heat insulation performance as a heat insulator is expected. In
15 addition, it is possible to produce PS fibers at low cost. Thus, in the following, a case will be described in which PS fibers, which have low elongation and are advantageous in shredability at a recycling center, are used for the core 3 of the vacuum heat insulator 1.

[0028]

20 <Manufacture of long-fiber nonwoven fabric>

 Next, a process will be described in which a PS resin is heated and melt-spun to obtain PS fibers and further a sheet-like long-fiber nonwoven fabric is made therefrom.

 First, PS resin pellets are fed to an extruder. The PS resin is heated,
25 kneaded, and melted to 270 to 310 degrees C at the extruder, and is passed through a polymer filter for removing foreign matters. Then, the PS resin is continuously extruded by a gear pump through a nozzle having a large number of holes with a diameter of 0.2 to 0.6 mm.

[0029]

The extruded PS resin is drawn at a spinning velocity of 2000 m/min to 6000 m/min by compressed air while being cooled by cold air, and is collected on a mesh conveyor as continuous fibers having a desired fiber diameter.

In Embodiment 1, a nozzle having about 4000 holes with a diameter of 0.4 mm is used, and spinning is conducted at a spinning velocity of 3800 m/min to obtain fibers with a diameter of about 13 μm . It should be noted that for an average fiber diameter, diameters are measured with a microscope at several locations to several hundreds of locations (e.g., 10 locations), and the average thereof is used.

[0030]

The fibers 7 that are heated and melt-spun from the PS resin pellets and collected on the mesh conveyor as described above are collected as a fiber web that is a lump of fibers. It should be noted that the fibers 7 are loose in the state of being the fiber web and are hard to handle as the core 3 in an operation of inserting the core 3 into the outer package 2.

[0031]

Thus, in order to prevent the fibers from falling apart, the fibers are pressed by a roller heated at 40 to 120 degrees C, and then are subjected to thermal embossing with a roller heated at 40 to 120 degrees C and thermally fused together to be made into a long-fiber nonwoven fabric 6 as in Fig. 4. In Fig. 4, recesses are the thermally embossed portions 8 where the thermal embossing has been conducted, and the fibers 7 are heated and pressed to be fused together with a minimum surface area, thereby preventing the fibers 7 from falling apart.

[0032]

In Embodiment 1, each thermally embossed portion 8 is formed in a substantially circular shape with a diameter of about 0.5 to 1 mm and provided at an interval of about 1 to 3 mm, and the proportion of the thermally embossed portions 8 occupying the sheet is set at about 6%. When the proportion of the thermally embossed portions 8 occupying the sheet is set at about 6% as described above, the heat insulation performance is not deteriorated as compared to an existing flocculent core of resin fibers using the same material, thermal fusion of fibers is reliably

conducted, and it is possible to obtain the long-fiber nonwoven fabric 6 that has such strength that the fabric is not torn even when stress is applied thereto in a subsequent core production process (a process of laminating a fiber assembly). It should be noted that it is possible to adjust the thickness of a nonwoven fabric that is normally represented as a weight per unit area (the weight (g) of fibers per 1 m²), by the velocity of a conveyor. The long-fiber nonwoven fabric 6 subjected to the thermal embossing as described above is wound up into a roll shape to obtain a raw fabric roll.

[0033]

<Perforation provided in long-fiber nonwoven fabric>

Next, specification examples of the perforation provided in the long-fiber nonwoven fabric 6 (hereinafter, referred to merely as nonwoven fabric) will be described with reference to Figs. 5 to 13.

Specification Example 1

Fig. 5 is a plan view showing a sheet-like fiber assembly constituting a core for explaining Specification Example 1 of the perforation processing in Fig. 4. A core 3 according to Specification Example 1 is composed of a laminated body 5 in which a plurality of sheet-like fiber assemblies 3a are laminated as shown in Figs. 1 to 4. In addition, in the core 3, a single perforation 9 is formed in each sheet-like fiber assembly 3a, and non-processed portions 9b and slit-like processed portions 9a penetrating the sheet are alternately and continuously arranged in the perforation 9. In other words, the perforation 9 is formed so as to extend along a center line extending in the longitudinal direction of each sheet-like fiber assembly 3a, from one end to another end in the longitudinal direction. In addition, the length of each non-processed portion 9b of the perforation 9 is set in a range of 1 to 5 mm, and the length of each slit-like processed portion 9a of the perforation 9 is set so as to be equal to or larger than 3 mm. These values are determined on the basis of the characteristics of each sheet-like fiber assembly 3a obtained from the following experiment conducted by the inventor and collaborators.

[0034]

The experiment was conducted by forming a perforation with a cutter in a sheet-like organic fiber assembly having a weight per unit area of 18 g/m^2 and made of polyester, as the core 3. It should be noted that the experiment was conducted on the polyester fibers, but polystyrene fibers, polypropylene fibers, polylactide fiber, aramid fibers, LCP (liquid crystal polymer) fibers, polyethylene fibers, or cellulose fibers may be used instead of the polyester fibers.

[0035]

The problem is entanglement with iron scraps and the like, and it is thought that this is caused due to a high extension percentage. Thus, attention is paid to an extension percentage.

[0036]

First, a sample was produced in which the length of each slit-like processed portion 9a was fixed at 4 mm and the length of each non-processed portion 9b was changed. The sample size is 25 mm wide and 100 mm long. Both ends of the sample in its longitudinal direction was pinched with chucks using a tension tester, the sample was pulled in its longitudinal direction, and an extension percentage was measured. The tension rate was 50 mm/min, and the distance between chucks was 15 mm. Here, the extension percentage is obtained by dividing the elongation of the sample (nonwoven fabric) at the time of breakage by the distance between chucks. The result of the measurement is shown in Fig. 6.

[0037]

Fig. 6 is a graph showing the relationship between the length of each non-processed portion in the perforation of the sheet-like fiber assembly constituting the core and the extension percentage. The length of each non-processed portion is taken on the horizontal axis, and the extension percentage is taken on the vertical axis. As is clear from Fig. 6, the extension percentage is decreased as the length of each non-processed portion 9b is decreased. Particularly, when the values of the extension percentage in the case where the length of each non-processed portion 9b is 6 to 8 mm are compared to the values of the extension percentage in the case where the length of each non-processed portion 9b is 3 to 5 mm, it is recognize that

the values of the extension percentage in the case where the length of each non-processed portion 9b is equal to or less than 5 mm are greatly decreased. It should be noted that when the length of each non-processed portion 9b is less than 1 mm, the sample is easily tore in forming the perforation 9, and the handleability is deteriorated. Thus, the length of each non-processed portion 9b is appropriate when it is 1 to 5 mm.

[0038]

Next, the length of each non-processed portion 9b was fixed at 2 mm, the length of each slit-like processed portion 9a was changed, and an extension percentage was measured. The result of the measurement is shown in Fig. 7.

[0039]

Fig. 7 is a graph showing the relationship between the length of each slit-like processed portion in the perforation of the sheet-like fiber assembly constituting the core and an extension percentage, the length of each slit-like processed portion is taken on the horizontal axis, and the extension percentage is taken on the vertical axis. As is clear from Fig. 7, the extension percentage is decreased as the length of each slit-like processed portion 9a is increased. Particularly, when the values of the extension percentage in the case where the length of each slit-like processed portion 9a is 1 to 2 mm are compared to the values of the extension percentage in the case where the length of each slit-like processed portion 9a is equal to or greater than 3 mm, it is recognized that the values of the extension percentage in the case where the length of each slit-like processed portion 9a is equal to or greater than 3 mm are greatly decreased. Thus, the length of each slit-like processed portion 9a is appropriate when it is equal to or greater than 3 mm.

[0040]

Next, a sheet-like organic fiber assembly 3a subjected to forming the perforation 9 in which the length of each non-processed portion 9b was 5 mm and the length of each slit-like processed portion 9a was 3 mm was inserted as the core 3 into the outer package 2 and dried at 100 degrees C, an adsorbent was inserted thereinto, and vacuum packaging was conducted at several pascals, thereby producing a

vacuum heat insulator 1. When the heat insulation performance was measured, the thermal conductivity was 0.0023 (W/mK) that is the same as that without any perforation. In other words, it is recognized that it is possible to improve the shredability while the heat insulation performance is kept. Thus, it is possible to make the core 3 hard to fall apart during production, and it is possible to make the core 3 easy to shred during recycling. As a result, the core 3 is hard to entangle with iron scraps and the like during recycling, and it is possible to increase the purities of iron scraps and the like. Then, as a result of the increase in the purities of iron scraps and the like, it is possible to increase the recycling rate.

[0041]

Specification Example 2

Fig. 8 is a plan view showing a sheet-like fiber assembly constituting a core for explaining Specification Example 2 of the perforation processing in Fig. 4, and the portions corresponding to portions in Specification Example 1 described above are designated by the same reference signs. It should be noted that a description will be given with reference to Figs. 1 to 4. In a core 3 according to Specification Example 2, a plurality of perforations 9 are aligned in one direction in each sheet-like fiber assembly 3a as shown in Fig. 8, and the interval 9c between each perforation 9 is set so as to be equal to or less than 6 mm. The other configuration is the same as Embodiment 1 described above.

[0042]

Although in the core 3 according to Specification Example 2, the plurality of perforations 9 are aligned in the one direction in the sheet-like fiber assembly 3a and the interval 9c between each perforation 9 is set so as to be equal to or less than 6 mm, the value is also determined on the basis of the characteristics of each sheet-like fiber assembly 3a obtained from an experiment conducted by the inventor and collaborators.

[0043]

Specifically, a sample (however, here, a nonwoven fabric in which a plurality of perforations are aligned in one direction) and a tension tester that are the same as

those used in Embodiment 1 described above were used, the interval 9c between each perforation 9 was changed, and an extension percentage was measured. The result of the measurement is shown in Fig. 9.

[0044]

Fig. 9 is a graph showing the relationship between the interval between each perforation in the sheet-like fiber assembly and the extension percentage, the interval between each perforation is taken on the horizontal axis, and the extension percentage being taken on the vertical axis. As is clear from Fig. 9, the extension percentage being decreased as the interval 9c between each perforation 9 is decreased, but no great change is seen in the decrease in the extension percentage when the interval 9c between each perforation is equal to or less than 6 mm. Thus, it is recognized that the interval 9c between each perforation is appropriately equal to or less than 6 mm. In other words, it is recognized that it is possible to improve the shredability while the heat insulation performance is maintained.

[0045]

Specification Example 3

Fig. 10 is a plan view showing sheet-like fiber assemblies constituting a core for explaining Specification Example 3 of the perforation processing in Fig. 4, and the portions corresponding to portions in Specification Example 1 described above are designated by the same reference signs. It should be noted that a description will be given with reference to Figs. 1 to 4. In a core 3 according to Specification Example 3, a plurality of perforations 9A and a plurality of perforations 9B are formed in each sheet-like fiber assembly 3a so as to be aligned in two directions (directions perpendicular to each other). The other configuration is the same as Embodiment 1 described above.

[0046]

Since the plurality of perforations 9A and the plurality of perforations 9B are aligned in the two directions (directions perpendicular to each other) in each sheet-like fiber assembly 3a in the core 3 according to Specification Example 3, it is possible to further decrease the extension percentage of each sheet-like fiber

assembly 3a, and it is possible to make each sheet-like fiber assembly 3a easy to shred. In other words, it is possible to further improve the shredability while the heat insulation performance is kept.

[0047]

5 Specification Example 4

Fig. 11 is an explanatory diagram of Specification Example 4 of the perforation processing in Fig. 4. In a core 3 according to Specification Example 4, a perforation 9 is formed in each sheet-like fiber assembly 3a as a grid-like perforation in which processed portions 9a formed by complete cutting (cutting the nonwoven fabric 6 so as to penetrate the nonwoven fabric 6 from the upper surface to the lower surface in its thickness direction) and non-processed portions 9b are alternately and continuously arranged so as to have predetermined lengths, respectively, and, for example, so as to form dotted lines, as shown in Fig. 11.

[0048]

15 Specification Example 5

Fig. 12 is an explanatory diagram of Specification Example 5 of the perforation processing in Fig. 4. In a core 3 according to Specification Example 5, a perforation 9 is formed in each sheet-like fiber assembly 3a as only a half-cut portion 9d that is a cut that does not penetrate the sheet-like fiber assembly 3a as shown in Fig. 12, and, for example, is formed in a grid shape by continuous straight shapes without the non-processed portions 9b.

[0049]

Specification Example 6

Fig. 13 is an explanatory diagram of Specification Example 6 of the perforation processing in Fig. 4. In a core 3 according to Specification Example 6, processed portions 9a formed by complete cutting are provided in each sheet-like fiber assembly 3a in a zigzag manner so as to be inclined relative to a direction C in which the nonwoven fabric 6 is manufactured, and a non-processed portion 9b between the adjacent processed portions 9a is formed, as shown in Fig. 13.

[0050]

<Method for forming perforation in nonwoven fabric>

In perforating the nonwoven fabric 6, the obtained raw fabric roll of the nonwoven fabric 6 is wound off, perforation processing is conducted in a state of being a single nonwoven fabric, and the nonwoven fabric is wound up into a roll again. According to this method, the perforation processing is conducted on the single nonwoven fabric 6, and then the nonwoven fabric 6 is laminated into multiple layers. Thus, the perforations do not completely overlap each other, and no adverse effect is given to the appearance of the vacuum heat insulator 1. It should be noted that since it is possible to increase the processing speed depending on the specifications of the perforations and the cutting method (a combination of a die roll and a slitter etc.), the perforation processing process may be incorporated into the above-described nonwoven fabric manufacturing process in such a case.

[0051]

Furthermore, after a nonwoven fabric lamination process described later, perforations may be formed by pressing the core 3 in which the nonwoven fabric 6 is laminated. In such a case, since the perforation processing is conducted after the nonwoven fabric 6 is laminated into the form of the core 3, there is no necessity to consider the handling strength of each single nonwoven fabric 6 in a later process. Thus, it is possible to conduct perforation processing that provides better shredability.

[0052]

<Method for laminating nonwoven fabric and method for manufacturing core>

Next, a method for laminating the nonwoven fabric 6 and a method for manufacturing the core 3 will be described.

Fig. 14 is an operation explanatory diagram of a raw fabric roll 101 and a spool 111 constituting a laminating apparatus for the core 3 of the vacuum heat insulator 1 and shows a core manufacturing process for the vacuum heat insulator 1.

[0053]

Fig. 14(a) shows a step of starting winding the nonwoven fabric 6 (hereinafter, referred to as fiber assembly). In a process of manufacturing the laminated body 5, the raw fabric roll 101 with a predetermined width formed by winding, several times,

the continuous sheet-like fiber assembly 6 subjected to thermal embossing, and the spool 111 with a predetermined width for winding up the fiber assembly 6 wound in the raw fabric roll 101, are provided. By rotating the raw fabric roll 101 and the spool 111, the fiber assembly 6 wound in the raw fabric roll 101 is started to be wound up on the spool 111.

[0054]

At that time, an end portion of the fiber assembly 6 drawn from the raw fabric roll 101 is clamped by a clamping mechanism of the spool 111, and the fiber assembly 6 is wound up with predetermined tension such that the fiber assembly 6 is not cut in the middle of winding up or is not stretched to be narrowed. It should be noted that the drawing shows a case where the raw fabric roll 101 and the spool 111 are in contact with each other, but they may be spaced apart from each other.

[0055]

Fig. 14(b) shows a step of ending winding of the fiber assembly 6. When the fiber assembly 6 wound up on the spool 111 from the raw fabric roll 101 in the winding start step is wound in an amount corresponding to the number of rotations equivalent to a predetermined thickness, the rotation of the raw fabric roll 101 and the spool 111 is stopped and the winding up of the fiber assembly 6 is ended. The predetermined number of rotations, that is, the number of lamination layers wound on the spool 111, is arbitrarily determined on the basis of the thickness of the fiber assembly 6 when packaging under reduced pressure and the thickness of the vacuum heat insulator 1 to be manufactured.

[0056]

Fig. 14(c) shows a step of cutting the fiber assembly 6. After the fiber assembly 6 is wound on the spool 111 in the amount corresponding to the predetermined number of rotations and the rotation of the raw fabric roll 101 and the spool 111 is stopped in the winding end step, the fiber assembly 6 is cut at a predetermined cutting location between the raw fabric roll 101 and the spool 111 in a state where the fiber assembly 6 is clamped at its portions before and after the cutting location, and the raw fabric roll 101 is separated from the spool 111.

[0057]

Fig. 14(d) shows a step of fixing the core 3. After the fiber assembly 6 is cut in the cutting step, clamping components 113a and 113b are inserted into clamping component installation portions 112a and 112b provided in the spool 111, and the substantially cylindrical fiber assembly 6 wound on the spool 111 is clamped by the clamping components 113a and 113b.

[0058]

Fig. 14(e) shows a spool transformation step. After the fiber assembly 6 is clamped by the clamping components 113a and 113b in the step of fixing the core 3, circumferential component retaining shafts 114a and 114b of the spool 111 are moved radially toward the center side so as to be retracted, and circumferential components 115a and 115b connected to the circumferential component retaining shafts 114a and 114b are moved radially toward the center side, that is, in a retracted direction. The spool 111 is transformed in this manner, and the winding tension of the cylindrical fiber assembly 6 wound on the spool 111 is reduced.

[0059]

Fig. 14(f) shows a spool separation step, and the substantially cylindrical fiber assembly 6 whose tension has been reduced is removed from the spool 111 in the axial direction of a rotating shaft 116.

[0060]

Fig. 14(g) shows a core formation step. In a state where the substantially cylindrical fiber assembly 6 removed from the spool 111 is clamped by the two clamping components 113a and 113b, the two clamping components 113a and 113b are pulled toward opposite sides in a substantially straight direction that is the winding direction, whereby the substantially cylindrical fiber assembly 6 is folded at its positions clamped by the clamping components 113a and 113b. Thus, a plate-like (sheet-like) laminated body 5 of the nonwoven fabric 6 having bending portions (folded portions) 5c and 5d in the winding direction and an upper plate portion 5a and a lower plate portion 5b, that is, a plate-like (sheet-like) core 3, is formed.

[0061]

The core 3 composed of the laminated body 5 formed in a plate shape is transferred to a conveyor in a state where the bent portions 5c and 5d are clamped by the clamping components 113a and 113b, and then the clamping components 113a and 113b are removed, whereby the core 3 shown in Fig. 14(h) is manufactured. It should be noted that reference sign 10 indicates a center portion of the substantially cylindrical fiber assembly 6 when the spool 111 is pulled out therefrom, and a laminated body forming the upper plate portion 5a and a laminated body forming the lower plate portion 5b are separated from each other but are closed by removing the clamping components 113a and 113b.

Due to the above, it is possible to obtain the laminated body 5 that has a structure in which the nonwoven fabric 6 is continuously wound from the inner side toward the outer side, that is less likely to fall apart, and that has excellent handleability.

[0062]

<Procedure of manufacturing vacuum heat insulator>

In manufacturing the vacuum heat insulator 1, first, the core 3 that is manufactured in the core manufacturing process and has a predetermined size and a predetermined thickness is inserted into the bag-like outer package 2 having the opening 2a, and the outer package 2 is fixed such that the opening 2a is not closed, and is dried in a thermostat bath at a temperature of 60 to 80 degrees C for about 0.5 to 2 hours. Normally, a hot air circulating type drying oven is used, but a drying oven using drying air that is previously dehumidified may be used.

[0063]

Since the moisture absorbency of polystyrene (PS) according to Embodiment 1 is low, it is possible to set the temperature and time period for the drying at low values as compared to a hygroscopic material such as polyethylene terephthalate. Then, after the drying, the adsorbent 4 such a gas adsorbent or a moisture adsorbent is inserted into the outer package 2 in order to absorb still remaining moisture, remaining gas after vacuum packaging, outgas emitted from the core 3 as time passes, transmitted gas entering through a seal layer of the outer package 2, and the

like, and vacuuming (pressure reducing treatment) is conducted, for example, by a Kashiwagi type vacuum packaging machine. The vacuuming is conducted until the degree of vacuum within a chamber becomes about 1 to 10 Pa. The opening 2a of the outer package 2 is heat-sealed within the chamber, and the vacuum heat insulator 1 is manufactured.

[0064]

In Embodiment 1, a plastic laminate film that has a thickness of not less than 5 μm and not greater than 100 μm , that is formed from, for example, nylon (thickness: 15 μm), alumina-deposited PET (polyethylene terephthalate) (thickness: 12 μm), aluminum-deposited EVOH (ethylene vinyl alcohol copolymer resin) (thickness: 15 μm), or polyethylene (thickness: 50 μm), and that has gas barrier properties, is used as the outer package 2 of the vacuum heat insulator 1.

[0065]

The heat insulation properties of the vacuum heat insulator 1 obtained thus are evaluated by, for example, its thermal conductivity measured with a thermal conductivity meter HC-074 manufactured by EKO Instruments, Co., Ltd. In addition, with regard to the shredability, a heat insulating box such as a refrigerator in which the obtained vacuum heat insulator 1 is provided within a heat insulating wall via urethane foam is put into a recycling process at a recycling center, and the shredability is evaluated on the basis of a degree of mixing into a metal recovery route.

[0066]

<Examples and Comparative Examples>

Next, the specifications of perforations and evaluation of examples (Examples 1 to 5) of the vacuum heat insulator 1 according to Embodiment 1 of the present invention and comparative examples (Comparative Examples 1 to 4) will be described. It should be noted that the perforation processing is conducted over the entire width and the entire length direction of the nonwoven fabric 6.

The results of the evaluation are shown in Table 1.

[0067]

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Example 5
Perforation specification	4 mm grid	6 mm grid	30 mm grid	50 mm grid	6 mm zigzag
Schematic diagram of perforation specification	Fig. 5	Fig. 5	Fig. 6	Fig. 6	Fig. 7
Cut form	Complete cut	Complete cut	Half cut	Half cut	Complete cut
Length of processed portion	3 mm	4 mm	30 mm	50 mm	6 mm
Length of non-processed portion	1 mm	2 mm	0 mm	0 mm	2 mm
Lamination processing	O	O	O	O	O
Shredability	O	O	O	O	O

	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Perforation specification	10 mm grid	6 mm grid	100 mm grid	No perforation processing
Schematic diagram of perforation specification	Fig. 5	Fig. 5	Fig. 6	
Cut form	Complete cut	Complete cut	Half cut	-
Length of processed portion	8 mm	3 mm	100 mm	0 mm
Length of non-processed portion	2 mm	3 mm	0 mm	-
Lamination processing	X	O	O	O
Shredability	O	X	X	X

[0068]

- 5 The processed portions 9a of the perforation 9 in the core 3 of the vacuum heat insulator 1 of Example 1 are according to Specification Example 4 shown in Fig. 11,

the length of each processed portion 9a is 3 mm, the length of each non-processed portion 9b is 1 mm, each processed portion 9a is a penetrating and completely-cut slit, and the processed portion ratio of the perforation 9 (the ratio of the processed portions 9a to the total length of the processed portions 9a and the non-processed portions 9b) is 75%.

[0069]

The processed portions 9a of the perforation 9 in the core 3 of Example 2 have the same specification as that of Example 1, each processed portion 9a is formed by complete cutting, its length is 4 mm, the length of each non-processed portion 9b is 2 mm, and the processed portion ratio is 67%. Comparative Example 1 has the same specification, the length of each processed portion 9a is 8 mm, the length of each non-processed portion 9b is 2 mm, and the processing ratio is 83%.

Comparative Example 2 also has the same specification, each of the lengths of each processed portion 9a and each non-processed portion 9b is 3 mm, and the processed portion ratio is 50%.

[0070]

In the cores 3 of Examples 1 and 2, the lamination processability in the lamination process and the shredability at the recycling center were favorable as shown in Table 1.

Meanwhile, with regard to the core 3 of Comparative Example 1, there was no problem with the shredability as shown in Table 1, but the nonwoven fabric 6 was torn during the lamination process. This is thought to be because the processed portion ratio was 83% and high, and thus the nonwoven fabric 6 could not withstand the winding tension.

[0071]

In addition, in the case of Comparative Example 2, there was no problem with the lamination processability as shown in Table 1. However, with regard to the shredability, since the processed portion ratio is 50% and the ratio of the non-processed portions 9b was too high, the shredding was insufficient, an amount of the nonwoven fabric 6 entangled with shredded metal pieces was increased, recovery of

the nonwoven fabric 6 to a urethane collection process was insufficient, and an amount of the nonwoven fabric 6 contained in a metal collection process was increased.

Due to the above, it can be said that the processed portion ratio of the perforation processing in the specification in Fig. 11 is appropriately 60 to 75%.
[0072]

Next, the processed portions 9a of the perforation 9 in the core 3 of Example 3 are according to the specification in Fig. 12, a continuous grid shape is provided in which the length of a half-cut portion 9d is 30 mm, and no non-processed portion 9d is provided. The half-cut portion 9d is in a state where fibers are pressed and settled so as to withstand the lamination process of the nonwoven fabric 6 and so as to be shredded by the impact during shredding.

In the embodiment, both the lamination processability and the shredability were favorable as shown in Table 1.

[0073]

The perforated portions of Example 4 and Comparative Example 3 are according to the specification in Fig. 12, and the size of each grid is changed.

The length of the half-cut portion 9d of Example 4 was set at 50 mm, and the length of the half-cut portion 9d of Comparative Example 3 was set at 100 mm.

In the case of Example 4, the lamination processability and the shredability were favorable as shown in Table 1. Meanwhile, in the case of Comparative Example 3, since the size of the nonwoven fabric 6 after shredding was too large, the amount of the nonwoven fabric 6 contained in a metal collection process was increased. Thus, it is recognized that the size of the grid by the perforation processing is preferably less than 100 mm². It should be noted that when the perforated portion is defined by the half-cut portion 9d, if the weight per unit area of the nonwoven fabric 6 is too low, the amount of fibers in the pressed portion is insufficient, and the nonwoven fabric 6 is hard to tear from the half-cut portion 9d during shredding. Thus, in the case of PS fibers, the weight per unit area is desirably equal to or greater than 26 g/m².

[0074]

Example 5 is according to the specification of the perforation processing in Fig. 13, completely cut slits are provided as the processed portions 9a in a zigzag manner so as to be inclined relative to the direction C in which the nonwoven fabric 6 is manufactured.

In Example 5, the length L of each processed portion 9a was 6 mm, the gap S_1 between each processed portion 9a and the processed portion 9a perpendicular thereto (the non-processed portion 9b) was set at 2 mm, the processed portion 9a perpendicular thereto was provided so as to be shifted from the center portion of the former processed portion 9a in its longitudinal direction, and the gap S_2 between ends of each processed portion 9a and the processed portion 9a perpendicular thereto was set at 2.8 mm.

[0075]

The lamination processability of the core 3 according to Embodiment 1 is favorable as shown in Table 1, and since the fibers of the nonwoven fabric 6 tend to be oriented in the manufacturing direction, it is possible to divide the fibers by conducting processing such that the slits as the processed portions 9a were shifted from each other. Thus, it is possible to suppress elongation of the fibers during shredding, and the shredability is improved. It should be noted that Comparative Example 4 is a case where no perforation 9 was provided in the nonwoven fabric 6, and thus there is no problem with the lamination processability, but the shredability is significantly inferior as described above.

[0076]

[Embodiment 2]

Fig. 15 is an explanatory diagram of a heat insulating box according to Embodiment 2 of the present invention and schematically shows a refrigerator.

The refrigerator 20 includes an outer box 21 formed of a coated steel plate and an inner box 22 that is provided within the outer box 21 with a gap and composed of a resin molded product. A later-described heat insulating wall 23 is provided within the gap formed between the outer box 21 and the inner box 22. A refrigeration unit (not

shown) that supplies cold air is provided within the inner box 22. In addition, the outer box 21 and the inner box 22 have openings in their surfaces corresponding to each other, and a door is provided at these openings (both are not shown).

[0077]

5 In the gap between the outer box 21 and the inner box 22 of the refrigerator 20, the vacuum heat insulator 1 (shown in an exaggerated manner) according to Embodiment 1 is provided and polyurethane foam 25 is injected, thereby forming the heat insulating wall 23. However, since the outer package 2 of the vacuum heat insulator 1 includes the aluminum foil, there is a concern that a heat bridge occurs in
10 which heat goes around through the aluminum foil into between the outer package 2 and the outer box 21.

[0078]

Accordingly, in order to prevent occurrence of such a heat bridge, the vacuum heat insulator 1 is provided so as to be spaced apart from the outer box 21 by using
15 spacers 24 that are nonconductive resin molded products. It should be noted that the spacers 24 are appropriately provided with holes for not impairing flow of the polyurethane foam 25 such that no void remains in the polyurethane foam 25 injected into the gap between the outer box 21 and the inner box 22 in a subsequent process.

[0079]

20 As described above, in the refrigerator 20 according to the embodiment, the heat insulating wall 23 composed of the vacuum heat insulator 1 according to Embodiment 1, the spacers 24, and the polyurethane foam 25 is formed between the outer box 21 and the inner box 22. It should be noted that the range where the heat insulating wall 23 is not limited, and may be the entire range of the gap formed
25 between the outer box 21 and the inner box 22, or may be a part thereof. In addition, the the polyurethane foam 25 may be provided both or either between the outer box 21 and the vacuum heat insulator 1 and between the inner box 22 and the vacuum heat insulator 1. Moreover, the heat insulating wall 23 may be provided within the door at the openings.

30 [0080]

Incidentally, post-consumer refrigerators are broken down at recycling centers in various regions, and are recycled, according to the Home Appliance Recycling Act. In this case, since the refrigerator 20 includes the vacuum heat insulator 1 including the core 3 composed of the fiber assembly 6, it is possible to shred the refrigerator 20 according to the present invention without removing the vacuum heat insulator 1, the combustion efficiency is not decreased in thermal recycling, and residue is not left. Thus, the recyclability of the refrigerator 20 is favorable.

[0081]

In the above, the case has been described in which the vacuum heat insulator 1 according to the present invention is used in a refrigerator as an example of a heat insulating box, and the use of the vacuum heat insulator 1 is not limited thereto. It is possible to use the vacuum heat insulator 1 according to the present invention in refrigerating and cooling equipment or heating equipment such as a heat retaining storage, a vehicle air conditioner, and a water heater as well as a heat insulating bag (heat insulating container) including deformable outer bag and inner bag, instead of a box having a predetermined shape.

Reference Signs List

[0082]

1 vacuum heat insulator, 2 outer package, 2a opening, 3 core, 3a sheet-like fiber assembly, 4 adsorbent, 5 laminated body, 6 long-fiber nonwoven fabric (fiber assembly), 7 fibers, 8 embossed portion, 9, 9A, 9B perforation, 9a processed portion, 9b non-processed portion, 9c inter-perforation interval, 9d half-cut portion, 20 refrigerator (heat insulating box), 21 outer box, 22 inner box, 23 heat insulating wall, 24 spacer, 25 polyurethane foam, 101 raw fabric roll, 111 spool, 112a, 112b clamping component installation portion, 113a, 113b clamping component, 114a, 114b circumferential component retaining shaft, 115a, 115b circumferential component, 116 rotating shaft

CLAIMS

[Claim 1]

A vacuum heat insulator comprising:

a core composed of a laminated body in which a plurality of sheet-like fiber
5 assemblies are laminated; and

an outer package covering the core, the outer package having a reduced
internal pressure, wherein

a perforation in which non-processed portions and slit-like processed portions
are alternately and continuously arranged is formed in each of the sheet-like fiber
10 assemblies in the core.

[Claim 2]

The vacuum heat insulator of Claim 1, wherein each slit-like processed portion
is a processed portion formed by complete cutting or a half-cut portion formed by half
cutting.

[Claim 3]

The vacuum heat insulator of Claim 1 or 2, wherein the perforation is formed in
one direction or two directions.

[Claim 4]

The vacuum heat insulator of Claim 3, wherein a plurality of the perforations
20 are formed so as to be aligned in the one direction or the two directions.

[Claim 5]

The vacuum heat insulator of Claim 4, wherein an interval between the aligned
perforations is equal to or smaller than 6 mm.

[Claim 6]

The vacuum heat insulator of any one of Claims 1 to 5, wherein
a length of each non-processed portion of the perforation is 1 to 5 mm, and
a length of each slit-like processed portion of the perforation is equal to or
larger than 3 mm.

[Claim 7]

The vacuum heat insulator of any one of Claims 1 to 4, wherein a ratio of the processed portions to a total length of the processed portions and the non-processed portions of the perforation is 60 to 75%.

[Claim 8]

5 The vacuum heat insulator of Claim 1 or 2, wherein the perforation includes: processed portions arranged in a zigzag manner so as to be inclined relative to a manufacturing direction of the fiber assemblies; and non-processed portions provided between the processed portions.

[Claim 9]

10 A vacuum heat insulator comprising:
 a core composed of a laminated body in which a plurality of sheet-like fiber assemblies are laminated; and
 an outer package covering the core, the outer package having a reduced internal pressure, wherein
15 a grid-like portion is formed in each of the sheet-like fiber assemblies in the core, and is defined by a half-cut portion formed by half cutting, the half-cut portion being formed as a non-penetrating cut, and a size of the grid-like portion defined by the half-cut portions is less than 100 mm².

[Claim10]

20 A heat insulating box comprising:
 an outer box; and
 an inner box disposed within the outer box, wherein
 the vacuum heat insulator of any one of Claims 1 to 9 is disposed between the
 outer box and the inner box.

25 [Claim11]

The heat insulating box of Claim 10, wherein a heat insulator is injected in both or either between the outer box and the vacuum heat insulator and between the inner box and the vacuum heat insulator.

[Claim12]

- 5 The heat insulating box of Claim 11, wherein a spacer is disposed between the outer box and the vacuum heat insulator for positioning the vacuum heat insulator and ensuring a flow path when the heat insulator is injected.