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(54) HOLDING SEAL MEMBER, METHOD FOR PRODUCING HOLDING SEAL MEMBER, AND EXHAUST GAS PURIFICATION DEVICE

(57) The holding sealing material of the present invention includes an inorganic fiber and a binding agent layer covering a surface of the inorganic fiber. The binding agent layer includes an organic binding agent, inorganic particles, and a polymer-based dispersant.

FIG.1A

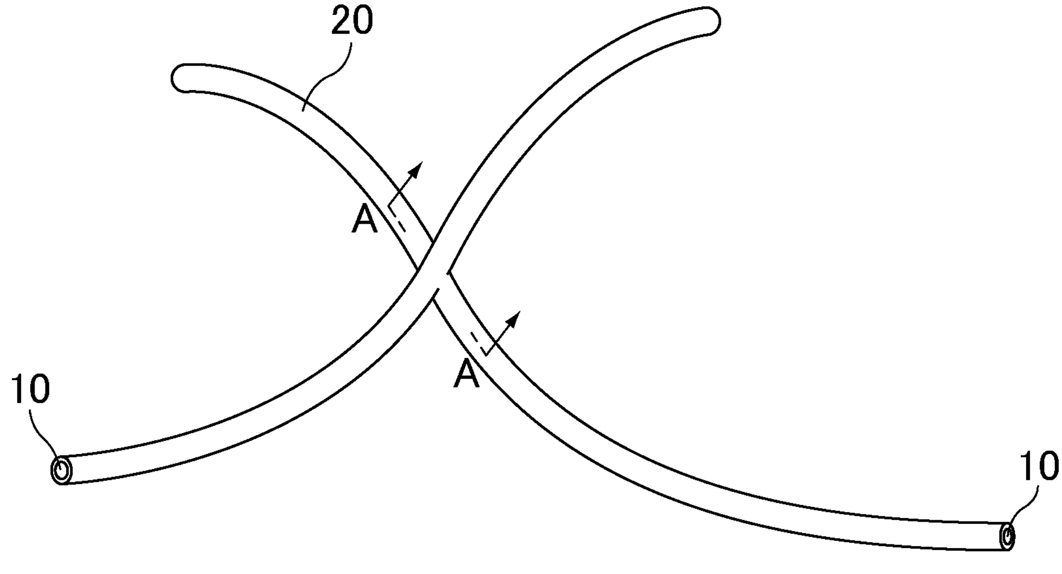

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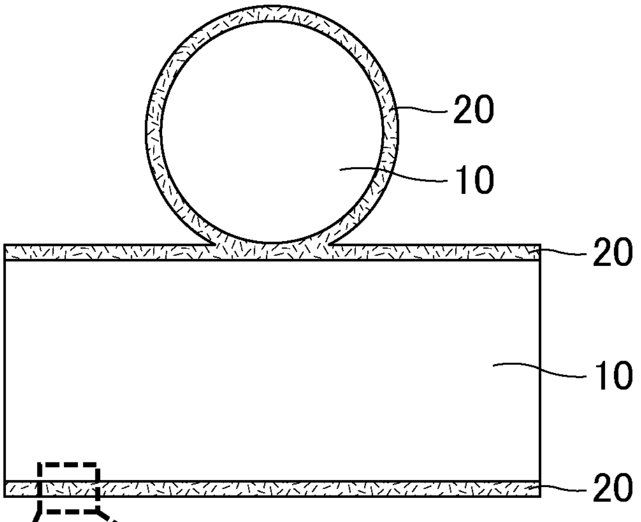
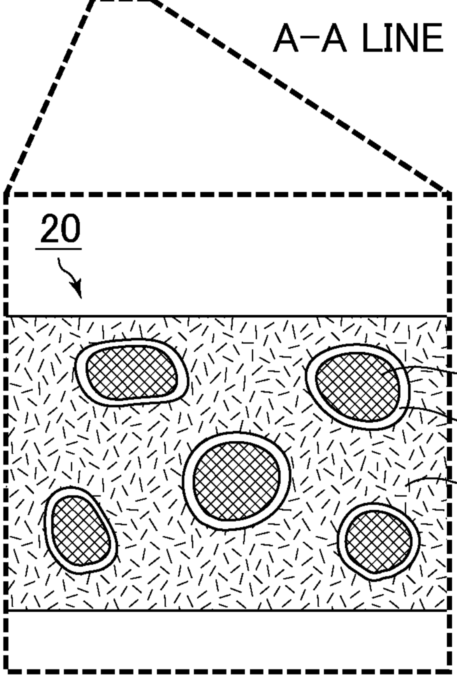
FIG.1B



A-A LINE CROSS SECTIONAL VIEW

FIG.1C



Description

Technical Field

[0001] The present invention relates to a holding sealing material, a method for manufacturing a holding sealing material, and an exhaust gas purifying apparatus.

Background Art

[0002] Exhaust gas discharged from internal combustion engines such as diesel engines contains particulate matter (hereinafter, also referred to as PM) such as soot, and the PM adversely affects the environment and human bodies, which has been a recent issue. Exhaust gas also contains harmful gas components such as CO, HC, and NOx, and the influence of these harmful gas components on the environment and human bodies has been another issue.

[0003] Therefore, a variety of exhaust gas purifying apparatuses have been proposed as an exhaust gas purifying apparatus for capturing the PM in exhaust gas or purifying the harmful gas components; these exhaust gas purifying apparatuses include an exhaust gas treatment body formed of a porous ceramic material such as silicon carbide or cordierite, a casing for housing the exhaust gas treatment body, and a holding sealing material which is formed of an inorganic fiber aggregate body and is disposed between the exhaust gas treatment body and the casing. The holding sealing material is provided mainly for preventing damages on the exhaust gas treatment body resulting from the contact with the casing covering the outer periphery of the exhaust gas treatment body due to vibrations or impacts generated by, for example, the driving of a vehicle, or for preventing the leakage of exhaust gas through between the exhaust gas treatment body and the casing. Therefore, the holding sealing material is required to have a function of increasing the surface pressure generated by a repulsive force when compressed, thereby reliably holding the exhaust gas treatment body.

[0004] One known example as the above-described holding sealing material is a holding sealing material including an agglomerate formed of an organic binding agent and inorganic particles and a mat which is formed of an inorganic fiber material and which is impregnated with the agglomerate (for example, refer to PTL 1).

Citation List

Patent Literature

[0005] [PTL 1] JP 2012-157809 A

Summary of Invention

Technical Problem

[0006] The surface pressure of the holding sealing material is derived from the force of the inorganic fiber constituting the holding sealing material for restoring itself to the origin when subjected to stress. Therefore, the surface pressure of the holding sealing material is high when the friction between the inorganic fiber strands is great or when the inorganic fiber strands are bound to each other.

[0007] In the holding sealing material disclosed in PTL 1, the agglomerate is attached to only part of the inorganic fiber constituting the mat. Therefore, the friction between the inorganic fiber strands is small in a portion to which the agglomerate is not attached, and the surface pressure-improving effect is not sufficiently exhibited. Therefore, there has been room for the improvement of the surface pressure of the holding sealing material disclosed in PTL 1. In addition, in the holding sealing material disclosed in PTL 1, the inorganic particles are present on only part of the surface of the inorganic fiber after the organic binding agent is burnt away due to the heat of exhaust gas. Therefore, there has been additional room for the improvement of the surface pressure after firing, and additional improvement of the surface pressure has been desired.

[0008] The present invention has been made in order to solve the above-described problems, and an object of the present invention is to provide a holding sealing material capable of sufficiently satisfying the pressure surface characteristics required for the holding sealing material and a method for manufacturing the holding sealing material. Another object of the present invention is to provide an exhaust gas purifying apparatus including the holding sealing material.

Solution to Problem

[0009] In order to achieve the above-described objects, the holding sealing material of the present invention characteristically includes an inorganic fiber and a binding agent layer, a surface of the inorganic fiber being covered with the binding agent layer, and the binding agent layer including an organic binding agent, inorganic particles, and a polymer-based dispersant.

[0010] Since the holding sealing material of the present invention includes the polymer-based dispersant in the binding agent layer, the agglomeration of the organic binding agent and the inorganic particles in the binding agent layer is suppressed. Since the agglomeration of the organic binding agent is suppressed, the binding agent layer including the organic binding agent is formed on a wide range of the surface of the inorganic fiber. Since the binding agent layer includes the inorganic particles, it has an excellent tensile strength. Since the agglomeration of the inorganic particles is suppressed by the polymer-based dispersant, the strength of the binding agent layer is high over a wide range.

[0011] If the strength of the binding agent layer is weak, the contact between the inorganic fiber strands causes peeling of the binding agent layer and slipping of the inorganic fiber strands, so that the surface pressure of the holding sealing material is low; however, the binding agent layer having high strength prevents the slipping of the inorganic fiber strands, and thus the holding sealing material can have a high surface pressure.

[0012] In the holding sealing material of the present invention, preferably, surfaces of the inorganic particles in the binding agent layer are covered with the polymer-based dispersant and the inorganic particles are dispersed in an organic binding agent component. When the surfaces of the inorganic particles are covered with the polymer-based dispersant, the agglomeration of the inorganic particles in the binding agent layer is more effectively suppressed and the inorganic particles are dispersed in the organic binding agent component. Thus, the strength of the binding agent layer is more uniformly improved over a wide range of the surface of the inorganic fiber. Therefore, a holding sealing material can have a higher surface pressure.

[0013] In the holding sealing material of the present invention, the contents of the inorganic particles and the organic binding agent are each preferably in a range of 0.1 parts by weight to 10 parts by weight in relation to 100 parts by weight of the inorganic fiber. The contents of the inorganic particles and the organic binding agent are more preferably in a range of 0.1 parts by weight to 3 parts by weight in relation to 100 parts by weight of the inorganic fiber.

[0014] It is known that an impact on the holding sealing material breaks the inorganic fiber and the broken inorganic fiber scatters. An ability to suppress such scattering of the inorganic fiber is also one of the characteristics required for the holding sealing material.

[0015] Even when the inorganic fiber is broken, a binding agent layer formed on the surface of the inorganic fiber can keep the broken inorganic fiber bound together in a portion where the binding agent layer is formed, thereby preventing the scattering of the fiber.

[0016] If the contents of the inorganic particles and the organic binding agent are each less than 0.1 parts by weight in relation to 100 parts by weight of the inorganic fiber, the binding agent layer is formed only in a small portion and the effect of suppressing the scattering of the inorganic fiber is weak. If the contents of the inorganic particles and the organic binding agent each exceed 10 parts by weight in relation to 100 parts by weight of the inorganic fiber, the effect of suppressing the scattering of the inorganic fiber and the effect of improving the surface pressure remain almost unchanged, whereas the amount of cracked gas generated due to the heat of exhaust gas increases, possibly adversely affecting the surrounding environment. Therefore, the content of the organic binding agent is preferably as low as possible, and more preferably 3 parts by weight or less.

[0017] In the holding sealing material of the present invention, the polymer-based dispersant is preferably an anionic polymer-based dispersant. Even when the surfaces of the inorganic particles are positively charged, an anionic polymer-based dispersant used as the polymer-based dispersant can offset the charges on the surfaces of the inorganic particles, and thus make it easy to disperse the inorganic particles.

[0018] In the holding sealing material of the present invention, the organic binding agent is preferably an acrylic resin. An acrylic resin used as the organic binding agent makes it easy to enhance the compatibility between the organic binding agent and the polymer-based dispersant in the binding agent layer, and thus makes it easy to improve the strength of the binding agent layer through an anchoring effect.

[0019] The holding sealing material of the present invention is preferably subjected to a needle punching treatment. When the inorganic fiber strands are entangled with each other through the needle punching treatment, the entanglement of the inorganic fiber strands is easily strengthened, improving the surface pressure.

[0020] In the holding sealing material of the present invention, irregularities by the inorganic particles are preferably formed on the entire surface of the inorganic fiber after the organic binding agent is burnt away due to heat.

[0021] Irregularities by the inorganic particles formed on the entire surface of the inorganic fiber suppress slipping of the inorganic fiber strands and strengthen the entanglement of the inorganic fiber strands. Therefore, the surface pressure of the holding sealing material can be easily increased.

[0022] In the holding sealing material of the present invention, the binding agent layer is preferably formed on the entire surface of the inorganic fiber. Formation of the binding agent layer on the entire surface of the inorganic fiber increases the friction when the inorganic fiber strands come into contact with each other, and thus makes it easy to improve the surface pressure.

[0023] Furthermore, a binding agent layer formed on the entire surface of the inorganic fiber can easily suppress the scattering of the inorganic fiber no matter where the inorganic fiber is broken.

[0024] Another aspect of the holding sealing material of the present invention is one manufactured through steps including: a mat preparation step of preparing a mat including an inorganic fiber; a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution mixture and then mixing the mixture with an organic binding agent dispersed in water; a supply step of supplying the binding agent solution to the mat; and a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

[0025] Mixing the solution of inorganic particles and the polymer-based dispersant allows the surfaces of the inorganic particles to be covered with the polymer-based dispersant. Further mixing of the organic binding agent dispersed in water with this mixture leads to a binding agent solution in which the inorganic particles are dispersed in the organic binding agent dispersed in water with the surfaces of the inorganic particles being covered with the polymer-based dispersant. Since the organic binding agent and the inorganic particles are dispersed in the binding agent solution, the organic binding agent and the inorganic particles easily spread throughout the entire surface of the inorganic fiber, and a high-strength binding agent layer is formed on the entire surface of the inorganic fiber. Therefore, the slipping of the inorganic fiber strands is prevented over the entire surface of the inorganic fiber, and thus the holding sealing material can have a high surface pressure.

[0026] Furthermore, since the binding agent layer is formed on the entire surface of the inorganic fiber, the scattering of the inorganic fiber can be easily suppressed no matter where the inorganic fiber is broken.

[0027] In the other aspect of the holding sealing material of the present invention, the organic binding agent used in the binding agent solution preparation step, is preferably an organic binding agent having a glass transition temperature of -5°C or lower. The binding agent layer obtained using the binding agent solution containing an organic binding agent having a glass transition temperature of -5°C or lower has a high strength, and has a high degree of coat elongation and is highly flexible. Therefore, the holding sealing material is less likely to fracture when, for example, the holding sealing material is wound around an exhaust gas treatment body.

[0028] Further, since the binding agent layer is not too hard, the scattering of the inorganic fiber can be easily suppressed.

[0029] In the other aspect of the holding sealing material of the present invention, the binding agent solution is preferably prepared in the binding agent solution preparation step such that the tensile strength of a binding agent layer obtained by drying the binding agent solution reaches 5.0 MPa or higher. With a binding agent layer having a tensile strength of lower than 5.0 MPa, the contact between the inorganic fiber strands may cause peeling off of the binding agent layer and slipping of the inorganic fiber strands, making it difficult to improve the surface pressure.

[0030] The method for manufacturing a holding sealing material of the present invention includes: a mat preparation step of preparing a mat including an inorganic fiber; a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution mixture and then mixing the mixture with an organic binding agent dispersed in water; a supply step of supplying the binding agent solution to the mat; and a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

[0031] Since the polymer-based dispersant covers the inorganic particles and thus suppresses the agglomeration of the inorganic particles with the organic binding agent, the binding agent solution prepared in the binding agent solution preparation step is in the form of an organic binding agent solution including the organic binding agent and the inorganic particles dispersed in water. Since the binding agent solution including the organic binding agent and the inorganic particles dispersed in water easily spreads over the entire surface of the inorganic fiber, supplying the binding agent solution to the mat enables to form a binding agent layer on the entire surface of the inorganic fiber.

[0032] Therefore, in the method for manufacturing a holding sealing material of the present invention, the entire surface of the inorganic fiber is covered with the binding agent layer and the slipping of the inorganic fiber is prevented over the entire surface of the inorganic fiber. Thus, the method can manufacture a holding sealing material having a high surface pressure and which can suppress the scattering of the inorganic fiber no matter where the inorganic fiber is broken.

[0033] The exhaust gas purifying apparatus of the present invention is an exhaust gas purifying apparatus including a metal casing, an exhaust gas treatment body housed in the metal casing, and a holding sealing material wound around the exhaust gas treatment body and interposed between the exhaust gas treatment body and the metal casing, in which the holding sealing material is the holding sealing material of the present invention.

[0034] The exhaust gas purifying apparatus of the present invention is an exhaust gas purifying apparatus including a metal casing, an exhaust gas treatment body housed in the metal casing, and a holding sealing material wound around the exhaust gas treatment body and interposed between the exhaust gas treatment body and the metal casing, in which the holding sealing material is the holding sealing material manufactured by the method for manufacturing a holding sealing material of the present invention.

Brief Description of Drawings

[0035]

Fig. 1A is a perspective view schematically showing an example of an inorganic fiber constituting a holding sealing material of the present invention and a binding agent layer covering the surface of the inorganic fiber, and Fig. 1B is an A-A line cross sectional view in Fig. 1A. Fig. 1C is a partial enlarged view of the binding agent layer of Fig. 1B.

Fig. 2A is a scanning electron microscope (hereinafter, also referred to as SEM) photograph of the inorganic fiber constituting the holding sealing material of the present invention with the binding agent layer formed on the surface thereof, and Fig. 2B is a SEM photograph of the inorganic fiber after an organic binding agent is burnt away by thermally treating the holding sealing material of the present invention.

Fig. 3 is a perspective view schematically showing an example of the holding sealing material of the present invention.

Fig. 4A is a side view schematically showing an example of a measurement instrument for measuring the scattering properties of the inorganic fiber, and Fig. 4B is a plan view schematically showing a part of sample-supporting arms constituting the measurement instrument for measuring the scattering properties of the inorganic fiber.

Fig. 5 is a line cross sectional view schematically showing an example of the exhaust gas purifying apparatus of the present invention.

Fig. 6 is a perspective view schematically showing an example of an exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention.

Fig. 7 is a perspective view schematically showing an example of a method for manufacturing the exhaust gas purifying apparatus of the present invention.

(Detailed description of the invention)

[0036] Hereinafter, the holding sealing material of the present invention will be specifically described. However, the present invention is not limited to the following constitution and can be applied in an appropriately modified manner within the scope of the spirit of the present invention.

[0037] Hereinafter, the holding sealing material of the present invention will be described.

[0038] The holding sealing material of the present invention includes an inorganic fiber and a binding agent layer which covers a surface of the inorganic fiber, and the binding agent layer includes an organic binding agent, inorganic particles, and a polymer-based dispersant.

[0039] First, the materials constituting the holding sealing material of the present invention will be described.

[0040] The inorganic fiber constituting the holding sealing material of the present invention is not particularly limited, and it preferably includes at least one selected from the group consisting of an alumina fiber, a silica fiber, an alumina silica fiber, a mullite fiber, a bio-soluble fiber, and a glass fiber.

[0041] The inorganic fiber which includes at least one of an alumina fiber, a silica fiber, an alumina silica fiber, and a mullite fiber has excellent heat resistance, and thus the inorganic fiber does not deteriorate and is capable of sufficiently maintaining its function as a holding sealing material even when an exhaust gas treatment body is exposed to a sufficiently high temperature. When the inorganic fiber is a bio-soluble fiber, even inhalation, for example, of the scattered inorganic fiber during the production of an exhaust gas purifying apparatus using the holding sealing material causes no harmful influence on the health of an operator because the inorganic fiber is dissolved in the body.

[0042] The alumina fiber may include additives such as calcia, magnesia, and zirconia in addition to alumina.

[0043] The compositional ratio of the alumina silica fiber (Al_2O_3:SiO_2) is preferably in a range of 60:40 to 80:20, and more preferably in a range of 70:30 to 74:26 in terms of weight ratio.

[0044] The inorganic fiber preferably has an average fiber length in a range of 5 mm to 150 mm, and more preferably in a range of 10 mm to 80 mm.

[0045] If the average fiber length of the inorganic fiber is shorter than 5 mm, the fiber length of the inorganic fiber is too short. Thus, the inorganic fiber strands are insufficiently entangled, and the holding sealing material is less easily wound around the exhaust gas treatment body, so that the holding sealing material is easily cracked. If the average fiber length of the inorganic fiber exceeds 150 mm, the fiber length of the inorganic fiber is too long. Thus, the number of fiber strands constituting the holding sealing material decreases and the denseness of a mat degrades. As a result, the holding sealing material has a low shear strength.

[0046] In the holding sealing material of the present invention, the surface of the inorganic fiber is covered with the binding agent layer.

[0047] Fig. 1A is a perspective view schematically showing an example of the inorganic fiber constituting the holding sealing material of the present invention and the binding agent layer covering the surface of the inorganic fiber, and Fig. 1B is an A-A line cross sectional view in Fig. 1A. Fig. 1C is a partial enlarged view of the binding agent layer of Fig. 1B.

[0048] As shown in Figs. 1A and 1B, in the holding sealing material of the present invention, the surface of an inorganic fiber 10 constituting the holding sealing material is covered with a binding agent layer 20. The binding agent layer 20 is preferably formed on the entire surface of the inorganic fiber 10. Furthermore, as shown in Fig. 1B, a plurality of the inorganic fiber strands 10 is preferably combined together by the binding agent layer 20.

[0049] As shown in Fig. 1C, the binding agent layer 20 includes inorganic particles 21, a polymer-based dispersant 23, and an organic binding agent component 22. In the binding agent layer 20, the surfaces of the inorganic particles 21 are covered with the polymer-based dispersant 23, and the inorganic particles 21 covered with the polymer-based dispersant 23 are dispersed in the organic binding agent component 22.

[0050] Covering of the surfaces of the inorganic particles 21 with the polymer-based dispersant 23 can effectively suppress the agglomeration of the inorganic particles 21 in the binding agent layer 20. Furthermore, dispersion of the inorganic particles 21 in the organic binding agent component 22 makes it easy to maintain the tensile strength of the binding agent layer at a high level.

[0051] The binding agent layer in the present invention preferably has a tensile strength of 5.0 MPa or higher. If the tensile strength of the binding agent layer is lower than 5.0 MPa, the contact between the inorganic fiber strands may cause peeling off of the binding agent layer and slipping of the inorganic fiber strands, making it difficult to improve the surface pressure.

[0052] The tensile strength of the binding agent layer in the present invention refers to the tensile strength at break of a test specimen which is a 0.4 mm-thick dumbbell-shaped binding agent layer, measured by carrying out a tensile test on the test specimen using an Instron-type tensile tester at room temperature and a rate of 300 mm/min.

[0053] The test specimen can be produced by pouring a binding agent solution, which serves as the raw material of the binding agent layer, into a framed glass plate, leaving the solution at room temperature until the solution is dried, and shaping the dried solution in a coat shape.

[0054] The organic binding agent constituting the holding sealing material of the present invention is obtained by drying the organic binding agent (organic binding agent solution) dispersed in water.

[0055] The organic binding agent is not particularly limited, and examples thereof include water-soluble organic polymers such as acrylic resin, acrylate-based latex, rubber-based latex, carboxymethyl cellulose, and polyvinyl alcohol, thermoplastic resins such as styrene resin, and thermosetting resins such as epoxy resin.

[0056] The content of the organic binding agent in the present invention, in terms of the solid content, is preferably in a range of 0.1 parts by weight to 10 parts by weight, more preferably in a range of 0.1 parts by weight to 3 parts by weight, and still more preferably in a range of 0.1 parts by weight to 2 parts by weight in relation to 100 parts by weight of the inorganic fiber constituting the holding sealing material.

[0057] If the content of the organic binding agent is less than 0.1 parts by weight in relation to 100 parts by weight of the inorganic fiber, the effect of suppressing the scattering of the inorganic fiber is weak. If the content of the organic binding agent exceeds 10 parts by weight, the effect of improving the surface pressure remain almost unchanged, whereas the amount of cracked gas generated due to the heat of exhaust gas increases, possibly adversely affecting the surrounding environment. Therefore, the content of the organic binding agent is preferably as low as possible, preferably 10 parts by weight or less, more preferably 3 parts by weight or less, and still more preferably 2 parts by weight or less.

[0058] The organic binding agent in the present invention preferably has a glass transition temperature of -5°C or lower, more preferably -10°C or lower, and still more preferably -30°C or lower. When the glass transition temperature of the organic binding agent in the present invention is -5°C or lower, the holding sealing material can have a high degree of coat elongation and be highly flexible while increasing the strength of the binding agent layer. Therefore, the holding sealing material is less likely to fracture when, for example, the holding sealing material is wound around an exhaust gas treatment body.

[0059] Further, the binding agent layer is not too hard, and thus the scattering of the inorganic fiber is less likely to be suppressed.

[0060] The inorganic particles constituting the binding agent layer in the present invention refer to a solid component obtained by removing a solvent from a solution of inorganic particles such as an inorganic sol dispersion solution.

[0061] The inorganic sol dispersion solution (solution of inorganic particles) is not particularly limited, and examples thereof include an alumina sol and a silica sol.

[0062] The inorganic particles are preferably alumina particles derived from an alumina sol or silica particles derived from a silica sol.

[0063] The fact that the organic binding agent component and the inorganic particles are dispersed in the binding agent layer in the present invention can be confirmed using a transmission electron microscope (hereinafter, also referred to as "TEM"). An organic binding agent containing a carbon atom as a main component has a lower electron density and more easily transmits an electron beam than inorganic particles made of alumina, silica, or the like. Therefore, in a TEM image, the organic binding agent component is displayed more brightly than the inorganic particles.

[0064] The content of the inorganic particles in the present invention is preferably in a range of 0.1 parts by weight to 10 parts by weight, more preferably in a range of 0.1 parts by weight to 3 parts by weight, and still more preferably in a range of 0.1 parts by weight to 2 parts by weight in relation to 100 parts by weight of the inorganic fiber constituting the holding sealing material.

[0065] If the content of the inorganic particles is less than 0.1 parts by weight in relation to 100 parts by weight of the inorganic fiber, the content of the inorganic particles is insufficient, and thus the effect of improving the surface pressure is likely to be weak. If the content of the inorganic particles exceeds 10 parts by weight, the effect of improving the surface pressure remains almost unchanged, whereas the binding agent layer may be too hard, making it difficult to suppress the scattering of the inorganic fiber. Therefore, in order to sufficiently suppress the scattering of the inorganic fiber, the content of the inorganic particles in the present invention is preferably in a range of 0.1 parts by weight to 3 parts by weight in relation to 100 parts by weight of the inorganic fiber constituting the holding sealing material of the present invention.

[0066] The inorganic particles in the present invention may have any particle diameters, and the average particle diameter of the inorganic particles is preferably in a range of 0.005 μm to 0.1 μm.

[0067] The number-average molecular weight of the polymer-based dispersant in the present invention is not particularly limited, and is preferably in a range of 500 to 100000.

[0068] The polymer-based dispersant in the present invention may be of any kind, and examples thereof include hydrophilic synthetic polymer substances such as anionic polymer-based dispersants, including polycarboxylic acids and/or salts thereof, naphthalenesulfonate formalin condensates and/or salts thereof, polyacrylic acids and/or salts thereof, polymethacrylic acids and/or salts thereof, and polyvinyl sulfonic acids and/or salts thereof, and nonionic polymer-based dispersants, including polyvinyl alcohol, polyvinylpyrrolidone, and polyethylene glycol; natural hydrophilic polymer substances such as gelatin, casein, and water-soluble starch; and hydrophilic semisynthetic polymer substances such as carboxymethyl cellulose.

[0069] Preferred among these are the hydrophilic synthetic polymer substances, and more preferred are the anionic polymer-based dispersants. For example, when alumina sol-derived alumina particles are used as the inorganic particles, the surfaces of the alumina particles are cationic in the dispersion solution. Therefore, the anionic polymer-based dispersant is likely to be adsorbed to the alumina particles due to the electrostatic attraction force. When the polymer-based dispersant has polarity, the organic binding agent is also preferably one having polarity such as an acrylic resin. This is because the compatibility between the organic binding agent and the polymer-based dispersant in the binding agent layer is enhanced and thus the strength of the binding agent layer is improved due to an anchoring effect.

[0070] In addition, these polymer-based dispersants may be used singly or a plurality thereof may be jointly used. The polymer-based dispersant may be a polymer-based dispersant having a structure exhibiting the properties of an anionic polymer-based dispersant and a structure exhibiting the properties of a nonionic polymer-based dispersant.

[0071] The polymer-based dispersant in the present invention is also particularly preferably an anionic polymer-based dispersant having a number-average molecular weight in a range of 500 to 100000.

[0072] The content of the polymer-based dispersant in the present invention is preferably in a range of 50 ppm to 1000 ppm in relation to the weight of the inorganic fiber constituting the holding sealing material. If the content of the polymer-based dispersant is lower than 50 ppm in relation to the weight of the inorganic fiber, the agglomeration of the inorganic particles and the organic binding agent in the binding agent solution is less likely to be suppressed. If the content of the polymer-based dispersant exceeds 1000 ppm, the effect of dispersing the inorganic particles in the organic binding agent component remains unchanged. Thus, the excessive addition thereof is not preferred.

[0073] In the holding sealing material of the present invention, the inorganic fiber may be a bio-soluble fiber. The bio-soluble fiber refers to an inorganic fiber including silica, for example, and at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds.

[0074] The bio-soluble fiber made of these compounds is easily dissolved even when inhaled into human bodies. Thus, a mat including this inorganic fiber is excellently safe for human bodies.

[0075] A specific example of the composition of the bio-soluble fiber is 60% by weight to 85% by weight of silica and 15% by weight to 40% by weight of at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds. The silica refers to SiO or SiO_2.

[0076] Examples of the alkali metal compounds include oxides of sodium or potassium and examples of the alkaline-earth metal compounds include oxides of magnesium, calcium, strontium, or barium. Examples of the boron compounds include oxides of boron.

[0077] The bio-soluble fiber having a composition in which the content of silica is lower than 60% by weight is difficult to produce by a glass melting method.

[0078] If the content of silica is lower than 60% by weight, the content of silica, which has flexibility, is low, and thus the fiber is structurally brittle. Further, the fraction of at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds, which are easily dissolved in a normal saline solution, is relatively high. Thus, the bio-soluble fiber tends to be too easily dissolved in a normal saline solution.

[0079] If the content of silica exceeds 85% by weight, the fraction of at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds is relatively low, and thus the bio-soluble fiber tends to have a great difficulty in dissolving in a normal saline solution.

[0080] The content of silica is calculated by converting the amounts of SiO and SiO_2 into the amount of SiO_2.

[0081] A bio-soluble fiber having a composition in which the content of at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds exceeds 40% by weight is difficult to produce by a glass melting method. Further, if the content of at least one compound selected from the group consisting of alkali metal compounds, alkaline-earth metal compounds, and boron compounds exceeds 40% by weight, the bio-soluble fiber is structurally brittle and is dissolved in a normal saline solution too easily.

[0082] The bio-soluble fiber in the present invention preferably has a solubility in a normal saline solution of 30 ppm or higher. This is because, if the solubility of the bio-soluble fiber is lower than 30 ppm, the inorganic fiber inhaled into a human body is less likely to be discharged from the human body, which is not preferred in terms of human health.

[0083] Among the inorganic fibers constituting the holding sealing material of the present invention, a glass fiber is a glass-form fiber including silica and alumina as main components and including, in addition to alkali metals, calcia, titania, zinc oxide, and the like.

[0084] In the holding sealing material of the present invention, irregularities by the inorganic particles are formed on the entire surface of the inorganic fiber after the organic binding agent is burnt away due to heat.

[0085] Fig. 2A is a SEM photograph of the inorganic fiber and the binding agent layer formed on the surface thereof constituting the holding sealing material of the present invention, and Fig. 2B is a SEM photograph of the inorganic fiber after the organic binding agent is burnt away by thermally treating the holding sealing material of the present invention.

[0086] The phrase "the organic binding agent is burnt away due to heat" herein means, unless particularly otherwise described, that the organic binding agent is heated at 600°C for one hour in the atmosphere.

[0087] As shown in Fig. 2A, the binding agent layer is formed on the surface of the inorganic fiber constituting the holding sealing material of the present invention, and thus forms a flat surface on which no irregularities are formed. In contrast, in Fig. 2B, a large number of irregularities are formed on the entire surface of the inorganic fiber. This is presumably because the organic binding agent is burnt away, and thus the inorganic particles dispersed in the binding agent layer are exposed. Such irregularities by the inorganic particles formed on the entire surface of the inorganic fiber allow the inorganic fiber strands to be caught by each other due to the irregularities when the inorganic fiber strands come into contact with each other after the organic binding agent is burnt away, and thus the slipping of the surface of the inorganic fiber is prevented. Thereby, the surface pressure is easily improved.

[0088] The shape and other properties of the holding sealing material of the present invention will be described.

[0089] Fig. 3 is a perspective view schematically showing an example of the holding sealing material of the present invention. As shown in Fig. 3, the holding sealing material of the present invention may be formed of a flat mat having a predetermined lengthwise length (hereinafter, indicated by the arrow L in Fig. 3), a width (indicated by the arrow W in Fig. 3), and a thickness (indicated by the arrow T in Fig. 3) and having a substantially rectangular planar shape.

[0090] In the holding sealing material shown in Fig. 3, a protrusion portion is formed at a first end portion 111 which is one end portion of the lengthwise end portions of the holding sealing material, and a recess portion is formed at a second end portion 112 which is the other end portion. The protrusion portion 111 and the recess portion 112 of the holding sealing material have shapes such that the protrusion portion and the recess portion fit together when the holding sealing material is wound around the exhaust gas treatment body in order to assemble an exhaust gas purifying apparatus described below.

[0091] The "substantially rectangular planar shape" conceptually includes the protrusion portion and the recess portion. A shape with a non-right corner angle may also be considered as the substantially rectangular planar shape.

[0092] The holding sealing material of the present invention is preferably subjected to a needle punching treatment. When the inorganic fiber strands are entangled with each other through the needle punching treatment, the entanglement of the inorganic fiber strands is easily strengthened, improving the surface pressure.

[0093] The needle punching treatment can be carried out using a needle punching apparatus. The needle punching apparatus includes a supporting plate for supporting a sheet-like article of an inorganic fiber precursor and a needle board which is provided above the supporting plate and is capable of reciprocally moving in the insertion direction (the thickness direction of a base mat). The needle board has a large number of needles attached thereon. When the needle board is moved toward a sheet-like article of an inorganic fiber precursor placed on the supporting plate and a large number of the needles are inserted into and removed from the sheet-like article of the inorganic fiber precursor, the inorganic fiber strands constituting the inorganic fiber precursor are entangled together in a complicated manner. The number of carrying out the needle punching treatment and the number of the needles may be changed in accordance with the target bulk density and the target basis weight.

[0094] The thickness of the holding sealing material is not particularly limited, and is preferably in a range of 2.0 mm to 20 mm. A holding sealing material having a thickness exceeding 20 mm is non-flexible, and thus it is difficult to handle when wound around the exhaust gas treatment body. Further, winding wrinkles or cracks are likely to be generated in the holding sealing material.

[0095] A holding sealing material having a thickness of smaller than 2.0 mm has an insufficient surface pressure to hold the exhaust gas treatment body. Therefore, the exhaust gas treatment body is likely to slip out. Further, if the volume of the exhaust gas treatment body changes, the holding sealing material has difficulty in absorbing the change in the volume of the exhaust gas treatment body. Therefore, cracks or other defects are easily generated in the exhaust gas treatment body.

[0096] The surface pressure of the holding sealing material of the present invention can be measured using a surface pressure measurement instrument through the following method.

[0097] In the measurement of the surface pressure, a hot surface pressure measurement instrument including a heater in a portion of a plate for compressing the mat is used, and a sample is compressed in a room-temperature state until the gap bulk density (GBD) of the sample reaches 0.3 g/cm^3. The surface pressure at this time is considered as the surface pressure before firing. After that, the sample was held for ten minutes. Meanwhile, the bulk density of the sample is a value obtained by "gap bulk density = weight of sample/(area of sample x thickness of sample)".

[0098] Next, while the sample is heated to 900°C on one surface and 650°C on the other surface at a temperature-rise rate of 40°C/min in a state in which the sample remains compressed, the compression is released until the gap bulk density reaches 0.273 g/cm^3. Further, the sample is held for five minutes in a state that the sample is at 900°C on one surface and at 650°C on the other surface and the gap bulk density is 0.273 g/cm^3.

[0099] Then, the sample is compressed at a rate of 1 inch (25.4 mm)/min until the gap bulk density reaches 0.3 g/cm^3. The load is measured when the gap bulk density reaches 0.273 g/cm^3 after the release of the compression to the gap bulk density of 0.273 g/cm^3 and the compression to the gap bulk density of 0.3 g/cm^3 are repeated 1000 times. The obtained load is divided by the area of the sample, thereby obtaining the surface pressure (kPa). The obtained surface pressure is considered as the surface pressure after firing.

[0100] The scattering properties of the inorganic fiber constituting the holding sealing material of the present invention can be measured in the following order.

[0101] First, a 100 mm x 100 mm specimen is cut out from the holding sealing material and is used as a scattering-test sample 210. For this scattering-test sample, the scattering rate of the inorganic fiber can be measured using a measurement instrument shown in Figs. 4A and 4B.
Fig. 4A is a side view schematically showing one example of the measurement instrument for measuring the scattering properties of the inorganic fiber. As shown in Fig. 4A, a testing apparatus 200 includes a base 250, two pillars 260 provided upright on the base 250, and sample-supporting arms 270 connected to the top end portions of the pillars 260 so as to be pivotable within a predetermined range. Furthermore, a vertical wall member 290 is fixed between the two pillars at a position at which the sample-supporting arms is to collide with the vertical wall member.

[0102] In addition, Fig. 4B is a plan view schematically showing an example of the sample-supporting arm constituting the measurement instrument for measuring the scattering properties of the inorganic fiber. As shown in Fig. 4B, the other end portions of the sample-supporting arms 270 are fixed using a first sample-fixing member 280 that connects the end portions of the sample-supporting arms 270. A second sample-fixing member 280 is disposed at a position a certain distance away from the first sample-fixing member 280 connected to the end portions of the sample-supporting arms 270 toward the pillars 260, and the two sample-supporting arms 270 are connected to each other using the sample-fixing members in at least two positions.

[0103] The sample-supporting arms 270 are locked using a predetermined locking mechanism at a position where the sample-supporting arms 270 form an angle of 90° with the pillars 260, and the scattering-test sample 210 is fixed to the sample-fixing member 280 using clips 220. When the sample-supporting arms 270 are unlocked, the sample-supporting arms 270 and the testing sample 210 begin to drop toward the base 250 fixing the pillars 260, and then change the direction so as to pivot around the connection portion between the sample-supporting arms 270 and the pillars 260. When the sample-supporting arms 270 and the pillars 260 become parallel to each other, the sample-supporting arms 270 collide with the vertical wall member 290. This collision causes part of the inorganic fiber constituting the testing sample 290 to break and scatter. Therefore, the fiber scattering rate can be obtained by measuring the weights of the scattering-test sample before and after the collision and using Equation (5) below:

$$\text{Fiber scattering rate (\% by weight)} = \{(\text{weight of scattering-test sample before testing}) - (\text{weight of scattering-test sample after testing})\}/(\text{weight of scattering-test sample before testing}) \times 100 \qquad (5)$$

[0104] The basis weight (the weight per unit area) of the holding sealing material of the present invention is not particularly limited, and is preferably in a range of 200 g/m^2 to 4000 g/m^2, and more preferably in a range of 1000 g/m^2 to 3000 g/m^2. If the basis weight of the holding sealing material is smaller than 200 g/m^2, the holding force is not sufficient. If the basis weight of the holding sealing material exceeds 4000 g/m^2, the bulk of the holding sealing material does not easily decrease. Therefore, if an exhaust gas purifying apparatus is manufactured using such a holding sealing material, the exhaust gas treatment body easily drops.

[0105] The bulk density of the holding sealing material of the present invention (the bulk density of the holding sealing material before being wound) is also not particularly limited, and is preferably in a range of 0.10 g/cm^3 to 0.30 g/cm^3. If the bulk density of the holding sealing material is lower than 0.10 g/cm^3, the entanglement of the inorganic fiber strands is weak and the inorganic fiber is easily peeled off, making it difficult to hold a predetermined shape of the holding sealing material.

[0106] If the bulk density of the holding sealing material exceeds 0.30 g/cm^3, the holding sealing material is hard, so that the winding properties of the inorganic fiber around the exhaust gas treatment body degrade and the holding sealing material is easily cracked.

[0107] The holding sealing material of the present invention may further include an expandable material. The expandable material preferably has a characteristic of expanding in a range of 400°C to 800°C.

[0108] The holding sealing material including the expandable material expands in a range of 400°C to 800°C, and thus can improve the holding force when the holding sealing material is used in a high temperature range of higher than 700°C in which the strength of the glass fiber weakens.

[0109] Examples of the expandable material include vermiculite, bentonite, phlogopite, pearlite, expandable graphite, and expandable fluoride mica. These expandable materials may be used singly or two or more threof may be jointly used.

[0110] The amount of the expandable material added is not particularly limited, and is preferably in a range of 10% by weight to 50% by weight, and more preferably in a range of 20% by weight to 30% by weight in relation to the total weight of the holding sealing material.

[0111] When the holding sealing material of the present invention is used as a holding sealing material of an exhaust gas purifying apparatus, the number of the holding sealing materials constituting the exhaust gas purifying apparatus is not particularly limited, and one holding sealing material may be used or a plurality of the holding sealing materials combined together may be used. A plurality of the holding sealing materials may be combined by any method, and examples thereof include a method of combining the holding sealing materials together by machine sewing and a method of bonding the holding sealing materials together using adhesive tape or adhesive.

[0112] Next, the method for manufacturing a holding sealing material of the present invention will be described.

[0113] The manufacturing method of the present invention is suitable as a method for manufacturing the holding sealing material of the present invention.

[0114] The method for manufacturing a holding sealing material of the present invention includes a mat preparation step of preparing a mat including an inorganic fiber; a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a mixture and then mixing the mixture with an organic binding agent dispersed in water; a supply step of supplying the binding agent solution to the mat; and a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

(a) Mat preparation step

[0115] In the method for manufacturing a holding sealing material of the present invention, first, the mat preparation step of preparing a mat including the inorganic fiber is carried out.

[0116] The mat constituting the holding sealing material can be obtained by a variety of methods. For example, the mat can be manufactured by a needling method or a sheet-making method.

[0117] In the case of the needling method, the mat can be manufactured by, for example, the following method.

[0118] That is, first, a mixture for spinning including raw materials such as a basic aqueous solution of aluminum chloride and a silica sol is spun by a blowing method, thereby producing an inorganic fiber precursor having an average fiber diameter in a range of 3 μm to 10 μm. Subsequently, the inorganic fiber precursor is compressed so as to produce a continuous sheet-like article having a predetermined size. A needle punching treatment is carried out on the sheet-like article, and then a firing treatment is carried out, thereby completing the preparation of the mat.

[0119] In the case of the sheet-making method, an inorganic fiber such as an alumina fiber or a silica fiber, inorganic particles, and water are mixed together so that the content of the inorganic fiber in a raw material solution reaches a predetermined value. The mixture is then stirred using a stirrer, thereby preparing a liquid mixture. To the liquid mixture may be added a colloid solution containing a polymer compound or a resin as necessary. Subsequently, the liquid mixture is poured into a molder having a filter formed on the bottom surface, and then water in the liquid mixture is dehydrated through the filter, thereby producing a raw material sheet. Thereafter, the raw material sheet is heated and compressed under predetermined conditions, thereby completing the preparation of the mat.

(b) Binding agent solution preparation step

[0120] Next carried out is the binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution and then mixing the solution with an organic binding agent (organic binding agent solution) dispersed in water. First, a solution containing the inorganic particles and the polymer-based dispersant mixed therein is prepared, so that the surfaces of the inorganic particles are covered with the polymer-based dispersant. Subsequently, the solution is mixed with an organic binding agent dispersed in water, whereby the inorganic particles covered with the polymer-based dispersant and the organic binding agent are dispersed in water.

[0121] The solution of inorganic particles used in the binding agent solution preparation step of the present invention is not particularly limited, and the solutions of inorganic particles mentioned in the description of the holding sealing material of the present invention can be used, such as alumina sol and silica sol.

[0122] In the binding agent solution preparation step of the present invention, the concentration of the solution of inorganic particles is not particularly limited, and a solution in which the concentration of the inorganic particles is diluted to approximately 0.2% by weight to 20% by weight in terms of solid content is preferably used.

[0123] In the binding agent solution preparation step of the present invention, the polymer-based dispersant to be mixed with the solution of inorganic particles is not particularly limited, and the polymer-based dispersants mentioned in the description of the holding sealing material of the present invention can be used, and thus the detailed description thereof is omitted here. The same shall apply to a preferred range of the number-average molecular weight and a preferred kind thereof.

[0124] The concentration of the polymer-based dispersant in the binding agent solution prepared in the binding agent solution preparation step of the present invention is not particularly limited, and is preferably in a range of 50 ppm to 1000 ppm. If the concentration of the polymer-based dispersant is lower than 50 ppm, the amount of the polymer-based dispersant is not sufficient, making it difficult to suppress the agglomeration of the inorganic particles and the organic binding agent in the binding agent solution. If the concentration of the polymer-based dispersant exceeds 1000 ppm, the effect of dispersing the inorganic particles remains unchanged, and thus the excessive addition thereof is not preferred.

[0125] The organic binding agent used in the binding agent solution preparation step of the present invention is not particularly limited, and the organic binding agents mentioned in the description of the holding sealing material of the present invention can be used. Thus, the detailed description thereof is omitted here.

[0126] In the binding agent solution preparation step of the present invention, the concentration of the organic binding agent solution is not particularly limited, and a solution in which the concentration of the organic binding agent solution is diluted to approximately 0.2% by weight to 20% by weight in terms of solid content is preferably used.

[0127] In the binding agent solution preparation step of the present invention, the glass transition temperature of the organic binding agent is not particularly limited, and is preferably -5°C or lower, more preferably -10°C or lower, and still more preferably -30°C or lower.

[0128] In the binding agent solution preparation step of the present invention, the mixing ratio between the solution of the inorganic particles and the polymer-based dispersant mixed therein and the organic binding agent solution is not particularly limited, and the solution of the inorganic particles and the polymer-based dispersant mixed therein and the organic binding agent solution are preferably mixed in a weight ratio ((weight of solid content of inorganic particles in solution of inorganic particles and polymer-based dispersant mixed therein):(weight of solid content of organic binding agent in organic binding agent solution)) in a range of 3:1 to 1:3.

[0129] In the binding agent solution preparation step of the present invention, a pH adjuster for adjusting the pH of the binding agent solution may be added.

(c) Supply step

[0130] Next, the supply step of supplying the binding agent solution to the mat is carried out.

[0131] In the supply step, the mat can be brought into contact with the binding agent solution by any method. For example, the binding agent solution may be supplied to the inorganic fiber in the mat by impregnating the mat with the binding agent solution; the binding agent solution may be supplied to the inorganic fiber in the mat by dropping the binding agent solution onto the mat using, for example, a curtain coating method; or the binding agent solution may be sprayed to the mat by spray coating.

[0132] Furthermore, the amount of the binding agent solution supplied is preferably adjusted to fall into a range of 50 parts by weight to 200 parts by weight in relation to 100 parts by weight of the inorganic fiber constituting the mat by dehydrating the mat supplied with the binding agent solution.

(d) Drying step

[0133] Thereafter, the drying step of drying the mat supplied with the binding agent solution at a temperature in a range of approximately 110°C to 140°C is carried out, so that the organic binding agent and the inorganic particles are dried and the solvent in the binding agent solution is evaporated, whereby the holding sealing material of the present invention including the organic binding agent, the inorganic particles, and the polymer-based dispersant in the binding agent layer is manufactured.

[0134] In order to give the holding sealing material a shape provided with a protrusion portion and a recess portion as shown in Fig. 3, a cutting step of cutting the holding sealing material into a predetermined shape may be further carried out.

[0135] In the method for manufacturing a holding sealing material of the present invention, the binding agent solution prepared by mixing the solution of inorganic particles and the polymer-based dispersant to prepare a mixture, and then mixing the mixture with the organic binding agent dispersed in water is supplied to the mat formed of the inorganic fiber. Since the solution of inorganic particles and the polymer-based dispersant are mixed in advance, the surfaces of the inorganic particles are covered with the polymer-based dispersant and the agglomeration of the organic binding agent and the inorganic particles is suppressed in the subsequent mixing with the organic binding agent. In addition, the agglomeration of the organic binding agent is also suppressed due to the effect of the polymer-based dispersant. Therefore, the binding agent solution is supplied to the entire surface of the inorganic fiber in the supply step, and formed into a binding agent layer through the drying step.

[0136] The binding agent layer formed through the steps (a) to (d) includes the organic binding agent, the inorganic particles, and the polymer-based dispersant, and thus has high tensile strength. Therefore, the surface pressure of a holding sealing material manufactured by the method for manufacturing a holding sealing material of the present invention is high. Furthermore, since the binding agent layer is formed on the entire surface of the inorganic fiber, the scattering of the inorganic fiber can be suppressed no matter where the inorganic fiber is broken.

[0137] Next, the other aspect of the holding sealing material of the present invention will be described.

[0138] The another aspect of the holding sealing material of the present invention is a holding sealing material manufactured by the method for manufacturing a holding sealing material of the present invention, and is manufactured through steps including a mat preparation step of preparing a mat including an inorganic fiber; a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution mixture and then mixing the mixture with an organic binding agent dispersed in water; a supply step of supplying the binding agent solution to the mat; and a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

[0139] Regarding the respective steps for manufacturing the other aspect of the holding sealing material of the present invention, the same steps as those described in the section of the method for manufacturing a holding sealing material of the present invention can be used unless particularly otherwise described.

[0140] In the other aspect of the holding sealing material of the present invention, the polymer-based dispersant used in the binding agent solution preparation step is preferably an anionic polymer-based dispersant.

[0141] In the binding agent solution preparation step of the other aspect of the holding sealing material of the present invention, the binding agent solution is preferably prepared so that the weight of the solid content of the inorganic particles falls in a range of 0.1 parts by weight to 10 parts by weight, the binding agent solution is more preferably adjusted so that the weight of the solid content of the inorganic particles falls in a range of 0.1 parts by weight to 3 parts by weight, and the binding agent solution is still more preferably adjusted so that the weight of the solid content of the inorganic particles falls in a range of 0.1 parts by weight to 2 parts by weight. The binding agent solution is preferably prepared so that the weight of the solid content of the organic binding agent falls in a range of 0.1 parts by weight to 10 parts by weight, the binding agent solution is more preferably adjusted so that the weight of the solid content of the organic binding agent falls in a range of 0.1 parts by weight to 3 parts by weight, and the binding agent solution is still more preferably adjusted so that the weight of the solid content of the organic binding agent falls in a range of 0.1 parts by weight to 2 parts by weight. The organic binding agent is preferably an organic binding agent having a glass transition temperature of -5°C or lower, more preferably an organic binding agent having a glass transition temperature of -10°C or lower, and still more preferably an organic binding agent having a glass transition temperature of -30°C or lower.

[0142] In the binding agent solution preparation step, the binding agent solution is preferably prepared such that the tensile strength of the binding agent layer obtained by drying the binding agent solution reaches 5.0 MPa or higher.

[0143] In the other aspect of the holding sealing material of the present invention, preferably, the surfaces of the inorganic particles are covered with the binding agent layer and the binding agent layer includes the organic binding agent, the inorganic particles, and the polymer-based dispersant.

[0144] The mat preparation step, the binding agent solution preparation step, the supply step, and the drying step make it possible to produce a holding sealing material in which the surfaces of the inorganic particles are covered with the binding agent layer and the binding agent layer includes the organic binding agent, the inorganic particles, and the polymer-based dispersant.

[0145] In the other aspect of the holding sealing material of the present invention, the binding agent layer is preferably formed on the entire surface of the inorganic fiber. In addition, preferably, the surfaces of the inorganic particles are covered with the polymer-based dispersant and the inorganic particles are dispersed in the organic binding agent component.

[0146] In a case in which the organic binding agent is burnt away due to heat, irregularities by the inorganic particles are preferably formed on the entire surface of the inorganic fiber.

[0147] Since the polymer-based dispersant suppresses the agglomeration of the inorganic particles and the organic binding agent in water, the binding agent solution prepared in the binding agent solution preparation step is an binding agent solution including the organic binding agent and the inorganic particles dispersed in water. The binding agent solution including the organic binding agent and the inorganic particles dispersed in water easily spread throughout the entire surface of the inorganic fiber, and thus the binding agent layer can be formed on the entire surface of the inorganic fiber by supplying the binding agent solution to the mat. This results in production of a holding sealing material including the binding agent layer formed on the entire surface of the inorganic fiber.

[0148] Since the surfaces of the inorganic particles are covered with the polymer-based dispersant by mixing the inorganic particles and the polymer-based dispersant, a holding sealing material can be produced in which the surfaces of the inorganic particles are covered with the polymer-based dispersant and the inorganic particles are dispersed in the organic binding agent component.

[0149] Since a structure is formed in which the inorganic particles spread over the entire surface of the inorganic fiber, a holding sealing material is produced in which irregularities by the inorganic particles are formed on the entire surface of the inorganic fiber after the organic binding agent is burnt away due to heat.

[0150] The holding sealing material of the present invention can be used as a holding sealing material in an exhaust gas purifying apparatus.

[0151] Hereinafter, an exhaust gas purifying apparatus of the present invention will be described.

[0152] The exhaust gas purifying apparatus of the present invention is an exhaust gas purifying apparatus including a metal casing, an exhaust gas treatment body housed in the metal casing, and a holding sealing material wound around the exhaust gas treatment body and interposed between the exhaust gas treatment body and the metal casing, in which the holding sealing material is the holding sealing material of the present invention, the other aspect of the holding sealing material of the present invention, or a holding sealing material manufactured by the method for manufacturing a holding sealing material of the present invention.

[0153] Fig. 5 is a cross sectional view schematically showing an example of the exhaust gas purifying apparatus of the present invention.

[0154] As shown in Fig. 5, an exhaust gas purifying apparatus 100 of the present invention includes a metal casing 130, an exhaust gas treatment body 120 housed in the metal casing 130, and a holding sealing material 110 interposed between the exhaust gas treatment body 120 and the metal casing 130.

[0155] The exhaust gas treatment body 120 is a pillar-shaped article including a plurality of cells 125 are arranged longitudinally in parallel with one another with a cell wall 126 interposed therebetween. If necessary, one end portion of the metal casing 130 is connected to an introduction pipe through which exhaust gas emitted from an internal combustion engine is introduced and an emission pipe through which exhaust gas that has passed through the exhaust gas purifying apparatus is discharged.

[0156] Next, the exhaust gas treatment body (honeycomb filter) and the metal casing constituting the exhaust gas purifying apparatus of the present invention will be described.

[0157] The structure of the holding sealing material constituting the exhaust gas purifying apparatus has been already described as the holding sealing material of the present invention, and thus is not described again.

[0158] The material of the metal casing constituting the exhaust gas purifying apparatus of the present invention can be any heat-resistant metal, and specific examples thereof include metals such as stainless steel, aluminum, and iron.

[0159] The shape of the metal casing constituting the exhaust gas purifying apparatus of the present invention can suitably be a substantially cylindrical shape, as well as a clamshell shape, a downsizing shape, or the like.

[0160] Subsequently, the exhaust gas treatment body constituting the exhaust gas purifying apparatus will be described.

[0161] Fig. 5 is a perspective view schematically showing an example of the exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention.

[0162] The exhaust gas treatment body 120 shown in Fig. 5 is a honeycomb structured body comprising a pillar-shaped ceramic material in which a plurality of the cells 125 are arranged longitudinally in parallel with one another with the cell wall 126 interposed therebetween. Either one end portion of each of the cells 125 is sealed with a sealing material 128.

[0163] When either one end portion of each of the cells 125 are sealed, cells each having a sealed end portion and cells each having a non-sealed end portions are preferably alternately disposed in a view of one end portion of the exhaust gas treatment body 120.

[0164] The cross sectional shape of the exhaust gas treatment body 120 cut in a direction perpendicular to the longitudinal direction is not particularly limited, and may be a substantially circular shape or a substantially elliptical shape, or may be a substantially polygonal shape such as a substantially triangular shape, a substantially rectangular shape, a substantially pentagonal shape, or a substantially hexagonal shape.

[0165] The cross sectional shape of the cell 125 constituting the exhaust gas treatment body 120 may be a substantially polygonal shape such as a substantially triangular shape, a substantially rectangular shape, a substantially pentagonal shape, or a substantially hexagonal shape, or may be a substantially circular shape or a substantially elliptical shape. The exhaust gas treatment body 120 may be a combination of cells having different cross-sectional shapes.

[0166] The material constituting the exhaust gas treatment body 120 is not particularly limited, and it may be a non-oxide such as silicon carbide or silicon nitride, or an oxide such as cordierite or aluminum titanate. Preferred among these is a non-oxide porous fired body such as silicon carbide or silicon nitride.

[0167] Since these porous fired bodies are brittle materials, they are likely to fracture due to a mechanical shock, for example. However, in the exhaust gas purifying apparatus of the present invention, the holding sealing material 110 is provided around the side faces of the exhaust gas treatment body 120 and absorbs the shock, and thus it can prevent cracks and other defects from being generated in the exhaust gas treatment body 120 due to a mechanical shock or a thermal shock.

[0168] The exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention may carry a catalyst for purifying exhaust gas, and preferable examples of the catalyst to be carried include noble metals such as platinum, palladium, and rhodium, and platinum is more preferred among these. Examples of other catalysts include alkali metals such as potassium and sodium and alkaline-earth metals such as barium. These catalysts may be used singly or two or more thereof may be jointly used. Such a catalyst carried makes it easy to burn and remove PM, and enables to purify toxic exhaust gas.

[0169] The exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention may be an integrated honeycomb structured body which is made of cordierite, for example, and is integrally formed, or an aggregated honeycomb structured body which is made of silicon carbide, for example, and is formed by bonding, through a paste mainly including a ceramic, a plurality of pillar-shaped honeycomb fired bodies in which a plurality of through holes are arranged longitudinally in parallel with one another with a partition wall interposed therebetween.

[0170] The exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention may have cells whose end portions are not sealed by a sealing material. When the exhaust gas treatment body in this case carries a catalyst such as platinum, the exhaust gas treatment body can function as a catalyst carrier that purifies harmful gas components such as CO, HC, and NOx contained in exhaust gas.

[0171] The exhaust gas treatment body constituting the exhaust gas purifying apparatus of the present invention may have a peripheral coat layer formed on the outer peripheral face. The peripheral coat layer formed on the outer peripheral face of the exhaust gas treatment body can reinforce the outer periphery of the exhaust gas treatment body, maintain the shape well organized, and improve the thermal insulation. The outer peripheral face of the exhaust gas treatment body refers to the side face portion of the pillar-shaped exhaust gas treatment body.

[0172] A case in which exhaust gas passes through the exhaust gas purifying apparatus 100 having the above-described constitution will be described below with reference to Fig. 5.

[0173] As illustrated in Fig. 5, exhaust gas emitted from an internal combustion engine and flowed into the exhaust gas purifying apparatus 100 (in Fig. 5, exhaust gas is indicated as G, and the flow of the exhaust gas is indicated using an arrow) flows into one cell 125 opened on an exhaust gas inflow end face 120a of the exhaust gas treatment body (honeycomb filter) 120 and passes through the cell wall 126 partitioning the cells 125. At this time, PM in the exhaust gas is captured in the cell wall 126, and thereby the exhaust gas is purified. The purified exhaust gas flows out from another cell 125 opened on an exhaust gas treatment-side end face 120b and is emitted outside.

[0174] Next, a method for manufacturing the exhaust gas purifying apparatus of the present invention will be described.

[0175] Fig. 7 is a perspective view schematically illustrating an example of a method for manufacturing the exhaust gas purifying apparatus of the present invention.

[0176] With respect to the exhaust gas treatment body and the holding sealing material constituting the exhaust gas purifying apparatus of the present invention, a holding sealing material 110 is wound along the periphery of an exhaust gas treatment body 120 to form a wound body 140, as shown in Fig. 7. Next, the wound body 140 is housed in the metal casing 130, thereby producing the exhaust gas purifying apparatus of the present invention.

[0177] Examples of a method for housing the wound body 140 in the metal casing 130 include a press-fitting method (stuffing method) in which the exhaust gas treatment body 120 provided with the holding sealing material 110 around the periphery is press-fitted into a predetermined position in the metal casing 130; a sizing method (swaging method) in which the metal casing 130 is compressed from the outer periphery side so that the inner diameter of the metal casing decreases; and a clamshell method in which the metal casing is provided with a shape that can be separated into a first casing component and a second casing component, the wound body 140 is placed on the first casing, and then is covered with the second casing, thereby sealing the wound body.

[0178] In the case of the press-fitting method (stuffing method) for housing the wound body in the metal casing, the inner diameter of the metal casing (the inner diameter of a portion to house the exhaust gas treatment body) is preferably set to be slightly smaller than the outer diameter of the wound body.

[0179] The exhaust gas purifying apparatus of the present invention may include two or more, a plurality of the holding sealing materials that are bonded together. The holding sealing materials may be bonded together by any method, and examples thereof include a method of binding the holding sealing materials together by machine sewing and a method of bonding the holding sealing materials together using adhesive tape or adhesive.

[0180] Through the above-described steps, the exhaust gas purifying apparatus of the present invention is manufactured.

[0181] In the exhaust gas purifying apparatus of the present invention, the holding sealing material is interposed between the exhaust gas treatment body and the metal casing, and the holding sealing material is the holding sealing material of the present invention, the other aspect of the holding sealing material of the present invention, or a holding sealing material manufactured using the method for manufacturing a holding sealing material of the present invention.

[0182] Therefore, the holding sealing material is capable of exhibiting a high surface pressure and stably holding the exhaust gas treatment body. After the organic binding agent in the binding agent layer is burnt away due to the heat of exhaust gas, irregularities by the inorganic particles are formed on the entire surface of the inorganic fiber. Such irregularities by the inorganic particles formed on the entire surface of the inorganic fiber make the inorganic fiber strands less likely to slip, make it possible to maintain a high surface pressure, and make it possible to suppress a damage of the exhaust gas treatment body.

[0183] Furthermore, the scattering of the inorganic fiber can be suppressed no matter where the inorganic fiber constituting the holding sealing material is broken.

[0184] Hereinafter, the effects of the holding sealing material of the present invention, the method for manufacturing a holding sealing material, the other aspect of the holding sealing material, and the exhaust gas purifying apparatus will be described.

[0185]

(1) In the holding sealing material of the present invention, the binding agent layer includes the polymer-based dispersant. Thus, the agglomeration of the organic binding agent and the inorganic particles in the binding agent layer is suppressed. As the agglomeration of the organic binding agent is suppressed, the binding agent layer including the organic binding agent is formed on a wide range of the surface of the inorganic fiber. Furthermore, since the binding agent layer includes the inorganic particles, the binding agent layer has an excellent tensile strength. Since the agglomeration of the inorganic particles is suppressed due to the polymer-based dispersant, the strength of the binding agent layer is high over a wide range.

[0186] If the strength of the binding agent layer is weak, the contact between the inorganic fiber strands causes peeling of the binding agent layer and slipping of the inorganic fiber strands, so that the surface pressure of the holding sealing material decreases. However, the binding agent layer having high strength prevents the slipping of the inorganic fiber strands, and thus the holding sealing material can have a high surface pressure.

[0187] Furthermore, in the holding sealing material of the present invention, the binding agent layer is formed on a wide range of the surface of the inorganic fiber. Thus, after the organic binding agent or the polymer-based dispersant in the binding agent layer is decomposed due to the heat of exhaust gas, the inorganic particles constituting the binding agent layer are exposed, forming irregularities on a wide range of the surface of the inorganic fiber. Such irregularites generated by the inorganic particles make the friction between the inorganic fiber strands stronger, and, thus the holding sealing material can have a high surface pressure even after the binding agent layer is decomposed due to the heat of exhaust gas.

[0188]

(2) The method for manufacturing a holding sealing material of the present invention can easily manufacture a holding sealing material having the above-described structure.

[0189]

(3) The another aspect of the holding sealing material of the present invention is capable of exhibiting the same effects as the holding sealing material of the present invention.

[0190]

(4) In the exhaust gas purifying apparatus of the present invention, the holding sealing material is interposed between

the exhaust gas treatment body and the metal casing. Thus, leakage of exhaust gas can be suppressed. In addition, since the binding agent layer including the polymer-based dispersant is formed on the surface of the inorganic fiber constituting the holding sealing material, the holding sealing material has a high surface pressure, and thus can stably hold the exhaust gas treatment body.

[0191]

(5) Furthermore, in the exhaust gas purifying apparatus of the present invention, the binding agent layer is burnt away due to, for example, the stream of exhaust gas passing through the exhaust gas treatment body constituting the exhaust gas purifying apparatus. After the binding agent layer is burnt away, the inorganic particles constituting the binding agent layer are exposed, and the friction between the inorganic fiber strands increases, which enables to maintain a high surface pressure.

(Examples)

[0192] Hereinafter, examples more specifically disclosing the present invention will be described. Meanwhile, the present invention is not limited only to these examples.

(Example 1)

(a) Mat preparation step

[0193] First, a mat including an inorganic fiber was prepared in the following order.

(a-1) Spinning step

[0194] A basic aqueous solution of aluminum chloride was prepared so as to have an Al content of 70 g/l and have an Al to Cl ratio of 1:1.8 (atomic ratio). To this aqueous solution was blended a silica sol so that the compositional ratio (Al_2O_3:SiO_2) in the fired inorganic fiber reached 72:28 (weight ratio). Furthermore, an appropriate amount of an organic polymer (polyvinyl alcohol) was added thereto, thereby preparing a liquid mixture.

[0195] The obtained liquid mixture was condensed to be a mixture for spinning, and this mixture for spinning was spun by a blowing method, thereby producing an inorganic fiber precursor having an average fiber diameter of 5.1 μm.

(a-2) Compression step

[0196] The inorganic fiber precursor obtained in the step (a-1) was compressed, thereby producing a continuous sheet-like article.

(a-3) Needle punching step

[0197] The sheet-like article obtained in the step (a-2) was continuously subjected to a needle punching treatment using the following conditions, thereby producing a needle-punched article.

[0198] First, a needle board provided with needles at a density of 21 needles/cm^2 was prepared. Next, this needle board was disposed above one surface of the sheet-like article and was moved up and down once along the thickness direction of the sheet-like article, i.e., a needle punching treatment was carried out, thereby producing a needle-punched article. At this time, the needles were sufficiently moved down so that barbs formed at the tip portions of the needles fully penetrated through the opposite surface of the sheet-like article.

(a-4) Sintering step

[0199] The needle-punched article obtained in the step (a-3) was continuously fired with a peak temperature of 1250°C, thereby manufacturing a fired sheet-like article including an inorganic fiber formed of alumina (72 parts by weight) and silica (28 parts by weight). The average fiber diameter of the inorganic fiber was 5.1 μm and the minimum value of the inorganic fiber diameter was 3.2 μm. The fired sheet-like article obtained as described above had a bulk density of 0.15 g/cm^3 and a basis weight of 1500 g/m^2.

(a-5) Cutting step

[0200] The fired sheet-like article obtained in the step (a-4) was cut, thereby producing a mat including the inorganic fiber.

(b) Binding agent solution preparation step

(b-1) Organic binding agent solution preparation step

[0201] An acrylate-based latex (NIPOL LX854E manufactured by ZEON Corporation (solid concentration: 45 wt%)) containing acryl rubber having a glass transition temperature of -10°C dispersed in water was diluted with water, thereby preparing an organic binding agent solution having a solid concentration of 2% by weight.

(b-2) Inorganic binding agent solution preparation step

[0202] An alumina colloid solution (alumina sol) (ALUMINA SOL 550 manufactured by Nissan Chemical Industries, Ltd. (solid concentration: 15 wt%)) was diluted with water. Then, an anionic polymer-based dispersant (NOPCOSANT RFA manufactured by San Nopco Limited) was added thereto and the components were sufficiently stirred, thereby preparing an inorganic binding agent solution having a solid concentration of the inorganic particles of 2% by weight and a concentration of the anionic polymer-based dispersant of 500 ppm.

(b-3) Binding agent solution preparation step

[0203] The organic binding agent solution obtained in the step (b-1) was added to the solution of inorganic particles obtained in the step (b-2) so that the weight ratio between the solution of inorganic particles and the organic binding agent solution reached 1:1. Then, the components were sufficiently stirred, thereby preparing a binding agent solution having a solid concentration of the organic binding agent of 1% by weight, a solid concentration of the inorganic particles of 1% by weight, and a concentration of the anionic polymer-based dispersant of 250 ppm.

(c) Supply step

[0204] The binding agent solution obtained in the binding agent solution preparation step (b) was supplied to the mat obtained in the mat preparation step (a) by a curtain coating method.

(d) Drying step

(d-1) Dehydration step

[0205] The mat to which the binding agent solution had been supplied in the supply step (c) was suction-dehydrated using a dehydrator so that 100 parts by weight of the binding agent solution was supplied to 100 parts by weight of the inorganic fiber.

(d-2) Drying step

[0206] The mat after the dehydration step (d-1) was heated and hot-air-dried by blowing hot air having a temperature of 130°C at a wind speed of 2 m/s, thereby producing a holding sealing material.

(Example 2)

[0207] A holding sealing material was manufactured in the same manner as in Example 1 except that an acrylate-based latex (NIPOL LX874 manufactured by ZEON Corporation (solid concentration: 45 wt%)) containing acryl rubber having a glass transition temperature of -31°C dispersed in water was used as the organic binding agent.

(Example 3)

[0208] A holding sealing material was manufactured in the same manner as in Example 2 except that the solid concentration of the organic binding agent solution was 1.0% by weight in the organic binding agent solution preparation step (b-1) and that the solid concentration of the inorganic particles in the solution of inorganic particles was changed to 3.0% by weight in the inorganic particle solution preparation step (b-2).

[0209] At this time, the amount of the inorganic particles included in the binding agent layer constituting the holding sealing material was 1.5 parts by weight in relation to 100 parts by weight of the inorganic fiber, and the amount of the organic binding agent was 0.5 parts by weight in relation to 100 parts by weight of the inorganic fiber.

(Example 4)

[0210] A holding sealing material was manufactured in the same manner as in Example 1 except that a polyethylene glycol-based dispersant (EMANON 1112 manufactured by Kao Corporation) was used as the polymer-based dispersant.

(Example 5)

[0211] A holding sealing material was manufactured in the same manner as in Example 1 except that a naphthalene sulfonate formalin condensate-based dispersant (DEMOL N manufactured by Kao Corporation) was used as the polymer-based dispersant.

(Example 6)

[0212] A holding sealing material was manufactured in the same manner as in Example 1 except that a polyvinyl alcohol-based dispersant (DENKA POVAL B-24N manufactured by Denki Kagaku Kogyo Kabushiki Kaisha) was used as the polymer-based dispersant.

(Comparative Example 1)

[0213] A holding sealing material was manufactured in the same manner as in Example 2 except that the polymer-based dispersant was not added in the inorganic particle solution preparation step (b-2).

(Comparative Example 2)

[0214] A holding sealing material was manufactured in the same manner as in Example 2 except that the organic binding agent was not added in the binding agent solution preparation step (b).

(Comparative Example 3)

[0215] A holding sealing material was manufactured in the same manner as in Example 2 except that the inorganic particles were not added in the binding agent solution preparation step (b).

(Test of tensile strength of binding agent layer)

[0216] The binding agent solution prepared in each of the Examples and the Comparative Examples was poured into a framed glass plate and left to stand at room temperature until it was dried. Then, the dried article was punched, thereby producing a 0.4-mm-thick dumbbell-shaped test specimen. A tensile strength test was carried out on this test specimen using an Instron-type tensile tester at a rate of 300 mm/min, thereby measuring the tensile strength (tensile strength at break) of the binding agent layer. The results are shown in Table 1.

[Table 1]

	Content of inorganic particles (parts by weight)	Content of organic binding agent (parts by weight)	Glass transition temperature of organic binding agent (°C)	Tensile strength of binding agent layer (MPa)	Surface pressure before firing (kPa)	Surface pressure after firing (kPa)	Scattering ratio of fiber (wt%)
Example 1	1.0	1.0	-10	11.6	176	41	0.12
Example 2	1.0	1.0	-31	9.1	170	37	0.07
Example 3	1.5	0.5	-31	6.3	178	40	0.14

(continued)

	Content of inorganic particles (parts by weight)	Content of organic binding agent (parts by weight)	Glass transition temperature of organic binding agent (°C)	Tensile strength of binding agent layer (MPa)	Surface pressure before firing (kPa)	Surface pressure after firing (kPa)	Scattering ratio of fiber (wt%)
Example 4	1.0	1.0	-10	10.5	174	39	0.11
Example 5	1.0	1.0	-10	9.8	172	38	0.10
Example 6	1.0	1.0	-10	11.3	175	39	0.11
Comparative Example 1	1.0	1.0	-31	0.4	138	29	0.09
Comparative Example 2	1.0	0.0	-	-	188	43	0.59
Comparative Example 3	0.0	1.0	-31	0.9	142	22	0.03

(Surface pressure test)

[0217] A surface pressure test was carried out on the holding sealing material of each of the Examples and the Comparative Examples.

[0218] The method for testing the surface pressure using a surface pressure measurement instrument has already been described in the description of the holding sealing material of the present invention.

[0219] The results are shown in Table 1.

(Test of scattering properties of inorganic fiber)

[0220] A test of the scattering properties of the inorganic fiber was carried out on the holding sealing material manufactured in each of the Examples and the Comparative Examples.

[0221] The method for testing the scattering properties of the inorganic fiber has already been described in the description of the present invention.

The results are shown in Table 1.

[0222] As shown in Table 1, the holding sealing materials according to Examples 1 to 6 each enabled to maintain a high surface pressure before firing of 150 kPa or higher and that after firing of 35 kPa or higher, and suppress the scattering of the inorganic fiber to 0.2 wt% or less. In addition, the binding agent layers each exhibited a high tensile strength of 5.0 MPa or higher.

[0223] On the other hand, in Comparative Example 1 in which the biding agent layer contained no polymer-based dispersant, the organic binding agent and the inorganic particles agglomerated in the binding agent solution, the tensile strength of the binding agent layer was a low value, and the surface pressure was also low.

[0224] In the holding sealing material of Comparative Example 2, the binding agent solution contained no organic binding agent. Thus, the binding agent layer was not formed. Therefore, the scattering of the inorganic fiber was not suppressed.

[0225] In the holding sealing material of Comparative Example 3, the binding agent layer contained no inorganic particles. Thus, the tensile strength of the binding agent layer was a low value, and the surface pressure was also low.

Explanation of References

[0226]

10	INORGANIC FIBER
20	BINDING AGENT LAYER
21	INORGANIC PARTICLE

22	ORGANIC BINDING AGENT COMPONENT
23	POLYMER-BASED DISPERSANT
100	EXHAUST GAS PURIFYING APPARATUS
110	HOLDING SEALING MATERIAL
120	EXHAUST GAS TREATMENT BODY
130	METAL CASING

Claims

1. A holding sealing material comprising an inorganic fiber and a binding agent layer,
a surface of the inorganic fiber being covered with the binding agent layer, and
the binding agent layer comprising an organic binding agent, inorganic particles, and a polymer-based dispersant.

2. The holding sealing material according to Claim 1,
wherein surfaces of the inorganic particles in the binding agent layer are covered with the polymer-based dispersant, and
the inorganic particles are dispersed in an organic binding agent component.

3. The holding sealing material according to Claim 1 or 2, wherein the contents of the inorganic particles and the organic binding agent are each in a range of 0.1 parts by weight to 10 parts by weight in relation to 100 parts by weight of the inorganic fiber.

4. The holding sealing material according to Claim 3,
wherein the contents of the inorganic particles and the organic binding agent are each in a range of 0.1 parts by weight to 3 parts by weight in relation to 100 parts by weight of the inorganic fiber.

5. The holding sealing material according to any one of Claims 1 to 4,
wherein the polymer-based dispersant is an anionic polymer-based dispersant.

6. The holding sealing material according to any one of Claims 1 to 5,
wherein the organic binding agent is an acrylic resin.

7. The holding sealing material according to any one of Claims 1 to 6, which is subjected to a needle punching treatment.

8. The holding sealing material according to any one of Claims 1 to 7,
wherein irregularities by the inorganic particles are formed on the entire surface of the inorganic fiber after the organic binding agent is burnt away due to heat.

9. The holding sealing material according to any one of Claims 1 to 8,
wherein the binding agent layer is formed on the entire surface of the inorganic fiber.

10. A holding sealing material manufactured through steps including:

    a mat preparation step of preparing a mat including an inorganic fiber;
    a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution mixture, and then mixing the mixture with an organic binding agent dispersed in water;
    a supply step of supplying the binding agent solution to the mat; and
    a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

11. The holding sealing material according to Claim 10,
wherein the organic binding agent used in the binding agent solution preparation step is an organic binding agent having a glass transition temperature of -5°C or lower.

12. The holding sealing material according to Claim 10 or 11, wherein the binding agent solution is prepared in the binding agent solution preparation step such that the tensile strength of a binding agent layer obtained by drying

the binding agent solution reaches 5.0 MPa or higher.

13. A method for manufacturing a holding sealing material comprising:

a mat preparation step of preparing a mat including an inorganic fiber;
a binding agent solution preparation step of preparing a binding agent solution by mixing a solution of inorganic particles and a polymer-based dispersant to prepare a solution mixture, and then mixing the mixture with an organic binding agent dispersed in water;
a supply step of supplying the binding agent solution to the mat; and
a drying step of drying the organic binding agent and the inorganic particles by drying the mat supplied with the binding agent solution.

14. An exhaust gas purifying apparatus comprising:

a metal casing;
an exhaust gas treatment body housed in the metal casing; and
a holding sealing material wound around the exhaust gas treatment body and interposed between the exhaust gas treatment body and the metal casing,
the holding sealing material being the holding sealing material according to any one of Claims 1 to 12.

15. An exhaust gas purifying apparatus comprising:

a metal casing;
an exhaust gas treatment body housed in the metal casing; and
a holding sealing material wound around the exhaust gas treatment body and interposed between the exhaust gas treatment body and the metal casing,
the holding sealing material being a holding sealing material manufactured by the method for manufacturing a holding sealing material according to Claim 13.

FIG.1A

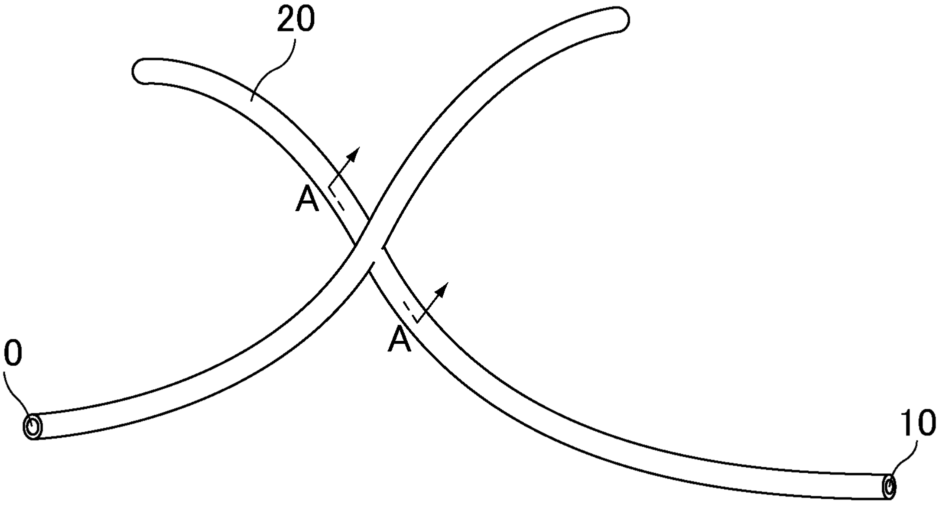
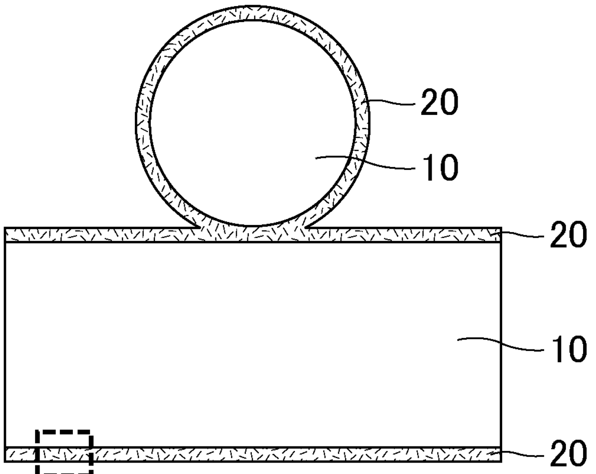


FIG.1B



A-A LINE CROSS SECTIONAL VIEW

FIG.1C

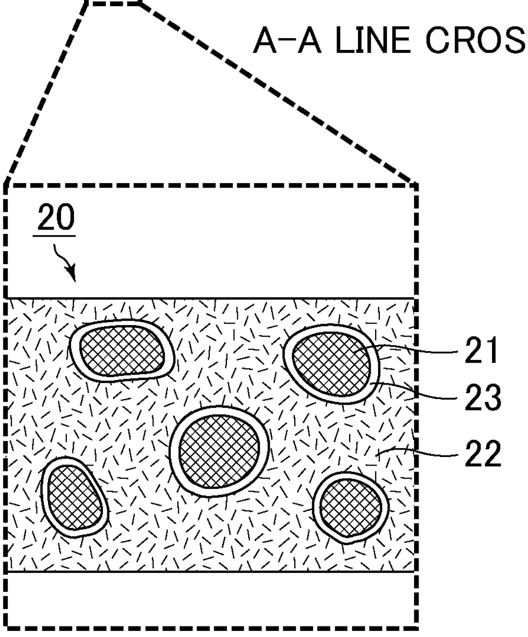


FIG.2A

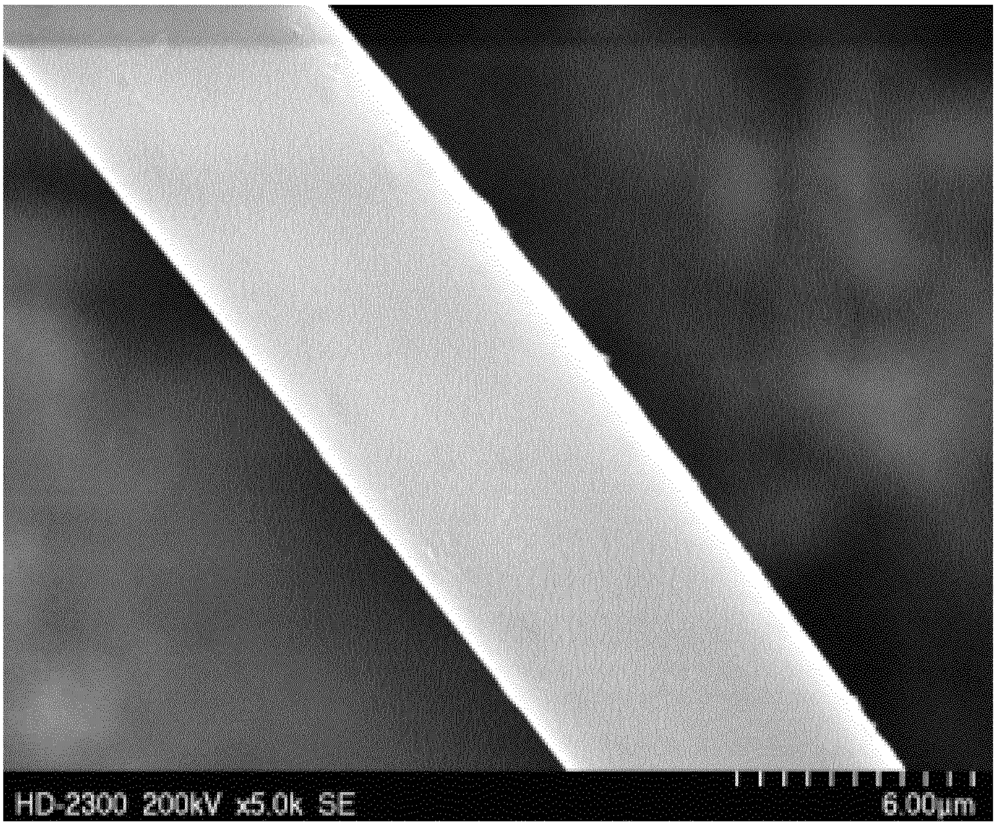


FIG.2B

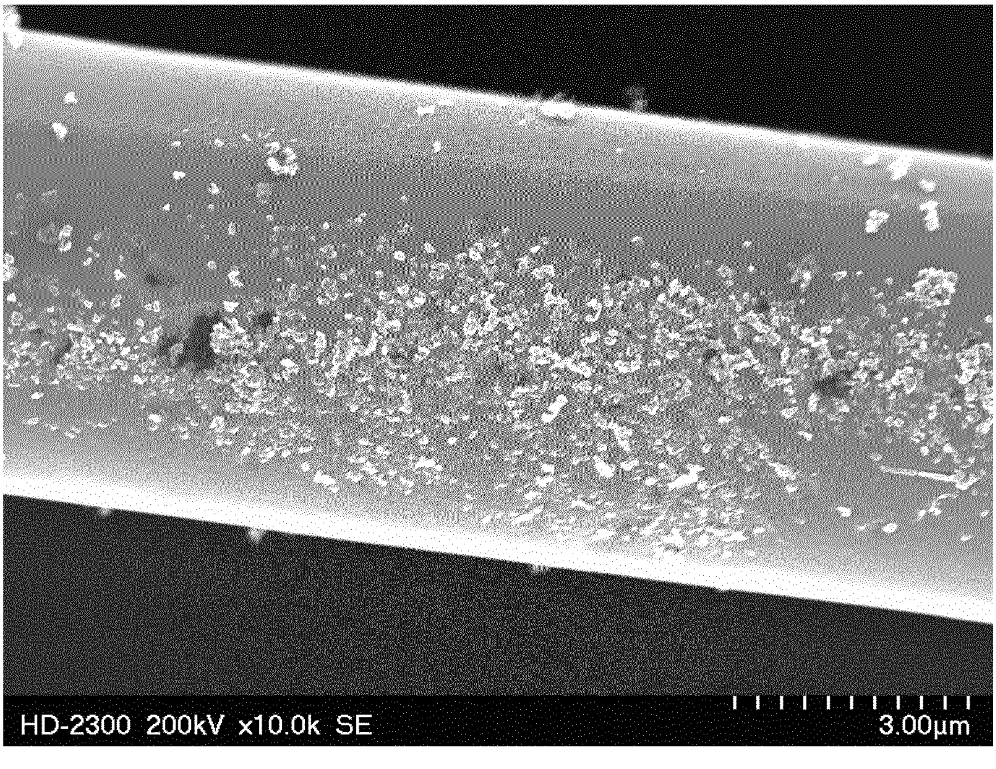


FIG.3

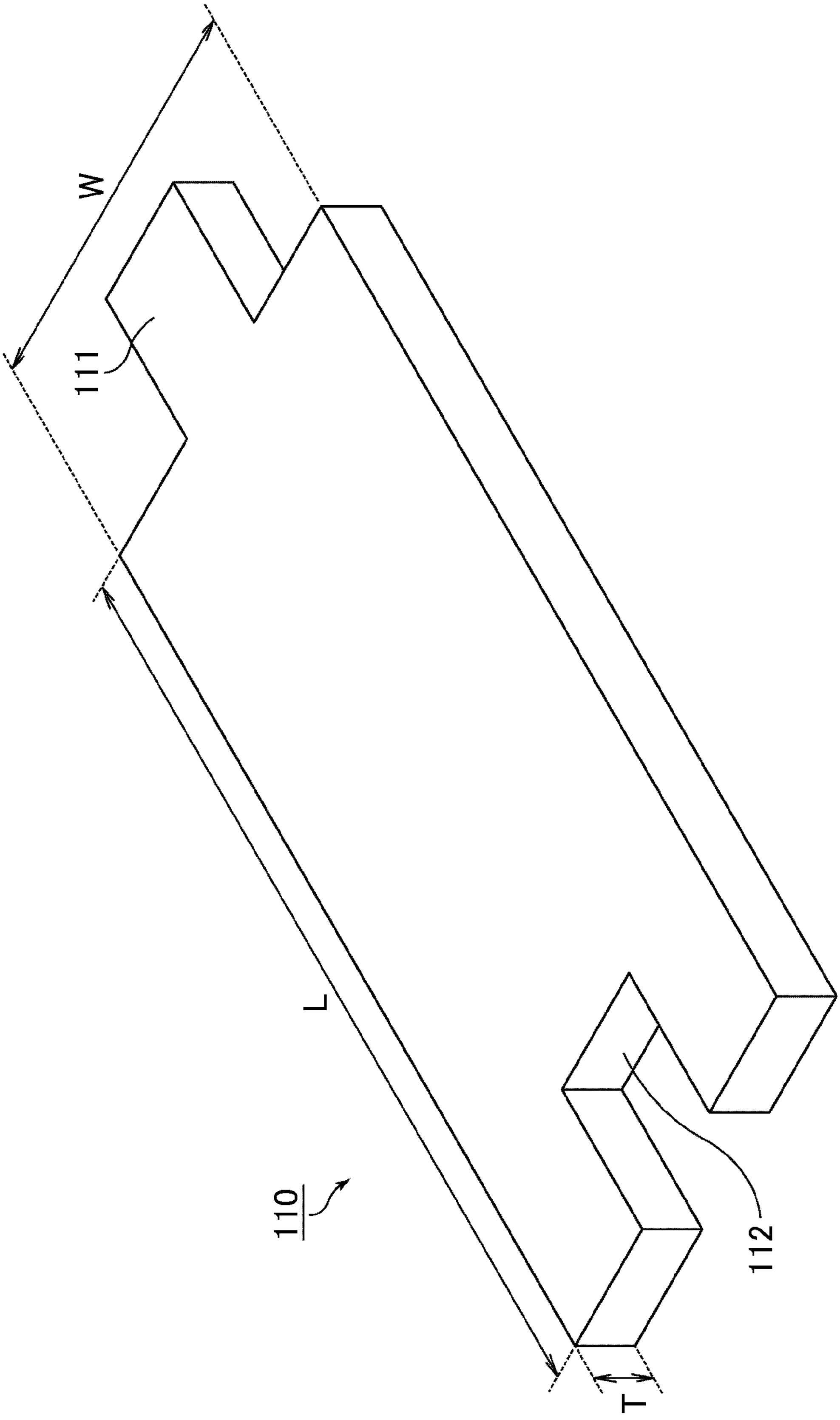


FIG.4A

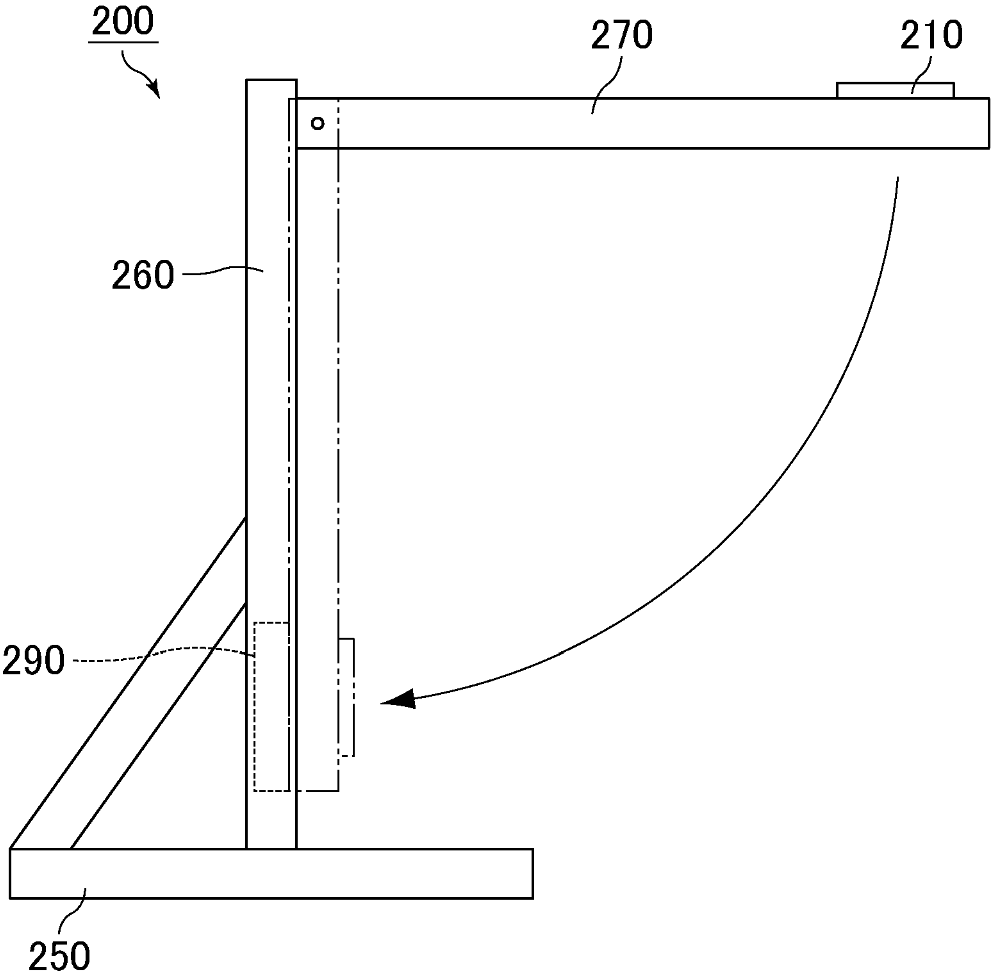


FIG.4B

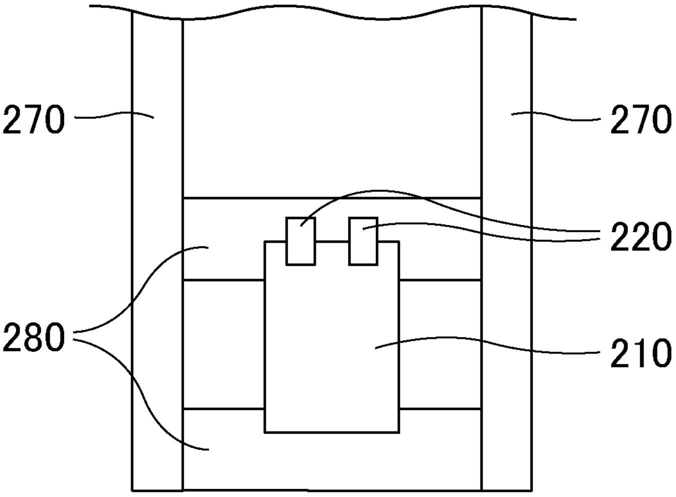


FIG.5

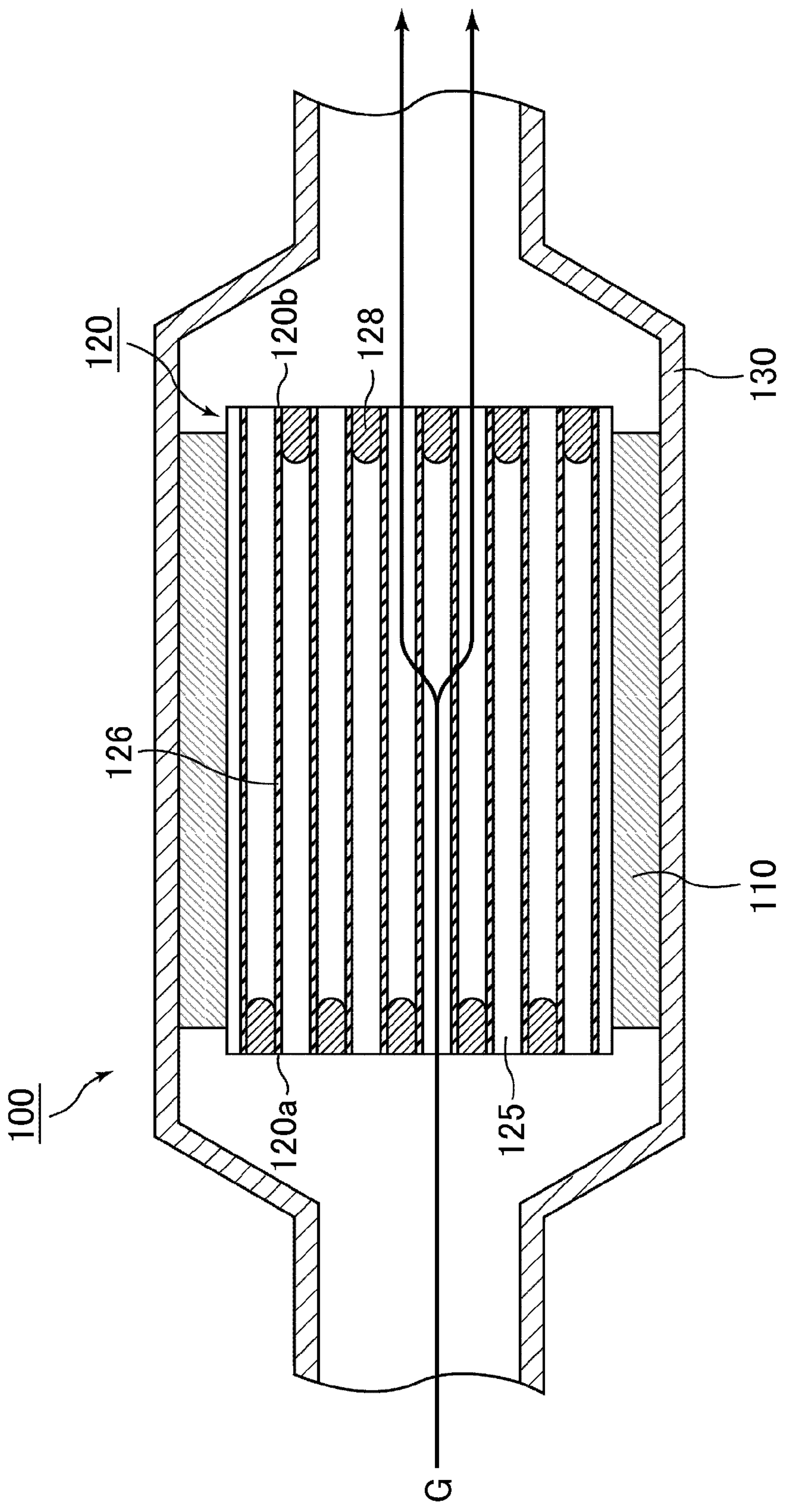


FIG.6

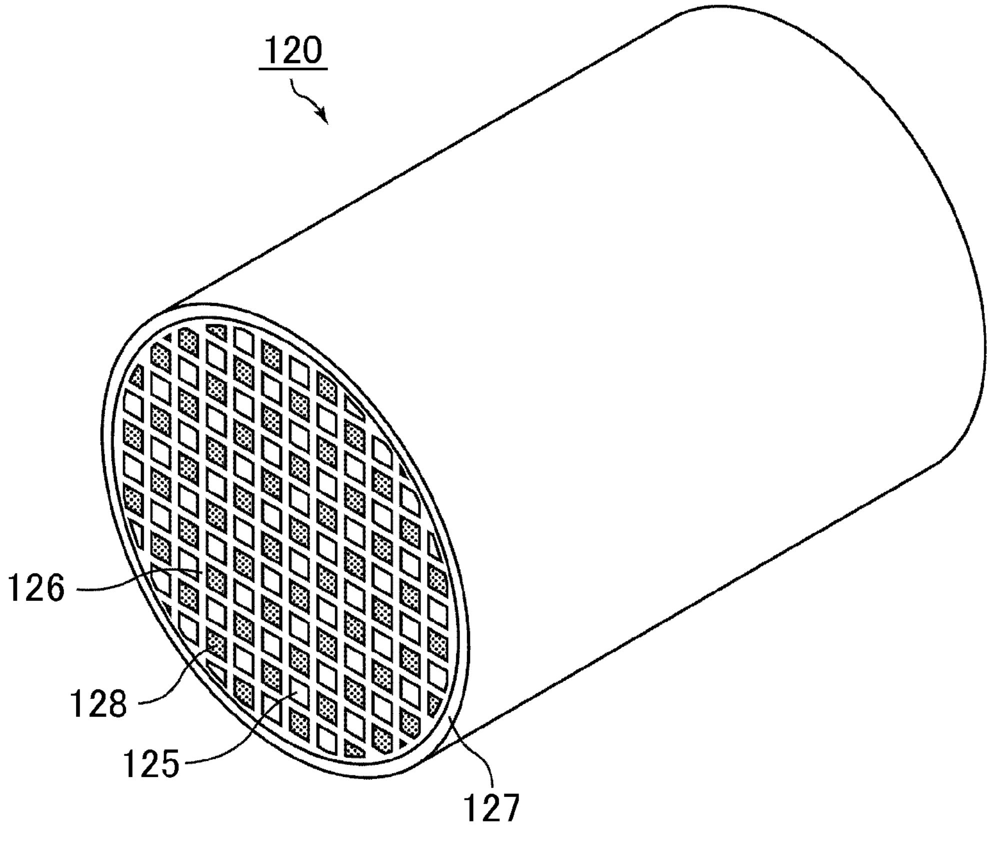
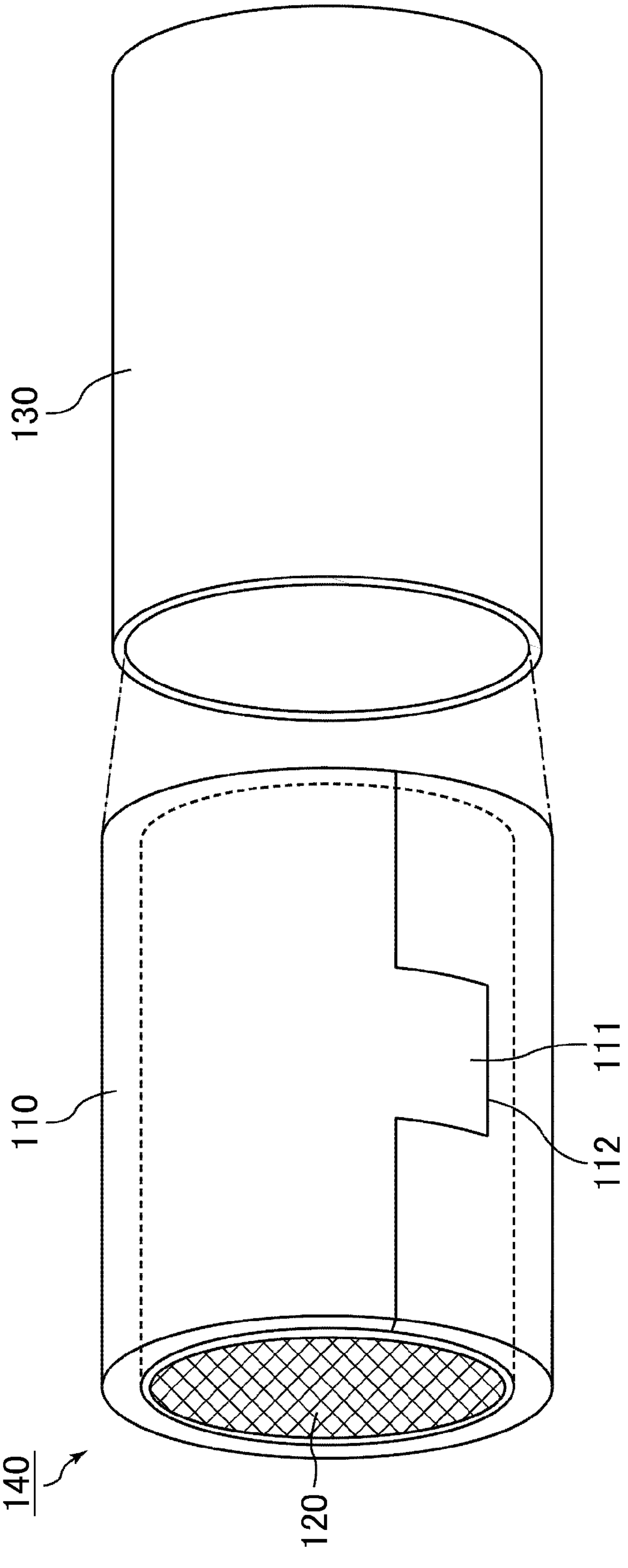


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/059985

A. CLASSIFICATION OF SUBJECT MATTER
F01N3/28(2006.01)i, *C04B41/85*(2006.01)i, *D04H1/4209*(2012.01)i, *D04H1/46*(2012.01)i, *D04H1/645*(2012.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N3/28

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-505400 A (Unifrax I LLC), 14 February 2013 (14.02.2013), claims 1, 7 to 8, 13 to 14; paragraphs [0007] to [0009], [0012] to [0016]; fig. 1 & US 2011/0097246 A1 & WO 2011/037617 A1 & CA 2770313 A & CN 102686302 A & KR 10-2012-0094905 A	1-15
Y	JP 2012-157809 A (3M Innovative Properties Co.), 23 August 2012 (23.08.2012), claims; paragraphs [0011] to [0015], [0023] to [0030], [0034] to [0045]; all drawings & WO 2012/106295 A1	1-15

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

* Special categories of cited documents:
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 18 June, 2014 (18.06.14)	Date of mailing of the international search report 01 July, 2014 (01.07.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/059985

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2002-13415 A (3M Innovative Properties Co.), 18 January 2002 (18.01.2002), claims 4 to 5; paragraph [0030] & US 2004/0057879 A1 & WO 2002/053511 A1 & DE 60103562 T	1-15
A	JP 2010-519419 A (3M Innovative Properties Co.), 03 June 2010 (03.06.2010), claims & US 2010/0115900 A1 & US 2012/0171457 A1 & EP 2466004 A1 & WO 2008/103525 A2 & CA 2677593 A & CN 101617082 A & KR 10-2009-0122245 A & CN 102154915 A	1-15

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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