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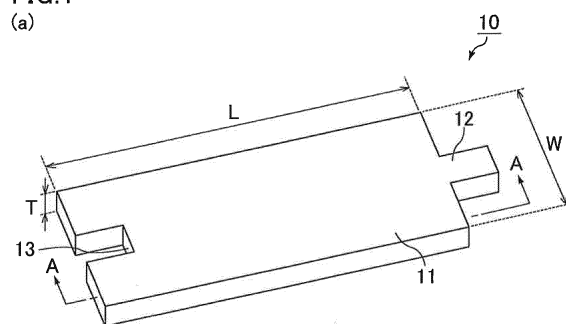
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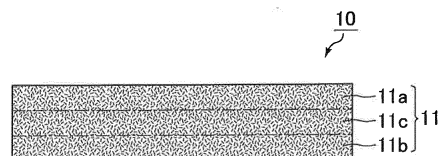
(54) **HOLDING SEAL MATERIAL, PRODUCTION METHOD FOR HOLDING SEAL MATERIAL, PRODUCTION METHOD FOR EXHAUST GAS PURIFICATION DEVICE, AND EXHAUST GAS PURIFICATION DEVICE**

(57) The holding sealing material of the present invention is a holding sealing material including a mat having a predetermined thickness, wherein the mat contains inorganic fibers having a surface coated with a binder layer, the binder layer contains an organic binder and an inorganic binder, and when the mat is trisected in a thickness direction into a first surface portion, a middle portion, and a second surface portion, the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion.

FIG. 1



(b)



CROSS-SECTIONAL VIEW TAKEN ALONG LINE A-A

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a holding sealing material, a method for producing the holding sealing material, a method for producing an exhaust gas purification apparatus, and the exhaust gas purification apparatus.

BACKGROUND ART

10 **[0002]** Exhaust gas discharged from internal combustion engines (e.g., diesel engines) contains particulates such as soot (hereinafter also referred to as "PM"), and adverse effects of PM on the environment and human bodies have been problems. Exhaust gas also contains harmful gas components such as CO, HC, and NO_x, and thus has raised concerns regarding effects of such harmful gas components on the environment and human bodies.

15 **[0003]** Thus, various exhaust gas purification apparatuses that collect PM in exhaust gas or purify harmful gas components have been proposed. Such exhaust gas purification apparatuses include an exhaust gas treating body made of porous ceramic such as silicon carbide or cordierite, a casing for housing the exhaust gas treating body, and a holding sealing material made of an inorganic fiber aggregate and arranged between the exhaust gas treating body and the casing. The holding sealing material is arranged mainly for preventing the exhaust gas treating body from being damaged by contact with the casing that covers the periphery of the exhaust gas treating body due to vibrations and impacts caused by traveling or the like of the automobile, and for preventing exhaust gas from leaking from a space between the exhaust gas treating body and the casing. Thus, the holding sealing material is required to have a function to reliably hold the exhaust gas treating body by increasing the contact pressure produced by repulsion upon compression. In addition, it is known that inorganic fibers constituting the holding sealing material are ruptured and scattered in the air when the exhaust gas treating body is housed into the casing. Such scattering of inorganic fibers in the air adversely affects the health of workers handling the holding sealing material.

25 **[0004]** To solve these problems, a holding sealing material including a mat in which an organic binder is attached to mainly upper and lower portions of the mat in the thickness direction has been suggested (for example, see Patent Literature 1).

30 CITATION LIST

- Patent Literature

35 **[0005]** Patent Literature 1: JP-A 2013-127244

SUMMARY OF INVENTION

- Technical Problem

40 **[0006]** The mat disclosed in Patent Literature 1 contains an organic binder attached mainly to its upper and lower portions in the thickness direction. Thus, in the case where the holding sealing material is arranged between an exhaust gas treating body and a metal casing, a large amount of the organic binder is present in the mat surface adjacent to the metal casing.

45 **[0007]** The organic binder is softened by being heated when the temperature of an exhaust gas purification apparatus is increased by the flow of high-temperature exhaust gas into the exhaust gas treating body during the use of the exhaust gas purification apparatus.

[0008] In some cases, the holding force between the mat and the metal casing becomes insufficient after the organic binder is softened by being heated.

50 **[0009]** The present invention aims to provide a holding sealing material capable of maintaining sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus.

[0010] The present invention also aims to provide a method for producing the holding sealing material, a method for producing an exhaust gas purification apparatus including the holding sealing material, and an exhaust gas purification apparatus including the holding sealing material.

55 - Solution to Problem

[0011] To solve the above problems, the present invention provides a holding sealing material including a mat having a predetermined thickness,

wherein the mat contains inorganic fibers having a surface coated with a binder layer, and when the mat is trisected in a thickness direction into a first surface portion, a middle portion, and a second surface portion, the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion.

[0012] In the holding sealing material of the present invention, the amount of the organic binder attached is non-uniformly distributed in the thickness direction of the mat; and the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion.

[0013] Thus, in the case where the holding sealing material is wound around the exhaust gas treating body in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing, the holding force between the mat and the metal casing is only slightly affected even when the organic binder is softened by being heated after the use of the exhaust gas purification apparatus, because the amount of the organic binder attached is small in the surface of the mat on the second surface portion side.

[0014] Thus, the holding sealing material can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus.

[0015] In the holding sealing material of the present invention, the binder layer that coats the surface of each inorganic fiber also contains an inorganic binder in addition to the organic binder.

[0016] The inorganic binder contains inorganic particles. The presence of the inorganic particles in the binder layer increases the coating strength of the binder layer, preventing the binder layer from being easily peeled off from the inorganic fibers.

[0017] The inorganic particles will remain on the surface of each inorganic fiber without being burned even after the exhaust gas purification apparatus is used, and numerous depressions and projections will be formed on the entire surface of each inorganic fiber, presumably due to exposure of the inorganic particles dispersed in the binder layer as a result of the organic binder being burned off. Once the depressions and projections resulting from the inorganic particles are formed on the entire surface of each inorganic fiber, the inorganic fibers are entangled with each other due to the depressions and projections when these inorganic fibers contact each other after the organic binder is burned off. This prevents slipping of the surface of each inorganic fiber, thus facilitating an increase in the contact pressure.

[0018] Herein, the surface of each inorganic fiber does not have to be entirely coated with the binder layer and may partially include portions where the binder layer is not formed, as long as the effects of the present invention are achieved.

[0019] In the holding sealing material of the present invention, the amount of the organic binder attached to the second surface portion of the mat is preferably substantially equal to or less than that in the middle portion.

[0020] The above arrangement is preferred because the holding force between the mat and the metal casing can be less affected when the holding sealing material is wound around the exhaust gas treating body in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

[0021] In the holding sealing material of the present invention, the inorganic particles as the inorganic binder are preferably dispersed in a polymer resin component as the organic binder.

[0022] The inorganic particles being dispersed in the polymer resin component provides a more uniform increase in the strength of the binder layer over a large part of the surface of each inorganic fiber. Thus, the contact pressure of the holding sealing material can be increased.

[0023] In the holding sealing material of the present invention, the percentage of weight loss of the first surface portion of the mat after heating at 600°C for one hour is preferably 0.5 to 10.0% relative to 100% by weight of the first surface portion before heating, and

the percentage of weight loss of the middle portion of the mat after heating at 600°C for one hour is preferably 0.1 to 7.0% relative to 100% by weight of the middle portion before heating.

[0024] The percentage of weight loss of the mat after heating at 600°C for one hour corresponds to the amount of the organic binder attached to the mat.

[0025] In the holding sealing material of the present invention, the amount of the inorganic binder attached is preferably 0.3 to 15.0 parts by weight relative to 100 parts by weight of the inorganic fibers in terms of solids content.

[0026] In the holding sealing material of the present invention, the organic binder preferably has a glass-transition temperature of 5°C or lower.

[0027] The organic binder having a glass-transition temperature of 5°C or lower is preferred because scattering of fibers can be easily prevented.

[0028] Preferably, the holding sealing material of the present invention is used by winding the mat around an exhaust gas treating body in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

[0029] When the holding sealing material is used in the manner described above, the effect resulting from the non-uniform distribution of the amount of the organic binder attached in the thickness direction of the mat can be suitably

exerted.

[0030] A method for producing the holding sealing material of the present invention includes the steps of:

preparing a mat containing inorganic fibers;
applying a binder solution containing an organic binder and an inorganic binder to the mat; and
drying the mat to which the binder solution was applied with hot air.

[0031] Through these steps, it is possible to produce the holding sealing material of the present invention in which the binder layer containing the organic binder and the inorganic binder is formed on the surface of each inorganic fiber, and the amount of the organic binder attached is non-uniformly distributed in the thickness direction of the mat.

[0032] In the method for producing the holding sealing material of the present invention, preferably, the binder solution further contains a polymeric dispersant.

[0033] The presence of the polymeric dispersant in the binder solution allows the inorganic particles in the inorganic binder to be uniformly dispersed in the binder solution so that the inorganic particles are attached to the inorganic fibers over a large part of the surface, thus uniformly increasing the strength of the binder layer.

[0034] A method for producing an exhaust gas purification apparatus of the present invention includes: preparing a wound body by winding the holding sealing material of the present invention around an exhaust gas treating body in such a manner that the surface of the mat on the first surface portion side is adjacent to the exhaust gas treating body; and arranging the wound body in a metal casing in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

[0035] According to the method for producing an exhaust gas purification apparatus of the present invention, it is possible to produce an exhaust gas purification apparatus capable of maintaining sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus because the surface of the mat on the second surface portion side where the amount of the organic binder attached is small is adjacent to the metal casing.

[0036] An exhaust gas purification apparatus of the present invention includes a metal casing; an exhaust gas treating body housed in the metal casing; and the holding sealing material of the present invention wound around the exhaust gas treating body and arranged between the exhaust gas treating body and the metal casing, wherein the mat is arranged in such a manner that a surface thereof on the first surface portion side is adjacent to the exhaust gas treating body and that a surface thereof on the second surface portion side is adjacent to the metal casing.

[0037] The exhaust gas purification apparatus of the present invention can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus because the surface of the mat on the second surface portion side where the amount of the organic binder attached is small is adjacent to the metal casing.

BRIEF DESCRIPTION OF DRAWINGS

[0038]

Fig. 1(a) is a schematic perspective view of an example of the holding sealing material of the present invention. Fig. 1(b) is a schematic cross-sectional view of the holding sealing material taken along the longitudinal direction.

Fig. 2 is a schematic cross-sectional view of an example of the exhaust gas purification apparatus of the present invention.

Fig. 3 is a schematic perspective view of an example of the exhaust gas treating body constituting the exhaust gas purification apparatus of the present invention.

Fig. 4 is a schematic perspective view of an example of the method for producing the exhaust gas purification apparatus of the present invention.

Fig. 5(a) and Fig. 5(b) are schematic diagrams of a friction coefficient measurement device for a holding sealing material.

DESCRIPTION OF EMBODIMENTS

[0039] The holding sealing material of the present invention is described in detail below. The present invention is not limited to the structures described below, and suitable modifications may be made without departing from the scope of the present invention. The present invention also encompasses a combination of two or more preferred structures of the present invention described below.

[0040] The holding sealing material of the present invention is described below.

[0041] The holding sealing material of the present invention is a holding sealing material including a mat having a

predetermined thickness,

wherein the mat contains inorganic fibers having a surface coated with a binder layer,

the binder layer contains an organic binder and an inorganic binder, and

when the mat is trisected in a thickness direction into a first surface portion, a middle portion, and a second surface portion, the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion.

[0042] Fig. 1(a) is a schematic perspective view of an example of the holding sealing material of the present invention. Fig. 1(b) is a schematic cross-sectional view of the holding sealing material taken along the longitudinal direction.

[0043] As illustrated in Fig. 1(a), a holding sealing material 10 of the present invention includes a tabular mat 11 having predetermined length (hereinafter indicated by an arrow L in Fig. 1(a)), width (indicated by an arrow W in Fig. 1(a)), and thickness (indicated by an arrow T in Fig. 1(a)). The mat 11 is generally rectangular in a plan view.

[0044] The mat 11 illustrated in Fig. 1(a) includes a projecting portion 12 on one end and a recessed portion 13 on the other end in the longitudinal direction of the mat 11. The projecting portion 12 and the recessed portion 13 of the mat 11 are formed to fit each other when the mat 11 is wound around an exhaust gas treating body to assemble an exhaust gas purification apparatus (described later).

[0045] The mat 11 contains inorganic fibers having a surface coated with a binder layer. The binder layer contains an organic binder and an inorganic binder.

[0046] Any inorganic fibers may be used. Preferably, the inorganic fibers include at least one selected from the group consisting of alumina fibers, silica fibers, alumina-silica fibers, mullite fibers, biosoluble fibers, and glass fibers.

[0047] The inorganic fibers including at least one selected from the group consisting of alumina fibers, silica fibers, alumina-silica fibers, and mullite fibers have excellent heat resistance. Thus, even when the exhaust gas treating body is exposed to a sufficiently high temperature, the function of the holding sealing material can be sufficiently maintained without being deteriorated or the like. In the case where the inorganic fibers are biosoluble fibers, there is no damage to the health of workers even if the workers inhale scattered inorganic fibers during production of an exhaust gas purification apparatus using the holding sealing material because the biosoluble fibers will be dissolved in the body.

[0048] Alumina fibers may contain additives such as calcia, magnesia, and zirconia, in addition to alumina.

[0049] The ratio of the components of the alumina-silica fibers by weight is preferably $\text{Al}_2\text{O}_3:\text{SiO}_2 = 60:40$ to $80:20$, more preferably $\text{Al}_2\text{O}_3:\text{SiO}_2 = 70:30$ to $74:26$.

[0050] The mat constituting the holding sealing material can be produced by various methods such as needling method or papermaking method.

[0051] The average fiber length of the inorganic fibers constituting the mat produced by the needling method is preferably 1 to 150 mm, more preferably 10 to 80 mm.

[0052] Inorganic fibers having an average fiber length of less than 1 mm are too short, resulting in insufficient entangling of the inorganic fibers. Thus, the holding sealing material will be poorly wound around an exhaust gas treating body and susceptible to cracking. Inorganic fibers having an average fiber length of more than 150 mm are too long, resulting in a low density mat due to a smaller number of fibers constituting the holding sealing material. As a result, the shear strength of the holding sealing material will decrease.

[0053] The average fiber length of the inorganic fibers constituting a mat produced by the papermaking method is preferably 0.1 to 20 mm.

[0054] Inorganic fibers having an average fiber length of less than 0.1 mm are too short and thus substantially no longer able to exhibit characteristics of the fibers. Thus, the fibers will not be suitably entangled with each other when assembled together in the form of a mat, failing to achieve a sufficient contact pressure. Inorganic fibers having an average fiber length of more than 20 mm are too long and thus too strongly entangled with each other in a slurry solution obtained by dispersing the fibers in water during a papermaking step. Thus, the fibers tend to accumulate unevenly when assembled together in the form of a mat.

[0055] Examples of the organic binder to be contained in the binder layer include acrylic resins, acrylate latex, rubber latex, water-soluble organic polymers (e.g., carboxymethyl cellulose and polyvinyl alcohol), thermoplastic resins (e.g., styrene resin), and thermosetting resins (e.g., epoxy resin).

[0056] When the mat 11 illustrated in Fig. 1(a) is trisected into a first surface portion 11a, a middle portion 11c, and a second surface portion 11b in the thickness direction as illustrated in Fig. 1(b), the amount of the organic binder attached to the first surface portion 11a is more than the amount of the organic binder attached to the middle portion 11c and is also more than the amount of the organic binder attached to the second surface portion 11b.

[0057] In the case where the holding sealing material 10 including the mat 11 is wound around the exhaust gas treating body in such a manner that the surface on the second surface portion 11b side is adjacent to the metal casing, the holding force between the mat and the metal casing is only slightly affected even when the organic binder is softened by being heated after the use of the exhaust gas purification apparatus, because the amount of the organic binder attached is small in the surface of the mat 11 on the second surface portion 11b side.

[0058] Thus, the holding sealing material can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus.

[0059] The percentage of weight loss of the first surface portion 11a after heating at 600°C for one hour is preferably 0.5 to 10.0% relative to 100% of the weight of the first surface portion before heating. The percentage of weight loss is more preferably 0.5 to 3.0%, still more preferably 0.5 to 2.0%.

[0060] The percentage of weight loss corresponds to the amount of the organic binder attached to the first surface portion 11a.

[0061] If the percentage of weight loss is less than 0.5%, the effect of suppressing scattering of the inorganic fibers will be reduced. If the percentage of weight loss is more than 10.0%, the effect of suppressing scattering of the inorganic fibers will remain substantially the same, and the amount of decomposed gas generated by heat of exhaust gas will be large, which may adversely affect the surrounding environment. Thus, it is preferred that the amount of the organic binder attached be as small as possible. The percentage of weight loss is preferably 10.0% or less, more preferably 3.0% or less, still more preferably 2.0% or less.

[0062] The percentage of weight loss (the amount of the organic binder attached) in the second surface portion 11b is preferably substantially equal to or less than the percentage of weight loss (the amount of attached the organic binder) in the middle portion 11c.

[0063] The percentage of weight loss of the middle portion 11c after heating at 600°C for one hour is preferably 0.1 to 7.0% relative to 100% by weight of the middle portion before heating. The percentage of weight loss is more preferably 0.1 to 2.0%, still more preferably 0.1 to 1.0%.

[0064] The percentage of weight loss corresponds to the amount of the organic binder attached to the middle portion 11c.

[0065] A preferred range of the percentage of weight loss (the amount of the organic binder attached) in the second surface portion 11b is also the same as that of the percentage of weight loss (the amount of the organic binder attached) in the middle portion 11c.

[0066] The glass-transition temperature of the organic binder is preferably 5°C or lower, more preferably -5°C or lower, still more preferably -10°C or lower, particularly preferably -30°C or lower. If the organic binder has a glass-transition temperature of 5°C or lower, the resulting holding sealing material will have a high degree of elongation and excellent flexibility while increasing the coating strength of the binder layer. Thus, the holding sealing material will be less likely to be broken, for example, when the holding sealing material is wound around the exhaust gas treating body. In addition, since the binder layer will not be too hard, scattering of the inorganic fibers will be likely to be suppressed.

[0067] Examples of the inorganic binder contained in the binder layer include inorganic particles in the solid form in which a solvent is removed from an inorganic particle solution such as an inorganic sol dispersion.

[0068] The inorganic sol dispersion (inorganic particle solution) is not particularly limited. Examples include an alumina sol and a silica sol.

[0069] The inorganic particles are preferably alumina particles derived from an alumina sol and silica particles derived from a silica sol.

[0070] Although the particle diameter of the inorganic particles is not particularly limited, the average particle diameter of the inorganic particles is preferably 0.005 to 0.1 μm .

[0071] The inorganic particles contained in the binder layer are preferably dispersed in the polymer resin component as the organic binder.

[0072] The presence of the inorganic particles in the binder layer increases the coating strength of the binder layer, and the binder layer is less likely to be peeled off from the inorganic fibers.

[0073] The inorganic particles will remain on the surface of each inorganic fiber without being burned even after the exhaust gas purification apparatus is used, and numerous depressions and projections will be formed on the entire surface of each inorganic fiber, presumably due to exposure of the inorganic particles dispersed in the binder layer as a result of the organic binder being burned off. Once the depressions and projections resulting from the inorganic particles are formed on the entire surface of each inorganic fiber, the inorganic fibers are entangled with each other due to the depressions and projections when these inorganic fibers contact each other after the organic binder is burned off. This prevents slipping on the surface of each inorganic fiber, thus facilitating an increase in the contact pressure.

[0074] Dispersion of the inorganic particles as the inorganic binder in the polymer resin component as the organic binder within the binder layer can be observed with a transmission electron microscope (hereinafter also referred to as "TEM"). The organic binder mainly containing carbon atoms has a low electron density and easily allows electron beams to pass therethrough, compared to the inorganic binder containing alumina, silica, and the like. Thus, in a TEM image, the polymer resin component as the organic binder is lighter in color than the inorganic particles as the inorganic binder.

[0075] In the holding sealing material of the present invention, the amount of the inorganic binder to be attached per unit weight of the inorganic fibers is preferably 0.3 to 15.0 parts by weight, more preferably 0.5 to 10.0 parts by weight, still more preferably 0.5 to 3 parts by weight, particularly preferably 0.5 to 2 parts by weight, relative to 100 parts by weight of the inorganic fibers.

[0076] If the amount of the inorganic binder attached is less than 0.3 parts by weight relative to 100 parts by weight

of the inorganic fibers, the effect of increasing the contact pressure tends to be small due to an insufficient amount of the inorganic particles. If the amount is more than 15.0 parts by weight, although the effect of increasing the contact pressure will remain substantially the same, the binder layer may become too hard, making it difficult to suppress scattering of the inorganic fibers.

[0077] The amount of the inorganic binder attached to each of the first surface portion, the middle portion, and the second surface portion is not particularly limited. A larger amount of the inorganic binder may be attached to the first surface portion as in the case of the amount of the organic binder attached, or the inorganic binder may be uniformly attached to all of the first surface portion, the middle portion, and the second surface portion.

[0078] Preferably, the binder layer further contains a polymeric dispersant.

[0079] If the binder layer contains a polymeric dispersant, the inorganic particles as the inorganic binder can be easily dispersed in the polymer resin component as the organic binder, further facilitating an increase in the coating strength of the binder layer.

[0080] The kind of the polymeric dispersant is not particularly limited. Examples include hydrophilic synthetic polymers such as anionic polymeric dispersants (e.g., polycarboxylic acids and/or salts thereof, naphthalene sulfonate formaldehyde condensates and/or salts thereof, polyacrylic acids and/or salts thereof, polymethacrylic acids and/or salts thereof, and polyvinylsulfonic acids and/or salts thereof) and nonionic polymeric dispersants (e.g., polyvinyl alcohol, polyvinyl pyrrolidone, and polyethylene glycol); natural hydrophilic polymers such as gelatin, casein, and water soluble starch; and hydrophilic semisynthetic polymers such as carboxymethyl cellulose.

[0081] Among these, hydrophilic synthetic polymers are preferred, and anionic polymeric dispersants are more preferred. The number average molecular weight of the anionic polymeric dispersant is preferably 500 to 100000. The number average molecular weight of the anionic polymeric dispersant can be calculated, for example, from molecular weight measurement by gel permeation chromatography (GPC).

[0082] The coating strength of the binder layer is preferably 5.0 MPa or more. If the coating strength of the binder layer is 5.0 MPa or more, separation of the binder layer and slipping of the inorganic fibers upon contact between the fibers contact are less likely to occur, thus facilitating an increase in the contact pressure.

[0083] The coating strength of the binder layer is the tensile strength at break of a dumbbell-shaped test piece having a thickness of 0.4 mm produced from the binder layer, as measured by a tension test at a speed of 300 mm/min at room temperature using an Instron tensile tester.

[0084] The test piece can be produced by pouring the binder solution as a raw material of the binder layer into a polypropylene resin plate having a frame, and leaving the binder solution at 50°C to be dried into a film.

[0085] Preferably, the holding sealing material of the present invention is needle-punched. The inorganic fibers are entangled by needle punching, which strengthens entanglement between the inorganic fibers, thus facilitating an increase in the contact pressure.

[0086] Needle punching can be performed using a needle punching device. The needle punching device includes a support plate for supporting a sheet of an inorganic fiber precursor, and a needle board disposed above the support plate and capable of moving back and forth in a punching direction (thickness direction of a base mat). A large number of needles are attached to the needle board. The needle board is moved relative to the sheet of the inorganic fiber precursor placed on the support plate, and the large number of needles are pushed in and out of the sheet of the inorganic fiber precursor. Thus, the fibers constituting the inorganic fiber precursor can be complicatedly entangled. The number of times to perform needle punching may be changed according to the target bulk density and the target basis weight.

[0087] The thickness of the holding sealing material of the present invention is not particularly limited, but it is preferably 2.0 to 20 mm. If the thickness of the holding sealing material is more than 20 mm, the holding sealing material will lose its flexibility and thus be difficult to handle at the time of being wound around the exhaust gas treating body, and the holding sealing material will be susceptible to winding wrinkles and cracking.

[0088] If the thickness of the holding sealing material is less than 2.0 mm, the contact pressure of the holding sealing material will be not be sufficient enough to hold the exhaust gas treating body. Thus, the exhaust gas treating body will easily come off. In addition, if the volume of the exhaust gas treating body changes, such a holding sealing material cannot easily absorb volume changes in the exhaust gas treating body. Thus, the exhaust gas treating body will be susceptible to cracking and the like.

[0089] The basis weight (weight per unit area) of the holding sealing material of the present invention is not particularly limited, but it is preferably 200 to 4000 g/m², more preferably 1000 to 3000 g/m². If the basis weight of the holding sealing material is less than 200 g/m², the holding force will be insufficient; whereas if the basis weight of the holding sealing material is more than 4000 g/m², it will be difficult to reduce the bulk of the holding sealing material. Thus, the exhaust gas treating body will easily come off if the exhaust gas purification apparatus is produced using such a holding sealing material.

[0090] The bulk density of the holding sealing material of the present invention (bulk density of the holding sealing material before being wound) is also not particularly limited, but it is preferably 0.10 to 0.30 g/cm³. If the bulk density of the holding sealing material is less than 0.10 g/cm³, it will be difficult to maintain the shape of the holding sealing material

in a predetermined shape because the inorganic fibers are loosely entangled and thus easily separated.

[0091] A holding sealing material having a bulk density of more than 0.30 g/cm^3 is rigid so that it is poorly wound around the exhaust gas treating body and susceptible to cracking.

[0092] The holding sealing material of the present invention may further contain an expansive agent. The expansive agent is preferably one that expands in the range of 400°C to 800°C .

[0093] If the holding sealing material contains an expansive agent, the holding sealing material will expand in the range of 400°C to 800°C . Thus, the holding force of the holding sealing material can be increased even in a high temperature range above 700°C in which a decrease in the strength of glass fibers occurs.

[0094] Examples of expansive agents include vermiculite, bentonite, phlogopite, pearlite, expandable graphite, and expandable fluorophlogopite. Each of these expansive agents may be used alone or in combination of two or more thereof.

[0095] The amount of the expansive agent to be added is not particularly limited, but it is preferably 10 to 50% by weight, more preferably 20 to 30% by weight, relative to the total weight of the holding sealing material.

[0096] The method for producing the holding sealing material of the present invention is described below.

[0097] The method for producing the holding sealing material of the present invention is suitable as a method for producing the holding sealing material of the present invention.

[0098] The method for producing the holding sealing material of the present invention includes the steps of:

preparing a mat containing inorganic fibers;

applying a binder solution containing an organic binder and an inorganic binder to the mat; and

drying the mat to which the binder solution was applied with hot air.

(a) Mat preparing step

[0099] In the method for producing the holding sealing material of the present invention, first, a mat containing inorganic fibers is prepared.

[0100] The mat constituting the holding sealing material can be obtained by various methods. For example, it can be produced by a method such as needling or papermaking.

[0101] In the case of needling, the mat can be produced by the following method, for example. Specifically, first, for example, a spinning mixture formed from raw materials such as an aqueous solution of basic aluminum chloride and a silica sol is spun by blowing to produce an inorganic fiber precursor having an average fiber diameter of 3 to $10 \mu\text{m}$. Subsequently, the inorganic fiber precursor is compressed into a continuous sheet having a predetermined size. The continuous sheet is needle-punched, and then fired. Thus, the preparation of a mat is completed.

[0102] In the case of papermaking, alumina fibers, inorganic fibers such as silica fibers, an inorganic binder, and water are mixed in such a manner that the amount of the inorganic fibers in the raw material solution reaches a predetermined value, followed by stirring with a stirrer. Thus, a mixture is prepared. The mixture may optionally contain a colloidal solution of a high molecular compound or resin. Subsequently, the mixture is poured into a mold having a filtration mesh screen formed on its bottom, and the water in the mixture is removed through the mesh screen. Thus, a raw material sheet is produced. Then, the raw material sheet is thermally compressed under predetermined conditions. Thus, the preparation of a mat is completed.

(b) Applying step

[0103] Next, a binder solution containing an organic binder and an inorganic binder is applied to the mat.

[0104] First, a mixture of an inorganic binder solution and a polymeric dispersant is prepared, and the mixture is mixed with an organic binder dispersed in water (i.e., an organic binder solution). Thus, a binder solution is prepared. The mixture of an inorganic binder and a polymeric dispersant is prepared first so as to allow the surface of the inorganic particles as the inorganic binder to be coated with the polymeric dispersant. The mixture is then mixed with the organic binder dispersed in water so as to allow the inorganic particles as the inorganic binder coated with the polymeric dispersant and the polymer resin component as the organic binder to be dispersed in water.

[0105] The addition of the polymeric dispersant is optional. In the case where the polymeric dispersant is not added, the binder solution may be prepared by mixing the inorganic binder and the organic binder.

[0106] The inorganic binder solution is not particularly limited, and those mentioned in the description of the holding sealing material of the present invention, such as alumina sol and silica sol, can be used.

[0107] The concentration of the inorganic binder solution is not particularly limited, but it is preferred to use a solution of the inorganic particles as the inorganic binder diluted to a concentration of about 0.2 to 20% by weight in terms of solids content.

[0108] The polymeric dispersant to be mixed with the inorganic binder solution is not particularly limited, and those mentioned in the description of the holding sealing material of the present invention can be used. Thus, a detailed

description thereof is omitted. A preferred kind of the polymeric dispersant and the range of the number average molecular weight are also as described above.

[0109] The concentration of the polymeric dispersant in the binder solution is not particularly limited, but it is preferably 50 to 1000 ppm. If the concentration of the polymeric dispersant is less than 50 ppm, the amount of the polymeric dispersant will be insufficient so that it will be difficult to suppress agglomeration of the inorganic particles as the inorganic binder and the polymer resin component as the organic binder in the binder solution; whereas if the concentration is more than 1000 ppm, the dispersing effect will remain the same so that the addition of an excess amount of the polymeric dispersant is not preferred.

[0110] The organic binder is not particularly limited, and those mentioned in the description of the holding sealing material of the present invention can be used. Thus, a detailed description thereof is omitted.

[0111] The concentration of the organic binder is not particularly limited, but it is preferred to use a solution of the polymer resin component as the organic binder diluted to a concentration of about 0.2 to 20% by weight in terms of solids content.

[0112] The mixing ratio of the mixture of the inorganic binder and the polymeric dispersant to the organic binder solution is not particularly limited, but it is preferred to mix at a mixing ratio by solids weight of the inorganic particles as the inorganic binder in the mixture of the inorganic binder and the polymeric dispersant to the polymer resin component as the organic binder component in the organic binder solution of 3:1 to 1:3.

[0113] A pH adjuster for adjusting the pH of the binder solution may be added to the binder solution.

[0114] Subsequently, the binder solution is applied to the mat.

[0115] The method for bringing the mat into contact with the binder solution during the applying step is not particularly limited. For example, the binder solution may be applied to the inorganic fibers in the mat by allowing the mat to be impregnated in the binder solution, or by dropping the binder solution onto the mat by a method such as curtain coating. Alternatively, the binder solution may be sprayed to the mat as in spray coating.

[0116] Further, preferably, the mat to which the binder solution was applied is dewatered so as to adjust the amount of the binder solution applied to 50 to 200 parts by weight relative to 100 parts by weight of the inorganic fibers constituting the mat.

(c) Drying step

[0117] Next, the mat to which the binder solution was applied is dried with hot air.

[0118] In the drying step, the mat to which the binder solution was applied is dried with hot air (drying step) to dry the organic binder and the inorganic binder to evaporate the solvent in the binder solution.

[0119] The temperature of drying with hot air is not particularly limited, but preferably, the temperature of hot air is about 100°C to 150°C.

[0120] During drying with hot air, the amount of the organic binder to be attached can be adjusted by changing the velocity of the hot air so as to produce a holding sealing material in which a large amount of the organic binder is attached to the first surface portion.

[0121] Blowing hot air at 100°C to 150°C to one main surface of the mat results in non-uniform distribution of the organic binder as described below.

[0122] If the air velocity is less than 1.0 m/s, the amount of the organic binder attached will be large in and near the main surface to which hot air was blown. Thus, for the production of the holding sealing material of the present invention, hot air is blown to the main surface on the first surface portion side.

[0123] If the air velocity is 1.0 m/s or more and less than 1.5 m/s, the amount of the organic binder attached will be uniform in the thickness direction, which is not suitable to the production of the holding sealing material of the present invention.

[0124] If the air velocity is 1.5 m/s or more, the amount of the organic binder attached will be large in and near the other main surface opposite to the main surface to which hot air was blown. Thus, for the production of the holding sealing material of the present invention, hot air is blown to the main surface on the second surface portion side.

[0125] During drying with hot air, preferably, the mat is sandwiched between plates with ventilation holes above and below to prevent the mat from being exposed to excessive load, and hot air is blown in a direction from one main surface of the mat (preferably, the main surface on the second surface portion side) to the other main surface through the mat from the ventilation holes.

[0126] The holding sealing material of the present invention can be produced through these steps.

[0127] Thereafter, the holding sealing material may further be subjected to a cutting step in which the holding sealing material is cut into a predetermined shape to obtain a holding sealing material having a projecting portion and a recessed portion as illustrated in Fig. 1(a).

[0128] The exhaust gas purification apparatus of the present invention is described below.

[0129] The exhaust gas purification apparatus of the present invention includes: a metal casing;

an exhaust gas treating body housed in the metal casing; and
the holding sealing material of the present invention wound around the exhaust gas treating body and arranged between
the exhaust gas treating body and the metal casing,

wherein the mat is arranged in such a manner that a surface thereof on the first surface portion side is adjacent to the
exhaust gas treating body and that a surface thereof on the second surface portion side is adjacent to the metal casing.

[0130] Fig. 2 is a schematic cross-sectional view of an example of the exhaust gas purification apparatus of the present invention.

[0131] As illustrated in Fig. 2, an exhaust gas purification apparatus 100 of the present invention includes a metal casing 130, an exhaust gas treating body 120 housed in the metal casing 130, and the holding sealing material 10 arranged between the exhaust gas treating body 120 and the metal casing 130.

[0132] The exhaust gas treating body 120 has a pillar shape in which a large number of cells 125 are arranged in parallel in a longitudinal direction with a cell wall 126 between each cell. If necessary, an inlet tube for introducing exhaust gas discharged from an internal combustion engine is connected to one end portion of the metal casing 130, and an outlet tube for discharging the exhaust gas that has passed through the exhaust gas purification apparatus to the outside is connected to the other end portion of the metal casing 130.

[0133] Passage of exhaust gas through the exhaust gas purification apparatus 100 having the above-described structure is described with reference to Fig. 2.

[0134] As illustrated in Fig. 2, exhaust gas discharged from the internal combustion engine into the exhaust gas purification apparatus 100 (in Fig. 2, the exhaust gas is indicated by G, and the flow of exhaust gas is indicated by arrows) flows into one cell 125 that is open at an exhaust gas inlet-side end face 120a of the exhaust gas treating body (i.e., the honeycomb filter) 120, and then passes through the cell wall 126 between each cell 125. At this point, PM in the exhaust gas is collected by the cell wall 126, and the exhaust gas is purified. The purified exhaust gas is discharged to the outside via another cell 125 that is open at an exhaust gas outlet-side end face 120b.

[0135] In the exhaust gas purification apparatus 100 illustrated in Fig. 2, the holding sealing material 10 is the holding sealing material of the present invention, wherein the mat constituting the holding sealing material 10 is arranged in such a manner that a surface thereof on the first surface portion 11a side is adjacent to the exhaust gas treating body 120 and that a surface thereof on the second surface portion 11b side is adjacent to the metal casing 130.

[0136] During the use of the exhaust gas purification apparatus, high-temperature exhaust gas flows into the exhaust gas treating body, increasing the temperature of the holding sealing material. As a result, the organic binder is heated and softened.

[0137] The holding sealing material of the present invention is used in the exhaust gas purification apparatus of the present invention, and the surface on the second surface portion side where the amount of the organic binder attached is small is adjacent to the metal casing. The holding force between the mat and the metal casing is only slightly affected when the amount of the organic binder attached is small.

[0138] Thus, the exhaust gas purification apparatus can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus.

[0139] The material of the metal casing constituting the exhaust gas purification apparatus of the present invention is not particularly limited as long as it is a heat-resistant metal. Specific examples include metals such as stainless steel, aluminum, and iron.

[0140] In addition to the substantially cylindrical shape, the casing can suitably have a shape such as a clam-shell shape, a shape with a substantially elliptical cross section, or a shape with a substantially polygonal cross section.

[0141] Fig. 3 is a schematic perspective view of an example of the exhaust gas treating body constituting the exhaust gas purification apparatus of the present invention.

[0142] The exhaust gas treating body 120 illustrated in Fig. 3 is a ceramic honeycomb structured body having a pillar shape in which the large number of cells 125 are arranged in parallel in the longitudinal direction with the cell wall 126 between each cell 125. One of the ends of each cell 125 is plugged with a plug material 128. In addition, a peripheral coat layer 127 is provided on the periphery of the honeycomb structured body in order to reinforce the periphery of the honeycomb structured body, arrange the shape, and improve thermal insulating properties of the honeycomb structured body.

[0143] In the case where each of the cells 125 is plugged at one end, it is preferred that the end-plugged cells and unplugged cells be alternately arranged when the exhaust gas treating body 120 is viewed from one of the ends.

[0144] The cross-sectional shape of the exhaust gas treating body 120 taken along a direction perpendicular to the longitudinal direction is not particularly limited. It may be a substantially circular shape or a substantially elliptical shape. Alternatively, it may be a substantially polygonal shape such as a substantially triangular shape, substantially quadrangular shape, substantially pentagonal shape, or substantially hexagonal shape.

[0145] The cross-sectional shape of each cell 125 constituting the exhaust gas treating body 120 may be a substantially polygonal shape such as a substantially triangular shape, substantially quadrangular shape, substantially pentagonal shape, or substantially hexagonal shape. Alternatively, it may be a substantially circular shape or a substantially elliptical

shape. The exhaust gas treating body 120 may include a combination of cells having different cross-sectional shapes.

[0146] The materials constituting the exhaust gas treating body 120 are not particularly limited. Non-oxide materials such as silicon carbide and silicon nitride and, oxide materials such as cordierite and aluminum titanate can be used. In particular, a porous fired body made of a non-oxide material such as silicon carbide or silicon nitride among the above is preferred.

[0147] Porous fired bodies made of these materials are brittle and thus easily breakable by mechanical shock or the like. However, in the case of the exhaust gas purification apparatus of the present invention, the holding sealing material 10 disposed around the lateral side of the exhaust gas treating body 120 absorbs shock. Thus, the exhaust gas treating body 120 can be prevented from cracking or the like resulting from mechanical shock and thermal shock.

[0148] The exhaust gas treating body constituting the exhaust gas purification apparatus of the present invention may support a catalyst for conversion of exhaust gas. Preferred examples of catalysts to be supported include noble metals such as platinum, palladium, and rhodium. Among these, platinum is more preferred. Examples of other catalysts that can be used include alkali metals such as potassium and sodium and alkaline-earth metals such as barium. Each of these catalysts may be used alone or in combination of two or more thereof. These catalysts being supported facilitates removal of PM by combustion and allow for conversion of toxic exhaust gas.

[0149] The exhaust gas treating body constituting the exhaust gas purification apparatus of the present invention may be an integral honeycomb structured body made of cordierite or the like and integrally formed. Alternatively, the exhaust gas treating body may be an aggregated honeycomb structured body formed by combining a plurality of pillar-shaped honeycomb fired bodies made of silicon carbide or the like via a paste mainly made of ceramic, each honeycomb fired body having a large number of through holes arranged in parallel in the longitudinal direction with a partition wall between each through hole.

[0150] In the exhaust gas treating body constituting the exhaust gas purification apparatus of the present invention, each cell may not be provided with a plug material and thus may not be plugged at one end. In this case, the exhaust gas treating body is used to support a catalyst such as platinum so as to function as a catalyst supporting carrier to convert harmful gas components such as CO, HC, or NO_x contained in exhaust gas.

[0151] Next, the method for producing the exhaust gas purification apparatus of the present invention is described below.

[0152] The method for producing the exhaust gas purification apparatus of the present invention includes preparing a wound body by winding the holding sealing material of the present invention around an exhaust gas treating body in such a manner that the surface of the mat on the first surface portion side is adjacent to the exhaust gas treating body; and arranging the wound body in a metal casing in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

[0153] Fig. 4 is a schematic perspective view of an example of the method for producing the exhaust gas purification apparatus of the present invention.

[0154] According to the method for producing the exhaust gas purification apparatus of the present invention, as shown in Fig. 4, the holding sealing material 10 is wound around the periphery of the exhaust gas treating body 120 to form a wound body 140. The wound body 140 is then housed in the metal casing 130. Thus, the exhaust gas purification apparatus of the present invention is produced.

[0155] While the wound body 140 is produced, the mat 11 constituting the holding sealing material 10 is wound with its surface on the first surface portion 11a side facing the exhaust gas treating body 120. As a result, the surface on the first surface portion 11a side is adjacent to the exhaust gas treating body 120, and the surface on the second surface portion 11b side is adjacent to the metal casing 130.

[0156] Examples of the method for housing the wound body 140 into the metal casing 130 include a press-fitting method (stuffing method) in which the exhaust gas treating body 120 (wound body 140) around which the holding sealing material 10 is wound is press-fitted up to a predetermined position inside the metal casing 130; a sizing method (swaging method) in which the outer periphery of the metal casing 130 is compressed to reduce the inner diameter of the metal casing 130; and a clam-shell method in which the metal casing is formed in a shape that can be separated into a first casing and a second casing, and the wound body 140 is placed on the first casing, which is then covered with the second casing for hermetic sealing.

[0157] In the case of housing the wound body in the metal casing by the press-fitting method (stuffing method), preferably, the inner diameter of the metal casing (i.e., the inner diameter of a portion where the exhaust gas treating body is housed) is slightly smaller than the outer diameter of the wound body.

[0158] The exhaust gas purification apparatus of the present invention is produced through these steps.

[0159] The effects of the holding sealing material of the present invention, the method for producing a holding sealing material, the method for producing an exhaust gas purification apparatus, and the exhaust gas purification apparatus are described below.

(1) In the holding sealing material of the present invention, the amount of the organic binder attached is non-uniformly

distributed in the thickness direction of the mat; and the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion. Thus, in the case where the holding sealing material is wound around the exhaust gas treating body in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing, the holding force between the mat and the metal casing is only slightly affected even when the organic binder is softened by being heated after the use of the exhaust gas purification apparatus, because the amount of the organic binder attached is small on the surface of the mat on the second surface portion side.

Thus, the holding sealing material can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus.

(2) The method for producing the holding sealing material of the present invention includes the steps of: preparing a mat containing inorganic fibers; applying a binder solution containing an organic binder and an inorganic binder to the mat; and drying the mat to which the binder solution was applied with hot air.

With these steps, it is possible to produce the holding sealing material of the present invention in which the binder layer containing the organic binder and the inorganic binder is formed on the surface of each inorganic fiber, and the amount of the organic binder attached is non-uniformly distributed in the thickness direction of the mat.

(3) The method for producing the exhaust gas purification apparatus of the present invention includes: producing a wound body by winding the holding sealing material of the present invention around the exhaust gas treating body in such a manner that the surface of the mat on the first surface portion side is adjacent to the exhaust gas treating body; and arranging the wound body in a metal casing in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

According to the above method, it is possible to produce an exhaust gas purification apparatus capable of maintaining sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus because the surface of the mat on the second surface portion side where the amount of the organic binder attached is small is adjacent to the metal casing.

(4) In the exhaust gas purification apparatus of the present invention, the mat is arranged in such a manner that a surface thereof on the first surface portion side is adjacent to the exhaust gas treating body and that a surface thereof on the second surface portion side is adjacent to the metal casing. The exhaust gas purification apparatus can maintain sufficient holding force between the mat and the metal casing even after the use of the exhaust gas purification apparatus because the surface of the mat on the second surface portion side where the amount of the organic binder attached is small is adjacent to the metal casing.

EXAMPLES

[0160] Examples that more specifically disclose the present invention are described below, but the present invention is not limited to these examples.

(Example 1)

(a) Mat preparing step

[0161] First, a mat containing inorganic fibers was prepared by the following procedure.

(a-1) Spinning step

[0162] An aqueous solution of basic aluminum chloride having an Al content of 70 g/l at a ratio of Al:Cl = 1:1.8 (atomic ratio) was prepared. A silica sol was added to the solution in such a manner that the ratio of components in inorganic fibers after firing would be $\text{Al}_2\text{O}_3:\text{SiO}_2:\text{SiO}_2 = 72:28$ (weight ratio), followed by addition of an appropriate amount of an organic polymer (polyvinyl alcohol). Thus, a mixture was prepared.

[0163] The resulting mixture was concentrated into a spinning mixture, and the spinning mixture was spun by blowing. Thus, an inorganic fiber precursor having an average fiber diameter of 5.1 μm was prepared.

(a-2) Compressing step

[0164] The inorganic fiber precursor obtained in step (a-1) above was compressed into a continuous sheet.

(a-3) Needle-punching step

[0165] The sheet obtained in step (a-2) above was continuously needle-punched under the following conditions to produce a needle-punched body.

[0166] First, a needle board having needles attached thereto at a density of 21 pcs/cm² was provided. Next, the needle board was set above one of the surfaces of the sheet, and the sheet was needle-punched by allowing the needle board to descend and ascend once in the thickness direction of the sheet. Thus, a needle-punched body was produced. At this point, the needles were allowed to penetrate the sheet until barbs formed on the tips of the needles had completely protruded from the opposite surface.

(a-4) Firing step

[0167] The needle-punched body obtained in step (a-3) above was continuously fired at a maximum temperature of 1250°C. Thus, a fired sheet formed from inorganic fiber including alumina and silica at a ratio (part by weight) of 72:28 was produced. The average fiber diameter of the inorganic fibers was 5.1 μm , and the minimum value was 3.2 μm . The fired sheet thus obtained had a bulk density of 0.15 g/cm³ and a basis weight of 1400 g/m².

(a-5) Cutting step

[0168] The fired sheet produced in step (a-4) above was cut into a mat containing the inorganic fibers.

(b) Applying step

(b-1) Organic binder solution preparing step

[0169] Acrylate-type latex (ZEON Corporation, Nipol LX874 (solids concentration: 45 wt%)) formed by dispersing acrylic rubber having a glass-transition temperature of -31°C in water was diluted with water. Thus, an organic binder solution having a solids concentration of 2% by weight was prepared.

(b-2) Inorganic binder solution preparing step

[0170] An alumina colloidal solution (alumina sol) (Nissan Chemical Industries, Ltd., alumina sol 550 (solids concentration: 15 wt%)) was diluted with water, and an anionic polymeric dispersant (SAN NOPCO Limited, Nopcosant RFA) was added thereto, followed by sufficient stirring. Thus, an inorganic binder solution was prepared in which the inorganic particles as the inorganic binder had a solids concentration of 2% by weight and the anionic polymeric dispersant had a concentration of 500 ppm.

(b-3) Binder solution preparing step

[0171] The organic binder solution obtained in step (b-1) above was added to the inorganic binder solution obtained in step (b-2) above at a weight ratio of the inorganic binder solution to the organic binder solution of 1:1, and the mixture was sufficiently stirred. Thus, a binder solution was prepared in which the polymer resin component as the organic binder component had a solids concentration of 1% by weight, the inorganic particles as the inorganic binder had a solids concentration of 1% by weight, and the anionic polymeric dispersant had a concentration of 250 ppm.

(b-4) Applying step

[0172] The binder solution obtained in step (b-3) above was applied to the mat produced in the mat preparing step (a) by curtain coating.

(b-5) Dewatering step

[0173] The mat to which the binder solution was applied, which was obtained in step (b-4) above, was dewatered by suction using dewatering equipment in such a manner that the amount of the binder solution applied would be adjusted to 100 parts by weight relative to 100 parts by weight of the inorganic fibers.

(c) Drying step

[0174] The mat that underwent step (b-5) above was heat-dried by blowing hot air to one main surface of the mat at a temperature of 130°C and at an air velocity of 2 m/s. Thus, a holding sealing material was obtained.

[0175] The main surface of the mat to which hot air was blown is regarded as the surface on the second surface portion side, and the other main surface of the mat on the opposite side is regarded as the surface on the first surface portion side.

(Comparative Example 1)

[0176] In the applying step (b-4), the binder solution was applied to the mat by spraying instead of curtain coating. Specifically, the binder solution was sprayed to both main surfaces of the mat in such a manner that the amount of the organic binder attached per unit weight of the inorganic fibers would be the same on both main surfaces.

[0177] In addition, the amount of the organic binder attached was adjusted to be substantially equal to the amount of the organic binder attached to the surface of the mat on the first surface portion side in the Example 1.

[0178] In addition, as for the drying conditions in the drying step, the mat was heat-dried by blowing hot air to one main surface of the mat at a temperature of 130°C and an air velocity of 1.2 m/s. Thus, a holding sealing material was obtained.

(Measurement of the amount of the organic binder attached)

[0179] As for the amount of the organic binder attached, the mat produced was cut into a sample having a size of 100 mm x 100 mm, and the sample was trisected into a first surface portion, a middle portion, and a second surface portion in a thickness direction, followed by heating at 600°C for one hour in an oxidizing atmosphere. Then, the percentage of weight loss of the sample was measured relative to the amount of the sample before heating.

(Measurement of friction coefficient)

[0180] The holding sealing materials of Example 1 and Comparative Example 1 were measured for changes in the friction coefficient before and after heating the organic binder by the method described below.

[0181] Fig. 5(a) and Fig. 5(b) are schematic diagrams of a friction coefficient measurement device for holding sealing materials.

[0182] A friction coefficient measurement device 600 includes stainless steel flat plates (a left plate 610 and a right plate 620) oppositely disposed on the left side and the right side of the device. The left plate 610 is a load cell and can measure the load applied to the right side (the side that comes into contact with a holding sealing material) of the left plate 610.

[0183] First, two holding sealing materials 10a and 10b and a middle plate 630 were arranged in such a manner that the left plate 610, the holding sealing material 10a, the stainless steel flat plate (middle plate 630), the holding sealing material 10b, and the right plate 620 would be arranged in the stated order.

[0184] Projecting members 640 were provided on the surface of the left plate 610 and the right plate 620 to prevent slipping between the left plate 610 and the holding sealing material 10a and between the right plate 620 and the holding sealing material 10b (i.e., between the plates and the holding sealing materials).

[0185] Each holding sealing material was arranged in such a manner that the surface on the second surface portion side was adjacent to the middle plate 630.

[0186] The holding sealing material 10a was sandwiched between the left plate 610 and the middle plate 630; and the holding sealing material 10b was sandwiched between the middle plate 630 and the right plate 620.

[0187] The middle plate 630 is a load cell and can measure the load applied to the middle plate.

[0188] First, pressure was applied to the left plate 610 and the right plate 620 in the direction toward the middle plate 630 so as to compress the holding sealing material to a bulk density (GBD) of 0.3 g/cm³.

[0189] The holding sealing material was maintained in the compressed state for 10 minutes (relaxation).

[0190] Subsequently, the middle plate 630 was moved at a speed of 25 mm/min in the direction (upward) indicated by an arrow in Fig. 5(a) at room temperature to apply shear stress to the main surface of the holding sealing material.

[0191] Fig. 5(b) illustrates the state after the middle plate has been moved.

[0192] The moving direction of the middle plate is the same as the direction in which shear stress was applied to the main surface of the holding sealing material in contact with the middle plate.

[0193] The load applied to the load cell and the static frictional force applied to the middle plate during moving were measured, and the friction coefficient at which the static frictional force was maximum (i.e., static friction coefficient) was measured.

[0194] The above measurement was carried out while the temperature between the holding sealing material and the

middle plate was 25°C immediately after the production of the holding sealing material so as to determine the friction coefficient in the presence of the organic binder.

[0195] Subsequently, the temperature between the holding sealing material and the middle plate was increased to 300 °C and maintained for 20 minutes to heat the organic binder. Then, the friction coefficient was measured with the temperature between the holding sealing material and the middle plate maintained at 300°C so as to determine the friction coefficient after the organic binder has been heated.

[0196] Table 1 shows the results of the example and the comparative example regarding the amount of the binder attached to the holding sealing material and the measurement of the friction coefficient on the second surface portion side of the holding sealing material.

[Table 1]

	Inorganic binder (wt%)	Organic binder (wt%)	Amount of the organic binder attached (percentage of weight loss, %)			Friction coefficient	
			First surface portion	Middle portion	Second surface portion	26°C	300°C
Example 1	1.0	1.0	1.8	0.5	0.3	0.241	0.378
Comparative Example 1	1.0	1.0	1.3	0.4	1.3	0.255	0.321

[0197] Table 1 clearly shows that the friction coefficient measured at 300°C is higher in Example 1 than in Comparative Example 1. This result indicates that softening of the organic binder affects only slightly in Example 1 because the amount of the organic binder attached is small in the second surface portion, and thus the friction coefficient after the organic binder has been softened is higher. In other words, the holding sealing material of Example 1 can maintain high holding force between the mat and the casing even after the organic binder has been softened.

REFERENCE SIGNS LIST

[0198]

- 10 holding sealing material
- 11 mat
- 11a first surface portion
- 11b second surface portion
- 11c middle portion
- 100 exhaust gas purification apparatus
- 120 exhaust gas treating body
- 130 metal casing
- 140 wound body

Claims

1. A holding sealing material comprising a mat having a predetermined thickness, wherein the mat contains inorganic fibers having a surface coated with a binder layer, the binder layer contains an organic binder and an inorganic binder, and when the mat is trisected in a thickness direction into a first surface portion, a middle portion, and a second surface portion, the amount of the organic binder attached to the first surface portion is more than the amount of the organic binder attached to the middle portion and is also more than the amount of the organic binder attached to the second surface portion.
2. The holding sealing material according to claim 1, wherein the amount of the organic binder attached to the second surface portion of the mat is substantially equal to or less than that in the middle portion.

3. The holding sealing material according to claim 1 or 2,
wherein inorganic particles as the inorganic binder are dispersed in a polymer resin component as the organic binder.

4. The holding sealing material according to any one of claims 1 to 3,
wherein the percentage of weight loss of the first surface portion of the mat after heating at 600°C for one hour is 0.5 to 10.0% relative to 100% by weight of the first surface portion before heating, and
the percentage of weight loss of the middle portion of the mat after heating at 600°C for one hour is 0.1 to 7.0% relative to 100% by weight of the middle portion before heating.

5. The holding sealing material according to any one of claims 1 to 4,
wherein the amount of the inorganic binder attached is 0.3 to 15.0 parts by weight relative to 100 parts by weight of the inorganic fibers in terms of solids content.

6. The holding sealing material according to any one of claims 1 to 5,
wherein the organic binder has a glass-transition temperature of 5°C or lower.

7. The holding sealing material according to any one of claims 1 to 6,
wherein the holding sealing material is used by winding the mat around an exhaust gas treating body in such a manner that a surface of the mat on the second surface portion side is adjacent to a metal casing.

8. A method for producing the holding sealing material according to any one of claims 1 to 7, the method comprising the steps of:

preparing a mat containing inorganic fibers;
applying a binder solution containing an organic binder and an inorganic binder to the mat; and
drying the mat to which the binder solution was applied with hot air.

9. The method for producing a holding sealing material according to claim 8,
wherein the binder solution further contains a polymeric dispersant.

10. A method for producing an exhaust gas purification apparatus, the method comprising:

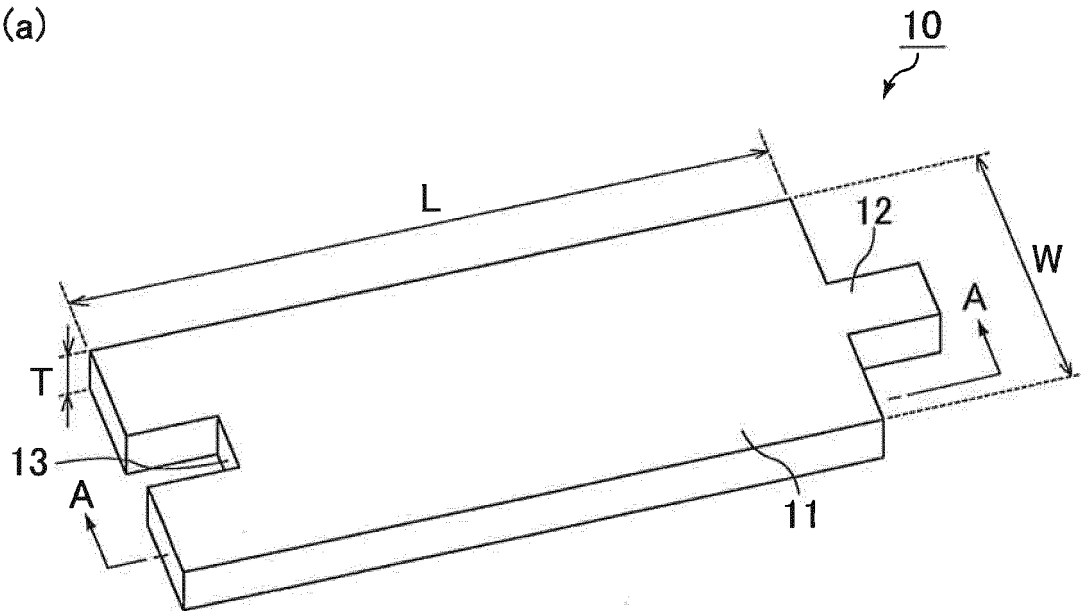
preparing a wound body by winding the holding sealing material according to any one of claims 1 to 7 around an exhaust gas treating body in such a manner that a surface of the mat on the first surface portion side is adjacent to the exhaust gas treating body; and
arranging the wound body in a metal casing in such a manner that the surface of the mat on the second surface portion side is adjacent to the metal casing.

11. An exhaust gas purification apparatus comprising:

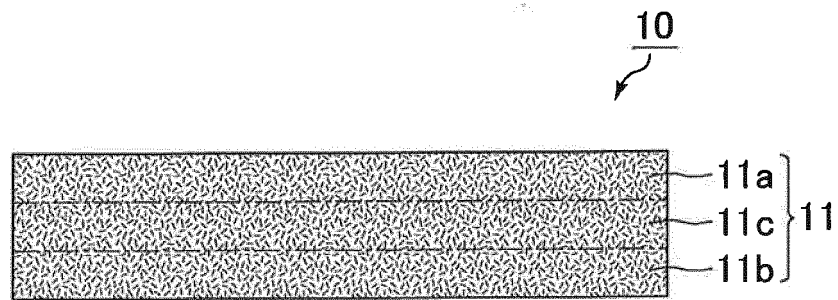
a metal casing;
an exhaust gas treating body housed in the metal casing; and
the holding sealing material according to any one of claims 1 to 7 wound around the exhaust gas treating body and arranged between the exhaust gas treating body and the metal casing,
wherein the mat is arranged in such a manner that a surface thereof on the first surface portion side is adjacent to the exhaust gas treating body and that a surface thereof on the second surface portion side is adjacent to the metal casing.

FIG. 1

(a)



(b)



CROSS-SECTIONAL VIEW TAKEN ALONG LINE A-A

FIG.2

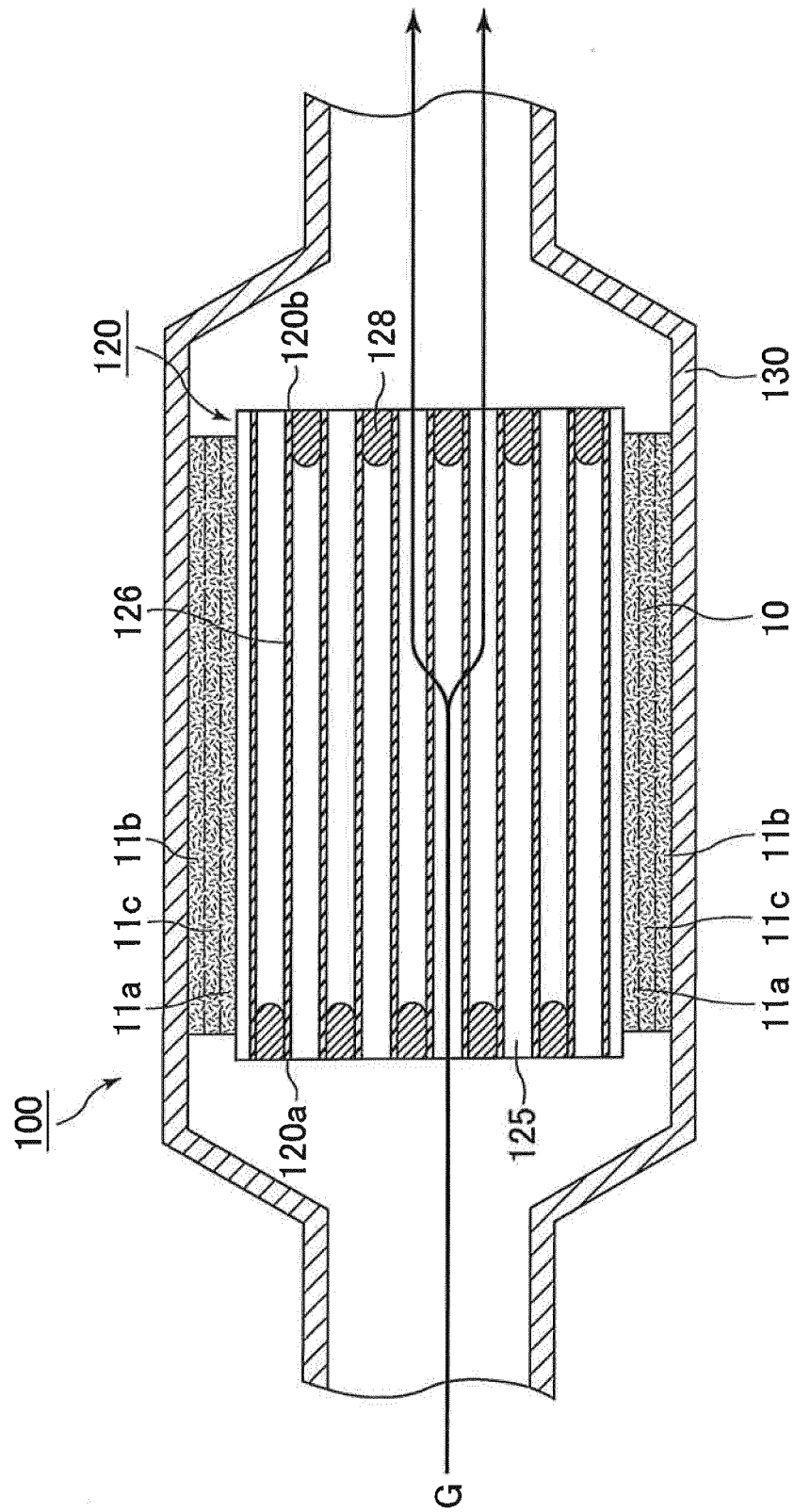


FIG.3

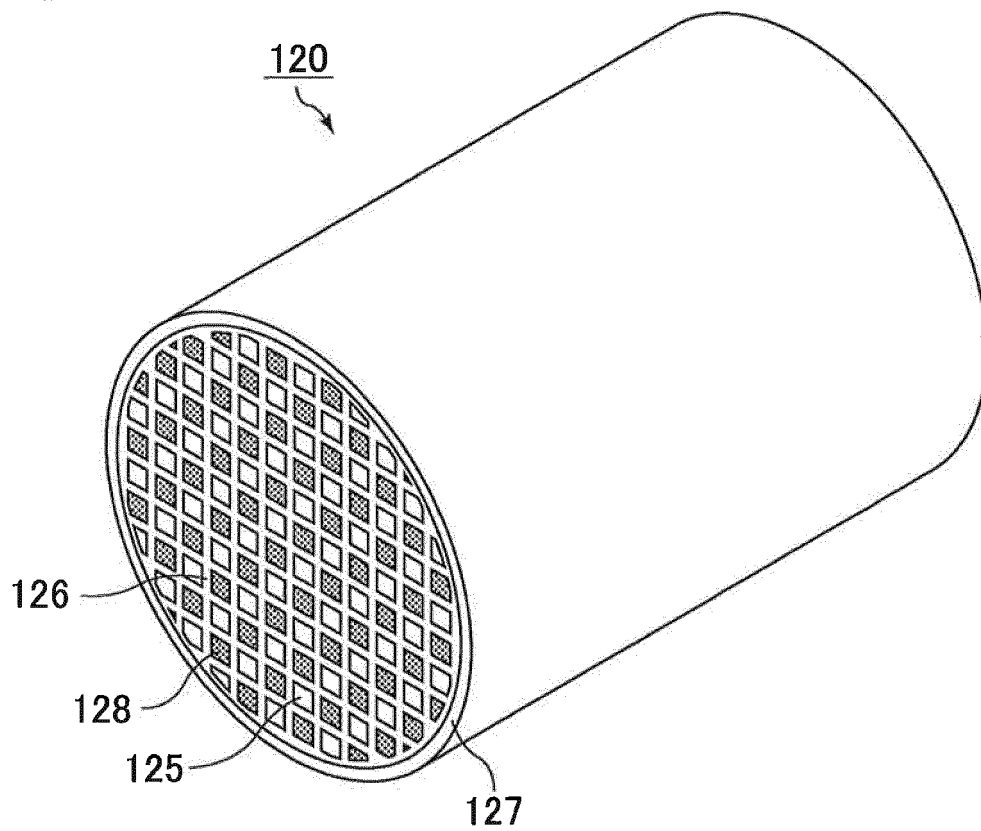


FIG.4

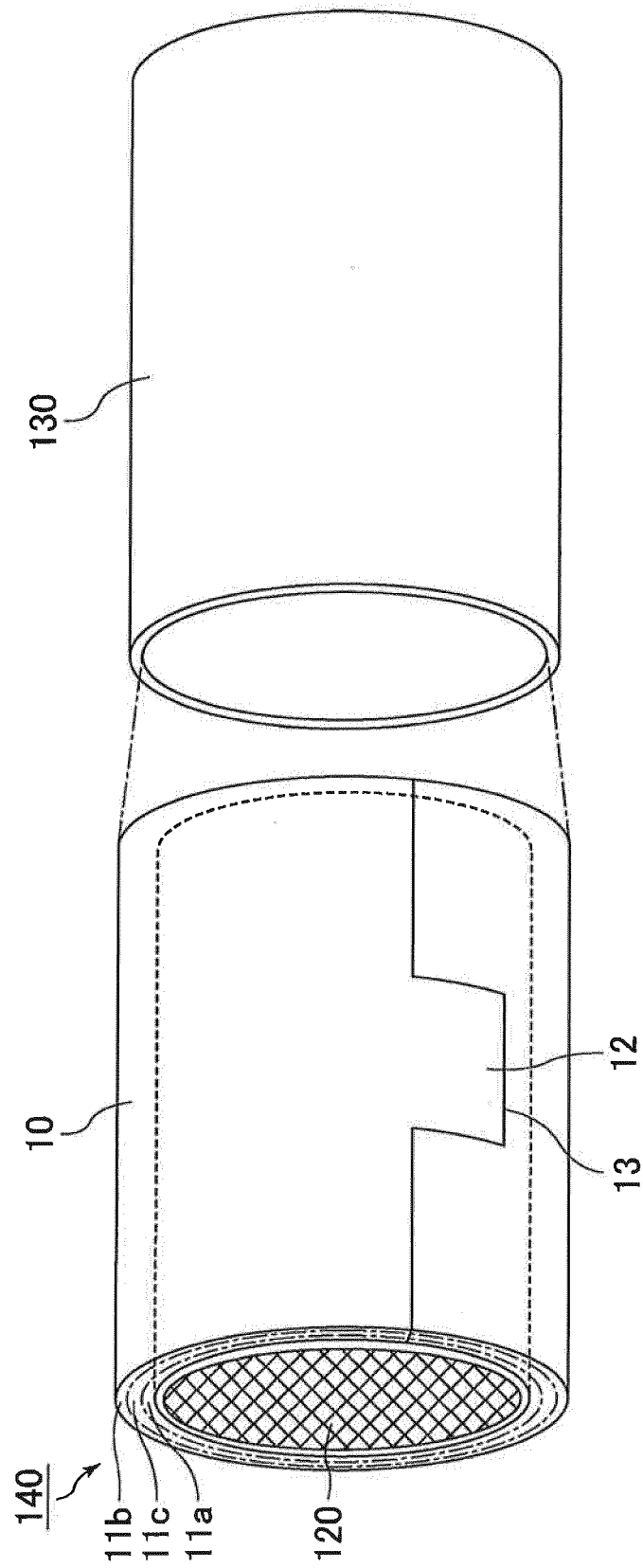
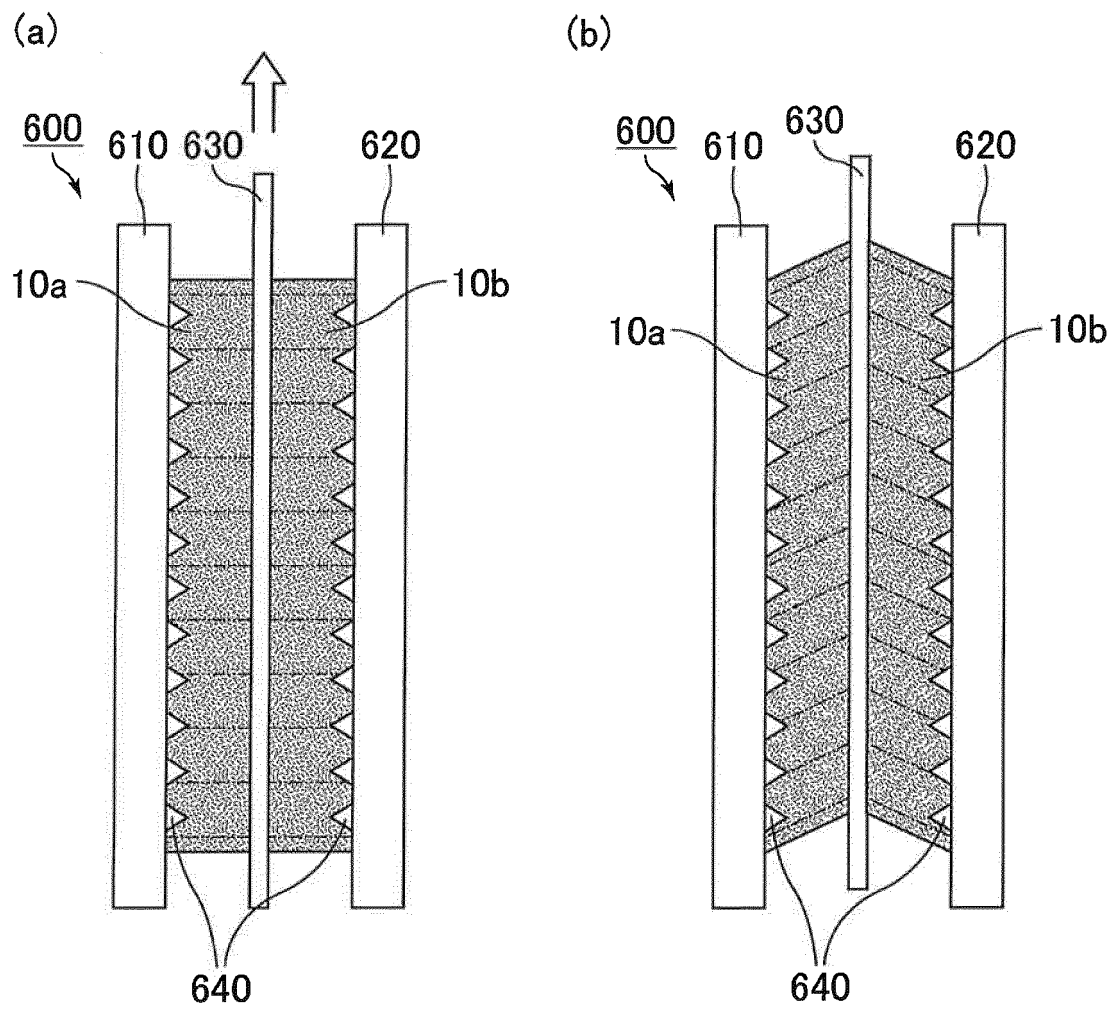


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/070867

A. CLASSIFICATION OF SUBJECT MATTER

F16J15/10(2006.01)i, F01N3/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16J15/10, F01N3/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-85093 A (Ibiden Co., Ltd.), 23 April 2009 (23.04.2009), claims; paragraphs [0022], [0037], [0042]; all drawings & US 2009/0084268 A1 & EP 2042636 A1	1-11
A	JP 2006-342774 A (Ibiden Co., Ltd.), 21 December 2006 (21.12.2006), claims; paragraph [0018]; all drawings & US 2006/0278323 A1 & US 2009/0049690 A1 & EP 1731729 A1	1-11
A	JP 2008-45521 A (Ibiden Co., Ltd.), 28 February 2008 (28.02.2008), claims; paragraphs [0035] to [0037], [0045] to [0054]; all drawings & US 2008/0044317 A1 & EP 1892393 A1	1-11



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

15 October, 2014 (15.10.14)

Date of mailing of the international search report

28 October, 2014 (28.10.14)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/070867

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, A	JP 2013-213463 A (Ibiden Co., Ltd.), 17 October 2013 (17.10.2013), claims; all drawings & US 2013/0255210 A1	1-11

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013127244 A [0005]