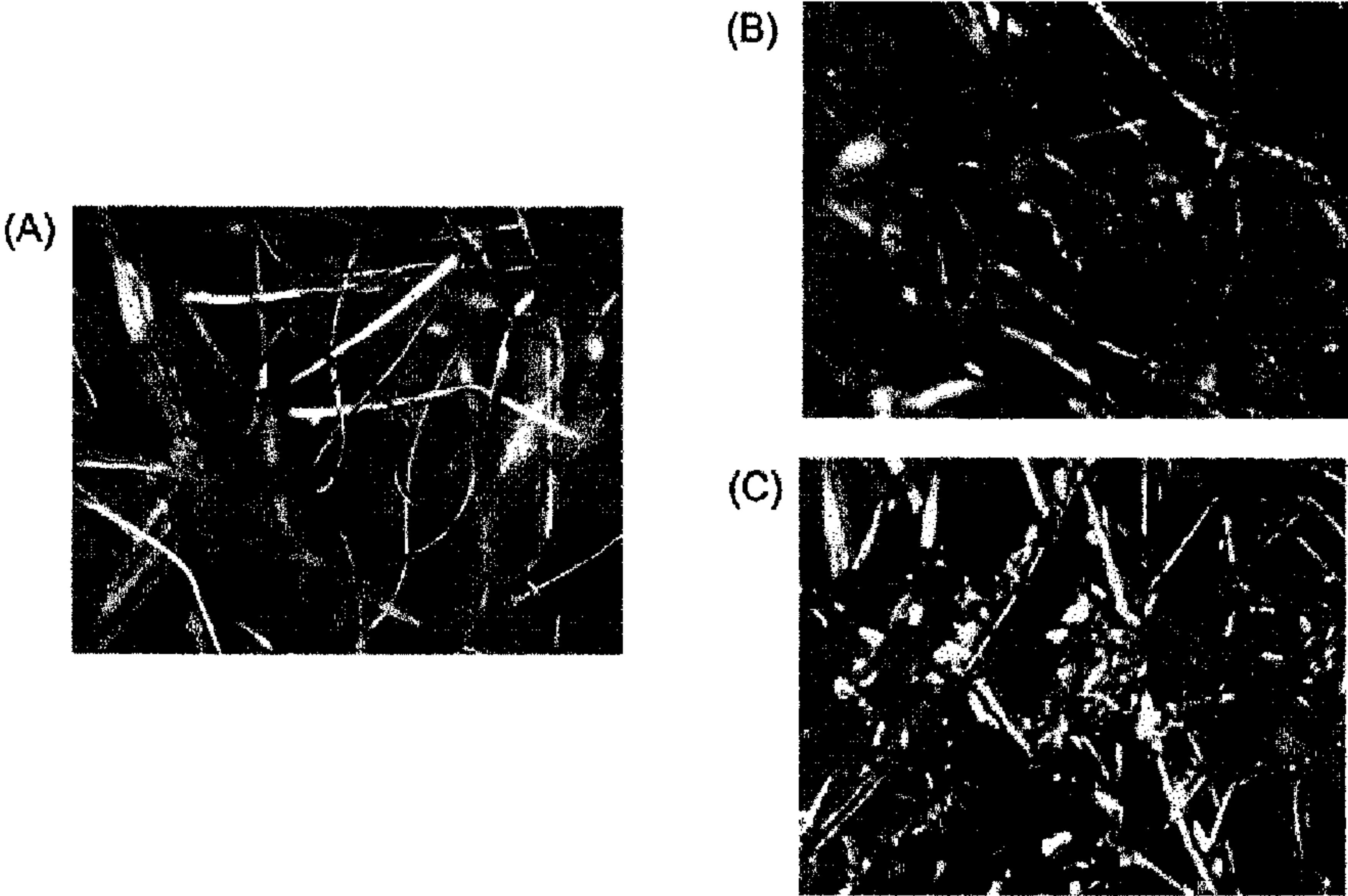




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(54) Titre : MATERIAU D'ECRAN ET D'ABSORPTION DES SONS ET PROCEDE POUR SA FABRICATION
(54) Title: SOUND ABSORBING AND SCREENING MATERIAL AND METHOD FOR MANUFACTURING SAME



(57) **Abrégé/Abstract:**
The present invention relates to a sound-absorbing material and a method for preparing the sound-absorbing material. More particularly, the sound-absorbing material, which may be prepared by impregnating a binder into a nonwoven fabric formed of a heat-resistant fiber, is provided. The sound-absorbing material may have superior sound-absorbing property, flame retardancy, heat resistance and heat-insulating property, thereby being applicable to parts operating at a temperature of 200 °C or greater and being shapeable due to the binder. In addition the method for preparing the sound-absorbing material is provided.

1 **ABSTRACT**

2 The present invention relates to a sound-absorbing material and a method for preparing
3 the sound-absorbing material. More particularly, the sound-absorbing material, which may be
4 prepared by impregnating a binder into a nonwoven fabric formed of a heat-resistant fiber, is
5 provided. The sound-absorbing may have superior sound-absorbing property, flame retardancy,
6 heat resistance and heat-insulating property, thereby being applicable to parts operating at a
7 temperature of 200 °C or greater and being shapeable due to the binder. In addition, the method
8 for preparing the sound-absorbing material is provided.

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SOUND ABSORBING AND SCREENING MATERIAL
AND METHOD FOR MANUFACTURING SAME

TECHNICAL FIELD

The present invention relates to a sound-absorbing material and a method for preparing same. More particularly, the present invention provides a sound-absorbing material and a method of preparing the sound-absorbing material by impregnating a binder into a nonwoven fabric formed of a heat-resistant fiber. Therefore, the prepared sound-absorbing material according to the present invention may have superior sound-absorbing property, flame retardancy, heat resistance and heat-insulating property, thereby being applicable to parts operating at a temperature of 200 °C or greater and being shapeable due to the binder.

BACKGROUND

Noise is inevitably generated in industry or by industrial products and may cause damages gradually. Accordingly, various methods may be considered to prevent or eliminate noise. In an exemplary effort to eliminate the noise, novel various sound-absorbing materials which may be capable of arresting, absorbing or insulating sound have been developed.

In related arts, sound-absorbing materials may be used in electric appliances such as air conditioner, refrigerator, washing machine, lawn mower, and the like; transportation such as vehicle, ship, airplane, and the like; and construction materials such as wall material, flooring material, and the like. The sound-absorbing material may also be used in other various industrial fields. In general, the sound-absorbing materials used in such industries may also require other properties, such as light-weightness, flame retardancy, heat resistance and heat-insulating property, depending on particular applications, in addition to good sound-absorbing property. Particularly, flame retardancy and heat resistance may be further required in sound-absorbing materials used in engines, exhaust systems, and the like, which operate at high temperature of 200 °C or greater. Currently, aramid fibers may be one of the sound-absorbing materials having superior heat resistance.

In related arts, in order to provide properties such as flame retardancy, water repellency, and the like to a sound-absorbing material, many sound-absorbing materials made from a

1 nonwoven fabric which may contain aramid fibers and a functional surficial material laminated
2 thereon have been developed.

3 For example, Korean Patent Application Publication No. 2007-0033310 discloses a
4 flame-retardant sound-absorbing material obtained from a nonwoven fabric layer in which a
5 heat-resistant short aramid fibers and short thermoplastic polyester fibers are bridged and a
6 surficial material layer formed of a wetlaid nonwoven fabric consisting of short aramid fibers are
7 laminated with each other.

8 Japanese Patent Application Publication No. 2007-0039826 discloses a water-repellent
9 sound-absorbing material obtained from a nonwoven fabric layer of a heat-resistant short aramid
10 fiber or a blend of a short aramid fiber and a short thermoplastic polyester fiber or a surficial
11 material layer treated with a water repellent laminated with the nonwoven fabric layer.

12 Japanese Patent Application Publication No. 2007-0138953 discloses a heat-resistant
13 sound-absorbing material wherein a nonwoven fabric layer consisting of a heat resistance aramid
14 fiber and a surficial material layer formed of a fiber sheet containing a heat resistance aramid
15 fiber are laminated with each other.

16 Since the sound-absorbing materials described above may have a structure in which a
17 surficial material layer may be laminated on one side of a nonwoven fabric to provide properties
18 such as flame retardancy, water repellency, and the like, a hot pressing process for integrating the
19 nonwoven fabric layer and the surficial material layer may be necessary. Consequently, the
20 overall process may be complicated and troublesome. Further, providing other properties, such
21 as a flame retardant, water repellent, and the like by additives may cause undesirable toxic gases
22 generated by combustion during the hot pressing process. In addition, deformation of the
23 internal structure of the nonwoven fabric may occur during the hot pressing process, thereby
24 deteriorating sound-absorbing property.

25 26 SUMMARY OF THE INVENTION

27 The present invention may provide a technical solution to above-described technical
28 difficulties. Accordingly, a novel sound-absorbing material, which may have superior sound-
29 absorbing property, flame retardancy, heat resistance and heat-insulating property and be
30 shapeable, is provided. In particular, in the novel sound-absorbing material, a binder may be

1 impregnated into a nonwoven fabric having irregular micro cavities with a complicated three-
2 dimensional labyrinth structure and may be cured while maintaining the three-dimensional shape
3 inside the nonwoven fabric without blocking the micro cavities. Therefore, the physical
4 properties of the nonwoven fabric including sound-absorbing property may be improved and a
5 desired shape may be obtained during the curing of the binder.

6 In one aspect, the present invention provides a sound-absorbing material having superior
7 sound-absorbing property, flame retardancy, heat resistance and heat-insulating property and
8 being shapeable into a desired shape during curing process in which a binder may be
9 impregnated into a nonwoven fabric formed of a heat-resistant fiber.

10 In other aspect, the present invention provides a method for preparing a sound-absorbing
11 material by impregnating a binder into a nonwoven fabric formed of a heat-resistant fiber and
12 drying the impregnated nonwoven fabric.

13 In another aspect, the present invention provides a method for reducing noise by using
14 the sound-absorbing material in a noise-generating device.

15 In one exemplary embodiment of the present invention a sound-absorbing material may
16 include: a nonwoven fabric containing an amount of 30 wt% to 100 wt% of a heat-resistant fiber;
17 and a binder impregnated in said nonwoven fabric and maintaining a three-dimensional shape
18 inside the nonwoven fabric.

19 In another exemplary embodiment of the present invention, a method for preparing a
20 sound-absorbing material may include: a) immersing a nonwoven fabric containing an amount of
21 30 wt% to 100 wt% of a heat-resistant fiber in a binder solution; and b) drying said nonwoven
22 fabric.

23 In still another exemplary embodiment of the present invention, a method for reducing
24 noise of a noise-generating device may include: i) checking a three-dimensional structure of a
25 noise-generating device; ii) preparing and shaping a sound-absorbing material so as to
26 correspond to said three-dimensional structure of the device partially or entirely; and iii) locating
27 the sound-absorbing material adjacent to the noise-generating device.

28 According to various exemplary embodiments of the present invention, when the binder
29 is impregnated into the nonwoven fabric formed of a heat-resistant fiber, the sound-absorbing
30 material may have superior sound-absorbing property, flame retardancy, heat resistance and

1 heat-insulating property and the sound-absorbing material further may be shaped into a three-
2 dimensional shape due to the binder.

3 In addition, in preparing the sound-absorbing material according to various exemplary
4 embodiments, a hot pressing process for integrating a nonwoven fabric with a surficial material
5 may be eliminated unlike other conventional sound-absorbing materials which may have
6 laminated structures.

7 Further, the sound-absorbing material in various exemplary embodiments of the present
8 invention may be prepared by including a functional additive in a binder solution, and desired
9 functionality may be provided to the sound-absorbing material without laminating a surficial
10 material, thereby providing advantages during manufacturing and fabricating process thereof.

11 Since flame retardancy, heat resistance and heat-insulating property of exemplary sound
12 absorbing materials of the present invention may be superior in addition to sound-absorbing
13 properties, the sound-absorbing material may not be deformed or denatured in a noise-generating
14 device operating at a temperature of 200 °C or greater.

15 In particular, when a thermosetting resin is used as a binder, a desired shape may be
16 obtained during the curing of the thermosetting resin, thereby simplifying the overall process by
17 simultaneous curing and shaping of the thermosetting resin. In addition, since a nonwoven
18 fabric formed of a heat-resistant fiber may be used, thermal deformation of the nonwoven fabric
19 due to the reaction heat of thermal curing may not occur even when a thermosetting resin is used
20 as a binder.

21 Accordingly, the sound-absorbing material in various exemplary embodiments of the
22 present invention may be used for appliances requiring arresting, absorbing or insulating of
23 sound, including electric appliances such as air conditioner, refrigerator, washing machine, lawn
24 mower, and the like; transportation such as vehicle, ship, airplane, and the like; and construction
25 materials such as wall material, flooring material, and the like. In particular, the sound-
26 absorbing material of the present invention may be used for a noise-generating device operating
27 at a temperature of 200 °C or greater. More particularly, when the sound-absorbing material of
28 the present invention is used in a vehicle, it may be closely attached to a noise-generating device
29 of vehicle parts, such as engine, exhaust system, and the like, and may be provided with a

1 distance from the noise-generating device, or being shaped as a part of the noise-generating
2 device.

3

4 **BRIEF DESCRIPTION OF DRAWINGS**

5 Fig. 1 shows electron microscopic images (x300) of an exemplary nonwoven fabric
6 before and after impregnation of a binder according to an exemplary embodiment of the present
7 invention. FIG. 1 (a) is a microscopic image of an exemplary nonwoven fabric before
8 impregnation of a binder, FIG. 1 (b) is a microscopic image of a nonwoven fabric in which
9 parts by weight of an exemplary binder has been impregnated based on 100 parts by weight of
10 the nonwoven fabric, and FIG. 1 (c) is a microscopic image of an exemplary nonwoven fabric in
11 which 50 parts by weight of an exemplary binder has been impregnated based on 100 parts by
12 weight of the nonwoven fabric.

13 Fig. 2 schematically shows an example of a sound-absorbing material applied to an
14 exemplary noise-generating device of a vehicle after shaping as a part, according to an
15 exemplary embodiment of the present invention. FIG. 2 (a) illustrates an exemplary sound-
16 absorbing material shaped for use in a vehicle engine, and FIG. 2 (b) illustrates an example of a
17 sound-absorbing material which may be applied in a part of a vehicle engine.

18 Fig. 3 schematically shows an example wherein a sound-absorbing material is applied to
19 an exemplary noise-generating device of a vehicle at certain distance according to an exemplary
20 embodiment of the present invention. FIG. 3 (a) illustrates an exemplary sound-absorbing
21 material shaped for use in an exemplary lower part of a vehicle, and FIG. 3 (b) shows an
22 example of a sound-absorbing material which may be attached to a lower part of a vehicle.

23 Fig. 4 is an exemplary graph showing sound-absorbing performance of a sound-
24 absorbing material depending on a density of a nonwoven fabric according to an exemplary
25 embodiment of the present invention.

26 Fig. 5 is an exemplary graph showing heat-insulating performance in comparison of an
27 aluminum heat-insulating plate and a sound-absorbing material according to an exemplary
28 embodiment of the present invention.

1 DETAILED DESCRIPTION

2 The present invention relates to a sound-absorbing material and a method for preparing
3 the sound-absorbing material. The sound-absorbing material of the present invention may have
4 superior sound-absorbing property, flame retardancy, heat resistance and heat-insulating property.
5 Furthermore, the sound-absorbing material may be shapeable into a desired three-dimensional
6 shape due to a binder which may be present in the same layer as the nonwoven fabric formed of
7 a heat-resistant fiber.

8 In one aspect, the present invention provides a sound-absorbing material which may
9 include: a nonwoven fabric containing an amount of 30 wt% to 100 wt% of a heat-resistant fiber;
10 and a binder present in the same layer as the nonwoven fabric to maintain a three-dimensional
11 shape of the nonwoven fabric.

12 In an exemplary embodiment of the present invention, the heat-resistant fiber may have
13 a limiting oxygen index (LOI) of 25 % or greater and a heat resistance temperature of 200 °C or
14 greater.

15 In an exemplary embodiment of the present invention, the heat-resistant fiber may be
16 one or more selected from the group consisting of aramid fiber, polyphenylene sulfide (PPS)
17 fiber, oxidized polyacrylonitrile (oxi-PAN) fiber, polyimide (PI) fiber, polybenzimidazole (PBI)
18 fiber, polybenzoxazole (PBO) fiber, polytetrafluoroethylene (PTFE) fiber, polyketone (PK) fiber,
19 metallic fiber, carbon fiber, glass fiber, basalt fiber, silica fiber and ceramic fiber. In particular,
20 the heat-resistant fiber may be an aramid fiber.

21 In an exemplary embodiment of the present invention, the nonwoven fabric may be a
22 single-layer nonwoven fabric formed of an aramid fiber having a fineness in a range of 1 denier
23 to 15 denier and a thickness in a range of 3 mm to 20 mm.

24 In an exemplary embodiment of the present invention, the nonwoven fabric may have a
25 density in a range of 100 to 2000 g/m². In particular, the nonwoven fabric may have a density
26 in a range of 200 to 1200 g/m².

27 In an exemplary embodiment of the present invention, the binder may be a thermosetting
28 resin. In particular, the thermosetting resin may be an epoxy resin which is capable of forming
29 a three-dimensional network structure in the internal structure of the nonwoven fabric. The
30 epoxy resin may be one or more epoxy resin selected from the group consisting of bisphenol A

1 diglycidyl ether, bisphenol B diglycidyl ether, bisphenol AD diglycidyl ether, bisphenol F
2 diglycidyl ether, bisphenol S diglycidyl ether, polyoxypropylene diglycidyl ether, bisphenol A
3 diglycidyl ether polymer, phosphazene diglycidyl ether, bisphenol A novolac epoxy, phenol
4 novolac epoxy resin and o-cresol novolac epoxy resin.

5 The structure of an exemplary sound-absorbing material according to the present
6 invention will be described in more detail as shown in Fig. 1.

7 Fig. 1 shows electron microscopic images of an exemplary sound-absorbing material
8 before and after impregnation of a binder into the nonwoven fabric and shows the three-
9 dimensional network structure inside a nonwoven fabric. In particular, Fig. 1 (A) is an electron
10 microscopic image of the internal structure inside a nonwoven fabric before impregnation of a
11 binder into the nonwoven fabric and shows that heat-resistant fiber yarns cross each other to
12 form irregular micro cavities. Each Fig. 1 (B) or (C) is an electron microscopic image of the
13 internal structure inside the nonwoven fabric after impregnation of a binder into the nonwoven
14 fabric and show that the binder is finely and uniformly distributed and attached to the heat-
15 resistant fiber yarns. Further, the content of the binder on the yarn surface increases as the
16 content of the binder increases.

17 Although there may be differences depending on the preparation method, fibers of a
18 nonwoven fabric may be randomly arranged in a three-dimensional structure. Accordingly, the
19 internal structure of a nonwoven fabric may have a substantially complicated labyrinth structure,
20 which may be formed of regularly or irregularly arranged fibers, may be three-dimensionally
21 interconnected, rather than bundles of independent capillary tubes. Thus, the nonwoven fabric
22 according to various exemplary embodiments of the present invention may have irregular micro
23 cavities formed as the yarns containing the heat-resistant fiber loosely cross each other.

24 When a binder is impregnated into the nonwoven fabric, the binder may be finely and
25 uniformly distributed and attached on the surface of the nonwoven fabric yarns containing the
26 heat-resistant fiber, thereby providing a much finer internal structure, micro cavities having
27 labyrinth structure, than before the impregnation. Forming finely modified micro cavities in the
28 internal structure of the nonwoven fabric may provide extended resonance path of sound or noise
29 and further provide improved sound-absorbing property. When the binder forms a three-

1 dimensional network structure as it is cured, the sound-absorbing property can be further
2 improved by forming more and finer micro cavities inside the nonwoven fabric.

3 Accordingly, since the nonwoven fabric may maintain the intrinsic three-dimensional
4 shape as the binder is uniformly impregnated into the nonwoven fabric, and additionally, since
5 more fine micro cavities (Micro ventilator) may be formed as the binder is cured, the sound-
6 absorbing material of the present invention may have remarkably improved sound-absorbing
7 performance due to the maximized noise absorption through increased and various resonance of
8 sound or noise in the nonwoven fabric.

9 As shown in exemplary electron microscopic images of Fig. 1, in an exemplary
10 embodiment of the present invention, the binder may be uniformly dispersed and distributed on
11 the surface of the heat-resistant fiber yarns constituting the nonwoven fabric of an exemplary
12 sound absorbing material.

13 Hereinafter, the composition of the sound-absorbing material according to various
14 exemplary embodiments of the present invention which may have an internal structure described
15 above will be described in more detail.

16 In an exemplary embodiment of the present invention, a heat-resistant fiber may be used
17 as the main fiber included in the nonwoven fabric. The heat-resistant fiber may be any type
18 having superior durability and high-temperature or ultrahigh-temperature resistance. In
19 particular, the heat-resistant fiber may have a limiting oxygen index (LOI) of 25 % or greater and
20 a heat resistance temperature of 150 °C or greater. More particularly, the heat-resistant fiber
21 may have a limiting oxygen index (LOI) in a range of 25 % to 80 % and a heat resistance
22 temperature in a range of 150 °C to 3000 °C. Further, the heat-resistant fiber may have a
23 limiting oxygen index (LOI) in a range of 25 % to 70% and a heat resistance temperature in a
24 range of 200 °C to 1000 °C. In addition, the heat-resistant fiber may have a fineness in a range
25 of 1 denier to 15 denier, or particularly of 1 denier to 6 denier; and a yarn length in a range of 20
26 mm to 100 mm, or particularly of 40 mm to 80 mm.

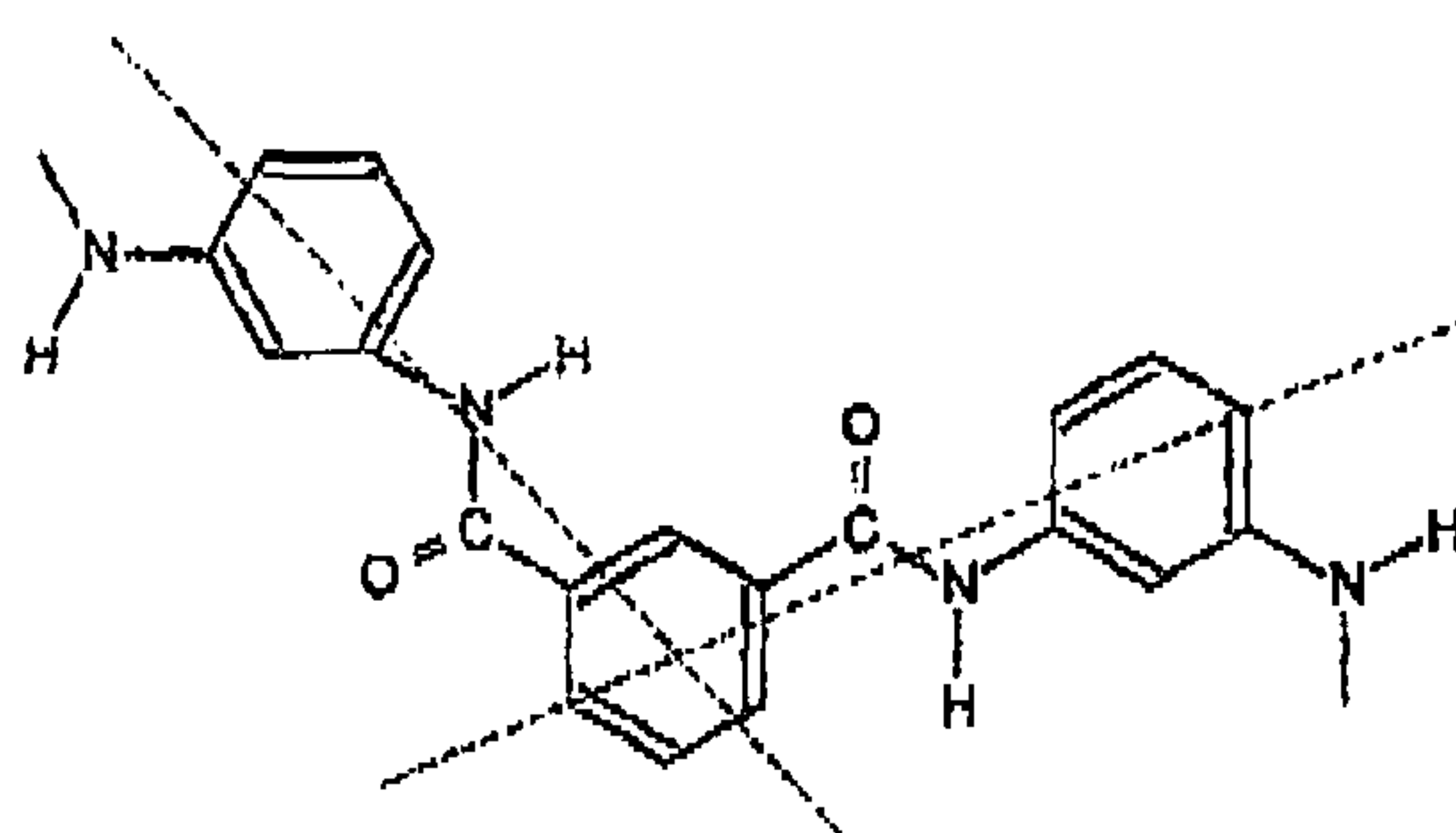
27 As used herein, a heat-resistant fiber may be 'super fiber' as generally known in the
28 related art. In an exemplary embodiment, the super fiber may be one or more selected from the
29 group consisting of aramid fiber, polyphenylene sulfide (PPS) fiber, oxidized polyacrylonitrile
30 (oxi-PAN) fiber, polyimide (PI) fiber, polybenzimidazole (PBI) fiber, polybenzoxazole (PBO)

1 fiber, polytetrafluoroethylene (PTFE) fiber, polyketone (PK) fiber, metallic fiber, carbon fiber,
2 glass fiber, basalt fiber, silica fiber, and ceramic fiber.

3 In an exemplary embodiment of the present invention, an aramid fiber may be used as
4 the heat-resistant fiber. In particular, meta-aramid (m-aramid), para-aramid (p-aramid) or a
5 mixture thereof may be used as the heat-resistant fiber in the present invention. The aramid
6 fiber used as the yarn of the nonwoven fabric may have a fineness in a range of 1 denier to 15
7 denier, or particularly of 1 denier to 6 denier; and a yarn length in a range of 20 mm to 100 mm,
8 or particularly of 40 mm to 80 mm. When the yarn length is shorter than a predetermined
9 length, bridging of yarns may be difficult during manufacturing, for instance, in needle punching.
10 As a result, cohesion of the nonwoven fabric may be weak. In contrast, when the yarn length is
11 longer than a predetermined length, cohesion of the nonwoven fabric may be superior but
12 movement of yarns may be difficult during manufacturing, for instance, in carding.

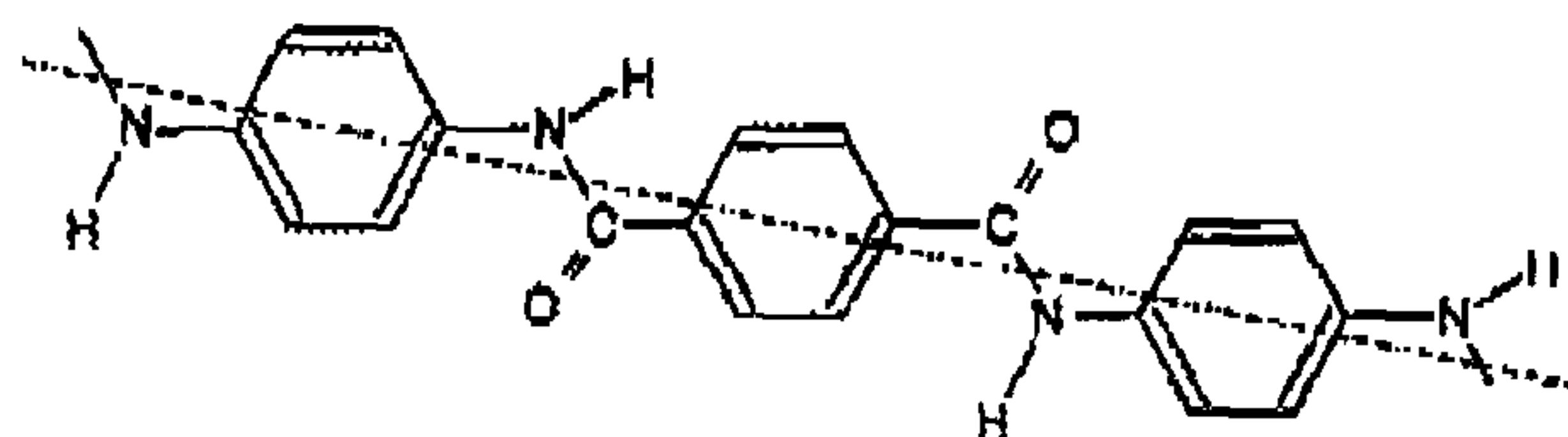
13 As used herein, the aramid fiber is an aromatic polyamide fiber in which aromatic rings
14 such as benzene ring are bonded with each other by amide groups. The aromatic polyamide
15 fiber is typically called as 'aramid' and distinguished from an aliphatic polyamide, for example,
16 nylon. The aramid fiber may be prepared by spinning of aromatic polyamide and classified as
17 m-aramid [Chemical Formula 1], and p-aramid [Chemical Formula 2] depending on the location
18 of the amid bonds on the aromatic ring.

19 [Chemical Formula 1]



20

1 [Chemical Formula 2]



2

3 The m-aramid represented by Chemical Formula 1 may be prepared by dry spinning
4 after dissolving isophthaloyl chloride and m-phenylenediamine in a dimethylacetamide (DMAc)
5 solvent. The m-aramid may have a relatively high tensile elongation at break of in a range of
6 22 % to 40 % due to the uneven polymer structure, may be dyed and may be easily prepared into
7 fibers. It is appreciated that Nomex™ (DuPont) and Conex™ (Teijin) may provide a range of
8 options for the m-aramid.

9 The p-aramid represented by Chemical Formula 2 may be prepared by wet spinning after
10 dissolving terephthaloyl chloride and p-phenylenediamine in an N-methylpyrrolidone (NMP)
11 solvent. The p-aramid may have high strength due to its highly oriented linear molecular
12 structure, and the strength of the p-aramid may be improved by about 3-7 folds compared to m-
13 aramid. Therefore, the p-aramid may be used for reinforcement or protection materials. Also,
14 the p-aramid may have substantial chemical resistance, reduced thermal shrinkage, superior
15 dimensional stability, high tear strength, flame resistance and self-extinguishing property. It is
16 appreciated that Kevlar™ (DuPont), Twaron™ (Teijin) and Technora™ (Teijin) may provide a
17 range of options for the p-aramid.

18 In an exemplary embodiment, the aramid may be provided in a form of filament, staple,
19 yarn, and the like. and may be used for reinforcing materials, for instance, a transformer, a motor
20 and the like, insulating materials, for instance, insulating paper, insulating tape, and the like,
21 heat-resistant fibers, for instance, fireproof clothing, gloves, and the like, high-temperature filters,
22 or the like.

23 Although the nonwoven fabric used in the sound-absorbing material according to
24 various embodiments of the present invention may be prepared from the heat-resistant fiber yarn
25 or super fiber, nonwoven fabrics may be prepared by further adding other types of fibers to the
26 heat-resistant fiber yarn, to reduce cost or provide the nonwoven fabric with light weightness,

1 functionality, and the like, within the scope of the present invention. In other words, although
2 the nonwoven fabric of the present invention may be prepared from the heat-resistant fiber yarn,
3 the present invention may the nonwoven fabric formed only of the heat-resistant fiber. The
4 nonwoven fabric of the present invention may include the heat-resistant fiber yarn in an amount
5 of 30 wt% to 100 wt%, or particularly of 60 wt% to 100 wt%, based on the total weight of the
6 nonwoven fabric.

7 Further, in an exemplary embodiment of the present invention, the sound-absorbing
8 material may include a binder which may present in the same layer as the nonwoven fabric and
9 maintain a three-dimensional shape inside the nonwoven fabric. Thus, the binder used may be
10 any one capable of maintaining the three-dimensional shape inside the nonwoven fabric. As
11 used herein, a language 'maintaining the three-dimensional shape inside the nonwoven fabric'
12 may be interpreted that the binder, which is impregnated into the nonwoven fabric, may be
13 uniformly distributed and attached to the surface of the fiber yarn of the nonwoven fabric and
14 maintains the structure of or facilitates the formation of irregular micro cavities, thereby
15 maintaining the original three-dimensional shape inside the nonwoven fabric.

16 In related arts, although a binder generally refers to a material used to adhere or join two
17 materials, the term 'binder' as used herein may refer to a material impregnated into the
18 nonwoven fabric formed of the heat-resistant fiber.

19 According to various embodiments, various materials may be used as the binder
20 impregnated into the nonwoven fabric. First of all, a thermoplastic resin or a thermosetting
21 resin may be considered as a binder material.

22 The thermoplastic resin such as a polyamide-based resin may include crystalline polar
23 groups like the aramid fiber which is a representative heat-resistant fiber as described above.
24 When a thermoplastic binder is impregnated into the nonwoven fabric formed of the
25 thermoplastic heat-resistant fiber, a solid interfacial layer may be formed between the
26 thermoplastic binder and the thermoplastic heat-resistant fiber due to face-to-face contact
27 between the comparable crystalline polar groups, thereby partially blocking or covering the
28 micro cavities of the nonwoven fabric. As consequence, when a thermoplastic resin is used as
29 the binder impregnated into the nonwoven fabric formed of the thermoplastic heat-resistant fiber,
30 sound-absorbing performance may be reduced due to the partial blocking of the micro cavity of

1 the nonwoven fabric which may provide a sound resonance path inside the nonwoven fabric. At
2 a glimpse, it may be thought that the sound-absorbing performance would be improved if the
3 micro cavities are blocked. Since noise is not eliminated inside the nonwoven fabric and is
4 transmitted via outer routes of the nonwoven fabric, improvement of sound-absorbing
5 performance may not be obtained if the thermoplastic binder is impregnated in the nonwoven
6 fabric. In addition, when the thermoplastic binder is impregnated into a nonwoven fabric formed
7 of the inorganic-based heat-resistant fiber, adhesive additive may be added to the binder because
8 of weak adhesive property of the thermoplastic binder.

9 In contrast, a thermosetting binder, as used herein, may have significantly different
10 physical and chemical properties from the thermoplastic heat-resistant fiber. Accordingly,
11 when a thermosetting binder is impregnated into the nonwoven fabric formed of the
12 thermoplastic heat-resistant fiber, an interfacial layer may be formed by edge-to-edge contact
13 because of the different characteristics in phase. As a result, the micro cavities of the
14 nonwoven fabric may remain open. Therefore, when a thermosetting resin is used as the binder
15 impregnated into the nonwoven fabric formed of the heat-resistant fiber, the three-dimensional
16 shape including micro cavities inside the nonwoven fabric may be maintained. Accordingly, a
17 thermosetting resin may be used as the binder in an exemplary embodiment of the present
18 invention.

19 In addition, the thermosetting resin may be curable with light, heat or a curing agent and
20 its shape may not be deformed even at elevated temperatures. Accordingly, by using the heat-
21 resistant fiber and the thermosetting binder in exemplary embodiments of the present invention,
22 the shape of the sound-absorbing material may be maintained even at high temperature condition
23 after shaping process. Therefore, when a thermosetting resin is used as the binder impregnated
24 into the nonwoven fabric, shaping the nonwoven fabric to a desired shape may be achieved
25 during the curing of the resin and the obtained shape may be maintained even at high
26 temperatures.

27 As described above, when a thermosetting resin is used as the binder impregnated into
28 the nonwoven fabric formed of the heat-resistant fiber, in addition to maintaining the three-
29 dimensional shape inside the nonwoven fabric, shaping the nonwoven fabric into a desired shape
30 during the curing of the binder resin may be obtained.

1 In an exemplary embodiment, an epoxy resin may be used as the binder. The epoxy
2 resin, as used herein, may be a representative thermosetting resin and be curable into a polymer
3 material having a three-dimensional network structure. Accordingly, since the epoxy resin may
4 form a network structure and micro cavities therein when cured inside the nonwoven fabric,
5 additional fine micro cavities may be formed inside the nonwoven fabric and the sound-
6 absorbing performance may be further improved.

7 Further, a more complicated three-dimensional network structure may be formed when
8 the curing is carried out in the presence of a curing agent, and thus the sound-absorbing effect
9 may be further improved. In detail a three-dimensional network-structured polymer may be
10 formed as the epoxide groups or hydroxyl groups of the epoxy resin react with the functional
11 groups of the curing agent such as amine groups or carboxylic acid groups to form covalent
12 crosslinkages. The curing agent may serve as a catalyst that catalyzes curing reaction and
13 further be involved in the reaction and linked to the chemical groups of the epoxy resin.
14 Accordingly, the size and physical properties of the micro cavities may be controlled by
15 selecting different curing agents.

16 In an exemplary embodiment, the epoxy resin may be one or more selected from the
17 group consisting of bisphenol A diglycidyl ether, bisphenol B diglycidyl ether, bisphenol AD
18 diglycidyl ether, bisphenol F diglycidyl ether, bisphenol S diglycidyl ether, polyoxypropylene
19 diglycidyl ether, bisphenol A diglycidyl ether polymer, phosphazene diglycidyl ether, bisphenol
20 A novolac epoxy, phenol novolac epoxy resin, and o-cresol novolac epoxy resin. In particular,
21 the epoxy resin may have an epoxy equivalent in a range of 70 to 400. When the epoxy
22 equivalent is less than a predetermined value intermolecular binding may be significantly
23 reduced to form the three-dimensional network structure or the physical properties of the sound-
24 absorbing material may be insufficient because of reduced adhesion with the heat-resistant fiber.
25 In contrast, when the epoxy equivalent is greater than a predetermined value, the physical
26 properties of the sound-absorbing material may not be sufficient because of excessively dense
27 network structure formed by the epoxy resin.

28 In an exemplary embodiment, when a thermosetting resin is used as a binder in the
29 present invention, the curing agent may be included in a binder solution. As used herein, the
30 curing agent may have a functional group that may react readily with the functional groups of the

1 binder such as epoxide groups or hydroxyl groups. In particular, the curing agent may be an
2 aliphatic amine, an aromatic amine, an acid anhydride, urea, an amide, imidazole, and the like.
3 In an exemplary embodiment, the curing agent may be one or more selected from the group
4 consisting of diethyltoluenediamine (DETDA), diaminodiphenylsulfone (DDS), boron
5 trifluoride-monoethylamine (BF₃·MEA), diaminocyclohexane (DACH), methyltetrahydrophthalic
6 anhydride (MTHPA), methyl-5-norbornene-2,3-dicarboxylic anhydride (NMA), dicyandiamide
7 (Dicy), and 2-ethyl-4-methylimidazole. In an exemplary embodiment, an aliphatic amine- or
8 amide-based curing agent may be used due to improved crosslinking ability, superior chemical
9 resistance and weather resistance. In particular, dicyandiamide (Dicy) may be used in
10 consideration of crosslinking ability, flame retardancy, heat resistance, storage stability,
11 processability, and the like. Since dicyandiamide (Dicy) has a high melting point above 200 °C,
12 it may remain highly stable after being mixed with the epoxy resin and may provide sufficient
13 processing time for curing and shaping.

14 In an exemplary embodiment of the present invention, a catalyst that facilitates the
15 curing of the thermosetting resin used as the binder may be used. In particular, catalyst may be
16 one or more selected from the group consisting of urea, dimethylurea, a tetraphenylborate salt of
17 quaternary DBU, and quaternary phosphonium bromide. The catalyst may be included in the
18 binder-containing solution.

19 In addition, various additives, for example, flame retardant, heat resistance improver,
20 water repellent, and the like, may be used to provide additional functionalities to the sound-
21 absorbing material. The additive may be included in the binder solution, and thus no additional
22 surficial material for providing functionalities to the sound-absorbing material may be necessary.

23 In an exemplary embodiment, the flame retardant may be melamine, phosphate, metal
24 hydroxide and the like. In particular, the flame retardant may be one or more selected from the
25 group consisting of melamine, melamine cyanurate, melamine polyphosphate, phosphazene, and
26 ammonium polyphosphate. More particularly, the flame retardant may be melamine, which
27 may provide flame retardancy and heat resistance simultaneously.

28 In an exemplary embodiment, the heat resistance improver may be alumina, silica, talc,
29 clay, glass powder, glass fiber, metal powder, and the like.

1 In an exemplary embodiment, one or more fluorine-based water repellent may be used as
2 the water repellent.

3 In addition, additives commonly used in the related art may be selected depending on
4 desired purposes.

5 In another aspect, the present invention provides a method for preparing a sound-
6 absorbing material, which may include: a) immersing a nonwoven fabric containing an amount
7 of 30 wt% to 100 wt% of a heat-resistant fiber in a binder solution; and b) drying the nonwoven
8 fabric.

9 Hereinafter, exemplary embodiments of each step of the method for preparing a sound-
10 absorbing material will be described in detail.

11 In an exemplary embodiment, in step a), a nonwoven fabric formed of a heat-resistant
12 fiber may be immersed in a binder solution. The nonwoven fabric may be immersed in the
13 binder solution to improve sound-absorbing and sound-insulating performance and to allow
14 shaping of the sound-absorbing material into a desired shape. The binder solution may include
15 a binder resin and further contain a curing agent, a catalyst, conventional additives and a solvent.

16 The binder, curing agent, catalyst and conventional additives included in the binder
17 solution may be the same as described above. The solvent used to prepare the binder solution
18 may be one or more selected from the group consisting of a ketone, a carbonate, an acetate, and a
19 cellosolve. In particular, the solvent may be one or more selected from the group consisting of
20 acetone, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), dimethyl carbonate
21 (DMC), ethyl acetate, butyl acetate, methyl cellosolve, ethyl cellosolve, and butyl cellosolve.

22 In an exemplary embodiment, the binder solution may contain an amount of 1 wt % to
23 60 wt% of a binder; and a solvent as the remainder. In addition, the binder solution may further
24 contain a curing agent and other additives including a catalyst. In particular, the binder solution
25 may contain an amount of 1 wt% to 60 wt% of a binder, an amount of 0.1 wt% to 10 wt% of a
26 curing agent, an amount of 0.01 wt% to 5 wt% of a catalyst, an amount of 1 wt% to 40 wt% of
27 additives and a solvent as the remainder. More particularly, the binder solution may contain an
28 amount of 1 wt % to 30 wt% of a binder, an amount of 0.1 wt% to 10 wt% of a curing agent, an
29 amount of 0.01 wt% to 5 wt% of a catalyst, an amount of 1 wt% to 30 wt% of a flame retardant
30 as an additive and an amount of 40 wt % to 95 wt% of a solvent.

1 In an exemplary embodiment, the degree of impregnation into the nonwoven fabric may
2 be controlled by controlling the concentration of the binder solution. For example, the binder
3 solution may be prepared to have a solid content in a range of 1 wt% to 60 wt%, or particularly
4 of 20 wt % to 50 wt%. When the binder solution has less concentrated than a predetermined
5 value, the purpose of the present invention may not be accomplished because the content of the
6 binder impregnated into the nonwoven fabric is small. In contrast, when the binder solution is
7 more concentrated than a predetermined value, the nonwoven fabric may become hard and may
8 not serve as a good sound-absorbing material.

9 In addition, when the content of the curing agent contained in the binder solution is less
10 than a predetermined amount, shaping to a desired shape may be difficult because curing of the
11 binder may not be completed. As a result, the effect of improving the mechanical strength of
12 the sound-absorbing material may not be achieved. And, when the content of the curing agent
13 is greater than a predetermined amount, the sound-absorbing material may become hard and
14 storage stability or the like may be unsatisfactory. Furthermore, when the content of the
15 catalyst is less than a predetermined amount, the catalytic effect for facilitating reaction may not
16 be sufficiently provided. In contrast, when the content of the catalyst is greater than a
17 predetermined amount, stability and the like may be unsatisfactory. The additives may be one
18 or more additive(s) conventionally used in the related art, which may include a flame retardant, a
19 heat resistance improver, a water repellent and the like. The content of these additives may be
20 adjusted adequately depending on the purpose of addition. When the amount of additives is
21 less than a predetermined amount, the desired effect may not be achieved. And, when the
22 amount of additives is greater than a predetermined amount, economical use thereof may not be
23 obtained and undesired side effects may be caused.

24 In an exemplary embodiment of the present invention, in step b), the nonwoven fabric
25 may be dried. The drying step may be carried out by taking out the nonwoven fabric from the
26 binder solution and removing the solvent. The drying may be carried out at appropriate
27 temperatures under a pressure. In an exemplary embodiment, the drying may be carried out at a
28 temperature in a range of 70 °C to 200 °C, or particularly of 100 °C to 150 °C. In addition, in
29 the drying step, the content of the binder in the nonwoven fabric may be controlled and the
30 physical properties of the sound-absorbing material may be controlled. Furthermore, the

1 content of the binder included in the nonwoven fabric after the drying may determine the sizes,
2 shapes and distribution of micro cavities inside the sound-absorbing material. Accordingly, the
3 sound-absorbing property and mechanical property of the sound-absorbing material may be
4 controlled therewith. In an exemplary embodiment, the drying may be carried out such that the
5 final content of the binder may be included in the nonwoven fabric in an amount of 1 part to 300
6 parts by weight, or particularly of 30 parts to 150 parts by weight, based on 100 parts by weight
7 of the nonwoven fabric.

8 In addition, the method for preparing a sound-absorbing material according to an
9 exemplary embodiment of the present invention may further include, after the step b), a step of
10 preparing a sound-absorbing material by shaping the dried nonwoven fabric at elevated
11 temperature (step c). When the step c) is included, the method for preparing a sound-absorbing
12 material may include: a) immersing a nonwoven fabric containing an amount of 30 wt% to 100
13 wt% of a heat-resistant fiber in a binder solution; b) drying the nonwoven fabric; and c)
14 preparing a sound-absorbing material by shaping the dried nonwoven fabric at an elevated
15 temperature. Particularly, in step c) is a step, a sound-absorbing material may be prepared by
16 shaping the dried nonwoven fabric at the elevated temperature. The shaping at elevated
17 temperature may include curing of the thermosetting binder and may be carried out at a
18 temperature in a range of 150 °C to 300 °C, or particularly of 170 °C to 230 °C.

19 The method for preparing a sound-absorbing material according to an exemplary
20 embodiment of the present invention may further include, before the step a), a step of forming a
21 nonwoven fabric by needle punching of a heat-resistant fiber (step a-1). For example, in the
22 step a-1), an aramid nonwoven fabric having a thickness in a range of 3 mm to 20 mm may be
23 formed by needle punching of a heat-resistant aramid fiber of 1 denier to 15 denier.

24 When the step a-1) is further included, the method for preparing a sound-absorbing
25 material may include: a-1) forming an aramid nonwoven fabric having a thickness in a range of 3
26 mm to 20 mm by needle punching of a heat-resistant aramid fiber of 1 denier to 15 denier; a)
27 immersing a nonwoven fabric containing an amount of 30 wt% to 100 wt% of a heat-resistant
28 fiber in a binder solution; and b) drying the nonwoven fabric.

29 In addition, the method for preparing a sound-absorbing material including the step a-1)
30 according to the present invention may include: a-1) forming an aramid nonwoven fabric having

1 a thickness in a range of 3 mm to 20 mm by needle punching of a heat-resistant aramid fiber of 1
2 denier to 15 denier; a) immersing a nonwoven fabric containing an amount of 30 wt% to 100 wt%
3 of a heat-resistant fiber in a binder solution; b) drying the nonwoven fabric; and c) preparing a
4 sound-absorbing material by shaping the dried nonwoven fabric at the elevated temperature.

5 In an exemplary embodiment, step a-1) of forming a nonwoven fabric may include
6 needle punching of a heat-resistant fiber. Since the sound-absorbing property may vary
7 depending on the thickness and density of the nonwoven fabric, the sound-absorbing property
8 may be enhanced with the increase of the thickness and density of the nonwoven fabric.

9 In an exemplary embodiment, the nonwoven fabric may have a thickness in a range of 3
10 mm to 20 mm according to its application or parts of the sound-absorbing material used. When
11 the thickness of the nonwoven fabric is less than 3 mm, the durability and shapeability of the
12 sound-absorbing material may be unsatisfactory. In contrast, when the thickness is greater than
13 20 mm, productivity may decrease and production cost may increase during manufacturing and
14 fabricating the nonwoven fabrics. In addition, the density of the nonwoven fabric may be in a
15 range of 100 g/m² to 2000 g/m², of 200 g/m² to 1200 g/m², or particularly of 300 g/m² to 800
16 g/m², in the respects of performance and cost.

17 The aramid nonwoven fabric may be formed by stacking a web of 30 g/m² to 100 g/m²
18 which is formed by carding 2 to 12 fold and continuously performing up-down preneedling,
19 down-up needling and up-down needling, thereby forming physical bridges and providing the
20 desired thickness, binding strength and other desired physical properties. The needle used to
21 perform the needling may be a barb-type needle, having a working blade of 0.5 mm to 3 mm and
22 a needle length measured as the distance from crank outside to point in a range of 70 mm to 120
23 mm. In addition, the needle stroke may be 30 times/m² to 350 times/m².

24 In particular, the fineness of yarn for the nonwoven fabric may be in a range of 1.5
25 denier to 8.0 denier, the thickness of the pile layer may be in a range of 6 mm to 13 mm, the
26 needle stroke may be in a range of 120 times/m² to 250 times/m², and the density of the
27 nonwoven fabric may be in a range of 300 g/m² to 800 g/m².

28 The internal structure of the sound-absorbing material prepared by the method according
29 to various exemplary embodiments described above may be confirmed using an electron
30 microscope. When observed with an electron microscope, the sound-absorbing material of the

1 present invention may have micro cavities which may have a size in a range of 1 μm to 100 μm ,
2 and be distributed inside thereof. The micro cavities may be distributed regularly or irregularly
3 with a distances therebetween in a range of 0.1 μm to 500 μm .

4 In another exemplary embodiment, the present invention provides a method for reducing
5 noise of a noise-generating device, including: i) checking the three-dimensional structure of a
6 noise-generating device; ii) preparing and shaping a sound-absorbing material to provide the
7 partial or entire three-dimensional structure of the device; and iii) installing the sound-absorbing
8 material adjacent to the noise-generating device.

9 An exemplary noise-generating device, as used herein, may be a motor, an engine, an
10 exhaust system, and the like. The sound-absorbing material may be provided in the three-
11 dimensional structure of the device partially or entirely. In particular, the sound-absorbing
12 material according to an exemplary embodiment of the present invention may be prepared and
13 shaped during curing of the binder in the three-dimensional structure of the device partially or
14 entirely.

15 Any operation with a language "adjacent", as used herein, may imply closely attaching
16 the sound-absorbing material to the noise-generating device, whether by providing it at a
17 distance from the noise-generating device, or by exactly shaping it as a part of the noise-
18 generating device. Further, the operation with the language "adjacent" may include mounting
19 the sound-absorbing material to a member connected to the noise-generating device, for example,
20 another sound-absorbing material.

21 Fig. 2 and Fig. 3 schematically show exemplary vehicle parts or noise-generating device
22 of a vehicle to which the sound-absorbing material according to an exemplary embodiment of the
23 present invention may be applied.

24 In particular, Fig. 2 schematically shows noise-generating devices of a vehicle to which
25 a sound-absorbing material may be applied after shaping as a part. Fig. 2 (a) is a schematic
26 view of an exemplary vehicle engine, and Fig. 2 (b) schematically illustrates an exemplary
27 sound-absorbing material which may be shaped and applied in a part of a vehicle engine.

28 Fig. 3 schematically shows an exemplary sound-absorbing material which may be
29 applied to a noise-generating device of a vehicle. Fig. 3 (a) schematically illustrates an

1 exemplary lower part of a vehicle, and Fig. 3 (b) schematically illustrates an exemplary sound-
2 absorbing material which may be shaped and attached to a lower part of a vehicle.

3 In various exemplary sound-absorbing material of the present invention, the binder may
4 be impregnated to maintain the three-dimensional shape inside the nonwoven fabric, and the
5 sound-absorbing material may have superior sound-absorbing property, flame retardancy, heat
6 resistance and heat-insulating property. Accordingly, the desired sound-absorbing performance
7 may be obtained when directly applied to a noise-generating device operating at a temperature of
8 200 °C or greater, without deformation.

9 The present invention will be described in more detail through examples, although the
10 scope of the present invention may be by the examples.

11

12 **EXAMPLES: Preparation of sound-absorbing material**

13 Example 1. Preparation of sound-absorbing material using epoxy resin-impregnated
14 aramid nonwoven fabric

15 A m-aramid short fiber having a limiting oxygen index (LOI) of 40%, a heat resistance
16 at a temperature of 300 °C, a fineness of 2 denier and a length of 51 mm may be air blown and
17 formed into a web of 30 g/m² through carding. The web may be stacked by overlapping 10-
18 fold on a conveyor belt operated at 5 m/min using a horizontal wrapper. An aramid nonwoven
19 fabric having a density of 300 g/m² and a thickness of 6 mm may be prepared by continuously
20 performing up-down needling, down-up needling and up-down needling with a needle stroke of
21 150 times/m².

22 The prepared nonwoven fabric may be immersed in a binder solution with 1 dip 1 nip, at
23 pick-up rate of 300%. The binder solution may include 8 wt% of bisphenol A diglycidyl ether,
24 2 wt% of bisphenol A diglycidyl ether polymer, 0.2 wt% of dicyandiamide, 0.02 wt% of
25 dimethylurea, 10 wt% of melamine cyanurate and 79.78 wt% of dimethyl carbonate (DMC).

26 The nonwoven fabric may be taken from the binder solution and dried at 150 °C. The
27 dried nonwoven fabric may contain 50 parts by weight of a binder based on 100 parts by weight
28 of the nonwoven fabric.

29 The dried nonwoven fabric may be shaped into a desired shape by curing at 200 °C for 2
30 minutes.

1

2 Comparative Example 1. Preparation of sound-absorbing material using aramid
3 nonwoven fabric

4 An aramid nonwoven fabric having a density of 300 g/m² and a thickness of 6 mm was
5 prepared by needle punching as described in Example 1.

6

7 Comparative Example 2. Preparation of sound-absorbing material using epoxy resin-
8 coated aramid nonwoven fabric

9 An aramid nonwoven fabric having a density of 300 g/m² and a thickness of 6 mm may
10 be prepared by needle punching as described in Example 1. Subsequently, a coating solution
11 may be coated on the surface of the nonwoven fabric so that the content of a binder may be 50
12 parts by weight based on 100 parts by weight of the nonwoven fabric. Then, the nonwoven
13 fabric may be shaped after drying at a temperature of 150 °C.

14 The coating solution may include 8 wt% of bisphenol A diglycidyl ether, 2 wt% of
15 bisphenol A diglycidyl ether polymer, 0.2 wt% of dicyandiamide, 0.02 wt% of dimethylurea, 10
16 wt% of melamine cyanurate and 79.78 wt% of dimethyl carbonate.

17

18 Comparative Example 3. Preparation of sound-absorbing material using thermoplastic
19 resin-impregnated aramid nonwoven fabric

20 An aramid nonwoven fabric having a density of 300 g/m² and a thickness of 6 mm may
21 be prepared by needle punching, immersed in a binder solution, dried and then shaped as
22 described in Example 1.

23 The binder solution may be a thermoplastic resin solution including 10 wt% of
24 polyethylene resin, 10 wt% of melamine cyanurate and 80 wt% of dimethyl carbonate.

25

26 Comparative Example 4. Preparation of sound-absorbing material using epoxy resin-
27 impregnated PET nonwoven fabric

28 A polyethylene terephthalate (PET) nonwoven fabric having a density of 300 g/m² and a
29 thickness of 6 mm may be prepared by needle punching, immersed in a binder solution, dried
30 and then shaped as described in Example 1.

The PET nonwoven fabric prepared in Comparative Example 4 was thermally deformed due to the reaction heat produced during the curing of epoxy and could not be shaped to a desired shape because it was completely thermally deformed during the drying and shaping processes.

[Test Example]

Evaluation of physical properties of sound-absorbing materials

The physical properties of the sound-absorbing materials of test samples were measured and compared as follows.

1. Evaluation of heat resistance

To evaluate heat resistance, the sound-absorbing material was aged in an oven at 260 °C for 300 hours. After keeping at standard state, i.e., temperature of 23±2 °C, relative humidity of 50±5%, for at least 1 hour, appearance was inspected and tensile strength was measured. It was visually inspected whether there were shrinkage or deformation, surface peeling, fluffing and cracking. The tensile strength was measured using a dumbbell-type No. 1 for randomly selected five sheets of test samples at a speed of 200 mm/min under a standard condition.

2. Evaluation of thermal cycle

The durability of the sound-absorbing material was evaluated by the thermal cycle test method. The durability was determined after performing five cycles.

1) Condition of one cycle

Room temperature → high temperature (150 °C x 3hr) → room temperature → low temperature (-30 °C x 3 hr) → room temperature → humid condition (50 °C x 95% RH)

2) Durability evaluation standard

After the thermal cycle test, the change in appearance of each test sample was inspected. For example, surface damage, swelling, breaking and discoloring may be inspected. If there was no change in appearance, the sound-absorbing material was evaluated as 'no abnormality'.

3. Evaluation of flame retardancy

The flame retardancy of the sound-absorbing material was measured according to standard ISO 3795 flammability test.

4. Evaluation of nonflammability

The nonflammability of the sound-absorbing material was measured according to standard UL94 vertical burn test.

5. Evaluation of sound-absorbing property

The sound-absorbing property of the sound-absorbing material was measured according to standard ISO 354 method.

6. Evaluation of air permeability**1) Evaluation method**

The test sample was mounted on a Frazier-type tester and the amount of air flowing through the test sample vertically was measured. The area of the test sample through which air passed was 5 cm² and the applied pressure was set to 125 pascal (Pa).

Test Example 1. Comparison of properties of sound-absorbing materials depending on types of heat-resistant fibers

In Test Example 1, the physical properties of sound-absorbing materials prepared with different heat-resistant fiber yarns were compared. Nonwoven fabrics having a density of 300 g/m² and a thickness of 6 mm were prepared by needle punching and sound-absorbing materials were prepared by immersing in a binder solution, drying and then shaping as described in Example 1. The nonwoven fabrics were prepared using yarns having a fineness of 2 denier and a length of 51 mm, which are described in Table 1.

The physical properties of the sound-absorbing material test samples were measured as described above. The results of measuring the properties of the sound-absorbing materials prepared with different heat-resistant fibers are shown in Table 1 and Table 2.

【Table 1】

		Yarn 1	Yarn 2	Yarn 3	Yarn 4	Yarn 5	Yarn 6	Yarn 7
Yarn	Yarn material	Aramid	PPS	PI	PBI	PBO	Oxi-PAN	PK
	Limiting oxygen index	40	30	50	40	60	65	30

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	Heat resistance temperature (°C x 1 hr)	300	230	300	300	300	300	300
Heat resistance	Appearance	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality
	Tensile strength (Kgf/cm ²)	200	180	220	200	210	210	200
Thermal cycle	Appearance	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality	No abnormality
Flame retardancy		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
Nonflammability		Nonflammable	Nonflammable	Nonflammable	Nonflammable	Nonflammable	Nonflammable	Nonflammable

1

2

【Table 2】

Frequency (Hz)	Sound-absorbing rate			
	Yarn 1 (aramid)	Yarn 2 (PPS)	Yarn 6 (oxi-PAN)	Yarn 7 (PK)
400	0.08	0.05	0.08	0.05
500	0.10	0.06	0.09	0.06
630	0.16	0.09	0.13	0.08
800	0.23	0.15	0.22	0.19
1000	0.35	0.30	0.35	0.26
1250	0.44	0.39	0.45	0.37
1600	0.59	0.49	0.57	0.31
2000	0.70	0.66	0.68	0.48

2500	0.79	0.71	0.80	0.67
3150	0.83	0.80	0.85	0.78
4000	0.86	0.83	0.88	0.84
5000	0.99	0.95	0.92	0.83
6300	0.98	0.96	0.98	0.89
8000	0.99	0.95	0.89	0.95
10000	0.98	0.97	0.99	0.95

As seen from Table 1 and Table 2, all the sound-absorbing materials prepared using heat-resistant fibers having a limiting oxygen index of 25% or greater and a heat resistance temperature of 150 °C or greater according to an exemplary embodiment of the present invention may obtain satisfactory heat resistance, durability, flame retardancy, nonflammability and sound-absorbing property. Accordingly, conventionally used heat-resistant fibers, i.e. super fiber, may be used as the material of the nonwoven fabric of the sound-absorbing material according to an exemplary embodiment of the present invention.

Test Example 2. Comparison of properties of sound-absorbing materials depending density of nonwoven fabric

In Test Example 2, sound-absorbing material test samples were prepared as described in Example 1 using nonwoven fabrics having different densities. The sound-absorbing performance of the sound-absorbing material test samples are shown in Fig. 4.

As seen from Fig. 4, the sound-absorbing performance of the sound-absorbing material may be superior when a nonwoven fabric having a density of 600 g/m² may be used in comparison to a nonwoven fabric having a density of 300 g/m².

Test Example 3. Evaluation of physical properties of sound-absorbing materials

In Test Example 3, the properties of sound-absorbing material test samples depending on the method by which a thermosetting binder may be applied to a nonwoven fabric were compared.

1 Accordingly, the sound-absorbing rate of the sound-absorbing material test samples
2 prepared by impregnating (Example 1) and coating (Comparative Example 2) the thermosetting
3 binder were compared. The results of measuring the sound-absorbing rate of the sound-
4 absorbing material formed of a nonwoven fabric (Comparative Example 1), the sound-absorbing
5 material on which the thermosetting binder was coated (Comparative Example 2) and sound-
6 absorbing material wherein the thermosetting binder was impregnated into the nonwoven fabric
7 (Example 1) are shown in Table 3.

8

9 **【Table 3】**

Frequency (Hz)	Sound-absorbing rate		
	Comparative Example 1 (nonwoven fabric)	Comparative Example 2 (binder-coated nonwoven fabric)	Example 1 (binder- impregnated nonwoven fabric)
400	0.01	0.02	0.08
500	0.03	0.03	0.10
630	0.12	0.05	0.16
800	0.16	0.08	0.23
1000	0.26	0.12	0.35
1250	0.32	0.15	0.44
1600	0.39	0.22	0.59
2000	0.48	0.29	0.70
2500	0.64	0.40	0.79
3150	0.63	0.57	0.83
4000	0.72	0.68	0.86
5000	0.80	0.77	0.99
6300	0.78	0.82	0.98
8000	0.89	0.98	0.99

10000	0.90	0.98	0.98
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As seen from Table 3, the sound-absorbing material of Example 1 according to an exemplary embodiment of the present invention may have superior sound-absorbing rate in all frequency ranges in comparison to the sound-absorbing material of Comparative Example 1 wherein the nonwoven fabric not impregnated with a thermosetting binder was used. In contrast, the sound-absorbing material of Comparative Example 2 of which the thermosetting binder was coated on the nonwoven fabric may have reduced sound-absorbing rate than the nonwoven fabric (Comparative Example 1) in the frequency range of 400 Hz to 5000 Hz.

Test Example 4. Evaluation of heat-insulating performance of sound-absorbing materials

In Test Example 4, the heat-insulating performance of each sound-absorbing material test sample prepared in Example 1 (thermosetting resin-impregnated aramid nonwoven fabric), Comparative Example 1 (aramid nonwoven fabric) or Comparative Example 3 (thermoplastic resin-impregnated aramid nonwoven fabric) was evaluated. After applying heat of 1000 °C from one side of 25 mm thick sample of each sound-absorbing material for 5 minutes, temperature was measured on the opposite side of the sample.

The temperature measured on the opposite side of the sound-absorbing material was 250 °C for Example 1 and 350 °C for Comparative Example 1. Accordingly, the sound-absorbing material according to an exemplary embodiment of the present invention of which the thermosetting resin was improved may have improved heat-insulating performance. In contrast, the thermoplastic resin-impregnated sound-absorbing material test sample of Comparative Example 3 was melt down as soon as the heat of 1000 °C was applied.

Accordingly, the sound-absorbing material according to an exemplary embodiment of the present invention may obtain superior heat-insulating property.

Test Example 5. Comparison of heat-insulating performance with aluminum heat-insulating plate

In Test Example 5, the heat-insulating performance of the sound-absorbing material of Example 1 was compared with that of the aluminum heat-insulating plate. While applying the

1 same heat from one side of the sound-absorbing material and the heat-insulating plate at 250 °C,
2 the temperature at the opposite side of the sound-absorbing materials was measured with time.
3 The results are shown in Fig. 5.

4 As seen from Fig. 5, the sound-absorbing material according to an exemplary
5 embodiment of the present invention may have improved heat-insulating performance by
6 lowering the transferred temperature at least by 11 °C as compared to the aluminum heat-
7 insulating plate.

8
9 Test Example 6. Comparison of properties of sound-absorbing material depending on
10 binder content

11 Sound-absorbing material test samples were prepared as described in Example 1. The
12 epoxy resin-impregnated aramid nonwoven fabric was dried to have different contents of the
13 final binder. The binder content may be represented as parts by weight of the binder included
14 in the sound-absorbing material based on 100 parts by weight of the dried nonwoven fabric.

15 The results of comparing the mechanical properties and sound-absorbing rate of the
16 sound-absorbing materials of Examples and Comparative Examples with different binder
17 contents are shown in Table 4 and Table 5.

18
19 **【Table 4】**

Physical properties of sound-absorbing materials with different binder contents					
Binder content (parts by weight)	0	10	50	100	200
Air permeability (mL/cm ² ·s)	500	380	350	320	210
Tensile strength (kg/cm ²)	40	60	200	240	310
Flammability	Nonflammable	Nonflammable	Nonflammable	Nonflammable	Nonflammable

20
21 **【Table 5】**

Frequency	Sound-absorbing rate of sound-absorbing materials with different binder
-----------	---

(Hz)	contents				
	0 parts by weight	10 parts by weight	50 parts by weight	100 parts by weight	200 parts by weight
400	0.01	0.01	0.08	0.06	0.02
500	0.03	0.04	0.10	0.09	0.04
630	0.12	0.14	0.16	0.15	0.09
800	0.16	0.17	0.23	0.25	0.11
1000	0.26	0.26	0.35	0.30	0.14
1250	0.32	0.34	0.44	0.42	0.17
1600	0.39	0.41	0.59	0.54	0.22
2000	0.48	0.55	0.70	0.58	0.35
2500	0.64	0.68	0.79	0.67	0.44
3150	0.63	0.69	0.83	0.72	0.52
4000	0.72	0.77	0.86	0.75	0.53
5000	0.80	0.83	0.99	0.79	0.57
6300	0.78	0.88	0.98	0.80	0.63
8000	0.89	0.91	0.99	0.90	0.70
10000	0.90	0.92	0.98	0.92	0.71

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In Table 4 and Table 5, the sound-absorbing rate may be improved as the binder is impregnated into the nonwoven fabric in comparison to the nonwoven fabric which is not impregnated with the binder. Therefore, the sound-absorbing rate of the sound-absorbing material may be controlled with the content of the binder.

Test Example 7. Comparison of properties of sound-absorbing material depending on types of binders

Sound-absorbing materials in which 50 parts by weight of a binder was impregnated based on 100 parts by weight of an aramid nonwoven fabric may be prepared as described in Example 1. The resins described in Table 6 were used as the binder.

The results of comparing the mechanical properties and sound-absorbing rate of the sound-absorbing materials of Examples and Comparative Examples with different binders composition are shown in Table 6.

【Table 6】

	Sound-absorbing rate of sound-absorbing materials with different binders				
Binder resin	Epoxy	Phenol	Urea	Melamine	Polyurethane
Heat resistance temperature (°C×1 hr)	300	260	190	300	200
Tensile strength (kg/cm ²)	200	165	180	180	170
Flame retardancy	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
Flammability	Nonflammable	Nonflammable	Nonflammable	Nonflammable	Nonflammable

Claims

1. A sound-absorbing material comprising:
a nonwoven fabric comprising an amount of 30 wt % to 100 wt % of a heat-resistant fiber; and
a binder impregnated in the same layer as the nonwoven fabric and maintaining a three-dimensional structure inside the nonwoven fabric,
wherein the binder is distributed and attached to the surface of the fiber yarn of the nonwoven fabric, thereby maintaining the structure of or facilitating the formation of micro-cavities of the nonwoven fabric.
2. The sound-absorbing material according to claim 1, wherein the heat-resistant fiber has a limiting oxygen index (LOI) of 25% or greater and a heat resistance temperature in a range of 150° C. or greater.
3. The sound-absorbing material according to claim 2, wherein the heat-resistant fiber is one or more selected from the group consisting of aramid fiber, polyphenylene sulfide (PPS) fiber, oxidized polyacrylonitrile (oxi-PAN) fiber, polyimide (PI) fiber, polybenzimidazole (PBI) fiber, polybenzoxazole (PBO) fiber, polytetrafluoroethylene (PTFE) fiber, polyketone (PK) fiber, metallic fiber, carbon fiber, glass fiber, basalt fiber, silica fiber and ceramic fiber.
4. The sound-absorbing material according to claim 3, wherein the heat-resistant fiber is an aramid fiber.
5. The sound-absorbing material according to claim 1, wherein the nonwoven fabric is a single-layer nonwoven fabric formed of an aramid fiber having a fineness in a range of 1 denier to 15 denier and having a thickness in a range of 3 mm to 20 mm.
6. The sound-absorbing material according to claim 1, wherein the nonwoven fabric has a density in a range of 100 g/m² to 2000 g/m².
7. The sound-absorbing material according to claim 5, wherein the nonwoven fabric has a density in a range of 200 g/m² to 1200 g/m².
8. The sound-absorbing material according to claim 1, wherein the binder is a thermosetting resin.
9. The sound-absorbing material according to claim 8, wherein the thermosetting resin is an epoxy resin.
10. The sound-absorbing material according to claim 9, wherein the epoxy resin is one or more selected from the group consisting of bisphenol A diglycidyl ether, bisphenol B diglycidyl ether, bisphenol AD diglycidyl ether, bisphenol F diglycidyl ether, bisphenol S diglycidyl ether, polyoxypropylene diglycidyl ether, bisphenol A diglycidyl ether polymer, phosphazene diglycidyl ether, bisphenol A novolac epoxy, phenol novolac epoxy resin and o-cresol novolac epoxy resin.

11. The sound-absorbing material according to claim 1, wherein the sound-absorbing material is shaped to have a three-dimensional shape to which the sound-absorbing material is applied.

12. The sound-absorbing material according to claim 1, wherein the sound-absorbing material is formed in a single layer or multiple layers.

13. The sound-absorbing material according to any one of claims 1 to 12, wherein the sound-absorbing material is used in a vehicle.

14. A method for preparing a sound-absorbing material according to claim 1, comprising:

a) immersing a nonwoven fabric comprising an amount of 30 wt % to 100 wt % of a heat-resistant fiber in a binder solution; and
b) drying the immersed nonwoven fabric,
wherein the binder is distributed and attached to the surface of the fiber yarn of the nonwoven fabric, thereby maintaining the structure of or facilitating the formation of micro-cavities of the nonwoven fabric.

15. The method for preparing the sound-absorbing material according to claim 14, which further comprises, after said drying the immersed nonwoven fabric, preparing the sound-absorbing material by shaping the dried nonwoven fabric at elevated temperature.

16. The method for preparing the sound-absorbing material according to claim 14, wherein the heat-resistant fiber has a limiting oxygen index (LOI) of 25% or greater and a heat resistance temperature of 150° C. or greater.

17. The method for preparing the sound-absorbing material according to claim 16, wherein the heat-resistant fiber is one or more selected from the group consisting of aramid fiber, polyphenylene sulfide (PPS) fiber, oxidized polyacrylonitrile (oxi-PAN) fiber, polyimide (PI) fiber, polybenzimidazole (PBI) fiber, polybenzoxazole (PBO) fiber, polytetrafluoroethylene (PTFE) fiber, polyketone (PK) fiber, metallic fiber, carbon fiber, glass fiber, basalt fiber, silica fiber and ceramic fiber.

18. The method for preparing the sound-absorbing material according to claim 14, wherein the heat-resistant fiber is an aramid fiber having a fineness in a range of 1 denier to 15 denier having a yarn length in a range of 20 mm to 100 mm.

19. The method for preparing the sound-absorbing material according to claim 14, wherein the nonwoven fabric has a thickness in a range of 3 mm to 20 mm and a density in a range of 100 g/m² to 2000 g/m².

20. The method for preparing the sound-absorbing material according to claim 15, which further comprises, before said immersing the nonwoven fabric, forming an aramid nonwoven fabric having a thickness in a range of 3 mm to 20 mm by needle punching of a heat-resistant aramid fiber having a fineness in a range of 1 denier to 15 denier.

21. The method for preparing the sound-absorbing material according to claim 20, wherein the nonwoven fabric is formed by continuously performing up-down needling, down-up needling and up-down needling.

22. The method for preparing the sound-absorbing material according to claim 20, wherein the nonwoven fabric is formed with a needle stroke in a range of 30 times/m² to 350 times/m².

23. The method for preparing the sound-absorbing material according to claim 14, wherein the binder solution comprises an amount of 1 wt % to 60 wt % of a binder, an amount of 0.1 wt % to 10 wt % of a curing agent, an amount of 0.01 wt % to 5 wt % of a catalyst, an amount of 1 wt % to 40 wt % of an additive and a solvent as the remainder, based on the total weight of the binder solution.

24. The method for preparing the sound-absorbing material according to claim 23, wherein the binder solution comprises an amount of 1 wt % to 30 wt % of a binder, an amount of 0.1 wt % to 10 wt % of a curing agent, an amount of 0.01 to 5 wt % of a catalyst, an amount of 1 wt % to 30 wt % of a flame retardant and an amount of 40 wt % to 95 wt % of a solvent, based on the total of the binder solution.

25. The method for preparing the sound-absorbing material according to claim 14, wherein the binder is a thermosetting resin.

26. The method for preparing the sound-absorbing material according to claim 25, wherein the thermosetting resin is an epoxy resin.

27. The method for preparing the sound-absorbing material according to claim 26, wherein the epoxy resin is one or more selected from the group consisting of bisphenol A diglycidyl ether, bisphenol B diglycidyl ether, bisphenol AD diglycidyl ether, bisphenol F diglycidyl ether, bisphenol S diglycidyl ether, polyoxypropylene diglycidyl ether, bisphenol A diglycidyl ether polymer, phosphazene diglycidyl ether, bisphenol A novolac epoxy, phenol novolac epoxy resin and o-cresol novolac epoxy resin.

28. The method for preparing a sound-absorbing material according to claim 14, wherein the drying is performed at a temperature in a range of 70° C. to 200° C. and the dried nonwoven fabric comprises an amount of 1 part to 300 parts by weight of a binder based on 100 parts by weight of the nonwoven fabric.

29. The method for preparing the sound-absorbing material according to claim 14, wherein the sound-absorbing material is for an automobile.

30. A method for reducing noise of a noise-generating device, comprising:
i) checking a three-dimensional shape of the noise-generating device;
ii) preparing and shaping a sound-absorbing material of according to claim 1 so as to correspond to the three-dimensional shape of the device partially or entirely; and
iii) bringing the sound-absorbing material adjacent to the noise-generating device.

31. The method for reducing noise of the noise-generating device according to claim 30, wherein the device is a motor, an engine or an exhaust system.

32. The method for reducing noise of the noise-generating device according to claim 30, wherein the sound-absorbing material is brought adjacent to the noise-generating device by attaching the sound-absorbing material to the noise-generating device, providing the sound-absorbing material with a distance from the noise-generating device, or shaping the sound-absorbing material as a part of the noise-generating device.

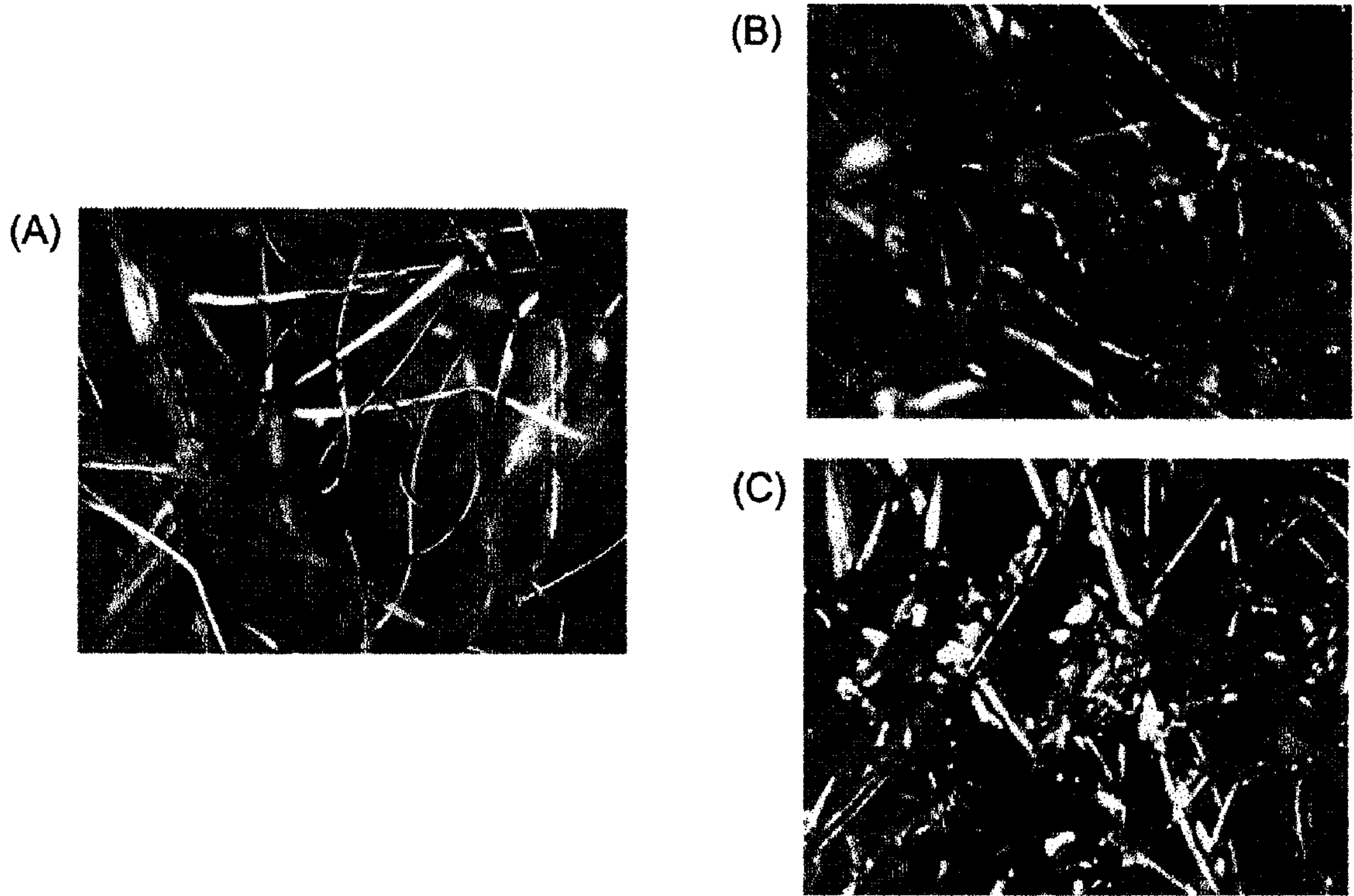
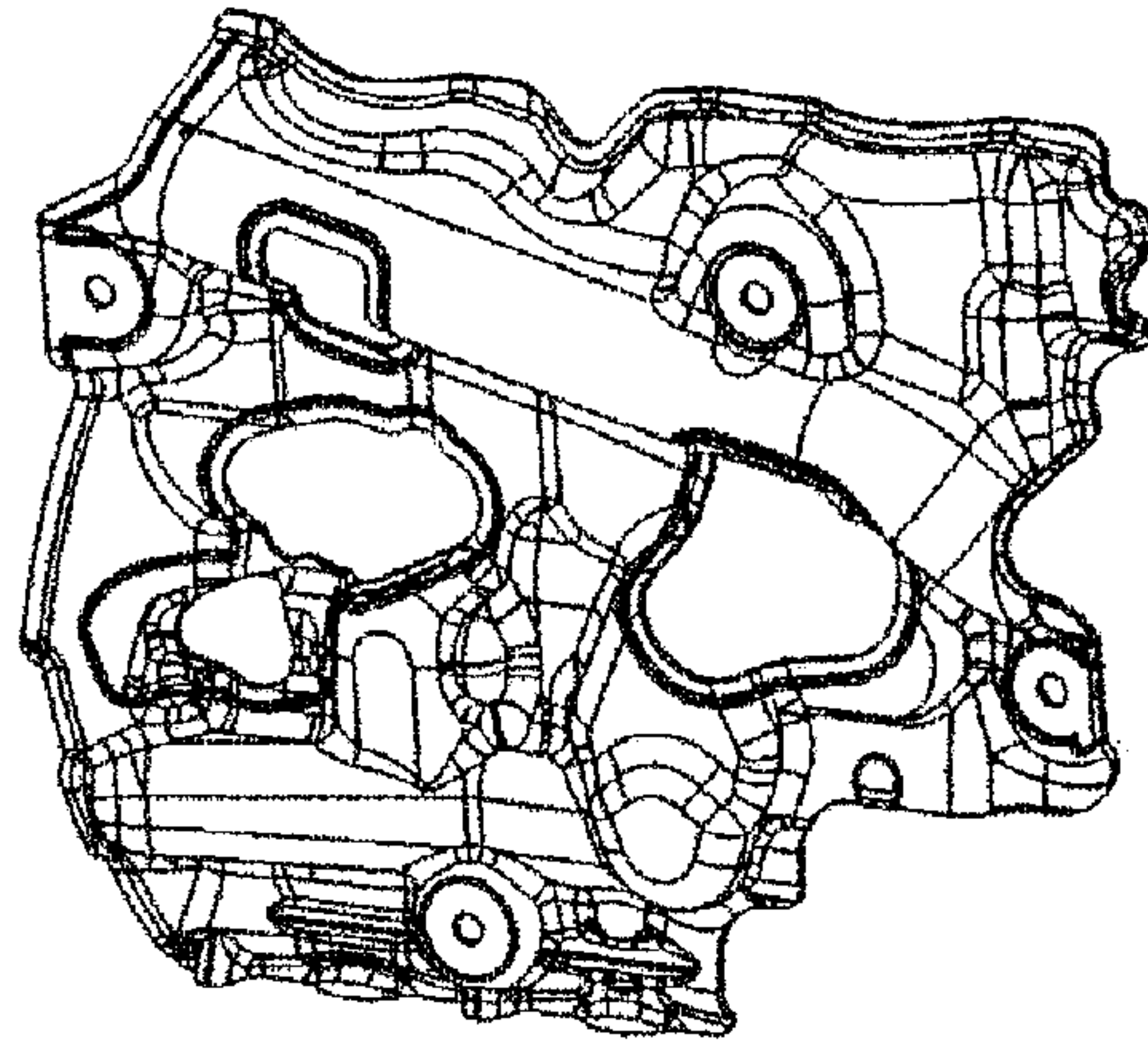
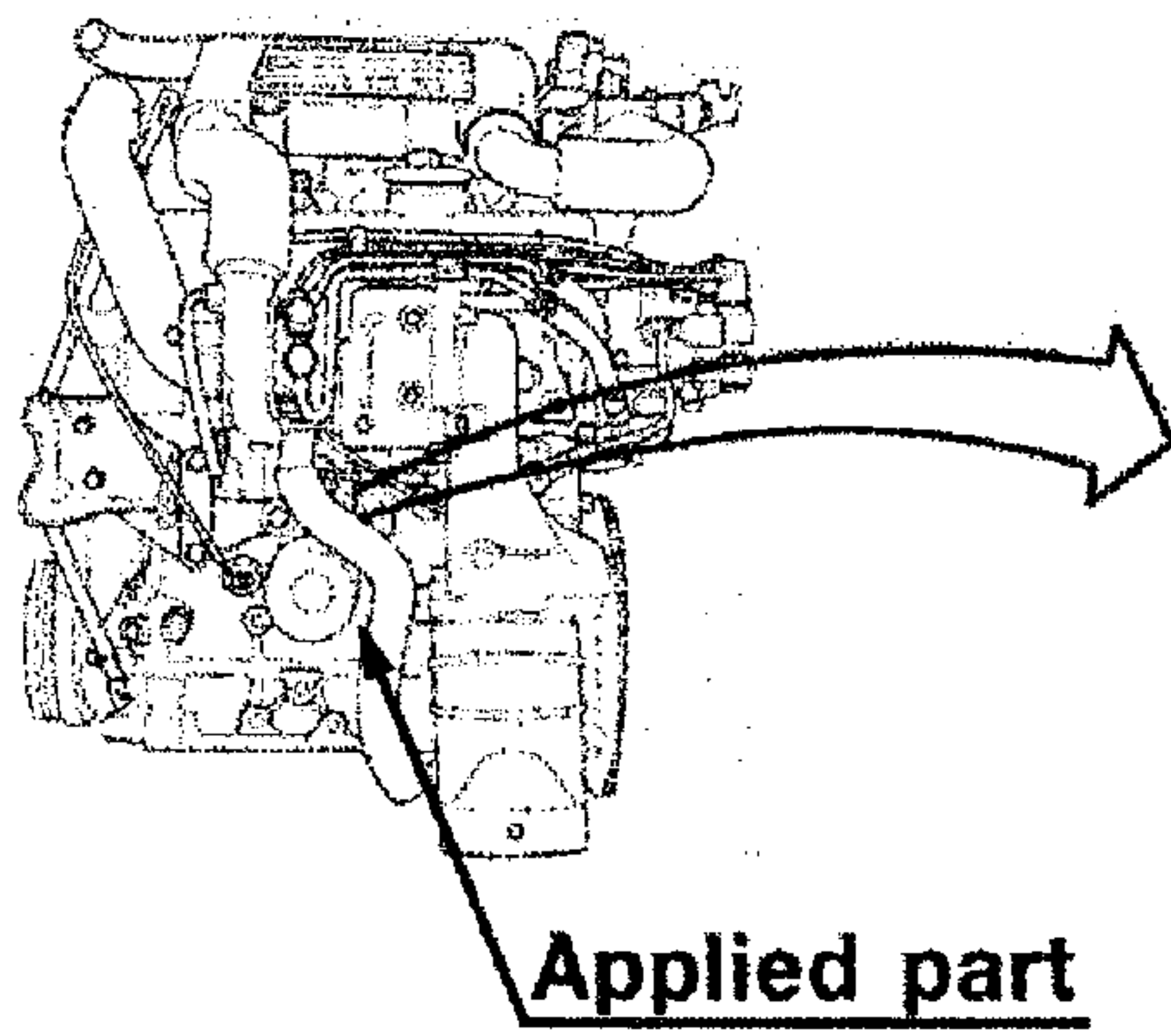


FIG.1



(a)



(b)

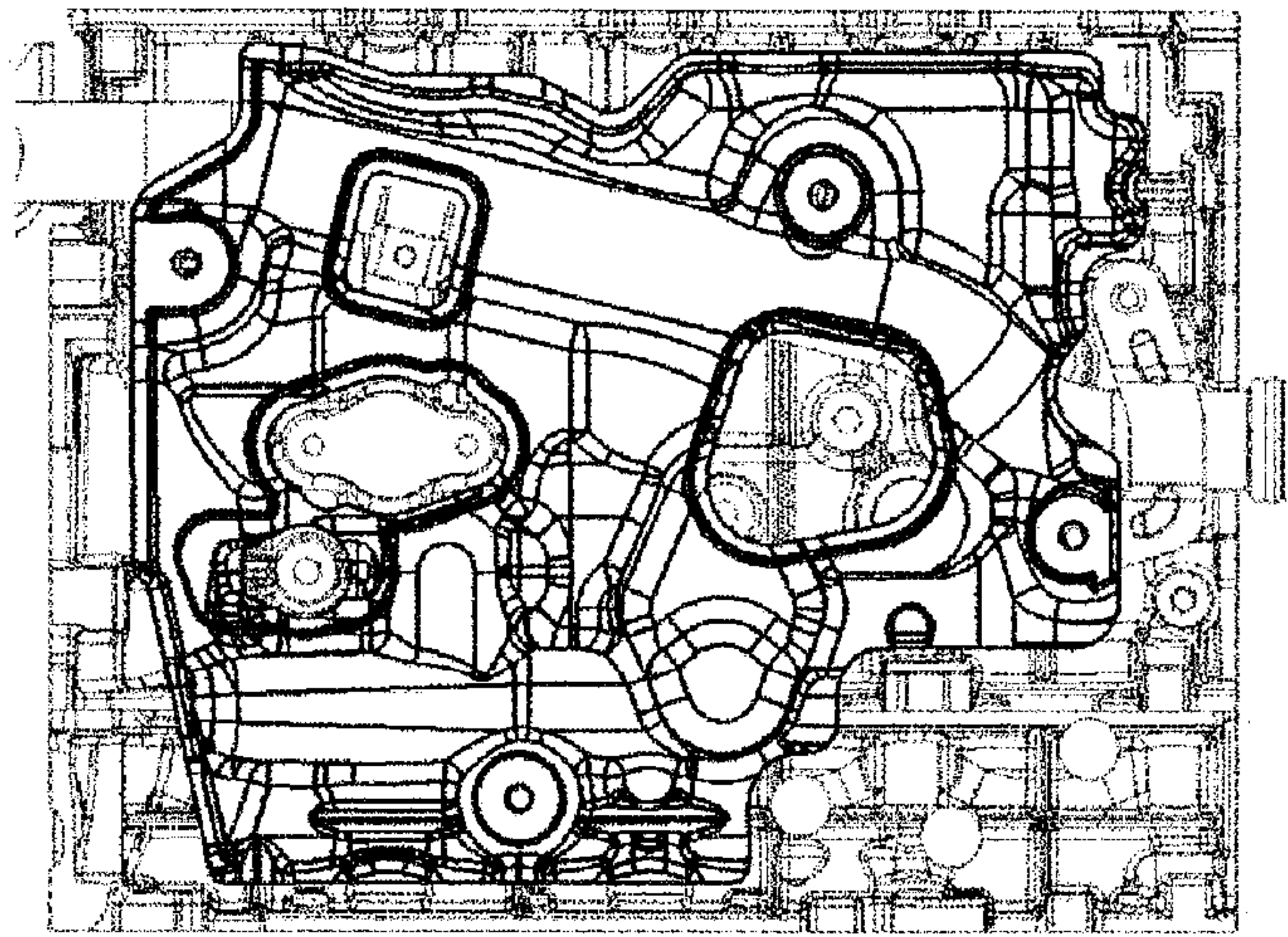
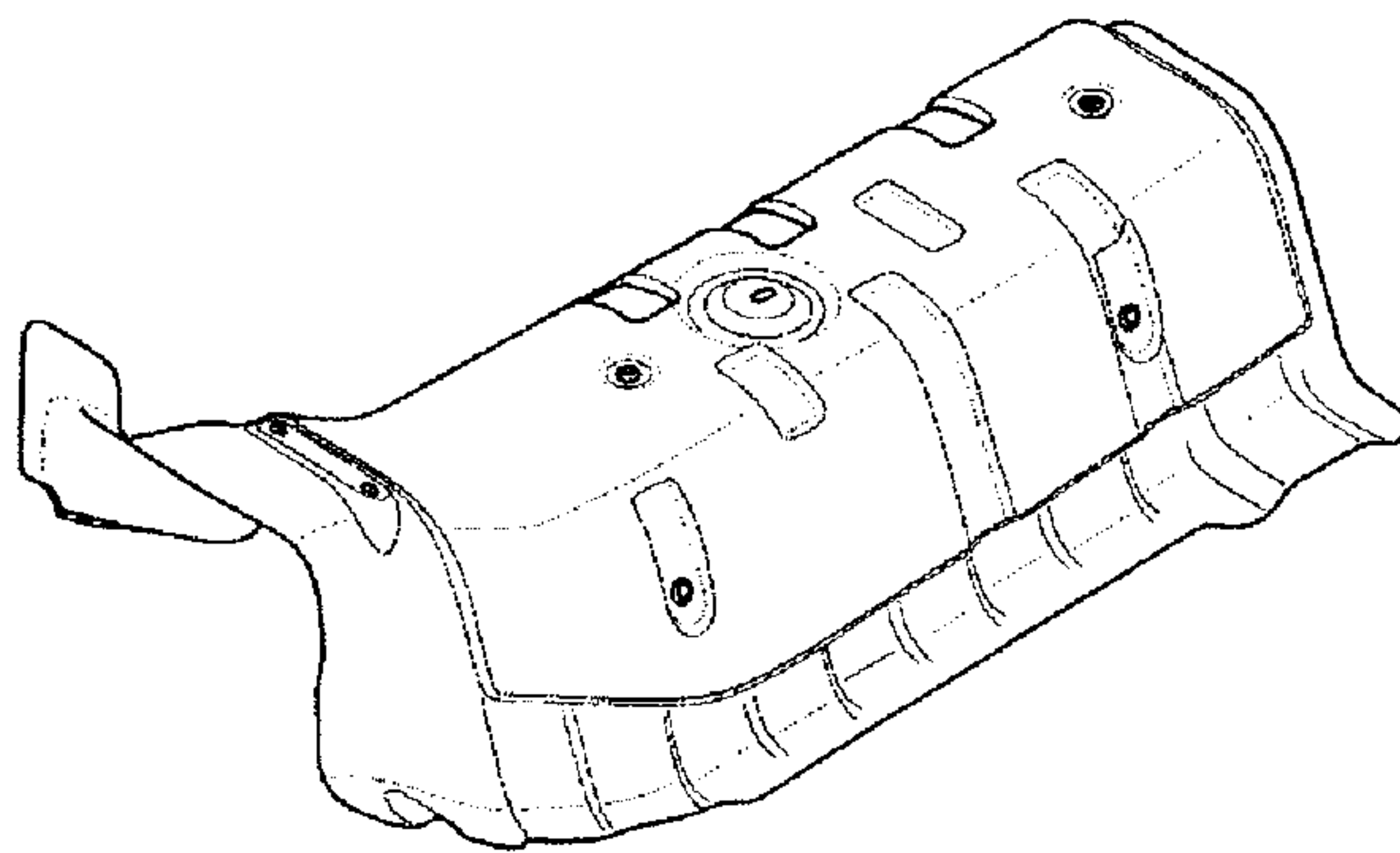
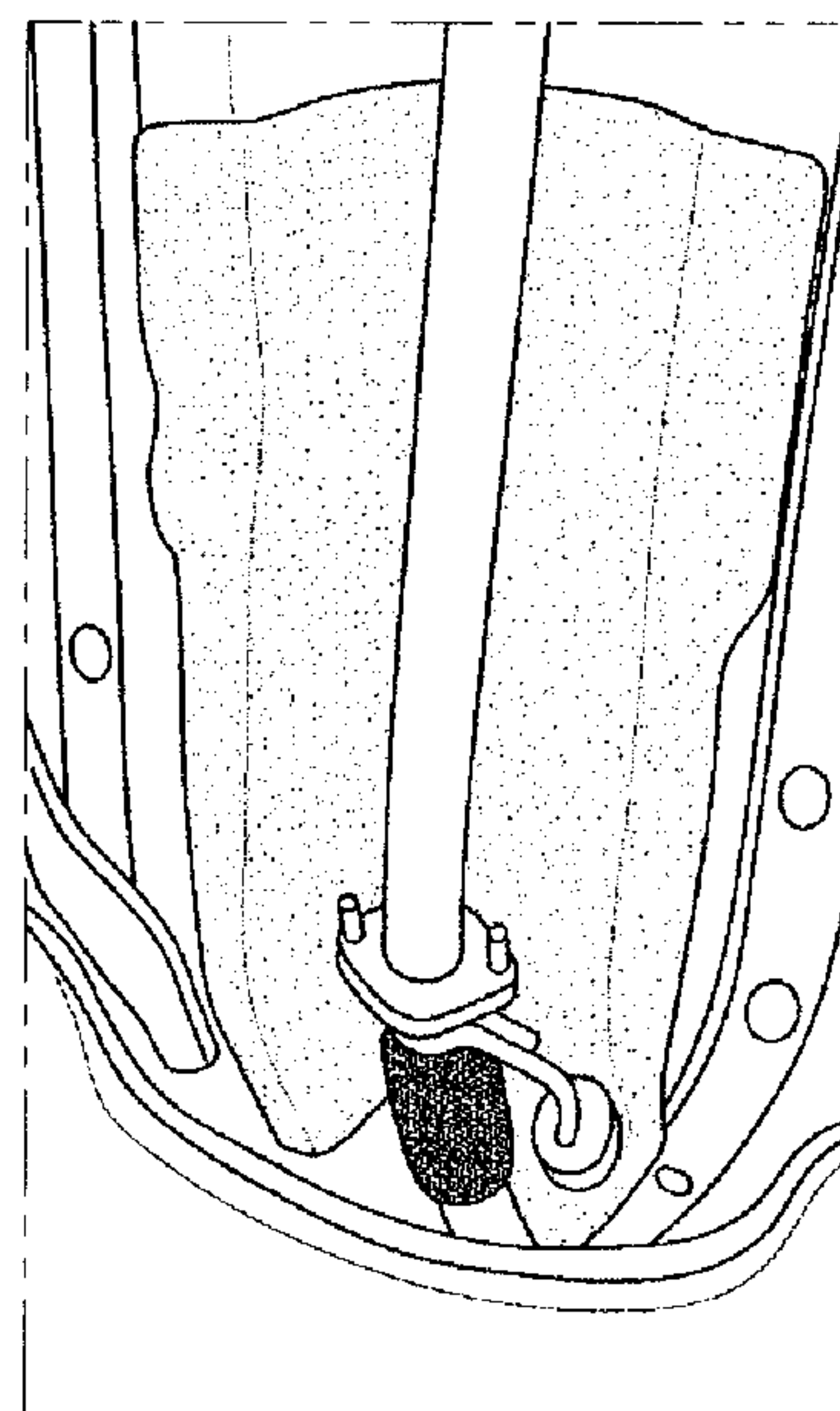
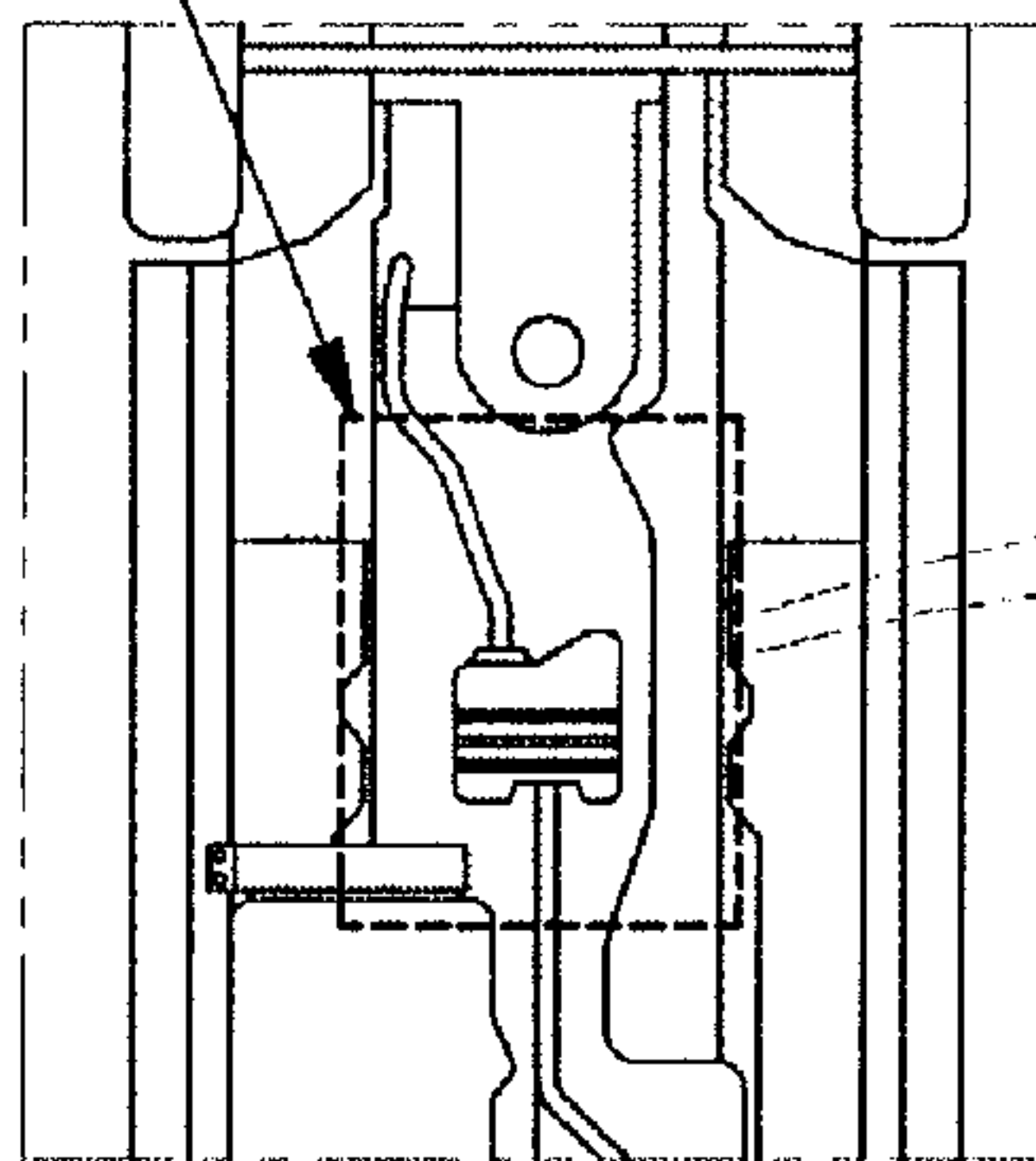


FIG.2



(a)

Applied part



(b)

FIG.3

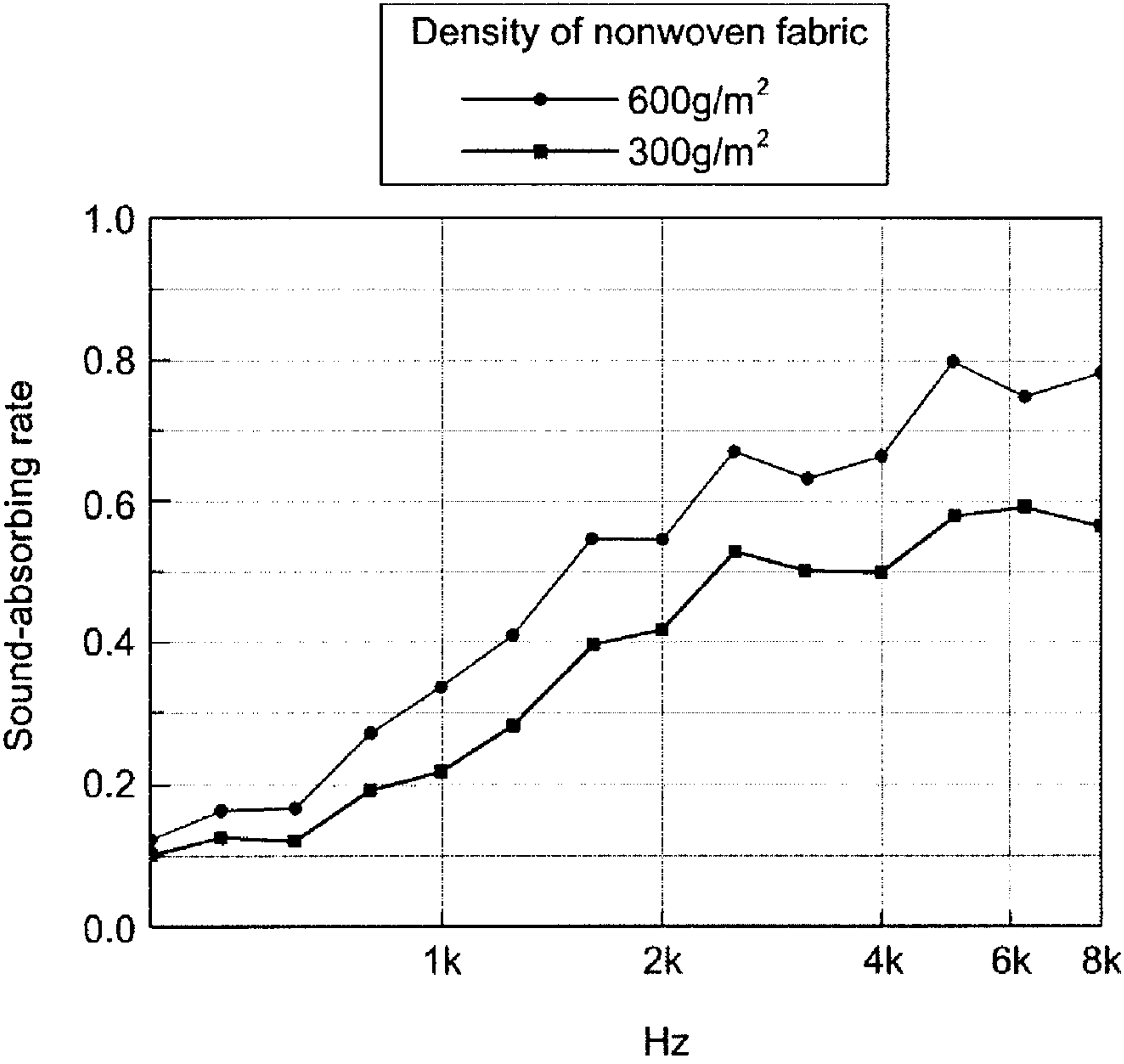


FIG.4

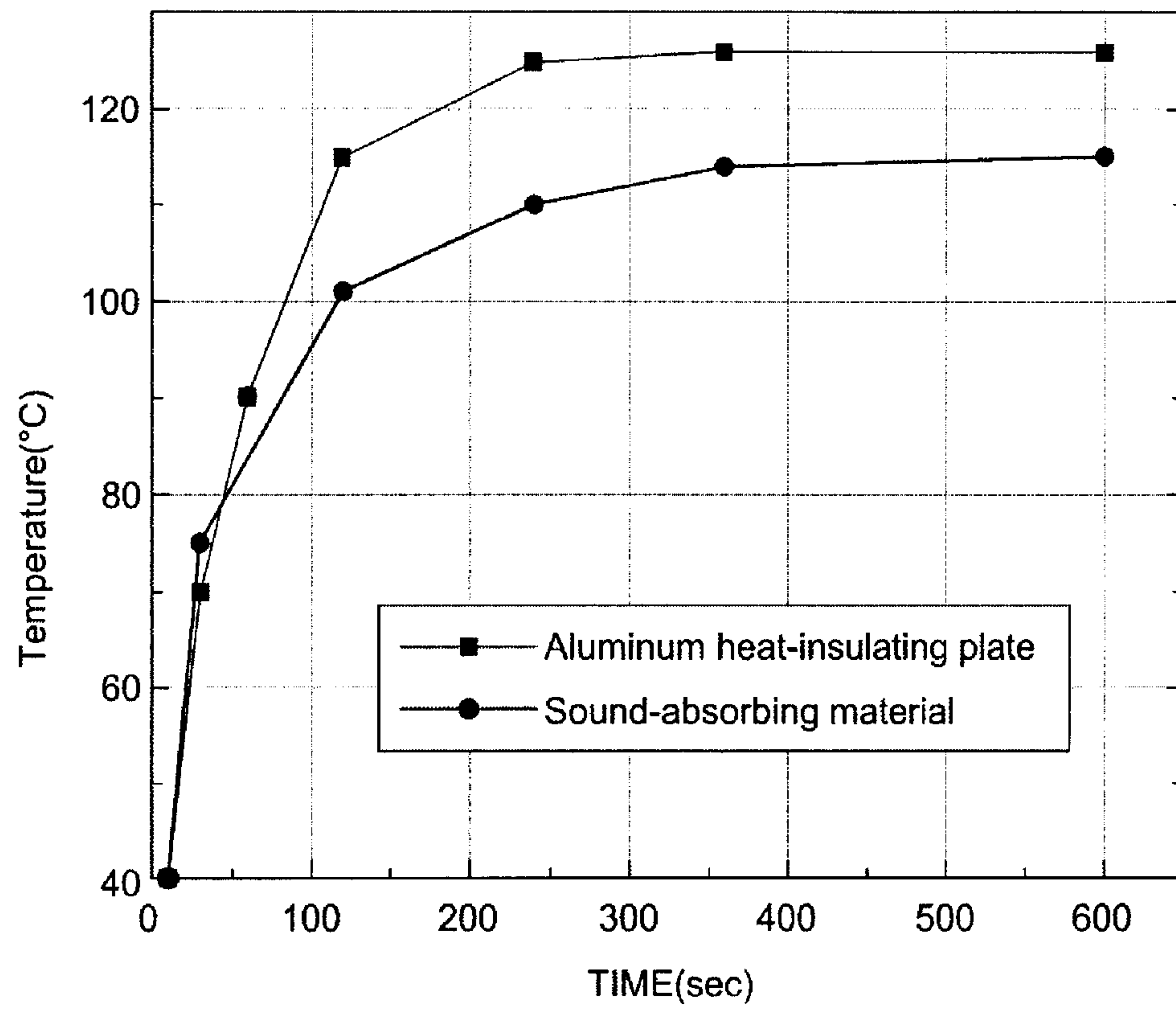


FIG.5

(A)



(B)



(C)

