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(72) Inventors:

- **MIYAZAKI, Shintaro**
Takahama-shi, Aichi 444-1301 (JP)
- **TARUYA, Koutaro**
Takahama-shi, Aichi 444-1301 (JP)

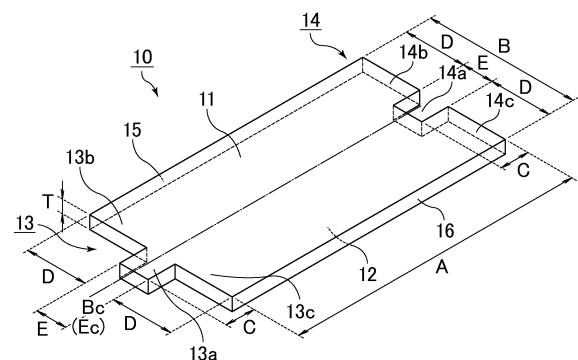
(74) Representative: **Winter, Brandl - Partnerschaft mbB****Alois-Steinecker-Straße 22
85354 Freising (DE)**(30) Priority: **09.06.2022 JP 2022093773**(71) Applicant: **IBIDEN CO., LTD.****Ogaki-shi, Gifu 503-8604 (JP)**

(54) **MAT MATERIAL, EXHAUST GAS PURIFICATION APPARATUS, AND METHOD FOR MANUFACTURING EXHAUST GAS PURIFICATION APPARATUS**

(57) A mat material having a generally rectangular shape in a plan view, the mat material including inorganic fibers, wherein the mat material includes a first main surface and a second main surface opposite to each other in a thickness direction, a first end surface and a second end surface opposite to each other in a longitudinal direction that is a winding direction, and a first side surface and a second side surface opposite to each other in a width direction perpendicular to the thickness direction and the longitudinal direction, the mat material includes, on the first end surface, a protrusion designed to protrude toward the second end surface during winding of the mat material, and non-protruding portions provided at both sides of the protrusion in the width direction and designed not to protrude toward the second end surface during winding of the mat material, the mat material includes, on the second end surface, a recess designed to fit the shape of the protrusion on the first end surface during winding of the mat material, and non-recessed portions provided at both sides of the recess in the width direction and designed to fit the shapes of the non-protruding portions on the first end surface during winding of the mat material, and a ratio $[D/C]$ of a length $[D]$ of the non-recessed portion in the width direction to a length $[C]$ of the non-recessed portion in the longitudinal

direction is 1.0 or more.

FIG. 1

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a mat material, an exhaust gas conversion apparatus, and a method for producing an exhaust gas conversion apparatus.

BACKGROUND ART

10 **[0002]** Exhaust gas discharged from an internal combustion engine such as a diesel engine contains a particulate matter (hereinafter, also referred to as "PM"). Adverse effects of PM on the environment and human bodies have been problems. The exhaust gas also contains harmful gas components such as CO, HC, and NOx. This causes concerns about the effects of such harmful gas components on the environment and human bodies.

15 **[0003]** In view of the above, various exhaust gas conversion apparatuses that collect PM in exhaust gas and convert harmful gas components have been proposed. Such an exhaust gas conversion apparatus includes an exhaust gas treatment unit including porous ceramic such as silicon carbide or cordierite, a casing for housing the exhaust gas treatment unit, and a mat material containing inorganic fiber aggregates between the exhaust gas treatment unit and the casing. This type of mat material is disposed mainly, for example, for preventing the exhaust gas treatment unit from being damaged by contact with the casing that covers the periphery of the exhaust gas treatment unit due to vibrations and impacts caused by operation of automobiles or the like, and for preventing exhaust gas leakage from a space between the exhaust gas treatment unit and the casing.

20 **[0004]** The mat material contains inorganic fibers. The basic shape of the mat material in a plan view is a rectangular shape including long sides extending in the longitudinal direction and short sides substantially perpendicular to the long sides. A recess is formed on one short side of the rectangular shape, and a protrusion having a shape similar to a cut out shape of the recess is formed on the other short side. The mat material is wound around an exhaust gas treatment unit, and the protrusion is fitted with the recess so as to prevent leakage of exhaust gas from the mat material.

25 **[0005]** The exhaust gas treatment unit having the mat material wound therearound is press-fitted into a casing and installed in an exhaust gas conversion apparatus.

30 **[0006]** For example, according to the disclosure of Patent literature 1, a first surface uses a sheet material (mat material) having concave parts and convex parts with an average difference h between the concave parts and the convex parts of $0.4 \text{ mm} \leq h \leq 9 \text{ mm}$ in order to decrease the contact area between the sheet material and another member, which makes it possible to easily place the sheet material at a predetermined position without using a surface lubricant.

CITATION LIST

35 - Patent Literature

[0007] Patent Literature 1: JP 2011-241837 A

40 SUMMARY OF INVENTION

 - Technical Problem

45 **[0008]** Patent literature 1 is silent about detailed dimensions of the recess and the protrusion. When a mat material is produced and press-fitted into a casing, a portion of the mat material on the most upstream side of the fitting portion may be deformed, and when an exhaust gas treatment unit is fixed at a predetermined position, a portion of the mat material may stick out from the casing in some cases.

50 **[0009]** The present invention was made to solve the above problems and aims to provide a mat material that does not easily stick out from a casing during press-fitting.

 - Solution to Problem

55 **[0010]** Specifically, the present invention provides a mat material having a generally rectangular shape in a plan view, the mat material including inorganic fibers, wherein the mat material includes a first main surface and a second main surface opposite to each other in a thickness direction, a first end surface and a second end surface opposite to each other in a longitudinal direction that is a winding direction, and a first side surface and a second side surface opposite to each other in a width direction perpendicular to the thickness direction and the longitudinal direction, the mat material includes, on the first end surface, a protrusion designed to protrude toward the second end surface during winding of the mat

material, and non-protruding portions provided at both sides of the protrusion in the width direction and designed not to protrude toward the second end surface during winding of the mat material, the mat material includes, on the second end surface, a recess designed to fit the shape of the protrusion on the first end surface during winding of the mat material, and non-recessed portions provided at both sides of the recess in the width direction and designed to fit the shapes of the non-protruding portions on the first end surface during winding of the mat material, and a ratio $[D/C]$ of a length $[D]$ of the non-recessed portion in the width direction to a length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more.

[0011] When a mat material having a protrusion and its corresponding recess as the one shown in Patent literature 1 is wound around an exhaust gas treatment unit, a portion of a first end surface and portions of a second end surface are arranged in a staggered manner at the fitting portion where the end surfaces of the mat material fit each other.

[0012] The portion of the first end surface is the protrusion on the first end surface, and the portions of the second end surface are the non-recessed portions on the second end surface. There are two non-recessed portions on the second end surface, with one adjacent to the first side surface and the other one adjacent to the second side surface. During winding of the mat material, the shape of the protrusion on the first end surface fits the shape of the recess on the second end surface, and the shapes of the non-protruding portions on the first end surface fit the shapes of the non-recessed portions on the second end surface.

[0013] During press-fitting into the casing, the mat material is easily deformed as it is pulled toward the upstream side in the press-fitting direction due to the shear stress generated between the exhaust gas treatment unit and the casing. This deformation easily occurs particularly at the non-recessed portion with no structure that prevents deformation at further upstream, i.e., the non-recessed portion on the most upstream side.

[0014] Presumably, in the non-recessed portions, portions closer to the main body of the mat material (i.e., portions excluding the protrusion and the non-recessed portions) are less easily deformed by the shear force, and portions further away from the main body of the mat material are more easily deformed by the shear force. In other words, the shorter the lengths of the non-recessed portions, the less easily the non-recessed portions are deformed.

[0015] Meanwhile, the larger the width of each non-recessed portion (the distance corresponding to the length from the first or second side surface to the recess), the longer the region where the non-recessed portions are fixed to the main body of the mat material, so that the non-recessed portions are not easily deformed by shear force.

[0016] In other words, presumably, the non-recessed portions can be made less susceptible to deformation by adjusting the length and the width of each non-recessed portion.

[0017] The above effect can be achieved even when there are multiple protrusions on the first end surface and multiple recesses on the second end surface.

[0018] In the mat material of the present invention, the ratio $[D/C]$ of the length $[D]$ of the non-recessed portion in the width direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more.

[0019] The structure described above is one in which the length $[C]$ of the non-recessed portion in the longitudinal direction is relatively short, and the length $[D]$ of the non-recessed portion in the width direction is relatively long, compared to the structure disclosed in Patent literature 1.

[0020] Thus, when the shape of the mat material satisfies the above conditions, the non-recessed portions are not easily deformed by the shear force during press-fitting, and the mat material does not easily stick out from the casing.

[0021] Preferably, the mat material of the present invention is a needle-punched mat.

[0022] Preferably, the mat material of the present invention is a mat material including multiple entanglement points formed by needling, wherein at least one of a $4\text{ mm} \times 4\text{ mm}$ first region without the entanglement points or a $3\text{ mm} \times 8\text{ mm}$ second region without the entanglement points is arranged in a $25\text{ mm} \times 25\text{ mm}$ region.

[0023] When the first region and/or the second region is arranged in the $25\text{ mm} \times 25\text{ mm}$ region, the surface pressure of the mat material can be increased.

[0024] In the mat material of the present invention, preferably, the inorganic fibers have an average fiber length of 1 to 150 mm.

[0025] Preferably, the mat material of the present invention is a papermaking mat.

[0026] In the mat material of the present invention, preferably, the inorganic fibers have an average fiber length of 200 to $20000\text{ }\mu\text{m}$.

[0027] In the mat material of the present invention, preferably, an inorganic binder is attached to a surface of each inorganic fiber.

[0028] When an inorganic binder is attached to the surface of each inorganic fiber, the inorganic binder attached to the surface of each inorganic fiber increases the frictional resistance between the inorganic fibers, so that the holding power can be increased.

[0029] In the mat material of the present invention, preferably an organic binder is attached to the surface of each inorganic fiber.

[0030] When an organic binder is attached to the surface of each inorganic fiber, the adhesion between the inorganic fibers can be increased to prevent inorganic fiber scattering during handling of the mat material.

[0031] In the mat material of the present invention, preferably, an inorganic binder and an organic binder are attached to

the surface of each inorganic fiber.

[0032] An inorganic binder, when attached to the surface of each inorganic fiber, increases the frictional resistance between the inorganic fibers and thus can increase the holding power.

[0033] An organic binder, when attached to the surface of each inorganic fiber, can improve the adhesion between the inorganic fibers and prevent inorganic fiber scattering during handling of the mat material.

[0034] Preferably, the mat material of the present invention further contains a polymeric dispersant.

[0035] When the mat material further contains a polymeric dispersant, the organic binder and the inorganic binder can be easily attached in a dispersed state to the surface of each inorganic fiber.

[0036] Preferably, in the mat material of the present invention, the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber.

[0037] When the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber, the inorganic binder is in a dispersed state in a coating formed from the organic binder. The coating in such a state has excellent mechanical strength and thus can prevent the inorganic fibers from slipping on each other and increase the holding power.

[0038] In the mat material of the present invention, preferably, aggregates of the inorganic binder and the organic binder are attached to the surface of each inorganic fiber.

[0039] Aggregates of the inorganic binder and the organic binder, when attached to the surface of each inorganic fiber, can increase the friction between the inorganic fibers and improve the holding power.

[0040] In the mat material of the present invention, preferably, the surface of each inorganic fiber is at least partially covered with a coating layer containing a mixture of the inorganic binder and the organic binder.

[0041] The coating layer containing a mixture of the inorganic binder and the organic binder has a higher mechanical strength than a coating layer containing only the organic binder. Thus, the coating layer does not easily peel off, making it possible to increase the frictional resistance between the inorganic fibers.

[0042] In the mat material of the present invention, preferably, the coating layer is formed from a continuous flaky mixture of the inorganic binder and the organic binder.

[0043] When the coating layer is formed from the flaky mixture, the surface roughness of the coating layer increases due to the flaky mixture, which can further increase the frictional resistance between the inorganic fibers.

[0044] In the mat material of the present invention, preferably, the coating layer has a stepped shape.

[0045] When the coating layer has a stepped shape, the frictional resistance between the inorganic fibers can be further increased.

[0046] In the mat material of the present invention, preferably, a particulate mixture of the inorganic binder and the organic binder is attached to a surface of the coating layer.

[0047] When the particulate mixture of the inorganic binder and the organic binder is attached to the surface of the coating layer, the frictional resistance between the inorganic fibers can be further increased than when no such particulate mixture is attached to the coating layer.

[0048] In the mat material of the present invention, preferably, a ratio $[A/C]$ of a length $[A]$ of the mat material in the longitudinal direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is 10 or more.

[0049] When the ratio $[A/C]$ of the length $[A]$ of the mat material in the longitudinal direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is in the above range, the non-recessed portions each have a shape that is not easily deformed during press-fitting.

[0050] An exhaust gas conversion apparatus of the present invention is an exhaust gas conversion apparatus including: a casing; an exhaust gas treatment unit; and a mat material between the casing and the exhaust gas treatment unit, wherein the mat material is the mat material of the present invention.

[0051] Since the exhaust gas conversion apparatus of the present invention includes the mat material of the present invention, the mat material is prevented from sticking out during press-fitting, and the exhaust gas treatment unit has excellent stability.

[0052] The method for producing an exhaust gas conversion apparatus of the present invention includes a press-fitting step of press-fitting an exhaust gas treatment unit having the mat material of the present invention wound therearound into a casing by hard stuffing, pre-calibration, or post-calibration.

[0053] The hard stuffing, pre-calibration, and post-calibration each require a step of press-fitting an exhaust gas treatment unit having the mat material wound therearound into a casing. Thus, the mat material of the present invention is particularly suitable for any of the above methods since displacement and deformation of the mat material during press-fitting can be prevented or reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0054]

FIG. 1 is a schematic perspective view of an example of a mat material of the present invention.

FIG. 2 is a schematic perspective view of an example of a step of winding the mat material shown in FIG. 1 around an exhaust gas treatment unit.

FIG. 3 is a schematic perspective view of an example of a wound body prepared in the step shown in FIG. 2.

FIG. 4 is a schematic view of an example of a press-fitting step of press-fitting the wound body shown in FIG. 3 into a casing.

FIG. 5 is a schematic view of an example of arrangement of entanglement points in the mat material of the present invention.

FIG. 6 is a schematic view of an example of the mat material in which the entanglement points are evenly arranged.

FIG. 7 is an example of an enlarged electron microscope image of the mat material of the present invention.

FIG. 8 is another example of an enlarged electron microscope image of the mat material of the present invention.

FIG. 9 is still another example of an enlarged electron microscope image of the mat material of the present invention.

FIG. 10 is still another example of an enlarged electron microscope image of the mat material of the present invention.

FIG. 11 is a conceptual schematic view of a shear failure load test device.

FIG. 12 is a schematic cross-sectional view of an example of the exhaust gas conversion apparatus of the present invention.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the present invention are specifically described. The present invention is not limited to the embodiments described below, and suitable modifications may be made without departing from the scope of the present invention.

[Mat material]

The present invention provides a mat material having a generally rectangular shape in a plan view, the mat material including inorganic fibers, wherein the mat material includes a first main surface and a second main surface opposite to each other in a thickness direction, a first end surface and a second end surface opposite to each other in a longitudinal direction that is a winding direction, and a first side surface and a second side surface opposite to each other in a width direction perpendicular to the thickness direction and the longitudinal direction, the mat material includes, on the first end surface, a protrusion designed to protrude toward the second end surface during winding of the mat material, and non-protruding portions provided at both sides of the protrusion in the width direction and designed not to protrude toward the second end surface during winding of the mat material, the mat material includes, on the second end surface, a recess designed to fit the shape of the protrusion on the first end surface during winding of the mat material, and non-recessed portions provided at both sides of the recess in the width direction and designed to fit the shapes of the non-protruding portions on the first end surface during winding of the mat material, and a ratio $[D/C]$ of a length $[D]$ of the non-recessed portion in the width direction to a length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more.

[0057] FIG. 1 is a schematic perspective view of an example of a mat material of the present invention.

[0058] As shown in FIG. 1, a mat material 10 has a flat plate-like shape that is generally rectangular in a plan view and includes: a first main surface 11 and a second main surface 12 opposite to each other in a thickness direction (the direction indicated by the double-headed arrow T in FIG. 1); a first end surface 13 and a second end surface 14 opposite to each other in a longitudinal direction that is a winding direction (the direction indicated by the double-headed arrow A in FIG. 1); and a first side surface 15 and a second side surface 16 opposite to each other in a width direction (the direction indicated by the double-headed arrow B in FIG. 1) perpendicular to the thickness direction and the longitudinal direction.

[0059] The length of the mat material 10 is indicated by the double-headed arrow A in FIG. 1.

[0060] The width of the mat material 10 is indicated by the double-headed arrow B in FIG. 1.

[0061] The thickness of the mat material 10 is indicated by the double-headed arrow T in FIG. 1.

[0062] The mat material includes, on the first end surface 13, a protrusion 13a designed to protrude toward the second end surface 14 during winding of the mat material, and non-protruding portions 13b and 13c provided at both sides of the protrusion 13a in the width direction and designed not to protrude toward the second end surface 14 during winding of the mat material.

[0063] The mat material includes, on the second end surface 14, a recess 14a designed to fit the shape of the protrusion 13a on the first end surface 13 during winding of the mat material, and non-recessed portions 14b and 14c provided at both sides of the recess 14a in the width direction and designed to fit the shapes of the non-protruding portions 13b and 13c on the first end surface 13 during winding of the mat material.

[0064] The length of the protrusion 13a in the longitudinal direction (hereinafter also simply referred to as "the length of the protrusion 13a") is indicated by the double-headed arrow C.

[0065] The shape of the protrusion 13a fits the shape of the recess 14a. Thus, the length of the recess 14a in the

longitudinal direction (hereinafter also simply referred to as "the length of the recess 14a") is the length indicated by the double-headed arrow C.

[0066] The length of the recess 14a in the width direction (hereinafter also simply referred to as "the width of the recess 14a") is the length indicated by the double-headed arrow E.

[0067] The shape of the recess 14a fits the shape of the protrusion 13a. Thus, the length of the protrusion 13a in the width direction (hereinafter also simply referred to as "the width of the protrusion 13a") is the length indicated by the double-headed arrow E.

[0068] Further, the center of the protrusion 13a in the width direction coincides with the center of the recess 14a in the width direction.

[0069] The length of the non-recessed portions 14b and 14c in the longitudinal direction (hereinafter also simply referred to as "the length of the non-recessed portions 14b and 14c") is the length indicated by the double-headed arrow C, which is the same as the length of the recess 14a in the longitudinal direction.

[0070] The length of each of the non-recessed portions 14b and 14c in the width direction (hereinafter also simply referred to as "the width of each of the non-recessed portions 14b and 14c") is indicated by the double-headed arrow D.

[0071] The length of each of the non-protruding portions 13b and 13c in the width direction (hereinafter also simply referred to as "the width of each of the non-protruding portions 13b and 13c") is the length indicated by the double-headed arrow D, which is the same as the length of each of the non-recessed portions 14b and 14c in the width direction.

[0072] In the mat material 10, portions excluding the protrusion 13a and the non-recessed portions 14b and 14c are also referred to as the main body of the mat material.

[0073] The length [A] of the mat material in the longitudinal direction corresponds to the length from the first end surface to the second end surface on each cut surface obtained by cutting the mat material along planes parallel to the longitudinal direction and the thickness direction.

[0074] In the mat material 10 shown in FIG. 1, when the length of each of the non-recessed portions 14b and 14c in the width direction is indicated by [D] and the length of the non-recessed portions 14b and 14c in the longitudinal direction is indicated by [C], the ratio [D/C] of the length [D] of the non-recessed portion 14b or 14c in the width direction to the length [C] of the non-recessed portion 14b or 14c in the longitudinal direction is 1.0 or more.

[0075] The ratio [D/C] in the mat material 10 shown in FIG. 1 is 2.1.

[0076] As described above, the length of the recess 14a in the longitudinal direction is equal to the length of the non-recessed portions 14b and 14c in the longitudinal direction.

[0077] The length of the recess 14a in the longitudinal direction is equal to the length of the protrusion 13a in the longitudinal direction. Further, the length of each of the non-recessed portions 14b and 14c in the width direction is equal to the length of each of the non-protruding portions 13b and 13c in the width direction.

[0078] Based on the above, the feature of the mat material according to the present invention, "the ratio [D/C] of the length [D] of the non-recessed portion in the width direction to the length [C] of the non-recessed portion in the longitudinal direction is 1.0 or more", can be rephrased as that "the ratio [D/C] of the length [D] of the non-protruding portion in the width direction to the length [C] of the protrusion in the longitudinal direction is 1.0 or more".

[0079] In the mat material according to the present invention, the ratio [D/C] of the length [D] of the non-recessed portion in the width direction to the length [C] of the non-recessed portion in the longitudinal direction is preferably 1.2 or more, more preferably 1.6 or more.

[0080] In the mat material according to the present invention, a center $[E_C]$ of the recess in the width direction may or may not coincide with a center $[B_C]$ of the mat material in the width direction.

[0081] In the mat material 10 shown in FIG. 1, the center $[E_C]$ of the recess 14a in the width direction coincides with the center $[B_C]$ of the mat material 10 in the width direction.

[0082] Thus, the width of the non-recessed portion 14c is the length indicated by the double-headed arrow D, which is the same as the width of the non-recessed portion 14b. The width of the non-protruding portion 13c is the length indicated by the double-headed arrow D, which is the same as the width of the non-protruding portion 13b.

[0083] When the center $[E_C]$ of the recess in the width direction does not coincide with the center $[B_C]$ of the mat material in the width direction, the two non-recessed portions have different widths. The width of one non-recessed portion is smaller than the width of the other non-recessed portion.

[0084] In this case, the length of a non-recessed portion having a smaller width is used as [D] for the calculation of the ratio [D/C] of the length [D] of the non-recessed portion in the width direction to the length [C] of the non-recessed portion in the longitudinal direction.

[0085] FIG. 2 is a schematic perspective view of an example of a step of winding the mat material shown in FIG. 1 around an exhaust gas treatment unit. FIG. 3 is a schematic perspective view of an example of a wound body prepared in the step shown in FIG. 2.

[0086] As shown in FIG. 2, the mat material 10 is wound around an exhaust gas treatment unit 230, whereby a wound body 250 shown in FIG. 3 is obtained.

[0087] In FIG. 2, the mat material 10 is wound around the exhaust gas treatment unit 230 such that the first main surface

11 of the mat material 10 is in contact with the exhaust gas treatment unit 230, but the mat material 10 may be wound such that its second main surface 12 is in contact with the exhaust gas treatment unit 230.

[0088] FIG. 4 is a schematic view of an example of a press-fitting step of press-fitting the wound body shown in FIG. 3 into a casing.

[0089] FIG. 4 shows press-fitting of the wound body 250 shown in FIG. 3 into a casing 220.

[0090] The press-fitting direction of the wound body 250 is a direction from the top to the bottom of the paper.

[0091] Thus, the mat material 10 is arranged such that one (the second side surface 16) of its two side surfaces is at the downstream side in the press-fitting direction, and the other side surface (the first side surface 15) is at the upstream side in the press-fitting direction.

[0092] When press-fitting the wound body 250 into the casing 220, a large shear force is applied to the mat material 10 due to the friction between the mat material 10 and the casing 220 and the friction between the mat material 10 and the exhaust gas treatment unit 230.

[0093] Specifically, a force is applied such that the surface of the mat material 10 constituting the wound body 250 is pulled toward the upstream side in the press-fitting direction.

[0094] The degree of deformation of the protrusion and the non-recessed portions by the shear force depends on the order of arrangement in the press-fitting direction and the contact area (distance) between these portions and the main body of the mat material.

[0095] In other words, deformation is greater on the upstream side in the press-fitting direction, and deformation is greater when the contact area (distance) between these portions and the main body of the mat material is smaller.

[0096] In the wound body 250 shown in FIG. 4, in the mat material 10, the non-recessed portion 14b is at the most upstream side in the press-fitting direction and is susceptible to deformation by the shear force.

[0097] Yet, in the case of the mat material according to the present invention, the ratio $[D/C]$ of the length $[D]$ of the non-recessed portion in the width direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more, so that deformation of the non-recessed portion at the upstream side in the press-fitting direction can be prevented or reduced.

[0098] In the mat material according to the present invention, the arrangement of the two side surfaces of the mat material in the press-fitting step is not limited. Thus, the mat material may be arranged such that the second side surface is at the downstream side in the press-fitting direction and the first side surface is at the upstream side in the press-fitting direction as shown in FIG. 4; or the mat material may be arranged such that the first side surface is at the downstream side in the press-fitting direction and the second side surface is at the upstream side in the press-fitting direction.

[0099] Yet, when the center of the recess in the width direction does not coincide with the center of the mat material in the width direction, preferably, the mat material is arranged such that its side surface with a non-recessed portion having a smaller width is at the downstream side in the press-fitting direction and its side surface with a non-recessed portion having a longer width is at the upstream side in the press-fitting direction. Since the mat material is oriented as described above, deformation of the non-recessed portion at the upstream side in the press-fitting direction can be prevented or reduced.

[0100] For example, in the case where the center of the recess in the width direction does not coincide with the center of the mat material in the width direction, the mat material will include two non-recessed portions having different lengths.

[0101] In such a case, a mat material that satisfies $D_1 > D_2$, where D_1 indicates the width of one of the non-recessed portions and D_2 indicates the width of the other non-recessed portion, is also the mat material of the present invention, as long as a ratio $[D_2/C]$ of the length $[D_2]$ of a smaller-width non-recessed portion, i.e., a non-recessed portion having the width D_2 , in the width direction, to the length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more. This is because since $D_1 > D_2$, when $[D_2/C]$ is 1.0 or more, $[D_1/C]$ will inevitably be 1.0 or more.

[0102] When the mat material is arranged such that its side surface with a non-recessed portion having the width D_2 is at the upstream side in the press-fitting direction, $[D_2/C]$ satisfies the conditions of being 1.0 or more. Thus, deformation of the non-recessed portion is prevented or reduced.

[0103] When the mat material is arranged such that its side surface with a non-recessed portion having the width D_1 is at the upstream side in the press-fitting direction, the $[D_1/C]$ is 1.0 or more and is greater than $[D_2/C]$, so that deformation of the non-recessed portion is further prevented or reduced than when the mat material is arranged such that its side surface with a non-recessed portion having the width D_2 is at the upstream side in the press-fitting direction.

[0104] In the mat material of the present invention, the ratio $[A/C]$ of the length $[A]$ of the mat material in the longitudinal direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is not limited, but it is preferably 10 or more.

[0105] When the ratio $[A/C]$ of the length $[A]$ of the mat material in the longitudinal direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is 10 or more, the non-recessed portions each have a shape that is not easily deformed during press-fitting. The ratio $[A/C]$ in the mat material 10 shown in FIG. 1 is 10.1.

[0106] As described above, the length $[C]$ of the non-recessed portion in the longitudinal direction is equal to the length $[C]$ of the recess and the length $[C]$ of the protrusion in the longitudinal direction.

[0107] Thus, the feature of the mat material of the present invention, "the ratio $[A/C]$ of the length $[A]$ of the mat material in

the longitudinal direction to the length [C] of the non-recessed portion in the longitudinal direction is 10 or more", can be rephrased as that "the ratio [A/C] of the length [A] of the mat material in the longitudinal direction to the length [C] of the protrusion in the longitudinal direction is 10 or more" or that "the ratio [A/C] of the length [A] of the mat material in the longitudinal direction to the length [C] of the recess in the longitudinal direction is 10 or more".

[0108] In the mat material 10 shown in FIG. 1 to FIG. 4, one protrusion 13a is formed on the first end surface 13, and one recess 14a is formed on the second end surface 14.

Yet, in the mat material of the present invention, the mat material may include two or more protrusions on the first end surface and two or more recesses on the second end surface of the mat material.

[0109] In such a case, the focus is given on the non-recessed portion closest to the first side surface of the mat material and the non-recessed portion closest to the second side surface of the mat material, and the calculation is carried out for each of these non-recessed portions to determine the ratio [D/C] of the length [D] of the non-recessed portion in the width direction to the length [C] of the non-recessed portion in the longitudinal direction.

[0110] When the ratio [D/C] of the non-recessed portion closest to the first side surface of the mat material and the ratio [D/C] of the non-recessed portion closest to the second side surface of the mat material are both 1.0 or more, the mat material corresponds to the mat material of the present invention.

[0111] In the mat material according to the present invention, the thickness of the mat material is not limited but is preferably 2 to 40 mm. At a mat thickness of more than 40 mm, the mat loses its flexibility, which makes handling difficult when the mat material is wound around an exhaust gas treatment unit, and which also makes the mat material prone to winding wrinkles and cracking.

[0112] At a mat thickness of less than 2 mm, the exhaust gas treatment unit easily falls out due to insufficient holding power of the mat material. In addition, when changes occur in the volume of the exhaust gas treatment unit, the mat material is less likely to absorb such changes in the volume of the exhaust gas treatment unit. Thus, the exhaust gas treatment unit becomes prone to cracking and the like.

[0113] The mat includes inorganic fibers.

[0114] Any inorganic fibers may be used, but the inorganic fibers preferably include at least one selected from the group consisting of alumina fibers, silica fibers, alumina silica fibers, mullite fibers, biosoluble fibers, and glass fibers.

[0115] The inorganic fibers including at least one selected from alumina fibers, silica fibers, alumina silica fibers, and mullite fibers have excellent heat resistance. Thus, even when the exhaust gas treatment unit is exposed to sufficiently high temperatures, the properties or the like will not change, and the mat material can sufficiently maintain its function. In the case where the inorganic fibers are biosoluble fibers, for example, even when workers inhale the inorganic fibers that are scattered during production of the exhaust gas conversion apparatus using the mat material, the inorganic fibers will dissolve *in vivo* and thus cause no harm to the health of the workers.

[0116] The alumina fibers may contain, in addition to alumina, additives such as calcia, magnesia, and zirconia.

[0117] The compositional ratio 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 $74:26$.

[0118] The mat can be produced by needling or papermaking. The inorganic fiber mass produced by needling is also referred to as "needle-punched mat", and the mat produced by papermaking is also referred to as "papermaking mat".

[0119] In the case of needling, the average fiber length of the inorganic fibers is preferably 1 to 150 mm, more preferably 10 to 80 mm.

[0120] Inorganic fibers having an average fiber length of less than 1 mm are too short, so that such inorganic fibers are insufficiently entangled with each other and result in poor winding properties of the mat material when the mat material is wound around the exhaust gas treatment unit, making the mat material easily breakable. Inorganic fibers having an average fiber length of more than 150 mm are too long, so that there are fewer fibers constituting the mat material, reducing the denseness of the mat material. As a result, the mat material has a low shear strength.

[0121] In the case of papermaking, the average fiber length of the inorganic fibers is preferably 200 to 20000 μm , more preferably 300 to 10000 μm , still more preferably 500 to 1500 μm .

[0122] In the case of needling, entanglement points are formed on the front surface or back surface of the mat material.

[0123] Preferably, the density ρ of the entanglement points is in the range of $0.5 \text{ pcs/cm}^2 \leq \rho < 18 \text{ pcs/cm}^2$.

[0124] When the entanglement points are formed on both the front surface and back surface of the mat material, the density ρ of the entanglement points is a density of the entanglement points measured on a main surface, either the front surface or back surface, with a higher density of the entanglement points.

[0125] In the case of needling, preferably, at least one of a 4 mm $\times$ 4 mm first region without the entanglement points or a 3 mm $\times$ 8 mm second region without the entanglement points is arranged in a 25 mm $\times$ 25 mm region of the front surface or back surface of the mat material.

[0126] A high surface pressure is exhibited owing to the arrangement of at least one of the first region or the second region.

[0127] The main surface of the mat material to be checked to determine whether the first region and/or the second region is arranged thereon is the main surface on which the density of the entanglement points is measured.

[0128] FIG. 5 is a schematic view of an example of arrangement of the entanglement points in the mat material of the present invention.

[0129] The mat material 10 shown in FIG. 5 has plan dimensions of 25 mm $\times$ 25 mm.

[0130] In FIG. 5, multiple entanglement points 115 are unevenly arranged. This arrangement is considered as including first regions 117 that are 4 mm $\times$ 4 mm regions without the entanglement points 115 (regions indicated by squares in solid lines in FIG. 5) and second regions 118 that are 3 mm $\times$ 8 mm regions without the entanglement points 115 (regions indicated by rectangles in dashed lines in FIG. 5).

[0131] FIG. 5 does not show all the first regions 117 or all the second regions 118.

[0132] FIG. 6 is a schematic view of an example of the mat material in which the entanglement points are evenly arranged.

[0133] The mat material 10 shown in FIG. 6 has plan dimensions of 25 mm $\times$ 25 mm.

[0134] In FIG. 6, the entanglement points 115 are evenly arranged at intervals of 2.8 mm.

[0135] Each of the 4 mm $\times$ 4 mm squares and the 3 mm $\times$ 8 mm rectangles shown in FIG. 6 includes one or more entanglement points. A symbol "x" is added to each of the 4 mm $\times$ 4 mm squares not corresponding to the first regions and the 3 mm $\times$ 8 mm rectangles not corresponding to the second regions.

[0136] Accordingly, neither the first regions nor the second regions can be arranged in the mat material shown in FIG. 6.

[0137] The number of the first regions and the second regions in the 25 mm $\times$ 25 mm region can be counted by the following method.

(1) A 4 mm $\times$ 4 mm region (first region) in which no entanglement points are formed is located. At this point, multiple first regions that do not overlap each other are selected.

(2) A 3 mm $\times$ 8 mm region (second region) in which no entanglement points are formed is located. At this point, multiple second regions that do not overlap each other are selected. The second region and the first region may overlap each other. When the first region and the second region overlap each other, the area without the entanglement points increases, which can increase the surface pressure of the mat material.

(3) A 25 mm $\times$ 25 mm region in which the total number of non-overlapping first regions and non-overlapping second regions is the maximum is selected.

[0138] The above operation is performed for 10 samples, and the average is calculated.

[0139] The above operation may be performed using commercially available image processing software or the like.

[0140] Preferably, multiple first regions and/or multiple second regions are arranged in the 25 mm $\times$ 25 mm region.

[0141] When multiple first regions and/or multiple second regions are arranged in the 25 mm $\times$ 25 mm region, the surface pressure of the mat material can be increased.

[0142] That "multiple first regions and/or multiple second regions are arranged" refers to a case where the total number of the first regions and the second regions is two or more, which includes, for example, a case where multiple first regions are arranged, a case where multiple second regions are arranged, and a case where multiple first regions and multiple second regions are arranged.

[0143] Preferably, a third region, which is a 4 mm $\times$ 4 mm region including four or more entanglement points, is arranged in the 25 mm $\times$ 25 mm region on the front surface or back surface of the mat material.

[0144] The arrangement of the third region can increase the shear strength of the mat material because the inorganic fibers in the third region are strongly entangled with each other.

[0145] The method for counting the number of the third regions in the 25 mm $\times$ 25 mm region is the same as the method for counting the number of the first regions described above.

[0146] Preferably, an inorganic binder (also referred to as "inorganic binding agent") is attached to the surface of each inorganic fiber.

[0147] An inorganic binder, when attached to the surface of each inorganic fiber, increases the frictional resistance between the inorganic fibers and thus can increase the holding power.

[0148] Examples of the inorganic binder include alumina sol and silica sol.

[0149] Preferably, an organic binder (also referred to as "organic binding agent") is attached to the surface of each inorganic fiber.

[0150] When an organic binder is attached to the surface of each inorganic fiber, the adhesion between the inorganic fibers can be increased to prevent inorganic fiber scattering during handling of the mat material.

[0151] Examples of the organic binder include water-soluble organic polymers such as acrylic resin, acrylate latex, rubber latex, carboxymethylcellulose, and polyvinyl alcohol; thermoplastic resins such as styrene resin; and thermosetting resins such as epoxy resin.

[0152] Preferably, an inorganic binder and an organic binder are attached to the surface of each inorganic fiber.

[0153] An inorganic binder, when attached to the surface of each inorganic fiber, increases the frictional resistance between the inorganic fibers and thus can increase the holding power.

[0154] When an organic binder is attached to the surface of each inorganic fiber, the adhesion between the inorganic fibers can be increased to prevent inorganic fiber scattering during handling of the mat material.

[0155] Preferably, the weight ratio of the inorganic binder to the mat material (weight of inorganic binder/weight of mat material) is more than 0 wt% and 10 wt% or less.

[0156] When the weight ratio of the inorganic binder to the mat material is in the above range, the holding power can be sufficiently increased.

[0157] Preferably, the weight ratio of the organic binder to the mat material (weight of organic binder/weight of mat material) is more than 0 wt% and 10 wt% or less.

[0158] At a weight ratio of the organic binder to the mat material in the above range, the effect of preventing fiber scattering and the high holding power can be both achieved.

[0159] The amounts of the organic binder and the inorganic binder in the mat material can be measured by the following method, for example.

[0160] First, a certain weight of a sample is taken out from a mat material in which the amounts of the organic binder and the inorganic binder therein are intended to be measured. Subsequently, an organic solvent (e.g., tetrahydrofuran) that dissolves the organic binder in the sample is selected, and the organic binder is dissolved in a Soxhlet extractor to separate the organic binder from the sample. At this point, the inorganic binder in the dissolved organic binder is also separated from the sample, so that the organic binder and the inorganic binder are both extracted in the organic solvent.

[0161] Next, the organic solvent containing the organic binder and the inorganic binder is placed in a crucible, and the organic solvent is removed by evaporation with heat. The amount (wt%) of the residue remaining in the crucible relative to the weight of the mat material is calculated, assuming that the weight of the residue is the total weight of the organic binder and the inorganic binder relative to the mat material.

[0162] Further, the crucible is heated at 600°C for one hour to burn out the organic binder. Since the inorganic binder remains in the crucible, the amount of the inorganic binder is calculated, assuming that the amount of the residue is the amount (wt%) of the inorganic binder relative to the total of the organic binder and the inorganic binder. The balance is the amount (wt%) of the organic binder.

[0163] In the mat material, preferably, the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber.

[0164] When the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber, the inorganic binder is in a dispersed state in a coating formed from the organic binder. The coating in such a state has excellent mechanical strength and thus can prevent the inorganic fibers from slipping on each other and increase the holding power.

[0165] In the mat material, preferably, the surface of each inorganic fiber is at least partially covered with a coating layer containing a mixture of the inorganic binder and the organic binder.

[0166] The coating layer containing a mixture of the inorganic binder and the organic binder has a higher mechanical strength than a coating layer containing only the organic binder. Thus, the coating layer does not easily peel off, making it possible to increase the frictional resistance between the inorganic fibers.

[0167] Preferably, the coating layer is formed from a continuous flaky mixture (mixture of the inorganic binder and the organic binder).

[0168] When the coating layer is formed from the flaky mixture, many irregularities derived from the flaky mixture are formed on a surface of the coating layer, which can further increase the frictional resistance between the inorganic fibers.

[0169] FIG. 7 is an example of an enlarged electron microscope image of the mat material of the present invention.

[0170] As shown in FIG. 7, the surface of an inorganic fiber 120 is partially covered with a coating layer 130 containing a mixture of the inorganic binder and the organic binder. The coating layer 130 is formed from a continuous flaky mixture of the inorganic binder and the organic binder. A particulate mixture 140 of the inorganic binder and the organic binder is attached to the surface of the inorganic fiber 120.

[0171] Whether the coating layer and the particles contain a mixture of the inorganic binder and the organic binder can be confirmed by a combination of field observation under an electronic microscope and elemental analysis.

[0172] FIG. 8 is another example of an enlarged electron microscope image of the mat material of the present invention.

[0173] As shown in FIG. 8, the surface of the inorganic fiber 120 is partially covered with the coating layer 130 containing a mixture of the inorganic binder and the organic binder. The coating layer 130 is formed from a continuous flaky mixture of the inorganic binder and the organic binder. The particulate mixture 140 of the inorganic binder and the organic binder is attached to the surface of the inorganic fiber 120.

[0174] The coating layer may or may not have a uniform thickness.

[0175] The shape of the coating layer having a non-uniform thickness is also referred to as "stepped shape".

[0176] That the coating layer has a stepped shape means that there are irregularities on the surface of the coating layer, so that the frictional resistance between the inorganic fibers can be further increased.

[0177] Whether the coating layer has irregularities on the surface, i.e., whether the coating layer has a stepped shape, can be determined by enlarging the surface of each inorganic fiber to a magnification of 3000 times using a scanning

electronic microscope and checking for the presence or absence of irregularities on the surface of the coating layer.

[0178] FIG. 9 is still another example of an enlarged electron microscope image of the mat material of the present invention.

[0179] As shown in FIG. 9, the surface of the inorganic fiber 120 is partially covered with the coating layer 130 containing a mixture of the inorganic binder and the organic binder. The coating layer 130 has a stepped shape with a non-uniform thickness.

[0180] The particulate mixture 140 of the inorganic binder and the organic binder is attached to the surface of the inorganic fiber 120.

[0181] Preferably, particles containing a mixture of the inorganic binder and the organic binder are attached to the surface of the coating layer.

[0182] When the particles containing a mixture of the inorganic binder and the organic binder are attached to the surface of the coating layer, the frictional resistance between the inorganic fibers can be further increased than when no such particles are attached to the coating layer.

[0183] FIG. 10 is still another example of an enlarged electron microscope image of the mat material of the present invention.

[0184] As shown in FIG. 10, the surface of the inorganic fiber 120 is partially covered with the coating layer 130 containing a mixture of the inorganic binder and the organic binder. The coating layer 130 is formed from a continuous flaky mixture of the inorganic binder and the organic binder. The coating layer 130 has a stepped shape with a non-uniform thickness. The particulate mixture 140 of the inorganic binder and the organic binder is attached to the surface of the coating layer 130.

[0185] Preferably, mat material further contains a polymeric dispersant.

[0186] When the mat material further contains a polymeric dispersant, the organic binder and the inorganic binder can be easily attached in a dispersed state to the surface of each inorganic fiber.

[0187] The amount of the polymeric dispersant is preferably 50 to 1000 ppm relative to the weight of the inorganic fibers.

[0188] In the mat material, preferably, aggregates of the inorganic binder and the organic binder are attached to the surface of each inorganic fiber.

[0189] The aggregates of the inorganic binder and the organic binder can form irregularities on the surface of each inorganic fiber, which can increase the friction between the inorganic fibers and improve the holding power.

[0190] The mat material may further contain a flocculant.

[0191] When the mat material further contains a flocculant, the organic binder and the inorganic binder can be easily attached in an aggregated state to the surface of each inorganic fiber.

[0192] Whether the inorganic binder and the organic binder attached to the surface of each inorganic fiber are either dispersed or aggregated can be checked by observing the surface of each inorganic fiber by SEM-EDX or the like.

[0193] Preferably, the mat material of the present invention has a shear modulus of 0.20 or more.

[0194] At a shear modulus of 0.20 or more, the mat material is less subjected to shear when an exhaust gas treatment unit is pressed into a metal casing using the mat material of the present invention.

[0195] The shear modulus is determined by dividing the shear failure load by the reduced surface pressure.

[0196] The shear failure load can be measured by a shear failure load test device shown in FIG. 11.

[0197] FIG. 11 is a conceptual schematic view of a shear failure load test device.

[0198] A shear failure load test device 170 shown in FIG. 11 includes specimens 1a and 1b, one on each side of a stainless-steel plate 173. The specimens 1a and 1b are sandwiched between a left jig 171 and a right jig 172. Many protruding members 174 are disposed on a specimen-contacting surface of each of the left jig 171 and the right jig 172 and specimen-contacting surfaces of the stainless-steel plate 173.

[0199] The specimens 1a and 1b are pierced by the protruding members 174 and are thereby fixed to the left jig 171, the right jig 172, and the stainless-steel plate 173.

[0200] In this state, the specimens are compressed to a gap bulk density (GBD) of 0.3 g/cm³.

[0201] Next, the stainless-steel plate 173 is moved at a rate of 5 mm/min toward the direction (upward) indicated by an arrow in FIG. 11. Yet, the stainless-steel plate 173 cannot slip out of the specimens 1a and 1b because the stainless-steel plate 173 is fixed to the specimens 1a and 1b with the protruding members 174. Thus, a shear failure occurs in the specimens 1a and 1b when a shear force equal to or greater than the shear failure load of the specimen is applied to the specimens 1a and 1b.

[0202] The shear force applied to the stainless-steel plate when a shear failure occurred in the specimens is determined.

[0203] The resulting shear force is divided by the area of the specimens, whereby the shear failure load (kPa) can be determined. The shear failure load may be measured using a specimen obtained by cutting out portions of the mat material.

[0204] The reduced surface pressure can be measured by the following procedure.

[0205] First, the mat material is compressed to a gap bulk density of 0.3 g/cm³ at room temperature and kept in the state for 20 minutes. Then, the load is measured.

[0206] The resulting load is divided by the area of the specimen, whereby the reduced surface pressure (kPa) can be

determined. The reduced surface pressure may be measured using a specimen obtained by cutting out portions of the mat material.

[0207] Preferably, the surface pressure after firing of the mat material is 50 kPa or more.

[0208] The post-firing surface pressure of the mat material can be measured by the following method using a hot surface pressure measurement device including a heater in a plate that compresses the mat material as a specimen.

[0209] First, a specimen (mat material) is compressed to a gap bulk density of 0.3 g/cm^3 at room temperature and kept in the state for 10 minutes. Subsequently, while the specimen is being compressed, the temperature is raised to 900°C on one side and 650°C on the other side at a heating rate of 45°C . Meanwhile, the compression is released to a gap bulk density of 0.27 g/cm^3 , and the state is kept for five minutes. Subsequently, the plate that compresses the mat material is moved at a rate of 1 inch (25.4 mm)/min to compress the mat material to a gap bulk density of 0.3 g/cm^3 . A cycle of release of compression to a gap bulk density of 0.27 g/cm^3 and compression to a gap bulk density 0.3 g/cm^3 is repeated 1000 times. Subsequently, the load at a gap bulk density of 0.27 g/cm^3 is measured. The resulting load is divided by the area of the specimen to determine the surface pressure (kPa) as the surface pressure after firing.

[Method for producing mat material]

[0210] The mat material of the present invention can be obtained, for example, by a cutting step of cutting a mat including inorganic fibers into a predetermined shape or a molding step of molding a mat including inorganic fibers into a predetermined shape.

[0211] The mat can be obtained, for example, by needling or papermaking.

[0212] In the case of needling, for example, the mat can be obtained by a spinning step of spinning a spinning mixture containing at least an inorganic compound and an organic polymer to produce an inorganic fiber precursor, a compressing step of compressing the inorganic fiber precursor to produce a sheet, a needle-punching step of needle-punching at least one surface of the sheet to produce a needle-punched article, and a firing step of firing the needle-punched article.

[0213] Specific examples of the spinning step, the compressing step, the needle-punching step, and the firing step are described below.

[Spinning step]

[0214] In the spinning step, the spinning mixture containing at least an inorganic compound and an organic polymer is spun to produce an inorganic fiber precursor.

[0215] In the spinning step, for example, a spinning mixture containing an aqueous solution of basic aluminum chloride, silica sol, and the like as raw materials is spun by blowing, whereby an inorganic fiber precursor having an average fiber diameter of 3 to $10 \mu\text{m}$ is produced.

[Compressing step]

[0216] In the compressing step, the inorganic fiber precursor obtained in the spinning step is compressed to produce a continuous sheet having a predetermined size.

[Needle-punching step]

[0217] In the needle-punching step, at least one surface of the sheet obtained in the compressing step is needle-punched to produce a needle-punched article.

[0218] In the needle-punching step, preferably, the needle arrangement density is set to 0.5 needles/cm^2 or more and less than 18 needles/cm^2 .

[0219] In the needle-punching step, the positions where the needles are arranged correspond to the entanglement points in the mat. Thus, when the needle arrangement density is set to 0.5 needles/cm^2 or more and less than 18 needles/cm^2 , a mat in which the density ρ of the entanglement points is in the range of $0.5 \text{ pcs/cm}^2 \leq \rho < 18 \text{ pcs/cm}^2$ can be obtained by single needle-punching.

[0220] The needle arrangement density is not limited to the above range when the same sheet is needle-punched several times.

[0221] By intentionally unevenly arranging the needles in the needle-punching step, the arrangement of the entanglement points to be formed on the needle-punched article can be varied in density so as to form a $4 \text{ mm} \times 4 \text{ mm}$ region without the entanglement points (first region) and/or a $3 \text{ mm} \times 8 \text{ mm}$ region without the entanglement points in a $25 \text{ mm} \times 25 \text{ mm}$ (second region) in a $25 \text{ mm} \times 25 \text{ mm}$ region, while the density ρ of the entanglement points is in the range of $0.5 \text{ pcs/cm}^2 \leq \rho < 18 \text{ pcs/cm}^2$.

[0222] Examples of methods for intentionally unevenly arranging the entanglement points include a method that

includes needle-punching such that the entanglement points are evenly arranged and then additionally needle-punching some portions. Other examples include a method that includes performing needle-punching several times while moving the inorganic fiber precursor, and a method that include performing needle-punching using a needle board on which needles are not arranged at equal intervals.

[0223] In the needle-punching step, the needles may or may not penetrate in the thickness direction of the sheet.

[Firing step]

[0224] In the firing step, the needle-punched article is fired to obtain a mat including inorganic fibers.

[0225] The firing temperature of the needle-punched article is not limited but is preferably 1000°C to 1600°C.

[0226] The mat can be obtained by the above steps.

[Cutting step]

[0227] The mat obtained by the above step is cut into a predetermined shape, whereby the mat material of the present invention can be obtained.

[0228] The production of the mat material of the present invention may include an attaching step of attaching an inorganic binder and/or an organic binder to the surface of each inorganic fiber constituting the mat or mat material.

[Attaching step]

[0229] In the attaching step, an inorganic binder and/or an organic binder is attached to the mat.

[0230] When no distinction is made between the inorganic binder and the organic binder, the inorganic binder and the organic binder are simply referred to as "the binder".

[0231] Examples of the inorganic binder include alumina sol and silica sol.

[0232] Examples of the organic binder include water-soluble organic polymers such as acrylic resin, acrylate latex, rubber latex, carboxymethylcellulose, and polyvinyl alcohol; thermoplastic resins such as styrene resin; and thermosetting resins such as epoxy resin.

[0233] Examples of methods for attaching the binder to the mat include a method that includes bringing a binder mixture of a solvent and the binder into contact with the mat and then drying the binder mixture.

[0234] Examples of methods for bringing the binder mixture into contact with the mat include a method that includes immersing the mat in the binder mixture and a method that includes dropping binder mixture onto the mat by curtain coating or the like.

[0235] The amount of the inorganic binder in the binder mixture is preferably 0.05 wt% or more and 5 wt% or less.

[0236] The amount of the organic binder in the binder mixture is preferably 0.05 wt% or more and 5 wt% or less.

[0237] In other words, the binder mixture may be one that contains only the inorganic binder as a binder, one that contains only the organic binder as a binder, or one that contains both the inorganic binder and the organic binder as binders.

[0238] The binder mixture may contain a polymeric dispersant.

[0239] When the binder mixture contains a polymeric dispersant, the binder is in a dispersed state in the binder mixture. When the inorganic binder mixture in such a state is brought into contact with the mat, the binder can be attached in a dispersed state to the surface of each inorganic fiber.

[0240] Examples of the polymeric dispersant include synthetic hydrophilic polymeric substances including anionic polymeric dispersants such as polycarboxylic acid and/or a salt thereof, a naphthalenesulfonate formalin condensate and/or a salt thereof, polyacrylic acid and/or a salt thereof, polymethacrylic acid and/or a salt thereof, and polyvinyl sulfonic acid and/or a salt thereof, and nonionic polymeric dispersants such as polyvinyl alcohol, polyvinylpyrrolidone, and polyethylene glycol; natural hydrophilic polymers such as gelatin, casein, and water-soluble starch; and semi-synthetic hydrophilic polymeric substances such as carboxymethylcellulose.

[0241] Of these, synthetic hydrophilic polymeric substances are preferred, and anionic polymeric dispersants are more preferred.

[0242] One of these polymeric dispersants may be used alone or two or more of these may be used in combination. A polymeric dispersant having both a structure that exhibits properties as an anionic polymeric dispersant and a structure that exhibits properties as a nonionic polymeric dispersant may also be used.

[0243] The binder mixture may contain a flocculant.

[0244] When the mixture contains a flocculant, the binder is in an aggregated state in the mixture. When the mixture in such a state is brought into contact with the mat, the binder can be attached in an aggregated state to the surface of each inorganic fiber.

[0245] The binder mixture may contain a polymeric dispersant.

[0246] When the binder mixture contains a polymeric dispersant, the binder is in a dispersed state in the binder mixture. In other words, the binder mixture is a dispersion in which the binder is dispersed in a dispersion medium. When the binder mixture (dispersion) in such a state is brought into contact with the mat, the binder can be attached in a dispersed state to the surface of each inorganic fiber.

[0247] The binder mixture may contain a flocculant.

[0248] When the binder mixture contains a flocculant, the binder is in an aggregated state in the mixture. In other words, the binder mixture is an aggregated dispersion in which the aggregates of the binder are dispersed in a dispersion medium. When the mixture (aggregated dispersion) in such a state is brought into contact with the mat, the binder can be attached in an aggregated state to the surface of each inorganic fiber.

[0249] In the attaching step, the attaching of an inorganic binder and the attaching of an organic binder may be separately performed.

[0250] Examples of methods for separately performing the attaching of an inorganic binder and the attaching of an organic binder include a method that includes bringing an inorganic binder mixture containing an inorganic binder into contact with the mat to attach the inorganic binder thereto and then further bringing an organic binder mixture containing an organic binder into contact with the inorganic fiber mass to attach the organic binder thereto. The inorganic binder and the organic binder may be attached in any order. The inorganic binder may be attached first, or the organic binder may be attached first.

[0251] The mat material of the present invention with the inorganic binder and/or the organic binder attached to the surface of each inorganic fiber can be obtained by the above steps.

[0252] Subsequently, the case where papermaking is used is described.

[0253] In the case of papermaking, for example, the mat can be obtained by a defibrating step of defibrating inorganic fibers, a slurry preparing step of mixing the defibrated inorganic fibers with a solvent, an inorganic binder, and an organic binder to prepare a slurry, a papermaking step of subjecting the slurry to papermaking to obtain an inorganic fiber aggregate, and a drying step of drying the inorganic fiber aggregate.

[0254] Specific examples of the defibrating step, the slurry preparing step, the papermaking step, and the drying step are described below.

[Defibrating step]

[0255] In the defibrating step, the inorganic fibers are made into short fibers (referred to as defibrating) with a grinder such as a feather mill or an agitator such as a pulper to adjust the fiber length to a desired length.

[0256] The inorganic fibers that were made into short fibers may be classified as needed. Preferably, the classification is performed such that the inorganic fibers having a fiber length of 200 μm or less are partially or entirely removed.

[0257] The classification may be performed by, for example, using a dry centrifugal classifier (also referred to as "dry cyclone"), a wet centrifugal classifier (also referred to as "wet cyclone"), or the like.

[Slurry preparing step]

[0258] In the slurry preparing step, the defibrated inorganic fibers are mixed with a solvent, an inorganic binder, and an organic binder, whereby a slurry is prepared.

[0259] The inorganic binder and the organic binder may be mixed in any order. Yet, preferably, the inorganic fibers and the inorganic binder are mixed first and left to stand for a while, and the organic binder is then added to the mixture. When the inorganic fibers and the inorganic binder are mixed first, the inorganic binder is certainly attached to the surface of each inorganic fiber. This can increase the friction between the inorganic fibers and improve the surface pressure. Further, aggregates in which the organic binder and the inorganic binder are aggregated by a flocculant may be added to the slurry.

[Papermaking step (molding step)]

[0260] In the papermaking step, the slurry is poured into a molding machine having a mesh for filtering on its bottom to remove the solvent in the slurry, whereby an inorganic fiber aggregate is obtained.

[0261] The shape of the molding machine here defines the shape of the mat. In other words, the papermaking step also serves as the molding step. Thus, it is preferred to use a molding machine having a shape that matches a desired shape of a mat to be obtained.

[0262] The solvent may be removed by any means as long as the solvent contained in the mat can be removed. For example, the solvent can be removed by means such as compression, rotation, suction, decompression, or the like.

[Drying step]

[0263] In the drying step, the inorganic fiber aggregate is dried while being compressed by a method such as compression drying with a hot plate using a press dryer or the like.

[0264] The mat material of the present invention with the inorganic binder and/or the organic binder attached to the surface of each inorganic fiber can be obtained by the above steps.

[Exhaust gas conversion apparatus]

[0265] An exhaust gas conversion apparatus of the present invention includes an exhaust gas treatment unit, a casing for housing the exhaust gas treatment unit, and a mat material arranged between the exhaust gas treatment unit and the casing for holding the exhaust gas treatment unit, wherein the mat material is the mat material of the present invention.

[0266] The exhaust gas conversion apparatus of the present invention can stably hold the exhaust gas treatment unit owing to the arrangement of the mat material of the present invention between the exhaust gas treatment unit and the casing.

[0267] FIG. 12 is a schematic cross-sectional view of an example of the exhaust gas conversion apparatus of the present invention.

[0268] As shown in FIG. 12, an exhaust gas conversion apparatus 200 includes the casing 220, the exhaust gas treatment unit 230 housed in the casing 220, and the mat material 10 between the exhaust gas treatment unit 230 and the casing 220. The mat material 10 is the mat material of the present invention.

[0269] The exhaust gas treatment unit 230 has a pillar shape in which many cells 231 are arranged in parallel in a longitudinal direction with cell walls 232 between the cells. If necessary, an inlet tube for introducing exhaust gas discharged from an internal combustion engine and an outlet tube for discharging the exhaust gas that has passed through the exhaust gas conversion apparatus are connected to ends of the casing 220.

[0270] In the exhaust gas conversion apparatus 200 shown in FIG. 12, although the exhaust gas treatment unit 230 is an exhaust gas filter (honeycomb filter) in which one of the ends of each cell is plugged with a plug 233, the exhaust gas treatment unit 230 may be a catalyst carrier not plugged with plugs at either end surface.

[0271] As shown in FIG. 12, the exhaust gas that was discharged from the internal combustion engine and that flowed into the exhaust gas conversion apparatus 200 (in FIG. 12, the exhaust gas is indicated by G, and the exhaust gas flow is indicated by arrows) flows into one of the cells 231 open at an exhaust gas inlet-side end 230a of the exhaust gas treatment unit (honeycomb filter) 230, and then passes through the cell wall 232 between the cells 231. At this point, PM in the exhaust gas is collected by the cell wall 232, and the exhaust gas is converted. The converted exhaust gas flows out from another cell 231 open at an exhaust gas discharge-side end 230b and is discharged to the outside.

[0272] The exhaust gas inlet-side end 230a and the exhaust gas discharge-side end 230b are determined depending on the direction of exhaust gas that flows into the exhaust gas conversion apparatus, not on the press-fitting direction.

[Method for producing an exhaust gas conversion apparatus]

[0273] The method for producing an exhaust gas conversion apparatus of the present invention includes a press-fitting step of press-fitting an exhaust gas treatment unit having the mat material of the present invention wound therearound into a casing by hard stuffing, pre-calibration, or post-calibration.

[0274] The hard stuffing, pre-calibration, and post-calibration each require a step of press-fitting an exhaust gas treatment unit having the mat material wound therearound into a casing. Since the mat material of the present invention is configured such that displacement and deformation of the mat material during press-fitting can be prevented or reduced, the mat material is particularly suitable for the above methods.

[0275] The hard stuffing is a method in which a cylindrical casing having a predetermined inner diameter is provided, and an exhaust gas treatment unit having a mat material wound therearound is press-fitted into the casing.

[0276] The pre-calibration is a method in which a cylindrical casing having a predetermined inner diameter is reduced in diameter once, and then an exhaust gas treatment unit having a mat material wound therearound is press-fitted into the casing.

[0277] The post-calibration is a method in which an exhaust gas treatment unit having a mat material wound therearound is press-fitted into a cylindrical casing having a predetermined inner diameter, and then the casing including the exhaust gas treatment unit and the mat material is reduced in diameter.

[0278] In each of these methods, a large shear force is applied to the mat material during press-fitting, so that the mat material is easily displaced and deformed.

[0279] Yet, in the case of the mat material of the present invention, displacement and deformation of the mat material during press-fitting can be prevented or reduced, so that the mat material is particularly suitable for a method for producing an exhaust gas conversion apparatus that includes the press-fitting step involving any of these methods.

[0280] In the method for producing an exhaust gas conversion apparatus of the present invention, in the press-fitting step, preferably, the mat material is press-fitted into the casing, with the first side surface of the mat material at the upstream side and the second side surface at the downstream side.

[0281] Preferably, the mat material is press-fitted into the casing, with the first side surface of the mat material at the upstream side and the second side surface at the downstream side, particularly when the width of the non-recessed portion adjacent to the first side surface is greater than the width of the non-recessed portion adjacent to the second side surface.

[0282] The present description discloses the following matters.

[0283] Disclosure (1) relates to a mat material having a generally rectangular shape in a plan view, the mat material including inorganic fibers,

wherein the mat material includes a first main surface and a second main surface opposite to each other in a thickness direction, a first end surface and a second end surface opposite to each other in a longitudinal direction that is a winding direction, and a first side surface and a second side surface opposite to each other in a width direction perpendicular to the thickness direction and the longitudinal direction,

the mat material includes, on the first end surface, a protrusion designed to protrude toward the second end surface during winding of the mat material, and non-protruding portions provided at both sides of the protrusion in the width direction and designed not to protrude toward the second end surface during winding of the mat material,

the mat material includes, on the second end surface, a recess designed to fit the shape of the protrusion on the first end surface during winding of the mat material, and non-recessed portions provided at both sides of the recess in the width direction and designed to fit the shapes of the non-protruding portions on the first end surface during winding of the mat material, and

a ratio $[D/C]$ of a length $[D]$ of the non-recessed portion in the width direction to a length $[C]$ of the non-recessed portion in the longitudinal direction is 1.0 or more.

[0284] Disclosure (2) relates to the mat material according to Disclosure (1), wherein the mat material is a needle-punched mat.

[0285] Disclosure (3) relates to the mat material according to Disclosure (2), wherein the mat material includes multiple entanglement points formed by needling at least one of a front surface or a back surface thereof, and at least one of a $4\text{ mm} \times 4\text{ mm}$ first region without the entanglement points or a $3\text{ mm} \times 8\text{ mm}$ second region without the entanglement points is arranged in a $25\text{ mm} \times 25\text{ mm}$ region.

[0286] Disclosure (4) relates to the mat material according to Disclosure (2) or (3), wherein the inorganic fibers have an average fiber length of 1 to 150 mm.

[0287] Disclosure (5) relates to the mat material according to Disclosure (1), wherein the mat material is a papermaking mat.

[0288] Disclosure (6) relates to the mat material according to Disclosure (5), wherein the inorganic fibers have an average fiber length of 200 to 20000 μm .

[0289] Disclosure (7) relates to the mat material of any combination of Disclosure (1) to Disclosure (6), wherein an inorganic binder is attached to a surface of each inorganic fiber.

[0290] Disclosure (8) relates to the mat material of any combination of Disclosure (1) to Disclosure (6), wherein an organic binder is attached to a surface of each inorganic fiber.

[0291] Disclosure (9) relates to the mat material of any combination of Disclosure (1) to Disclosure (6), wherein an inorganic binder and an organic binder are attached to a surface of each inorganic fiber.

[0292] Disclosure (10) relates to the mat material of any combination of Disclosure (1) to Disclosure (9), further containing a polymeric dispersant.

[0293] Disclosure (11) relates to the mat material according to Disclosure (9), wherein the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber.

[0294] Disclosure (12) relates to the mat material according to Disclosure (9), wherein aggregates of the inorganic binder and the organic binder are attached to the surface of each inorganic fiber.

[0295] Disclosure (13) relates to the mat material according to Disclosure (12), wherein the surface of each inorganic fiber is at least partially covered with a coating layer containing a mixture of the inorganic binder and the organic binder.

[0296] Disclosure (14) relates to the mat material according to Disclosure (13), wherein the coating layer is formed from a continuous flaky mixture of the inorganic binder and the organic binder.

[0297] Disclosure (15) relates to the mat material according to Disclosure (13) or (14), wherein the coating layer has a stepped shape.

[0298] Disclosure (16) relates to the mat material of any combination of Disclosure (13) to Disclosure (15), wherein a particulate mixture of the inorganic binder and the organic binder is attached to a surface of the coating layer.

[0299] Disclosure (17) relates to the mat material of any combination of Disclosure (1) to Disclosure (16), wherein a ratio

[A/C] of a length [A] of the mat material in the longitudinal direction to the length [C] of the non-recessed portion in the longitudinal direction is 10 or more.

[0300] Disclosure (18) relates to an exhaust gas conversion apparatus including: a casing; an exhaust gas treatment unit; and a mat material between the casing and the exhaust gas treatment unit,

wherein the mat material is the mat material according to any combination of Disclosure (1) to Disclosure (17).

[0301] Disclosure (19) relates to a method for producing an exhaust gas conversion apparatus, the method including a press-fitting step of press-fitting an exhaust gas treatment unit having the mat material according to any combination of Disclosure (1) to Disclosure (17) wound therearound into a casing by hard stuffing, pre-calibration, or post-calibration.

(EXAMPLES)

[0302] Examples that more specifically disclose the present invention are described below. In the following Examples, the mats were produced by needling, but the present invention is not limited to these Examples.

(Example 1)

(a) Spinning step

[0303] To an aqueous solution of basic aluminum chloride prepared to have an Al content of 70 g/L and an Al:Cl ratio of 1:1.8 (atomic ratio) was added silica sol to give a compositional ratio of $\text{Al}_2\text{O}_3\text{:SiO}_2$ of 72:28 (weight ratio) in inorganic fibers after firing. Then, an organic polymer (polyvinyl alcohol) was further added thereto in an appropriate amount, whereby a mixture was prepared.

[0304] The resulting mixture was concentrated to obtain a spinning mixture, and the spinning mixture was spun by blowing, whereby an inorganic fiber precursor having an average fiber diameter of 5.1 μm was produced.

(b) Compressing step

[0305] The inorganic fiber precursor obtained in the spinning step (a) was compressed to produce a continuous sheet.

(c) Needle-punching step

[0306] The sheet obtained in the compressing step (b) was needle-punched several times using a needle board with needles at a predetermined density, whereby a needle-punched article was produced.

[0307] First, a needle board with needles attached thereto at a predetermined density was provided. Next, this needle board was set above one surface of the sheet. Then, needle-punching was performed several times by moving the needle board up and down once in the thickness direction of the sheet while moving the inorganic fiber precursor.

[0308] Thus, a needle-punched article was produced. At this point, the needles were allowed to penetrate the sheet until barbs formed on the tips of the needles had completely penetrated the sheet from one surface to the other surface.

(d) Firing step

[0309] The needle-punched article obtained in the needle-punching step (c) was continuously fired at a maximum temperature of 1250°C, whereby a fired sheet containing inorganic fibers including alumina and silica at a ratio of parts by weight of 72:28 was produced. The average fiber diameter of the inorganic fibers was 5.1 μm . The minimum fiber diameter was 3.2 μm . The thus-obtained fired sheet had a gap bulk density of 0.15 g/cm³ and a basis weight of 1400 g/m². The density ρ of the entanglement points was 9 pcs/cm². Ten 4 mm × 4 mm first regions without the entanglement points and four 3 mm × 8 mm second regions without the entanglement points were arranged in a 25 mm × 25 mm region.

(e) Cutting step

[0310] The fired needle-punched article was cut into a mat.

[0311] The mat had a generally rectangular shape in a plan view with the following dimensions: the length [A] in the longitudinal direction: 348.0 mm; the length [B] in the width direction: 93.5 mm; the length [C] of the protrusion: 20.0 mm; the widths [D₁ and D₂] of the non-recessed portions: 31 mm; and the width [E] of the protrusion: 31.5 mm. The center [E_C] of the recess in the width direction coincided with the center [B_C] of the mat in the width direction.

(f) Attaching step

(f-1) Organic binder mixture preparing step

- 5 **[0312]** Acrylate latex as an organic binder was diluted with water, whereby an organic binder mixture having a solids concentration of 2.0 wt% was prepared.

(f-2) Inorganic binder mixture preparing step

- 10 **[0313]** Alumina as an inorganic binder was diluted with water and blended with a polymeric dispersant, followed by sufficient stirring. Thus, an inorganic binder mixture was prepared in which the solids concentration of the inorganic particles was 2.0 wt% and the concentration of the polymeric dispersant was 1000 ppm.

(f-3) Binder mixture preparing step

- 15 **[0314]** The organic binder mixture obtained in the organic binder mixture preparing step (f-1) was added to the inorganic binder mixture obtained in the inorganic binder mixture preparing step (f-2) to give a weight ratio of 1:1, followed by sufficient stirring. Thus, a binder mixture was prepared in which the solids concentration of the organic binder was 1.0 wt%, the solids concentration of the inorganic binder was 1.0 wt%, and the concentration of the polymeric dispersant was 500 ppm.

(f-4) Contacting step

- 25 **[0315]** The binder mixture obtained in the binder mixture preparing step (f-3) was brought into contact with the mat obtained in the cutting step (e) by curtain coating.

(f-5) Dehydrating step

- 30 **[0316]** The mat to which the binder mixture was added, which was obtained in the contacting step (f-4) above, was sucked and dehydrated by a dehydrator such that the amount of the binder mixture added was adjusted to 100 parts by weight relative to 100 parts by weight of the inorganic fibers.

(f-6) Drying step

- 35 **[0317]** The mat that underwent the dehydrating step (f-5) was dried in a dryer, whereby a mat material according to Example 1 was produced.

(Examples 2 to 6 and Comparative Examples 1 to 3)

- 40 **[0318]** Mat materials according to Examples 2 to 6 and Comparative Examples 1 to 3 were produced with the same procedure as in Example 1, except that the cutting shape in the cutting step (e) was changed to satisfy the conditions shown in Table 1.

- [0319]** $[D_1]$ indicates the width of the non-recessed portion adjacent to the first side surface, and $[D_2]$ indicates the width of the non-recessed portion adjacent to the second side surface.

(Press-fitting test)

- 50 **[0320]** The mat materials according to Examples 1 to 3 and Comparative Examples 1 and 2 were separately wound around exhaust gas treatment units each having a diameter of 103 mm and a length of 105 mm to obtain wound bodies each having a diameter of 115 mm. Using a press-fitting jig having a taper angle of 4.5° and a drawing diameter of 110.7 mm, each wound body was press-fitted into a stainless-steel casing having an inner diameter of 110.8 mm at a rate of 500 mm/min such that the first side surface of the mat material was at the upstream side and the second side surface of the mat material was at the downstream side.

- 55 **[0321]** When winding each mat material around the exhaust gas treatment unit, the length $[L_0]$ from the upstream-side end surface of the exhaust gas treatment unit to the upstream-side end surface (first side surface) of the mat material was recorded. After press-fitting, again, the length $[L_1]$ from the upstream-side end surface of the exhaust gas treatment unit to the upstream-side end surface (first side surface) of the mat material was measured. Then, the difference $[\Delta L]$ was evaluated as the amount of deformation (amount of displacement) of the mat material based on the following criteria.

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[0322] The mat materials according to Examples 4 to 6 and Comparative Example 3 were separately wound around exhaust gas treatment units each having a diameter of 129 mm and a length of 105 mm to obtain wound bodies each having a diameter of 141 mm. Using a press-fitting jig having a taper angle of 4.5° and a drawing diameter of 145.3 mm, each wound body was press-fitted into a stainless-steel casing having an inner diameter of 145.4 mm at a rate of 500 mm/min such that the first side surface of the mat material was at the upstream side and the second side surface of the mat material was at the downstream side.

[Evaluation criteria]

[0323] ∞: The amount of deformation (amount of displacement) is 6 mm or less, and deformation of the mat material is particularly prevented or reduced.

[0324] ∘: The amount of deformation (amount of displacement) is more than 6 mm and 8 mm or less, and deformation of the mat material is sufficiently prevented or reduced.

[0325] ×: The amount of deformation (amount of displacement) is more than 8 mm, and deformation of the mat material is not sufficiently prevented or reduced.

[Table 1]

	Catalyst diameter [mm]	A [mm]	B [mm]	C [mm]	D ₁ [mm]	D ₂ [mm]	E [mm]	D/C	A/C	Amount of deformation (amount of displacement) [mm]	Evaluation
Example 1	103	348.0	93.5	20.0	31	31	31.5	1.6	17.4	5.8	○○
Example 2	103	348.0	93.5	25.0	31	31	31.5	1.2	13.9	4.5	○○
Example 3	103	348.0	93.5	30.0	31	31	31.5	1.0	11.6	4.8	○○
Example 4	129	429.0	135.5	29.0	45	45	45.5	1.6	14.8	6.0	○○
Example 5	129	429.0	135.5	37.0	45	45	45.5	1.2	11.6	5.5	○○
Example 6	129	429.0	135.5	44.5	45	45	45.5	1.0	9.6	7.7	○
Comparative Example 1	103	348.0	93.5	35.0	31	31	31.5	0.9	9.9	8.9	×
Comparative Example 2	103	348.0	93.5	50.0	31	31	31.5	0.6	7.0	8.5	×
Comparative Example 3	129	429.0	135.5	50	45	45	45.5	0.9	8.6	11.2	×

[0326] As shown in Table 1, in each of the mat materials according to the present invention, it was confirmed that deformation and displacement of the mat material during press-fitting was successfully prevented or reduced. Further, a comparison between Examples 1 to 5 and Example 6 shows that deformation and displacement of the mat material during press-fitting was particularly prevented or reduced when the ratio [A/C] of the length [A] of the mat material in the longitudinal direction to the length [C] of the non-recessed portion in the longitudinal direction was 10 or more.

REFERENCE SIGNS LIST

[0327]

- 1a, 1b specimen
- 10 mat material
- 11 first main surface
- 12 second main surface
- 13 first end surface
- 13a protrusion
- 13b, 13c non-protruding portion
- 14 second end surface

14a	recess
14b, 14c	non-recessed portion
15	first side surface
16	second side surface
5 115	entanglement point
117	first region
118	second region
120	inorganic fiber
130	coating layer
10 140	particulate mixture
170	shear failure load test device
171	left jig
172	right jig
173	stainless-steel plate
15 174	protruding member
200	exhaust gas conversion apparatus
220	casing
230	exhaust gas treatment unit
230a	exhaust gas inlet-side end
20 230b	exhaust gas discharge-side end
231	cell
232	cell wall
233	plug
250	wound body

Claims

1. A mat material having a generally rectangular shape in a plan view, the mat material comprising

inorganic fibers,
 wherein the mat material includes a first main surface and a second main surface opposite to each other in a thickness direction, a first end surface and a second end surface opposite to each other in a longitudinal direction that is a winding direction, and a first side surface and a second side surface opposite to each other in a width direction perpendicular to the thickness direction and the longitudinal direction,
 the mat material includes, on the first end surface, a protrusion designed to protrude toward the second end surface during winding of the mat material, and non-protruding portions provided at both sides of the protrusion in the width direction and designed not to protrude toward the second end surface during winding of the mat material,
 the mat material includes, on the second end surface, a recess designed to fit the shape of the protrusion on the first end surface during winding of the mat material, and non-recessed portions provided at both sides of the recess in the width direction and designed to fit the shapes of the non-protruding portions on the first end surface during winding of the mat material, and
 a ratio [D/C] of a length [D] of the non-recessed portion in the width direction to a length [C] of the non-recessed portion in the longitudinal direction is 1.0 or more.

2. The mat material according to claim 1,
 wherein the mat material is a needle-punched mat.

3. The mat material according to claim 2,
 wherein the mat material includes multiple entanglement points formed by needling at least one of a front surface or a back surface thereof, and at least one of a 4 mm × 4 mm first region without the entanglement points or a 3 mm × 8 mm second region without the entanglement points is arranged in a 25 mm × 25 mm region.

4. The mat material according to claim 2 or 3,
 wherein the inorganic fibers have an average fiber length of 1 to 150 mm.

5. The mat material according to claim 1,
 wherein the mat material is a papermaking mat.

6. The mat material according to claim 5,
wherein the inorganic fibers have an average fiber length of 200 to 20000 μm .
7. The mat material according to any one of claims 1 to 6,
wherein an inorganic binder is attached to a surface of each inorganic fiber.
8. The mat material according to any one of claims 1 to 6,
wherein an organic binder is attached to a surface of each inorganic fiber.
9. The mat material according to any one of claims 1 to 6,
wherein an inorganic binder and an organic binder are attached to a surface of each inorganic fiber.
10. The mat material according to any one of claims 1 to 9, further comprising a polymeric dispersant.
11. The mat material according to claim 9,
wherein the inorganic binder and the organic binder are attached in an individually dispersed state to the surface of each inorganic fiber.
12. The mat material according to claim 9,
wherein aggregates of the inorganic binder and the organic binder are attached to the surface of each inorganic fiber.
13. The mat material according to claim 12,
wherein the surface of each inorganic fiber is at least partially covered with a coating layer containing a mixture of the inorganic binder and the organic binder.
14. The mat material according to claim 13,
wherein the coating layer is formed from a continuous flaky mixture of the inorganic binder and the organic binder.
15. The mat material according to claim 13 or 14,
wherein the coating layer has a stepped shape.
16. The mat material according to any one of claims 13 to 15,
wherein a particulate mixture of the inorganic binder and the organic binder is attached to a surface of the coating layer.
17. The mat material according to any one of claims 1 to 16,
wherein a ratio $[A/C]$ of a length $[A]$ of the mat material in the longitudinal direction to the length $[C]$ of the non-recessed portion in the longitudinal direction is 10 or more.
18. An exhaust gas conversion apparatus comprising:
a casing;
an exhaust gas treatment unit; and
a mat material between the casing and the exhaust gas treatment unit,
wherein the mat material is the mat material according to any one of claims 1 to 17.
19. A method for producing an exhaust gas conversion apparatus, the method comprising
a press-fitting step of press-fitting an exhaust gas treatment unit having the mat material according to any one of claims 1 to 17 wound therearound into a casing by hard stuffing, pre-calibration, or post-calibration.

FIG. 1

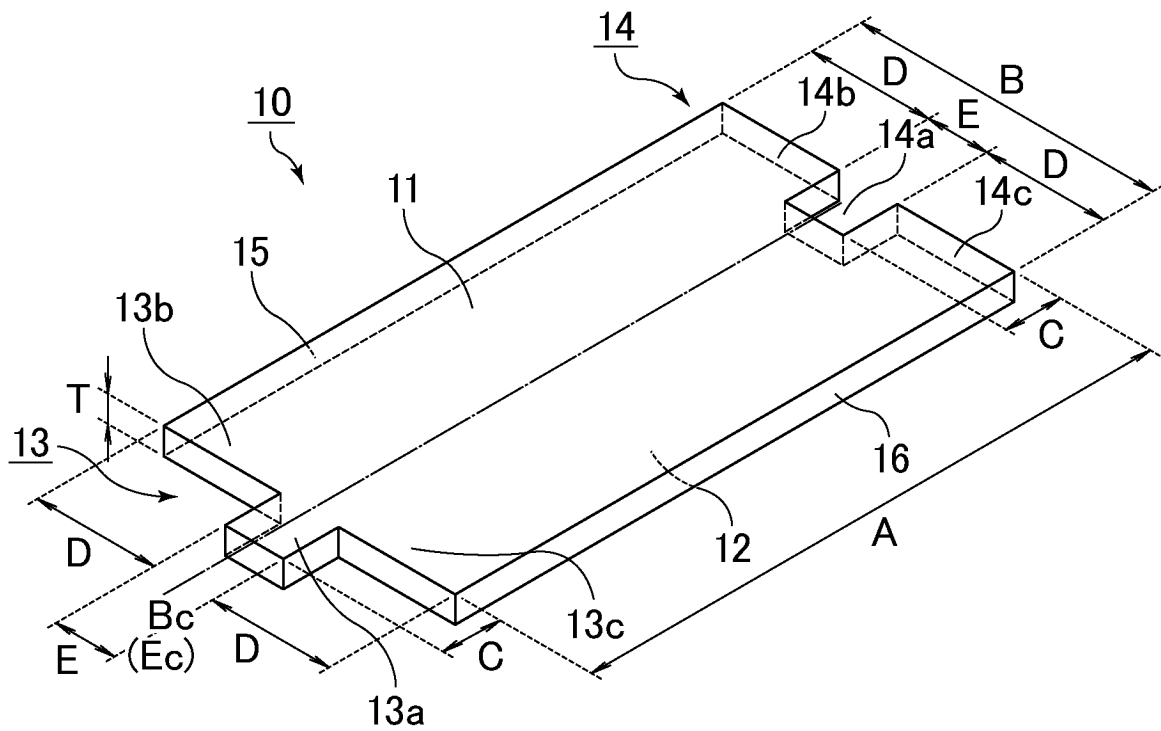


FIG. 2

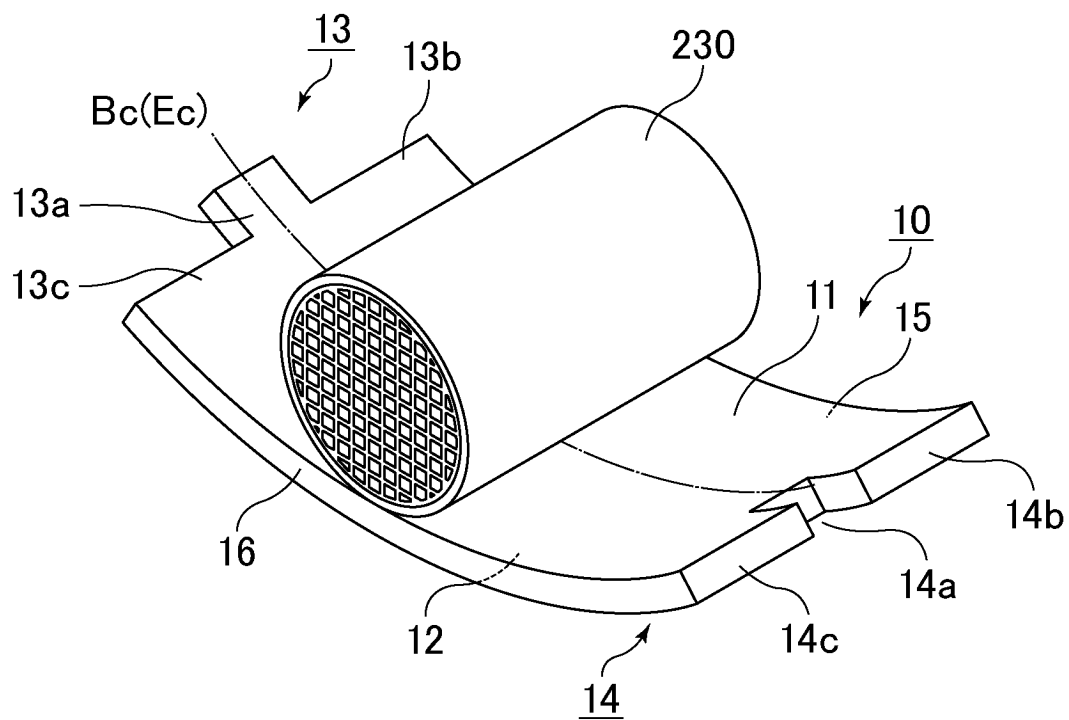


FIG. 3

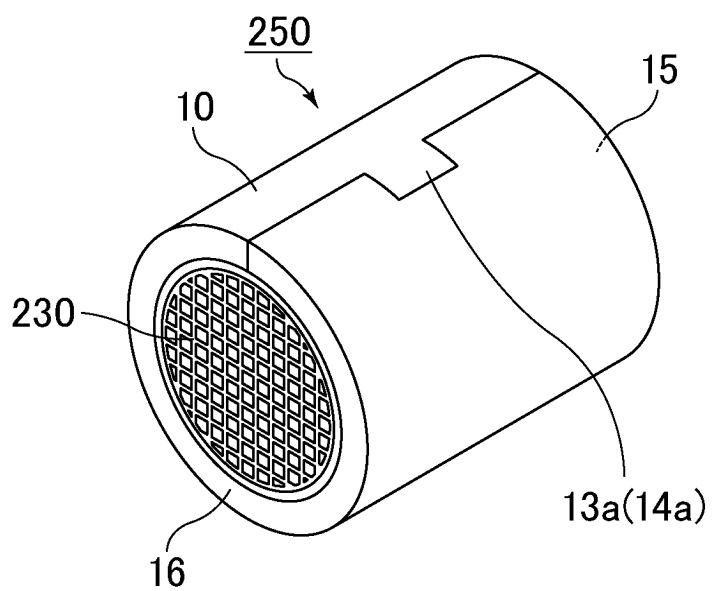


FIG. 4

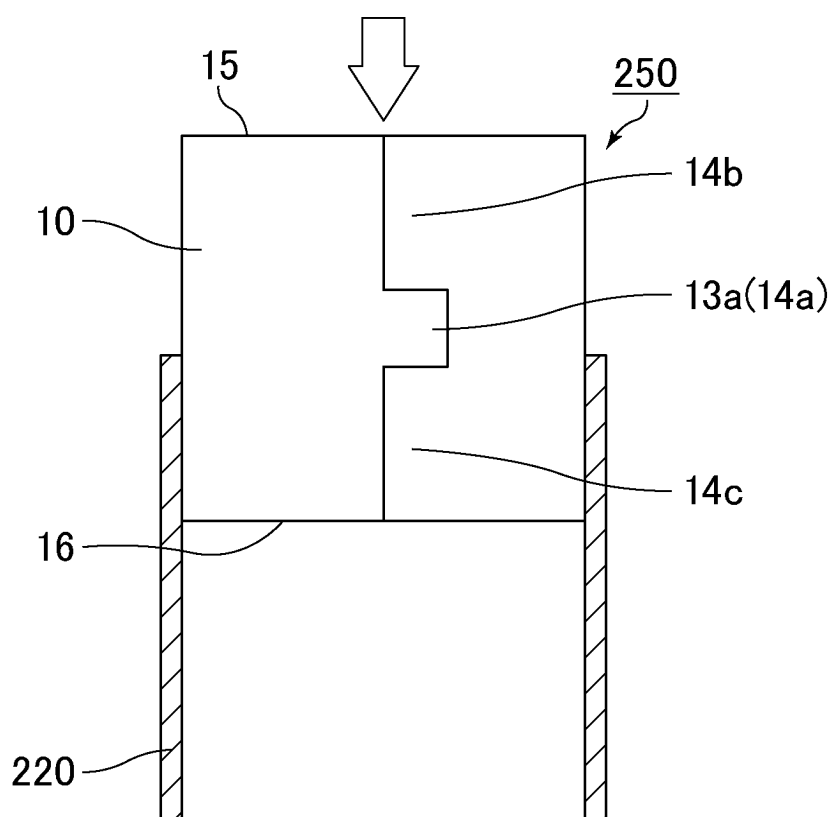


FIG. 5

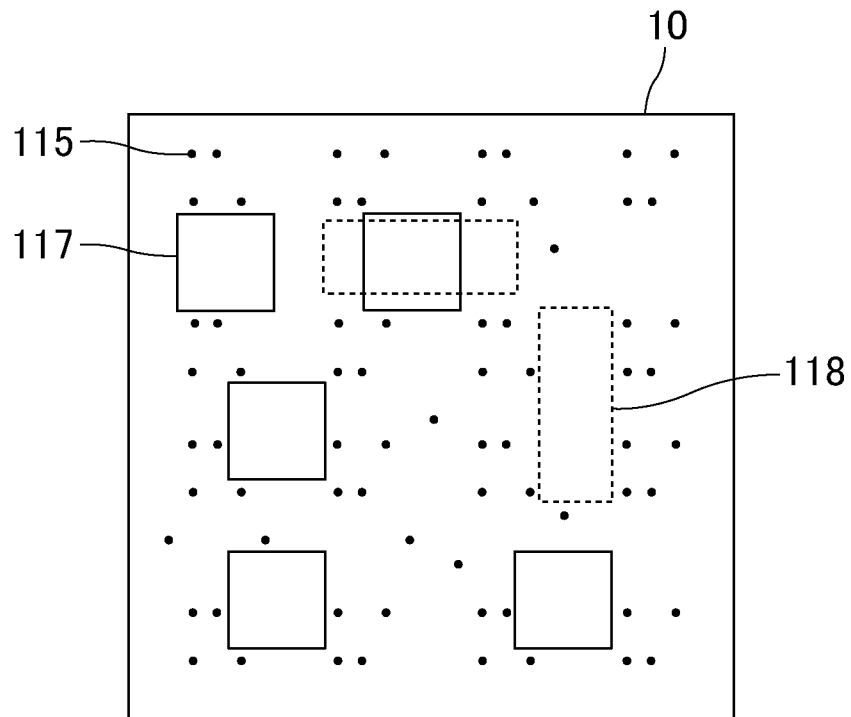


FIG. 6

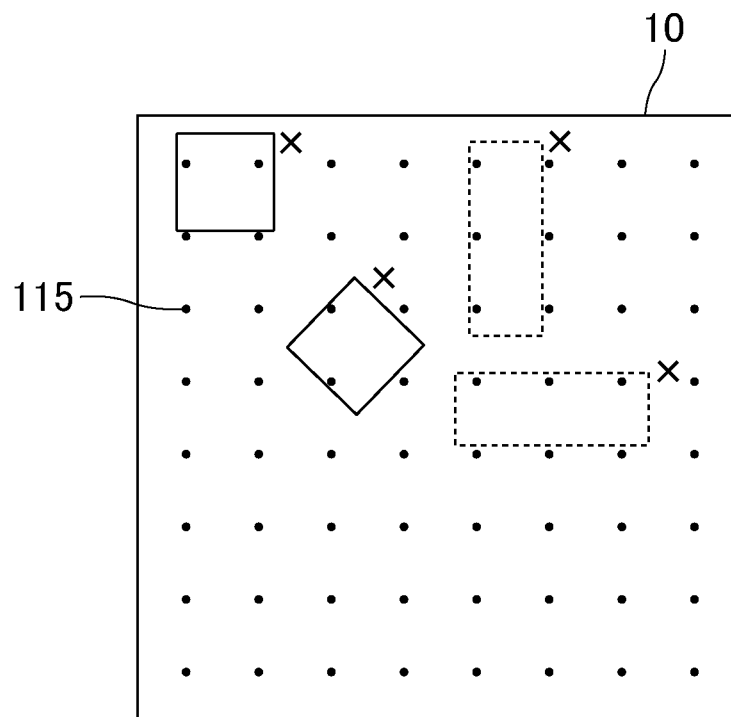


FIG. 7

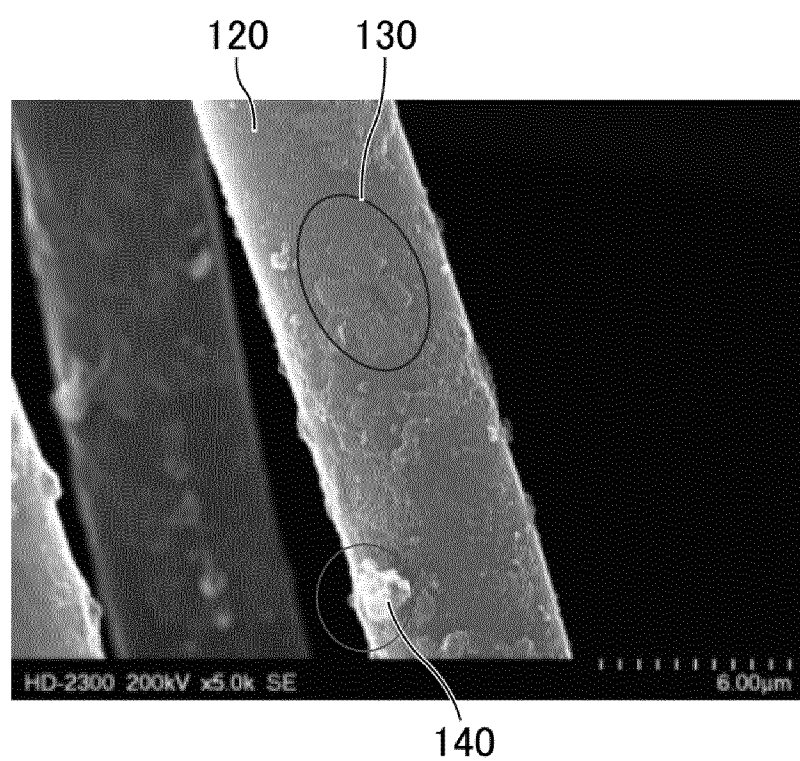


FIG. 8

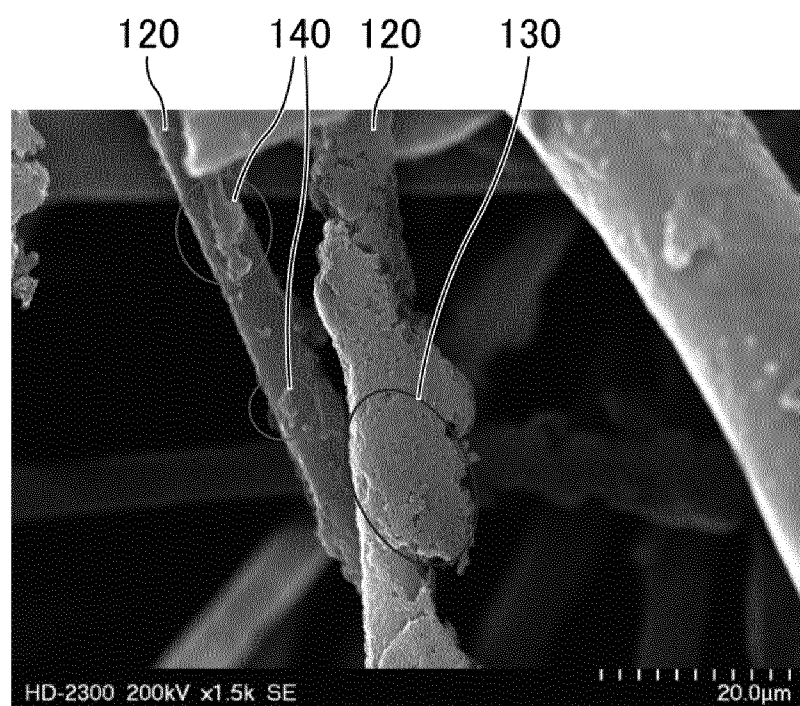


FIG. 9

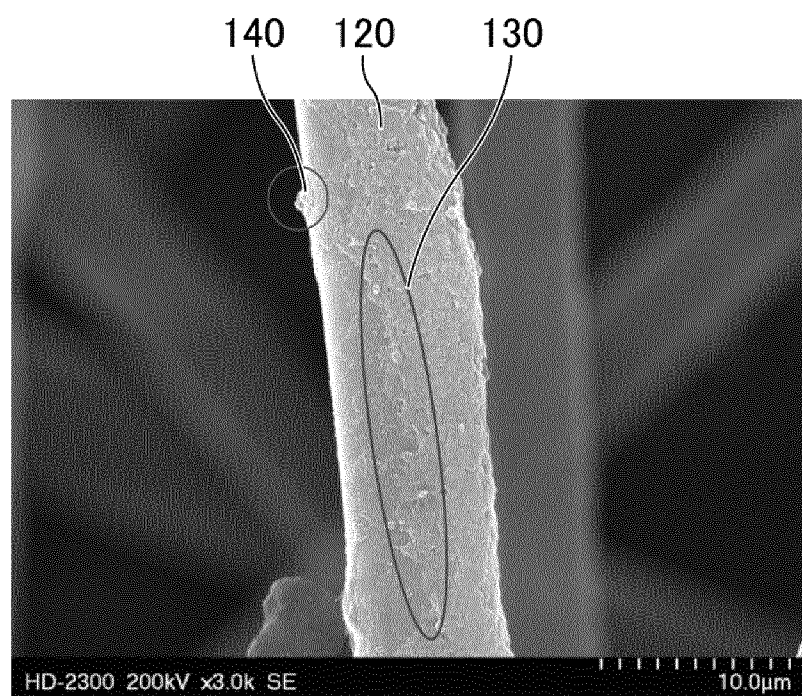


FIG. 10

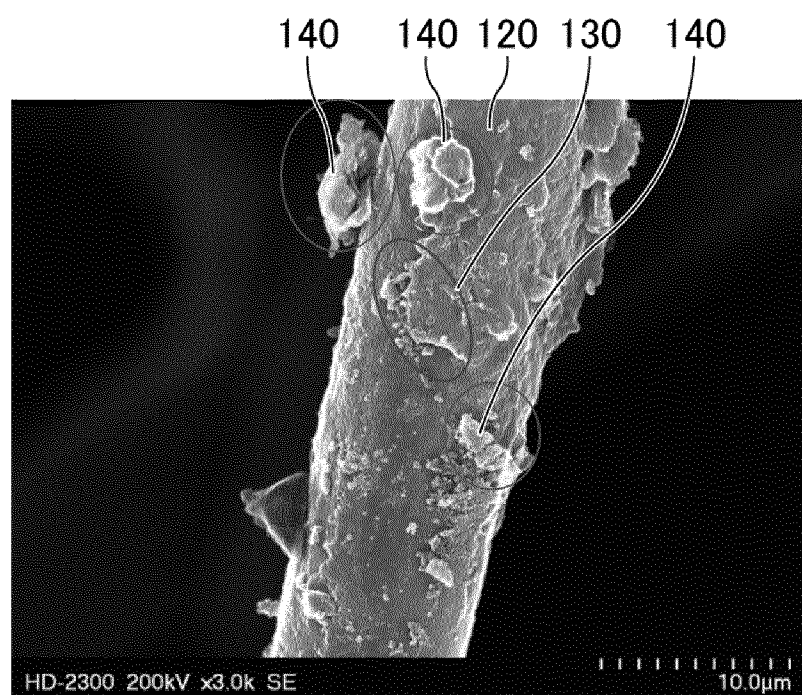
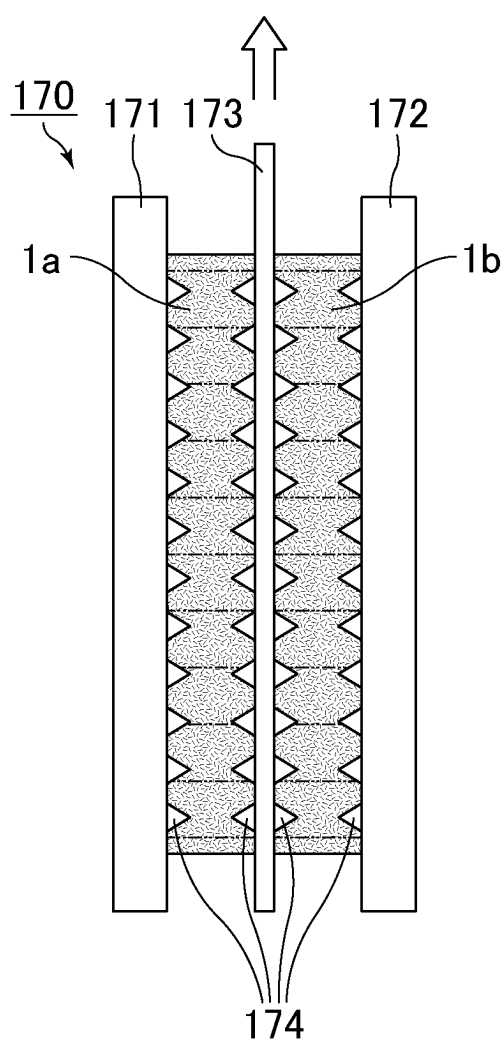
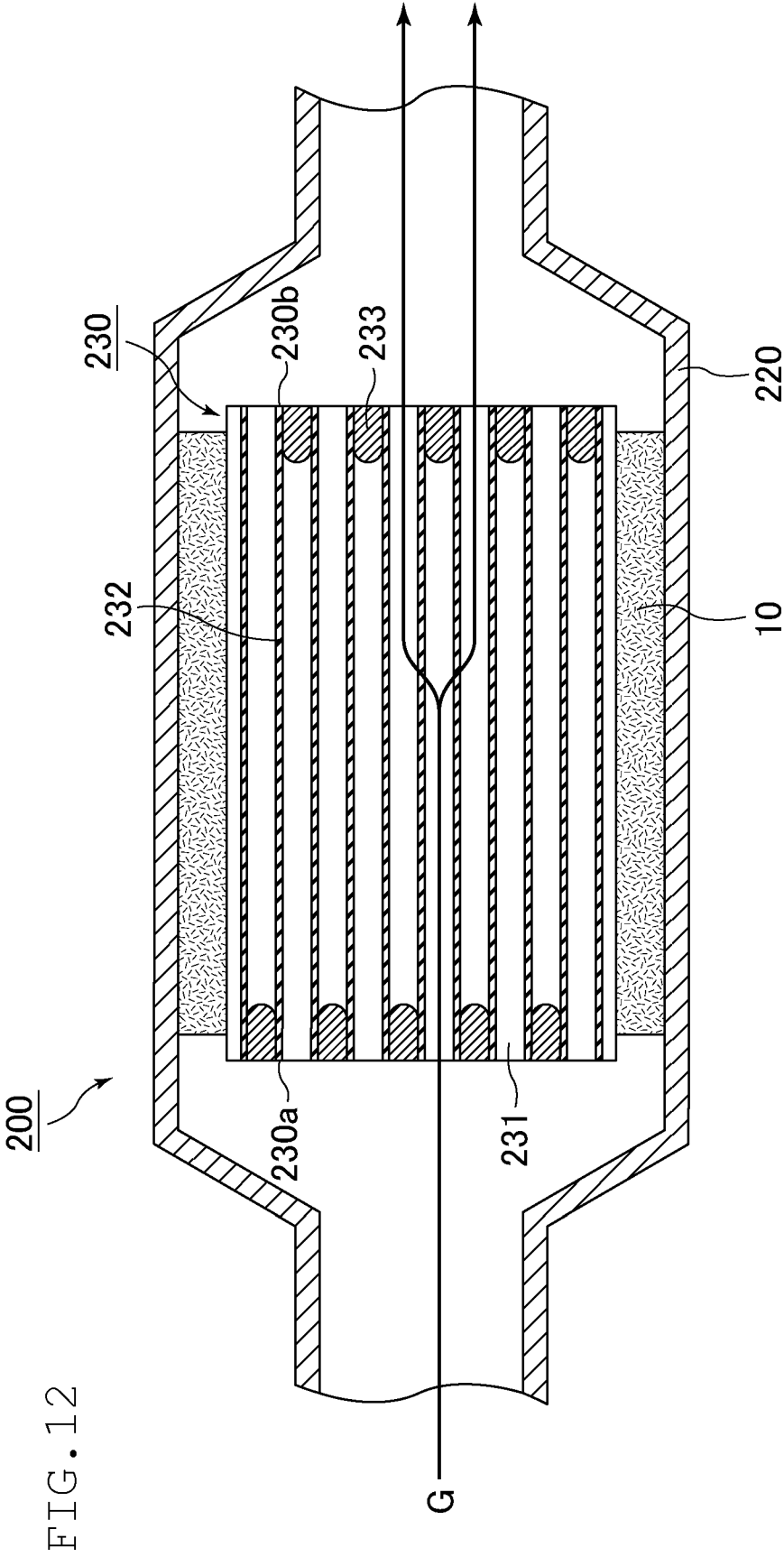


FIG. 11





INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/017666

A. CLASSIFICATION OF SUBJECT MATTER

B01J 33/00(2006.01)i; **F01N 3/28**(2006.01)i

FI: F01N3/28 311N; B01J33/00 G

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)

B01J33/00; F01N3/28

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

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.
Y	JP 2016-108987 A (IBIDEN CO LTD) 20 June 2016 (2016-06-20) claim 1, paragraph [0045], fig. 1, 5	1, 5-9, 12-19
Y	JP 2015-63925 A (IBIDEN CO LTD) 09 April 2015 (2015-04-09) claim 1, paragraphs [0046], [0057], fig. 1, 4	1-4, 7-11, 17-19
Y	JP 2009-24615 A (NICHIAS CORP) 05 February 2009 (2009-02-05) fig. 3	1-19
Y	JP 2015-45338 A (UNIFRAX I LLC) 12 March 2015 (2015-03-12) fig. 2	1-19

☐ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

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Date of the actual completion of the international search

05 June 2023

Date of mailing of the international search report

13 June 2023

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2023/017666

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2016-108987 A	20 June 2016	(Family: none)	
JP 2015-63925 A	09 April 2015	EP 3051187 A1 claim 1, paragraphs [0085], [0104], fig. 1, 4	
		WO 2015/045637 A1	
JP 2009-24615 A	05 February 2009	US 2009/0022633 A1 fig. 3	
		CN 101349183 A	
JP 2015-45338 A	12 March 2015	US 2010/0055004 A1 fig. 2	
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REFERENCES CITED IN THE DESCRIPTION

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